



City of Guelph Climate Adaptation Plan Final Report

Prepared for:
City of Guelph

Prepared by:
Matrix Solutions Inc.

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Guelph, Ontario

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City of Guelph Climate Adaptation Plan

Final Report

Prepared for the City of Guelph, July 2023



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Message from the Chief Administrative Officer

On behalf of Council and all our staff, I'm proud to share the City of Guelph's first Climate Adaptation Plan. This plan marks a significant milestone, as it aligns with our strategic plan's commitment to addressing the impacts of climate change.

Climate change is a global challenge that requires local action. The City is committed to fighting climate change and is already implementing several measures to win the Race To Zero and become a net-zero carbon community by 2050.

Now we're taking a proactive approach to climate adaptation, recognizing that we must prepare for the impacts of climate change to protect our community and ensure our long-term sustainability. The Climate Adaptation Plan is the result of extensive research, consultation, and collaboration with internal teams across the City and community partners. It is a corporate strategy that ensures our community is prepared to withstand and recover from the effects of climate change, including extreme weather events, flooding, and heat warnings, by taking action to adapt our policies, plans, assets, operations and services.

Thank you to all the staff and community partners who contributed to the development of this plan. Your hard work and dedication have resulted in a comprehensive and forward-thinking strategy that will guide the City's efforts to adapt to the impacts of climate change.

I am proud to endorse the City of Guelph's Climate Adaptation Plan, and I look forward to working with all of you to implement its recommendations and ensure a sustainable future for our community.

Sincerely,

A handwritten signature in blue ink, appearing to read "Scott Stewart", with a horizontal line extending to the right.

Scott Stewart
Chief Administrative Officer
City of Guelph

City of Guelph Territorial Acknowledgements

We are reminded that Guelph is situated on treaty land that is steeped in rich Indigenous history and home to many First Nations, Inuit and Métis people today.

As a City we have a responsibility for the stewardship of the land on which we live and work.

We acknowledge the Mississaugas of the Credit First Nation of the Anishinaabek Peoples on whose traditional territory we are situated.

Acknowledgements

The Project Team would like to acknowledge the contributions of all those who participated in the City of Guelph's Climate Adaptation Plan development. Extensive engagement with internal and external stakeholders was critical to the project's success, resulting in meaningful dialogue about climate change impacts in Guelph and collaboration on adaptation action recommendations.

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Glossary

Adaptation. The process of adjustment through the application of soft (operations) or hard (infrastructure) measures to actual or expected climate and its effects, in order to moderate harm or reduce vulnerability and to capitalize upon beneficial opportunities.

Adaptation options. The array of strategies and measures that are available and appropriate for addressing adaptation. They include a wide range of actions that can be categorized as structural, institutional, ecological, or behavioural.

Adaptive capacity. The combination of the strengths, attributes, and resources available to the City of Guelph as an organization that can be used to prepare for and undertake actions to reduce adverse impacts, moderate harm, or exploit beneficial opportunities from climate change.

Adaptive management. Adaptive management is a systematic process for continually improving management policies and practices by learning from the outcomes of operational programs. Adaptive management also provides a framework for actively responding to any inaccurate forecasts and ineffective mitigation measures.

Baseline/reference. The baseline (or reference) is the state against which change is measured. It might be a “current baseline,” in which case it represents observable, present-day conditions. It might also be a “future baseline,” which is a projected future set of conditions based on “business-as-usual.” Alternative interpretations of the reference conditions can give rise to multiple baselines.

Carbon dioxide (CO₂). A naturally occurring gas fixed by photosynthesis into organic matter. A by-product of fossil fuel combustion and biomass burning, it is also emitted from land-use changes and other industrial processes. It is the principal anthropogenic greenhouse gas that affects the earth’s radiative balance. It is the reference gas against which other greenhouse gases are measured.

Climate. Climate in a narrow sense is usually defined as the “average weather,” or more rigorously, as the statistical description in terms of the mean and variability of relevant quantities over a period of time ranging from months to thousands or millions of years. These quantities are most often surface variables such as temperature, precipitation, and wind. Climate in a wider sense is the state, including a statistical description, of the climate system. The classical period of time is 30 years, as defined by the World Meteorological Organization (WMO).

Climate change. Climate change refers to any change in climate over time, whether due to natural variability or as a result of human activity. This usage differs from that in the United Nations Framework Convention on Climate Change, which defines “climate change” as “a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods.”

Climate change impacts. A series of changes within the overall global climate system, brought about as a result of increased atmospheric concentrations of greenhouse gases. These impacts may have far-reaching and unpredictable environmental, social, and economic consequences, and may include global sea level rise, increases in severe weather events, and changes in precipitation.

Climate model. A numerical representation of the climate system based on the physical, chemical, and biological properties of its components, their interactions and feedback processes, and accounting for all or some of its known properties. The climate system can be represented by models of varying complexity (i.e., for any one component or combination of components a hierarchy of models can be identified, differing in such aspects as the number of spatial dimensions, the extent to which physical, chemical, or biological processes are explicitly represented, or the level at which empirical parameterizations are involved). Coupled atmosphere/ocean/sea-ice General Circulation Models (AOGCMs) provide a comprehensive representation of the climate system. More complex models include active chemistry and biology. Climate models are applied as a research tool to study and simulate the climate, but also for operational purposes, including monthly, seasonal, and inter-annual climate predictions.

Climate change parameters. The measurable physical properties of climate. Where climate is the average pattern of weather for a particular region, this average is commonly taken over a 30-year time period. Climatic elements include precipitation, temperature, humidity, sunshine, wind velocity, phenomena such as fog, frost, hailstorms, etc.

Climate projection. The calculated response of the climate system to emissions or concentration scenarios of greenhouse gases and aerosols, or radiative forcing scenarios, often based on simulations by climate models. Climate projections are distinguished from climate predictions, in that the former critically depend on the emissions/ concentration/radiative forcing scenario used, and therefore on highly uncertain assumptions of future socio-economic and technological development.

Climate (change) scenario. A plausible and often simplified representation of the future climate, based on an internally consistent set of climatological relationships and assumptions of radiative forcing, typically constructed for explicit use as input to climate change impact models. A climate change scenario is the difference between a climate scenario and the current climate.

Coldest minimum temperature. The coldest temperature of the year.

Cooling degree-days. The total number of degrees (averaged per day) that are over 18°C in a year. For example, if it is 23°C on a given day that will add 5 degrees-days to the measure. This is a measure of how much energy will be needed to cool down a building. The more cooling degree-days there are, the more energy is needed.

Coping capacity. The ability of people, institutions, organizations, and systems, using available skills, values, beliefs, resources, and opportunities, to address, manage, and overcome adverse conditions in the short to medium term.

Cost-benefit analysis. Monetary assessment of all negative and positive impacts associated with a given action. Cost-benefit analysis enables comparison of different interventions, investments or strategies and reveal how a given investment or policy effort pays off for a particular person, company, or country. Cost-benefit analyses representing society's point of view are important for climate change decision making, but there are difficulties in aggregating costs and benefits across different actors and across timescales.

Cost-effectiveness. A measure of the cost at which a policy goal or outcome is achieved. The lower the cost the greater the cost effectiveness.

Critical infrastructure. Systems, facilities, technologies, and services essential to the well-being and safety of the residents of the City of Guelph.

Current Replacement Value (CRV). The current cost of rebuilding an infrastructure asset with the equivalent capacity, functionality, and performance.

Drought. A climate event characterized by exceptionally dry and warm weather conditions. In most definitions, the severity of a drought is assessed by the number of consecutive days without precipitation.

Dry days. The number of days a year without rain or snow.

Equity versus Equality. Equality means providing everyone equal access to opportunities and benefits in society. Equity means taking into consideration some people’s particular needs and situations such that the opportunities provided to individuals or groups differ in order to achieve an equal outcome for all.

Equity. There are four parts or pillars to equity: i) Equitable distribution of resources: distributing resources to those who need them most or those who face systemic barriers to accessing resources to ensure equitable outcomes; ii) Accessibility: ensuring that both physical locations but also services and resources are available in the most appropriate manner; iii) Accountability: transparency of policies and processes along with services, meeting the needs of the entire community; and iv) Safety: culturally appropriate/sensitive, safe spaces and environments – both internal and external – checking our biases to build trust among communities In this context, climate adaptation solutions should cover all protected grounds under the Ontario Human Rights Code.

Exposure. Presence of people, livelihoods, assets, services, resources, or infrastructure in place in a specific region that could be adversely affected by climate change.

Extreme weather event. An event that is rare within its statistical reference distribution at a particular place. Definitions of “rare” vary, but an extreme weather event would normally be as rare as or rarer than the tenth or 90th percentile. By definition, the characteristics of what is called “extreme weather” may vary from place to place. Extreme weather events may typically include floods and droughts.

Food security. A situation that exists when all people, at all times, have physical, social, and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life.

Freeze-thaw cycles. The process of water freezing and thawing multiple times during a winter season. This is a problem when water slips into a material, such as a pipe or a road, and then freezes and expands, causing cracking. Each instance of water freezing and then thawing is one freeze-thaw cycle.

Governance. A comprehensive and inclusive concept of the full range of means for deciding, managing, implementing and monitoring policies and measures. Whereas government is defined strictly in terms of the nation-state, the more inclusive concept of governance recognizes the contributions of various levels of government (global, international, regional, sub-national, and local) and the contributing roles of the private sector, of non-governmental

actors, and of civil society to addressing the many types of issues facing the global community, and the local context where the effectiveness of policies and measures are determined.

Greenhouse gas (GHG). GHGs are those gaseous constituents of the atmosphere, both natural and anthropogenic, that absorb and emit radiation at specific wavelengths within the spectrum of infrared radiation emitted by the earth's surface, the atmosphere, and clouds. This property causes the greenhouse effect. Water vapour (H₂O), carbon dioxide (CO₂), nitrous oxide (N₂O), methane (CH₄) and ozone (O₃) are the primary GHGs in the earth's atmosphere. In addition to carbon dioxide, nitrous oxide, and methane, the Kyoto Protocol deals with the GHGs sulphur hexafluoride (SF₆), hydrofluorocarbons (HFCs) and perfluorocarbons (PFCs).

Green infrastructure. The interconnected set of natural and constructed ecological systems, green spaces, and other landscape features. It includes planted and indigenous trees, wetlands, parks, green open spaces, and original grassland and woodlands, as well as possible building and street level design interventions that incorporate vegetation. Green infrastructure provides services and functions in the same way as conventional infrastructure.

Growing degree-days. An index of the amount of heat available for the growth and maturation of plants and insects. Different based temperatures (5°C, 10°C, and 15°C) are used to cover organisms which need different amounts of heat.

Hazard. The potential occurrence of a natural or human-induced physical event or trend that may cause loss of life, injury, or other health impacts, as well as damage and loss to property, infrastructure, livelihoods, service provision, ecosystems, and environmental resources.

Heating degree-days. The total number of degrees (average per day) that are under 18°C in a year. For example, if it is 11°C on a given day that will add 7 degrees days to the measure. This is a measure of how much heating energy will be required to warm a building. The more heating-degree days there are, the more energy is needed to heat buildings

Heat island. An urban area characterized by ambient temperatures higher than those of the surrounding non-urban area. The cause is a higher absorption of solar energy by materials of the urban fabric such as asphalt.

Heat warning. A period of excessively hot weather, which may or may not be accompanied by high humidity. In southern Ontario, a heat warning occurs when there are two consecutive days when the temperatures reach greater than 31°C and do not fall below 20°C or when the humidex is above 40.

Heavy precipitation day. A day when the total precipitation (rainfall, hail, or snow) is above a designated mark (10 or 20 mm) in liquid form.

Humidex. A Canadian meteorological system of measuring how hot a human body feels by combining measurements of air temperature and humidity.

Icing days. The number of days that the temperature does not rise above freezing. This is a good measure of the severity of a winter season.

(Climate change) Impact assessment. The practice of identifying and evaluating, in monetary and/or non-monetary terms, the effects of climate change on natural and human systems.

(Climate change) Impacts. The effects of climate change on natural and human systems. Depending on the consideration of adaptation, one can distinguish between potential impacts and residual impacts.

Incremental adaptation. Adaptation that maintains the essence and integrity of a system or process at a given scale.

Indigenous knowledge. The understandings, skills, and philosophies developed by societies with long histories of interaction with their natural surroundings. For many Indigenous peoples, Indigenous knowledge informs decision-making about fundamental aspects of life, from day-to-day activities to longer term actions. This knowledge is integral to cultural complexes, which also encompass language, systems of classification, resource use practices, social interactions, values, ritual, and spirituality. These distinctive ways of knowing are important facets of the world's cultural diversity

Inequality. Uneven opportunities and social positions, and processes of discrimination within a group or society, based on gender, class, ethnicity, age, and (dis)ability, often produced by uneven development. Income inequality refers to gaps between highest and lowest income earners.

Infrastructure. The basic equipment, utilities, productive enterprises, installations, and services essential for the development, operation and growth of an organization, city, or nation.

Level of Service (LOS). In an Asset Management Plan, it is the component of the infrastructure for which people experience. LOSs are specific parameters that describe the extent and quality of services that the municipality provides to users. LOSs link an asset's performance to target performance goals.

Likelihood. The state of a phenomenon being likely, namely its probability to occur.

Max 1-day precipitation. The largest amount of rain or snow that can be accumulated in a 24h-period once a year. This is an indicator of extreme precipitation.

Max 3-day precipitation. The largest amount of rain or snow that can accumulate in a 3-day period once a year. This is an indicator of extreme precipitation.

Max 5-day precipitation. The largest amount of rain or snow that can be accumulated in a 5-day period once a year. This is an indicator of extreme precipitation.

Mean annual temperature. The average temperature over the course of one year.

Natural Assets. A subcategory of “green infrastructure (assets)” that refer specifically to naturally occurring features (e.g., wetlands, watercourses, forests).

Operations and Maintenance (O&M). The routine activities performed on an asset that maximize service life and minimize service disruptions without altering the physical components of the asset.

Potential impacts. All impacts that may occur given a projected change in climate, without considering adaptation.

Race To Zero. A global campaign to rally leadership and support from businesses, cities, regions, investors for a healthy, resilient, zero carbon recovery that prevents future threats, creates decent jobs, and unlocks inclusive, sustainable growth. The campaign is committed to achieving net-zero carbon emissions by 2050 at the latest.

Race to Resilience. The sibling campaign to “Race To Zero,” the “Race to Resilience” campaign sets out to catalyze a step-change in global ambition for climate resilience, that will mobilize businesses, investors, cities, and civil society to strengthen the resilience of 4 billion people in vulnerable communities by 2030.

Rehabilitation. Repairing part or most of an asset to extend its service life, without adding to its capacity, functionality, or performance.

Renewal. Replacement of an existing asset, resulting in a new or as-new asset with an equivalent capacity, functionality, and performance as the original asset. Renewal is different from rehabilitation, as renewal rebuilds the entire asset.

Representative Concentration Pathways (RCPs). The Intergovernmental Panel on Climate Change (IPCC) AR5 presents a new way of looking at greenhouse gas emission scenarios with a range of greenhouse gas emission “pathways” that is wider than earlier scenarios, reflecting a general shift in outlook to more extreme future emissions trajectories than were expected a decade ago. There are four RCPs: PCP2.6, RCP4.5, RCP6.0, and RCP8.5 (reflecting low to high emission scenarios), with each defining a specific emissions trajectory and subsequent radiative forcing (a radiative forcing is a measure of the influence a factor has in altering the balance of incoming and outgoing energy in the Earth-atmosphere system, measured in watts per square metre).

Resilience. The ability of municipal departments, their infrastructure assets, and the component parts of their asset base to anticipate, absorb, accommodate, or recover from the effects of a hazardous event in a timely and efficient manner, including through ensuring the preservation, restoration, or improvement of its essential basic structures and functions.

Risk. A measure of the expected outcome of an uncertain event, which is estimated by combining an event’s likelihood and expected consequences or severity. The potential for adverse consequences for human or ecological systems, recognizing the diversity of values and objectives associated with such systems. In the context of climate change, risks can arise from potential impacts of climate change as well as human responses to climate change. Relevant adverse consequences include those on lives, livelihoods, health and well-being, economic, social and cultural assets and investments, infrastructure, services (including ecosystem services), ecosystems, and species. In the context of climate change impacts, risks result from dynamic interactions between climate-related hazards with the exposure and vulnerability of the affected human or ecological system to the hazards. Hazards, exposure, and vulnerability may each be subject to uncertainty in terms of magnitude and likelihood of occurrence, and each may change over time and space due to socio-economic changes and human decision-making

Risk rating. The assessment of the level of risk to the community through use of a pre-defined scale. For example, ranking risks as “low,” “medium,” and “high.”

Scenario. A plausible and often simplified description of how the future may develop, based on a coherent and internally consistent set of assumptions about driving forces and key relationships. Scenarios may be derived from projections but are often based on additional information from other sources, sometimes combined with a “narrative storyline.”

Sensitivity. The degree to which a system is affected by climatic conditions or a specific climate change impact.

Transformational adaptation. Adaptation that changes the fundamental attributes of a social-ecological system in anticipation of climate change and its impacts.

Uncertainty. An expression of the degree to which a value (e.g., the future state of the climate system) is unknown. Uncertainty can result from lack of information or from disagreement about what is known or even knowable. It may have many types of sources, from quantifiable errors in the data to ambiguously defined concepts or terminology, or uncertain projections of human behaviour. Uncertainty can therefore be represented by quantitative measures (e.g., a range of values calculated by various models) or by qualitative statements (e.g., reflecting the judgement of a team of experts).

Useful Service Life (USL): An estimate of the average number of years an asset is useable in the context of design, physical, capacity, and economic criteria.

Vulnerability. The propensity or predisposition to be adversely affected. Vulnerability to climate change is the degree to which public infrastructure assets, customers, employees and contractors, and the region within which we provide services, are susceptible to, and unable to cope with, the adverse impacts of climate change.

Vulnerable Population. The portion of the population that is more affected by the impacts of climate change. Within Guelph, this population may include seniors, youth and children, Indigenous Peoples, racialized populations, people with disabilities, people who are pregnant, frontline emergency responders, individuals who are socially and economically disadvantaged, people who are immunocompromised, and those living with pre-existing illness.

Executive Summary

Introduction

The City of Guelph (the City) developed this Climate Adaptation Plan as a comprehensive strategy to outline how the City will implement actions to manage and reduce the risk of climate change impacts on Guelph and its infrastructure.

There are two overarching responses to climate change: mitigation measures and adaptation measures. Mitigation measures refer to actions that reduce the greenhouse gas (GHG) emissions that cause climate change. The City has set ambitious targets to reduce GHG emissions and become a net-zero carbon community by 2050 or earlier (in alignment with the United Nations’ “Race to Zero,” the global campaign to prevent future climate threats) and has a number of initiatives underway and planned to achieve this goal. Adaptation measures, the focus of this Climate Adaptation Plan, refers to actions that manage and reduce the risk of climate change impacts. There are also actions called co-benefits that benefit both mitigation and adaptation measures and those that generate additional benefits for ecosystems, biodiversity, and social well-being. The City’s One Canopy strategy is a co-benefiting action, with a goal of planting at least 3.6 million trees and achieving a 40% tree canopy in Guelph by 2070.

The City is taking a proactive approach to climate adaptation, recognizing that they must prepare for the impacts of climate change to protect the community and ensure long-term sustainability. The Climate Adaptation Plan is the result of extensive research, consultation, and collaboration with internal teams across Guelph and community partners. It is a corporate strategy that ensures the Guelph community is prepared to withstand and recover from the effects of climate change, including extreme weather events, flooding, and heat warnings, by taking action to adapt Guelph’s policies, plans, assets, operations, and services.

The Climate Adaptation Plan’s vision is as follows:

“Guelph is adaptable and resilient in the face of a changing climate. We are leaders in environment and sustainability.

We protect city assets and sustain what we have for an equitable, strong, healthy, vibrant, and safe community.

We are future ready.”

The implementation of the Climate Adaptation Plan will help meet Guelph’s immediate needs regarding its vulnerability and risks to the current climate, help position the City to take further action, and provide clearer direction regarding what the City needs to move forward to meet its

goal to become a net-zero carbon community by 2050. The Climate Adaptation Plan demonstrates the City’s leadership and innovation in environmental stewardship and social responsibility and supports the City’s vision of being a resilient city that adapts to a changing world.

As part of the overall framework for developing the Climate Adaptation Plan, the plan’s vision provides long-term direction with respect to climate adaptation planning, while the Climate Adaptation Plan’s strategic goals (Table ES.1) reflect the City’s commitment to environment and health, infrastructure, economy, safety, and equity.

Table ES.1 Climate Adaptation Plan Strategic Goals

Symbol	Strategic Goal
	<p>Environment and Health Sustain environmental health, biodiversity, and individual well-being</p>
	<p>Infrastructure Prepare for the future with resilient built and natural infrastructure, while protecting existing resources</p>
	<p>Economy Strengthen economic prosperity by reducing the risk of economic loss; focus on adaptation actions that are fiscally responsible and achieve measurable long-term benefits</p>
	<p>Safety Reduce risk, strengthen our community’s emergency preparedness and disaster response</p>
	<p>Equity Ensure climate adaptation solutions cover all protected grounds under the Ontario Human Rights Code</p>

The Climate Adaptation Plan was developed over four stages, as illustrated in Figure ES.1.

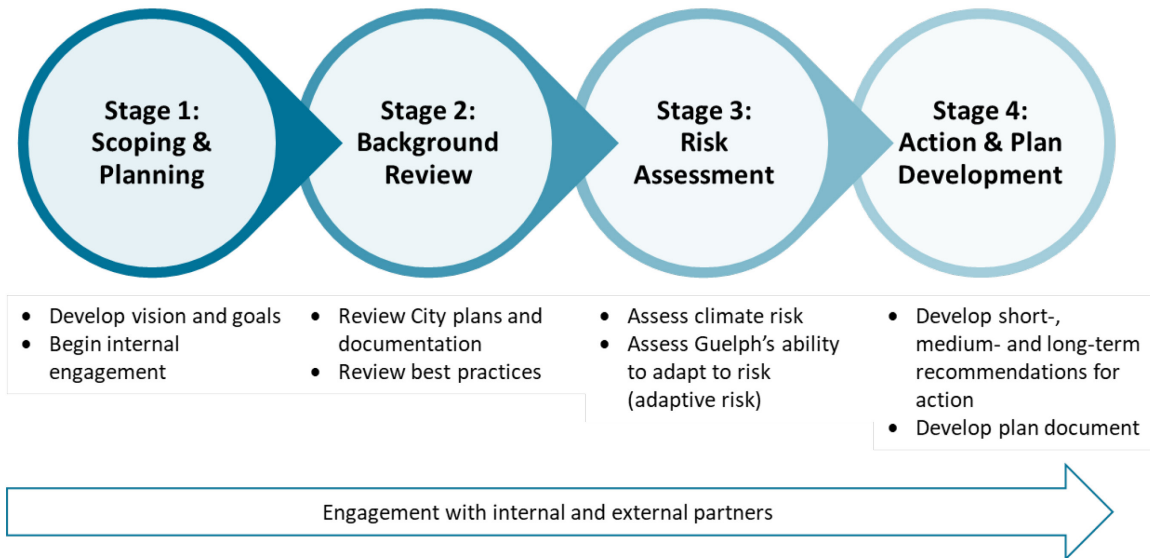


Figure ES.1 Climate Adaptation Plan Stages

Stakeholder Consultation

The Climate Adaptation Plan is a corporate-focused plan and stakeholder engagement efforts were paramount in the plan's development and to facilitate ownership of the outcomes of the plan within the organization. Engagement and communications with internal and external stakeholders were a focus throughout all four project stages. Internal stakeholders include those within the Corporation of the City of Guelph and affiliated Services including Guelph Police Services and Guelph Library Services. Three internal project groups contributed to the success of the project, including: the Core Project Team, the Staff Working Group, and the Steering Committee (Figure ES.2). The City staff's knowledge of their own infrastructure, programming, operations and services was a key factor in developing the Climate Adaptation Plan and consultation with staff was conducted throughout the project to leverage their roles and knowledge risk assessment, adaptation action and plan development.

The Project Team also consulted external partner organizations, collectively denoted as the Partner Working Group, that provide adaptation-related services and programming in Guelph. Other external influencers included Indigenous governments, community organizations, and the general public. Guelph City Council was informed of the project progress and will be asked to provide approval of the final Climate Adaptation Plan.

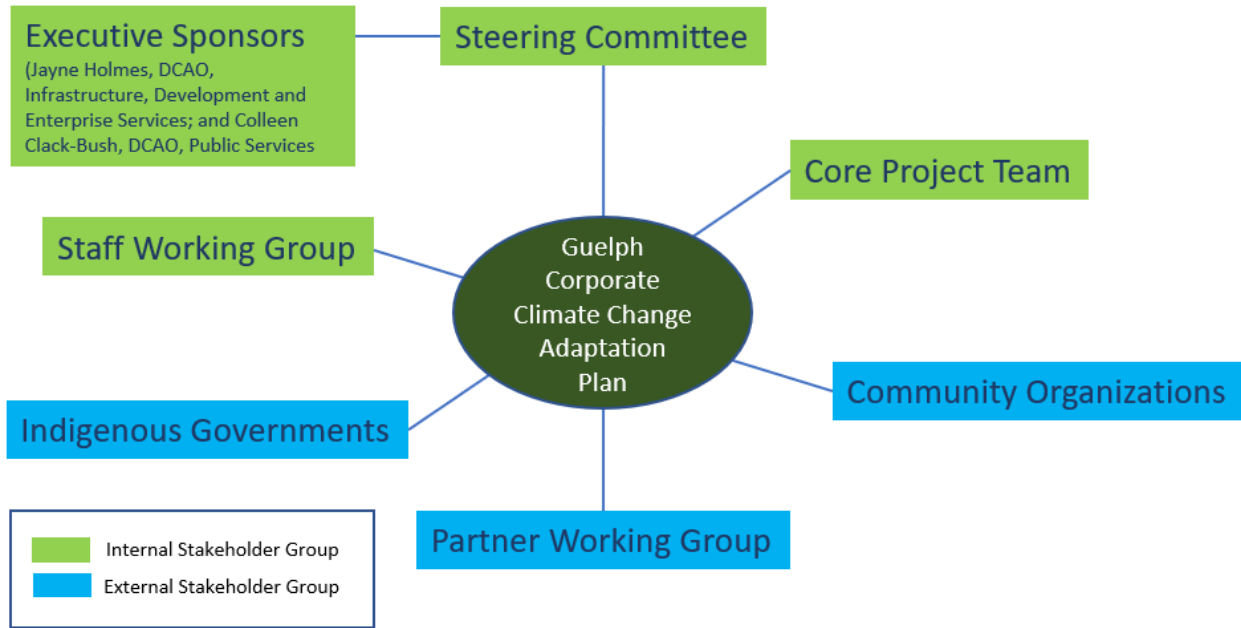


Figure ES.2 Internal and External Stakeholder Groups

Throughout the engagement process, the Project Team worked to apply an equity, diversity, and inclusion (EDI) lens and a reconciliation lens collaboratively with the City’s EDI Team and Indigenous-relations advisor. Advancing EDI through the Climate Adaptation Plan was important because climate change disproportionately impacts vulnerable populations, such as seniors, racialized communities, and low-income residents. By acknowledging and addressing inequalities in the development and implementation of adaptation actions, where possible, the Climate Adaptation Plan can help reduce the impact of climate change on vulnerable populations and ensure that the benefits of the adaptation actions are distributed fairly.

Strategic Context

A strategic context review of internal and external documents was conducted during Stage 2 of the project and provided a high-level assessment of how the Climate Adaptation Plan could build upon the City’s current efforts to address climate change, to draw from Climate Adaptation Plan developed by other municipalities, and to identify where there may be opportunities for funding. This review was intended to help identify the City’s current adaptive methods (based on existing and planned actions) and areas where the City may enhance their adaptive capacity. The City’s Core and Corporate Asset Management Plans were at the centre of the review process, followed by key Master Plans that address both asset management and climate change risks, and then other strategies, plans, and protocols that could be modified and aligned with climate change adaptation goals. The City’s response to climate risks is largely

driven by provincial legislation, notably the Provincial Policy Statement, 2020 and Ontario Regulation 588/17: Asset Management Planning for Municipal Infrastructure (Figure ES.3).

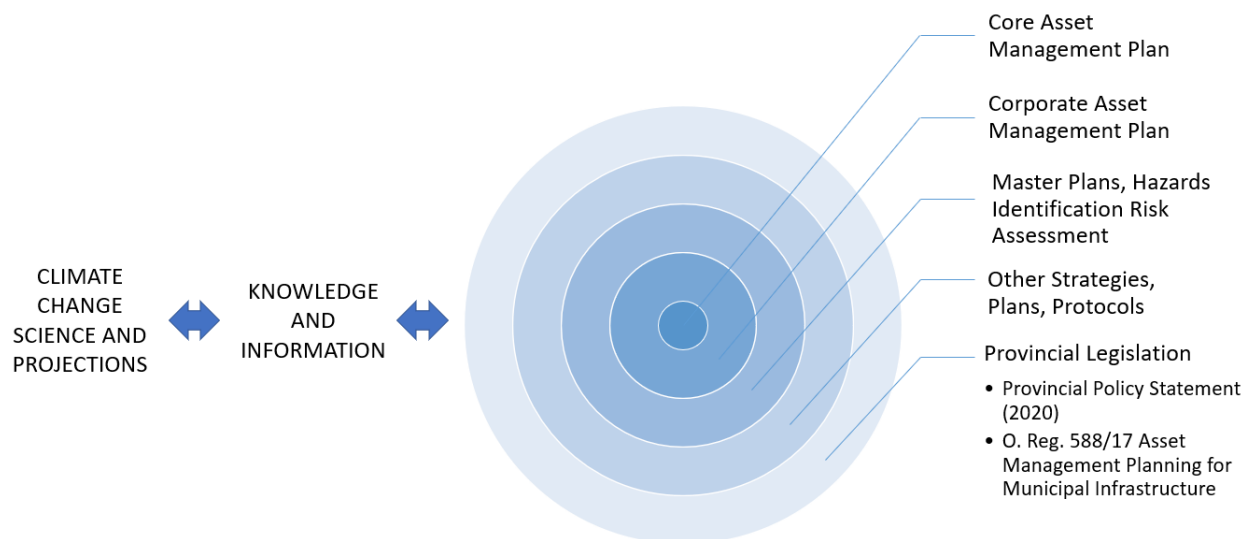


Figure ES.3 Strategic Context

In recent years, the federal and provincial governments and various agencies have produced a wide range of climate change strategies, assessments, data, actions, and guidance. In the case of infrastructure, the goal of Canada’s National Adaptation Strategy (Government of Canada 2022a) is that all infrastructure systems in Canada will be climate-resilient and undergo continuous adaptation to adjust for future impacts to deliver reliable, equitable, and sustainable services to all of society. This is a challenge for towns and cities across Ontario, noting that public infrastructure is vulnerable to climate change, the application of adaptive management to climate risks is relatively fragmented, there is little evidence of adaptation being mainstreamed into municipal decision-making, and systems for monitoring and evaluating adaptation action and effectiveness remain inadequate (Douglas and Pearson 2022, Warren and Lulham 2021).

The document review covered five key areas:

- (1) climate change science,
 - (2) national and provincial climate change impact assessments,
 - (3) municipal adaptation plans,
 - (4) risk assessment frameworks, and
 - (5) City department/division services and programs.
-

There are a growing number of municipalities across Canada that have developed, or are in the process of developing, Climate Adaptation Plans or climate strategies. Many of the municipalities that have developed Climate Adaptation Plans are located in southern Ontario, including communities across the Greater Toronto and Hamilton Area. The Climate Adaptation Plans developed by these municipalities are the outcome of climate impact risk assessments that follow the International Organization for Standardization (ISO) 31000: Risk Management approach or other variations such as the International Council for Local Environmental Initiatives (ICLEI) Building Adaptive & Resilient Communities (BARC) methodology. However, with the primary focus still largely placed on the assessment of vulnerability and risk, progress on municipal adaptation planning and implementation remains limited in Ontario. In contrast, with the development and implementation of the Climate Adaptation Plan, along with other plans, practices, and protocols where climate change is considered, the City is well-positioned to progress toward achieving their goal of becoming climate resilient.

The “City of Guelph Strategic Plan 2019-2023” (City of Guelph 2019), for example, builds upon the vision of “A United Vision: Guelph's Community Plan” (City of Guelph n.d.) to strategize actions over the next few years. One of the strategic pillars is called “Sustaining our Future,” which references the Climate Adaptation Plan and includes goals to improve sustainability within Guelph with considerations for associated measures of success, initiatives, suggested implementation priorities, dependencies (i.e., other plans), and funding resources. The City’s forthcoming Strategic Plan (2024-2027) builds on this commitment. Similarly, “Current State and Trends Report” (City of Guelph 2022a) mentioned the Climate Adaptation Plan and its importance in asset management planning to make the City “future proof.” Proactive infrastructure investment will be a key component to providing a ready and resilient Guelph.

The City’s website lists 12 Master Plans and 38 additional plans, strategies, and design manuals. Many of these plans consider climate change impacts directly and are highly complementary to the Climate Adaptation Plan, particularly those that address natural and water utility infrastructure assets. Key plans with a climate change and asset management focus include:

- natural infrastructure:
 - ✦ City of Guelph Natural Assets Inventory, Condition, Risk and Service Attribution, 2022
 - ✦ City of Guelph Natural Heritage Action Plan, 2018
 - ✦ City of Guelph Urban Forest Management Plan, 2013-2032, 2012

- water utility infrastructure:
 - ✦ City of Guelph Tier Three Water Quantity Risk Assessment, 2017
 - ✦ City of Guelph Water Efficiency Strategy, 2016
 - ✦ City of Guelph Water Supply Master Plan, 2022
 - ✦ City of Guelph Water and Wastewater Servicing Master Plan, 2008
 - ✦ City of Guelph Wastewater Treatment and Biosolids Master Plan, 2009
 - ✦ City of Guelph Stormwater Management Master Plan, 2011

In addition, the “City of Guelph Emergency Response Plan, 2015” and the “City of Guelph Emergency Management Hazard Identification and Risk Assessment, 2018” have also considered extreme weather and climate-related hazards, although not specifically in reference to future climate change projections.

Asset Management at the City of Guelph

Asset management planning is the process of managing an organization's physical assets, such as buildings, equipment, infrastructure, and other tangible assets, to ensure they are maintained, operated, and utilized in a cost-effective manner. The objective of asset management planning is to optimize the performance and value of assets while minimizing costs and risks. Not only is the evolving asset management approach becoming standard practice for managing infrastructure assets, but it is also a logical approach from which to establish a climate adaptation strategy and to incorporate climate adaptation actions into a municipality’s regular operating practice.

Municipalities in Ontario are required by the province to develop Asset Management Plans. On January 1, 2018, Ontario Regulation 588/17: Asset Management Planning for Municipal Infrastructure came into effect. This regulation requires that municipalities recommend actions to address the vulnerabilities to municipalities’ infrastructure assets that may be caused by climate change.

The City’s 2020 Corporate Asset Management Plan and the 2021 Core Asset Management Plan provide estimates of the current replacement value (CRV) for infrastructure-related assets.

The asset management planning framework is the most appropriate method to address the costs of climate change for infrastructure because it provides for the ability to proactively plan for the long-term management of assets in a changing climate.

The Corporate Asset Management Plan provides a framework for the long-term planning of capital, operations, and maintenance expenditures for each of the following asset management categories:

- core assets
 - ✦ stormwater
 - ✦ wastewater
 - ✦ transportation
 - ✦ water

- other corporate assets:
 - ✦ parking
 - ✦ solid waste
 - ✦ administrative facilities
 - ✦ corporate vehicles and equipment
 - ✦ transit
 - ✦ culture and recreation
 - ✦ parks (natural heritage)
 - ✦ emergency services
 - ✦ information technology

The Core Asset Management Plan is a detailed assessment of the City’s core asset types, which comprise more than 80% of the total infrastructure asset base owned and managed by the City, such as roads and related assets such as sidewalks, street lighting, and traffic controls; bridges; water services; wastewater services; and stormwater management.

The City has an infrastructure asset base with a 2020 calculated replacement value of approximately \$4.2 billion, approximately \$1.8 billion of which will need replacing within the next 10 to 20 years (32% of assets have below 40% remaining life). The City also has an investment backlog of infrastructure assets that have exceeded their service life, valued at approximately \$292 million for the City asset portfolio. Within the next 1 to 5 years there is almost \$1 billion of assets that are in “very poor” or “past due” condition that may require complete replacement or significant renewal efforts to ensure continued long-term performance. The Core Asset Management Plan provides a detailed financial analysis of the 25-year and 10-year forecast requirements for the City’s core assets. The plan identifies that over the 25-year period, there is an expected \$1.9 billion funding gap or an average of

\$77.5 million per year. Over the 10-year period, the predicted funding gap totals \$1.05 billion or \$105 million per year.

Methods for integrating climate change risk assessments into asset management are rapidly advancing. The Federation of Canadian Municipalities, under the Municipalities for Climate Innovation Program, commissioned the “Guide for Integrating Climate Change Considerations into Municipal Asset Management” (FCM 2019), which provides a roadmap that municipalities can use to understand climate change and its implications for municipal services and infrastructure. The Financial Accountability Office of Ontario’s (FAO’s) recent series of reports represent best practices in this field and provide useful insights and guidance regarding the treatment of climate hazards and their impacts on infrastructure asset performance.

City of Guelph’s Future Climate

The primary source used for climate change projections for Guelph was the Canadian Centre for Climate Services and their web portal (<https://www.climatedata.ca>). Another source of future climate data that was used to confirm the direction and relative magnitude of change was a recent climate science-based report titled “The Climate Science Report for the Climate Change and Health Vulnerability Assessment for Waterloo Region, Wellington County, Dufferin County, and the City of Guelph” (ICLEI Canada 2022). The data published in this report was drawn from a provincial climate data portal that is comparable to the national portal in its use of ensemble model projections and consideration of different GHG emission scenarios. The localized climate projections developed for the City of Waterloo was a third (supplementary) source of climate information.

Climate Hazards

A climate hazard refers to the potential occurrence of a climate-related physical event or trend that may cause damage and loss. Table ES.2 lists the climate hazards and key thresholds (where applicable) applied in this risk assessment. Climate parameters alone do not necessarily represent climate-related hazards but are at the root cause of hydrological events, changes in ecological conditions, and biophysical effects that can directly or indirectly cause significant impacts. Consideration of climate variables may also take into account cumulative, cascading, or compounding effects, in which a series or sequence of events and conditions occur over a short or longer period of time that creates the conditions for a severe effect.

Table ES.2 Climate Hazards, Climate Parameters, and Thresholds

Climate Hazards	Climate Parameters and Thresholds
Acute Weather Events	Number of days with high wind gusts >40 and 70 km/hour
Drought	Average summer soil water content (mm)
Extreme Cold	Number of days <-15°C
Extreme Heat	Number of days >30°C
Flooding	Return levels for maximum 24-hour and 5-day rainfall
Freeze/Thaw	Number of days experiencing freeze/thaw conditions
Snow	Days >5 cm
Freezing Rain	Days with freezing rain
Warmer Ambient Temperatures	Winter season mean temperatures and/or number of days >31°C and nights >20°C
Winter/Spring Rainfall	Days with rainfall ≥25 mm during January to March (rain on snow or frozen ground)

Future Climate Conditions in 2050 and 2080

Generally, Guelph's future climate is expected to be warmer, wetter, and wilder compared to current and historical conditions. For the ten climate hazards and 11 critical thresholds, Table ES.3 outlines their historical baseline (1986-2005) and future projections (2050 and 2080) under a high GHG emissions scenario. Table ES.3 also indicates the projected direction and magnitude of change, with a single arrow (↑) representing an increase (or decrease) of 10% to 50% compared to the historical baseline, and double arrows (↑↑) representing an increase (or decrease) 50% to 100% compared to the historical baseline. Hazards that are projected to be within ±10% of their historical baseline are considered to have no appreciable changes in their likelihood of occurrence.

Generally, temperature hazards are expected to change significantly by 2050 and 2080, while changes in the likelihood of precipitation hazards are projected to change 50% to 100% from their historical baseline. For example, the number of days with maximum temperatures greater than 30°C are projected to increase from 9 days per year to 38 days per year by the 2050s and 67 days per year by the 2080s. In contrast, the number of extreme cold days below -15°C, which have occurred on average 22 days per year in the past, are projected to decrease to 6 days/year by the 2050s and become a rare event (occurring about once per year) by the 2080s.

For the City's Climate Adaptation Plan development, these climate projections were then converted into a likelihood score as input into the risk assessment process, where the method to determine scores was based on a best practice approach adopted by the "PIEVC [Public Infrastructure Engineering Vulnerability Committee] High Level Screening Guide"

(O’Driscoll et al. 2022). In this case a middle baseline approach was used, whereby scores were assigned from 1 to 5, with 3 representing the expectation of the status quo (where the historical and current conditions are projected to remain relatively the same for the forecasted timeline), and scores above or below represent increases or decreases that range from ±10% to 50% and ±50% to 100%, respectively.

Table ES.3 Climate Conditions: Historical Baseline (1986-2005) and Future Projections (2050 and 2080) Under High Emissions Scenarios

Climate Variables	Hazard Represented	Historical Baseline 1986-2005	Projections 2050s	Projections 2080s	Change from Baseline
Acute Weather Events	Number of days with high wind gusts >40 and 70 km/hour	-	+10-20% by 2100	+20-40% by 2100	↑
Drought	Number of periods with more than 5 consecutive dry days (less than 1 mm per day)	12	12	12	-
Extreme Cold	Number of days <-15°C	22	6	<1	↓↓↓
Extreme Heat	Number of days >30°C	9	38	67	↑↑↑
Flooding	Return levels for max 24-hour rainfall	39	43	46	↑
Flooding	Return levels for max 5-day rainfall	67	73	78	↑
Freeze/Thaw	Number of days experiencing freeze/thaw conditions	70	61	52	↓
Snow	Days >5 cm	11	10	7	↓
Freezing Rain	Days with freezing rain	-	+40%	+45%	↑
Warmer Ambient Temperatures	Winter season mean temperatures and/or number of days >31°C and nights >20°C	<1	9	28	↑↑↑
Winter/Spring Rainfall	Winter season precipitation (mm)	193	217	232	↑

Note: single arrow (↑) representing an increase (or decrease) of 10% to 50% compared to the historical baseline, and double arrows (↑↑) representing an increase (or decrease) 50% to 100% compared to the historical baseline.

Risk Assessment

The risk/vulnerability assessment process provided an opportunity to apply existing knowledge and evidence about climate-related impacts and risks across the City into a formal climate risk assessment process based on best practices (e.g., ISO 31000, ISO 14091, ICLEI BARC, and the PIEVC Protocol). City staff played an essential role in this stage of the process and worked closely with the Project Team to quantify their perceived level of climate-related risks to their individual department's/division's assets, based on historical experiences, and in relation to projected climate change conditions. The risk assessment process essentially involved three main steps: risk identification, risk analysis, and risk evaluation, which is at the core of the risk management framework. The three steps in the risk assessment process, followed by implementation and monitoring steps are further outlined in Figure ES.4.



Figure ES.4 Risk Assessment, Implementation, and Monitoring Steps (Source: adapted from ISO 31000)

Risk Identification: Climate Hazard/Asset Interaction

The risk identification step involved identifying where climate hazards can potentially impact infrastructure assets and service delivery. A climate hazard/asset interaction is the relationship between a climate hazard and built or natural infrastructure (assets, components, and subcomponents) that can involve individual assets or broader systems and networks and leads to a measurable impact. Of the 306 total potential interactions between a climate hazard and an infrastructure asset, the City staff confirmed that there were 56 cases where no interactions existed, while there were 250 cases where interactions existed, leading to a measurable consequence. Table ES.4 provides a small example of the risk identification exercise, whereby climate hazard/asset interactions were marked with an “x.” The distribution of interactions provided some initial insights regarding the extent that departments/divisions own, operate, and maintain infrastructure assets that are exposed to different climate hazards. In consultation with the Staff Working Group, the flooding hazard caused by different heavy rainfall events were amalgamated into a singular metric (e.g., treating return levels for a 24-hour and 5-day storm event as a single hazard).

Table ES.4 Example of Climate Hazard/Asset Interactions

Asset Subclass	Service	Drought	Extreme Cold	Extreme Heat	Freeze/Thaw
Water Treatment Plant	Providing potable water to residents and businesses	x	x	x	
Groundwater Well	Providing potable water to residents and businesses	x			
Hydrants	Fire protection		x		

Consequences

A consequence is the direct or indirect outcome when an interaction occurs between a climate hazard and infrastructure asset that involves the exceedance of a critical threshold, leading to a measurable shift in asset condition and performance and LOS delivery. Consequences typically involve damage to a built or natural infrastructure asset, component, or subcomponent that leads to a measurable change in the LOS delivery. For example, changes in ambient temperatures could pose a health and safety hazard to people or affect the functionality of an asset. In the case of infrastructure asset condition and performance, heavy rainfall could exceed the capacity of a stormwater culvert, leading to asset failure and/or flooding that then impacts other infrastructure assets, property, and people.

Characterizing consequences generally followed a standard format in which the consequences were described within a range of categories that included economic, environmental, social, safety, and reputational considerations, and were evaluated in terms of their magnitude, extent, or duration of occurrence. These categories of concern were then refined to form five main pillars that were of key importance to the City and became the five consequence categories used in the calculation of the risk rating (Table ES.5):

- physical human health
- mental human health
- asset management (property and infrastructure)
- environment
- community and economy

The Project Team assigned values of consequences for the asset interactions and City staff reviewed these ratings. It was noted that, generally, City staff were reluctant to assign a negligible/no consequence score (e.g., a score of 1) or an extreme value consequence score (e.g., a score of 5).

Table ES.5 Consequence Criteria

Area	None	Low	Medium	High	Very High
Physical Human Health	Unlikely to result in injuries, illness, or fatalities.	Minor injuries or illness; few individuals; small portion of the City.	Minor injuries or illness. Many individuals. Small portion of the city.	Severe injuries, illness, or fatalities. Many individuals. Large portion of the city.	Mass severe injuries, illness, and fatalities. Many communities. Throughout the city.
Mental Health	Unlikely to result in mental and emotional distress.	Short-term mental or emotional distress. Few individuals. Small portion of the city.	Short-term mental or emotional distress. Many individuals. Small portion of the city.	Long-term mental or emotional distress. Many individuals. Large portion of the city.	Mass long-term mental or emotional distress. Many communities. Throughout the city.
Asset Management	Unlikely to result in property damage or damage or disrupt function of civic assets.	Minor property damage, infrastructure damage, or disruption. Few properties or civic assets. Small portion of the city.	Minor property damage, infrastructure damage, or disruption. Many properties or civic assets. Small portion of the city.	Severe property damage, infrastructure damage, or disruption. Many properties or civic assets. Large portion of the city.	Widespread severe property damage, infrastructure damage, or disruption. Many properties or civic assets. Throughout the city.
Environment	Unlikely to result in damage or loss of habitat or ecological function; no regulatory consequences.	Short-term damage or loss. Few ecological features. Small portion of the city. Regulatory reporting may be required.	Short-term damage or loss. Few ecological features. Small portion of the city. Reporting of regulatory violation required.	Long-term damage or loss. Many ecological features. Large portion of the city. Reporting of regulatory violation required.	Widespread long-term damage or loss. Many ecological features. Throughout the city. Reporting of regulatory violation required.
Community and Economy	Unlikely to impact access to support services, disrupt income generating activities or result in political or reputational impacts.	Short-term disruption or political/reputational damage. Few support services/individuals/businesses and a small portion of the city affected.	Short-term disruption or political/reputational damage. Many support services/individuals/businesses affected over a small portion of the city. Negative sentiment expressed on many media sources.	Long-term disruption or political/reputational damage. Many support services/individuals/businesses affected over a large portion of the city. Negative sentiment expressed on many media sources.	Widespread long-term disruption or political or reputational damage. Many support services, individuals, or businesses. Negative sentiment expressed on many media sources. Throughout the city.

Source: Adapted from the City of Guelph (2022)

Risk Rating

The risk rating score represents the magnitude of change in risk from current to future climate conditions. After assigning consequence scores, the next step in the process was to calculate risk rating scores. The risk rating was calculated as consequence (severity) × likelihood (probability) of occurrence ($R = S \times P$) to determine individual risk scores ranging from low to very high (e.g., low: 1-5; moderate: 6-12; high: 15 -16; and very high: 20-25), as outlined in the risk matrix (Figure ES.5). Likelihood scores were calculated based on the historical baseline (1986-2005) for each climate parameter, and projections under a high emissions scenario for 2050 and 2080. Noting that each asset and climate variable could generate five possible risk scores (i.e., one for each of the five consequence categories, which were physical human health, mental human health, asset management, environment, and community and economy), it was necessary to consider prioritization based on either valuing each consequence category equally and calculating an average score; weighing the consequence categories based on specific criteria and calculating a cumulative score across all categories; or selecting the maximum score, regardless of consequence category. Feedback from City staff indicated that extracting the maximum risk amongst the five categories of concern was favourable because it would ultimately represent the most conservative approach.

L I K E L I H O O D	5	5	10	15	20	25
	4	4	8	12	16	20
	3	3	6	9	12	15
	2	2	4	6	8	10
	1	1	2	3	4	5
		1	2	3	4	5
		CONSEQUENCES				

Risk Rating Level
Very High
High
Moderate
Low

Figure ES.5 Climate Risk Matrix

City staff were given two opportunities to reevaluate the risk ratings. A total of 80 (56 high risk and 24 very high risk, not considering any existing adaptive capacity measures in place) assets were reviewed and evaluated more closely drawing from City staff feedback, as well as the

broader literature and neighbouring studies. The top three hazards that warranted the most severe risks were extreme heat, acute weather events (high winds and hail), and flooding. These were generally triggered because of impacts to physical human health, mental human health, and asset management. Since likelihood for some climate hazards were projected to decline relative to the middle baseline, risk scores associated with climate hazards that are projected to become less severe or frequent (e.g., snow events, cold temperatures, and freeze/thaw cycles) were lower. As a result, projections of only six of the nine climate hazards were drivers of climate risk for the 80 assets deemed to be at high or very high risk.

Across 11 City departments/divisions there were a total of 306 interactions identified by the Staff Working Group (Table ES.6), distributed by risk level as follows: none (56), low (44), moderate (126), high (56), and very high (24).

Table ES.6 Number of Climate Interactions Categorized by Risk Level (by Department/Division)

Department(s)/Division(s)	Risk Rating Scores					Total
	None	Low	Moderate	High	Very High	
Engineering and Transportation Services	15	3	17	10	-	45
Emergency Services	4	3	13	6	1	27
Transit Services	7	5	15	5	4	36
Information Technology	2	1	4	1	1	9
Parks; Culture and Recreation	-	10	15	7	4	36
Parks; Planning and Building Services	3	4	8	3	9	27
Planning and Building Services; Operations	5	6	12	3	1	27
Solid Waste Services, Environmental Services	3	3	9	1	2	18
Stormwater Services, Engineering and Transportation	-	1	3	5	-	9
Wastewater Services, Environmental Services	2	2	9	4	1	18
Water Services, Environmental Services	15	6	21	11	1	54
Total	56	44	126	56	24	306

Adaptative Capacity

The goal of the Climate Adaptation Plan is to understand the City’s current adaptive capacity and provide feasible recommendations to strengthen it. In this context, adaptive capacity is defined as a system’s ability to adjust to climate change and avoid or reduce damages while taking advantage of opportunities. Essentially, adaptive capacity demonstrates how well a system (asset, service, or department/division) can manage a change or disturbance. Staff were asked, “how well do the

City’s currently-implemented plans/policies/programs address the assets, operations and services with high climate risks?” The staff were then engaged to put their filtered high-risk assets (as per the climate risk rating) on a scale to gauge the individual adaptive capacity based on their currently implemented plans, policies, and programs. Each at-risk asset was placed under one of the three headings: fully addressed, somewhat addressed, and not addressed by existing adaptive capacity actions implemented at the City.

Many assets had more than one adaptation measure that (partially or fully) addressed more than one asset or more than one climate risk. For example, increasing Guelph’s tree canopy and urban forest (as recommended in the Urban Forest Management Plan and Natural Heritage Action Plan) promotes shade and lessens the impact of a warmer ambient temperature, and also promotes stormwater infiltration and uptake which lessens the impact of high intensity rainfall events. (Planting trees is also considered a mitigative action).

A total of 163 adaptation measures/actions were established through the development of the Climate Adaptation Plan. Of these, 89 were existing actions and 74 were recommended actions. Existing actions are measures that contribute to the City’s current level of adaptive capacity, and represents actions that the City has already implemented or are planning to implement such as recommendations from approved master plan. In other words, more than 50% of the climate adaptation actions are existing and represents the important work that the City is already doing around responding to climate-related hazards and risks.

The City of Guelph has existing and/or planned adaptive capacity measures addressing 95% of the high or very-high risk interactions.

Implementation

Action Prioritization

The framework adopted to prioritize the 162 adaptive measures/actions was based on the following criteria, while scoring each as 1 (low), 2 (medium), or 3 (high):

- Measure of benefit: will it eliminate or partially eliminate the risk, in addition to consideration of both ancillary benefits and the co-benefits between mitigation and adaptation measures?
- EDI: does it benefit to many people including vulnerable populations?
- Ease of implementation: are the resources (staff and funding) identified and able to be secured?

Adaptation Actions

The list of 163 climate adaptation actions (including both existing and recommended) was separated out by the department/division that was tasked to lead each particular action (denoted as the Managing Department/Division; Table ES.7). This was done for ease of integration of the Climate Adaptation Plan since the City’s Capital and O&M budgets, Master Plans, and annual business plans are developed on a department-by-department/division-by-division basis. Implementation timeframes for the Climate Adaptation Plan are short-term actions (0 to 4 years); medium-term actions (4 to 7 years); long-term actions (over 7 years); and ongoing actions (ongoing).

Table ES.7 Number of Recommended Climate Adaptation Actions (by Department/Division)

Managing Department/Division	Ongoing Actions	Short-term Actions	Medium-term Actions	Long-term Actions
All Departments	1	1	-	-
Asset Management	6	4	2	-
CAO’s Office	1	-	-	-
Communications	6	1	-	-
Environmental Services, Compliance and Performance	1	3	-	-
Economic Development	1	-	-	-
Emergency Services	4	3	3	1
Engineering (Contaminated Lands)	2	3	-	-
Engineering (Stormwater)	4	3	1	1

Managing Department/Division	Ongoing Actions	Short-term Actions	Medium-term Actions	Long-term Actions
Engineering (Transportation)	1	4	2	-
Equity, Diversity, and Inclusion	3	2	-	-
Facilities	2	3	3	-
Fleet	1	1	1	-
Guelph Public Library	3	1	1	-
Health and Safety	5	2	-	-
Information Technology	3	3	1	-
Parks	4	2	4	-
Culture and Recreation	3	1	1	-
Planning and Building Services	2	2	2	-
Public Works (Operations)	7	1	2	-
Environmental Services, Solid Waste Services	3	5	2	-
Transit Services	5	1	1	-
Environmental Services, Wastewater Services	5	1	2	-
Environmental Services, Water Services	4	6	3	-

Notes:

CAO - Chief Administrative Officer

Key City-wide adaptive capacity actions that are already being undertaken include communications and partnership building with internal (e.g., EDI) and external local groups, and emergency response measures such as continued involvement with emergency shelter support, providing buses as an emergency shelter when requested by Emergency Services, having Public Works staff on standby during inclement weather, and having backup generators available to supply power in the event of a power outage. Key recommended adaptive actions focus on expanded communication and consultation with various groups, namely, establishing regular meetings with the City’s Community Emergency Management Coordinator, Red Cross, and County of Wellington; conducting emergency drills that include many City departments/divisions (rather than conducting drills for each department/division in isolation); and engaging Indigenous governments in pre-consultation processes for projects. Prioritization of staff retention was highlighted as an important recommended action since staff knowledge is one of the City’s best assets in the event of an emergency situation.

The full list of adaptive capacity actions is found in the main Climate Adaptation Plan. Selected existing and recommended actions are highlighted in Table ES.8.

Table ES.8 Selected Highlights of Adaptation Actions (Existing and Recommended)

No. ⁽¹⁾	Adaptive Capacity Action	Managing Department/Division
3	Implement Guelphs Official Plan Natural Heritage Policies, which seek to protect and restore natural heritage features and areas for the long term.	Planning and Business Services
5	Continue performance condition assessment and LOS reviews on all assets. Work with project managers to recommend priority lists for upgrades and replacement.	Asset Management
6	Continue to undertake tree planting initiatives.	Parks
8	Continue assessing risk as per the Drinking Water Quality Management System.	Environmental Services (Water Services)
20	Maintain service and maintenance contracts for critical equipment to store or obtain spares within 4 hours.	Information Technology
24	Periodically review, maintain, and update use of recreation facilities as emergency shelter buildings. Review with an equity lens. This includes coordination with the County of Wellington and Emergency Services.	Culture and Recreation
26	Liaise with the fire department on a mock transfer station fire scenario.	Environmental Services (Solid Waste)
29	Pursue venture to create a City-wide urban heat island effect map.	Engineering (Transportation)
42	Include climate change in current planning/formula in asset state assessment (e.g., follow Municipal Finance Officers' Association for guidance)	Asset Management
50	Investigate and provide adequate shelter for users at popular transit stops, consider equity lens.	Transit
70	Establish an Integrated Water Management Strategy for Guelph. The strategy should look at water reuse opportunities from wastewater and stormwater for non-potable uses (industry, vehicle washing, fire suppression, etc.)	Environmental Services (Compliance and Performance)
74	Continue to have Public Works workers on standby for inclement weather based on forecasting.	Public Works
75	Continue conducting pilot project with the University of Guelph to optimize salt application during winter.	Public Works

No. ⁽¹⁾	Adaptive Capacity Action	Managing Department/Division
80	Complete a Facility Needs Assessment for all critical infrastructure to determine if a backup source of power available is required and available for onsite. Establish redundancy plan for power for critical buildings (e.g., diesel available if grid goes down).	Facilities and Energy Management
86	Continue inflow and infiltration investigation program. Explore means to add resources during rain events to investigate flows within the system.	Environmental Services (Wastewater)
87	Continue Complete Streets Design Guide project that includes consideration for street trees, stormwater management, and low impact development).	Engineering (Transportation)
88	Continue infrastructure upsizing to accommodate rainfall intensity-duration-frequency curve updates.	Engineering (Stormwater)
96	Develop a storm sewer maintenance program.	Engineering (Stormwater)
102	Liaise with Engineering (stormwater) to prioritize contaminated site clean ups on lands that can be used for stormwater management purposes (e.g., Bull Frog stormwater management project).	Engineering (Contaminated Lands)
107	Establish a business continuity plan in case an emergency building is compromised and provide alternate/redundant work environment in case the emergency buildings cannot be safely occupied.	Emergency Services
135	Continue to send out alerts on Guelph's alert system from the Community Emergency Management Coordinator.	Public Works (Operations)
137	Develop a list of support agencies to contact during an emergency to accelerate assistance to those in need. Create a plan outlining how and when these agencies will be contacted efficiently.	Communications
140	Engage Mississaugas of the Credit First Nations and Six Nations of the Grand River in the City's pre-consultation process.	All departments/divisions
142	Continue to play an active role in supporting new businesses and industries to Guelph that align with the City's sustainability and resiliency goals	Economic Development
145	Establish business continuity plan in case communications are not available.	Communications

No. ⁽¹⁾	Adaptive Capacity Action	Managing Department/Division
146	Work with City Departments to apply an equity, diversity, and inclusion lens when planning and prioritizing services or infrastructure upgrades/replacements. Establish a formal means of communication.	Equity, Diversity and Inclusion
147	Continue to follow and adopt the Community Engagement and Communications Plan, and coordinate community consultation with the Sustainability Master Plan.	Communications
148	Leverage appropriate communications tactics during climate-related events	Communications
157	Participate in regular emergency exercises with Wellington County, with whom paramedic services are shared and police services work closely together.	Emergency Services
161	Develop cold stress policy, policy for staff working outside in high winds, flooding, and update as needed heat stress policy. Communicate these to all departments.	Health & Safety
162	City managers to prioritize staff retention recognizing that the knowledge of staff is one of the City's best assets in an emergency situation.	All Departments/Divisions
163	Formalize incident tracking including identifying root cause. Flag those that are weather related.	Health & Safety

Notes:

(1) Action number (out of 163)

CAO - Chief Administrative Officer

The Costs of Climate Change and Climate Change Adaptation

Climate change can have significant economic costs on a municipality’s infrastructure and resulting operations and services. Some of the ways that climate change can impact costs faced by the City in the future include:

- damage from acute extreme weather events
- damage from chronic or long-term changes in climate parameters
- increased insurance costs
- higher energy costs
- reduced capacity to meet design criteria
- new community services and infrastructure

Estimating for these costs should be integrated into all of the City’s short-term and long-term programs including Master Plans and the asset management planning process.

In 2019, the FAO initiated the Costing Climate Change Impacts to Public Infrastructure (CIPI) project to analyze the costs that the impacts of climate change could impose on Ontario’s provincial and municipal infrastructure. The methodology developed as part of the CIPI project is very granular and includes the use of climate-cost elasticities to estimate the change in useful service life, operations and maintenance (O&M) costs, or adaptation costs for specific asset components (e.g., building foundation) and climate indicator of interest (e.g., freeze-thaw cycle) as a function of the CRV. The CIPI project applied this methodology to estimate the cumulative cost of climate change for all publicly-owned buildings (Afroz et al. 2021), transportation (Afroz et al. 2022a), or stormwater/wastewater assets (Afroz et al. 2022b). The FAO reports illustrate that the level of uncertainty is considerable for long-term cost projections.

The City has estimated the CRV for most of its assets through the “Corporate Asset Management Plan” (City of Guelph 2020a) and “Core Asset Management Plan” (City of Guelph 2021a). Using the results of the CIPI project, the total cost to maintain the City’s infrastructure under stable climate conditions for the 2022-2100 period will be more than \$14 billion or approximately \$184 million per year.

The additional annual cost of adapting the City’s infrastructure to climate change is about \$43 million to \$53 million, or about 25% additional cost.

Using the CIPI framework, the City’s total cumulative cost of adapting infrastructure to climate change ranges from \$3.4 billion to \$4.1 billion depending on the adaptation strategy used. On an annual basis, this total additional cost equates to a range of \$43 million to \$53 million which is approximately 25% of the cost of maintaining assets under a stable climate. This additional cost of climate change is incremental to the \$77.5 million per year funding gap already in place for the next 25-year period.

Funding Opportunities

There are a limited number of ways that a municipality can raise revenue and cover the costs of climate adaptation measures for existing infrastructure assets, and for developing new infrastructure that incorporates a higher design standard in response to future climate change risks. Municipalities can allocate funds from its budget for O&M and asset management towards climate adaptation projects, such as setting aside resources for upgrading infrastructure, implementing nature-based solutions, and improving emergency services delivery. For existing infrastructure assets and services, the main financial source to support

adaptation actions by the City is internal, primarily through the asset management program and capital budget. There may be an opportunity to allocate some of the federal and provincial gas tax towards climate adaptation measures.

The recommended adaptation actions have not been adjusted as a result of Bill 23; however, it may require the City to implement projects at a faster pace (e.g., the 2023-2041 horizon may need to be accelerated to 2031). This impact will be addressed through the multiyear budget for 2024-2027 where resource and budgetary requirements from all City Master Plans are incorporated. Ultimately, Bill 23 and the associated pace of growth will require monitoring and future update of the Master Plans, which will occur in the next planned 5-year cycle.

For existing infrastructure assets and services, the City's main financial source to support adaptation actions is internal, primarily through the asset management program and capital budget.

The Government of Canada has taken an active role in addressing the need for public infrastructure to become climate resilient by providing funding for new infrastructure projects either directly or in partnership with other levels of government, and through the improvement of design standards that take climate change into account. The primary support by the federal government is through the Investing in Canada Plan, that was launched in 2016 as the pillar to the federal/provincial/territorial “Pan-Canadian Framework on Clean Growth and Climate Change: Canada’s Plan to Address Climate Change and Grow the Economy” (Government of Canada 2016). The plan commits Canada to over \$180 billion over 12 years for infrastructure that benefits Canadians and has three objectives including for new infrastructure to be sustainable and resilient. Investment streams include Public Transit, Green, Social, and Trade and Transportation. Other programs where municipalities across Ontario have received funding include the Disaster Mitigation and Adaptation Fund, and the Sustaining Healthy Communities Through a New Clean Water and Wastewater Fund.

The City has been relatively successful in receiving federal funds for various Infrastructure projects: over \$23 million to date from Infrastructure Canada, Canada Mortgage and Housing Corporation, Employment and Social Development Canada, and Regional Development Agencies. While opportunities will continue to exist to access federal funding towards new infrastructure, this option is neither expansive enough, nor sustainable to address all of the immediate and/or foreseeable needs for the City’s infrastructure and adaptation deficit. For example, the \$23 million the City has received from the federal government for various

infrastructure projects represents about 0.5% of the CRV of the City of Guelph’s infrastructure assets, or 33% of the estimated funding gap expected from the additional annual costs of managing assets under climate change over the next 25 years.

Department/Division Integration through Master Planning and Policy Documentation

The City’s Master Plans can be a critical process for incorporating climate change into infrastructure management and planning framework. Integration at the master planning process allows for prioritization to maintain economic stability while furthering the City’s resilience. Further, the City can identify opportunities where these actions can also support their commitments to reduce greenhouse gas emissions. We recommend that future master planning documents specifically identify climate risks and the cost of climate change and the adaptation alternatives recommended to mitigate those risks. These would then be referenced in the next update to the Climate Adaptation Plan. Further, master plan recommendations should be sufficient to carry forward the information needed to embed the cost of climate change into the Asset Management Plan.

Lead Integration and Implementation by Asset Management

We recommend that the City’s Asset Management Group manage the Climate Adaptation Plan update on a 5-year frequency, and take on the management and leadership of overseeing the implementation and integration of the Climate Adaptation Plan as the program leader. The program leader from the Asset Management Group would be responsible for reporting to the City on the annual progress of implementation of the Climate Adaptation Plan.

The City’s Asset Management Group will manage implementation of the Climate Adaptation Plan.

The Asset Management Group is the most appropriate department/division to lead the Climate Adaptation Plan implementation because the plan approach was an asset-based approach, with the climate risks initially evaluated at the asset level before expanding to develop adaptive capacity actions that consider both City assets and services.

The City has demonstrated considerable progress with the development of its asset management planning process, and within the next revision cycle should have the ability to incorporate the approach laid out by FAO’s CIPI project (FAO 2019) into its Corporate Asset Management Plan. Achieving this goal, however, will require the City to embed climate change planning into related master planning and departmental/divisional management activities to

ensure that these business functions can provide the information needed to account for the costs of climate change into future plans.

Key Performance Indicators

Overall, developing climate adaptation key performance indicators (KPIs) is a critical step in helping municipalities evaluate their progress towards resiliency, the effectiveness of their actions, and to help them better prepare for new or unexpected impacts of climate change. Most importantly, by identifying and tracking key metrics, organizations can better understand their vulnerabilities and take action to reduce the risks associated with climate change. As part of the ongoing resilience plan monitoring, KPIs are recommended for each action that can be used to track the effects of mitigating strategies on reducing the risk exposure. Indicators must meet SMART criteria.

Based on best practice, there are two types of indicators that are recommended to be tracked: Process Indicators and Outcome Indicators. Process indicators measure the degree to which the City is implementing the actions outlined in the Climate Adaptation Plan, but do not measure if the actions have succeeded in reducing vulnerabilities to climate change. Outcome Indicators are outcome-based and by definition assume a greater importance but are more challenging to measure. This type of indicator may be something which the City can actively control or cannot control but still chooses to monitor, for example, the number of basement flooding complaints per year. A significant, prolonged change in outcome indicators would indicate that the potential risk exposure may have changed.

It is expected that the collection of data and reporting on the Climate Adaptation Plan's implementation success will be done on a yearly basis, with an annual update to Council once implementation begins. Annual reporting will allow City staff to identify trends and allow for the re-calibration of actions as needed. Public reporting on implementation may be done through Microsoft® PowerBI or other tool and in alignment with the City of Guelph's corporate webpage.

Monitoring, Review, and Update of the Climate Adaptation Plan

The Climate Adaptation Plan is intended to be used as a living document, developed in consultation with City staff. The intention is that implementation is sustainable, effective, integrated, inclusive, and iterative. We recommend using the number of implemented/completed actions as the overall KPI for the implementation of the Climate Adaptation Plan, as a part of the City's Strategic Plan performance.

Consistent with the City’s typical master planning cycle for most departments/divisions, a formal review and update to the Climate Adaptation Plan should be undertaken once every five years, taking into account any advances in climate change science and projections, improved understanding of vulnerability and risks to City assets and services, the City’s progress in achieving their KPIs, and the overall effectiveness of integrating climate change into the City’s Asset Management Plan, Master Plans, and other practices and protocols.

The Climate Adaptation Plan will be updated every 5 years in collaboration with each department’s/division’s budgeting and master planning/policy update cycles.

There is the opportunity to apply lessons learned and assess whether the context of the risks and vulnerabilities has changed, and whether the actions being implemented are reducing vulnerability and increasing resiliency and adaptive capacity.

As noted previously, it is recommended that the Climate Adaptation Plan update be managed by the City’s Asset Management Group. We note that the current adaptive capacity of the City provides a good foundation of existing and planned actions. In responding to an increase in vulnerability and risk to climate hazards in the future, the City’s departments/divisions will need to strengthen coordination between departments/divisions (e.g., where assets and services at high risk are the responsibility of multiple departments/divisions), address knowledge gaps through additional research (e.g., cumulative and compounding climate-related impacts), and adopt a more integrative approach to their management of assets and delivery of services (e.g., into key planning initiatives).

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1 Introduction

The City of Guelph (the City) is well-known for its forward-looking environmental initiatives and leadership. This reputation also applies to the City's commitment to take action against climate change. There are two overarching responses to climate change: mitigation and adaptation measures. Mitigation measures refer to actions that reduce the greenhouse gas (GHG) emissions that cause climate change, and adaptation measures refer to actions that manage and reduce the risk of climate change impacts. There are also actions that co-benefit both mitigation and adaptation and actions that generate additional benefits for ecosystems, biodiversity, and social well-being.

In 2018, the City joined the Global Covenant of Mayors for Climate and Energy (GcoM). The GcoM is a coalition of city leaders from around the world that recognize the important role that municipalities can take to cut GHGs (i.e., mitigation) and prepare for the impacts of climate change (i.e., adaptation). The City set mitigation targets to reduce GHG emissions and become a net-zero carbon community by 2050 or earlier (as per the "Race To Zero") and has a number of initiatives underway and planned to achieve this goal (Section 3.1). As a co-benefiting action, the City's One Canopy strategy is a plan to plant at least 3.6 million trees and achieve a 40 per cent tree canopy cover in Guelph by 2070.

To map out an adaptation pathway to become climate resilient, the City's "Strategic Plan" (City of Guelph 2019) includes a strategic priority of "Sustaining our Future," which includes a commitment to "create and execute an ambitious and achievable adaptation plan." This Corporate Climate Adaptation Plan outlines how the City will adapt its policies and plans, assets, operations, and services to the impacts of climate change, to help build a more adaptive and resilient community. The City's forthcoming Strategic Plan (2024-2027) builds on this commitment with the objectives of "Be a leader in climate action" and "Empower the community to help create a sustainable city."

The City has current plans and protocols that provide departments/divisions with the direction and tools to operate and maintain infrastructure assets and deliver municipal services, and many of these take into account climate/climate change. While collectively these plans provide a solid foundation from which to develop a Corporate Climate Adaptation Plan, separately they these plans do not represent a coherent and integrative approach. This Climate Adaptation Plan is intended to be comprehensive and provide a single, unified approach to climate adaptation across the organization. Further, the Climate Adaptation Plan also considers where the City may influence aspirational community-led adaptation actions to be considered as complementary to corporate and community efforts to reduce GHG emissions contributing to climate change. The

Climate Adaptation Plan’s recommended actions (Section 6) represent a strategic and evidence-based response to projected future climate risks (Section 4) to the City’s infrastructure assets and the services that they provide, and which actions can be implemented in the short-, medium-, and long-term (Section 7).

The Climate Adaptation Plan aligns with provincial direction on climate change adaptation, as outlined in the Preserving and Protecting our Environment for Future Generations: A Made-in-Ontario Environment Plan (MECP 2018), and the more recent “Ontario’s Climate Change Strategy” (Government of Ontario 2021a). In addition, the Province of Ontario has updated key pieces of legislation and policy that highlight the importance of municipalities to consider the vulnerabilities and risks that may be caused by climate change. These include “A Place to Grow: Growth Plan for the Greater Golden Horseshoe” (Government of Ontario 2020), the “Provincial Policy Statement, 2020” (MMAH 2020) under the Planning Act, and Ontario Regulation (O. Reg.) 558/17: Asset Management Planning for Municipal Infrastructure. These policies direct municipalities to assess infrastructure risks and vulnerabilities to climate change; identify actions and investments to address these challenges; consider public infrastructure that includes water, wastewater, and stormwater infrastructure; and to develop asset management planning that considers the anticipated costs that could arise from those vulnerabilities and adaptation opportunities.

In developing a Climate Adaptation Plan that is complementary to the City’s mitigation efforts, the plan needed to be consistent with best practices adopted by other leading municipalities across Canada, but also leverage the City’s existing and planned strategies, plans, and protocols. This Climate Adaptation Plan achieves these goals by focussing on the City’s municipal infrastructure assets and their services, noting that the City is already mandated to consider climate change in their asset management practices. The implementation of the Climate Adaptation Plan will help meet the immediate needs of the City regarding their vulnerability and risks to current climate, help position the City to take further action, and provide clearer direction regarding what they need to move forward to meet their goal to become a net-zero carbon community by 2050.

1.1 City of Guelph Organizational Description

The City’s organizational structure consists of the Office of the Chief Administrative Officer (CAO) and three main services: Corporate Services; Infrastructure, Development and Enterprise Services; and Public Services. Figure 1 illustrates the departments and divisions under the Office of the CAO and the three main services. The Guelph Police Service and Guelph Public Library are not services within the Corporation of the City of Guelph but were considered in the

Climate Adaptation Plan development because of the connections and interactions between these services and City departments and divisions.

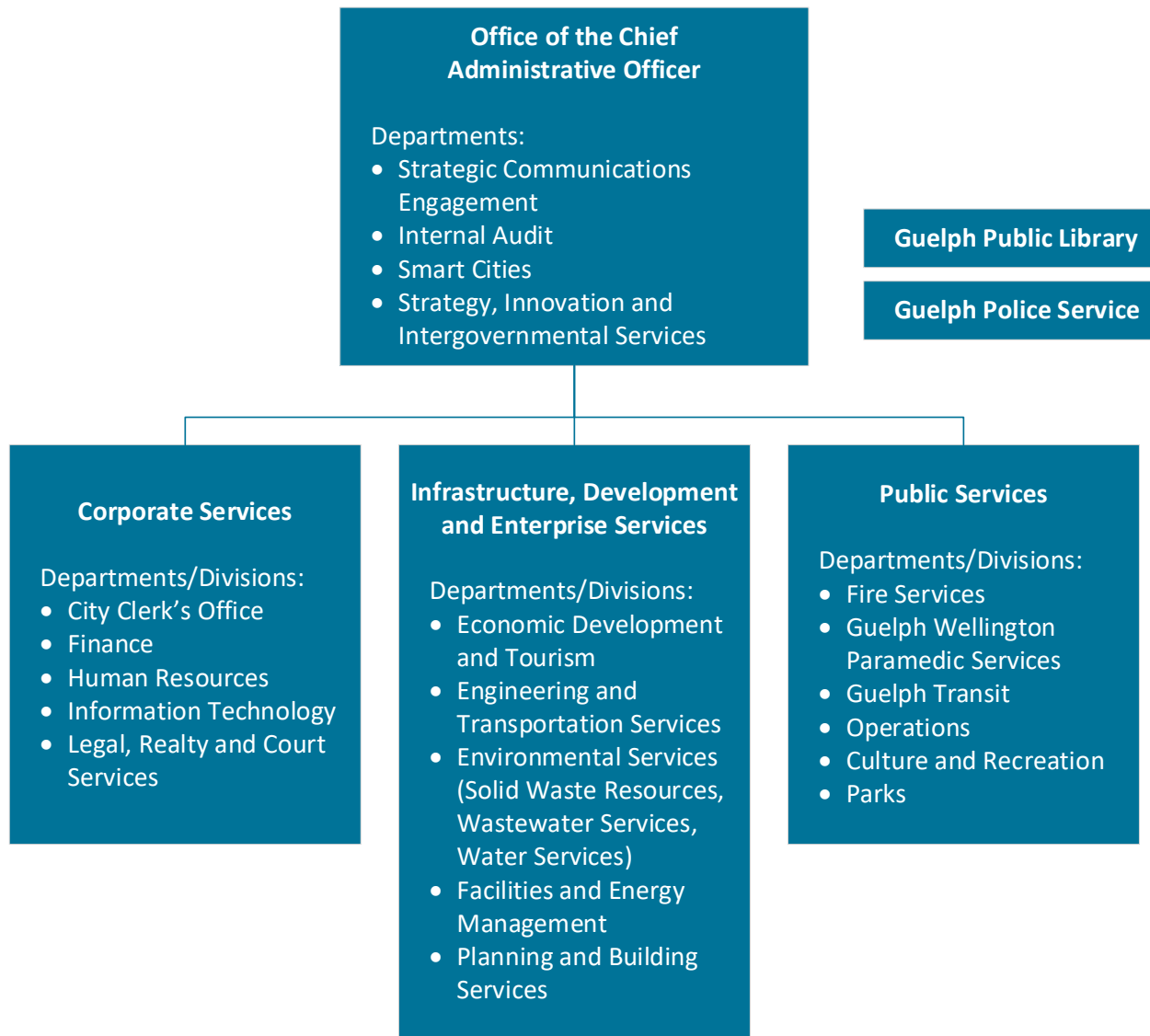


Figure 1 Corporation of the City of Guelph Organizational Chart

1.2 Visions, Goals, and Guiding Principals

As part of the overall framework for developing the Climate Adaptation Plan, the vision for the plan provides long-term direction with respect to climate adaptation planning, while the goals of the Climate Adaptation Plan reflect the short-term plans (Figure 2).

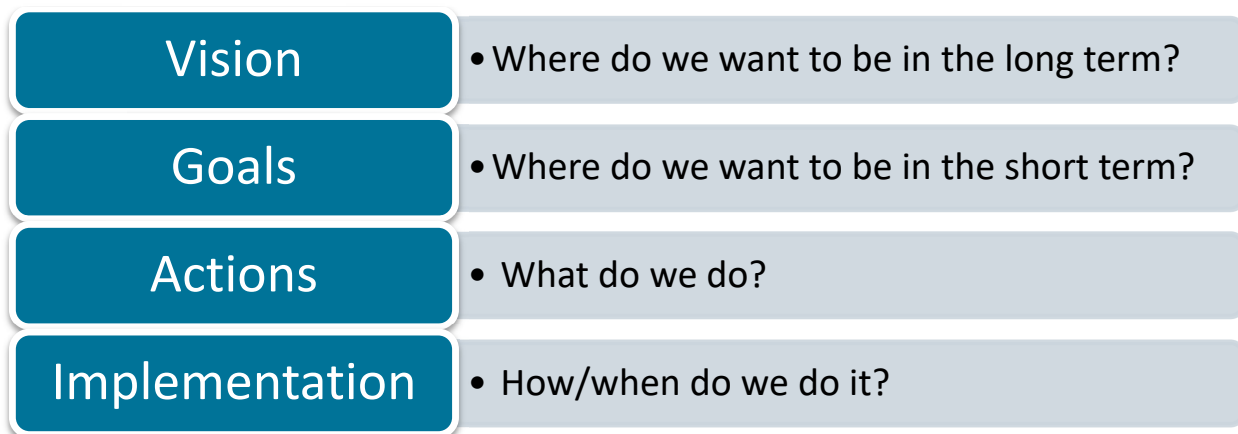


Figure 2 Climate Adaptation Plan Framework

The vision and goals for the City’s Climate Adaptation Plan were first established at the onset of the project, based on discussion with the City’s Project Team. Following this, staff from the City’s Equity, Diversity, and Inclusion (EDI) department reviewed the vision and goals, and subsequently they were introduced to the public, including external organizations. As a result, changes to the vision and goals were made to highlight the health of the community and emphasize solutions that benefit the most vulnerable.

The Climate Adaptation Plan’s vision is as follows:

“Guelph is adaptable and resilient in the face of a changing climate. We are leaders in environment and sustainability.

We protect city assets and sustain what we have for an equitable, strong, healthy, vibrant, and safe community.

We are future ready.”

The strategic goals that fulfill the vision are presented in Table 1.

Table 1 Climate Adaptation Plan Strategic Goals

Symbol	Strategic Goal
	<p>Environment and Health Sustain environmental health, biodiversity, and individual well-being</p>
	<p>Infrastructure Prepare for the future with resilient built and natural infrastructure, while protecting existing resources</p>
	<p>Economy Strengthen economic prosperity by reducing the risk of economic loss; focus on adaptation actions that are fiscally responsible and achieve measurable long-term benefits</p>
	<p>Safety Reduce risk, strengthen our community’s emergency preparedness and disaster response</p>
	<p>Equity Ensure climate adaptation solutions cover all protected grounds under the Ontario Human Rights Code</p>

1.3 Objective and Scope: City of Guelph’s Climate Adaptation Plan

The objective of the Climate Adaptation Plan is to outline how the City will adapt its policies, plans, assets, operations, and services to manage the impacts of climate change toward building a more adaptive and resilient community. The Climate Adaptation Plan is:

- corporate focused but also highlights community and other external group-led actions where appropriate, recognizing that the City only has control over the action of its own corporation
- a single, comprehensive document that includes and considers actions for all City departments and divisions
- organized into existing and recommended short-, medium-, and long-term and ongoing implementation actions
- a repository for example key performance indicators (KPIs) with which to monitor and evaluate the City’s success in adapting to climate change (i.e., implementing the recommended actions)

- adaptable and will be reviewed and updated every 5 years. (The City’s master planning and other planning documents will reference climate adaptation actions)

To develop the Climate Adaptation Plan, the project was broken into four stages, as illustrated in Figure 3 and briefly described below.

- **Stage 1 Scoping and Planning:** project planning, including project timelines, establishing geographic boundaries, confirming the climate data used, and developing the Engagement and Communications Plan for the project.
- **Stage 2 Strategic Context Review:** included a document review of the City’s policies and master and asset planning documents, local municipal Climate Adaptation Plans, and provincial and federal policies and guidance.
- **Stage 3 Risk/Vulnerability Assessment:** worked with City staff (subject matter experts) in all departments/divisions to identify City assets, services, and operations that may be affected by climate hazards. Assessed the likelihood of the climate hazards and the consequences of those climate hazards on the City’s assets, services, and operations.
- **Stage 4 Actions and Plan Development:** met with City staff to understand their current adaptive capacity measures (i.e., actions taken to adapt to climate hazards to avoid or reduce the impact on the City’s assets, services, and operations), development and recommendation of actions to reduce or eliminate the climate risk to the City’s assets and services, a schedule for implementation and an evaluation process to monitor the City’s progress toward climate resiliency.

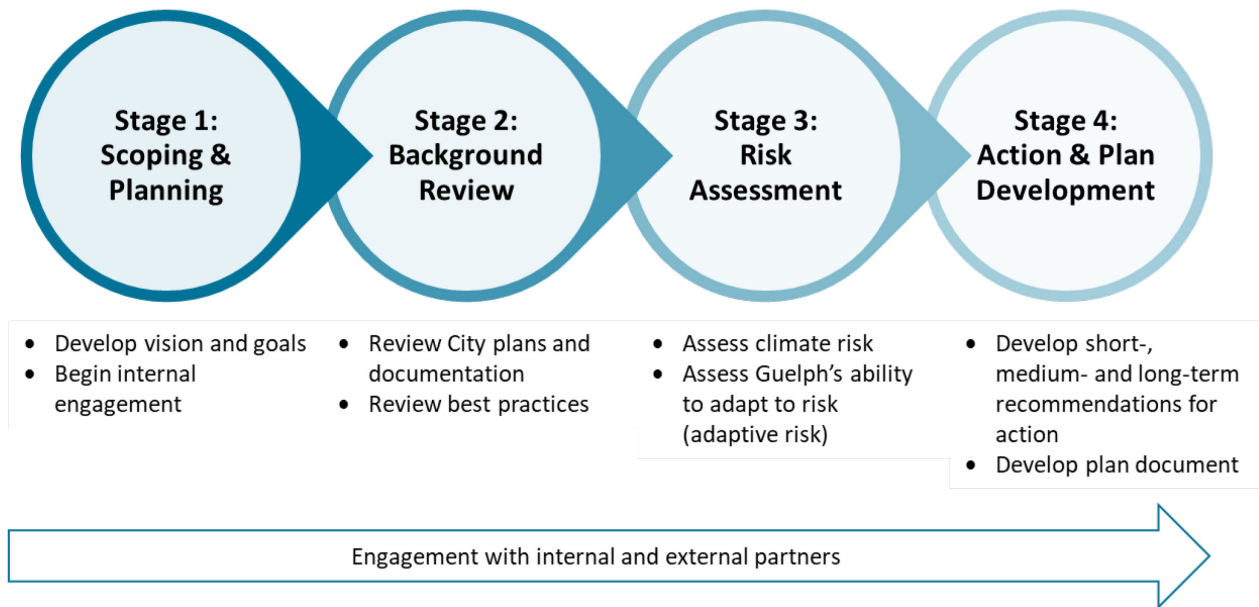


Figure 3 City of Guelph Climate Adaptation Plan Project Stages and Description

1.4 Project Methodology

The overall project methodology is summarized in the flow chart in Figure 4 and outlines four stages, beginning with the establishment of a work plan and culminating in the completion of the Climate Adaptation Plan, along with guidance to implement and evaluate the plan.

The methodology is a combination of risk assessment and asset management techniques, with a Climate Lens applied. The methodology is based on the International Organization for Standardization (ISO) 31000 risk framework, which includes risk assessment and implementation and risk management, involves ongoing engagement with City staff, and applies continuous monitoring and review in its development. By framing the risk management process on infrastructure assets and service delivery, the Climate Adaptation Plan tends to lean more toward assets than services, although it provides a holistic and broad perspective to the evaluation of risk and the development of adaptation measures. This approach elevated the existing Asset Management Plans and their list of infrastructure assets to become a key layer of information in the risk management process (Section 1.5) and also influenced the review of other plans, practices, and protocols and the determination of existing adaptive capacity across different City departments/divisions. The selective use of best practices in incorporating climate change into asset management planning also influenced the Climate Adaptation Plan development process and played an important role in the methodology, drawing from examples and guidance from the work by the Federation of Canadian Municipalities (FCM) and the Financial Accountability Office of Ontario (FAO), which were used to inform estimates of the

potential costs of climate change on infrastructure assets and help describe asset-specific actions.

Based on a review of a selection of municipal Climate Adaptation Plans, there is a wide range in climate-related consequences that municipalities have identified and an equally large number of corresponding adaptation actions that have been proposed, and the overall direction and tone of the plans are often biased toward either assets or services, or some balance between both. While neither approach is “better” or “worse,” driving the Climate Adaptation Plan process through infrastructure assets had the benefit of building the plan on an established practice that cuts across multiple departments/divisions, with clear roles and responsibilities that already exist, and known funding sources and regulatory requirements. Although more work remains for the City to fully integrate climate change considerations into their asset management planning process, the Climate Adaptation Plan should nonetheless provide an initial and solid foundation for the City to make meaningful progress toward becoming more climate resilient.

The recommendations of the Climate Adaptation Plan build upon areas and actions that the City is already addressing with regard to extreme weather conditions, and even climate change, through existing and planned measures, although much of these are being delivered on an individual basis rather than in a coordinated and evidence-based fashion. As the first iteration of what is intended to be an ongoing plan that is updated on a regular basis, the Climate Adaptation Plan highlights where the risks of climate hazards may become more significant for infrastructure assets performance and the City’s ability to deliver services. As such, the results of the risk assessment should help identify where the level of effort and investment to maintain levels of service (LOS) requires tweaking over the next 5 to 10 years of the planning and capital budget cycle.

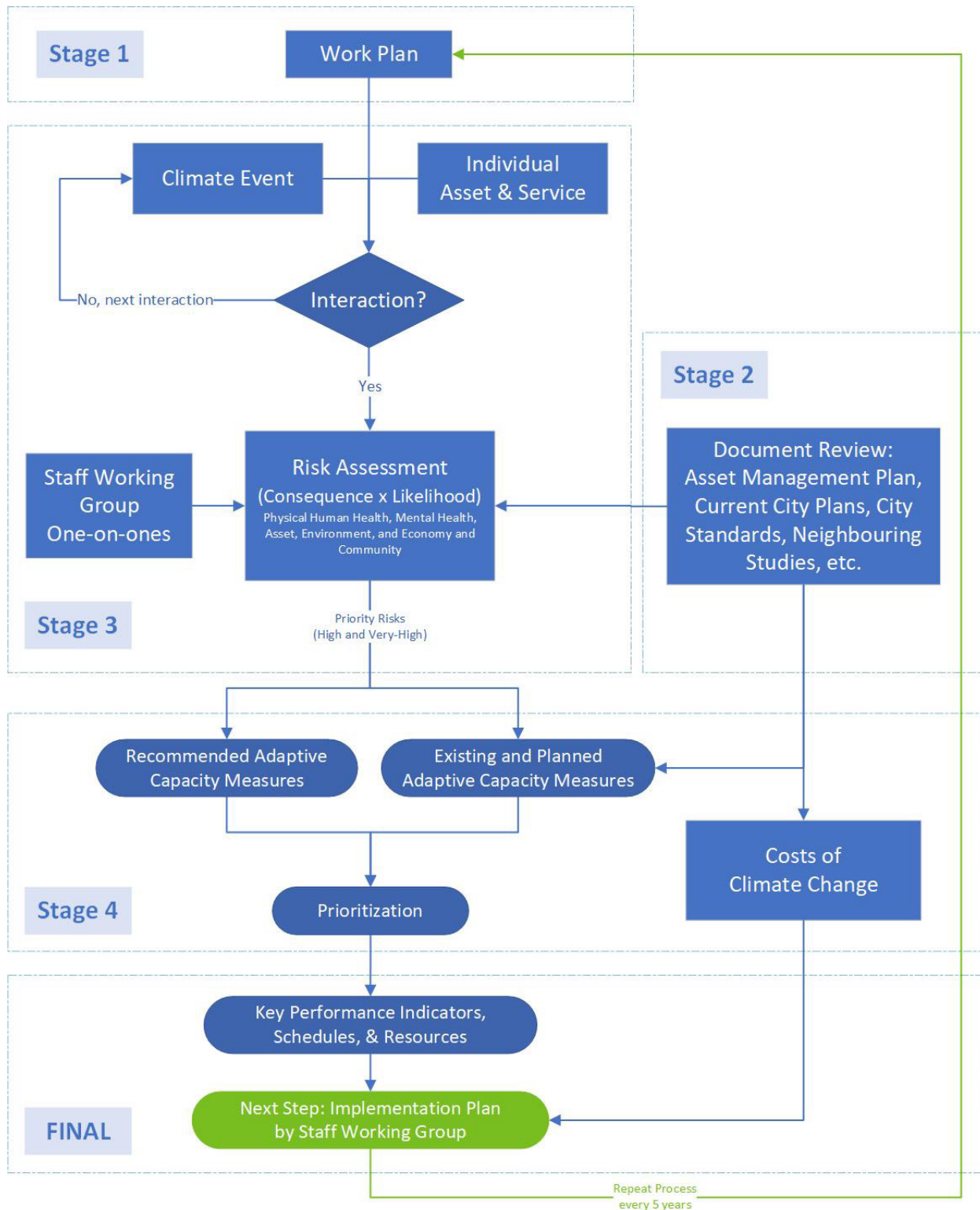
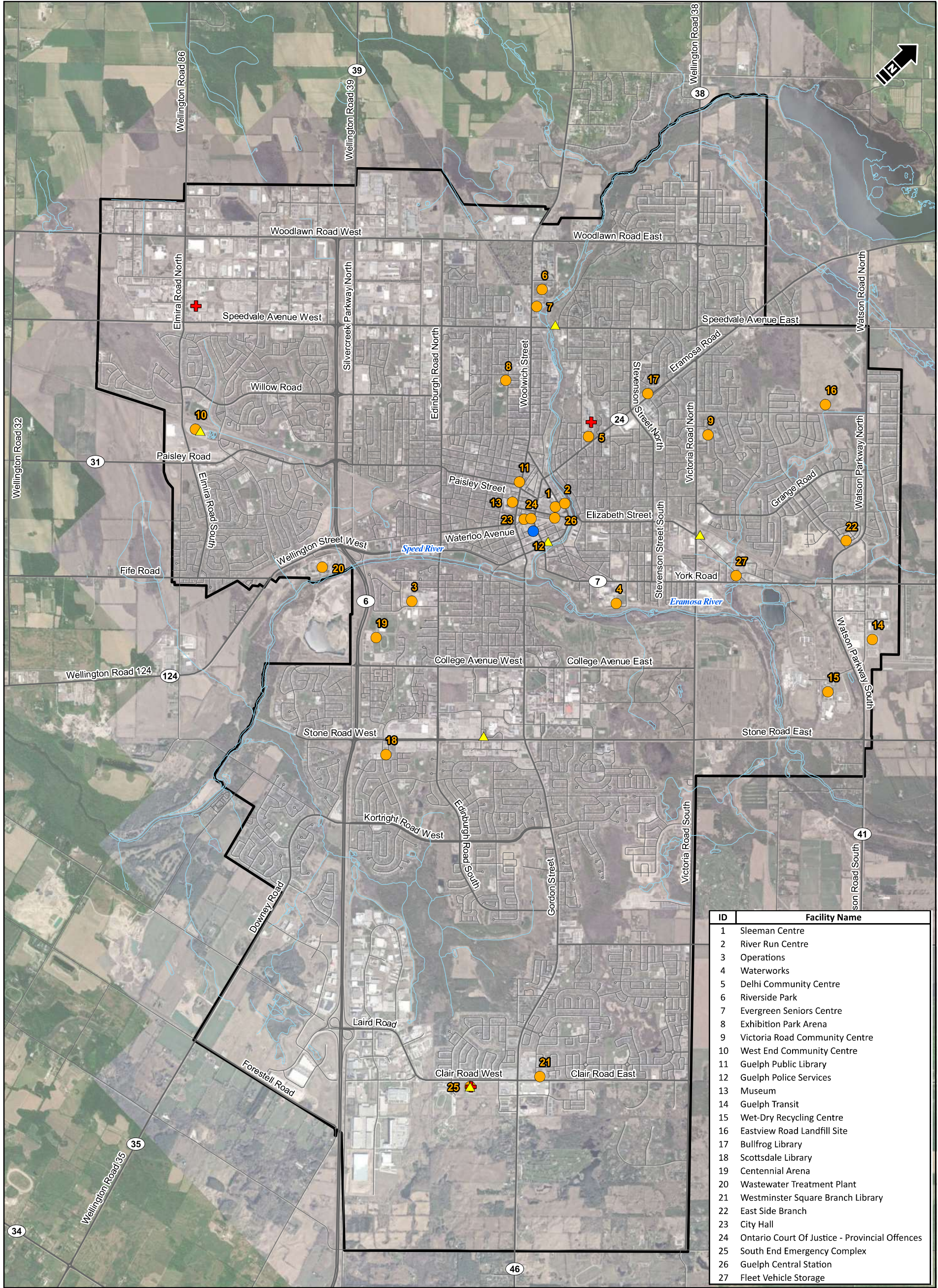


Figure 4 Project Methodology and Reporting

1.4.1 Project Geographical Limits

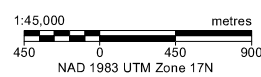
Generally, the geographic scope of the Climate Adaptation Plan is limited to the City's boundaries, while recognizing the impact of climate beyond these boundaries. For example, upstream, the Guelph Lake Dam is owned and operated by the Grand River Conservation Authority (GRCA) who control the downstream Speed River flows. The City's Water Resource Recovery Centre (for wastewater treatment) relies on minimum streamflow thresholds in the Speed River to assimilate treated effluent. Further, there are communities located downstream of the City of Guelph in the Grand River watershed, who subsequently may be affected by the actions put forward in the Climate Adaptation Plan; however, improved climate resiliency within the City of Guelph boundary will have a positive impact on all communities within the watershed.

Figure 5 displays the City buildings within the City boundary, including the police station, paramedic stations and fire stations. Subsequent maps (Figures 6 to 9) provide higher resolutions for each quadrant of the City, defined as northwest, northeast, southwest, and southeast, and include an overlay of the regulatory floodplain, delineated by the GRCA, and vegetative cover (e.g., parkland and trees inventoried by the City). There is also City infrastructure located outside of City boundaries, such as water supply wells (Calico, Carter, Arkell) and the Arkell Springs infrastructure, including the Arkell Aqueduct, Glen Collector, and Lower Road Collector (Figure 10).



ID	Facility Name
1	Sleeman Centre
2	River Run Centre
3	Operations
4	Waterworks
5	Delhi Community Centre
6	Riverside Park
7	Evergreen Seniors Centre
8	Exhibition Park Arena
9	Victoria Road Community Centre
10	West End Community Centre
11	Guelph Public Library
12	Guelph Police Services
13	Museum
14	Guelph Transit
15	Wet-Dry Recycling Centre
16	Eastview Road Landfill Site
17	Bullfrog Library
18	Scottsdale Library
19	Centennial Arena
20	Wastewater Treatment Plant
21	Westminster Square Branch Library
22	East Side Branch
23	City Hall
24	Ontario Court Of Justice - Provincial Offences
25	South End Emergency Complex
26	Guelph Central Station
27	Fleet Vehicle Storage

- City Boundary
- Watercourse
- Highway
- Road
- Police Station
- Fire Station
- Paramedic Location
- City Facility

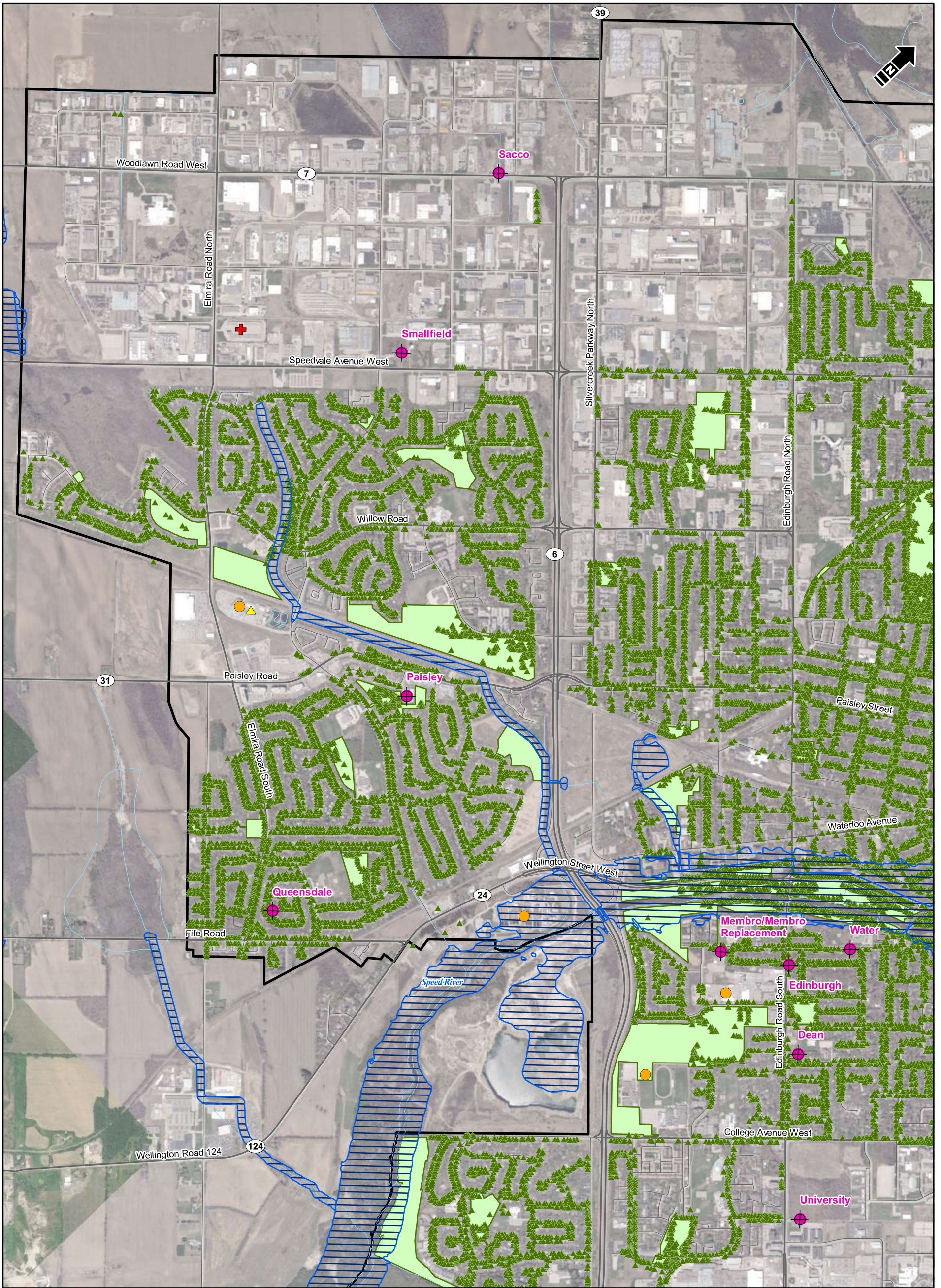













City of Guelph
Climate Adaptation Plan

City of Guelph Buildings

Date: July 2023 Project: 34718 Submitter: M. Samson Reviewer: T. Roumeliotis

Reference: Data obtained from City of Guelph Open Data (2023). Produced under Licence with the Ontario Ministry of Northern Development, Mines, Natural Resources and Forestry © Queen's Printer for Ontario (2023). Imagery (2018-2021) Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community.



-  City Boundary
-  Park
-  Regulatory Floodplain
-  Watercourse
-  Highway
-  Road
-  Fire Station
-  Paramedic Location
-  City Facility
-  Water Supply Well
-  Tree Inventory

1:20,000
 0 200 400 metres
 NAD 1983 UTM Zone 17N

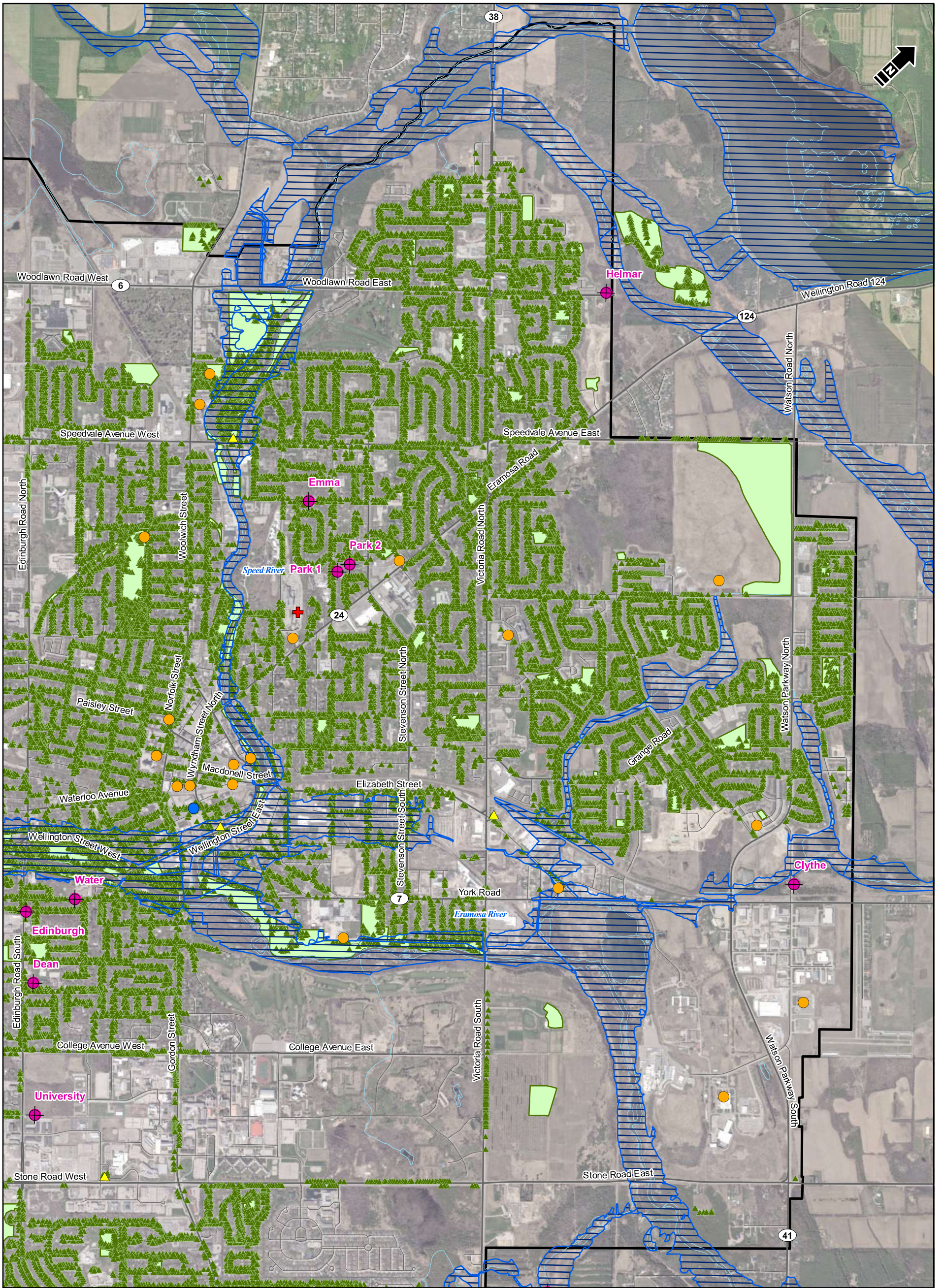


City of Guelph
 Climate Adaptation Plan

City of Guelph Assets Northwest

Date: July 2023 Project: 34718 Submitter: M. Samson Reviewer: T. Roumeliotis

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- City Boundary
- Park
- Regulatory Floodplain
- Watercourse
- Highway
- Road
- Police Station
- Fire Station
- Paramedic Location
- City Facility
- Water Supply Well
- Tree Inventory

1:25,000 metres
 250 0 250 500
 NAD 1983 UTM Zone 17N

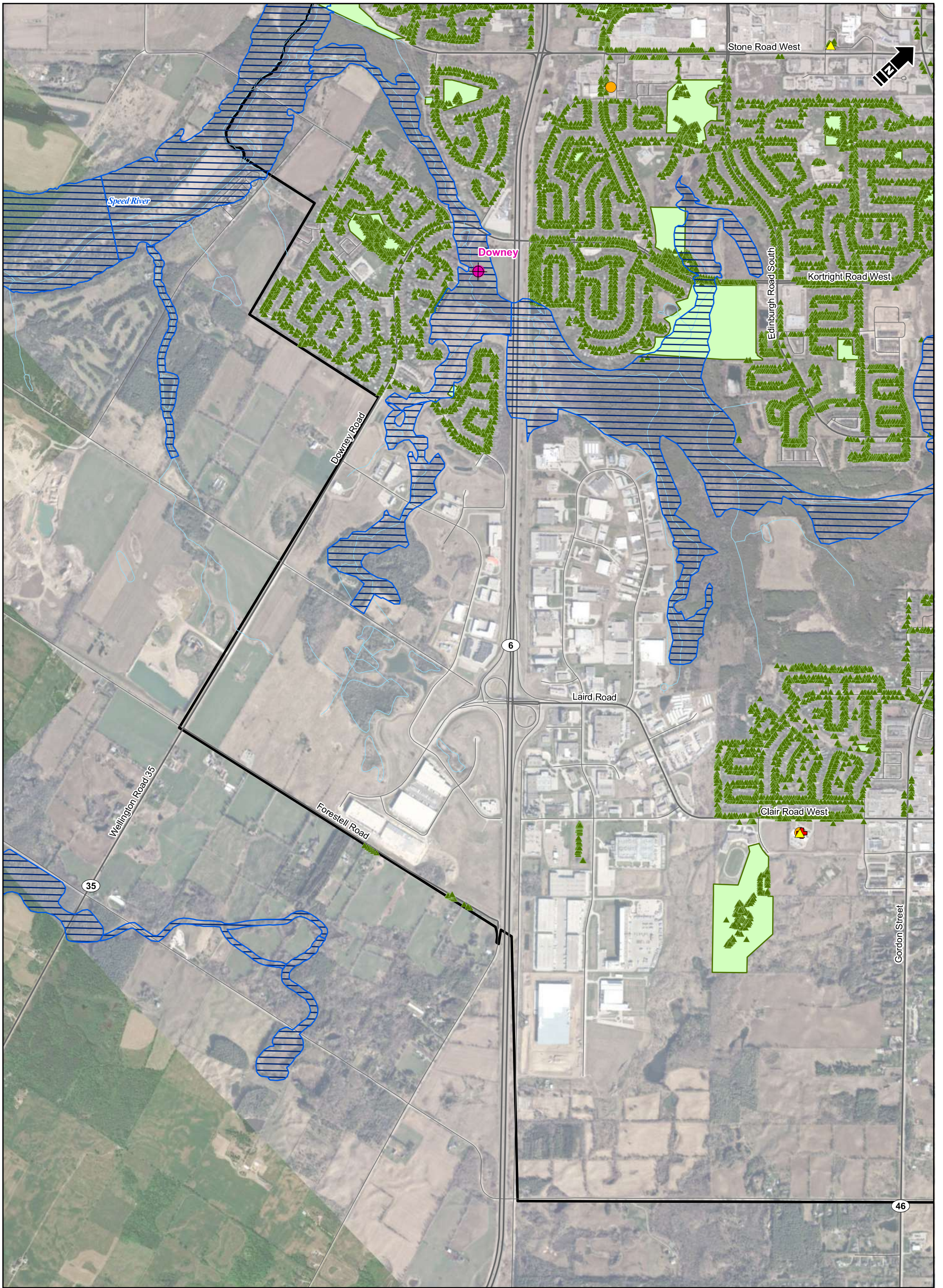













City of Guelph
 Climate Adaptation Plan

City of Guelph Assets Northeast

Date: July 2023 Project: 34718 Submitter: M. Samson Reviewer: T. Roumeliotis

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-  City Boundary
-  Park
-  Regulatory Floodplain
-  Watercourse
-  Highway
-  Road
-  Fire Station
-  Paramedic Location
-  City Facility
-  Water Supply Well
-  Tree Inventory

1:20,000
 200 0 200 400 metres
 NAD 1983 UTM Zone 17N

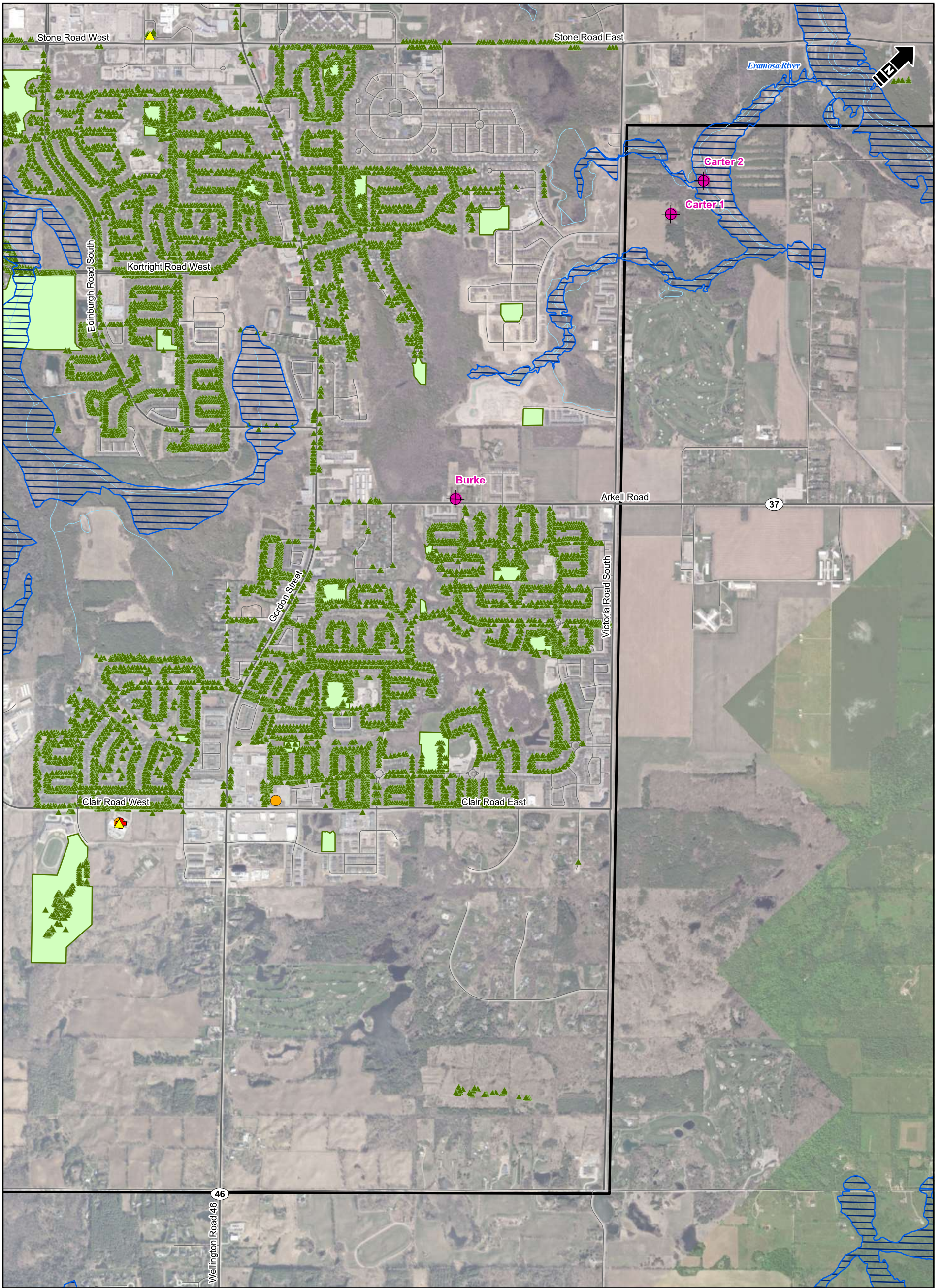













City of Guelph
 Climate Adaptation Plan

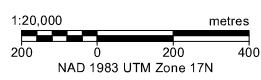
City of Guelph Assets Southwest

Date: July 2023	Project: 34718	Submitter: M. Samson	Reviewer: T. Roumeliotis
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-  City Boundary
-  Park
-  Regulatory Floodplain
-  Watercourse
-  Highway
-  Road
-  Fire Station
-  Paramedic Location
-  City Facility
-  Water Supply Well
-  Tree Inventory

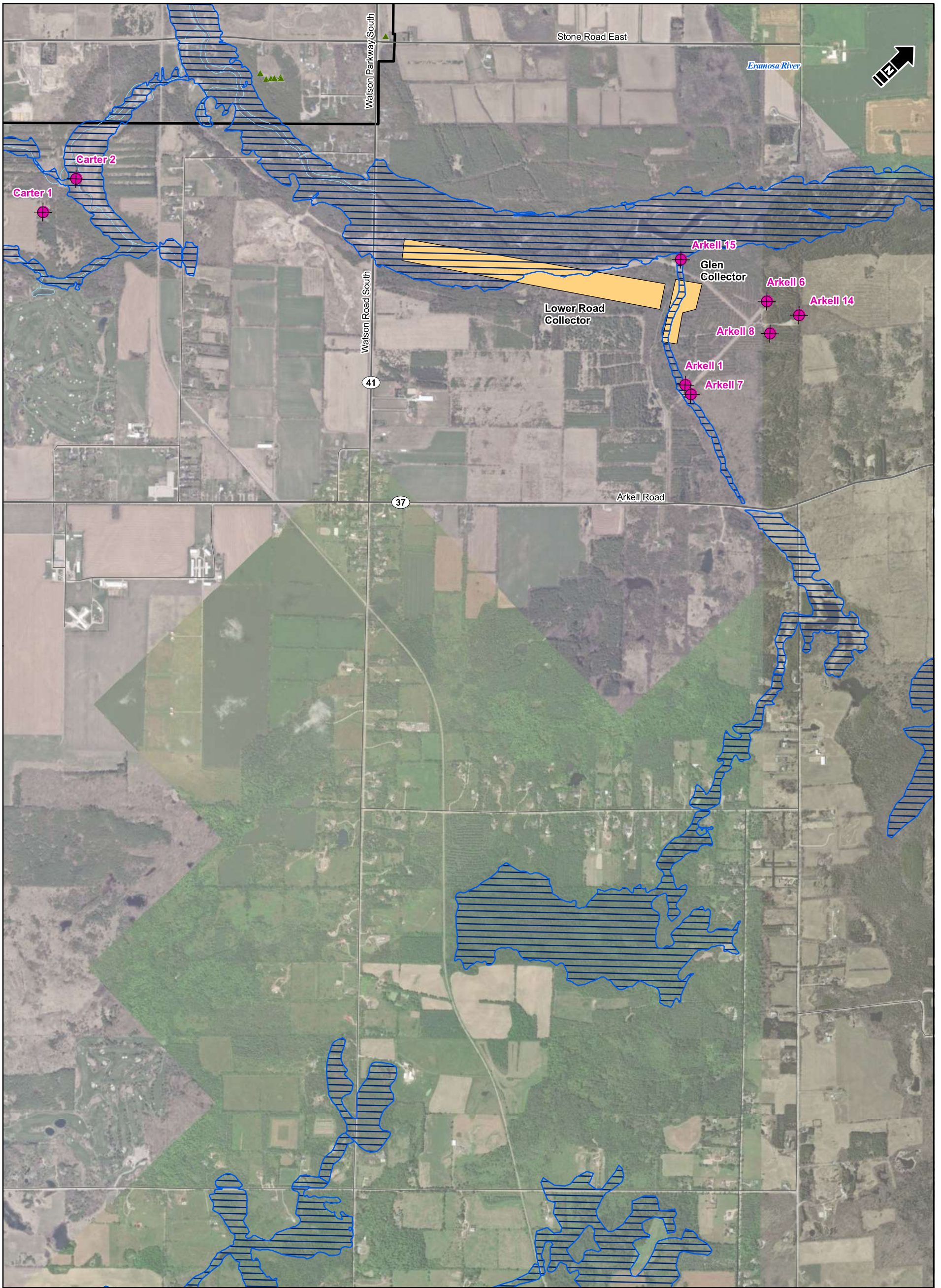









City of Guelph
Climate Adaptation Plan

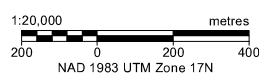
City of Guelph Assets Southeast

Date: July 2023 Project: 34718 Submitter: M. Samson Reviewer: T. Roumeliotis

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-  City Boundary
-  Collector
-  Regulatory Floodplain
-  Watercourse
-  Highway
-  Road
-  Water Supply Well



City of Guelph
Climate Adaptation Plan

City of Guelph Assets Far Southeast

Date: July 2023	Project: 34718	Submitter: M. Samson	Reviewer: T. Roumeliotis
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1.5 Asset Management Planning and Summary of the Asset-based Approach to Developing the Climate Adaptation Plan

Asset management planning is the process of managing an organization's physical assets, such as buildings, equipment, infrastructure, and other tangible assets, to ensure they are maintained, operated, and utilized in a cost-effective manner. The objective of asset management planning is to optimize the performance and value of assets while minimizing costs and risks.

The asset management planning process introduces some specific terminology intended to standardize the methods by which municipalities account for their assets. Some of the terminology specific to asset management planning includes:

- **Current Replacement Value (CRV):** The current cost of rebuilding an infrastructure asset with the equivalent capacity, functionality, and performance.
- **LOS:** LOSs are specific parameters that describe the extent and quality of services that the municipality provides to users. LOSs link an asset's performance to target performance goals.
- **Operations and Maintenance (O&M):** The routine activities performed on an asset that maximize service life and minimize service disruptions without altering the physical components of the asset.
- **Rehabilitation:** Repairing part or most of an asset to extend its service life, without adding to its capacity, functionality, or performance.
- **Renewal:** Replacement of an existing asset, resulting in a new or as-new asset with an equivalent capacity, functionality, and performance as the original asset. Renewal is different from rehabilitation, as renewal rebuilds the entire asset.
- **Useful Service Life (USL):** An estimate of the average number of years an asset is useable in the context of design, physical, capacity, and economic criteria.

Municipalities in Ontario are required by the province to develop Asset Management Plans. On January 1, 2018, O. Reg. 588/17 came into effect. This regulation describes the requirement for municipal asset management planning with the following milestones as described in Table 2.

Table 2 Requirement for Municipal Asset Management Planning (O. Reg. 588/17)

Date	Milestone
July 1, 2022	Municipal asset management plans for “core municipal infrastructure assets” (includes water, wastewater, and stormwater management) that addresses current service levels, asset performance, condition, age, and replacement cost.
July 1, 2024	Asset management plans for all “other municipal infrastructure assets” (including green infrastructure assets).
July 1, 2025	Asset management plans for all municipal infrastructure assets that build on the requirements set out for the 2022/2024 Asset Management Plans and address proposed LOS, activities, and funding required to meet those LOSs and any estimated funding short fall.
Ongoing (every 5 years)	Review and update of every Asset Management Plan.

Notes: LOS – level of service

The City has had an asset management program in place since 2018, and that year published a “Strategic Asset Management Policy” (City of Guelph 2018a). The City’s first Corporate Asset Management Plan was developed and published in 2017, with an updated version published in 2020, that surpasses compliance with O. Reg. 588/17. There is also a Core Asset Management Plan that was published in 2021, which focuses on four core asset types that make up over 80% of the total infrastructure asset base owned and managed by the City: transportation, water services, wastewater services, and stormwater management systems.

O. Reg. 588/17 addresses the need for municipalities to incorporate climate change into their Strategic Asset Management Policy as follows:

“3. (1) Every municipality shall prepare a strategic asset management policy that includes the following:

5. The municipality’s commitment to consider, as part of its asset management planning,

i. the actions that may be required to address the vulnerabilities that may be caused by climate change to the municipality’s infrastructure assets, in respect of such matters as,

- A. operations, such as increased maintenance schedules,
- B. levels of service, and
- C. lifecycle management,

- ii. the anticipated costs that could arise from the vulnerabilities described in subparagraph i,
- iii. adaptation opportunities that may be undertaken to manage the vulnerabilities described in subparagraph i,
- iv. mitigation approaches to climate change, such as greenhouse gas emission reduction goals and targets, and
- v. disaster planning and contingency funding.”

Although the O. Reg. 588/17 speaks to addressing climate change in its policy, as described in the above-noted quotation, it does not explicitly instruct municipalities to incorporate the effects of climate change in its assessment of the lifecycle of its assets or the increased costs associated with maintenance, rehabilitation, and renewal. However, municipalities such as Guelph will likely integrate the impacts and costs of climate change into all aspects of asset management planning as these plans are developed and operationalized.

Therefore, the asset management planning framework is the most appropriate method to address the costs of climate change (further discussed in Section 7.1) for infrastructure, because it provides for the ability to proactively plan for the long-term management of assets in a changing climate. Specific advantages of the asset management process include:

- **Comprehensive approach:** An asset management planning framework considers all aspects of infrastructure management, including design, construction, maintenance, and operation. The approach is designed to identify vulnerabilities and risks affecting assets and to develop strategies to manage them.
- **Prioritization:** An asset management planning framework helps organizations to prioritize investments in infrastructure assets based on their importance, condition, and risks. This enables the allocation of resources to manage the most important risks and reduce long-term costs effectively and efficiently.
- **Adaptation and resilience:** An asset management planning framework is designed to evaluate strategies to evaluate the cost and benefit of alternatives to enhance asset performance and reduce long-term costs.

The asset-based approach for the City and the consideration of climate change through the Climate Adaptation Plan can be imagined as a multi-layer data source and journey of discovery (Figure 11). The Core Asset Management Plan (City of Guelph 2021a) and Corporate Asset

Management Plan (City of Guelph 2020a) provide the most detailed and comprehensive level of information on asset condition and performance from which to assess climate-related vulnerabilities and risks and identify existing and planned actions that will enhance adaptive capacity. However, each subsequent “ring” emanating from the centre broadened in scope (e.g., the next level of detail captured in the Corporate Asset Management Plan), provided lesser levels of detail regarding asset condition and performance, and outlined a wider range of actions and measures that includes those not tied specifically to infrastructure assets. At the outer ring was provincial legislation, which mandates the requirement and provides general direction, but lacks detailed guidance regarding application. Conversely, the combination of the Climate Adaptation Plan and preliminary consideration of climate change into the asset management planning process should help the City meet its regulatory obligations under O. Reg. 588/17.

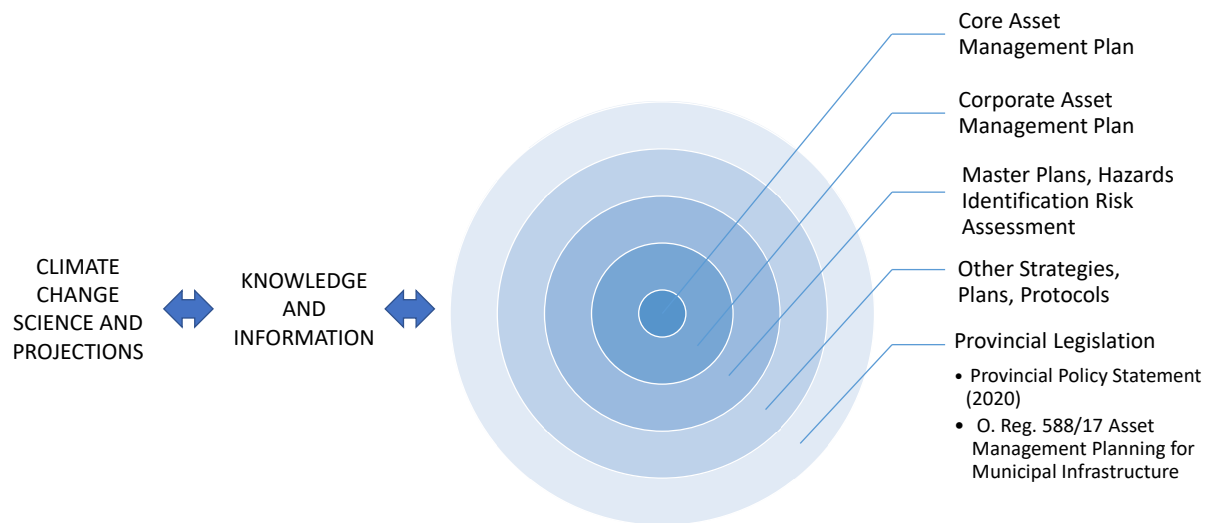


Figure 11 Asset-based Approach for the City of Guelph

The physical asset systems, described in the Corporate Asset Management Plan and Core Asset Management Plan and integrated into the Climate Adaptation Plan risk assessment, include administrative facilities, emergency services, stormwater, corporate vehicles and equipment, information technology, transit, culture and recreation, parking, transportation, wastewater, solid waste, and water services. A complete list of assets is provided in Table 3. Note that the list of assets is not restricted to each department building and considers ancillary assets, such as fleet vehicles and bus shelters, that are not tied to a specific building location.

Table 3 Assets Considered in this Assessment

Asset Category	Items included	Group Categories
<ul style="list-style-type: none"> • Administrative and Operations Facilities • Contaminated Sites • Corporate Vehicles and Equipment • Emergency Services • Green Infrastructure (Natural Assets) • Parking • Parks, Recreation and Culture • Software and Hardware • Solid Waste • Stormwater • Transit Services • Transportation • Wastewater • Water 	<ul style="list-style-type: none"> • Arkell Springs, Water, Spring Recharge System • Bridges and Structures • Bus – Conventional; Bus – Mobility; Transit Vehicle – Other • Bus Stops/Shelters • Bus Terminal • Channels, Culvert, Management Ponds, Oil and Grit Separator, Pipes • Collector Aqueduct • Commercial Facilities, Corporate Administration Facilities, Operations Facilities • Contaminated Land • Emergency Buildings • Emergency Equipment • Emergency Vehicles • Equipment • Fleet Vehicles • Groundwater Well Station, Pumping Station, Well Station (inactive) • Hydrants, Water Flow Meter Stations, Watermains 	<ul style="list-style-type: none"> • Maintenance Hole, Sanitary Pipe, Siphon, Wastewater Pumping Station • Natural Heritage • Parking Garage • Parking • Parks • Recreation Facility • Roads, Sidewalks, Bike paths/Trails • Signage, Streetlights, Traffic Controls • Transit • Transit Facilities • Waste Collection Fleet Vehicles • Waste Resource Innovation Centre (Facility) • Water Resource Recovery Centre • Water Tower • Water Treatment Plant • Wetlands
		<ul style="list-style-type: none"> • Arkell Springs and Recharge System • Bridges and Structures • Buildings • Bus Stops/Shelters • Bus Terminal • Collector Aqueduct • Contaminated Land • Emergency Buildings • Emergency Equipment • Emergency Vehicles • Equipment • Forest and Plants • Library, Culture, Tourism and Community Investment • Parking • Parks • Recreation Facility • Roads • Signage • Stormwater Infrastructure • Surface Water • Vehicles • Wastewater infrastructure • Wastewater Treatment Facility • Water Infrastructure • Water Tower • Water Treatment Plant • Well Station • Wetlands

To simplify the initial screening of the assets, similar assets were grouped within departments/divisions and analyzed together. For example, stormwater was listed as one asset but comprises channels, culverts, management ponds, oil and grit separators, and pipes. However, the analysis of these assets was not restricted to its designated group; where individual consideration was warranted, the asset was analyzed separately to derive unique adaptation actions.

City staff were engaged to confirm the lists of assets and asset groupings and asked to outline the services their respective department/division provides to the City. While the direct impacts of climate hazards on each of these assets were the focus of the assessment, the process also considered how changes in climate could interact with the environment to generate indirect impacts on infrastructure assets and service delivery. For example, extreme heat and heat warnings could exacerbate the urban heat island effect in areas of the City where asphalt and concrete dominates land uses (e.g., roads and surface parking), compared to areas where natural infrastructure, including tree cover, would act to reduce extreme maximum temperatures. Similarly, heavy rainfall could lead to increased runoff, and an increase in water levels and velocities in rivers and streams, leading to riverine flooding, whereas natural infrastructure and low impact development could result in higher volumes of rainfall being retained onsite through infiltration, thereby reducing overland flows and potential riverine flooding.

This opens the door to consider the spatial relationships between assets, climate hazards, and the land uses that increase or reduce exposure. This led to consideration of spatial data, such as the City's open data portal that provides interactive maps for various nature features, infrastructure assets, and land uses.

Figures 5 through 10 show that many of the City's buildings are located near rivers or creeks and some within the regulatory floodplain, including the wastewater treatment plant, two fire stations, and the F.M. Woods water treatment facility.

The tree inventory is not inclusive of all trees within the City, but rather those in the urban footprint outside of parks or forested areas. Figures 6 through 9 show that the City does have notable tree coverage throughout the City. While trees can help reduce flooding and lower urban maximum temperatures, they can also act as hazards (e.g., branches) for roads and overhead infrastructure (e.g., electricity and communication) during high wind and freezing rain events.

2 Project Engagement

2.1 Engagement and Communications Objectives

Guelph's Climate Adaptation Plan is an important project for the City, its residents, businesses, and its partners. Ongoing engagement with stakeholders (both internal and external), the community, and local Indigenous governments was critical to the project's success, resulting in meaningful dialogue about climate change impacts and adaptations and a more collaborative implementation of the adaptation actions.

Engagement and communications with internal and external stakeholders and Indigenous governments were a focus throughout all four project stages. Internal stakeholders include those within the Corporation of the City of Guelph and affiliated services including Guelph Police Services and Guelph Library Services. The City staff's knowledge of their own infrastructure, programming, operations, and services was the single most important factor in developing the Climate Adaptation Plan, and as such, significant staff engagement was conducted throughout the project to leverage this knowledge for the risk assessment and adaptation action and plan development.

External stakeholders included organizations that provide adaptation-related services and programming in Guelph, external groups that have an interest in the plan, and members of the public.

The engagement objectives of the project included:

- involving and collaborating with internal stakeholders and partner organizations in all aspects of the Climate Adaptation Plan's development, including:
 - ✦ confirming the Climate Adaptation Plan's vision and goals
 - ✦ identifying climate hazard interactions with City assets and services
 - ✦ reviewing the risk assessment scores
 - ✦ identifying corporate adaptation actions
 - ✦ validating the implementation program and monitoring and evaluation processes
- building support and buy-in for the Climate Adaptation Plan, ensuring sustainable implementation across the organization by aligning with master planning documents, the multi-year budget process, and business planning

- consulting with members of the public and external stakeholders and providing avenues for feedback at specific points in the process

The communications objectives of the project included:

- establishing a baseline understanding amongst the internal and partner organizations of climate adaptation, Guelph's changing climate, and the risks posed by climate change
- ensuring that key internal stakeholders and partner organizations are aware of the project, its goals, progress, and timelines
- providing an overall summary of the knowledge supplied from strategic context sources (Section 3)
- keeping members of the public and external stakeholders informed about the Climate Adaptation Plan and its development progress

2.2 Engagement Audiences

The Climate Adaptation Plan is a corporate-focused plan, and as such, internal engagement efforts were a major piece of the Plan's development. There were three staff project groups who contributed to the success of the project, and these were denoted as the Core Project Team, Staff Working Group, and Steering Committee (defined in Table 4). The Project Team also consulted external partner organizations (collectively denoted as the Partner Working Group, defined in Table 4) that provide adaptation-related services and programming in Guelph. City Council was informed of the project progress and will be asked to provide approval of the final Climate Adaptation Plan.

Community organizations and the public were kept informed about the project through email updates and City website updates, respectively, and were invited to review the draft Climate Adaptation Plan at information booth sessions held near the end of the project. The relationship between these stakeholder groups and their role descriptions are summarized in Figure 12 and in Table 4, respectively.

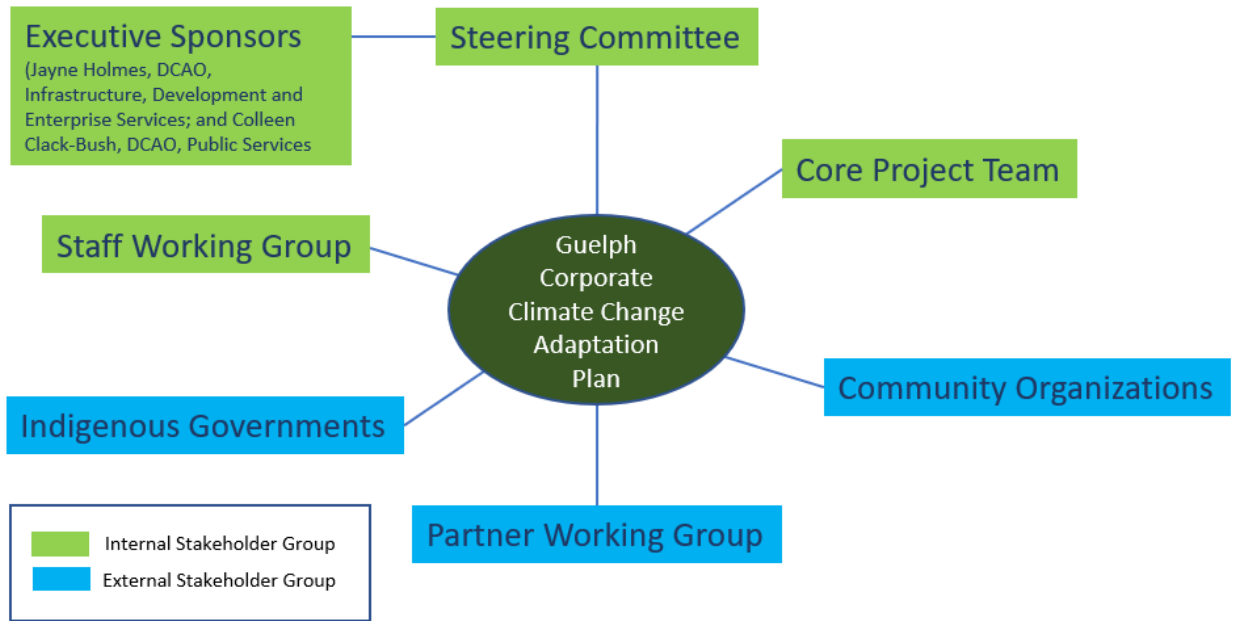


Figure 12 Internal and External Stakeholder Groups to the Climate Adaptation Plan Project

Table 4 Project Communication and Consultation Groups

Group	Role Description and Group Members	Timing of Engagement
Core Project Team	<p>Responsible for project management and Steering Committee.</p> <p>Members from:</p> <ul style="list-style-type: none"> • Environmental Services • Operations • Facilities and Energy Management • CAO’s Office (Strategic Communications and Community Engagement; Strategy, Innovation and Intergovernmental Services) • Employee Health, Safety and Wellness • Corporate Legal • Corporate Finance • Asset Management 	All Stages

Group	Role Description and Group Members	Timing of Engagement
Steering Committee	<p>Responsible for direction and decision making, approval ahead of City Council.</p> <p>Members from:</p> <ul style="list-style-type: none"> • Environmental Services • Operations • Facilities and Energy Management • Fire Services • Engineering and Transportation Services • CAO’s Office (Strategic Communications and Community Engagement) • Parks • Planning and Building Services 	Stages 1, 3, 4
Staff Working Group	<p>Providing input from various departments/divisions and implementing adaptation programs within the Corporation of the City of Guelph (subject matter experts).</p> <p>Members from:</p> <ul style="list-style-type: none"> • Environmental Services (Solid Waste, Wastewater, Water Services, Compliance and Performance) • Engineering and Transportation Services (Contaminated Sites, Stormwater, Transportation) • Facilities and Energy Management • Asset Management • Planning and Building Services • Operations • Fire Services • Paramedic Services • CAO’s Office (SMART Cities; Strategic Communications and Community Engagement; Strategy, Innovation and Intergovernmental Services) • Parks • Corporate Health and Safety • Information Technology • Economic Development and Tourism • Transit • Culture and Recreation • Guelph Library Services • Guelph Police Services 	All Stages

Group	Role Description and Group Members	Timing of Engagement
	<ul style="list-style-type: none"> Equity, Diversity, and Inclusion (Community Investment, Accessibility, Indigenous Relations, Intergovernmental Relations, Equity, and Anti-racism). 	
Partner Working Group	<p>Groups interested in, or influencing, adaptation programs (i.e., the external equivalent of the Staff Working Group).</p> <p>Members from:</p> <ul style="list-style-type: none"> University of Guelph Grand River Conservation Authority Wellington-Dufferin-Guelph Public Health County of Wellington Wellington County Housing Alectra Enbridge Gas Guelph General Hospital Wellington Catholic District School Board Red Cross Upper Grand District School Board Guelph Junction Railway Metrolinx CN Rail 	All Stages
City Council	Responsible for the final approval of the Climate Adaptation Plan, the ultimate decisionmaker.	Stages 1, 3, 4
General Public	Consulted on the draft Climate Adaptation Plan at two separate public information sessions and informed through project webpage updates throughout the project.	Stage 4
Indigenous Governments	<p>Consulted and informed throughout the process.</p> <p>Members from:</p> <ul style="list-style-type: none"> Six Nations of the Grand River Mississaugas of the Credit First Nation <p>Invited to be engaged in the process:</p> <ul style="list-style-type: none"> Grand River Métis Council The Haudenosaunee Confederacy 	All Stages
Community Organizations	<p>Consulted and informed throughout the process.</p> <p>Members from, for example: Guelph Chamber of Commerce, Business Centre Guelph Wellington, Innovation Guelph, Toward Common Ground, eMERGE, Our Energy Guelph, 10C. A full list is presented in Appendix A</p>	Stages 1, 3, 4

2.3 Level of Engagement

The City’s Community Engagement Framework contains a spectrum of engagement, demonstrating the possible types of engagement with stakeholders and communities from “consult” to “empower.” Engagement levels for each stakeholder group are outlined in Table 5. Engagement and influence increase as you move from left to right on the table.

Table 5 Level of Engagement of Internal and External Stakeholders

Consult (Gather Information)	Involve (Discuss)	Collaborate (Work Together)	Empower (Partner)
<ul style="list-style-type: none"> Public Community Organizations 	<ul style="list-style-type: none"> Staff Working Group Partner Working Group Indigenous Government 	<ul style="list-style-type: none"> Core Project Team Steering Committee 	<ul style="list-style-type: none"> City Council

Sharing information (informing) takes place across all levels of engagement

2.4 Equity, Diversity, and Inclusion and Reconciliation

Throughout engagement in the development of the Climate Adaptation Plan, Matrix and LURA worked to apply an EDI lens and a reconciliation lens collaboratively with the City’s EDI Team and Indigenous Relations Advisor. The intent was to incorporate EDI and Reconciliation meaningfully when considering the adaptive capacity measures and recommended actions for the City’s Climate Adaptation Plan.

2.4.1 What are Equity, Diversity, and Inclusion and Reconciliation?

EDI is a framework for advancing fairness, justice, and equal access to opportunities and resources for all individuals and groups, regardless of their backgrounds or identities.

Equity ensures that underrepresented and/or marginalized people and groups have access to the same opportunities and outcomes as everyone else. Diversity refers to involving, considering, and representing the demographic, attitudinal, and experiential diversity of the communities impacted by a decision or process. Inclusion refers to creating environments and processes that nurture a sense of belonging where everyone can contribute and participate.

The City’s EDI Team identified four key pillars to enacting EDI as it relates to the Climate Adaptation Plan:

- **Equitable distribution of resources:** distributing resources to those who need them most or those who face systemic barriers to accessing resources to ensure equitable outcomes.
- **Accessibility:** ensuring that physical locations, services, and resources are available in a manner that is appropriate for all.
- **Accountability:** demonstrating the transparency of policies, processes, and services in meeting the needs of the entire community.
- **Safety:** offering culturally appropriate, sensitive, and safe spaces and environments—both internal and external—and checking our biases to build trust among communities.

Reconciliation is the ongoing process of establishing and maintaining respectful relationships with Indigenous peoples by acknowledging and addressing the historical and ongoing harm caused by colonialism and other forms of discrimination against Indigenous peoples in Canada. The “Truth and Reconciliation Commission of Canada: Calls to Action” (TRC 2015) notes that this process will require repairing damaged trust and following through with concrete actions that demonstrate real social change.

2.4.2 Why apply Equity, Diversity, and Inclusion and Reconciliation Lenses?

Advancing EDI through the Climate Adaptation Plan is important because climate change disproportionately impacts vulnerable populations, such as seniors, racialized communities, and low-income residents. By acknowledging and addressing inequalities, where possible, in the development and implementation of adaptation actions, the Climate Adaptation Plan can help reduce the impact of climate change on vulnerable populations and ensure that the benefits of the adaptation actions are distributed fairly.

The Climate Adaptation Plan is an opportunity for the City to take meaningful actions that advance reconciliation and deepen the City’s relationship with Indigenous communities. It is important for the City to acknowledge that Indigenous peoples are uniquely vulnerable to the impacts of climate change due to their connections to the natural world (McGregor 2019). By engaging with Indigenous peoples throughout the Climate Adaptation Plan process, the City can show recognition for the unique vulnerability to climate change impacts that Indigenous peoples face, integrate traditional knowledge and approaches for stewarding the natural world, and work together on adaptation actions.

2.4.3 How we advanced Equity, Diversity, and Inclusion

International Council for Local Environmental Initiatives (ICLEI) Canada and the FCM’s “Integrating Equity, Diversity and Inclusion into Municipal Climate Action” (ICLEI and FCM 2022) and the Clean Air Council’s “Equity and Climate Action Synergies Workshop” (2022) informed the EDI approach. The former emphasizes incorporating EDI elements as an iterative process, meaning this first version of the Climate Adaptation Plan will be updated in future years and continue to evolve as the City tailors its approaches to specific local issues and assesses the City and community response to adaptation efforts. The Clear Air Council’s equity considerations have been interpreted to include identifying communities at risk (a recommended adaptation measure in this Climate Adaptation Plan, Section 6), fostering partnerships with key stakeholders, collaborating with departments/divisions that work on equity (i.e., EDI Team), and considering funds for EDI-led or -supported initiatives.

Engagement with the City’s EDI Team has been instrumental in providing the City’s perspective on current EDI issues and ways to improve upon these issues through the adaptive capacity measures as co-benefits. As members of the Staff Working Group, the EDI Team was part of the engagement since the project initiation. Further, the Project Team interviewed the EDI Team on January 3, 2023, to discuss items in the Climate Adaptation Plan that they would like to see as complementary asset-driven actions and overarching services in response to climate change impacts. The input from the EDI Team contributed to the alignment of the Climate Adaptation Plan’s strategic goals with EDI and the shaping of adaptation actions to deliver benefits to the most vulnerable in the community. For instance, a revision to an action that involves updating emergency routes to consider the location of vulnerable communities. Further, an EDI lens was applied in prioritizing the recommended adaptive capacity actions (Section 6.3).

2.4.4 How We Advanced Reconciliation

The development of the Climate Adaptation Plan included engagement with local Indigenous governments. This engagement represents a step on the path as part of the City’s overall efforts to build respectful relationships with Indigenous peoples. The City reached out to the Mississaugas of the Credit First Nation (MCFN), Six Nations of the Grand River (SNGR), Grand River Métis Council, and the Haudenosaunee Confederacy at the inception of the Climate Adaptation Plan project to invite them to participate. Both MCFN and SNGR responded that they would like to be engaged and/or informed of the project process. The City provided status updates, including summaries of the four technical memorandums (Stages 1 to 4), to MCFN and SNGR throughout all project stages and corresponded via email and phone calls with MCFN and SNGR representatives about areas of interest in the project. The City provided a draft copy of

the Climate Adaptation Plan to MCFN and SNGR to conceptualize how reconciliation may tie into the City's Climate Adaptation Plan. SNGR expressed their desire to see any natural environment-based adaptive action prioritized. MCFN requested to be involved in the City's pre-consultation process for upcoming development projects, which became one of the recommended actions in the Climate Adaptation Plan (Section 6).

The City will continue to consider and advance reconciliation through the Climate Adaptation Plan's implementation based on the feedback provided by MCFN and SNGR.

2.5 Engagement Highlights

Throughout the project, a mix of meetings, workshops, memorandums, and email notices were used to engage with project stakeholders and partners. A list of the engagement and communications activities are in Appendix A. The following summaries provides an overview of key engagement activities that occurred.

2.5.1 Staff Working Group Meetings, Workshops, and One-on-One Meetings

Throughout the project, Staff Working Group members participated in meetings, small group workshops, and one-on-one meetings. The Staff Working Group contributed to a number of key elements in developing the Climate Adaptation Plan, including the vision and goal setting, discussing their department's/division's services to the City and the interconnectivity between departments/divisions, assessing climate hazard interaction with their department's/division's assets and services, reviewing risk assessment scores and identifying and prioritizing adaptation actions.

Forty-five City staff members were part of the Staff Working Group and participated in meetings, workshops, and/or one-on-one meetings during the project, contributing to building support and buy-in for the plan and ownership of the actions. The Staff Working Group engagement events advanced the objectives of establishing a baseline understanding among City staff about climate adaptation, Guelph's changing climate and climate risks, and awareness of the project's goals, progress, and timelines. The one-on-one meetings with Staff Working Group members from each represented group were particularly valuable to the Climate Adaptation Plan development because these meetings provided an opportunity to thoroughly understand respective department's/division/s existing and planned adaptive capacity actions and brainstorm and discuss ideas for new actions.

2.5.2 Partner Working Group Meeting and One-on-One Meetings

Throughout the project, Partner Working Group members participated in a Partner Working Group meeting and/or a series of one-on-one meetings to familiarize these members with the project and collect relevant data, plans, and information from them.

Sixteen partner organization staff participated in a Partner Working Group meeting and/or one-on-one meetings throughout the project. Their insights contributed to building support for the Climate Adaptation Plan and establishing a baseline understanding among partner organizations about climate adaptation, Guelph's changing climate and climate risks, and awareness of the project's goals, progress, and timelines. The one-on-one meetings with selected Partner Working Group members were valuable in understanding the implications of City-led exiting and recommended adaptive capacity actions on these external groups.

2.5.3 Staff Poster Session

On March 23, 2023, as part of Stage 4 of the project, the City hosted an in-person "staff poster session" at City Hall for staff involved in the Staff Working Group to showcase their department's/division's existing proposed actions from the draft Climate Adaptation Plan and seek peer feedback. This event was promoted as a drop-in, fair-style event and staff from across the corporation were encouraged to attend to learn more about the Climate Adaptation Plan and review the draft actions. Staff shared a series of posters providing an overview of the project and department/division-specific posters summarizing each department's/division's components of the draft plan.

Sixty City staff participated in the staff poster session. City staff across the organization, including those previously not engaged, dropped in to provide comments and suggestions to refine the proposed climate adaptation actions. This event advanced the objectives of establishing a baseline understanding among City staff about climate adaptation, Guelph's changing climate and climate risks, and awareness of the project's goals, progress, and timelines.

2.5.4 Public Information Events

During Stage 4, the City hosted two in-person information booths at community events to share information about the Climate Adaptation Plan development and draft adaptive actions with the public and answer questions about the project and the City's climate action efforts. On April 15, 2023, the City hosted an information booth at the Guelph Farmer's Market, and on April 22, 2023, the City hosted an information booth at the Hanlon Forest Tree Planting event.

These events were chosen as it was anticipated that community organizations and members of the public interested in climate change would be present.

Seventy-five members of the public engaged in discussions about the Guelph Climate Adaptation Plan through the two information booth events. Participants expressed their understanding that weather is becoming more extreme and that adaptation measures are necessary for Guelph to be resilient. They expressed enthusiasm and appreciation that City is developing the Climate Adaptation Plan and were interested in reading the Climate Adaptation Plan once completed. Several participants also expressed interest in learning more about the City's climate mitigation work, including community action support. The engagement events contributed to building support for the plan and establishing a baseline understanding among the general public about climate adaptation, Guelph's changing climate and climate risks, and awareness about the project's goals, progress, and timelines.

Tables A1 to A4 in Appendix A summarize the engagement and communications activities conducted with internal and external project stakeholders throughout the project. Table A5 in Appendix A provides a log of the engagement and communications activities conducted with Indigenous governments throughout the project. All correspondence is from Shelley Lorenz, Project Manager, Environmental Services, City of Guelph, unless noted otherwise.

3 Strategic Context Review

A strategic context review of internal and external documents was conducted in Stage 2 of the project and provides a high-level assessment of how the Climate Adaptation Plan can build upon the City's current efforts to address climate change, draw from Climate Adaptation Plans developed by other municipalities, and identify where there may be opportunities for funding. This review was intended to help identify the City's current adaptive methods (based on existing and planned actions) and where the City may enhance their adaptive capacity, (which became the basis for Stage 3 of the project [Figure 4]).

The documents reviewed spanned across five key areas: (1) climate change primer, (2) national and provincial climate change impact assessments, (3) municipal adaptation plans, (4) risk assessment frameworks, and (5) City department/division services and programs (e.g., policy documents), which could provide useful insights into municipal adaptation, the Climate Adaptation Plan process, and the City's adaptive capacity to future climate hazards.

3.1 A Primer on Climate Change and Adaptation

Climate is the weather we experience averaged over an extended period of time, and the term climate change refers to long-term shifts in our climate, including temperature, precipitation, and weather patterns. Throughout the history of the earth, there have been shifts in our climate due to natural causes such as variations in the solar cycle; however, since the 1800s our climate has been changing more rapidly due to human activities (e.g., the burning of fossil fuels, methane emissions from livestock and landfills, land use changes, and deforestation) that generate GHGs (IPCC 2022). These GHGs trap the heat radiating from the earth and prevent it from escaping into space, which raises the temperatures in our atmosphere. The earth's mean temperature today is about 1.1°C warmer than in the late 1800s, and the last decade (2011-2020) was the warmest on record (WMO 2022).

With the increases in temperature, we are experiencing rising sea levels, loss of snowpack and ice (thinning glaciers, thawing permafrost), more extreme heat, less extreme cold, longer growing seasons, shorter snow and ice cover seasons, earlier spring peak streamflow, and shifting precipitation patterns (Warren and Lulham 2021). This has led to other environmental impacts, including increased incidences of poor air quality (e.g., from ground level ozone, particulate matter); short-duration, high-intensity rainfall events; windstorms; more frequent and prolonged periods of drought; wildfires and urban interface fires; increased coastal erosion; storm surge flooding; decreased water quality; increased spread of invasive species and decrease in biodiversity; and the increased spread of vector-borne diseases (Warren and Lulham 2021).

The earth's climate is a dynamic system, with changes in one area affecting and influencing other areas. There is an interdependence of climate, ecosystems and biodiversity, and human societies that play out across continents, nations, and at the regional level. Physical infrastructure has been identified as the highest area of risk to extreme weather events and climate change risk facing Canada along with coastal communities, northern communities, human health and wellness, ecosystems, and fisheries (CCA 2019). Urban areas are a particular concern because more people live in cities than in rural areas (55% globally, 80% in Canada), and many of the natural surfaces (e.g., forests, fields) have been replaced by impervious surfaces, which exacerbate flood risk and also absorb and reradiate heat. Further, increased population density in urban areas often results in greater consequences due to climate change impacts on grey and green infrastructure and the services that they provide, which in turn impacts individuals, communities, and economies (Brown et al. 2021).

There are two overarching responses to climate change: mitigation and adaptation measures. Mitigation measures refer to actions that reduce the GHG emissions that cause climate change, such as switching to clean energy from fossil fuels and using less energy by being more energy efficient. Adaptation measures refer to actions that manage and reduce the risk of climate change impacts, such as infrastructure upgrades, flood protection, disaster management, and business continuity planning. There are also initiatives that co-benefit both mitigation and adaptation, such as planting trees (e.g., to increase the urban tree canopy, sequester carbon, help reduce flood risk, and reduce the effects of the urban heat island), water conservation efforts (e.g., which reduces the amount of water use, water treatment requirements, and amount of energy used in treatment and distribution), and more intensive land use (e.g., reducing energy use, and providing residents with more resilient transportation options; Figure 13).

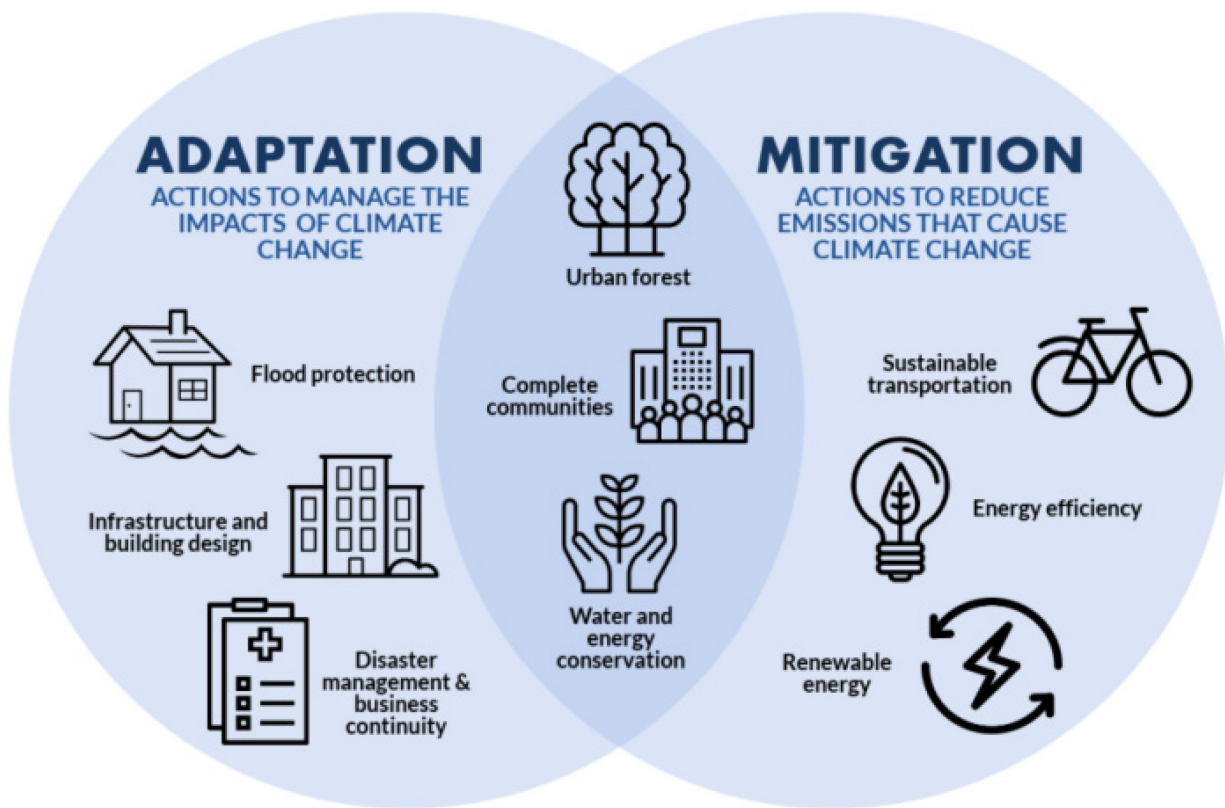


Figure 13 Mitigation versus Adaptation (from The Corporation of the City of Waterloo 2019)

The need to act is also shaped by recent experience with extreme weather events and their impacts on infrastructure asset performance and disruptions in service delivery and growing concern about how vulnerability and risk to acute and chronic changes in climate will increase

in the future. Under the climate mitigation, the City is working on ways to use energy more wisely and reduce their carbon emissions to fight climate change. The City is taking an energy conservation and GHG emissions-reduction approach to reach their goal of having City facilities and operations using 100% renewable energy (100RE) sources by 2050. This supports the City's "Race To Zero" commitments to be a net-zero carbon community by 2050.

The City incorporates environmental stewardship in all municipal operations and services to support the "Race To Zero" targets by:

- reducing GHG emissions from municipal operations (energy and climate change)
- supporting and encouraging walking, cycling, carpooling, car-sharing and transit-use within Guelph (sustainable transportation)
- leading in sustainable waste management (solid waste resources)
- protecting Guelph's natural heritage system and urban forest (urban forest and natural heritage)
- restoring clean water (wastewater services)
- efficiently supplying high-quality drinking water (water services)

Adaptation builds resilience and reduces risk related to current and future climate change impacts, and adaptive capacity refers to the ability of economic and social systems, institutions, and ecosystems to adjust to impacts, to capitalize upon opportunities, and to minimize consequences. Generally, social and economic systems in Canada, including municipalities across Ontario, have a relatively high level of adaptive capacity but the damage inflicted by extreme weather events is a reminder that vulnerability and risk continues to be a concern. As a signatory of the GcoM, the development of the Climate Adaptation Plan meets the City's commitment toward acting on the physical risks of climate change and adaptation.

3.2 Climate Change Strategies, Assessments and Guidance: National and Provincial Level

In recent years there has been a wide-range of climate change strategies, assessments, data, actions, and guidance that has been produced by the federal and provincial governments. Since the Pan-Canadian Framework on Clean Growth and Climate Change was adopted in 2016, which focused on growing Canada's economy, reducing GHG emissions, and building resilience to climate change, the federal government's activities greatly influence municipalities. This

includes supporting national climate change vulnerability assessments at the sectoral and regional scale; developing climate data portals (e.g., through the Canadian Centre of Climate Services); committing over \$180 billion in funding over 12 years for new infrastructure funding through multiple programs; establishing requirements for the application of a “Climate Lens” to new federally-funded infrastructure projects that account for mitigation and adaptation; and updating standards and building codes, including guidance on using climate data to inform design standards for buildings and infrastructure.

In December 2020, the Government of Canada committed to develop a National Adaptation Strategy (Government of Canada 2022a) with provincial, territorial, and municipal governments; Indigenous Peoples; and other key partners. As part of a strengthened climate plan “A Healthy Environment and a Healthy Economy,” the strategy aims to establish a shared vision for climate resilience in Canada. This includes the identification of key priorities for increased collaboration and the establishment of a framework for measuring progress at the national level. The National Adaptation Strategy was released in December 2022 in conjunction with the “Government of Canada Adaptation Action Plan” (Government of Canada 2022b), which is intended to be an implementation document for the strategy. The National Adaptation Strategy outlines a shared path to a more climate resilient Canada that addresses five key systems: (i) disaster resilience; (ii) health and well-being; (iii) nature and biodiversity; (iv) infrastructure; and (v) economy and workers. The action plan outlines 84 actions to advance adaptation throughout the five National Adaptation Strategy systems and address both immediate and future climate risks to Canada. In the case of infrastructure, the goal of the National Adaptation Strategy is that all infrastructure systems in Canada will be climate-resilient and undergo continuous adaptation to adjust for future impacts to deliver reliable, equitable, and sustainable services to all of society.

The vulnerability of public infrastructure in Canadian towns and cities is highlighted in “Canada in a Changing Climate: National Issues Report” (Brown et al. 2021). Many of the key overarching messages around climate change and adaptation for municipalities are applicable to the City and the process to develop a Climate Adaptation Plan, including, but not limited to the following:

- Climate change is threatening Canada’s ageing infrastructure. Safe and reliable infrastructure and resilient buildings are essential to life in cities and towns.
- Enhancing green spaces helps cities and towns adapt to climate change. Green infrastructure, such as parks, wetlands, and green roofs, in Canada’s cities and towns increases the quality of life for residents and improves climate resilience.

- Working together yields the most successful outcomes. Effective adaptation approaches to climate change consider diverse perspectives and priorities. Local governments are increasingly playing a strong role in driving meaningful collaboration with different groups when it comes to designing, planning, and implementing adaptation in their communities.
- Indigenous peoples in cities and towns are often affected in unique ways by climate change. Strengthening collaboration with Indigenous peoples will require increased capacity and additional research.
- Implementation of adaptation initiatives by cities and towns is not keeping pace with the risks posed by current weather extremes and future climate changes. However, examples of implementation are becoming more common, and the barriers to action are being reduced.
- Monitoring and evaluation of adaptation is an important and often overlooked step. Monitoring and evaluation methods are required to track adaptation progress and measure whether adaptation efforts are resulting in their desired outcomes.

In regard to Ontario, six of the seven key messages outlined in “Canada in a Changing Climate: Regional Perspective Report - Ontario” (Douglas and Pearson 2022) are relevant to the City and the Climate Adaptation Plan process:

- Ontario’s infrastructure is vulnerable to climate change, noting that due to interdependencies between multiple infrastructure types, climate change and especially extreme weather events can have cascading economic and social impacts.
- Nature-based approaches help address climate change impacts on biodiversity and ecosystem services, which are magnified through the cumulative effects of climate change, habitat loss, urbanization, pollution, and other threats.
- Adaptive management is key for addressing impacts in the Great Lakes Basin, where the combined effects of climate change, land use changes, and other stressors have negative impacts. Despite mechanisms to address complex governance challenges, adaptation across the Great Lakes Basin remains relatively fragmented; however, many communities have embraced adaptive management practices in light of uncertainties in future changes in climate.
- Adaptation improves forest health, carbon storage, and biodiversity, noting that changes in drought, pests, fire, and wind regimes are of particular concern given the resulting cumulative impacts.

- Existing human health inequities will be worsened by climate change, and local assessments of climate change vulnerability that include consideration of health equity will provide a foundation for stronger and more widespread adaptation action.
- Progress on adaptation planning and implementation remains limited in Ontario, where the primary focus is still placed on the assessment of risk and vulnerability. Although there are examples of implementation, there is little evidence of adaptation being mainstreamed into decision making broadly. Further, in most jurisdictions, systems for monitoring and evaluating adaptation action and effectiveness remain inadequate.

At the provincial level, the Province of Ontario released the “Preserving and Protecting our Environment for Future Generations: A Made-in-Ontario Environment Plan” (MECP 2018), which expressed a commitment to help prepare families and communities for the costs and impacts of climate change and to protect the natural environment, communities, business, and municipalities. In terms of municipalities, their main focus has been on planning and asset management, specifically “A Place to Grow: Growth Plan for the Greater Golden Horseshoe” (Government of Ontario 2020), the “Provincial Policy Statement, 2020” (MMAH 2020), and O. Reg. 588/17 Asset Management Planning for Municipal Infrastructure. In August 2020, the Ontario Ministry of the Environment, Conservation and Parks announced that they were commissioning the province’s first ever multisector climate change impact assessment. The study, expected to be released in 2023, is intended to be based upon the best science and information to understand where and how climate change is likely to affect communities, critical infrastructure, economies, and the natural environment, while helping to strengthen the province’s resilience to the impacts of climate change. There is no public indication that this assessment will lead to an updated provincial adaptation plan, with actions that support resiliency and adaptive capacity, other than those noted above.

3.3 Related Municipal Climate Change Adaptation Plans/Strategies

There is a growing number of municipalities that have developed, or are in the process of developing, climate change adaptation plans and/or strategies across Canada (summaries in Appendix B). Many of the plans that have been developed have been completed by municipalities in southern Ontario, including most communities across the Greater Toronto and Hamilton Area. Each of these adaptation plans are the outcome of a climate impact risk assessment where the process follows the ISO 31000 approach or variations, such as the ICLEI Building Adaptive & Resilient Communities (BARC) methodology. The plans and/or strategies reviewed were selected because of a) the municipality’s proximity to Guelph, b) the communities were of comparable size and population in southern Ontario, or c) the adaptation

plans/strategies were notable for specific aspects of the risk method adopted that are unique and were of interest in the development of the City's Climate Adaptation Plan.

Generally, each plan and/or strategy was reviewed with respect to the climate hazards considered, the historical climate data presented, the climate change projections, and the emission scenarios and time periods selected. In addition, each plan was reviewed to identify the impact statements attributed to specific climate hazards, the prioritization frameworks selected, descriptions of adaptation actions, the identification of departments/divisions responsible for these actions, anticipated timing, duration and frequency of actions, and estimates of the financial and human resources required. The intent of this review was to help inform the Project Team of the process to assess risk, identification of specific adaptation measures, and next steps in terms of implementation and monitoring.

A select list of Ontario municipalities with climate change adaptation plans is provided in Table 6, which includes, but is not limited to, the complete list of plans reviewed. This list, which includes the name of their respective Climate Adaptation Plans and their date of publication, reflects the level of attention that municipalities across Ontario are placing on adaptation. The approaches adopted by other municipalities to determine hazards, select historical baseline data, and calculate future climate change projections are consistent with that which was used in developing the City's Climate Adaptation Plan and further detailed in Section 4). There is an important difference, however, insofar as the ICLEI BARC approach tends to be applied somewhat generically and ubiquitously, often lacking direct connectivity to asset management and service delivery. Of interest within these local municipal reports is the array of impact statements, albeit more at a high level rather than at the infrastructure asset level, and a list of adaptation and resiliency response measures, of which only a few can be described as asset specific. As such, their statements were only partially useful to the Climate Adaptation Plan process, placing greater need for identifying and building upon existing and planned actions from the Asset Management Plan and various Master Plans, and the importance of engagement and input from City staff who are responsible for operating, maintaining, and managing infrastructure assets and their services.

Table 6 List of Select Ontario Municipalities with Climate Change Adaptation Plans

Tier	Comparator	Climate Adaptation Plans
Single Tier	City of Barrie	City of Barrie Climate Change Adaptation Strategy (2017)
Single Tier	City of Brantford	A Community Climate Change Action Plan for the City of Brantford (2022)
Single Tier	Municipality of Chatham-Kent	Chatham-Kent Climate Change Action Plan (in progress)
Single Tier	City of Hamilton	Climate Science Report for the City of Hamilton (2021)
Single Tier	City of Kingston	Kingston Climate Action Plan (2014); Climate Leadership Plan (in progress)
Single Tier	City of Greater Sudbury	Greater Sudbury Community Energy and Emissions Plan (2021)
Lower Tier	City of Brampton	Our 2040 Energy Transition: Community Energy Emissions Reduction Plan (2020; as part of chapter 1)
Lower Tier	City of Burlington	Climate Action Plan (2020, to be updated); Climate Resilient Burlington: Climate Change Vulnerability and Risk Assessment (2021)
Lower Tier	City of Cambridge	City of Cambridge Energy Conservation and Demand Management Plan (2020)
Lower Tier	City of Kitchener	Kitchener, Changing for Good: Our Corporate Climate Action Plan for Sustainability (2019)
Lower Tier	City of Mississauga	Climate Change Action Plan (2020)
Lower Tier	Town of Oakville	Town of Oakville Climate Change Strategy - Technical Report (2015)
Lower Tier	City of Waterloo	City of Waterloo Corporate Climate Change Adaptation Plan (2019)
Upper Tier	Regional Municipality of Halton	Climate Change Discussion Paper: Regional Official Plan Review (2020)
Upper Tier	Regional Municipality of Waterloo	Community Climate Change Adaptation Plan for Waterloo Region (2019); Transform WR: Waterloo Region's Transition to an Equitable, Prosperous, Resilient Low Carbon Community
Upper Tier	Regional Municipality of Peel	Climate Change Master Plan (2019)

3.4 Climate Risk Assessment Methods

There is a growing literature regarding climate risk assessment methods which served as useful resources when informing the methodology applied to developing the City’s Climate Adaptation Plan. This includes ISO 31000 for risk management, the ISO 1409X series of climate adaptation standards, ICLEI BARC and their worksheets, and the Public Infrastructure Engineering Vulnerability Committee (PIEVC) family of vulnerability protocols. The “PIEVC High Level Screening Guide” is particularly noteworthy as it has become the de facto climate risk assessment method to support applications for federal funding of new infrastructure through the Climate Lens requirements. In addition to assessing climate vulnerability, risk and resilience of new infrastructure, its application can also be applied to:

- asset management, capital and master planning
- infrastructure operations and management evaluation and review
- asset portfolio assessment and evaluation
- municipal climate vulnerability and risk assessment (O’Driscoll et al. 2022)

Of particular note is the likelihood framework, that is based on a “middle-baseline” scoring method, which assigns changes in the probabilities of occurrence to climate hazards relative to a historical period. This framework is more relatable to decision makers than conventional likelihood scales adopted through the original PIEVC Protocol, the Intergovernmental Panel on Climate Change (IPCC), Climate Lens, and many ICLEI BARC climate risk assessments.

Another area where consideration of climate change is advancing in decision-making has been in the field of asset management. The “Guide for Integrating Climate Change Considerations into Municipal Asset Management” (FCM 2019) was commissioned by the FCM under the Municipalities for Climate Innovation Program, and provides a roadmap that municipalities can use to understand climate change and its implications for municipal services and infrastructure. The intention of the guide is to help municipalities integrate climate change considerations and systematically build climate resiliency into asset management policies, plans and practices. The guide is part of a package of materials, including information briefs and a companion video. The guide is based on the input and best practices from 11 municipalities across Canada, including the City of Guelph. Of note, the City’s “Strategic Asset Management Policy” (City of Guelph 2018a) was highlighted, including the principles and general framework for asset management. Other highlights included the City’s integration of climate-related performance indicators as reflected in the LOS for infrastructure assets across all 17 service areas. Quarterly reporting on key LOS projects and phases is also highlighted.

In addition, FCM has produced a series of fact sheets aimed at municipal infrastructure and different asset groups, including water infrastructure, sewer infrastructure, drainage infrastructure, transportation infrastructure, parks infrastructure, buildings, vehicles, and information technology (IT) infrastructure. The fact sheets provide high-level guidance and cover a wide range of asset types for each asset group, while also identifying the service that is provided to the community (e.g., pipes and culverts provide flood protection). Multiple climate hazards are considered, with a wide range of potential impacts to both assets and LOS. General actions are also provided, characterized as measures aimed at O&M, as well as the renewal of infrastructure. These actions are further differentiated as actions that can be described as adaptation, mitigation, or a combination of both, from which co-benefits are generated.

Recent work conducted by the FAO on climate change and asset management is also worth noting. Their series of reports represent best practice in this field and provide useful insights and guidance regarding the treatment of climate hazards and their impacts on infrastructure asset performance. Two of their reports, “Costing Climate Change Impacts to Public Infrastructure: Assessing the financial impacts of extreme rainfall, extreme heat, and freeze-thaw cycles on public buildings in Ontario” (Afroz et al. 2021) and “Costing climate change impacts and adaptation for provincial and municipal public infrastructure in Ontario, Deliverable #10 – Final Report” (WSP 2021), are particularly relevant to the Climate Adaptation Plan process as they provide credible and transparent estimates of the costs associated with advanced deterioration in assets and LOS caused by climate change.

3.5 City of Guelph Departments/Divisions, Services and Programs

Matrix reviewed a list of documents produced by the City for climate change considerations, current and/or planned adaptive capacity measures, and potential funding opportunities. The City has done notable work already in advancing their current Master Plans and policies to incorporate climate change.

This section provides a shortened summary of key documents reviewed. Longer descriptions for each document are provided in Appendix B along with summaries for selected other City documents.

3.5.1 City of Guelph Official Plan Consolidation, 2021

The City’s Official Plan acts as a guideline for development of Guelph to 2031 (City of Guelph 2021b). The Official Plan acknowledges the impact of climate change and the importance of mitigation and adaptation to increase community resiliency. A few explicit policy ideas in the

Official Plan included preparing a climate change adaptation strategy (this project) and implementing standards that reduce impacts on Public Works and infrastructure.

The Official Plan discusses the City's Master Plans and their individual update requirements. There is opportunity to collaborate and strategize methods to incorporate climate change resiliency through these Master Plans. It is mandated that the Wastewater Treatment Master Plan, Solid Waste Management Plan, Downtown Implementation Strategy, and the Official Plan itself (in part or as a whole) be revised at 5-year intervals, so there are frequent opportunities ahead to incorporate climate change initiatives into the master planning process.

3.5.2 City of Guelph Strategic Plan, 2019-2023, and Subsequent Documents

The Strategic Plan (City of Guelph 2019) builds upon the vision of the Community Plan to strategize actions over the next few years. One of the strategic priorities is called "Sustaining our Future," which references the Climate Adaptation Plan and includes goals to improve sustainability within the City and their associated measures of success, initiatives, suggested implementation priorities, dependencies (i.e., other plans), and funding resources. An excerpt of these details is provided in Appendix B.

Since its publication, the City has also released the "Implementation of the City's Strategic Plan, Guelph: Future Ready" (Optimus SBR 2020), "Guelph. Future Ready. Progress Report 2020" (City of Guelph 2020b), and the "Current State and Trends Report" (City of Guelph 2022a). In the progress report, the City summarized its goals, including the "Sustaining our Future" pillar and the development and implementation for the Climate Adaptation Plan. KPIs provided the progress in the form of the target, results, and brief notes. Similarly, the "Current State and Trends Report" (City of Guelph 2022a) mentioned the Climate Adaptation Plan and its importance in asset management planning to make the City "future proof." Proactive infrastructure investment will be a key component to providing a ready and resilient Guelph.

3.5.3 City of Guelph Corporate Asset Management Plan, 2020

The Corporate Asset Management Plan (City of Guelph 2020a) is a strategic document that states how the City's assets are to be managed over a period of time. The Corporate Asset Management Plan describes the characteristics and condition of infrastructure assets, the LOS expected from them, planned actions to ensure the assets are providing the expected LOS, and financing strategies to implement the planned actions. The following sections provide a summary of the key components of the Corporate Asset Management Plan. The City has been rapidly advancing the City-wide asset management program since 2016, with the end goal of ensuring that the City makes the best possible decisions regarding its assets. Initiatives have

been implemented to increase the knowledge of infrastructure, documenting LOS, managing risks, and implementing full lifecycle planning. In the development of its Asset Management Plan, the City has surpassed compliance with O. Reg. 588/17: Asset Management Planning for Municipal Infrastructure, including selected highlights as follows:

- Since 2016, the City has been rapidly advancing their City-wide asset management program. They have advanced their asset management capabilities from “Basic” to “Core,” when measured against the International Infrastructure Management Manual maturity index and are developing a work-plan to move the City to “Intermediate” and “Advanced” categories by 2024.
- The City is taking a leadership role on asset management by integrating the Asset Management Plan data into their budget analysis to help develop the capital budget.
- Other advancements include:
 - ✦ developed performance and financial forecasts for 17 asset portfolios
 - ✦ incorporated performance forecasting into the budget process
 - ✦ developed LOS metrics for all asset types; defined O. Reg. 588/17 mandated LOS for the Core assets (roads, bridges, water, wastewater, and stormwater) and will continue to define LOS for all asset types while also defining the City’s community-driven LOS
 - ✦ developed water, wastewater, and stormwater risk management framework
 - ✦ completed inventory and condition assessments for roads, bridges, sewers, solid waste, wastewater infrastructure, water facilities, corporate facilities, recreation facilities, and structures.
 - ✦ developed an Integrated Corridor Model Tool to assist in lifecycle planning for all road network assets; new innovation was recognized by municipalities across the province and won an award in early 2020 through the Ontario Public Works Association.

The 2020 Corporate Asset Management Plan does not specifically address the linkages between the effects of climate change and the need to implement climate change adaptation measures; however, the foundational aspects of having the Asset Management Plan in place make it possible to further develop and realign the asset management strategy so that it directly accounts for the effects of climate change.

The physical asset systems included in the plan:

- administrative facilities
- corporate vehicles and equipment
- culture and recreation (including parks)
- wastewater
- emergency services
- IT
- parking
- solid waste
- stormwater
- transit
- transportation
- water

The asset management strategy summarizes planned actions that include non-infrastructure solutions, maintenance activities, renewal/rehabilitation activities, replacement activities, disposal activities, and expansion activities. The strategy also provides a budget analysis that outlines yearly expenditure forecasts for each of its planned actions, along with actual expenditures from previous years and yearly revenues.

The Corporate Asset Management Plan identifies sustainable funding targets that focus on supporting the renewal and replacement of assets but does not include maintenance or growth funding requirements. Sustainable funding needed includes annual transfers to capital renewal reserve funds for tax and non-tax services, in addition to reliable annual funding from other levels of government. From 2017-2020, sustainability funding for non-tax services has increased by 8%, noting that parking and wastewater has decreased, while stormwater and water have increased. A majority of funding continues to be from federal and provincial gas tax funding programs, generating over \$60 million annually.

3.5.4 City of Guelph Core Asset Management Plan, 2021

The Core Asset Management Plan (City of Guelph 2021a) is a detailed assessment of the City's core asset types which comprise more than 80% of the total infrastructure asset base owned and managed by the City. These are roads (and related assets such as sidewalks, street lighting, and traffic controls), bridges, water services, wastewater services, and stormwater management.

The Core Asset Management Plan does not include a complete climate risk assessment although a key focus is to identify the potential impacts of climate change on City infrastructure and the delivery of services. The plan recognizes that climate change may present direct risks to the physical assets, whereby occurrences such as strong rainstorms may overload the City stormwater management infrastructure, droughts may negatively affect domestic water supply, and hotter average yearly temperatures may require the installation of more and stronger cooling and ventilation systems for facilities. A brief discussion of climate hazards and potential short-term and long-term effects to each of the core asset groups is provided making this report a foundational reference for the Climate Adaptation Plan. The Core Asset Management Plan also included specific description and findings pertaining to the City's transportation assets, water services, wastewater services, and stormwater assets, and summaries of these are included in Appendix B. Also of note, completed or in progress climate change adaptation initiatives were collected during the preparation of the Core Asset Management Plan.

The commitment to maturing along the asset management cycle and the City's immediate focus on core assets provides both a source of information to understand adaptive capacity and risk, while representing a mechanism to implement and fund resiliency measures.

The 2020 Corporate Asset Management Plan and the 2021 Core Asset Management Plan, combined, provide estimates of the CRV for infrastructure-related assets (e.g., buildings and facilities, transportation, water supply, wastewater, and stormwater assets). Table 7 summarizes the estimated 2020 CRV for these assets as reported in the Corporate Asset Management Plan and Core Asset Management Plan.

Table 7 Current Replacement Value for City of Guelph Core Assets and Facilities (from City of Guelph “2021 Core Asset Management Plan and 2020 Corporate Asset Management Plan”)

Department/Division and Asset Class	Current Replacement Value (2020)
Stormwater	\$852,780,072
• Stormwater Linear Network	\$719,219,573
• Stormwater Management Ponds	\$133,560,499
Transportation	\$1,222,163,376
• Bridges and Structures	\$119,713,749
• Roads	\$871,362,183
• Sidewalk	\$188,293,246
• Streetlights	\$10,127,994
• Traffic	\$32,666,204
Wastewater	\$679,705,984
• Wastewater Facilities	\$233,484,565
• Linear Asset Types	\$446,221,419
Water	\$770,702,740
• Water – Distribution	\$539,934,459
• Water – Facility	\$230,768,281
Other Assets	
Administrative and Operations Facilities	\$153,110,097
• City Operations	\$28,632,862
• Commercial	\$4,492,668
• Corporate Administration	\$119,984,567
Emergency Facilities	\$49,076,180
Parking Facilities	\$59,583,107
Parks, Recreation and Cultural	\$326,740,614
• Library, Culture and Tourism	\$101,634,109
• Parks	\$141,356,605
• Recreation	\$83,749,900
Solid Waste Facilities	\$67,039,125
Transit Facilities	\$19,271,307
Total	\$4,200,172,602

The City has an infrastructure asset base with a 2020 calculated replacement value of approximately \$4.2 billion, of which approximately \$1.8 billion will need replacing (32% have below 40% remaining life and will need replacing within the next 10 to 20 years). These assets will be addressed as priority within the capital budget, with support provided through the Infrastructure Renewal Funding Strategy. The City also has an investment backlog of infrastructure assets that have exceeded their service life, valued at approximately \$292 million for the City asset portfolio. Of note, within the next 1 to 5 years there is almost \$1 billion of assets that are “very poor” or “past due” conditions that may require complete replacement or significant renewal efforts to ensure continued long-term performance.

The Core Asset Management Plan provides a detailed financial analysis of the 25-year and 10-year forecast requirements for the core assets. This analysis identifies that over the 25-year period there is an expected \$1.9 billion funding gap, or an average of \$77.5 million per year. Over the 10-year period, the predicted funding gap totals \$1.05 billion, or \$105 million per year.

3.5.5 City of Guelph Natural Assets Inventory, Condition, Risk and Service Attribution, 2022

City of Guelph Natural Assets Inventory, Condition, Risk and Service Attribution (Green Analytics and Grounded Solutions 2022) estimated and mapped the City’s natural assets, summarized the current condition of the assets, and identified the hazards to the assets and the level of risk associated with the hazard. The City’s Natural Assets Inventory consists of three main categories of inventory: street and park tree assets, watercourse feature assets, and terrestrial natural features. As watersheds and natural features do not follow municipal boundaries, a 120 m buffer was provided for terrestrial natural features.

The Natural Assets Inventory provided a list of primary hazards to the City’s natural assets and a number of these hazards were viewed under climate change conditions, including flooding, invasive plants and wildlife, erosion and sedimentation, extreme weather events, and drought. The City’s risk score table was used, in which impact was scaled from 1 to 4 and likelihood was scaled from 1 to 5 (similarly used for the Enterprise Risk Management Framework). The document also lists 12 main ecological services associated with the natural assets. The Natural Assets Inventory described the ecosystem function, associated ecological service(s), and a short description. For example, by implementing or improving the urban heat management, there would be reduced energy consumption, and this would be provided by natural assets providing shade to buildings. The Natural Assets Inventory also identified climate change mitigation as an ecological service through carbon sequestration and storage by natural assets. Maps of the assets providing each main ecological service, including climate change mitigation, was provided by asset type (e.g., upland forest, marsh, etc.).

3.5.6 City of Guelph Natural Heritage Action Plan, 2018

The Natural Heritage Action Plan (City of Guelph 2018b) recognizes the impacts of climate change and the importance for action. From a natural heritage perspective, there is opportunity to promote healthy and biologically diverse ecosystems as a way of addressing climate change vulnerability. One of the objectives in the plan is to support a natural heritage system in Guelph that is resilient to climate change with the goal of informing actions and decision-making practices by science.

The City's intent to create a Climate Adaptation Plan is mentioned in this document, and it is emphasized as an important future companion to the Natural Heritage Action Plan. The creation of a natural asset inventory (now completed and summarized above) was a key recommendation from the Natural Heritage Action Plan as it acts as a comparative tool for natural heritage items to other infrastructure in terms of climate change vulnerability, budgeting (i.e., by assigning a value associated with the item and its associated ecosystem services and role as a buffer in natural disasters), and savings/revenue opportunities. The Natural Heritage Action Plan also indicates various opportunities to collaborate across departments including aligning budgets for funding opportunities and creating a centralized and integrated monitoring program that supports the City's natural spaces, water resources and ecosystem services. Finally, in alignment with the Official Plan, the Natural Heritage Action Plan laid out specific priority actions and their respective outcomes, target dates, budget status, and lead divisions.

3.5.7 City of Guelph Urban Forest Management Plan, 2013-2032, 2012

The Urban Forest Management Plan (Beacon Environmental 2012) discusses Guelph's urban forest as a valuable green infrastructure asset. There is a dedicated climate change section and long-term plan that is broken up into 5-year intervals to allow for the integration of changing conditions, new findings, and resource availability. The Urban Forest Management Plan acknowledges the reality of climate change stressors and discusses the importance of trees and their benefits in all aspects of the community. The Urban Forest Management Plan has overlapping goals with the Climate Adaptation Plan. Some examples of the benefits of urban forests vis-à-vis climate change are shade (e.g., provide cooling, extend the lifecycle of asphalt), flood control and stormwater management, reduction of local energy use (e.g., trees beside buildings can moderate extreme temperatures), and improved physical and mental human health.

The Urban Forest Management Plan goes on to describe trees as a “practical and relatively inexpensive opportunity to both mitigate and adapt to climate changes” and the plan includes its own section on climate change with strategies that are consistent with best practice urban forest management from other Canadian jurisdictions. These strategies include, but are not limited to, planting trees that are tolerant of warmer and drier summer conditions, developing extreme weather response plans, and moving toward adaptive management by monitoring the responses of different tree species to changing conditions and pests.

At the time of its writing, the Urban Forest Management Plan discussed opportunity to translate trees (or “green infrastructure”) as an asset and use them as a comparative tool to “hard” assets, which was accomplished in the completion of the Natural Assets Inventory, Condition, Risk and Service Attribution (Green Analytics and Grounded Solutions 2022). Though most assets and infrastructure depreciate over time, a unique consideration for trees is that they will appreciate over time. Other municipalities have quantified how much money trees have saved through air pollution control, stormwater management, and residential energy savings; the Town of Oakville has estimated that their 1.9 million trees have saved \$2 million and the Town of Ajax has reported a savings of over \$1 million annually for their 1.4 million trees.

Each recommendation given in the Urban Forest Management Plan provides an indication of the lead department, support/partners, cost, funding source (either capital or operating and broken down for 2013-2017, i.e., the first 5-year evaluation stage), priority level, and the related goals.

3.5.8 City of Guelph Transportation Master Plan, 2022

The City’s Transportation Master Plan (Dillon 2022a) discusses the City’s transportation plan for the next 30 years, with part of the vision that seeks to “[minimize] and even [reverse] transportation impacts on the natural environment.” In terms of sustainability and resiliency, the Transportation Master Plan describes the need to create a more efficient transportation plan for the future that can adapt to changes that include, but are not limited to, climate change, user behaviour changes, and a growing population.

The City is aiming for a modal shift within the next 30 years; the City would like to see less cars driven (80% to 58%) and a gravitation toward walking, cycling, and transit.

The Transportation Master Plan also lays out a plan to release a series of Master Plans (e.g., Pedestrian Master Plan), guidelines (e.g., Multimodal LOS Guidelines), and programs/actions (e.g., Active Transportation Program) that will be prepared or continuously updated. Among external plans that will need to align with the Transportation Master Plan, the Source Water Protection Plan and Stormwater Management Master Plan will specifically need to coordinate efforts for low impact development (LID) projects that also act as climate change adaptive capacity measures. The Transportation System Resilience paper (Dillon 2022b) discusses other common actions that can be integrated to promote “flexible streets” with adaptive capacity to respond to the impacts of climate change, such as managing impermeable pavements, increasing LIDs, and increasing urban tree canopies.

The City also recognizes that it needs to adopt and create resilient transportation through diversity in travel options, route redundancy, and the capability to adapt to changes. The Transportation Master Plan aims to achieve this through both short-term (2022-2031) and long-term (2032-2051) road projects. These retrofit or capital projects were analyzed with a weighting system that includes relative sustainability and affordability scores for each project. Budgeting for these projects is not specific in the Transportation Master Plan; however, it is mentioned that the capital budget is reviewed annually by the City to target the recommended capital projects and continuously move toward the transportation mode shift envisioned by the City. The Transportation System Resilience paper (Dillon 2022b) discusses the possibility of tying budgeting with transportation objectives rather than project completion as a form of added flexibility and adaptive capacity. The budget is subject to changes depending on the following fluctuations: market prices, property values, external funding, and policy changes to tax and development charge rates.

3.5.9 City of Guelph Tier Three Water Quantity Risk Assessment, 2017

A Tier Three Assessment Water Quantity Risk Assessment (Matrix 2017) was completed for the City of Guelph’s municipal drinking water system. As a requirement under the province’s Clean Water Act (Bill 43; Government of Ontario 2021b), the purpose of the Tier Three Assessment was to identify the Water Quantity Threats to municipal drinking water systems where those systems are located within a subwatershed classified during a Tier Two Water Quantity Stress Assessment (AquaResource 2009a, 2009b) as having a moderate or significant potential for water quantity stress. One of the tasks included was to develop, assess, and recommend risk management measures that if implemented would help ensure that the City could meet its future planned water demand requirements considering the cumulative effects of non-municipal water use, future municipal water use, and drought conditions.

The Tier Three Assessment included a Climate Change Assessment (Matrix 2018), which evaluated the potential impacts of climate change on groundwater recharge rates and streamflow, and in the resulting impacts to water supply. The results illustrated that under average annual conditions, groundwater recharge rates supplying the City's water supply aquifers are likely to increase due to higher winter temperatures. However, there remains the potential for climate change to result in extended drought periods which would result in acute stresses to the drinking water supply.

The results of the Tier Three Assessment favourably recognized the City's Water Efficiency Strategy (C3 Water and Gauley 2016), which establishes a plan to minimize future water consumption.

3.5.10 City of Guelph Water Efficiency Strategy, 2016

The Water Efficiency Strategy (C3 Water and Gauley 2016) is a guide that sets Guelph up for reduced water consumption to promote availability for future water supply, accounting for stressors such as population growth and unpredictable rainfall and aquifer recharge due to climate change. The implementation of water efficiency programs has also helped the City reduce operational costs and GHG emissions. Water conservation and efficiency program alternatives were identified for a 10-year timeframe to meet the goal to reduce daily water consumption by 9,147 m³, set in the Water Supply Master Plan. The Water Efficiency Strategy used a weighted evaluation criteria that included a climate change resiliency factor and incorporated the International Water Association/American Water and Wastewater Association Water Audit Method (which uses the Infrastructure Leakage Index) to evaluate and recommend programs suitable for the City.

3.5.11 City of Guelph Water Supply Master Plan, 2022

The Water Supply Master Plan (AECOM et al. 20210) provides short-term, mid-term and long-term water supply options to ensure that the City can continue to meet the demands of Guelph's growing population. The Water Supply Master Plan update integrates a number of technical tools and functions already present at the City. The modelling work completed in the project relies on the Tier Three groundwater flow model. The Water Supply Master Plan recommends water conservation and efficiency alternatives to reduce future water demand. The City will follow up with these recommendations by updating its Water Efficiency Strategy, where appropriate.

The feedback received through the various engagement tools and activities indicates that there is a continued interest from community members and stakeholders about water supply in Guelph, notably the community identified concerns about the impact of climate change on the water supply. The Water Supply Master Plan re-iterates the results of the Tier Three Water Quantity Risk Assessment, which concluded that climate change is not likely to have an adverse effect on average water supply availability. However, the significant drought conditions similar to those observed in Guelph during the 1960s will stress the water supply.

The conclusions from the Water Supply Master Plan relating to additional water supplies and water conservation measures can also be considered as climate adaptation measures, as they ultimately help the City become more resilient to long-term climate stresses and increased water demand.

3.5.12 City of Guelph Water and Wastewater Servicing Master Plan, 2008

The Water and Wastewater Servicing Master Plan (Earth Tech 2008) addresses climate change implicitly through capacity/resiliency of infrastructure and providing appropriate distribution and conveyance of water and wastewater respectively for the projected future growth of the City. The Water and Wastewater Servicing Master Plan commits to sustainable growth and will align with the City's Growth Management Study upon its completion. This plan is intended to guide the City until 2031; however, it is acknowledged that the finalized growth study may change priorities and longer maintenance items may extend beyond this timeframe. Matrix notes that the City's Growth Management Strategy has been informed by the Shaping Guelph process, which included several technical background studies.

The Water and Wastewater Servicing Master Plan evaluated alternative solutions for optimal water and wastewater servicing in the City. The plan indicates the need for City Council to properly fund maintenance and replacement of its watermains and sanitary sewers before investing in the infrastructure required for growth. As the basis for a comprehensive Asset Management Plan, the Water and Wastewater Servicing Master Plan is structured to support decision-making relating to expected service levels, risk mitigation, and infrastructure funding (i.e., rehabilitation and replacements).

The Water and Wastewater Servicing Master Plan is currently being updated by the City, with expected completion in 2023.

3.5.13 City of Guelph Wastewater Treatment and Biosolids Master Plan, 2009

The Wastewater Treatment and Biosolids Master Plan (CH2M HILL 2009) addresses capacity at the Guelph Wastewater Treatment Plant, renamed to the Guelph Water Resource Recovery Centre (WRRC) in 2022, to meet future growth in the City, aligning with projections shown in the Local Growth Management Plan and Water Supply Master Plan. An update is expected to be completed in 2022.

Among other studies that would complement the Wastewater Treatment and Biosolids Master Plan, it was recommended to conduct a climate change adaptation study specific to the WRRC (2009 cost estimate of \$35,000). The Wastewater Treatment and Biosolids Master Plan recommended an examination of potential climate change impacts to the WRRC that would warrant emergency planning and adaptation. It recommended that climate change scenarios specific to Guelph be analyzed including flooding, inflow and infiltration, and droughts. Low flow conditions are a component of drought periods that pose a threat to the general functionality of WRRCs. The Speed River historically experiences its lowest flows during the summer months. These low flows are expected to increase in frequency as a result of climate change. It was recommended that these efforts be coordinated with the GRCA who regulate flow augmentation on the Speed River. The GRCA are also conducting climate change investigations under Source Water Protection Planning and these efforts should align with future plans for the Guelph WRRC.

The Wastewater Treatment and Biosolids Master Plan is currently being updated by the city, with the environmental study report completed January 2023.

3.5.14 City of Guelph Stormwater Management Master Plan, 2012

The Stormwater Management Master Plan (AMEC 2012) provides a long-term management plan for stormwater in the City, progressing as a “Water Cycle City” that treats stormwater runoff as a resource instead of a liability. The Stormwater Management Master Plan addresses water quality, water quantity, and the natural environment for urban areas as well as the Eramosa and Speed Rivers and their tributaries. The Stormwater Management Master Plan provided suggestions for maintenance and retrofits that incorporate LID and best management practices.

In evaluating for climate change conditions, the Stormwater Management Master Plan estimated that return period storms would shift to increase in frequency, e.g., a 5-year storm would become a 2-year. To meet the 5-year capacity sewer standard in the City, a summary of preliminary upgrades was made for the entirety of the City’s drainage networks, including the

number of sewers impacted and estimated costs. Note that since the publication of this plan, the City has indicated that they have used the Intensity-duration-frequency curves that account for climate change to map future infrastructure needs (i.e., IDFC Representative Concentration Pathway [RCP] 4.5, which is a moderate scenario where emissions peak around 2040 and then decline).

The Stormwater Management Master Plan is currently being updated to plan for the next 25 years, with a projected completion date for 2023 (City of Guelph 2022b).

3.5.15 City of Guelph Emergency Response Plan, 2015

The Emergency Response Plan (City of Guelph 2014) provides staff members and citizens with direction and contact information in the event of an emergency. The Emergency Response Plan is intended to be flexible to account for a variety of emergencies. It indicates that the three most likely community risks to the City are severe weather (including tornadoes and ice storms), hazardous material releases from fixed or mobile sites, and human health emergencies. The Office of the Fire Marshal and Emergency Management require each community to conduct the Hazard Identification and Risk Assessment (HIRA), which is outlined in the next subsection.

3.5.16 City of Guelph Emergency Management Hazard Identification and Risk Assessment, 2018

The HIRA (OFMEM 2018) is a provincial document that has been designed to help Ontario communities record hazard data, determine the risk level, and provide context for risk assessors and decision makers. The user is guided to list the exposure and vulnerability of the population and infrastructure, identify the likelihood and consequence, and note the capacity and residual risks. For each hazard (e.g., dam failure, geopolitical pressures, food shortage, etc.), the consequences are classified as none, low, medium, and high for the following categories: fatalities, injury/illness, evacuation, psycho-social, support system impact, property damage, critical infrastructure, environmental, economic, and reputational. Weather-related hazards are captured in the HIRA process, including hazards that are an outcome of extreme weather events.

The City has completed an emergency HIRA, which addresses most of the potential hazards outlined in the provincial guidance, reflecting the geography of the City with regard to hazards (e.g., nuclear facilities are not included). Numerous climate-related hazards are addressed in the City's HIRA, such as drought or low water, extreme temperatures (cold and heat), flood, high winds, and winter weather. The consequences or impacts of extreme weather events are

also addressed, such as: water quality, dam failure, electrical energy supply and distribution, and water or wastewater disruption.

The HIRA process represents an important and useful exercise to identify hazards at a high level and provides a useful starting point to gauge the City's Emergency Management Team's perception of climate-related hazards. We note that while the evaluation has merit and should be explored in more detail, in the absence of a corresponding discussion document, it provides limited explanation regarding the calculation of risk scores. The HIRA scores are also likely based on historical climate conditions and do not include how climate is projected to change in the future.

3.6 Summary

Overall, the measures captured in these reports are plentiful, and this section has highlighted some of those, or at least has identified plans that represent sources of information where a deeper investigation is warranted. The City's Corporate Asset Management Plan provides significant content for roads and bridges, water, wastewater, and stormwater when it comes to climate risks and adaptation, but for other asset areas additional information was required. Additional assets are addressed in other plans, with the natural environment addressed in the Natural Heritage Action Plan (2018) and Urban Forest Management Plan 2013-2032 (2012), and water through the Tier Three Water Quantity Risk Assessment (2017), Water Efficiency Strategy (2016), and the Water Supply Master Plan (2022). Among the other plans and reports that offer useful insights include the HIRA (OFMEM 2018) for providing initial risk scores from an emergency management team perspective regarding various climate-related hazards, noting that their assessment does not include future climate change.

In addition to the internal documents identified by the research team and confirmed by the Staff Working Group, there is a large library of plans and strategies developed by and for the City that present additional documents worthy of consideration. Other design documents include the Stormwater Management Practices Planning and City of Guelph Community Urban Design Manual (City of Guelph 2017), City of Guelph Development Engineering Manual (City of Guelph Engineering and Transportation Services 2019), and the City of Guelph Linear Infrastructure Standards (City of Guelph 2022c). We note that the list of plans and strategies on the City's website lists 12 Master Plans and 38 additional plans and strategies. Since climate change is a cross-cutting issue, it can be anticipated that some, if not many, of these other plans and strategies may provide additional information about climate-related vulnerability and risk, adaptive capacity, and opportunities for funding.

The main financial source described in the summarized Master Plans is through the asset management program and budget. There is a shortfall; however, even for the four key asset groups covered through the Asset Management Plans, and financial support for the implementation of plans for other asset groups remains somewhat unclear. Potential financial sources are provided in the Stage 2 Technical Memorandum presented in Appendix B.

4 City of Guelph's Future Climate

Climate data are an essential and foundational element of a climate risk assessment and development of a Climate Adaptation Plan. The level of detail and granularity will be determined by the purpose and scope of the plan and involves both historical data and future climate change projections. A scan of key reference documents that represent useful sources of climate data for the City, in addition to a selection of neighbouring municipal climate change adaptation strategies/plans yielded a wide range of climate change projections for consideration in the Climate Adaptation Plan. Similarly historical data can be drawn from various sources, although Environment and Climate Change Canada data are often used because they are based on up-to-date weather station data that have a linear dataset and provide at least a 30-year record. This section outlines the sources of climate data used in the Climate Adaptation Plan, the climate hazards and parameters that were used in the climate risk assessment, future climate conditions that are projected for the City, and future likelihood of occurrence.

4.1 Climate Data Sources

There are a number of data portals and past reports that provide climate change projections for the City; three of these are highlighted in this report. The primary source for climate change projections is the Canadian Centre for Climate Services and their climatedata.ca portal. This data are based on the latest IPCC climate change projections developed through the Coupled Model Intercomparison Project 6 (CMIP6). This data portal was the primary source for the majority of the climate hazards addressed in the Climate Adaptation Plan (e.g., extreme heat), in addition to the climate parameters (e.g., the number of hot days), and critical thresholds (>30°C). Another source that was used to confirm the direction and relative magnitude of change was a recent climate science-based report titled “The Climate Science Report for the Climate Change and Health Vulnerability Assessment for Waterloo Region, Wellington County, Dufferin County, and the City of Guelph” (ICLEI Canada 2022). The data was drawn from a provincial climate data portal that is comparable to the national portal. A third source were the localized climate projections developed for the City of Waterloo which supported provincial and national data portals and their projections.

4.1.1 Climatedata.ca (currently active)

The Canadian Centre for Climate Services provides two key climate data portals: climatedata.ca (Climatedata.ca 2022) and climateatlas.ca (Climateatlas.ca 2022), and since their launch, are widely considered to be the primary source of climate projections in Canada. For the purposes of the Guelph Climate Adaptation Plan, the climatedata.ca portal was more useful. The climatedata.ca portal provides “modelled” historical climate data back to 1950, and future projections to 2100 on a year-by-year basis. The portal has recently introduced actual historical climate data. Projections provided at this portal are for three emission scenarios (net-zero carbon [RCP2.6], aggressive mitigation [RCP4.5], and business-as-usual [RCP8.5]) and consider a range of uncertainty by providing “low,” “median,” and “high” values. The “analyze” function also provides additional flexibility to calculate future projections of various climate variables where you can select specific values (e.g., days where heat stress may be a particular health concern, such as when maximum temperatures are above 31°C and nighttime minimum temperature exceeds 21°C). These projections, along with those developed for Waterloo Region and Wellington County, form the basis of climate projections for the Climate Adaptation Plan and in the determination of likelihood scores for key climate hazards. The flexibility and wide range of climate data provided in the portal has additional value for future analysis of climate risk for infrastructure assets and components; specific critical thresholds may be of interest to determine asset failure and performance. The national climatedata.ca portal provided most of the climate data needed to describe future conditions for the nine climate hazards (Section 4.2) selected for the Climate Adaptation Plan and were largely consistent with the other climate data sources.

4.1.2 Climate Science Report for the Climate Change and Health Vulnerability Assessment for Waterloo Region, Wellington County, Dufferin County, and the City of Guelph (2022)

The science report for climate change and health vulnerability assessment (ICLEI Canada 2022) provides climate change projections for a wide range of climate variables (42) that are drawn from the Ontario provincial climate data portal Laboratory of Mathematical Parallel Systems, based at York University. The baseline for projections is 1986-2005, and future projections are provided for three emission scenarios (RCP2.6, RCP4.5, and RCP8.5) for the 2050s and 2080s. Data for Wellington County are directly applicable to Guelph and provide a wider range of future climate projections than the localized climate projections developed for the Regional Municipality of Waterloo (Region of Waterloo). The projections however do not include climate variables where there is high uncertainty, notably freezing rain and snowfall.

4.1.3 Localized Climate Projections for Waterloo Region Final Report (2015)

The Interdisciplinary Centre on Climate Change and the University of Waterloo developed climate change projections for the City of Cambridge, City of Kitchener, City of Waterloo and the Region of Waterloo in 2015 (ICCC and University of Waterloo 2015). Projections compared to a 1981-2010 baseline were developed for a select and limited number of temperature and precipitation variables under three different emission scenarios (RCP2.6, RCP4.5, and RCP8.5) for the 2020s, 2050s, and 2080s. The projections developed for this report have informed the climate data used for the Climate Adaptation Plans developed for the City of Waterloo and Region of Waterloo. Projections include climate variables where considerable uncertainty applies, such as snowfall and freezing rain where their occurrence is dependent upon a combination of temperature and precipitation and are variables that climate data portals are reluctant to project into the future. As such the projections serve as a useful foundation from which to compare more updated projections drawn from other sources that apply to a wider range of variables, and as a source for future climate conditions of variables typically not addressed in climate data portals.

4.2 Climate Hazards

Climate hazards come in many forms, and how they impact a community is a function of geography (e.g., coastal communities or those on lakes with ports and shorelines), sensitivity, and vulnerability.

The process to select climate hazards can draw upon external sources such as other neighbouring municipalities with similar geographies, and from staff members themselves whose experience with recent extreme weather events are likely to greatly influence their selection. The Project Team looked at municipalities of comparable size and location (e.g., southern Ontario, inland communities), and the climate hazards commonly identified as a concern, as well as their parameters and thresholds drawn from previous studies and/or those that were available through credible climate data portals. In addition, the uniqueness of the City in terms of its location was considered, and how climate hazards have been known to impact infrastructure assets and service delivery, based on historical experience, through an infrastructure asset and service delivery lens.

Specific climate parameters and thresholds can have a wide range of effects on health and safety, asset performance, and service delivery. The exceedance of these thresholds, for example, can create conditions that prompt an operational response, have an impact on asset management decisions and planning, and may even call for the improvement of design standards for new infrastructure. For the purposes of the Climate Adaptation Plan; however, the focus was more at a general level and not intended to reflect critical thresholds that apply to specific assets and components. In fact, thresholds were subjective, and in some cases, served as a necessary metric to measure change at a more general level, such as in seasonal or annual amounts (e.g., number of hot days when the maximum daily temperature exceeds 30°C), as opposed to more temporally specific metrics, such as mean maximum daily temperature (e.g., greater than or equal to 37.5°C).

The list of climate hazards, specific climate parameters, and key thresholds (where applicable) that were applied in the risk assessment are provided in Table 8. An explanation regarding each variable’s likelihood is provided in Section 4.3. A more detailed account of climate hazards, climate parameters, and thresholds is also provided in Appendix B as a detailed table that outlines the range of climate variables that have been used to describe climate hazards, and the sources (e.g., reports, plans, and data portals).

Table 8 Climate Hazards, Climate Parameters, and Thresholds

Climate Hazards	Climate Parameters and Thresholds
Acute Weather Events	Number of days with high wind gusts >40 and 70 km/h
Drought	Average summer soil water content (mm)
Extreme Cold	Number of days <-15°C
Extreme Heat	Number of days >30°C
Flooding	Return levels for maximum 24-hour and 5-day rainfall
Freeze/Thaw	Number of days experiencing freeze/thaw conditions
Snow	Days >5 cm
Freezing Rain	Days with freezing rain
Warmer Ambient Temperatures	Winter season mean temperatures and/or number of days >31°C and nights >20°C
Winter/Spring Rainfall	Days with rainfall ≥25 mm from January to March (rain on snow or frozen ground)

In brief, the following climate parameters and thresholds describe the climate hazards that informed the climate risk assessment:

- Acute Weather Events: the first climate hazard consists of one “aggregate” hazard that captures three types of acute weather events, each of which are regarded as rare events with high impact, and where the scientific confidence in projections is low. However, the level of certainty and confidence in the occurrence of high wind events is higher than it is for hail and lightning, both in terms of future changes and geographical location, and is a hazard that is included on neighbouring studies. As a result, our parameter for acute weather events is high wind gusts, with a speed threshold that is based on neighbouring studies.
- Drought: the second climate hazard is drought, which is broadly defined as a period of heat and low precipitation, that impacts surface water levels, water temperatures, and ecosystem stress. Drought is typically defined in climate data portals in terms of the number of consecutive days with daily precipitation less than 1 mm, but this metric was rejected for trends in future average summer soil water content (in millimetres) as it better reflected a broader ecological impact.
- Extreme Cold: the third climate hazard is extreme cold, as reflected by extreme minimum temperatures that cause infrastructure to freeze and/or poses health risks in terms of exposure. Extreme cold is typically defined by a specific minimum daily temperature, or the number of days below freezing (0°C). The metric of the number of days that reaches or exceeds -15°C was selected, reflecting the health risks that temperatures at and below this threshold pose for staff, City residents, and visitors.
- Extreme Heat: the fourth climate hazard is extreme heat, as reflected by extreme daily maximum temperatures that cause infrastructure to overheat and/or poses health risks in terms of exposure. Extreme heat is typically defined by a maximum daily temperature, or the number of days above a health risk threshold. The metric of +30°C was selected as it is recognized as a health-related threshold where staff, City residents, and visitors may be at risk.
- Flooding: the fifth climate hazard is flooding, as an outcome of heavy rainfall that leads to overland and/or riverine flooding. Flooding as a hazard needs little explanation, as it can damage property, buildings, infrastructure, and put people at risk. Heavy rainfall that leads to flooding can be expressed by many metrics, such as maximum rainfall projected on a daily/24-hour period and over a continuous 5-day period, in addition to the number of wet days when daily heavy rainfall exceeds 20 mm. The metric of flooding considered the amount of maximum rainfall that would occur over a daily and 5-day period.

- **Freeze/Thaw:** the sixth climate hazard is freeze/thaw conditions, described as “cycles” when the temperature moves above or below 0°C. Freeze/thaw conditions, especially when there is precipitation involved, can exert stress onto infrastructure through freezing and/or thawing, causing damage and breakage. For example, freeze/thaw cycles can have a direct impact on road surfaces, and thereby influence the number of “potholes” that occur during the winter season. The metric is defined as the number of freeze/thaw cycles on an annual basis, or the number of days that cross over $\pm 0^{\circ}\text{C}$.
- **Snow and Freezing Rain:** the seventh climate hazard covers winter season precipitation events, as reflected by snowfall and freezing rain. Winter precipitation can have a direct impact on infrastructure assets, as well as limiting accessibility along roads, sidewalks, and trails, which can affect service delivery or access to services. This metric is a difficult one to project into the future, as winter precipitation is directly influenced by temperature. Given that precipitation is projected to increase, the likelihood of precipitation falling as freezing rain is also projected to increase, at least until the time when winter temperatures are consistently above the freezing point. The metrics typically applied to this climate hazard are the number of days with snow and/or freezing rain conditions, although there are other metrics that can be considered to provide supporting evidence in regard to projected changes. For example, whereas few if any climate studies and data portals provide projections of the number of days where snowfall will occur, a common metric is annual mean snowfall (cm) and in some cases the number of days when daily snowfall exceeds 5 cm.
- **Warmer Ambient Temperature:** the ninth climate hazard is warmer ambient temperatures, which is intended to supplement other metrics for warming temperatures, such as maximum daily temperatures on an annual, seasonal, or daily basis. Warmer ambient temperatures in the winter season that includes an increase in minimum temperatures could have ecological implications where the indirect impacts may lead to the spread of ticks carrying Lyme disease, and thus increase health risk exposure during late spring, summer and early autumn. Similarly, warmer nighttime temperatures, coupled with higher daytime temperatures, will combine to create ambient temperature conditions that place vulnerable members of the population at risk to heat exposure. The metrics typically applied to this climate hazard are annual mean temperature, winter season mean temperature, winter minimum temperature, and number of days $>31^{\circ}\text{C}$ and nights $>20^{\circ}\text{C}$. In the latter case these thresholds were identified as the metrics for heat-related mortality across the Health Region.

- Winter/Spring Rainfall: the eighth climate hazard is winter/spring rainfall, which is intended to capture both flood risk from an increase of rainfall on snow or frozen ground, and implications for groundwater with more precipitation falling as rain than snow during the winter, and increases in rainfall during the spring. Three metrics were considered for this climate hazard: days with rainfall ≥ 25 mm during January, February, and March, when there is snow accumulation on the ground or the ground is frozen, winter season precipitation, and spring season precipitation.

Climate parameters do not necessarily by themselves represent climate-related hazards, but are at the root cause of hydrological events, changes in ecological conditions, and biophysical effects that can directly or indirectly cause significant impacts. For example, more intense rainfall events can lead to more riverine and/or overland flooding; warmer winters can result in the proliferation of ticks that transmit Lyme disease; and hotter minimum temperatures during the summer can result in heat exposure and heat-stress mortality among the elderly who do not have access to air conditioning.

Consideration of climate variables may also take into account cumulative, cascading or compounding effects, where a series or sequence of events and conditions occur over a short or longer period of time that creates the conditions for a severe effect. For example, the contamination of well heads that resulted in the 2000 e. coli outbreak in Walkerton, Ontario, was partly attributable to a dry winter, followed by intense rainfall events in the spring. Similarly, a combination of heat, drought and lightning strikes can lead to wildfires, resulting in damage to buildings and infrastructure, loss of life, and mass evacuations. However, climate data portals typically do not provide projections of how such events may occur in the future, and these estimates require deeper analysis and expert judgement. As a result, there was limited consideration of cumulative or compounding climate effects in the Climate Adaptation Plan process, but they were considered by City staff on an ad hoc basis during the risk assessment process.

4.2.1 Future Climate Conditions in 2050 and 2080

Generally future climate is expected to be warmer, wetter, and wilder compared to current and historical conditions. In fact, it is widely accepted that historical weather conditions are not a good indicator of the future considering projections under medium and high emission scenarios. Both the average conditions and extreme weather events are going to increase in frequency, duration, and intensity. Some changes are not necessarily linear or consistent over time, noting that snowfall is determined by both precipitation amounts and temperature conditions, that can result in a trajectory that increases and then decreases by the 2050s or

2080s. It should also be noted that climate model projections for future time periods are intended to represent averages of model projections, and will not capture the range of uncertainty that the models generate (e.g., 10th or 90th percentiles). Nonetheless, it is important for the sake of the overall Climate Adaptation Plan and especially for communicating to the public to provide a defensible, evidence-based picture of the future climate for Guelph. Table 9 outlines future climate projections under a high emissions scenario (RCP8.5) for the 2050s and 2080s, relative to the historical baseline (1986-2005). While 30-year baselines (e.g., 1981-2010) are typically used to compare the relative changes in future climate conditions, the 20-year baseline used in the Climate Adaptation Plan is consistent with the approach taken in the recent climate science report for climate change and health (“Science Report for the Wellington, Dufferin and Guelph Climate Change and Health Vulnerability Assessment for Waterloo Region, Wellington County, Dufferin County and the City of Guelph” [ICLEI Canada 2022]) that included climate data for the City of Guelph.

In terms of future climate conditions, of the 10 climate hazards and 11 climate parameters listed in Table 9, there are some variables where there is less confidence in the science and the ability of climate models to project future conditions (e.g., high wind gust days and the number of days with freezing rain) compared to others. Further, the level of confidence in projections of temperature related variables tends to be higher than for precipitation. In brief, future climate in Guelph is projected to change in the following ways:

- The number of days with high wind gusts > 40 and 70 km/hour will increase between 10% to 40% by the end of this century.
- The number of periods without measurable rainfall will not likely change by 2050 or even 2080, but the overall likelihood of drought impacting ecosystems is expected to increase.
- The number of extreme cold days is projected to decline dramatically by 2050 and could virtually become a rare event (less than once per year) by 2080.
- The number of hot days is projected to increase dramatically, quadrupling by 2050 and increasing over 7-fold by 2080.
- Heavy rainfall events that typically lead to flooding is projected to increase by 10-18% for 24-hour events, and 6-16% for 5-day rainfall events by 2050 and 2080.
- The number of days where freeze/thaw cycles occur is projected to decrease by 13% by 2050 and 26% by 2080.

- The number of days where more than 5 cm of snowfall occurs will decline slightly from 11 to 10 by 2050, and then drop further to 7 days by 2080. The number of days with freezing rain is projected to increase by 40% and 45% for 2050 and 2080, respectively. Snowfall and freezing rain will continue to be present throughout the rest of this century.
- The number of hot days with warm nights which are currently rare events (less than once per year) will become more common in the future, rising to 8 days in 2050 and rising further to 28 days by 2080.
- Winter season precipitation is projected to increase by 12% by 2050 and 20% by 2080, noting that the amount of snowfall will decline, and amount of rainfall will increase.

Table 9 Climate conditions: historical baseline (1986-2005) and future projections (2050 and 2080) under high emissions scenarios

Climate Variables	Hazard Represented	Historical Baseline 1986-2005	Projections 2050s	Projections 2080s
Acute Weather Events	Number of days with high wind gusts >40 and 70 km/hour	-	+10-20% by 2100	+20-40% by 2100
Drought	Number of periods with more than five consecutive dry days (less than 1 mm a day)	12	12	12
Extreme Cold	Number of days <-15°C	22	6	<1
Extreme Heat	Number of days >30°C	9	38	67
Flooding	Return levels for max 24-hour rainfall (mm)	39	43	46
Flooding	Return levels for max 5-day rainfall (mm)	67	73	78
Freeze/Thaw	Number of days experiencing freeze/thaw conditions	70	61	52
Snow	Days >5 cm	11	10	7
Freezing Rain	Days with freezing rain		+40%	+45%
Warmer Ambient Temperatures	Winter season mean temperatures and/or number of days >31°C and nights >20°C	<1	9	28
Winter/Spring Rainfall	Winter season precipitation (mm)	193	217	232

4.3 Likelihood of Future Climate Hazards

Risk is a function of consequence (severity) × likelihood (probability) of occurrence ($R = S \times P$), and there are a variety of methods in the climate change and adaptation literature that are used to define likelihood. To date there is no singular “best practice” in terms of the likelihood method applied in municipal adaptation plans. A detailed explanation of options and process for the selection of the likelihood framework is provided in the “Climate Hazards, Data and Likelihood” memorandum (Appendix B), and is briefly summarized in this section. The memorandum also provides a detailed explanation for the establishment of likelihood scores for each climate hazard, for future time periods (2050 and 2080).

The likelihood scale adopted for developing the City’s Climate Adaptation Plan was drawn from the “PIEVC High Level Screening Guide” (Table 10), which is the middle baseline approach that describes future changes in likelihood relative to the historical baseline. Future likelihood that is as frequent as current climate (within ±10%) was given a mid score of 3, while increases and decreases in likelihood ranging from 10% to 50% and 50% to 100% were granted higher or lower scores (2 and 1 when likelihood decline exceeds 10% of the baseline; 4 and 5 when likelihood increases exceed 10% of the baseline).

Table 10 Public Infrastructure Engineering Vulnerability Committee High Level Screening Guide Probability Scoring Method Adopted in the Climate Risk Assessment

Likelihood	Middle Baseline Approach	Method	Suggested Rational
1	Establish Current Climate Baseline Per Parameter	Likely to occur less frequently than current climate	50% to 100% reduction in frequency or intensity with reference to baseline mean
2	Establish Current Climate Baseline Per Parameter	Likely to occur less frequently than current climate	10% to 50% reduction in frequency or intensity with reference to baseline mean
3	Establish Current Climate Baseline Per Parameter	Likely to occur as frequently as current climate	Baseline mean conditions or a change in frequency or intensity of ±10% with reference to the baseline mean
4	Establish Current Climate Baseline Per Parameter	Likely to occur as frequently as current climate	10% to 50% increase in frequency or intensity with reference to baseline mean
5	Establish Current Climate Baseline Per Parameter	Likely to occur more frequently than current climate	50% to 100% increase in frequency or intensity with reference to baseline mean

Municipal planning and asset management tends to be highly influenced by recent experience, and although it is widely accepted that historical weather is not a good indicator of future climate conditions, the case of informing asset management and planning decisions in the foreseeable future may be the exception. Upon further discussion with City staff, it was determined that the likelihood scale strongly resonated with asset owners and operators across all City departments/divisions.

Informed by external reports completed for neighbouring municipalities, and updated through the climatedata.ca portal, the likelihood values for each of the nine climate hazards (combining snow and freezing rain into one hazard) were calculated for the historical baseline, and future time periods (2050 and 2080), under a high-emissions scenario (Table 11). Detailed likelihood scores and their justification can be found in the “Climate Data Summary Table” in the “Climate Hazards, Data and Likelihood” memorandum (Appendix B), which outlines key references and sources in support of the scores.

Table 11 Likelihood Scores for Climate Hazards and Climate Parameters, for 2050 and 2080

Climate Variables	Hazard Represented	Likelihood (2050s)	Likelihood (2080s)
Acute Weather Events	Number of days with high wind gusts >40 and 70 km/hour	4	4
Drought	Number of periods with more than five consecutive dry days (less than 1 mm a day)	4	5
Extreme Cold	Number of days <-15°C	1	1
Extreme Heat	Number of days >30°C	5	5
Flooding	Return levels for max 24-hour and 5-day rainfall (mm)	4	4
Freeze/Thaw	Number of days experiencing freeze/thaw conditions	2	2
Snow	Days >5 cm	3	2
Freezing Rain	Days with freezing rain	4	4
Warmer Ambient Temperatures	Winter season mean temperatures and/or number of days >31°C and nights >20°C	5	5
Winter/Spring Rainfall	Winter season precipitation (mm)	4	4

Notes: As noted, the level of certainty and confidence in projections of wind is much higher, compared to those for hail and lightning. Where studies and data portals include hail and lightning among their climate hazards and parameters, likelihood is projected to remain relatively the same by 2050 and 2080, thereby resulting in a score of 3 for each future time

period. However, for wind, a number of studies conducted in the region and across the Greater Toronto and Hamilton Area are in agreement that wind gusts will increase by more than 10% but less than 50% by 2050 and 2080.

After consultation with the City, it was decided that the likelihood scoring value used for the climate risk assessment process should be 2080 under a high-emissions scenario (RCP 8.5), which is consistent with other climate change assessments that account for the full lifecycle of infrastructure assets.

5 Risk/Vulnerability Assessment

5.1 Risk/Vulnerability Assessment Process

The risk/vulnerability assessment process provided an opportunity to apply existing knowledge and evidence about climate-related impacts and risks across the City into a formal climate risk assessment process based on best practices (e.g., ISO 31000, ISO 14091, ICLEI BARC, and PIEVC Protocol). City staff played an essential role in this stage of the process and worked closely with the Project Team to quantify their perceived level of climate-related risks to their individual department's/division's assets, based on historical experiences, and in relation to projected climate change conditions.

The risk assessment process essentially involved three main steps: risk identification, risk analysis, and risk evaluation (Figure 14). A breakdown of the process is provided in this section through identifying risk hazards, designating those risks and rating the risks (Sections 5.2 to 5.4).

THE ISO31000 RISK MANAGEMENT PROCESS

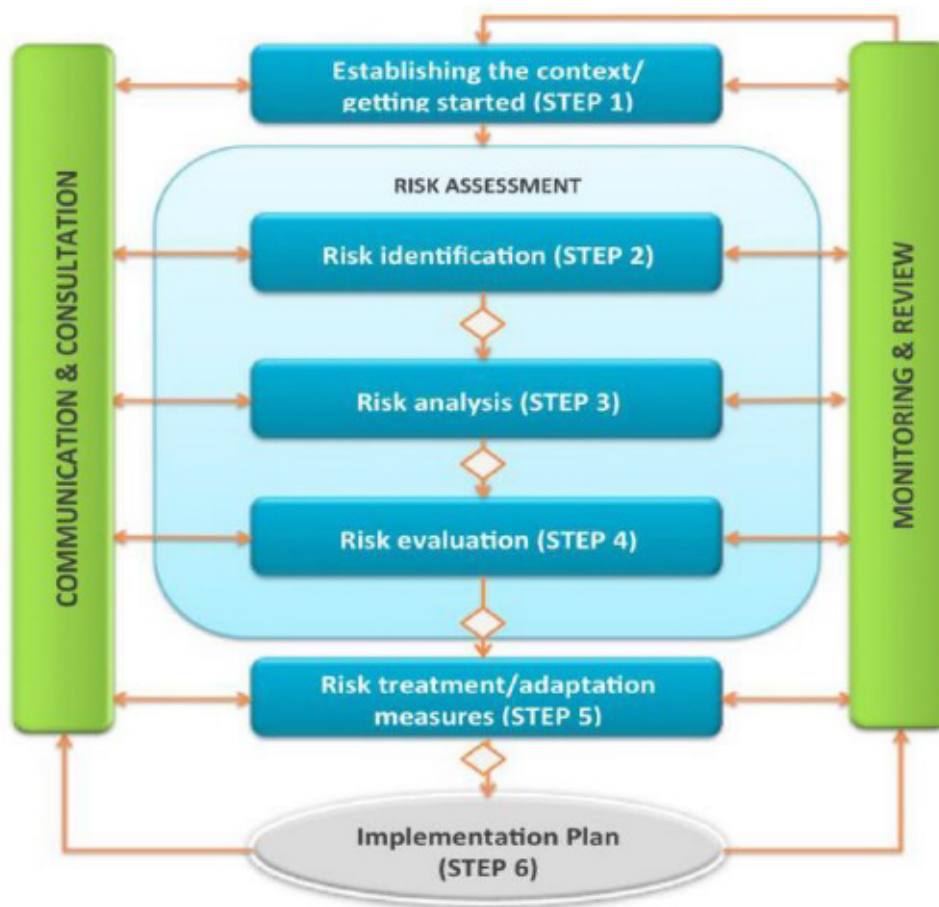


Figure 14 ISO 31000 Risk Management Process (ICLEI 2010)

5.2 Climate Hazard/Asset Interactions (Risk Identification)

The first step in the vulnerability assessment was to determine whether there is an interaction between climate variables and the City’s assets, operations, and services. This was a relatively simple exercise noting that there was no consideration of the degree of the interaction, merely a binary choice between “yes” and “no” before proceeding to subsequent steps involving further assessment. The interaction was between the climate parameter and asset performance, and by extension implications for service delivery. This was an important and initial “screening” phase to separate interactions of potential concern, from those where an increase in frequency or severity will have minimal if any impact on asset performance and LOSs delivery. For example, a streetlight may be affected by an acute weather event (high winds) but not by extreme heat. An example of the screening process is provided in Table 12.

Table 12 Example of Hazard/Asset Interaction Table

Asset Subclass	Service	Drought	Extreme Cold	Extreme Heat	Freeze/Thaw
Arkell Collector Aqueduct	Providing potable water to residents and businesses	x	x		x
F.M. Woods Water Treatment Plant	Providing potable water to residents and businesses	x	x	x	
Groundwater Well Station	Providing potable water to residents and businesses	x			
Hydrants	Fire protection		x		

Note: “X” denotes an interaction

Of the 306 total potential interactions, the City staff confirmed that there were 56 cases where no interactions existed, while there were 250 cases where interactions existed. The distribution of interactions provides some initial insights regarding the extent that departments/divisions own, operate, and maintain infrastructure assets that are exposed to the nine different climate hazards (Table 13).

Table 13 Interactions Between Infrastructure Assets and Nine Climate Hazards across City Departments/Divisions

Department(s)/Division(s)	No Interaction	Interaction
Engineering and Transportation Services	15	30
Fire Services, Paramedic Services	4	23
Guelph Transit	7	29
Information Technology	2	7
Culture and Recreation	0	36
Parks, Planning and Building Services	3	24
Planning and Building Services, Public Works (Operations)	5	22
Solid Waste Services	3	15
Stormwater Services	0	9
Wastewater Services	2	16
Water Services	15	39
Total	56	250

5.3 Consequences (Risk Analysis)

Characterizing consequences generally follows a standard format where they can be described within a range of categories that includes economic, environmental, social, safety, and reputational considerations. These are then scored according to a scale of 1 through 5 that can be qualitative or quantitative in detail. There is no singular approach that should be applied to the development of a municipal Climate Adaptation Plan, although examples can be drawn from various sources, including the IPCC, ICLEI, PIEVC, and others. Note that the City has a relatively streamlined consequence table that was incorporated in a recent report for FCM which was asset oriented, and a more detailed consequence table has also been developed with a health and safety focus through the City's risk management process. There is no right or wrong in the selection of consequence descriptions and scoring, but for the purpose of Guelph's Climate Adaptation Plan, there was merit in aligning the Climate Adaptation Plan process to the existing consequence table adopted through the City's risk management process, since it will be easier to incorporate the assessment outcomes and ranking with existing programs and initiatives.

A consequence score was then established for each climate interaction (Section 5.2), drawing from a consequence matrix which provided different levels of consequence that were differentiated by the degree and scope of damage. The consequence categories described the nature and type of impacts and were initially described in seven categories: property damage, infrastructure, physical human health, mental health, environment, community support services, economy, and reputation. These categories of concern were then refined to form five main pillars that are at the forefront of the City's attention and became the five consequence categories used in the calculation of the risk rating (Table 14):

- physical human health
- mental human health
- asset management
- environment
- community and economy

Table 14 Consequence Determination Matrix

	Asset Management	Asset Management	Physical Human Health	Mental Health	Environment	Community & Economy	Community & Economy	Community & Economy
	Property Damage	Infrastructure				Community Support Services	Economy	Reputational
Rank	Will property be damaged due to the hazard?	Will public infrastructure be damaged due to the hazard?	Will people be ill, injured, or killed due to the hazard?	Will the mental or emotional well-being of an individual, family group and/or community be impacted due to the hazard?	Will there be damage or loss to the environment, including the soil, water, air and/or plants and animals, due to the hazard?	Will the ability to deliver or access community support services be impacted due to the hazard?	Will there be a disruption or loss in the ability of individuals, businesses or governments to generate income, due to the hazard?	Will the perception of the government in the minds of the community and partners be negatively impacted due to the hazard?
None	Unlikely to result in property damage.	Unlikely to damage or disrupt function of civic assets.	Unlikely to result in injuries, illness, or fatalities.	Unlikely to result in mental and emotional distress.	Unlikely to result in damage or loss of habitat or ecological function; no regulatory consequences.	Unlikely to impact access to support services.	Unlikely to disrupt income generating activities.	Unlikely to result in political or reputational impacts.
Low (minor impacts, few impacted)	Minor property damage Few properties Small portion of the city	Minor damage or disruption Few civic assets Small portion of the city	Minor injuries or illness Few individuals Small portion of the city	Short-term mental or emotional distress Few individuals Small portion of the city	Short-term damage or loss Few ecological features Small portion of the city Regulatory reporting may be required	Short-term disruption Few support services Small portion of the city	Short-term disruption Few individuals or businesses Small portion of the city	Short-term political or reputational damage Negative sentiment expressed on few media sources Small portion of the population
Medium (minor impacts, many impacted)	Minor property damage Many properties Small portion of the city	Minor damage or disruption Many civic assets Small portion of the city	Minor injuries or illness Many individuals Small portion of the city	Short-term mental or emotional distress Many individuals Small portion of the city	Short-term damage or loss Few ecological features Small portion of the city Reporting of regulatory violation required	Short-term disruption Many support services Small portion of the city	Short-term disruption Many individuals or businesses Small portion of the city	Short-term political or reputational damage Negative sentiment expressed on many media sources Small portion of the population
High (major impacts, many impacted)	Severe property damage Many properties Large portion of the city	Severe damage or disruption Many civic assets Large portion of the city	Severe injuries, illness, or fatalities Many individuals Large portion of the city	Long-term mental or emotional distress Many individuals Large portion of the city	Long-term damage or loss Many ecological features Large portion of the city Reporting of regulatory violation required	Long-term disruption Many support services Large portion the city	Long-term disruption Many individuals or businesses Large portion of the city	Long-term political or reputational damage Negative sentiment expressed on many media sources Majority of the population
Extreme (extreme impacts, full city impacted)	Widespread severe property damage Many properties Throughout the city	Widespread severe damage or disruption Many civic assets Throughout the city	Mass severe injuries, illness, and fatalities Many communities Throughout the city	Mass long-term mental or emotional distress Many communities Throughout the city	Widespread long-term damage or loss Many ecological features Throughout the city Reporting of regulatory violation required	Widespread long-term disruption Many support services Throughout the city	Widespread long-term disruption Many individuals or businesses Throughout the city, with impacts to the region and province	Widespread long-term political or reputational damage Negative sentiment expressed on many media sources Large majority of the population

The consequence categories initially ranged from none to extreme (e.g., none (1), low [minor impacts, few impacted] (2), medium [minor impacts, many impacted] (3), high [major impacts, many impacted] (4), and very high [extreme impacts, full city impacted]) (5), with the degree and extent of impacts varying between them. It was decided that if there was an interaction between an asset and a climate hazard, then some level of consequences would exist (e.g., at least a low consequence score).

The Project Team assigned values of consequences for the asset interactions and City staff confirmed or edited the rating of each asset per hazard under each of the five pillar categories of concern. In the workshop(s) and follow up sessions with each department/division, however, staff members were reluctant to assign a negligible/no consequence score (e.g., a score of 1), while at the maximum end they were also hesitant to assign an extreme value consequence (e.g., a score of 5). This can partly be explained by the complexity of the category definitions, and the subtle differences between them. As a result, the workshop discussions ended up considering five levels of consequence: none, low, medium, high, and very high where the differences between values were more clearly defined among staff members (see Table 15 for a sample; full risk table is available in Appendix C).

Table 15 Sample of Consequence Scoring by Asset and Climate Hazard

Asset	Hazard	Physical Human Health	Mental Health	Asset Management	Environment	Community & Economy
Fleet Vehicles	Extreme Cold	Low	Low	Low	Low	Low
Transit Facilities	Extreme Heat	High	High	Low	Low	Low
Wetlands	Warmer Ambient Temperature	Medium	Low	High	High	Low

5.4 Risk Rating (Risk Evaluation)

Once there was agreement in the consequence scores, the next step in the process was to calculate risk scores. The risk rating was calculated as consequence (severity) × likelihood (probability) of occurrence ($R = S \times P$) to determine individual risk scores ranging from low to very high (e.g., low: 1-5; moderate: 6-12; high: 15 -16; and very high: 20-25), as outlined in the risk matrix (Figure 15).

L I K E L I H O O D	5	5	10	15	20	25
	4	4	8	12	16	20
	3	3	6	9	12	15
	2	2	4	6	8	10
	1	1	2	3	4	5
		1	2	3	4	5
	CONSEQUENCES					

Risk Rating Level	
Very High	20-25
High	15-19
Moderate	10-14
Low	1-9

Figure 15 Risk Matrix

Noting that each asset and climate variable could generate five possible risk scores (i.e., one for each of the five consequence categories, which are physical human health, mental human health, asset management, environment, and community and economy), it was necessary to consider prioritization based on either valuing each consequence category equally, and calculating an average score; weighing the consequence categories based on specific criteria, calculating a cumulative score across all categories; or selecting the maximum score, regardless of consequence category. Feedback from City staff indicated that extracting the maximum risk amongst the five categories of concern was favourable because it would ultimately represent the most conservative approach. As an example, provided below in Table 16, if we adjusted the table to consider likelihood scores and thus calculate risks, the highest risk is “high” as listed under asset management and environment which would be taken to represent the overall risk and then multiplied by a likelihood of 5 for warmer ambient temperatures, resulting in a risk score of “very high” of 20.

Table 16 Example of Calculating Risk Score for Wetlands Exposed to Warmer Ambient Temperatures

Asset	Climate Hazard	Consequence Ranking					Likelihood	Risk Score					Maximum Score
		Physical Human Health	Mental Health	Asset Management	Environment	Community & Economy		Physical Human Health	Mental Health	Asset Management	Environment	Community & Economy	
Wetlands	Warmer Ambient Temperatures	Medium	Low	High	High	Low	5	15	10	20	20	10	20

A summary of the final risk scores for each asset by hazard, organized by department/division, is provided in Table 17. City staff were given two opportunities to reevaluate the risk ratings. A total of 80 (56 high risk and 24 very high risk, not considering any existing adaptive capacity measures in place) assets were reviewed and evaluated more closely drawing from City staff feedback, as well as the broader literature and neighbouring studies. An impact statement was created for each of the assets or services with high and very high-risk rating scores, noting that many of the statements could be grouped together if they were not tied to specific assets. In a select few cases, and in consultation with the Staff Working Group, asset risk ratings for a particular climate hazard were either elevated from a medium rating to a high rating, or de-escalated from a high rating to a medium rating. For example, the impact of freeze/thaw cycles on road surfaced was escalated from a medium to high risk because the Staff Working Group expressed the importance of maintaining roads despite the estimated lower frequency of freeze/thaw cycles projected out to 2050.

A summary of the complete list of assets with high and very high climate risk ratings is provided in Table 18, which the full table (with impact statements, ratings for each consequence, etc.) is provided in Appendix C1.

There were a few emerging trends amongst the identified high- and very-high-risk assets. Namely, the top three hazards that warranted the most severe risks were extreme heat, acute weather events (high winds and hail), and flooding. These were generally triggered because of impacts to physical human health, mental human health, and asset management. Since likelihood for some climate hazards were projected to decline relative to the middle baseline (Section 4.3), risk scores associated with climate hazards that are projected to become less severe or frequent (e.g., snow events, cold temperatures, and freeze/thaw cycles) were lower. As a result, projections of only six of the nine climate hazards were drivers of climate risk for the 80 assets deemed to be at high or very high risk.

Table 17 Summary of Final Risk Ratings of Assets × Hazards by Department/Division

Department(s)/Division(s)	Risk Rating Score					Total
	None	Low	Moderate	High	Very High	
Engineering and Transportation Services	15	3	17	10	0	45
Emergency Services	4	3	13	6	1	27
Transit Services	7	5	15	5	4	36
Information Technology	2	1	4	1	1	9
Parks; Culture and Recreation	0	10	15	7	4	36
Parks; Planning and Building Services	3	4	8	3	9	27
Planning and Building Services; Operations	5	6	12	3	1	27
Solid Waste Services	3	3	9	1	2	18
Stormwater Services	0	1	3	5	0	9
Wastewater Services	2	2	9	4	1	18
Water Services	15	6	21	11	1	54
Total	56	44	126	56	24	306

Table 18 Summary of Final Risk Ratings - Full Asset List

Department/Division	Asset Category	Assets	Asset Groups	Hazard	Likelihood	Risk Calculation and Adjustment								Revised Risk	Rational for Risk Change
						Physical Human Health Risk	Mental Health Risk	Physical Damage Risk	Environmental Risk	Economic Risk	Maximum Risk	Altered Based on One-on-Ones?			
Culture and Recreation	Culture and Recreation	Culture and Recreation	Buildings	Extreme Heat	5	Very High	Very High	Moderate	Moderate	Moderate	Very High	No	Very High	N/A	
Culture and Recreation	Culture and Recreation	Culture and Recreation	Library, Culture, Tourism and Community Investment	Extreme Heat	5	Very High	Moderate	Moderate	Moderate	High	Very High	No	Very High	N/A	
Culture and Recreation	Culture and Recreation	Culture and Recreation	Recreation Facility	Extreme Heat	5	Very High	Moderate	Moderate	Moderate	Moderate	Very High	No	Very High	N/A	
Culture and Recreation	Culture and Recreation	Culture and Recreation	Buildings	Acute Weather Events	4	Moderate	Moderate	High	Moderate	Moderate	High	No	High	N/A	
Culture and Recreation	Culture and Recreation	Culture and Recreation	Library, Culture, Tourism and Community Investment	Acute Weather Events	4	Moderate	Moderate	High	Moderate	Moderate	High	No	High	N/A	
Culture and Recreation	Culture and Recreation	Culture and Recreation	Recreation Facility	Warmer Ambient Temperature	5	High	High	None	None	Moderate	High	No	High	N/A	
Culture and Recreation	Culture and Recreation	Culture and Recreation	Recreation Facility	Acute Weather Events	4	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Yes	High	Expressed that they would like to try to maintain their functions as much as possible for wellness (in lieu of their facilities being used as an emergency shelter)	
Culture and Recreation	Culture and Recreation	Culture and Recreation	Recreation Facility	Flooding	4	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Yes	High	Expressed that they would like to try to maintain their functions as much as possible for wellness (in lieu of their facilities being used as an emergency shelter)	
Engineering and Transportation Services	Contaminated Sites	Contaminated Land	Contaminated Land	Acute Weather Events	4	Moderate	Moderate	Moderate	Moderate	None	Moderate	Yes	High	Expressed this may lead to sediment transfer	
Engineering and Transportation Services	Parking	Parking Garage, Parking	Parking	Extreme Heat	5	High	High	High	Moderate	Moderate	High	No	High	N/A	
Engineering and Transportation Services	Parking	Parking Garage, Parking	Parking	Freeze/Thaw	2	Low	Low	Moderate	Moderate	Low	Moderate	Yes	High	Assuming the same rationale for roads and freeze/thaw can be applied here	

Department/ Division	Asset Category	Assets	Asset Groups	Hazard	Likelihood	Risk Calculation and Adjustment								
						Physical Human Health Risk	Mental Health Risk	Physical Damage Risk	Environmental Risk	Economic Risk	Maximum Risk	Altered Based on One-on- Ones?	Revised Risk	Rational for Risk Change
Engineering and Transportation Services	Transportation	Bridges and Structures	Bridges and Structures	Acute Weather Events	4	High	High	Moderate	Moderate	Moderate	High	No	High	N/A
Engineering and Transportation Services	Transportation	Bridges and Structures	Bridges and Structures	Freeze/Thaw	2	Moderate	Moderate	Low	Low	Low	Moderate	Yes	High	Assuming the same rationale for roads and freeze/thaw can be applied here
Engineering and Transportation Services	Transportation	Roads, Sidewalks, bike paths/trails	Roads	Extreme Heat	5	High	High	High	Moderate	High	High	No	High	N/A
Engineering and Transportation Services	Transportation	Roads, Sidewalks, bike paths/trails	Roads	Acute Weather Events	4	Moderate	Moderate	High	Moderate	High	High	No	High	N/A
Engineering and Transportation Services	Transportation	Roads, Sidewalks, bike paths/trails	Roads	Freeze/Thaw	2	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Yes	High	Staff mentioned that though cycles are decreasing, they would like to keep this on their radar
Engineering and Transportation Services	Transportation	Signage, Streetlights, Traffic Controls	Signage	Acute Weather Events	4	Moderate	Moderate	High	Moderate	Moderate	High	No	High	N/A
Facilities and Energy Management	Administrative and Operations Facilities	Commercial Facilities, Corporate Administration Facilities, Operations Facilities	Buildings	Extreme Heat	5	Very High	Very High	Moderate	Moderate	Moderate	Very High	No	Very High	N/A
Facilities and Energy Management	Transit Services	Transit	Bus Terminal	Extreme Heat	5	Moderate	High	None	None	Moderate	High	No	High	N/A
Facilities and Energy Management	Administrative and Operations Facilities	Commercial Facilities, Corporate Administration Facilities, Operations Facilities	Buildings	Acute Weather Events	4	Moderate	Moderate	High	Moderate	Moderate	High	No	High	N/A

Department/ Division	Asset Category	Assets	Asset Groups	Hazard	Likelihood	Risk Calculation and Adjustment								
						Physical Human Health Risk	Mental Health Risk	Physical Damage Risk	Environmental Risk	Economic Risk	Maximum Risk	Altered Based on One-on- Ones?	Revised Risk	Rational for Risk Change
Facilities and Energy Management	Administrative and Operations Facilities	Commercial Facilities, Corporate Administration Facilities, Operations Facilities	Buildings	Flooding	4	Moderate	Moderate	High	Moderate	Moderate	High	No	High	Note: Staff requested to explicitly mention buildings for funding
Facilities and Energy Management	Corporate Vehicles and Equipment	Equipment	Equipment	Extreme Heat	5	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Yes	High	Consistent with plans for IT
Fire Services, Paramedic Services	Emergency Services	Emergency Buildings	Emergency Buildings	Extreme Heat	5	Very High	Very High	High	Moderate	High	Very High	No	Very High	N/A
Fire Services, Paramedic Services	Emergency Services	Emergency Buildings	Emergency Buildings	Flooding	4	Moderate	Moderate	High	Moderate	High	High	No	High	N/A
Fire Services, Paramedic Services	Emergency Services	Emergency Buildings	Emergency Buildings	Acute Weather Events	4	Moderate	Moderate	High	Moderate	High	High	No	High	N/A
Fire Services, Paramedic Services	Emergency Services	Emergency Equipment	Emergency Equipment	Extreme Heat	5	High	High	High	Moderate	High	High	No	High	N/A
Fire Services, Paramedic Services	Emergency Services	Emergency Vehicles	Emergency Vehicles	Acute Weather Events	4	High	High	Moderate	None	Moderate	High	No	High	N/A
Fire Services, Paramedic Services	Emergency Services	Emergency Vehicles	Emergency Vehicles	Extreme Heat	5	High	High	Moderate	Moderate	High	High	No	High	N/A
Fire Services, Paramedic Services	Emergency Services	Emergency Vehicles	Emergency Vehicles	Flooding	4	High	High	Moderate	Moderate	Moderate	High	No	High	N/A
Fire Services, Paramedic Services	Emergency Services	Emergency Equipment	Emergency Equipment	Flooding	4	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Yes	High	Staff expressed and consistent with IT equipment
Guelph Transit	Transit Services	Bus - Conventional, Bus - Mobility, Transit Vehicle - Other	Vehicles	Extreme Heat	5	Very High	High	Moderate	Moderate	Moderate	Very High	No	Very High	N/A

Department/ Division	Asset Category	Assets	Asset Groups	Hazard	Likelihood	Risk Calculation and Adjustment								
						Physical Human Health Risk	Mental Health Risk	Physical Damage Risk	Environmental Risk	Economic Risk	Maximum Risk	Altered Based on One-on- Ones?	Revised Risk	Rational for Risk Change
Guelph Transit	Transit Services	Transit	Bus Stops/Shelters	Extreme Heat	5	High	Very High	None	None	High	Very High	No	Very High	N/A
Guelph Transit	Transit Services	Transit	Bus Terminal	Extreme Heat	5	High	Very High	None	None	High	Very High	No	Very High	N/A
Guelph Transit	Transit Services	Transit Facilities	Buildings	Extreme Heat	5	Very High	Very High	Moderate	Moderate	Moderate	Very High	No	Very High	N/A
Guelph Transit	Transit Services	Transit	Bus Stops/Shelters	Acute Weather Events	4	Moderate	Moderate	High	Moderate	Moderate	High	No	High	N/A
Guelph Transit	Transit Services	Transit	Bus Stops/Shelters	Snow and Freezing Rain	2	Moderate	Moderate	Moderate	Low	Low	Moderate	Yes	High	Mentioned efforts to improve shelter from the elements
Guelph Transit	Transit Services	Transit	Bus Terminal	Acute Weather Events	4	Moderate	Moderate	High	Moderate	Moderate	High	No	High	N/A
Guelph Transit	Transit Services	Transit	Bus Terminal	Snow and Freezing Rain	2	Moderate	Moderate	Moderate	Low	Low	Moderate	Yes	High	Mentioned efforts to improve shelter from the elements
Guelph Transit	Transit Services	Transit Facilities	Buildings	Acute Weather Events	4	Moderate	Moderate	High	Moderate	Moderate	High	No	High	N/A
Information Technology	Software and Hardware	Equipment	Equipment	Extreme Heat	5	Moderate	Moderate	Very High	Moderate	High	Very High	No	Very High	N/A
Information Technology	Software and Hardware	Equipment	Equipment	Flooding	4	Moderate	Moderate	Moderate	None	Moderate	Moderate	Yes	High	The equipment is currently stored in the basement and may be damaged in the event of a flood
Parks	Parks	Parks	Parks	Extreme Heat	5	Moderate	Moderate	High	High	Moderate	High	No	High	N/A
Parks	Parks	Parks	Parks	Warmer Ambient Temperature	5	High	Moderate	None	Very High	Moderate	Very High	No	Very High	N/A
Planning and Building Services, Parks	Natural Assets	Natural Heritage	Forest and Plants	Drought	5	High	High	High	Very High	High	Very High	No	Very High	N/A
Planning and Building Services, Parks	Natural Assets	Natural Heritage	Forest and Plants	Extreme Heat	5	High	High	High	Very High	High	Very High	No	Very High	N/A
Planning and Building Services, Parks	Natural Assets	Natural Heritage	Forest and Plants	Warmer Ambient Temperature	5	High	High	None	Very High	Very High	Very High	No	Very High	N/A
Planning and Building Services, Parks	Natural Assets	Natural Heritage	Surface Water	Drought	5	Moderate	High	Moderate	Very High	Moderate	Very High	No	Very High	N/A

Department/ Division	Asset Category	Assets	Asset Groups	Hazard	Likelihood	Risk Calculation and Adjustment								
						Physical Human Health Risk	Mental Health Risk	Physical Damage Risk	Environmental Risk	Economic Risk	Maximum Risk	Altered Based on One-on- Ones?	Revised Risk	Rational for Risk Change
Planning and Building Services, Parks	Natural Assets	Natural Heritage	Surface Water	Extreme Heat	5	None	None	Moderate	Very High	None	Very High	No	Very High	N/A
Planning and Building Services, Parks	Natural Assets	Natural Heritage	Surface Water	Warmer Ambient Temperature	5	High	Moderate	None	Very High	None	Very High	No	Very High	N/A
Planning and Building Services, Parks	Natural Assets	Natural Heritage	Wetlands	Drought	5	Moderate	Moderate	Moderate	Very High	Moderate	Very High	No	Very High	N/A
Planning and Building Services, Parks	Natural Assets	Natural Heritage	Wetlands	Extreme Heat	5	Moderate	Moderate	Moderate	Very High	None	Very High	No	Very High	N/A
Planning and Building Services, Parks	Natural Assets	Natural Heritage	Wetlands	Warmer Ambient Temperature	5	High	Moderate	Very High	Very High	Moderate	Very High	No	Very High	N/A
Parks	Parks	Parks	Parks	Acute Weather Events	4	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Yes	High	Expressed staffing/equipment issues in the event that many trees are damaged (could be grouped in Forests and Plants)
Planning and Building Services, Parks	Natural Assets	Natural Heritage	Forest and Plants	Acute Weather Events	4	High	High	High	Moderate	Moderate	High	No	High	N/A
Planning and Building Services, Parks	Natural Assets	Natural Heritage	Forest and Plants	Flooding	4	Moderate	Moderate	Moderate	High	Moderate	High	No	High	N/A
Planning and Building Services, Parks	Natural Assets	Natural Heritage	Surface Water	Flooding	4	High	High	None	High	Moderate	High	No	High	N/A
Solid Waste Services	Solid Waste	Waste Collection Fleet Vehicles	Vehicles	Extreme Heat	5	Very High	Moderate	Moderate	Moderate	Moderate	Very High	No	Very High	N/A
Solid Waste Services	Solid Waste	Waste Resource Innovation Centre (Facility)	Buildings	Extreme Heat	5	Very High	Very High	Moderate	Moderate	Moderate	Very High	No	Very High	N/A

Department/ Division	Asset Category	Assets	Asset Groups	Hazard	Likelihood	Risk Calculation and Adjustment								
						Physical Human Health Risk	Mental Health Risk	Physical Damage Risk	Environmental Risk	Economic Risk	Maximum Risk	Altered Based on One-on- Ones?	Revised Risk	Rational for Risk Change
Solid Waste Services	Solid Waste	Waste Resource Innovation Centre (Facility)	Buildings	Acute Weather Events	4	Moderate	Moderate	High	Moderate	Moderate	High	No	High	N/A
Stormwater Services	Stormwater	Channels, Culvert, Management Ponds, Oil and Grit Separator, Pipe	Stormwater Infrastructure	Extreme Heat	5	None	None	Moderate	High	Moderate	High	No	High	N/A
Stormwater Services	Stormwater	Channels, Culvert, Management Ponds, Oil and Grit Separator, Pipe	Stormwater Infrastructure	Flooding	4	High	High	Moderate	Moderate	Moderate	High	No	High	N/A
Stormwater Services	Stormwater	Channels, Culvert, Management Ponds, Oil and Grit Separator, Pipe	Stormwater Infrastructure	Warmer Ambient Temperature	5	High	High	None	High	None	High	No	High	N/A
Stormwater Services	Stormwater	Channels, Culvert, Management Ponds, Oil and Grit Separator, Pipe	Stormwater Infrastructure	Winter/Spring Rainfall	4	High	Moderate	Moderate	Moderate	Moderate	High	No	High	N/A
Wastewater Services	Wastewater	Water Resource Recovery Centre	Wastewater Treatment Facility	Extreme Heat	5	Very High	Very High	Moderate	Moderate	High	Very High	No	Very High	N/A
Wastewater Services	Wastewater	Maintenance Hole, Sanitary Pipe, Siphon, Wastewater Pumping Station	Wastewater Infrastructure	Extreme Heat	5	None	None	Moderate	High	Moderate	High	No	High	N/A

Department/ Division	Asset Category	Assets	Asset Groups	Hazard	Likelihood	Risk Calculation and Adjustment								
						Physical Human Health Risk	Mental Health Risk	Physical Damage Risk	Environmental Risk	Economic Risk	Maximum Risk	Altered Based on One-on- Ones?	Revised Risk	Rational for Risk Change
Wastewater Services	Wastewater	Water Resource Recovery Centre	Wastewater Treatment Facility	Acute Weather Events	4	Moderate	Moderate	High	High	High	High	No	High	N/A
Wastewater Services	Wastewater	Water Resource Recovery Centre	Wastewater Treatment Facility	Winter/Spring Rainfall	4	None	Moderate	None	High	Moderate	High	No	High	N/A
Wastewater Services	Wastewater	Water Resource Recovery Centre	Wastewater Treatment Facility	Warmer Ambient Temperature	5	Moderate	Moderate	High	High	None	High	No	High	N/A
Water Services	Water	Water Treatment Plant	Water Treatment Plant	Extreme Heat	5	Very High	Very High	Moderate	Moderate	Moderate	Very High	No	Very High	N/A
Water Services	Water	Arkell Springs, Water Spring Recharge System	Arkell Springs and Recharge System	Acute Weather Events	4	Moderate	Moderate	Moderate	Moderate	High	High	No	High	N/A
Water Services	Water	Arkell Springs, Water Spring Recharge System	Arkell Springs and Recharge System	Flooding	4	Moderate	Moderate	Moderate	Moderate	High	High	No	High	N/A
Water Services	Water	Arkell Springs, Water Spring Recharge System	Arkell Springs and Recharge System	Drought	5	High	High	None	None	High	High	No	High	N/A
Water Services	Water	Collector Aqueduct	Collector Aqueduct	Acute Weather Events	4	High	High	High	Moderate	Moderate	High	No	High	N/A
Water Services	Water	Collector Aqueduct	Collector Aqueduct	Drought	5	High	High	None	None	None	High	No	High	N/A
Water Services	Water	Groundwater Well Station, Pumping Station, Well Station (Inactive)	Well Station	Extreme Heat	5	None	None	Moderate	High	Moderate	High	No	High	N/A

Department/ Division	Asset Category	Assets	Asset Groups	Hazard	Likelihood	Risk Calculation and Adjustment								
						Physical Human Health Risk	Mental Health Risk	Physical Damage Risk	Environmental Risk	Economic Risk	Maximum Risk	Altered Based on One-on- Ones?	Revised Risk	Rational for Risk Change
Water Services	Water	Groundwater Well Station, Pumping Station, Well Station (Inactive)	Well Station	Drought	5	High	High	Moderate	High	High	High	No	High	N/A
Water Services	Water	Water Tower	Water Tower	Acute Weather Events	4	High	High	High	Moderate	Moderate	High	No	High	N/A
Water Services	Water	Water Tower	Water Tower	Drought	5	High	High	None	None	Moderate	High	No	High	N/A
Water Services	Water	Water Treatment Plant	Water Treatment Plant	Acute Weather Events	4	High	High	High	Moderate	High	High	No	High	N/A
Water Services	Water	Water Treatment Plant	Water Treatment Plant	Drought	5	Moderate	High	None	None	None	High	No	High	N/A

6 Adaptation Opportunities

6.1 Adaptive Capacity

The goal of the Climate Adaptation Plan is to understand the City's current adaptive capacity and provide feasible recommendations to strengthen it. In this context, adaptive capacity is defined as a system's ability to adjust to climate change and avoid or reduce damages while taking advantage of opportunities. Essentially, adaptive capacity demonstrates how well a system (asset, service, or department/division) can manage a change or disturbance.

As described, Matrix took an asset-based approach to readily quantify and analyze the City's current adaptive capacity. After completing the risk rating (Section 5), meetings were held with the City's Staff Working Group to discuss the adaptive capacity measures and actions currently in place in their respective departments/divisions and opportunities for additional measures and actions. Staff were asked, "how well do the City's currently-implemented plans/policies/programs address the assets, operations and services with high climate risks?" The staff were then engaged to put their filtered high-risk assets on a scale to gauge the individual adaptive capacity based on their currently implemented plans, policies, and programs. Each at-risk asset was placed under one of the three headings: fully addressed, somewhat addressed, and not addressed. For example, the City puts winter tires on ambulances as an adaptive capacity measure for increased safety during snow and freezing rain events, thus reducing the risk to physical and mental human health. This adaptive capacity measure somewhat addresses the climate hazard risk (snow and freezing rain) but does not fully address/eliminate it.

As part of the final consultation, one-on-one meetings with the Staff Working Group were used to gauge future opportunities to improve adaptive capacity in their individual departments/divisions. For example, establishing emergency internal and external communications that include digital and broadcast media in multiple languages, was suggested by the Project Team staff from the Strategic Communications and Community Engagement department.

6.2 Summary of Adaptive Capacity Actions

Appendix C.2 provides details of the current and planned adaptive capacity measures implemented in each department/division, as described to the Project Team during the one-to-one meetings with the Staff Working Group members, as well as suggested adaptive capacity measures that were discussed. From this discussion, high-level adaptive capacity actions were pulled out and put forth in the final column of the Appendix C.2 table. Many

assets had more than one adaptive capacity measure and/or adaptive capacity measures that (partially or fully) addressed more than one asset or more than one climate risk. For example, Guelph's Asset Management Plan and system is integral in logging asset conditions across many City departments/divisions and prioritizing assets for renewal or rehabilitation.

A total of 163 adaptive capacity actions were established through the development of the Climate Adaptation Plan. Of these, 89 were existing actions and 74 were recommended actions. Existing actions refers to adaptive capacity measures that the City has already implemented or is planning to implement such as a recommendation from an approved master plan. In other words, more than 50% of the adaptive capacity actions are existing and represents the important work that the City is already doing around climate change adaptation.

While Appendices C.2 and C.3 provide the full list of adaptive capacity actions, summaries of the key existing and recommended adaptive capacity actions in the Climate Adaptation Plan are highlighted below. Further, the existing and recommended actions are broken down by department/division in Section 7.4.1.

6.2.1 City Wide

- Existing Actions - Key City-wide adaptive capacity actions that are already being undertaken centre around communications and partnership building with internal (e.g., EDI) and external local groups, and emergency response measures such as continued involvement with emergency shelter support, providing buses as an emergency shelter when requested by Emergency Services, having Public Works staff on standby during inclement weather, and having diesel generators available to supply power in the event of a power outage.
- Recommended Actions - Key recommended actions focus on expanded communication and consultation with various groups, namely, establishing regular meetings with the City's Community Emergency Management Coordinator, Red Cross, and County of Wellington; conducting emergency drills that include many City departments/divisions (rather than conducting drills for each department/division in isolation); and engaging First Nations communities in pre-consultation processes for projects. Prioritization of staff retention was highlighted as an important recommended action since staff knowledge is one of the City's best assets in the event of an emergency situation.

As a key recommended action in following through on the adaptive capacity actions, the Asset Management team was recommended to manage the Climate Adaptation Plan integration and implementation, including plan updates.

6.2.2 Communications and Information Technology

- Existing Actions - Key actions include continuing to follow the Community Engagement and Communications Plan and considering how to weave in climate change adaptation and mitigation messaging and make connections across the corporation. From a software and hardware aspect, key existing actions include maintaining the IT asset management program and having critical equipment readily available for replacement, either by maintaining storage or swiftly obtaining spares.
- Recommended Actions - Key actions include identifying a City staff as a prime contact person for community support agencies in the event of an emergency, and developing a list of support agencies to contact in the event of an emergency. From a software and hardware aspect, it was recommended to formalize emergency plans which include assessing the length of time backup power supplies provide.

6.2.3 Economic Development

- Existing Actions - A key action was to continue to play an active role in supporting new businesses and industries to Guelph that align with the City's sustainability and resiliency goals.

6.2.4 Emergency Services and Response

- Existing Actions - Key actions included continuing to maintain first aid training for public-facing City employees such as recreational facility and library staff, continuing to provide health and safety alerts (typically heat alerts) internally to City staff, and updating and maintaining the current Memorandum of Understanding with the University of Guelph. This Memorandum of Understanding allows for the sharing of assets and resources in times of emergency.
- Recommended Actions - Key actions focused on establishing business continuity and redundancy planning in the event that buildings, equipment or vehicles are compromised, establishing a formal communications plan between Emergency Services and Public Works, and participating in regular emergency exercises with Wellington County.

6.2.5 Green Infrastructure (Natural Heritage)

- Existing Actions - Key actions focused around continuing to undertake tree planting initiatives and invasive species management, and implementing/following/updating the

Urban Forest Management Plan, Natural Heritage Action Plan, Sustainable City Master Plan and Natural Assets Inventory.

- Recommended Actions - Key actions centre around increasing the granularity of the City's Natural Assets Inventory by maintaining a log of trees and vegetation within the City's floodplain, assessing aquatic biota and aquatic habitat at a set frequency, and identifying vulnerable areas and creating and updating a log of green infrastructure damages.

6.2.6 Grey Infrastructure (Buildings, Equipment, Vehicles, Roads, Sidewalks and Paths, Signals and Signage)

- Existing Actions - The overarching key existing action is to continue with the Asset Management program for full lifecycle planning, integrating climate change, for the City's grey infrastructure and assets and identifying priority repairs and replacements.

Other key existing actions include continuing Building Condition Assessments for City-owned buildings and Facility Needs Assessments, maintaining heating, ventilation and air conditioning (HVAC) systems in buildings, and road inspections and repairs.

- Recommended Actions - The key existing action is to improve communication between City project managers and the Asset Management Group such that Asset Management is made aware of infrastructure repairs and replacements in near real-time to inform the lifecycle planning and modelling.

Other key recommended actions include itemizing building components and equipment susceptible to climate hazard impacts and establishing a plan for back up or spares, and to create a City-wide urban heat island effect map.

6.2.7 Environmental Services (Wastewater, Water Services, Solid Waste)

- Existing Actions - Key actions applicable to the Waste Resource Innovation Centre include maintaining fire suppression equipment and back up power (diesel). The City's investment in the Circular Economy Framework was also highlighted.

Key actions applicable to the City's wastewater and WRRRC include continuing the inflow and infiltration investigation program to address increased wastewater influent flows during rain events, and liaising with the GRCA on Speed River flows and assimilative capacity.

Key actions applicable to the City's Water Services include continuing to assess risk to the system as per the Drinking Water Quality Management System, implementing the Water

Efficiency Strategy, and completing a Drought Response Operational Plan for the City. Another key action is to continue working with the University of Guelph on road salt application optimization during the winter.

- Recommended Actions - A key action applicable to the Waste Resource Innovation Centre included liaising with the fire department on a mock transfer station fire scenario.

A key action for the City's WRRRC was to install backflow prevention at the outfall to the Speed River.

Key actions applicable to the City's Water Services include participating in the Water Managers Working Group with municipalities in the watershed and the GRCA, and to consider redundancy in the aqueduct to direct some portion of flow to other City locations.

6.2.8 Stormwater

- Existing Actions - Key actions focused on implementing the recommendations of the recently-updated Stormwater Management Master Plan, continuing to size new infrastructure accommodating climate change predictions for rainfall, and liaising with Wellington Dufferin Guelph Public Health on the mosquito larvicide program.
- Recommended Actions - Key actions included developing a formal storm sewer maintenance program in collaboration with Public Works, conducting a storm sewer condition assessment and working with Parks to design LID features around City-owned facilities and dual use of recreational fields and parks for stormwater management purposes.

6.2.9 Transit

- Existing Actions - Key actions included maintaining the practice of changing over to winter tires, continuing to convert the bus fleet to electric vehicles, and continuing Guelph Transit's policy of continuing bus service during inclement weather to ensure that riders are not left stranded.
- Recommended Actions - A key action included investigating and providing shelter for riders at popular transit stops and considering an equity lens.

7 Climate Adaptation Plan Implementation

7.1 Action Prioritization

In this section the rationale for the method used to prioritize the proposed actions is outlined. In assessing the 80 high or very high climate risks to City assets, 163 adaptive capacity measures (actions) were subsequently identified, a portion of which were existing (i.e., actions that the department/division was currently undertaking or was planning to undertake) and the remaining were recommended (Appendix C.2 and C.3). Compared to other municipal Climate Adaptation Plans, this places the City's list of actions somewhere in the middle range, where the number of actions vary from less than 40 to over 400. A large number of actions may present a significant challenge for municipalities to implement at the same time, or within an immediate or short time frame. A prioritized list of the actions was created to guide City staff in case budget and/or time were limiting factors.

To inform the prioritization methodology, the Project Team examined the practices adopted by other municipalities to prioritize their actions, if they did so at all. We note that not all municipalities prioritize their actions, especially when the plans assessed climate-related risks at a high level, where the number of actions tend to be lower. The methods used to present actions are often wide and variable, with no single approach that consistently stands out as best practice. However, the City of Waterloo and the City of Barrie adopted a prioritization framework that was developed in 2008 for Environment Canada: untitled (publications.gc.ca). The framework adopted is based on the following criteria: (i) sustainability: social, economic, and environmental; (ii) effectiveness; (iii) risk and uncertainty; (iv) opportunity; and (v) implementation, treating each of these categories equally, while scoring each as 1 (low), 2 (medium), or 3 (high). This framework was prepared during a time when there was growing interest in aligning climate risk responses with Sustainable Development Goals. The framework covers a wide range of criteria that generally remain valid today, noting that some criterion such as "equity" have since been superseded by the addition of inclusion and diversity regarding EDI considerations, acknowledging that climate change does not impact all populations equally. Those considered part of the vulnerable population are often more affected by the impacts of climate change. For example, those who have a pre-existing health conditions, work outdoors, low socioeconomic status, immigrated recently, or have a disability (Buse et al. 2022).

The approach adopted for the City of Guelph was to prioritize actions by applying a hybrid of the 2008 Environment Canada framework, that reduced the 16 different criteria across 5 different criteria to a simplified triple bottom line (economic, social, and environmental). The

criteria chosen are outlined in Table 19 and have been adapted to relate more directly with infrastructure assets. The criteria and descriptions are also in alignment with the Climate Adaptation Plan vision and goals, as set by the Project Team (Section 1.3). Prioritization of the actions was based on the following criteria:

- Measure of benefit: will it eliminate or partially eliminate the risk, in addition to consideration of both ancillary benefits and the co-benefits between mitigation and adaptation measures;
- EDI: benefits to many people including vulnerable populations; and
- Ease of implementation: are the resources (staff and funding) identified and able to be secured

Table 19 Criteria for Prioritizing Adaptation Actions

Category	Description	Low (1)	Medium (2)	High (3)
Measure of benefit, including ancillary benefits and co-benefits	Will it eliminate or partially eliminate the risk; will the completion of this action benefit more than one risk identified	Partially eliminate the risk; little or no benefits to other risks identified	Somewhat eliminate the risk; some benefits to other risks identified	Effective at eliminating the risk; significant benefits to other risk identified
Equity, diversity, and inclusion	Are there benefits to vulnerable populations	Benefits to few vulnerable populations	Benefits to many vulnerable populations	Significant benefits to many vulnerable populations
Ease of implementation	Are the resources (staff and funding) identified and able to be secured	Funding sources have not been identified; current staff capacity is insufficient	Funding sources required and likely to be secured. Staff gaps exist but can be addressed	Funding is available. Staff capacity is sufficient.

Each action was assigned a 1 (low), 2 (medium), or 3 (high) rating for each category, and a cumulative score calculated resulting in a final prioritization score of between 3 and 9. These scores could be grouped from low to high, such as 3-4 for low priority, 5-6 for medium priority, and 7-9 for high priority. The revised list of priority actions would then be compared to the risk

ratings scores calculated for the City's assets (Section 5), and adjusted accordingly (e.g., medium priority actions raised to a higher priority if the risk rating was very high and warranted the adjustment based on the information derived from the In-depth one on one City staff interviews.

Appendix C.4 presents the prioritized list of adaptive capacity actions for the Climate Adaptation Plan. The actions are listed along with the following columns:

- **Basis:** refers to whether the recommended action is an adaptive measure for an asset or a service.
- **Existing, Planned, or Recommended:-** refers to whether the action is existing (i.e., already budgeted for and implemented in the department/division), planned (i.e., already budgeted for but not yet implemented in the department/division) or recommended (i.e., no budget exists at this time).
- **Asset(s) Addressed:** refers to the assets or services addressed by the adaptive action since there are actions presented that partially or fully eliminate the climate risk for more than a single asset or service.
- **Climate Hazard(s):** refers to the climate hazard(s) impacting the asset or service.
- **Managing Department:** refers to the department/division that will take on the implementation of the action, including reporting on progress of implementation.
- **Impacted Department:** refers to the department(s)/division(s) that will also participate in the implementation of the action in some form.
- **Benefitting Departments/Partner Working Groups:** refers to the department(s)/division(s) and/or Partner Work Groups that will ultimately benefit from the action being implemented. For example, if the Parks department plant trees, the Stormwater group will benefit from the reduced runoff to the storm sewer system as a result of the increased natural heritage assets.
- **Prioritization:** these display the risk rating calculated previously (Section 5), the triple bottom line (economic, social, and environmental) scores, the resulting prioritization score, and the overall priority rank. The overall priority rank was calculated by multiplying the priority score by the risk rating.

As seen in Appendix C.4, many of the highest priority actions are City-wide recommendations that focus on improved and deliberate communications between departments/divisions.

7.2 The Costs of Climate Change and Climate Change Adaptation

Climate change can have significant economic costs on a municipality's infrastructure due to the increased frequency and intensity of extreme weather events as well as the chronic and long-term effects of changes in climate parameters. Some of the ways that climate change can manifest itself into costs faced by the City in the future include:

- **Damage from acute extreme weather events:** Buildings can suffer severe damage from extreme weather events like floods and high winds. The cost of repairing or maintaining buildings or retrofitting or renewing to a higher design standard can be substantial.
- **Damage from chronic or long-term changes in climate parameters:** The City's existing infrastructure may face a decreased service life due to long-term changes in climate parameters. As an example, the integrity of road surfaces may be eroded by the combined effects of higher rainfall and freeze/thaw cycles. The municipality may respond to this type of deterioration by addressing higher maintenance costs or by renewing or reconstructing existing infrastructure at a higher design standard or by building new infrastructure at a higher design standard.
- **Increased insurance costs:** As the frequency and severity of extreme weather events increase, insurance companies may raise their premiums or refuse coverage altogether. This can make it more difficult and expensive to insure buildings, particularly in areas that are prone to weather-related damage.
- **Higher energy costs:** As temperatures rise, buildings may require more energy to keep them cool. This can increase the cost of energy bills, accelerate the deterioration of HVAC system performance, and make buildings less affordable to operate.
- **Reduced capacity to meet design criteria:** The capacity of stormwater and wastewater infrastructure may be affected by increased frequency and intensity of storm events or changes in seasonal conditions (e.g., wet winters, high water table, basement flooding). Mitigating these effects may require retrofitting existing assets, adding LID measures, or renewing with new assets.

- New community services and infrastructure: The City may respond to a changing climate by planning for new services or infrastructure helping the community adapt to this changing climate. Services and infrastructure may be related to social programs, or recreational or transportation needs, as required for the City to thrive.

Overall, the cost of climate change on the City’s infrastructure and services can be substantial and varied. Estimating for all these costs is difficult, and over time should be integrated into all of the City’s short-term and long-term budgeting and planning programs.

7.2.1 Costing Climate Change Impacts to Public Infrastructure Project

In 2019, the FAO initiated the Costing Climate Change Impacts to Public Infrastructure (CIPI) project to analyze the costs that the impacts of climate change could impose on Ontario’s provincial and municipal infrastructure. Over the past several years, the CIPI project has released a number of publications which provide a very useful framework for estimating the costs of climate change. The following table summarizes key reports released through the CIPI project.

Table 20 Costing Climate Change Impacts to Public Infrastructure Project Publications

Report Title	Description
“Costing Climate Change Impacts and Adaptation for Provincial and Municipal Public Infrastructure in Ontario” (WSP 2021)	This report presents the results of two phases within the CIPI project: Phase 1, which includes the development of the methodology used to estimate the costs of climate change on infrastructure and methodology and testing on a select number of climate infrastructure interactions (buildings); and Phase 2, which integrates the lessons learned from Phase 1 and extends the model to the remainder of the climate infrastructure interactions. https://www.fao-on.org/en/Blog/Publications/cipi-wsp
“Costing Climate Change Impacts to Public Infrastructure Project Backgrounder and Methodology” (Park et al. 2021)	The purpose of this report is to: discuss the project’s context, origins and future releases; describe the selection rationale for the climate hazards to public infrastructure included in the project; discuss the climate projections used to project these hazards to public infrastructure; and outline the project’s costing methodology including key concepts, caveats and assumptions. https://www.fao-on.org/en/Blog/Publications/cipi-backgrounder

Report Title	Description
<p>“Costing Climate Change Impacts to Public Infrastructure: Assessing the financial impacts of extreme rainfall, extreme heat, and freeze-thaw cycles on public buildings in Ontario” (Afroz et al. 2021)</p>	<p>This report examines the impacts of changes in extreme rainfall, extreme heat, and freeze-thaw cycles on the long-term costs of maintaining public buildings in a state of good repair.</p> <p>https://www.fao-on.org/en/Blog/Publications/cipi-buildings</p>
<p>“Costing Climate Change Impacts to Public Infrastructure Transportation: Assessing the financial impacts of extreme rainfall, extreme heat and freeze-thaw cycles on public transportation infrastructure in Ontario” (Afroz et al. 2022a)</p>	<p>This report examines how changes in extreme rainfall, extreme heat and freeze-thaw cycles will impact the long-term costs of maintaining public transportation infrastructure in a state of good repair.</p> <p>https://www.fao-on.org/en/Blog/Publications/cipi-transportation</p>
<p>“Costing Climate Change Impacts to Public Infrastructure Linear Storm and Wastewater: Assessing the financial impacts of extreme rainfall on public linear storm and wastewater infrastructure in Ontario” (Afroz et al. 2022b)</p>	<p>This report examines the impacts of more extreme rainfall on the long-term costs of maintaining public linear storm and wastewater infrastructure in a state of good repair.</p> <p>https://www.fao-on.org/en/Blog/Publications/cipi-water</p>

The methodology developed as part of the CIPI project is very granular. This methodology is presented in detail in WSP (WSP 2021) and includes the use of climate-cost elasticities to estimate the change in USL, O&M cost, or adaptation cost for specific asset components (e.g., building foundation) and climate indicator of interest (e.g., freeze-thaw cycle) as a function of the CRV. The CIPI project applied this methodology to estimate the cumulative cost of climate change for all publicly owned buildings (Afroz et al. 2021), transportation (Afroz et al. 2022a), or stormwater/wastewater assets (Afroz et al. 2022b). The reports illustrate that the impact of uncertainty is considerable for long-term cost projections.

The CIPI reports for buildings, transportation, and water provide estimates of total O&M and capital costs for publicly owned assets under the stable climate (2022-2100) and also provide estimates for total costs under future climate conditions. Moderate and high GHG emissions

scenarios account for three adaptation strategies including no adaptation, reactive adaptation, and proactive adaptation. These adaptation strategies are described as follows:

- **No Adaptation Strategy:** An asset management strategy where public infrastructure assets are not adapted to a changing climate.
- **Reactive Adaptation Strategy:** An asset management strategy where public infrastructure assets are only adapted at the time of renewal to withstand changes in climate.
- **Proactive Adaptation Strategy:** An asset management strategy where most public infrastructure assets are adapted to withstand changes in climate during the asset's service life.

Figure 16 illustrates some of the key results from the CIPI reports for buildings, transportation, and water assets, illustrating the total cumulative costs of climate change under the high GHG emissions scenario from 2022 to 2100 and the three adaptation strategies. These cumulative costs represent those costs over and above the O&M and capital costs needed to maintain assets and asset performance under a stable climate. The CIPI analysis suggest that the total cumulative costs of climate change on water (stormwater, wastewater) assets will be between 102% and 119% of the CRV. The total costs of climate change on buildings will range from 36% to 46% of the CRV of these assets. The total costs of climate change on transportation assets will be between 68% and 98% of the current replacement costs of these assets depending on the adaptation strategy implemented.

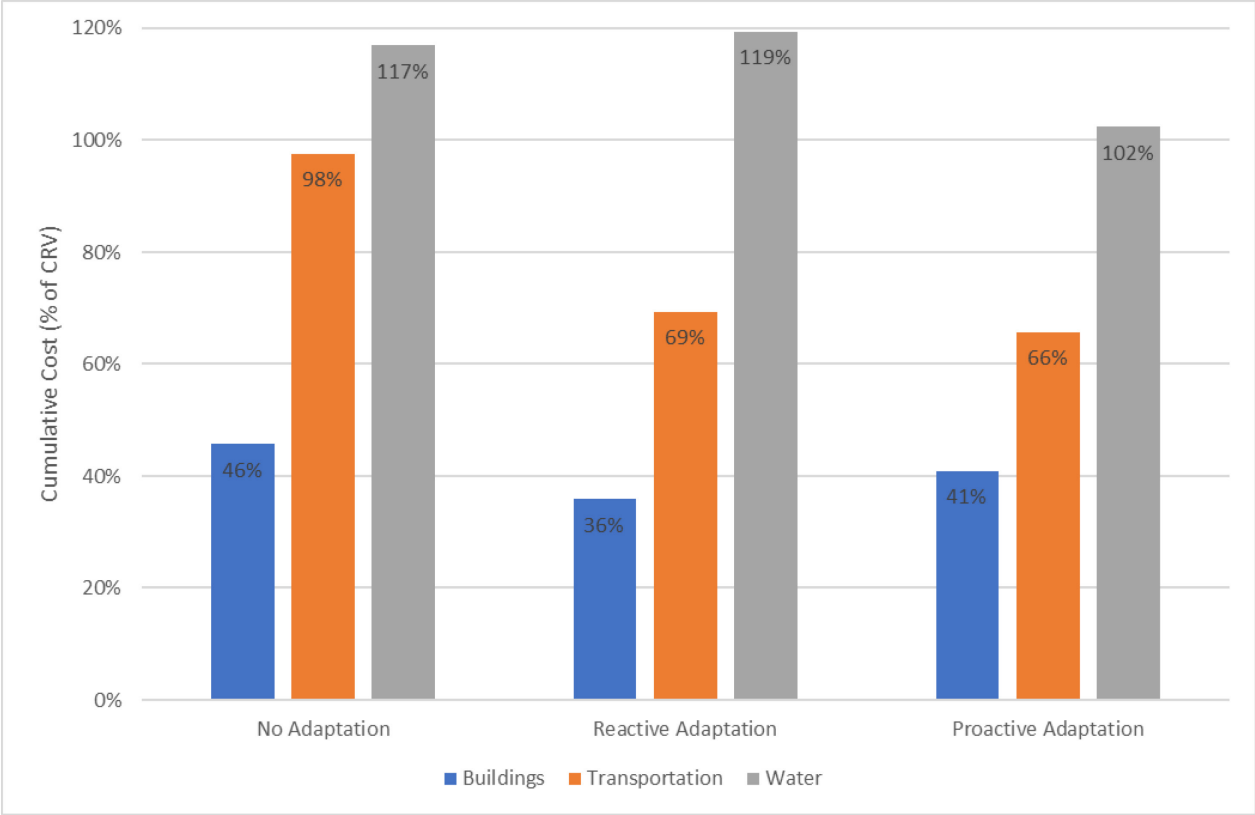


Figure 16 Cumulative Cost of Climate Change on Public Sector Assets, 2022-2100, Percentage of Current Replacement Value, High Emissions Scenario (Afroz et al. 2022a, 2022b, 2021)

7.2.2 Estimated Long-Term Cost of Climate Change for the City of Guelph

By developing its “Corporate Asset Management Plan” (City of Guelph 2020a) and “Core Asset Management Plan” (City of Guelph 2021a), the City has estimated the CRV for most of its assets. The estimated CRVs and the cumulative cost factors illustrated in Figure 16 can be used to estimate the cumulative cost of climate change on the City’s buildings, infrastructure, and water assets. Table 21 summarizes these estimate costs for each main asset class. This table only includes building, infrastructure, and stormwater/wastewater assets. The CIPI project did not include water supply infrastructure in its analysis, and the FAO’s cumulative cost estimates for stormwater/wastewater are used to for illustrative purposes. Table 21 also calculates the total cost of maintaining assets (O&M and Capital Costs) under a stable climate calculated from CRV according to results published by the CIPI project.

Table 21 Estimated Cumulative Cost of Climate Change on Buildings, Transportation, and Water Assets

City of Guelph Assets	CRV (\$ millions) (2021)	Total Cost to Maintain Infrastructure Under Stable Climate (\$ millions)		Cumulative Cost of Adapting Infrastructure to Climate Change (\$ millions) (2022-2100)			Annual Cumulative Cost of Adapting Infrastructure to Climate Change (\$ millions)		
		Total (2022-2100)	Annual	No Adaptation	Reactive Adaptation	Proactive Adaptation	No Adaptation	Reactive Adaptation	Proactive Adaptation
Administrative and Operations Facilities	\$153	\$482	\$6.17	\$70	\$55	\$63	\$0.90	\$0.70	\$0.80
Emergency Services	\$49	\$154	\$1.98	\$22	\$18	\$20	\$0.29	\$0.23	\$0.26
Parking	\$60	\$187	\$2.40	\$27	\$21	\$24	\$0.35	\$0.27	\$0.31
Parks; Recreation and Cultural (Facilities)	\$327	\$629	\$8.06	\$91	\$72	\$82	\$1.17	\$0.92	\$1.05
Solid Waste	\$67	\$211	\$2.70	\$31	\$24	\$27	\$0.39	\$0.31	\$0.35
Stormwater	\$853	\$1,651	\$21.16	\$997	\$1,018	\$873	\$12.78	\$13.05	\$11.20
Transit	\$19	\$61	\$0.78	\$9	\$7	\$8	\$0.11	\$0.09	\$0.10
Transportation	\$1,222	\$3,759	\$48.19	\$1,193	\$848	\$804	\$15.29	\$10.87	\$10.30
Wastewater	\$680	\$1,316	\$16.87	\$795	\$811	\$696	\$10.19	\$10.40	\$8.93
Water	\$771	\$5,868	\$75.23	\$901	\$920	\$789	\$11.55	\$11.79	\$10.12
Grand Total	\$4,200	\$14,317	\$183.55	\$4,136	\$3,793	\$3,387	\$53.03	\$48.63	\$43.42

Notes:

CRV - current replacement value

As summarized in Table 21 and reported in the City's asset management program, the CRV of the City's buildings, transportation, and water infrastructure is \$4.2B. Using the results of the CIPI project, the total cost to maintain this infrastructure under stable climate conditions for the 2022-2100 period will be more than \$14B or approximately \$184M per year. This annual O&M and capital cost compares to the City's total approved funding of \$225M per year covering the costs of replacement, renewal, rehabilitation, and maintenance of existing assets as reported in the 2020 Corporate Asset Management Plan.

Using the CIPI framework, the City's total cumulative cost of adapting infrastructure to climate change ranges from \$3.4B to \$4.1B depending on the adaptation strategy used. On an annual basis, this total additional cost equates to a range of \$43M to \$53M which is approximately 25% of the cost of maintaining assets under a stable climate. This additional cost of climate change is incremental to the \$77.5M per year funding gap already in place for the next 25-year period (Section 3.5).

These costs only address buildings, built or grey infrastructure, and water and do not include costs related to future disasters or emergency events, green infrastructure, services, health and social welfare, equipment, or vehicles. A recommended next step for the Climate Adaptation Plan and the Natural Assets Inventory, Condition, Risk and Service Attribution will be to establish the cost of climate change to the City's natural assets.

7.3 Funding Opportunities

Generally, municipalities in Canada raise revenue internally through the "Pay as You Go" principle, from property taxes and user fees or utility rates. Municipal budgets can also be supplemented through external sources of revenue, such as federal and provincial gas tax programs. In cases of emergencies and disasters, municipalities can also receive response and relief funding from federal and provincial governments through the Disaster Financial Assistance Arrangements. In terms of new infrastructure projects, municipalities in Ontario have traditionally relied on development charges to cover the capital costs for new infrastructure and services such as roads, water, fire protection, and recreation facilities for new areas being developed. Debt financing is also an option, but one that is rarely used by municipalities.

There are a limited number of ways that a municipality can raise revenue and cover the costs of climate adaptation measures for existing infrastructure assets, and for developing new infrastructure that incorporates a higher design standard in response to future climate change risks. Municipalities can allocate funds from its budget for O&M and asset management toward

climate adaptation projects, such as setting aside resources for upgrading infrastructure, implementing nature-based solutions, and improving emergency services delivery. Grants and loans are also available from external sources, such as federal and provincial agencies, non-profit organizations, or private foundations. In theory, Public-private partnerships (P3s) are also an option but are rarely used at the municipal level unless it is for major capital projects such as transit infrastructure. Insurance and risk management strategies are also an important tool that municipalities can use to protect themselves against the financial risks associated with climate change.

For existing infrastructure assets and services, the main financial source to support adaptation actions by the City is internal, primarily through the asset management program and capital budget. There may be an opportunity to allocate some of the federal and provincial gas tax toward climate adaptation measures that apply to O&M and asset management, but otherwise the City must rely upon its existing revenue stream. However, in terms of managing the City's infrastructure assets to existing climate, there is already a shortfall, even for the four key asset groups covered through the Asset Management Plans: transportation, stormwater, wastewater, and water (Section 3.5). The City also has an infrastructure renewal strategy in place with sustainable funding targets, 25-year capital plans, etc. to address financial needs for maintaining, renewing, and replacing infrastructure assets. Components of Bill 23 could also accelerate development within the City and may affect the implementation of climate adaptation actions and protection of the existing natural heritage system. Bill 23 removes the need for Site Plan Approval for developments with ten units or less, limiting the ability of the City to apply site-specific stormwater management or tree planting conditions. Additionally, Bill 23 limits the extent to which wetlands can be preserved and protected, potentially leading to a loss of their crucial stormwater retention and infiltration functions.

The recommended adaptation actions have not been adjusted as a result of Bill 23; however, it may require the City to implement projects at a faster pace (e.g., the 2023-2041 horizon may need to be accelerated to 2031). This impact will be addressed through the multi-year budget for 2024-2027 where resource and budgetary requirements from all City Master Plans are incorporated. Ultimately, Bill 23 and the associated pace of growth will require monitoring and future update of the Master Plans, which will occur in the next planned 5-year cycle.

The Government of Canada has taken an active role in addressing the need for public infrastructure to become climate resilient, by providing funding for new infrastructure projects either directly or in partnership with other levels of government, and through the improvement of design standards that take climate change into account. In the latter case, the Climate

Resilient Buildings and Core Public Infrastructure Initiative was in effect from 2016-2021 and had an initial budget of \$42.5 million in financial support from Infrastructure Canada, to support the National Research Council to integrate climate resilience into building and infrastructure design, guides, and codes. Among the list of standards and guidelines upgraded to consider climate change into buildings and infrastructure that may be of interest to municipalities includes:

- new standards related to the Construction of Bioretention Systems (CSA: W200 and W201) that outline requirements and recommendations for LID
- CSA Z800 Guideline on basement flood protection and risk reduction that covers measures to reduce the risks of basement flooding
- CSA standard for Climate Change Adaptation to Wastewater Treatment Plants (S900.1)
- CSA standard for Flood Resilient Design of New Residential Communities (CSA/W204)

This program was renewed into the Climate Resilient Built Environment initiative and the Standards to Support Resilience in Infrastructure Program in 2022, with a budget of \$46.7 million. The latter program's share of the budget is \$11.7 million over 5 years, and is led by the Standards Council of Canada to deliver standards and guidance that address priority areas such as heat, flooding, and permafrost degradation in the North.

The primary support by the federal government is through the Investing in Canada Plan, that was launched in 2016 as the pillar to the federal/provincial/territorial Pan-Canadian Framework on Clean Growth and Climate Change: Canada's Plan to Address Climate Change and Grow the Economy. The plan commits Canada to over \$180 billion over 12 years for infrastructure that benefits Canadians and has three objectives including for new infrastructure to be Sustainable & Resilient. Investment streams include Public Transit, Green, Social, and Trade and Transportation. Other programs where municipalities across Ontario have received funding include the Disaster Mitigation and Adaptation Fund, and the Sustaining Healthy Communities Through a New Clean Water and Wastewater Fund.

The City of Guelph has been relatively successful in receiving federal funds for various Infrastructure projects: over \$23 million from Infrastructure Canada, Canada Mortgage and Housing Corporation, Employment and Social Development Canada, and Regional Development Agencies. Projects funded by Infrastructure Canada typically have the requirement to have a "Climate Lens" applied to their design, taking into account their GHG emissions and their resiliency to the physical risks of climate change. Funding received includes almost \$19 million towards the construction of a new Guelph Transit Bus Storage Facility. In addition, the City of Guelph and Wellington County was one of two communities with populations under 500,000

people that was awarded \$10 million towards the “Our Food Future” initiative through the SMART Cities Challenge. Initiated in 2017, the Government of Canada challenged communities across the country to develop bold and ambitious ideas to improve the lives of their residents' using data and connected technology. The funding would support Guelph-Wellington efforts to become Canada’s first technology-enabled Circular Food Economy, where an inclusive food-secure ecosystem increases access to affordable, nutritious food by 50% and where “waste” becomes a resource.

There are also programs delivered by the FCM, such as their Green Municipal Fund which is a \$1.6 billion program to help local governments switch to sustainable practices faster, while their mix of funding, resources and training gives municipalities the tools they need to build resiliency. The five priority areas are energy, waste, transportation, land use, and water, noting that funding is available as grants and loans, and can cover between 50 and 80% of eligible costs. Of note among their resources and training materials, FCM has recently focused attention on climate change and asset management, and some of their materials have been helpful in informing the development of this Climate Adaptation Plan.

Overall, there is no simple solution or singular source for paying for the costs of climate adaptation. Finding the resources needed will require a combination of financial strategies, partnerships, and creative solutions. Municipalities must consider a range of funding sources and explore new models of collaboration to ensure that they are adequately prepared for the impacts of climate change. While opportunities will continue to exist to access federal funding towards new infrastructure, this option is neither expansive enough, nor sustainable to address all of the immediate and/or foreseeable needs for the City of Guelph’s infrastructure and adaptation deficit. For example, the \$23 million the City has received from the federal government for various infrastructure projects represents about 0.5% of the CRV of the City of Guelph’s infrastructure assets, or 33% of the estimated funding gap expected from the additional annual costs of managing assets under climate change over the next 25 years. Internal funding through property tax and user/utility fees will continue to be the primary financial source to support future asset management and capital planning needs, and given that there is already a shortfall that exists, it is expected that climate change will exacerbate this shortfall even further.

7.4 Departmental/Divisional Responsibilities for Implementation

The list of 163 climate adaptation actions (including both existing and recommended) was separated out by the department/division that was tasked to lead each particular action (denoted as the Managing Department). This was done for ease of implementation of the

Climate Adaptation Plan since the City’s Capital and O&M budgets and annual business plans are developed on a department-by-department/division-by-division basis. The actions assigned to each department/division were developed from the one-on-one meetings with the Staff Working Group and further refined through the staff poster session (Section 2.5.3) and in the recent multi-year budget internal submission process.

Tables 23 to 46 present the climate adaptation actions, separated by Managing Department. Appendix C.5 presents the full Implementation Plan for the Climate Adaptation Plan. The implementation plan actions are listed with the following columns:

- Action Number (No.): Each action (City-wide) was given a unique number for ease of reference in the future.
- Action Status: Existing or Recommended. Existing actions refer to those that are either already being implemented by the respective department/division or are planned to be implemented in an already-approved budgetary item and/or Master Plan.
- Collaborating/Benefitting Departments: This refers to any key internal or external partnerships required to support the implementation of the particular action, and also any departments/divisions that benefit from the action’s implementation.
- Action Type: Capital, O&M, Planning/Policy. Refers to whether the action would be a capital expenditure, an O&M item, or a policy/planning exercise.
- Schedule: refers to the recommended timeline for implementation. Based on input from the Core Project Team, the schedule timeframes were adjusted to align with the City’s multi-year budget planning process and intended to complement the master planning cycles. The schedule terms are defined in Table 22.

Table 22 Climate Adaptation Plan Implementation Timeframes

Term	Timeframe
Short-term Actions	0 to 4 years
Medium-term Actions	4 to 7 years
Long-term Actions	Over 7 years
Ongoing Actions	Ongoing

- **Estimated Resources:** refers to the approximate cost range to complete the recommended action, where “\$” - \$0 to \$100,000; “\$\$” - \$100,000 to \$1Million”; and “\$\$\$” - Greater than \$1Million. Section 7.3 provides a summary of potential funding avenues based on current literature and examples.
- **Goal Alignment:** refers to which Climate Adaptation Plan goal(s) established for the project (Section 1.2) are satisfied by completing the action.
- **Example of KPIs:** These are quantifiable measurement(s) that can be used to gauge progress on a particular action. The tables provide example KPIs based on literature review. Ultimately, it will be up to the Managing Department to set the key performance indicator(s) that are most appropriate and resonate best. A more fulsome descriptions of the KPIs is provided in the subsection below.

7.4.1 Key Performance Indicators

Overall, developing climate adaptation KPIs is a critical step in helping municipalities evaluate their progress towards resiliency, the effectiveness of their actions, and to help them better prepare for new or unexpected impacts of climate change. Most importantly, by identifying and tracking key metrics, organizations can better understand their vulnerabilities and take action to reduce the risks associated with climate change.

As part of the ongoing resilience plan monitoring, KPIs are recommended for each action that can be used to track the effects of mitigating strategies on reducing the risk exposure.

Indicators must meet SMART criteria:

- specific area for improvement
- measurable indicator of progress
- assignable responsibility
- realistic outcomes that can be achieved given available resources, and
- time-related when results can be achieved

The Managing Department for a given action will also track the KPIs associated with that action. The department/division will need to determine their data collection and reporting methods. This could involve collecting data from various departments/divisions within the organization, implementing monitoring systems, or conducting surveys to gather information. The Managing Department will then need to monitor and review these KPIs at some established frequency (i.e., annually) to confirm that the organization is making progress towards its climate

adaptation goals. This will involve analyzing the KPI data, identifying areas for improvement, and making necessary adjustments to the organization's climate adaptation strategies.

Based on best practice, there are two types of indicators that are recommended to be tracked, reported, and evaluated: Process Indicators and Outcome Indicators.

Process Indicators - are process-based that measure activities and outputs. Examples include:

- Number of adaptation actions from the Climate Adaptation Plan that have been implemented
- Percentage of allocated budget utilized
- Number of residents engaged through climate change adaptation programs, events and online
- Number of trees planted (total and annual)
- Staff time spent on planning and implementing actions
- Kilometers of storm sewer replaced (annual)
- Number of City-owned buildings that have undergone flood-resiliency upgrades or retrofits
- Percentage of critical infrastructure with backup power
- Number of shade structures and other cooling features in public spaces
- Number of new green infrastructure or LID projects undertaken by the City

Since process indicators measure the degree to which the City is implementing the actions outlined in the Climate Adaptation Plan, but not measure if the actions have succeeded in reducing vulnerabilities to climate change, it is important to also set develop outcome indicators.

Outcome Indicators - are outcome-based and by definition assume a greater importance but are more challenging to measure. This type of indicator may be something which the City can actively control or cannot control but still chooses to monitor. A significant, prolonged change in these indicators would indicate that the potential risk exposure may have changed. Examples include:

- Percent change in Guelph's tree canopy
- Staff time spent on disaster recovery/clean up (e.g., tree damage)
- Change in greenhouse gas emissions from Guelph's buildings, transit fleet, operations vehicles
- Decrease in building and services downtime after a major climate event

- Number of flooded basement complaints year over year/Dollar value of City insurance claims for water damage due to flooding
- Staff lost time due to climate-related illness (e.g., heat stroke, sun stroke)
- Number of heat-related brownouts
- Number and volume of sanitary sewer overflows per year
- Amount of local food production
- Number of cases of West Nile and Lyme disease

It is expected that the collection of data and reporting on the Climate Adaptation Plan's implementation success will be done on a yearly basis, with an annual update to City Council once implementation begins. Annual reporting will allow decision-makers to identify trends and allow for the re-calibration of actions as needed. Public reporting on implementation may be done through Microsoft® Power BI or other tool and in alignment with the City of Guelph's corporate webpage.

Table 23 All Departments

No.	Adaptation Actions	Action Status	Collaborating /Benefitting Departments	Implementation				Example Key Performance Indicators
				Action Type	Schedule	Estimated Resources ⁽¹⁾	Goal Alignment	
140	Engage MCFN and SNGR in the City's pre-consultation process.	Recommended	<ul style="list-style-type: none"> All departments/ divisions MCFN SNGR 	Policy	Short term	\$	<ul style="list-style-type: none"> Environment & Health Equity 	Number of projects that engage MCFN and SNGR in the City's pre-consultation process.
162	City managers to prioritize staff retention recognizing that the knowledge of staff is one of the City's best assets in an emergency situation.	Recommended	<ul style="list-style-type: none"> All departments/ divisions 	Policy	Ongoing	\$\$	<ul style="list-style-type: none"> Environment & Health Safety 	Percentage of staff retention annually.

Notes:

(1) Estimated Resources: \$ less than \$100,000; \$\$ between \$100,000 and \$1,000,000; and \$\$\$ more than \$1,000,000

MCFM - Mississaugas of the Credit First Nations

SNGR - Six Nations of the Grand River

Table 24 Asset Management

No.	Adaptation Actions	Action Status	Collaborating /Benefitting Departments	Implementation				Example Key Performance Indicators
				Action Type	Schedule	Estimated Resources ⁽¹⁾	Goal Alignment	
5	Continue performance condition assessment and level of service reviews on all assets. Work with project managers to recommend priority lists for upgrades and replacement.	Existing	<ul style="list-style-type: none"> All departments/ divisions 	Capital	Ongoing	\$\$	<ul style="list-style-type: none"> Environment & Health Infrastructure Safety Equity 	<ul style="list-style-type: none"> Number of assets with an up-to-date condition assessment and level of service review Number/percentage of assets where climate-related risks have been incorporated into their condition assessment and review of LOS
12	Continue performance rating for each asset and send recommended priority lists to project managers.	Existing	<ul style="list-style-type: none"> All departments/ divisions 	Capital	Ongoing	\$\$	<ul style="list-style-type: none"> Environment & Health Infrastructure Safety 	<ul style="list-style-type: none"> Completion of list of asset performance rating and prioritization.
18	Maintain the Building Condition Assessments to inform Asset Management Plan and renewal planning.	Existing	<ul style="list-style-type: none"> All departments/ divisions 	Capital	Ongoing	\$ to \$\$	<ul style="list-style-type: none"> Environment & Health Infrastructure Safety Equity 	<ul style="list-style-type: none"> Number of buildings with up-to-date building condition assessments that consider climate-related risks (e.g., conducted within the last 2 years).
23	Establish a regular communication plan between all departments with assets and the Asset Management Group to keep up to date on asset upgrades/replacements.	Recommended	<ul style="list-style-type: none"> All departments/ divisions 	Policy	Ongoing	\$	<ul style="list-style-type: none"> Infrastructure Economy Safety 	<ul style="list-style-type: none"> Apply learnings from the Climate Action Plan across all departments/divisions with infrastructure assets regarding decisions on asset upgrades/replacements.

No.	Adaptation Actions	Action Status	Collaborating /Benefitting Departments	Implementation				Example Key Performance Indicators
				Action Type	Schedule	Estimated Resources ⁽¹⁾	Goal Alignment	
40	Update the Natural Assets Inventory.	Existing	<ul style="list-style-type: none"> All departments/ divisions 	Capital	Medium term	\$	<ul style="list-style-type: none"> Environment & Health Infrastructure Safety 	<ul style="list-style-type: none"> Up-to-date Natural Assets Inventory.
42	Include climate change in current planning/formula in asset state assessment (e.g., follow Municipal Finance Officers' Association for guidance)	Recommended	<ul style="list-style-type: none"> All departments/ divisions 	Capital	Short term	\$	<ul style="list-style-type: none"> Environment & Health Infrastructure Safety 	<ul style="list-style-type: none"> Inclusion of the formula into the asset state assessment.
55	Continue pavement condition monitoring in collaboration with Engineering (Transportation).	Existing	<ul style="list-style-type: none"> Engineering (Transportation) Public Works (Operations) 	O&M	Ongoing	\$	<ul style="list-style-type: none"> Infrastructure Economy Safety Equity 	<ul style="list-style-type: none"> Number of logs in collaboration with Asset Management regarding pavement condition. Number of pavement projects scoped.
56	Communicate with Engineering (Transportation) to identify priority capital or repair works at a corridor level and provide feedback when those works are completed.	Existing	<ul style="list-style-type: none"> Engineering (Transportation) Public Works (Operations) Transit Alectra Enbridge Gas Guelph Junction Railway CN Rail Metrolinx 	O&M	Ongoing	\$	<ul style="list-style-type: none"> Infrastructure Economy Safety Equity 	<ul style="list-style-type: none"> Percentage of completed work reported to Asset Management. Number of regular meetings to discuss priority capital and repair works at a corridor level.
66	Conduct a storm sewer condition assessment. The storm sewer condition is largely unknown, especially in the older sections of Guelph (which are also typically home to the more vulnerable population).	Recommended	<ul style="list-style-type: none"> Engineering (Stormwater) Public Works (Operations) Wastewater Water Services Planning Parks 	O&M	Short term	\$\$	<ul style="list-style-type: none"> Environment & Health Infrastructure Safety Equity 	<ul style="list-style-type: none"> Length of storm sewer assessed.
77	Determine if development of a local Guelph climate change model/data portal with maps and data specific to the City's vulnerabilities is a worthwhile City project.	Recommended	<ul style="list-style-type: none"> Parks Public Works (Operations) Facilities Stormwater Planning Contaminated Sites Wellington Dufferin Guelph Public Health 	Capital	Short term to medium term	\$	<ul style="list-style-type: none"> Environment & Health Infrastructure Economy Safety 	<ul style="list-style-type: none"> Scope out work to initiate climate change model/data portal.

No.	Adaptation Actions	Action Status	Collaborating /Benefitting Departments	Implementation				Example Key Performance Indicators
				Action Type	Schedule	Estimated Resources ⁽¹⁾	Goal Alignment	
139	Asset Management to take on the role of monitoring progress on implementing actions recommended in the City's Climate Adaptation Plan and updating this Plan every five years.	Recommended	<ul style="list-style-type: none"> All departments/ divisions 	Capital	Short term	\$	<ul style="list-style-type: none"> Environment & Health Infrastructure Safety Equity 	<ul style="list-style-type: none"> Update of the Climate Action Plan. Continued monitoring and implementation of actions in the Climate Action Plan.
141	Form an internal climate change working group, to be led by Asset Management, as per the Asset Management Plan recommendations.	Recommended	<ul style="list-style-type: none"> All departments/ divisions 	Planning	Short-term	\$	<ul style="list-style-type: none"> Environment & Health Infrastructure Safety Equity 	<ul style="list-style-type: none"> Number of meetings held by the Climate Change Working Group.

Notes:

(1) Estimated Resources: \$ less than \$100,000; \$\$ between \$100,000 and \$1,000,000; and \$\$\$ more than \$1,000,000

O&M - operation and maintenance

LOS - loss of service

Table 25 Chief Administrative Officer's Office

No.	Adaptation Actions	Action Status	Collaborating /Benefitting Departments	Implementation				Example Key Performance Indicators
				Action Type	Schedule	Estimated Resources ⁽¹⁾	Goal Alignment	
154	Grow the circular economy by creating and implementing the Circular Economy Framework.	Existing	<ul style="list-style-type: none"> Solid Waste County of Wellington Wellington Dufferin Guelph Public Health 	Capital	Ongoing	\$\$	<ul style="list-style-type: none"> Environment & Health Economy Safety Equity 	<ul style="list-style-type: none"> Investment (\$) in Circular Economy Framework. Budget allocated for resiliency in the food stream.

Notes:

(1) Estimated Resources: \$ less than \$100,000; \$\$ between \$100,000 and \$1,000,000; and \$\$\$ more than \$1,000,000

O&M - operation and maintenance

Table 26 Communications

No.	Adaptation Actions	Action Status	Collaborating /Benefitting Departments	Implementation				Example Key Performance Indicators
				Action Type	Schedule	Estimated Resources ⁽¹⁾	Goal Alignment	
132	Continue involvement in the Emergency Operations Group.	Existing	<ul style="list-style-type: none"> All departments/ divisions 	Planning	Ongoing	\$	<ul style="list-style-type: none"> Safety Equity 	<ul style="list-style-type: none"> Attendance to meetings or regular correspondence with the Emergency Operations Group.
133	Consider how to use communications to weave in climate change adaptation and mitigation messaging and make connections across the corporation.	Existing	<ul style="list-style-type: none"> All departments/ divisions 	Planning	Ongoing	\$	<ul style="list-style-type: none"> Economy Safety Equity 	<ul style="list-style-type: none"> Number of communications with climate change adaptation and mitigation messaging.
136	Establish emergency internal and external communications that include digital and broadcast media in multiple languages, as well as American Sign Language.	Recommended	<ul style="list-style-type: none"> All departments/ divisions County of Wellington Red Cross 	Capital	Ongoing	\$	<ul style="list-style-type: none"> Infrastructure Safety Equity 	<ul style="list-style-type: none"> Percentage of population that receive messaging in their first language (in accordance with census). Number of languages included in messaging.
137	Develop a list of support agencies to contact during an emergency to accelerate assistance to those in need. Create a plan outlining how and when these agencies will be contacted efficiently.	Recommended	<ul style="list-style-type: none"> All departments/ divisions County of Wellington Red Cross Wellington Dufferin Guelph Public Health 	Capital	Ongoing	\$	<ul style="list-style-type: none"> Infrastructure Safety Equity 	<ul style="list-style-type: none"> Completion of list of support agencies and plan to contact these agencies efficiently.
145	Establish business continuity plan in case communications are not available.	Recommended	<ul style="list-style-type: none"> All departments/ divisions All Partner Working Group 	Planning	Short term	\$	<ul style="list-style-type: none"> Economy Safety Equity 	<ul style="list-style-type: none"> Percentage of business continuity plans that consider climate-related risks.
147	Continue to follow and adopt the Community Engagement and Communications Plan, and coordinate community consultation with the Sustainability Master Plan.	Existing	<ul style="list-style-type: none"> All departments/ divisions All Partner Working Group 	Policy	Ongoing	\$	<ul style="list-style-type: none"> Environment & Health Infrastructure Economy Safety Equity 	<ul style="list-style-type: none"> Continued adoption of the Community Engagement and Communications Plan. Continued consultation with the Sustainability Master Plan.
148	Leverage appropriate communications tactics during climate-related events.	Existing	<ul style="list-style-type: none"> All departments/ divisions All Partner Working Group 	O&M	Ongoing	\$	<ul style="list-style-type: none"> Safety Equity 	<ul style="list-style-type: none"> Strategies in place to target communications during climate-related events.

Notes:

(1) Estimated Resources: \$ less than \$100,000; \$\$ between \$100,000 and \$1,000,000; and \$\$\$ more than \$1,000,000

O&M - operation and maintenance

PWG - Partner Working Group

Table 27 Compliance and Performance

No.	Adaptation Actions	Action Status	Collaborating /Benefitting Departments	Implementation			Goal Alignment	Example Key Performance Indicators
				Action Type	Schedule	Estimated Resources ⁽¹⁾		
68	Continue implementing the Water Efficiency Strategy programming, with periodic updates to programming offered, and evaluate its effectiveness at reducing water demand in the City.	Existing	<ul style="list-style-type: none"> Water Services Wastewater Stormwater Communications Grand River Conservation Authority 	Capital	Short term	\$\$\$	<ul style="list-style-type: none"> Environment & Health Infrastructure Economy Safety Equity 	<ul style="list-style-type: none"> Measure of water demand (litres per person).
69	Complete a Drought Response Operational Plan for the City.	Planned	<ul style="list-style-type: none"> Water Services Communications Grand River Conservation Authority 	Capital	Short term	\$	<ul style="list-style-type: none"> Environment & Health Infrastructure Economy Safety Equity 	<ul style="list-style-type: none"> Completion of an Operational Drought Response Plan.
70	Establish an Integrated Water Management Strategy for Guelph. The strategy should look at water reuse opportunities from wastewater and stormwater for non-potable uses (industry, vehicle washing, fire suppression, etc.).	Planned	<ul style="list-style-type: none"> Water Services Wastewater Stormwater Solid Waste 	Capital	Short term	\$\$ to \$\$\$	<ul style="list-style-type: none"> Environment & Health Infrastructure Economy Safety Equity 	<ul style="list-style-type: none"> Estimated reuse of water (litres). Number of places offering reusable water.
159	Expand upon rebate program for private rainwater harvesting, rain barrels, and downspout disconnect.	Recommended	<ul style="list-style-type: none"> Engineering (Stormwater) Asset Management Public Works (Operations) Communications 	Capital	Ongoing	\$	<ul style="list-style-type: none"> Environment & Health Infrastructure Equity 	<ul style="list-style-type: none"> Number of rainwater harvesting units and rain barrels sold. Percentage of downspouts disconnected.

Notes:

(1) Estimated Resources: \$ less than \$100,000; \$\$ between \$100,000 and \$1,000,000; and \$\$\$ more than \$1,000,000

Table 28 Culture and Recreation

No.	Adaptation Actions	Action Status	Collaborating /Benefitting Departments	Implementation				Example Key Performance Indicators
				Action Type	Schedule	Estimated Resources ⁽¹⁾	Goal Alignment	
1	Work with Facilities to ensure adequate air conditioning in offices and recreation facilities, continue with routine maintenance on these systems.	Existing	<ul style="list-style-type: none"> Culture and Recreation Asset Management Facilities and Energy Management Red Cross 	O&M	Ongoing	\$	<ul style="list-style-type: none"> Environment & Health Infrastructure Safety Equity 	<ul style="list-style-type: none"> Number of air conditioning units in good condition. Percentage of spaces with air conditioning. Percentage of air conditioning units in need of repair and/or replacement (reverse key performance indicator); amount of time to repair and/or replace air conditioner units.
24	Periodically review, maintain, and update use of recreation facilities as emergency shelter buildings. Review with an equity lens. This includes coordination with the County of Wellington, Wellington Dufferin Guelph Public Health, and Emergency Services.	Recommended	<ul style="list-style-type: none"> Asset Management Equity, Diversity, and Inclusion Emergency Services County of Wellington Red Cross Wellington Dufferin Guelph Public Health 	Planning	Ongoing	\$	<ul style="list-style-type: none"> Environment & Health Infrastructure Safety Equity 	<ul style="list-style-type: none"> Develop and apply a protocol to review recreational facilities as emergency shelter buildings, taking into account climate-related risks and equity concerns. Percentage of recreation facilities where the protocol for climate-related risks and equity concerns have been applied. The percentage of recreation facilities where onsite evaluations have been completed, regarding climate-related risks and equity concerns.
103	Itemize culture and recreation buildings components for their resilience to climate hazard impacts and plan with Asset Management for itemization and replacement.	Recommended	<ul style="list-style-type: none"> Asset Management Facilities and Energy Management 	Planning	Short term	\$	<ul style="list-style-type: none"> Infrastructure Safety Equity 	<ul style="list-style-type: none"> Completion of an inventory of culture and recreation building assets and components and their risk to climate-related hazards. Percentage of updated and/or replaced items with a low resilience rating.
124	Work with Parks to design and upgrade low impact development features around the culture and recreation facilities.	Recommended	<ul style="list-style-type: none"> Culture and Recreation Parks Asset Management Engineering (Stormwater) 	Capital	Medium term	\$\$	<ul style="list-style-type: none"> Infrastructure 	<ul style="list-style-type: none"> Number of low impact developments implemented.
151	Maintain first-aid training for staff at recreational facilities, including equity considerations.	Existing	<ul style="list-style-type: none"> Asset Management Equity, Diversity, and Inclusion Emergency Services County of Wellington Red Cross 	O&M	Ongoing	\$	<ul style="list-style-type: none"> Environment & Health Safety Equity 	<ul style="list-style-type: none"> Number of staff with first-aid training. Ensure equity components are integrated in first aid training.

Notes:

(1) Estimated Resources: \$ less than \$100,000; \$\$ between \$100,000 and \$1,000,000; and \$\$\$ more than \$1,000,000

O&M - operation and maintenance

Table 29 Economic Development

No.	Adaptation Actions	Action Status	Collaborating /Benefitting Departments	Implementation				Example Key Performance Indicators
				Action Type	Schedule	Estimated Resources ⁽¹⁾	Goal Alignment	
142	Continue to play an active role in supporting new businesses and industries to Guelph that align with the City's sustainability and resiliency goals.	Existing	<ul style="list-style-type: none"> All departments/ divisions 	Planning	Ongoing	\$	<ul style="list-style-type: none"> Economy Safety Equity 	<ul style="list-style-type: none"> Percentage of businesses and industries committing to the City's sustainability and resiliency goals.

Notes:

(1) Estimated Resources: \$ less than \$100,000; \$\$ between \$100,000 and \$1,000,000; and \$\$\$ more than \$1,000,000

Table 30 Emergency Services

No.	Adaptation Actions	Action Status	Collaborating /Benefitting Departments	Implementation				Example Key Performance Indicators
				Action Type	Schedule	Estimated Resources ⁽¹⁾	Goal Alignment	
32	Continue to update and keep current the Memorandum of Understanding with University of Guelph to share assets and resources at times.	Existing	<ul style="list-style-type: none"> Asset Management University of Guelph 	Ongoing	Short term	\$	<ul style="list-style-type: none"> Environment & Health Infrastructure Safety 	<ul style="list-style-type: none"> Updated and current Memorandum of Understanding
33	Work with Facilities to ensure emergency building heating, ventilation and air conditioning systems are maintained and replaced as per the Asset Management Plan.	Existing	<ul style="list-style-type: none"> Facilities and Energy Management Asset Management 	O&M	Ongoing	\$	<ul style="list-style-type: none"> Environment & Health Infrastructure Safety 	<ul style="list-style-type: none"> Percentage of system that are considered maintained satisfactorily.
91	Establish route and alternate emergency route plans with team (compare with Transit) and consider with equity lens.	Recommended	<ul style="list-style-type: none"> Transit Wellington County Housing 	Planning	Short term	\$	<ul style="list-style-type: none"> Environment & Health Safety 	<ul style="list-style-type: none"> Establishment of emergency routes throughout the City with an equity lens.
92	Itemize emergency building components susceptible to hazard impacts and plan with Asset Management for replacement.	Recommended	<ul style="list-style-type: none"> Asset Management 	Capital	Short term to medium term	\$	<ul style="list-style-type: none"> Environment & Health Infrastructure Safety 	<ul style="list-style-type: none"> Create list of components with associated resilience level. Percentage of updated and/or replaced items with a low resilience rating.
100	Ensure adequate air conditioning in the building and confirm storage temperature requirements of assets.	Existing	<ul style="list-style-type: none"> Asset Management Facilities and Energy Management 	O&M	Ongoing	\$	<ul style="list-style-type: none"> Environment & Health Infrastructure Safety 	<ul style="list-style-type: none"> Percentage of systems that are considered maintained satisfactorily. Percentage of building with adequate air conditioning available.

No.	Adaptation Actions	Action Status	Collaborating /Benefitting Departments	Implementation				Example Key Performance Indicators
				Action Type	Schedule	Estimated Resources ⁽¹⁾	Goal Alignment	
106	Pursue building relocation potential outside the floodplain, consider locations with an equity lens.	Existing	<ul style="list-style-type: none"> Asset Management 	Capital	Planned long term	\$\$\$	<ul style="list-style-type: none"> Environment & Health Infrastructure Safety Equity 	<ul style="list-style-type: none"> Establish plan to relocate building outside the floodplain.
107	Establish a business continuity plan in case emergency building is compromised and provide alternate/redundant work environment in case the emergency buildings cannot be safely occupied.	Recommended	<ul style="list-style-type: none"> Asset Management County of Wellington Red Cross 	Planning	Short term to medium term	\$	<ul style="list-style-type: none"> Environment & Health Infrastructure Safety 	<ul style="list-style-type: none"> Establish a business continuity plan. Number of employees with an alternative workspace available in the event of an emergency.
108	Establish redundancy plan in case emergency vehicles are compromised.	Recommended	<ul style="list-style-type: none"> Asset Management 	Planning	Short term	\$	<ul style="list-style-type: none"> Environment & Health Safety 	<ul style="list-style-type: none"> Number of redundant vehicles available.
112	Maintain cooling feature in vehicles with adequate hydration available for staff. Provide redundancy in case cooling fails in a vehicle.	Existing	<ul style="list-style-type: none"> Asset Management 	O&M	Ongoing	\$	<ul style="list-style-type: none"> Environment & Health Safety 	<ul style="list-style-type: none"> Number of emergency vehicles with cooling feature. Number of redundant vehicles available with cooling feature.
113	Provide redundant equipment elsewhere or a plan to access equipment in case the assets are damaged.	Recommended	<ul style="list-style-type: none"> Asset Management 	Capital	Medium term	\$\$	<ul style="list-style-type: none"> Environment & Health Infrastructure Safety Equity 	<ul style="list-style-type: none"> Number of redundant equipment available. Establishment of plan to access equipment, as necessary.
157	Participate in regular emergency exercises with Wellington County, with whom paramedic services are shared and police services work closely together.	Recommended	<ul style="list-style-type: none"> Emergency Services Equity, Diversity and Inclusion County of Wellington 	Planning	Ongoing	\$	<ul style="list-style-type: none"> Environment & Health Safety 	<ul style="list-style-type: none"> Number of emergency exercises conducted with Wellington County.

Notes:

(1) Estimated Resources: \$ less than \$100,000; \$\$ between \$100,000 and \$1,000,000; and \$\$\$ more than \$1,000,000

Table 31 Engineering - Contaminated Lands

No.	Adaptation Actions	Action Status	Collaborating /Benefitting Departments	Implementation			Goal Alignment	Example Key Performance Indicators
				Action Type	Schedule	Estimated Resources ⁽¹⁾		
102	Liase with Engineering (Stormwater) to prioritize contaminated site clean ups on lands that can be used for stormwater management purposes (e.g., Bull Frog stormwater management project).	Existing	<ul style="list-style-type: none"> Asset Management Public Works (Operations) Parks Engineering (Stormwater) 	Existing	Ongoing	\$	<ul style="list-style-type: none"> Environment & Health Infrastructure Economy Equity Safety 	<ul style="list-style-type: none"> Area of contaminated lands safely repurposed for stormwater management purposes.
120	Continue completing risk assessments of contaminated lands and prioritize climate resiliency when implementing risk management measures.	Existing	<ul style="list-style-type: none"> Asset Management Public Works (Operations) Parks Engineering (Stormwater) 	Existing	Ongoing	\$\$	<ul style="list-style-type: none"> Environment & Health Infrastructure Economy Safety 	<ul style="list-style-type: none"> Number of risk assessments completed with a climate change lens for prioritization.
121	Apply lessons from other jurisdictions into planning (e.g., British Columbia Contaminated Lands, federal guidelines).	Recommended	<ul style="list-style-type: none"> Asset Management Public Works (Operations) Engineering (Stormwater) Parks 	Planning	Short term	\$	<ul style="list-style-type: none"> Environment & Health Economy 	<ul style="list-style-type: none"> Incorporation of new lessons learned from other documents into the main planning document.
122	Include climate change as part of prioritization of site remediation.	Recommended	<ul style="list-style-type: none"> Asset Management Public Works (Operations) Engineering (Stormwater) Parks 	Planning	Short term	\$	<ul style="list-style-type: none"> Environment & Health Economy 	<ul style="list-style-type: none"> Incorporation of climate change into the planning documents. Number of sites assessed with climate change in mind.
123	Communicate with MECP to prioritize cleanup of brownfield sites.	Recommended	<ul style="list-style-type: none"> Asset Management Public Works (Operations) Parks Engineering (Stormwater) 	Planning	Short term	\$	<ul style="list-style-type: none"> Environment & Health Infrastructure Economy Safety 	<ul style="list-style-type: none"> Number of brownfield sites reported to MECP.

Notes:

(1) Estimated Resources: \$ less than \$100,000; \$\$ between \$100,000 and \$1,000,000; and \$\$\$ more than \$1,000,000

MECP - Ontario Ministry of the Environment, Conservation and Parks

Table 32 Engineering - Stormwater

No.	Adaptation Actions	Action Status	Collaborating /Benefitting Departments	Implementation			Goal Alignment	Example Key Performance Indicators
				Action Type	Schedule	Estimated Resources ⁽¹⁾		
53	Continue working with Public Works on the storm sewer infrastructure maintenance program.	Existing	<ul style="list-style-type: none"> Asset Management Public Works (Operations) Engineering (Transportation) 	O&M	Short term	\$	<ul style="list-style-type: none"> Environment & Health Infrastructure Safety Equity 	<ul style="list-style-type: none"> Create a system to continuously update the maintenance catalogue and inform Asset Management. Percentage of storm sewers that meet a climate change design standard.
62	Develop a scheduled and proactive storm sewer maintenance program with Public Works, which includes flushing, inspections, catch basin clearing, etc.	Recommended	<ul style="list-style-type: none"> Asset Management Public Works (Operations) Engineering (Transportation) 	Planning	Short term	\$\$	<ul style="list-style-type: none"> Environment & Health Infrastructure Safety Equity 	<ul style="list-style-type: none"> Percentage of storm sewers inspected and cleared on an annual basis. Percentage of storm sewers that meet higher climate change standards. Establishment of a climate-related storm sewer maintenance program.
65	Consider equity when prioritizing stormwater project and conducting storm sewer condition assessments.	Recommended	<ul style="list-style-type: none"> Asset Management Public Works (Operations) Equity, Diversity and Inclusion Wastewater Wellington County Housing 	Capital	Short term	\$\$	<ul style="list-style-type: none"> Infrastructure Safety Equity 	<ul style="list-style-type: none"> Establish list of minimum criteria to ensure equity lens is applied when conducting storm sewer condition assessments and prioritizing stormwater projects.
67	Communicate with Wellington Dufferin Guelph Public Health to ensure continuation of mosquito larvicide programming.	Existing	<ul style="list-style-type: none"> Asset Management Public Works (Operations) Engineering (Transportation) Compliance and Performance Wellington Dufferin Guelph Public Health Planning (Operations) Parks Water Services 	Planning	Ongoing	\$	<ul style="list-style-type: none"> Environment & Health Safety Equity 	<ul style="list-style-type: none"> Number of joint public facing awareness campaigns.
88	Continue infrastructure upsizing to accommodate IDF curve updates and align the timing with the timing of other infrastructure work.	Existing	<ul style="list-style-type: none"> Asset Management Public Works Planning (Operations) Water Services Wastewater 	Capital	Ongoing	\$\$\$	<ul style="list-style-type: none"> Environment & Health Infrastructure Economy Safety Equity 	<ul style="list-style-type: none"> Length of infrastructure updated.

No.	Adaptation Actions	Action Status	Collaborating /Benefitting Departments	Implementation				Example Key Performance Indicators
				Action Type	Schedule	Estimated Resources ⁽¹⁾	Goal Alignment	
96	Develop a storm sewer maintenance program.	Recommended	<ul style="list-style-type: none"> Engineering (Stormwater) Asset Management Health & Safety Wastewater 	O&M	Ongoing	\$\$	<ul style="list-style-type: none"> Environment & Health Infrastructure Economy Safety 	<ul style="list-style-type: none"> Create or update a storm sewer maintenance program in collaboration with Public Works and Asset Management. Number of items addressed in the storm sewer maintenance program.
98	Implement the recommended actions from the forthcoming Stormwater Management Master Plan (e.g., restoration of erosion sites, constructing new and retrofitting stormwater facilities).	Recommended	<ul style="list-style-type: none"> Asset Management Public Works (Operations) Engineering (Transportation) Compliance and Performance Planning and Business Services Parks Wastewater Water Services 	Capital	Short term to long term	\$\$\$	<ul style="list-style-type: none"> Environment & Health Infrastructure Safety Equity 	<ul style="list-style-type: none"> Number of actions implemented from the Stormwater Management Master Plan.
105	Include direction to consider and incorporate LIDs in the Stormwater and Transportation Master Plans.	Existing	<ul style="list-style-type: none"> Asset Management Public Works (Operations) Engineering (Transportation) Compliance and Performance Planning and Business Services Parks Wastewater 	Capital	Medium term	\$\$	<ul style="list-style-type: none"> Environment & Health Infrastructure 	<ul style="list-style-type: none"> Inclusion of more information regarding LIDs in the Stormwater Master Plan with respect to climate adaptation. Inclusion of more information regarding LIDs in the Transportation Master Plan with respect to climate adaptation. Number of LIDs implemented.
144	Continue incentive programs for private rainwater harvesting and rain barrels.	Existing	<ul style="list-style-type: none"> Asset Management Compliance and Performance Planning and Business Services 	Capital	Ongoing	\$\$	<ul style="list-style-type: none"> Environment & Health Infrastructure Equity 	<ul style="list-style-type: none"> Number of rainwater harvesting units and rain barrels sold.

Notes:

(1) Estimated Resources: \$ less than \$100,000; \$\$ between \$100,000 and \$1,000,000; and \$\$\$ more than \$1,000,000

O&M - operation & maintenance

IDF - intensity-duration-frequency

LID - low impact development

Table 33 Engineering - Transportation

No.	Adaptation Actions	Action Status	Collaborating /Benefitting Departments	Implementation				Example Key Performance Indicators
				Action Type	Schedule	Estimated Resources ⁽¹⁾	Goal Alignment	
29	Pursue venture to create a City-wide urban heat island effect map. Assess the data by considering areas of vulnerability and the vulnerable population within the City.	Recommended	<ul style="list-style-type: none"> • Planning and Business Services • Parks • Asset Management • Health & Safety • Engineering (Stormwater) • Wellington County Housing • Wellington Dufferin Guelph Public Health 	Capital	Medium term	\$\$	<ul style="list-style-type: none"> • Environment & Health • Infrastructure • Equity 	<ul style="list-style-type: none"> • Commission new work to generate a City-wide urban heat island effect map. • Number of planning documents (i.e., Master Plans) that integrate the urban heat island effect map.
54	Add a climate adaptation lens to the Goods Movement Strategy.	Existing	<ul style="list-style-type: none"> • Economic Development • Asset Management • Public Works (Operations) • Transit • Emergency Services 	Planning	Short term	\$	<ul style="list-style-type: none"> • Economy • Equity 	<ul style="list-style-type: none"> • Addition of climate adaptation to the Goods Movement Strategy document.
57	Pursue investigation to provide real-time weather conditions for roads and bridges.	Existing	<ul style="list-style-type: none"> • Emergency Services • Public Works (Operations) • Asset Management • Transit 	Capital	Medium term	\$\$	<ul style="list-style-type: none"> • Environment & Health • Safety • Equity 	<ul style="list-style-type: none"> • Pursue and finalize study/project to provide real-time weather conditions for roads and bridges. • Length of roads/bridges with real-time weather conditions coverage.
63	Establish communication plan with Emergency Services and Public Works.	Recommended	<ul style="list-style-type: none"> • Emergency Services • Public Works (Operations) • Asset Management • Transit 	Planning	Short term	\$	<ul style="list-style-type: none"> • Environment & Health • Infrastructure • Safety 	<ul style="list-style-type: none"> • Inclusion of extreme weather in Emergency Response Plan.
84	Work with equity group to map out vulnerable communities to ensure equitable service delivery.	Existing	<ul style="list-style-type: none"> • Asset Management • Public Works (Operations) • Transit • Equity • Emergency Services • Wellington County Housing • Wellington Dufferin Guelph Public Health 	Planning	Short term	\$	<ul style="list-style-type: none"> • Environment & Health • Infrastructure • Equity 	<ul style="list-style-type: none"> • Creation of vulnerable communities map. • Number of planning documents (e.g., Master Plans) that integrate a map of vulnerable communities.

No.	Adaptation Actions	Action Status	Collaborating /Benefitting Departments	Implementation				Example Key Performance Indicators
				Action Type	Schedule	Estimated Resources ⁽¹⁾	Goal Alignment	
87	Continue Complete Streets Design Guide project that includes consideration for street trees, stormwater management, and LIDs.	Existing	<ul style="list-style-type: none"> Asset Management Engineering (Stormwater) Parks Public Works (Operations) Transit 	Capital	Ongoing	\$\$	<ul style="list-style-type: none"> Environment & Health Infrastructure Safety Equity 	<ul style="list-style-type: none"> Length of complete streets implemented. Percentage of street trees surviving. Length of roads with LID and stormwater management components.
126	Investigate areas where permeable pavements and low impact development can be applied.	Recommended	<ul style="list-style-type: none"> Asset Management Engineering (Stormwater) Public Works (Operations) 	Capital	Short term	\$ to \$\$	<ul style="list-style-type: none"> Environment & Health Infrastructure 	<ul style="list-style-type: none"> Completion of assessment for appropriate areas for permeable pavements and LIDs. Area of permeable pavements implemented. Number of LIDs implemented.

Notes:

(1) Estimated Resources: \$ less than \$100,000; \$\$ between \$100,000 and \$1,000,000; and \$\$\$ more than \$1,000,000

LID - low impact development

Table 34 Equity, Diversity, and Inclusion

No.	Adaptation Actions	Action Status	Collaborating /Benefitting Departments	Implementation				Example Key Performance Indicators
				Action Type	Schedule	Estimated Resources ⁽¹⁾	Goal Alignment	
134	Continue involvement with emergency shelter support.	Existing	<ul style="list-style-type: none"> All departments/ divisions County of Wellington Red Cross 	Policy	Ongoing	\$	<ul style="list-style-type: none"> Environment & Health Infrastructure Safety Equity 	<ul style="list-style-type: none"> Capacity (number of people) of emergency shelters throughout the City.
138	Establish regular meetings with the Community Emergency Management Coordinator, Red Cross, and County of Wellington.	Recommended	<ul style="list-style-type: none"> All Departments/ divisions County of Wellington Red Cross 	Planning	Short term	\$	<ul style="list-style-type: none"> Environment & Health Economy Safety Equity 	<ul style="list-style-type: none"> Attendance of regular meetings with the Community Emergency Management Coordinator, Red Cross, and County of Wellington.
146	Work with City departments to apply an equity, diversity, and inclusion lens when planning and prioritizing services or infrastructure upgrades/ replacements. Establish a formal means of communication.	Recommended	<ul style="list-style-type: none"> All departments/ divisions 	Planning	Short term	\$	<ul style="list-style-type: none"> Environment & Health Economy Safety Equity 	<ul style="list-style-type: none"> Number of plans and services confirming an Equity, Diversity, and Inclusion consideration. Establishment of a formal means of communication.

No.	Adaptation Actions	Action Status	Collaborating /Benefitting Departments	Implementation				Example Key Performance Indicators
				Action Type	Schedule	Estimated Resources ⁽¹⁾	Goal Alignment	
149	Continue to enhance partnerships with Partner Working Groups.	Existing	<ul style="list-style-type: none"> All Partner Working Groups 	Policy	Ongoing	\$	<ul style="list-style-type: none"> Environment & Health Infrastructure Economy Safety Equity 	<ul style="list-style-type: none"> Number of touchpoints with the Partner Working Group.
156	Identify a specific person in the City that community support agencies can contact in the event of an emergency	Recommended	<ul style="list-style-type: none"> All departments/ divisions 	Policy	Ongoing	\$	<ul style="list-style-type: none"> Environment & Health Safety Equity 	<ul style="list-style-type: none"> Assign emergency contact for community support agencies.

Notes:

(1) Estimated Resources: \$ less than \$100,000; \$\$ between \$100,000 and \$1,000,000; and \$\$\$ more than \$1,000,000

Table 35 Facilities and Energy Management

No.	Adaptation Actions	Action Status	Collaborating /Benefitting Departments	Implementation				Example Key Performance Indicators
				Action Type	Schedule	Estimated Resources ⁽¹⁾	Goal Alignment	
10	Work with the appropriate department to ensure adequate air conditioning in all City-owned buildings (e.g., offices, recreation facilities, libraries) and continue with routine maintenance on these systems.	Existing	<ul style="list-style-type: none"> All departments/ divisions 	Ongoing	Ongoing	\$\$	<ul style="list-style-type: none"> Infrastructure Safety 	<ul style="list-style-type: none"> Number of air conditioning units in good condition. Percentage of spaces with air conditioning.
22	Backup generators available to supply power if grid goes down.	Existing	<ul style="list-style-type: none"> All departments/ divisions 	Capital	Ongoing	\$\$	<ul style="list-style-type: none"> Infrastructure Safety 	<ul style="list-style-type: none"> Number of diesel generators available. Average outage time. Area with redundant power readily available.
30	Work with Transit (Facilities to lead) and consider climate change in setting design standards for new south end and downtown bus terminals.	Recommended	<ul style="list-style-type: none"> Transit Asset Management 	Capital	Short term to medium term	\$\$\$	<ul style="list-style-type: none"> Environment & Health Infrastructure Equity 	<ul style="list-style-type: none"> Incorporation of climate change into the design standards for the new south end bus terminal. Incorporation of climate change into the design standards for the new downtown bus terminal.
34	Set new building designs and building upgrades to consider climate change and air conditioning needs (e.g., incorporate renewable energy, air conditioning and heating sized at 99 th percentile to provide sufficient buffer).	Existing	<ul style="list-style-type: none"> Administrative and Operations Asset Management Health & Safety 	Planning	Short term	\$	<ul style="list-style-type: none"> Infrastructure Safety 	<ul style="list-style-type: none"> Number of new designs and upgrades that incorporate climate change. Number of new designs and upgrades that consider air conditioning needs.

No.	Adaptation Actions	Action Status	Collaborating /Benefitting Departments	Implementation				Example Key Performance Indicators
				Action Type	Schedule	Estimated Resources ⁽¹⁾	Goal Alignment	
41	Complete a Facility Needs Assessment to consider relocation of fire and emergency management systems located below the floodplain.	Existing	<ul style="list-style-type: none"> All departments/ divisions 	Capital	Planned Short term	\$\$	<ul style="list-style-type: none"> Infrastructure Safety 	<ul style="list-style-type: none"> Completion of a Facility Needs Assessment.
44	Ensure adequate air conditioning in the corporate buildings and confirm storage temperature requirements of assets. Consider managing air conditioning through smart monitoring and forecasting to minimize impacts on existing equipment.	Recommended	<ul style="list-style-type: none"> Administrative and Operations Asset Management Health & Safety 	O&M	Short term	\$	<ul style="list-style-type: none"> Environment & Health Infrastructure Safety 	<ul style="list-style-type: none"> Percentage of systems that are considered maintained satisfactorily. Number of systems equipped with smart monitoring and forecasting.
80	Complete a Facility Needs Assessment for all critical infrastructure to determine if a backup source of power available is required and available for onsite. Establish redundancy plan for power for critical buildings (e.g., diesel available if grid goes down).	Recommended	<ul style="list-style-type: none"> All departments/ divisions 	Capital	Short term to medium term	\$\$	<ul style="list-style-type: none"> Infrastructure Safety 	<ul style="list-style-type: none"> Completion of Facility Needs Assessment for all critical infrastructure. Creation of redundancy plan for power for critical buildings.
93	Itemize corporate building components susceptible to hazard impacts and plan for replacement with Asset Management.	Recommended	<ul style="list-style-type: none"> Administrative and Operations Asset Management 	Planning	Medium term	\$	<ul style="list-style-type: none"> Infrastructure Safety 	<ul style="list-style-type: none"> Create list of components with associated resilience level. Percentage of updated and/or replaced items with a low resilience rating.

Notes:

(1) Estimated Resources: \$ less than \$100,000; \$\$ between \$100,000 and \$1,000,000; and \$\$\$ more than \$1,000,000

O&M – operation and management

Table 36 Fleet

No.	Adaptation Actions	Action Status	Collaborating /Benefitting Departments	Implementation			Goal Alignment	Example Key Performance Indicators
				Action Type	Schedule	Estimated Resources ⁽¹⁾		
14	Continue to convert bus fleet to electric vehicles, collaboration with Transit.	Existing	<ul style="list-style-type: none"> Transit Asset Management 	Capital	Short term to medium term	\$\$\$	<ul style="list-style-type: none"> Environment & Health Safety 	<ul style="list-style-type: none"> Number of electric vehicles.
16	Maintain cooling feature and changeover to winter tires in corporate vehicles and buses. Provide redundancy.	Existing	<ul style="list-style-type: none"> Transit Asset Management 	O&M	Ongoing	\$	<ul style="list-style-type: none"> Environment & Health Safety Equity 	<ul style="list-style-type: none"> Number of vehicles with adequate cooling feature. Number of corporate vehicles and buses with winter tires. Number of vehicular accidents during the winter season. Percentage of vehicles available for alternative use.
81	Work collaboratively with Facilities and Energy Management to provide redundant vehicles elsewhere or a plan to access vehicles in case of damage.	Recommended	<ul style="list-style-type: none"> Facilities and Energy Management Asset Management 	Planning	Short term	\$\$	<ul style="list-style-type: none"> Infrastructure Economy Safety 	<ul style="list-style-type: none"> Number of redundant vehicles available.

Notes:

(1) Estimated Resources: \$ less than \$100,000; \$\$ between \$100,000 and \$1,000,000; and \$\$\$ more than \$1,000,000

O&M – operation and management

Table 37 Guelph Library

No.	Adaptation Actions	Action Status	Collaborating /Benefitting Departments	Implementation			Goal Alignment	Example Key Performance Indicators
				Action Type	Schedule	Estimated Resources ⁽¹⁾		
15	Work with Facilities to ensure adequate air conditioning in the libraries, continue with routine maintenance on heating, ventilation, and air conditioning systems.	Existing	<ul style="list-style-type: none"> Guelph Public Library Asset Management Emergency Services Facilities and Energy Management County of Wellington Red Cross 	O&M	Ongoing	\$	<ul style="list-style-type: none"> Environment & Health Infrastructure Safety Equity 	<ul style="list-style-type: none"> Number of air conditioning units in good condition. Percentage of spaces with air conditioning. Percentage of air conditioning units in need of repair and/or replacement (reverse key performance indicator); amount of time to repair and/or replace air conditioning units.
43	Periodically review, maintain, and update use of libraries as emergency shelter buildings. Review with an equity lens. This includes coordination with the County of Wellington, Wellington Dufferin Guelph Public Health, and Emergency Services.	Recommended	<ul style="list-style-type: none"> Asset Management Equity, Diversity and Inclusion Emergency Services County of Wellington Red Cross Wellington Dufferin Guelph Public Health 	Planning	Ongoing	\$	<ul style="list-style-type: none"> Environment & Health Infrastructure Safety Equity 	<ul style="list-style-type: none"> Initiate a tour of facilities to review its usage as an emergency shelter and establish frequency of review. Establish list of minimum criteria to ensure equity lens is applied.
90	Itemize library building (functioning as a shelter, as needed) components susceptible to hazard impacts and plan with Asset Management for replacement.	Recommended	<ul style="list-style-type: none"> Culture and Recreation Asset Management Emergency Services County of Wellington 	Planning	Short-term	\$	<ul style="list-style-type: none"> Environment & Health Infrastructure Safety Equity 	<ul style="list-style-type: none"> Create list of components with associated resilience level. Percentage of updated and/or replaced items with a low resilience rating.
118	Design and build new Baker Street Library with climate adaptation lens.	Recommended	<ul style="list-style-type: none"> Culture and Recreation Asset Management 	Capital	Short term to medium term	\$\$\$	<ul style="list-style-type: none"> Infrastructure 	<ul style="list-style-type: none"> Incorporation of climate change into building design. Number of elements incorporating climate adaptation.
150	Maintain first aid training for staff at library, including equity considerations.	Existing	<ul style="list-style-type: none"> Asset Management Equity, Diversity and Inclusion Emergency Services County of Wellington Red Cross 	O&M	Ongoing	\$	<ul style="list-style-type: none"> Environment & Health Safety Equity 	<ul style="list-style-type: none"> Number of staff with first aid training. Ensure equity components are integrated in first aid training.

Notes:

(1) Estimated Resources: \$ less than \$100,000; \$\$ between \$100,000 and \$1,000,000; and \$\$\$ more than \$1,000,000

O&M - operation and maintenance

Table 38 Health and Safety

No.	Adaptation Actions	Action Status	Collaborating /Benefitting Departments	Implementation			Goal Alignment	Example Key Performance Indicators
				Action Type	Schedule	Estimated Resources ⁽¹⁾		
61	Consider developing an updated municipal heat response plan with support from Wellington Dufferin Guelph Public Health.	Recommended	<ul style="list-style-type: none"> All departments/divisions Wellington Dufferin Guelph Public Health 	Planning	Short-term	\$	<ul style="list-style-type: none"> Environment & Health Safety Equity 	<ul style="list-style-type: none"> Completion of response plan update.
71	Staff are aware of heat alerts from Corporate Health & Safety.	Existing	<ul style="list-style-type: none"> Emergency Services Wellington Dufferin Guelph Public Health 	Policy	Ongoing	\$	<ul style="list-style-type: none"> Environment & Health Safety 	<ul style="list-style-type: none"> Percentage of staff receiving training for heat alerts and/or who receive heat alert notifications (e.g., text message or emails). Percentage of staff that can work from home, if necessary.
143	Continue to be a member of the Fire Services Joint Health & Safety committee and be involved in fire drills.	Existing	<ul style="list-style-type: none"> All departments/ divisions 	Planning	Ongoing	\$	<ul style="list-style-type: none"> Environment & Health Safety 	<ul style="list-style-type: none"> Continued membership in the Fire Services Joint Health & Safety committee. Number of fire drills participated in.
153	Update thermal stress policies as appropriate.	Existing	<ul style="list-style-type: none"> All departments/ divisions 	Policy	Ongoing	\$	<ul style="list-style-type: none"> Environment & Health Safety 	<ul style="list-style-type: none"> Up-to-date thermal stress policies.
155	Dedicated Health & Safety Specialists for Environmental Services (Water Services, Wastewater and Solid Waste), Public Works, Parks, and Transit.	Existing	<ul style="list-style-type: none"> All departments/ divisions 	Capital	Ongoing	\$\$	<ul style="list-style-type: none"> Environment & Health Safety 	<ul style="list-style-type: none"> Number of departments/divisions with a dedicated Health & Safety Specialist.
161	Develop cold stress policy, policy for staff working outside in high winds, flooding, and update as needed heat stress policy. Communicate these to all departments.	Recommended	<ul style="list-style-type: none"> All departments/ divisions 	Policy	Short term	\$	<ul style="list-style-type: none"> Environment & Health Safety 	<ul style="list-style-type: none"> Completion of policy for staff working in extreme weather conditions. Percentage of alerts sent to staff for weather events (i.e., goal of at least one alert per event).
163	Formalize incident tracking including identifying root cause. Flag those that are weather related.	Recommended	<ul style="list-style-type: none"> All departments/ divisions 	Capital	Ongoing	\$	<ul style="list-style-type: none"> Environment & Health Safety 	<ul style="list-style-type: none"> Number of incidents that are weather related.

Notes:

(1) Estimated Resources: \$ less than \$100,000; \$\$ between \$100,000 and \$1,000,000; and \$\$\$ more than \$1,000,000

Table 39 Information Technology

No.	Adaptation Actions	Action Status	Collaborating /Benefitting Departments	Implementation				Example Key Performance Indicators
				Action Type	Schedule	Estimated Resources ⁽¹⁾	Goal Alignment	
19	Develop and maintain internal IT asset management program.	Existing	<ul style="list-style-type: none"> Asset Management Communications 	O&M	Ongoing	\$\$	<ul style="list-style-type: none"> Infrastructure Safety 	<ul style="list-style-type: none"> Formalization of an internal IT asset management program.
20	Maintain service and maintenance contracts for critical equipment to store or obtain spares within 4 hours.	Existing	<ul style="list-style-type: none"> Asset Management Communications 	O&M	Ongoing	\$\$	<ul style="list-style-type: none"> Infrastructure Economy Safety 	<ul style="list-style-type: none"> Number of key assets with maintenance contracts. Number of key assets with spares readily available within 4 hours.
25	Formalize emergency plans, understand length (time) of backup power, and have redundant staff available at all hours.	Recommended	<ul style="list-style-type: none"> Asset Management Communications All Partner Working Groups 	Planning	Short term	\$	<ul style="list-style-type: none"> Infrastructure Economy Safety 	<ul style="list-style-type: none"> Completion of formalized emergency plans. Percentage of Emergency Response Plans that consider climate-related risks. Incorporation of climate-related risks into emergency Standard Operating Procedures. Completed assessment of back-up power requirements for critical assets and services. Number of tabletop emergency response exercises that take into account extreme weather.
37	Conduct trial emergency exercise planned for 2023.	Existing	<ul style="list-style-type: none"> Asset Management Communications 	Planning	Short term	\$	<ul style="list-style-type: none"> Environment & Health Infrastructure Safety 	<ul style="list-style-type: none"> Completion of the trial emergency exercise.
38	Continue to liaise with surrounding municipalities for information sharing and networking.	Existing	<ul style="list-style-type: none"> Asset Management Communications County of Wellington Region of Waterloo 	Planning	Ongoing	\$	<ul style="list-style-type: none"> Infrastructure Safety 	<ul style="list-style-type: none"> Communication with surrounding municipalities for information sharing and networking.
49	Work with Asset Management to include climate change aspect in life cycle analyses in addition to considering industry standards.	Recommended	<ul style="list-style-type: none"> Asset Management Communications 	Planning	Medium term	\$\$	<ul style="list-style-type: none"> Infrastructure Economy Safety 	<ul style="list-style-type: none"> Number of assets that include climate change in the life cycle analyses.
115	Create relocation plan for assets and stage the rollout to avoid service disruption. Create an interim plan to protect equipment from flooding at data centres.	Recommended	<ul style="list-style-type: none"> Asset Management Communications 	Planning	Short term	\$\$	<ul style="list-style-type: none"> Infrastructure Economy Safety 	<ul style="list-style-type: none"> Creation of relocation plan. Creation of interim plan to protect equipment.

Notes:

(1) Estimated Resources: \$ less than \$100,000; \$\$ between \$100,000 and \$1,000,000; and \$\$\$ more than \$1,000,000

IT - information technology

O&M - operation and maintenance

Table 40 Parks

No.	Adaptation Actions	Action Status	Collaborating /Benefitting Departments	Implementation			Goal Alignment	Example Key Performance Indicators
				Action Type	Schedule	Estimated Resources ⁽¹⁾		
2	Develop a sports field strategy including a mowing (and potential irrigation) strategy that accommodates a changing climate, including shared use (e.g., for stormwater management).	Existing	<ul style="list-style-type: none"> • Planning and Business Services • Public Works (Operations) • Asset Management 	Planning	Short term	\$	<ul style="list-style-type: none"> • Environment & Health • Infrastructure • Safety • Equity 	<ul style="list-style-type: none"> • Development of a sports field strategy that includes climate change.
6	Continue to undertake tree planting initiatives.	Existing	<ul style="list-style-type: none"> • Planning and Business Services • Public Works (Operations) • Asset Management • University of Guelph 	Capital	Ongoing	\$\$	<ul style="list-style-type: none"> • Environment & Health • Infrastructure • Safety • Equity 	<ul style="list-style-type: none"> • Number of trees planted. • Percentage canopy cover.
7	Follow the guidelines put forth in the Urban Forest Management Plan (e.g., types of trees to plant, how long to monitor new trees, tree planting strategy for Guelph).	Existing	<ul style="list-style-type: none"> • Planning and Business Services • Public Works (Operations) • Asset Management 	Planning	Ongoing	\$\$	<ul style="list-style-type: none"> • Environment & Health • Infrastructure • Safety • Equity 	<ul style="list-style-type: none"> • Number of trees planted in accordance with the Urban Forest Management Plan.
21	Continue invasive species management (e.g., buckthorn).	Existing	<ul style="list-style-type: none"> • Planning and Business Services • Public Works (Operations) • Asset Management • Wellington Dufferin Guelph Public Health 	Capital	Ongoing	\$\$	<ul style="list-style-type: none"> • Environment & Health 	<ul style="list-style-type: none"> • Population of recorded invasive species.
64	Maintain a log of trees and vegetation within the floodplain as an additional criterion of the conditions report as part of the Natural Asset Inventory. Coordinate with Asset Management; refer to Tree Technical Manual for any new or replacement trees or vegetation within the floodplain.	Recommended	<ul style="list-style-type: none"> • Asset Management • Engineering (Stormwater) • University of Guelph 	Capital	Medium term	\$	<ul style="list-style-type: none"> • Environment & Health • Infrastructure 	<ul style="list-style-type: none"> • Establish minimum frequency of updates for log of trees and vegetation. • Number of trees planted that are confirmed to be appropriate for the floodplain. • Percentage of vegetative restoration within the floodplain.
79	Consider planting additional shade trees around City-owned emergency buildings.	Recommended	<ul style="list-style-type: none"> • Emergency Services • Asset Management 	Capital	Short term to Medium term	\$ to \$\$	<ul style="list-style-type: none"> • Environment & Health • Infrastructure 	<ul style="list-style-type: none"> • Number of trees planted around City-owned emergency buildings.

No.	Adaptation Actions	Action Status	Collaborating /Benefitting Departments	Implementation				Example Key Performance Indicators
				Action Type	Schedule	Estimated Resources ⁽¹⁾	Goal Alignment	
82	Conduct an assessment of aquatic biota once every 5 to 10 years to determine if the warmer ambient temperatures are affecting the species and health of the aquatic biota.	Recommended	<ul style="list-style-type: none"> Planning and Business Services 	Capital	Medium term	\$\$	<ul style="list-style-type: none"> Environment & Health Infrastructure 	<ul style="list-style-type: none"> Confirmation of up-to-date assessment of aquatic biota. Average health level of aquatic biota.
85	Update and keep current the Memorandum of Understanding with Grand River Conservation Authority.	Existing	<ul style="list-style-type: none"> Planning and Business Services Parks Compliance and Performance Public Works (Operations) Grand River Conservation Authority 	Planning	Ongoing	\$	<ul style="list-style-type: none"> Environment & Health Infrastructure Safety 	<ul style="list-style-type: none"> Establish an annual review of the Memorandum of Understanding with Grand River Conservation Authority.
94	Create a plan for handling and removal of felled trees within parks and public rights-of-way with Public Works, University of Guelph, and others as necessary.	Recommended	<ul style="list-style-type: none"> Emergency Services Asset Management Public Works (Operations) Emergency Services University of Guelph 	Planning	Short term	\$	<ul style="list-style-type: none"> Environment & Health Infrastructure Economy Safety 	<ul style="list-style-type: none"> Create a collaborative plan between Public Works, University of Guelph, and others as necessary. Average removal time of felled trees.
111	Actively update a data log of damages by location and hazard, and work with Public Works to pinpoint best locations for tree plantings for long-term growth and wind protection of assets.	Recommended	<ul style="list-style-type: none"> Planning and Business Services Public Works (Operations) Asset Management University of Guelph 	Capital	Short term to medium term	\$\$	<ul style="list-style-type: none"> Environment & Health Infrastructure 	<ul style="list-style-type: none"> Percentage of City with a tree canopy. Number of new trees planted. Frequency of data log update.

Notes:

(1) Estimated Resources: \$ less than \$100,000; \$\$ between \$100,000 and \$1,000,000; and \$\$\$ more than \$1,000,000

Table 41 Planning and Business Services

No.	Adaptation Actions	Action Status	Collaborating /Benefitting Departments	Implementation			Goal Alignment	Example Key Performance Indicators
				Action Type	Schedule	Estimated Resources ⁽¹⁾		
3	Implement Guelphs Official Plan Natural Heritage Policies, which seek to protect and restore natural heritage features and areas for the long term.	Existing	<ul style="list-style-type: none"> • Parks • Public Works (Operations) • Asset Management 	Planning	Short term	\$	<ul style="list-style-type: none"> • Environment & Health • Safety 	<ul style="list-style-type: none"> • Number of protected and restored natural heritage features. • Area of protected and restored natural heritage features.
4	Complete the Sustainable City Master Plan.	Existing	<ul style="list-style-type: none"> • Parks • Public Works (Operations) • Asset Management • All Partner Working Groups 	Policy	On going	\$	<ul style="list-style-type: none"> • Environment & Health • Infrastructure • Economy • Safety • Equity 	<ul style="list-style-type: none"> • Completion of the Sustainable City Master Plan.
13	Complete the climate change-related actions specified in the Natural Heritage Action Plan including: <ul style="list-style-type: none"> • launching a City-wide environmental monitoring program • producing a status of the natural heritage system report that measures the effectiveness of our natural heritage policies • developing an environmental implementation report guideline • developing restoration and management plans for City-owned/managed natural areas 	Existing	<ul style="list-style-type: none"> • Parks • Public Works (Operations) • Asset Management 	Capital	Short term to medium term	\$	<ul style="list-style-type: none"> • Environment & Health • Safety 	<ul style="list-style-type: none"> • Launch of the City-wide environmental monitoring program. • Production of the natural heritage system report. • Development of an environmental implementation report guideline. • Develop restoration and management plans for City owned/managed natural areas.
45	Update the Environmental Impact Study Guidelines to clarify that thermal impacts to surface water features are to be assessed as part of the stormwater quality and quantity controls.	Recommended	<ul style="list-style-type: none"> • Parks • Asset Management • Public Works (Operations) 	Planning	short term	\$	<ul style="list-style-type: none"> • Environment & Health • Infrastructure 	<ul style="list-style-type: none"> • Update of the Environmental Impact Study to provide clarity on thermal impacts to surface water features.

No.	Adaptation Actions	Action Status	Collaborating /Benefitting Departments	Implementation				Example Key Performance Indicators
				Action Type	Schedule	Estimated Resources ⁽¹⁾	Goal Alignment	
48	When the Environmental Implementation Report guidelines are developed, include actions for responding to climate change, such as providing directions on tree planting, shading watercourses and stormwater features, reducing thermal impacts, and assisted migrations of appropriate species.	Recommended	<ul style="list-style-type: none"> Asset Management Parks Public Works (Operations) Facilities and Energy Management Stormwater 	Capital	short term to medium term	\$	<ul style="list-style-type: none"> Environment & Health Infrastructure Economy Safety 	<ul style="list-style-type: none"> Number of actions implemented from the Environmental Implementation Report related to climate change.
83	Ensure that the identification of vulnerable areas and opportunities for adapting to climate change are identified and incorporated throughout the completion of the Natural Heritage Action Plan.	Recommended	<ul style="list-style-type: none"> Parks Asset Management Public Works (Operations) 	Capital	Ongoing	\$\$	<ul style="list-style-type: none"> Environment & Health Infrastructure 	<ul style="list-style-type: none"> Identification of vulnerable areas completed. Incorporation of climate change adaptation in the Natural Heritage Action Plan.

Notes:

(1) Estimated Resources: \$ less than \$100,000; \$\$ between \$100,000 and \$1,000,000; and \$\$\$ more than \$1,000,000

Table 42 Public Works (Operations)

No.	Adaptation Actions	Action Status	Collaborating /Benefitting Departments	Implementation				Example Key Performance Indicators
				Action Type	Schedule	Estimated Resources ⁽¹⁾	Goal Alignment	
27	Involvement of Public Works department in emergency drills led by other departments.	Recommended	<ul style="list-style-type: none"> All Departments/ divisions 	Planning	Short term	\$	<ul style="list-style-type: none"> Environment & Health Infrastructure Safety Equity 	<ul style="list-style-type: none"> Number of emergency drills conducted. Number of employees participating in emergency drills.
58	Conduct minor road repairs.	Existing	<ul style="list-style-type: none"> Asset Management Engineering (Transportation) Transit Emergency Services Health & Safety Economic Development 	O&M	Ongoing	\$\$	<ul style="list-style-type: none"> Infrastructure Safety 	<ul style="list-style-type: none"> Length of roads with minor repairs implemented.

No.	Adaptation Actions	Action Status	Collaborating /Benefitting Departments	Implementation				Example Key Performance Indicators
				Action Type	Schedule	Estimated Resources ⁽¹⁾	Goal Alignment	
59	Conduct road inspections.	Existing	<ul style="list-style-type: none"> Asset Management Engineering (Transportation) Transit Emergency Services Health & Safety Economic Development 	O&M	Ongoing	\$\$	<ul style="list-style-type: none"> Infrastructure Safety 	<ul style="list-style-type: none"> Length of road inspections conducted.
60	Maintain Level of Service agreement with Engineering (Stormwater) to conduct storm sewer treatment system maintenance and inspections.	Existing	<ul style="list-style-type: none"> Engineering (Stormwater) Asset Management Health & Safety 	Planning	Ongoing	\$\$	<ul style="list-style-type: none"> Infrastructure Safety 	<ul style="list-style-type: none"> Confirm Level of Service agreement is active. Length of storm sewer that is maintained and inspected.
74	Continue to have Public Works workers on standby for inclement weather based on forecasting.	Existing	<ul style="list-style-type: none"> All Departments/ divisions 	Capital	Ongoing	\$\$	<ul style="list-style-type: none"> Economy Safety Equity 	<ul style="list-style-type: none"> Number of workers available on standby.
75	Continue conducting pilot project with the University of Guelph to optimize salt application during winter.	Existing	<ul style="list-style-type: none"> Asset Management Water Services Engineering (Stormwater) Emergency Services University of Guelph 	Capital	Short term to medium term	\$\$	<ul style="list-style-type: none"> Environment & Health Infrastructure 	<ul style="list-style-type: none"> Completion of pilot project. Implementation of project findings into maintenance documents.
127	Investigate updating the Property Standards By-law to including providing cooling facilities to maintain ambient temperatures below a maximum temperature, (in addition to the existing provision of providing heating facilities to maintain a minimum temperature).	Recommended	<ul style="list-style-type: none"> Planning Wellington Dufferin Guelph Public Health 	Planning	Short term to medium term	\$	<ul style="list-style-type: none"> Environment & Health Equity 	<ul style="list-style-type: none"> Number of heat-related illnesses reported.
128	Continue to plan plowing (road and sidewalk) routes with equity lens, in addition to schools and seniors.	Existing	<ul style="list-style-type: none"> Engineering (Transportation) Emergency Services Asset Management Wellington Catholic District School Board Upper Grand District School Board Guelph General Hospital 	Planning	Ongoing	\$	<ul style="list-style-type: none"> Infrastructure Safety Equity 	<ul style="list-style-type: none"> Establish equity criteria applicable to plowing and incorporate into planning documents.

No.	Adaptation Actions	Action Status	Collaborating /Benefitting Departments	Implementation				Example Key Performance Indicators
				Action Type	Schedule	Estimated Resources ⁽¹⁾	Goal Alignment	
135	Continue to send out alerts on Guelph's alert system from the Community Emergency Management Coordinator.	Existing	<ul style="list-style-type: none"> All departments/divisions 	O&M	Ongoing	\$	<ul style="list-style-type: none"> Environment & Health Economy Safety Equity 	<ul style="list-style-type: none"> Number of alerts sent from the Community Emergency Management Coordinator.
152	Continue to set up traffic control in emergency situations for emergency management systems.	Existing	<ul style="list-style-type: none"> Engineering (Transportation) Transit Asset Management 	O&M	Ongoing	\$	<ul style="list-style-type: none"> Environment & Health Infrastructure Safety 	<ul style="list-style-type: none"> Average response time in establishing traffic control in emergency situations.

Notes:

(1) Estimated Resources: \$ less than \$100,000; \$\$ between \$100,000 and \$1,000,000; and \$\$\$ more than \$1,000,000

O&M - operation and maintenance

Table 43 Solid Waste

No.	Adaptation Actions	Action Status	Collaborating /Benefitting Departments	Implementation				Example Key Performance Indicators
				Action Type	Schedule	Estimated Resources ⁽¹⁾	Goal Alignment	
26	Liaise with the fire department on a mock transfer station fire scenario.	Recommended	<ul style="list-style-type: none"> Asset Management Health & Safety Emergency Services 	Planning	Short term	\$	<ul style="list-style-type: none"> Environment & Health Infrastructure Safety 	<ul style="list-style-type: none"> Establish procedure with fire department for a mock transfer station fire scenario. Number of areas with an adequate procedure in place.
28	Conduct emergency exercise drills and include Public Works. Recommended to include this department in the future.	Recommended	<ul style="list-style-type: none"> Emergency Services Public Works (Operations) Asset Management 	Planning	Short term	\$	<ul style="list-style-type: none"> Infrastructure Safety 	<ul style="list-style-type: none"> Number of emergency drills conducted. Number of employees participating in emergency drills.
72	Ensure staff are abiding by Corporate Health & Safety protocols for heat days.	Existing	<ul style="list-style-type: none"> Health & Safety 	Policy	Ongoing	\$	<ul style="list-style-type: none"> Environment & Health Safety 	<ul style="list-style-type: none"> Number of staff working under heat advisory days. Number of staff that are sent alerts for heat days.
73	Maintain cooling feature in waste collection fleet vehicles with adequate hydration available for staff. Provide vehicle redundancy.	Existing	<ul style="list-style-type: none"> Fleet Asset Management Health & Safety 	O&M	Ongoing	\$	<ul style="list-style-type: none"> Environment & Health 	<ul style="list-style-type: none"> Number of waste collection fleet vehicles with cooling feature. Number of redundant vehicles available with cooling feature.
76	Ensure fire suppression equipment are maintained.	Existing	<ul style="list-style-type: none"> Asset Management Health & Safety Emergency Services 	O&M	Ongoing	\$\$	<ul style="list-style-type: none"> Environment & Health Infrastructure Safety 	<ul style="list-style-type: none"> Number of fire suppression equipment in good condition.

No.	Adaptation Actions	Action Status	Collaborating /Benefitting Departments	Implementation				Example Key Performance Indicators
				Action Type	Schedule	Estimated Resources ⁽¹⁾	Goal Alignment	
78	Create a formal protocol for yard waste pick up during the summer.	Recommended	<ul style="list-style-type: none"> Asset Management Health & Safety 	Planning	Short term	\$	<ul style="list-style-type: none"> Environment & Health 	<ul style="list-style-type: none"> Creation of yard waste pick up protocol for the summer. Frequency of pick ups. Approximate yard pick up load.
95	Itemize Waste Resource Innovation Centre (Facility) components susceptible to hazard impacts and plan for replacement with Asset Management.	Recommended	<ul style="list-style-type: none"> Asset Management 	Planning	Short term to medium term	\$	<ul style="list-style-type: none"> Infrastructure Safety 	<ul style="list-style-type: none"> Create list of components with associated resilience level. Percentage of updated and/or replaced items with a low resilience rating.
104	Maintain and update as necessary lightning protocols for Waste Resource Innovation Centre (Facility).	Existing	<ul style="list-style-type: none"> Asset Management Emergency Services Health & Safety 	Planning	Short term	\$	<ul style="list-style-type: none"> Environment & Health Safety 	<ul style="list-style-type: none"> Assurance that the lightning protocol is up-to-date.
117	Add inclement weather shelters to the facility.	Recommended	<ul style="list-style-type: none"> Emergency Services Asset Management Health & Safety 	Capital	Medium term	\$ to \$\$	<ul style="list-style-type: none"> Environment & Health Infrastructure 	<ul style="list-style-type: none"> Number of weather shelters available.
160	Improve communication to the community to manage windy days. Carts must be heavier or kept them inside.	Recommended	<ul style="list-style-type: none"> Communications 	Planning	Short term	\$	<ul style="list-style-type: none"> Economic Safety 	<ul style="list-style-type: none"> Number of cart replacements or complaints.

Notes:

(1) Estimated Resources: \$ less than \$100,000; \$\$ between \$100,000 and \$1,000,000; and \$\$\$ more than \$1,000,000

Table 44 Transit

No.	Adaptation Actions	Action Status	Collaborating /Benefitting Departments	Implementation				Example Key Performance Indicators
				Action Type	Schedule	Estimated Resources ⁽¹⁾	Goal Alignment	
35	Ensure adequate air conditioning in the transit buildings and that staff is aware of alerts from Health & Safety.	Existing	<ul style="list-style-type: none"> Asset Management 	O&M	Ongoing	\$	<ul style="list-style-type: none"> Environment & Health Safety Equity 	<ul style="list-style-type: none"> Percentage of adequately air-conditioned rooms over number of rooms with an air conditioning recommendation. Percentage of alerts sent to staff over extreme heat events.
46	Establish a business continuity plan in case building is compromised, itemize the transit building components, and provide alternate/redundant work environment in case the transit buildings cannot be safely occupied.	Recommended	<ul style="list-style-type: none"> Asset Management 	Planning	Short term to medium term	\$	<ul style="list-style-type: none"> Infrastructure Equity 	<ul style="list-style-type: none"> Establish a business continuity plan. Completion of an itemized list of assets within the building.

No.	Adaptation Actions	Action Status	Collaborating /Benefitting Departments	Implementation				Example Key Performance Indicators
				Action Type	Schedule	Estimated Resources ⁽¹⁾	Goal Alignment	
50	Investigate and provide adequate shelter for users at popular transit stops, consider equity lens.	Recommended	<ul style="list-style-type: none"> Asset Management Public Works (Operations) Engineering (Transportation) 	Capital	Short term	\$\$	<ul style="list-style-type: none"> Environment & Health Infrastructure Equity 	<ul style="list-style-type: none"> Number of shelters in place (shelters per squared km).
125	Maintain communications with Public Works under by-law stipulation for snow plowing.	Existing	<ul style="list-style-type: none"> Asset Management Public Works (Operations) 	Planning	Ongoing	\$	<ul style="list-style-type: none"> Environment & Health Safety Equity 	<ul style="list-style-type: none"> Estimated delays (time) due to unplowed streets. Number of complaints received during a snow event.
129	Continue to provide buses as an emergency shelter when requested by Emergency Services.	Existing	<ul style="list-style-type: none"> Emergency Services Fleet Asset Management County of Wellington Red Cross 	Planning	Ongoing	\$	<ul style="list-style-type: none"> Environment & Health Infrastructure Equity 	<ul style="list-style-type: none"> Number of buses available as an emergency shelter. Average response time after request for bus as an emergency shelter.
130	Continue policy and practice of continuing bus service during inclement weather.	Existing	<ul style="list-style-type: none"> Emergency Services Fleet Asset Management 	Policy	Ongoing	\$	<ul style="list-style-type: none"> Environment & Health Infrastructure Equity 	<ul style="list-style-type: none"> Up-to-date bus service policy during inclement weather.
131	Continue training staff on how to do route detours.	Existing	<ul style="list-style-type: none"> Emergency Services Asset Management Fleet 	Capital	Ongoing	\$	<ul style="list-style-type: none"> Environment & Health Infrastructure Equity 	<ul style="list-style-type: none"> Number of staff trained in route detours.

Notes:

(1) Estimated Resources: \$ less than \$100,000; \$\$ between \$100,000 and \$1,000,000; and \$\$\$ more than \$1,000,000

O&M - operation and maintenance

Table 45 Wastewater

No.	Adaptation Actions	Action Status	Collaborating /Benefitting Departments	Implementation				Example Key Performance Indicators
				Action Type	Schedule	Estimated Resources ⁽¹⁾	Goal Alignment	
17	Continue to provide backup power (diesel generator) at the Water Resource Recovery Centre in then event of a power outage.	Existing	<ul style="list-style-type: none"> Asset Management Grand River Conservation Authority 	O&M	Ongoing	\$	<ul style="list-style-type: none"> Environment & Health Infrastructure Safety 	<ul style="list-style-type: none"> Provision of diesel generator.
39	Continue to liaise with Grand River Conservation Authority on Speed River flows and assimilative capacity.	Existing	<ul style="list-style-type: none"> Asset Management Grand River Conservation Authority 	Planning	Ongoing	\$	<ul style="list-style-type: none"> Environment & Health Infrastructure Economy Safety 	<ul style="list-style-type: none"> Regular correspondence with Grand River Conservation Authority on Speed River flows and assimilative capacity.
47	Itemize Water Resource Recovery Centre components susceptible to hazard impacts and plan with Asset Management for replacement.	Recommended	<ul style="list-style-type: none"> Asset Management Public Works 	Planning	Short term	\$	<ul style="list-style-type: none"> Infrastructure Safety 	<ul style="list-style-type: none"> Completion of an itemized list of assets within the building. Percentage of items in good working condition.
52	Continue to work with Asset Management to identify sanitary sewer infrastructure requiring upgrades and replacement.	Existing	<ul style="list-style-type: none"> Asset Management 	Planning	Ongoing	\$	<ul style="list-style-type: none"> Environment & Health Infrastructure Safety 	<ul style="list-style-type: none"> Length (km) of sanitary sewer infrastructure requiring upgrades and replacement.
86	Continue inflow and infiltration investigation program. Explore means to add resources during rain events to investigate flows within the system.	Existing	<ul style="list-style-type: none"> Asset Management Public Works 	Capital	Ongoing	\$	<ul style="list-style-type: none"> Infrastructure Safety Equity 	<ul style="list-style-type: none"> Estimate of "leaky" pipes (km).
89	Continue to optimize treatment process as ambient temperatures change (increase).	Existing	<ul style="list-style-type: none"> Asset Management Public Works 	Capital	Ongoing	\$\$\$	<ul style="list-style-type: none"> Environment & Health Infrastructure 	<ul style="list-style-type: none"> Continued optimization of treatment process.
97	Install backflow prevention at outfall to Speed River.	Recommended	<ul style="list-style-type: none"> Asset Management Grand River Conservation Authority 	Capital	Short term to medium term	\$\$	<ul style="list-style-type: none"> Environment & Health Infrastructure Safety 	<ul style="list-style-type: none"> Installation of backflow prevention at outfall to Speed River.
101	Add permanent flow meters in the collection system, as specified in the Linear Water/Wastewater Master Plan.	Existing	<ul style="list-style-type: none"> Asset Management Public Works 	Capital	Medium term	\$	<ul style="list-style-type: none"> Infrastructure Economy Safety Equity 	<ul style="list-style-type: none"> Addition of flow meters as specified in the Linear Water/Wastewater Master Plan.

Notes:

(1) Estimated Resources: \$ less than \$100,000; \$\$ between \$100,000 and \$1,000,000; and \$\$\$ more than \$1,000,000

O&M - operation and maintenance

Table 46 Water Services

No.	Adaptation Actions	Action Status	Collaborating /Benefitting Departments	Implementation				Example Key Performance Indicators
				Action Type	Schedule	Estimated Resources ⁽¹⁾	Goal Alignment	
8	Continue assessing risk as per the Drinking Water Quality Management System.	Existing	<ul style="list-style-type: none"> Asset Management 	Policy	Ongoing	\$\$	<ul style="list-style-type: none"> Infrastructure Economy 	<ul style="list-style-type: none"> Average risk status as dictated by the Drinking Water Quality Management System. Conducting annual risk assessment.
9	Continue Source Water Protection program.	Existing	<ul style="list-style-type: none"> Asset Management 	Capital	Ongoing	\$\$ to \$\$\$	<ul style="list-style-type: none"> Environment & Health Infrastructure Economy 	<ul style="list-style-type: none"> Continuation of the Source Water Protection program.
11	Continue to stock backup equipment in the event of equipment failure.	Existing	<ul style="list-style-type: none"> Asset Management 	O&M	Ongoing	\$\$	<ul style="list-style-type: none"> Infrastructure Safety 	<ul style="list-style-type: none"> Number of assets with backup equipment readily available.
31	Continue to pursue venture with Rezatec to take into account history of breaks, combine with weather conditions, and soil type to order to advise when to replace infrastructure.	Existing	<ul style="list-style-type: none"> Engineering (Stormwater) Wastewater Asset Management 	Capital	Short term	\$\$	<ul style="list-style-type: none"> Environment & Health Infrastructure Safety 	<ul style="list-style-type: none"> Length (km) of infrastructure requiring maintenance and replacement. Completion of City-wide assessment.
36	Continue to review and update as necessary emergency plan to include the loss of Woods Station or a water storage facility.	Existing	<ul style="list-style-type: none"> All Departments/ Divisions 	Planning	Short term	\$	<ul style="list-style-type: none"> Infrastructure Safety 	<ul style="list-style-type: none"> Establish a regular review of the emergency plan.
51	Source Water Protection group to work with Public Works to consider alternative means of de-icing instead of salt use.	Recommended	<ul style="list-style-type: none"> Asset Management Public Works (Operations) 	Capital	Short term to medium term	\$\$	<ul style="list-style-type: none"> Environment & Health Economy Safety 	<ul style="list-style-type: none"> Amount (kg) of salt application.
99	Consider redundancy in aqueduct to direct some portion of flow to southern area of the City.	Recommended	<ul style="list-style-type: none"> Asset Management 	Capital	Medium term	\$\$\$	<ul style="list-style-type: none"> Infrastructure Safety 	<ul style="list-style-type: none"> Area of the City with redundant source of water.
109	Establish plan with Public Works if additional assistance is needed to clear route to the Arkell Spring Grounds.	Recommended	<ul style="list-style-type: none"> Public Works 	Planning	Short term	\$	<ul style="list-style-type: none"> Infrastructure Safety 	<ul style="list-style-type: none"> Establishment of plan with Public Works to clear route to the Arkell Spring Grounds.
110	Review redundancy planning for all water storage facilities.	Recommended	<ul style="list-style-type: none"> Asset Management 	Planning	Short term	\$	<ul style="list-style-type: none"> Infrastructure Safety 	<ul style="list-style-type: none"> Number of water storage facilities with a redundancy plan.
114	Update the Automated Meter Reading technology to inform and account for water within each City district.	Recommended	<ul style="list-style-type: none"> Asset Management 	Capital	Short term to medium term	\$\$	<ul style="list-style-type: none"> Infrastructure Economy 	<ul style="list-style-type: none"> Update of the Automated Meter Reading technology.
116	Continue to consider climate adaptation measures in the design of the Woods Water Treatment Plan upgrade.	Existing	<ul style="list-style-type: none"> Asset Management Facilities and Energy Management 	Capital	Short term	\$\$\$	<ul style="list-style-type: none"> Infrastructure Safety 	<ul style="list-style-type: none"> Incorporation of the climate adaptation measures in the design of the Woods Water Treatment Plant upgrade.

No.	Adaptation Actions	Action Status	Collaborating /Benefitting Departments	Implementation				Example Key Performance Indicators
				Action Type	Schedule	Estimated Resources ⁽¹⁾	Goal Alignment	
119	Continue the water meter program.	Existing	<ul style="list-style-type: none"> Asset Management 	Capital	Ongoing	\$\$ to \$\$\$	<ul style="list-style-type: none"> Infrastructure Economy 	<ul style="list-style-type: none"> Continuation of the water meter program.
158	Participate in the Water Managers Working Group with GRCA and other municipalities in the watershed.	Recommended	<ul style="list-style-type: none"> Wastewater Grand River Conservation Authority 	Planning	Short term	\$	<ul style="list-style-type: none"> Environment & Health Infrastructure Safety 	<ul style="list-style-type: none"> Number of meetings/communication with the Water Managers Working Group with GRCA.

Notes:

(1) Estimated Resources: \$ less than \$100,000; \$\$ between \$100,000 and \$1,000,000; and \$\$\$ more than \$1,000,000

7.5 Integration of the Climate Adaptation Plan into the City's Business Plans

7.5.1 Monitoring and Review of the Climate Adaptation Plan

The Climate Adaptation Plan is intended to be used as a living document, developed in consultation with City staff. The intention is that implementation is sustainable, effective, integrated, inclusive, and iterative. We recommend using the number of implemented/completed actions as the overall KPI for the implementation of the Climate Adaptation Plan, as a part of the City's Strategic Plan performance.

Consistent with the City's typical master planning cycle for most departments/divisions, a formal review and update to the Climate Adaptation Plan should be undertaken once every five years. There is the opportunity to apply lessons learned and assess whether the context of the risks and vulnerabilities has changed, and whether the actions being implemented are reducing vulnerability and increasing resiliency and adaptive capacity.

It is recommended that the Climate Adaptation Plan update be managed by the City's Asset Management Group. The rationale for this is further detailed in the following subsection.

7.5.2 Lead Integration and Implementation by Asset Management

In addition to managing the Climate Adaptation Plan update on a five-year frequency, we recommend that the Asset Management Group also take on the management and leadership of overseeing the implementation and integration of the Climate Adaptation Plan as the program leader. Practically, this would involve liaising with representatives from the other City departments/divisions to a) track the status of adaptive capacity action integration into their respective business plans, b) track the status of action implementation, and c) work with the representatives to define and monitor KPIs for their respective adaptive capacity actions. The program leader from the Asset Management Group would be responsible for reporting to the City on the annual progress of implementation of the Climate Adaptation Plan.

The Asset Management Group is the most appropriate department to lead the Climate Adaptation Plan implementation because the plan approach was an asset-based approach, with the climate risks initially evaluated at the asset level before expanding to develop adaptive capacity actions that consider both City assets and services. Further, the cost of climate change with respect to the City's infrastructure is already an element of the Asset Management Plan and therefore provides for the ability to proactively plan for the long-term management of assets. This approach will include accounting for the effect of climate change on the USL of core

assets, the effect of a reduction in USL maintenance, rehabilitation and renewal costs and efforts.

The City has demonstrated considerable progress with the development of its asset management planning process, and within the next revision cycle should have the ability to incorporate the approach laid out by FAO's CIPI project (FAO 2019) into its Corporate Asset Management Plan. Achieving this goal; however, will require the City to embed climate change planning into related master planning and departmental/divisional management activities to ensure that these business functions can provide the information needed to account for the costs of climate change into future plans. This is described further in the following subsection.

7.5.3 Department/Division Integration through Master Planning and Policy Documentation

The City's Master Plans can be a critical process for incorporating climate change into its infrastructure management and planning framework and should account for climate change and adaptation for the following reasons:

- Climate change is already affecting Guelph and will continue to do so in the future. It is important to consider the risks and impacts of climate change when developing and implementing Master Plans to ensure that the City is resilient to these changes.
- Climate change can exacerbate existing vulnerabilities and inequalities, particularly for low-income and marginalized communities. By incorporating climate change adaptation measures into Master Plans, we can help ensure that these communities are not left behind and that they can withstand the impacts of climate change.
- Existing and future infrastructure and buildings will be in place for decades, if not centuries. Accounting for climate change in Master Plans can help ensure that these structures are designed to withstand future climate conditions and avoid costly retrofits or repairs.
- Climate change can also affect the economy, particularly in sectors such as tourism, and transportation. Master plans can help address these impacts by identifying and prioritizing adaptation measures that can help maintain economic stability.
- Finally, by accounting for adaptation in Master Plans, the City can identify opportunities where these actions can also support their commitments to reduce greenhouse gas emissions. This is particularly important given the urgent need to address climate change from both mitigation and adaptation. These measures may also generate many other co-benefits for the community and the environment that enhance biodiversity, ecosystem services, and overall human health.

The City currently maintains and updates the following Master Plans and other relevant planning documents:

- Corporate and Core Asset Management Plan
- Cycling Master Plan - Bicycle-Friendly Guelph
- Digital and Technology Master Plan
- Natural Assets Inventory
- Natural Heritage Action Plan
- Parking Master Plan
- Parks and Recreation Master Plan update
- Paramedic Service Master Plan
- Solid Waste Management Master Plan
- Stormwater Management Master Plan
- Transportation Master Plan
- Wastewater Treatment and Biosolids Management Master Plan
- Water and Wastewater Servicing Master Plan
- Water Supply Master Plan
- Water Efficiency Strategy
- Urban Forest Management Plan

Master plans build on the goals and policies from the Official Plan to define long-term objectives for specific municipal programs and services. Master plans integrate existing and future land use and infrastructure planning with the principles of environmental assessment planning. The plans identify preferred options and estimated costs for infrastructure rehabilitation and renewal over the foreseeable planning period. Climate change is currently considered or partially addressed within many of the Master Plans, and in these cases these recommendations were included as “existing” actions in this Climate Adaptation Plan for consistency between the Master Plans and the Climate Adaptation Plan.

Going forward and carrying on this consistency will be key in successfully implementing the Climate Adaptation Plan. To this end we recommend that future master planning documents specifically identify climate risks and the cost of climate change and the adaptation alternatives recommended to mitigate those risks. These would then be referenced in the next update to the Climate Adaptation Plan. Further, master plan recommendations should be sufficient to carry forward the information needed to embed the cost of climate change into the Asset Management Plan.

8 Conclusion and Recommendations

As the City of Guelph moves towards meeting its commitments to become a carbon net-zero community by 2050, it is also moving towards its commitment to become climate resilient through the implementation of an achievable Climate Adaptation Plan. The Climate Adaptation Plan outlines a path forward in support of the City’s efforts to become climate resilient by

assessing vulnerability and risk and implementing climate adaptation measures. By doing so, the Climate Adaptation Plan will help the City meet its obligations as a member of the Global Covenant of Mayors for Climate and Energy.

Based on the output of the climate risk assessment of City assets, the number of assets that were considered to be at high or very high risk, without accounting for existing adaptive capacity measures, was generally consistent with other comparable or nearby municipalities. The number of high and very high risks may also be attributable to the large number of assets assessed, noting that they cut across 13 different City departments/divisions.

Notwithstanding uncertainties of future climate conditions, the risk assessment has provided the City with a clearer and more certain sense of the risks to climate-related hazards by the 2050s and 2080s. The current risks to assets and service delivery are generally manageable, based on historical experience, but it is expected that operating, maintaining, and managing the City's array of assets, operations and services in a climate change future will become more challenging and potentially lead to an increase in asset failure and costs, and a decrease in asset performance and service delivery.

We note that the current adaptive capacity of the City provides a good foundation of existing and planned actions. In responding to an increase in vulnerability and risk to climate hazards in the future, the City's departments/divisions will need to strengthen coordination between departments/divisions (e.g., where assets and services at high risk are the responsibility of multiple departments/divisions), address knowledge gaps through additional research (e.g., cumulative and compounding climate-related impacts), and adopt a more integrative approach to their management of assets and delivery of services (e.g., into key planning initiatives).

While nine climate hazards were included in the climate risk assessment of municipal assets, only six generated high and/or very high risks over the next 30 years. Of these, the hazards that pose the greatest risk are extreme heat, acute weather events (e.g., high wind gusts), and heavy rainfall/flooding. The departments/divisions facing the largest number of high and/or very high climate-related risks (prior to accounting for existing adaptive capacity measures) are: (i) Water Services, (ii) Parks, (iii) Planning Services, (iv) Culture and Recreation, and (v) Engineering and Transportation Services. In the short-term the City can continue to operate, maintain, and manage these risks through their existing tool kit of asset management, Master Plans, and other practices and protocols. As the climate-related risks to infrastructure assets and services increase, the Climate Adaptation Plan provides the City with a path forward involving numerous actions across all departments/divisions, where improved coordination, collaboration, and integration will be needed.

Asset management should be at the core of implementing the Climate Adaptation Plan, followed by the City’s Master Plans and planning documents, and then other practices and protocols. Taking a holistic and integrative approach is essential given the fact that (i) the cost of managing infrastructure assets currently through the Asset Management Plan faces a financial shortfall; (ii) the costs of managing infrastructure assets under climate change are projected to increase; and (iii) the effects of climate change will widen the shortfall.

The City should focus on adaptation measures that can be implemented in the short-term, and consider where they need to reallocate funding/tweak the capital budget to address shifting needs and in response to evolving risks. Monitoring and reporting will be important, in addition to tracking KPIs. This approach is consistent with the application of the adaptive management cycle and a commitment to continuous improvement. Further integration of climate change into asset management planning is needed, and this process can be partly informed by the Climate Adaptation Plan risk assessment. However, to more effectively manage climate-related risks in the future, this likely requires a deeper analysis into specific assets and components that was covered in this first iteration of the Climate Adaptation Plan. In the future, there may need to be greater spatial consideration of EDI, etc.

Lastly, we recommend that the Climate Adaptation Plan be updated every five years, taking into account any advances in climate change science and projections, improved understanding of vulnerability and risks to City assets and services, the City’s progress in achieving their KPIs, and the overall effectiveness of integrating climate change into the City’s Asset Management Plan, Master Plans, and other practices and protocols.

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Appendix A

Staff Engagement

A1 Appendix A - Project Engagement

A.1 Engagement & Communication Activities

The following table summarizes the engagement and communications activities conducted with internal and external project stakeholders throughout the project.

Table A.1 Stage 1: Engagement & Communications Activities

Activity	Audience	Timing	Description	Purpose/Key Outcomes
Kick-off Meeting	Core Project Team	March 2022	<ul style="list-style-type: none"> Two-hour virtual meeting to introduce and launch the project internally 	<ul style="list-style-type: none"> Introduced project objectives, scope, stakeholders to be engaged, and project schedule Discussed issues and opportunities
Core Project Team Meeting #1	Core Project Team	May 2022	<ul style="list-style-type: none"> Two-hour virtual meeting to provide an update to the Core Project Team on Stage 1 progress and confirm the approach to future work 	<ul style="list-style-type: none"> Reviewed and confirmed scope, vision and goals, methodology, sources to review, and communications and engagement approach
Staff Working Group Meeting #1	Staff Working Group	May 2022	<ul style="list-style-type: none"> Two-hour virtual meeting to orient the Staff Working Group to the project 	<ul style="list-style-type: none"> Reviewed project progress, vision and goals, methodology, and communications and engagement approach Collected feedback on assets and services impacted by climate change
Public Webpage Created	General Public	June 2022	<ul style="list-style-type: none"> Creation of a public-facing webpage for the project: https://guelph.ca/plans-and-strategies/climate-adaptation-plan/ 	<ul style="list-style-type: none"> Provided background information on climate adaptation, the purpose of the project, and the plan's vision and goals
Stage 1 Memo	Steering Committee, Core Project Team, Staff Working Group	July 2022	<ul style="list-style-type: none"> Stage 1 Memo circulated via email for internal review and comment 	<ul style="list-style-type: none"> Solicited feedback on Stage 1 Scope and Planning Memo

Activity	Audience	Timing	Description	Purpose/Key Outcomes
Introductory Email	Partner Working Group, Community Organizations	July 2022	<ul style="list-style-type: none"> Email update sent to Partner Working Group and relevant community organizations 	<ul style="list-style-type: none"> Partner Working Group provided a project update, information about engagement opportunities and a condensed version of the Stage 1 Memo Community organizations provided with a project update

Table A.2 Stage 2: Engagement & Communications Activities

Activity	Audience	Timing	Description	Purpose/Key Outcomes
Core Project Team Meeting #2	Core Project Team	June 2022	<ul style="list-style-type: none"> Two-hour virtual meeting to provide an update to the Core Project Team on Stage 2 progress and confirm the approach to future work 	<ul style="list-style-type: none"> Discussion and approval of vulnerability and risk assessment matrices
Small Group Workshops (4)	Staff Working Group – all departments/divisions	June 2022	<ul style="list-style-type: none"> Series of four small group workshops Staff were invited to participate in one session based on their area of expertise 	<ul style="list-style-type: none"> Solicited insights from staff on the interaction between services/assets and hazards to inform the draft risk assessment spreadsheet
Calls	Internal: Contaminated Lands, Parks: Culture & Recreation, Emergency Services, Public Works, Transit, IT External: Wellington Dufferin Guelph Public Health	July - August 2022	<ul style="list-style-type: none"> Series of individual and small group discussions with internal staff and members of the Partner Working Group 	<ul style="list-style-type: none"> Gap filling for those unable to attend the small group workshops (above) and the Partner Working Group meeting (below)
Partner Working Group Meeting	Partner Working Group	July 2022	<ul style="list-style-type: none"> One-hour virtual meeting with key partners (those whose assets or operations impact the City's corporate climate adaptation efforts) 	<ul style="list-style-type: none"> Familiarized partners with project Collected relevant data, plans, and information from partners to inform the corporate plan
Stage 2 Memo	Steering Committee, Core Project Team, Staff Working Group	September 2022	<ul style="list-style-type: none"> Stage 2 Memo circulated via email for internal review and comment 	<ul style="list-style-type: none"> Solicited feedback on Stage 2 Background Review Memo
Public Webpage Updated	General Public	November 2022	<ul style="list-style-type: none"> Webpage updated 	<ul style="list-style-type: none"> Provided additional information on work to date and upcoming engagement opportunities

Activity	Audience	Timing	Description	Purpose/Key Outcomes
Email Update	Partner Working Group, Community Organizations	December 2022	<ul style="list-style-type: none"> Email update sent to Partner Working Group and relevant community organizations 	<ul style="list-style-type: none"> Partner Working Group provided a project update, information about engagement opportunities and condensed version of Stage 2 Memo Community organizations provided with project update

Table A.3 Stage 3: Engagement & Communications Activities

Activity	Audience	Timing	Description	Purpose/Key Outcomes
Core Project Team Meeting #3	Core Project Team	September 2022	<ul style="list-style-type: none"> Two-hour virtual meeting to provide an update to the Core Project Team on Stage 3 progress and confirm the approach to future work 	<ul style="list-style-type: none"> Solicited high-level input on risk assessment results, adaptive capacity, and risk prioritization
Steering Committee Meeting	Steering Committee	September 2022	<ul style="list-style-type: none"> One-hour virtual meeting to provide an update to the Steering Committee on Stage 3 progress and confirm the approach to future work 	<ul style="list-style-type: none"> Solicited high-level input on risk assessment results, adaptive capacity, and risk prioritization
Email Update	Core Project Team	October 2022	<ul style="list-style-type: none"> Email update outlining a proposed approach to engaging staff in Stage 4 	<ul style="list-style-type: none"> Solicited feedback and confirmed approach for staff engagement
Staff Working Group Meeting #2	Staff Working Group	October 2022	<ul style="list-style-type: none"> Two-hour virtual meeting to provide an update to the Staff Working Group on Stage 3 progress and solicit input 	<ul style="list-style-type: none"> Solicited initial input on risk assessment results, adaptive capacity, and risk prioritization
Email Update	Steering Committee	December 2022	<ul style="list-style-type: none"> Email update with comprehensive project status update attached 	<ul style="list-style-type: none"> Updated Steering Committee on progress to date
Public Webpage Updated	General Public	January & March 2023	<ul style="list-style-type: none"> Webpage updated 	<ul style="list-style-type: none"> Provided additional information on work to date and upcoming engagement opportunities
Stage 3 Memo	Steering Committee, Core Project Team, Staff Working Group	March 2023	<ul style="list-style-type: none"> Stage 3 Memo circulated via email for internal review and comment 	<ul style="list-style-type: none"> Solicited feedback on Stage 3 Risk Assessment Memo

Activity	Audience	Timing	Description	Purpose/Key Outcomes
Email Update	Partner Working Group, Community Organizations	March 2023	<ul style="list-style-type: none"> Email update sent to Partner Working Group and relevant community organizations 	<ul style="list-style-type: none"> Partner Working Group provided a project update, information about engagement opportunities and a condensed version of the Stage 3 Memo Community organizations provided a project update and upcoming engagement opportunities

Table A.4 Stage 4: Engagement & Communications Activities

Activity	Audience	Timing	Description	Purpose/Key Outcomes
Staff Working Group Meeting #3	Staff Working Group	November 2022	<ul style="list-style-type: none"> Two-hour virtual meeting to provide an update to the SWG on Stage 4 progress and solicit input 	<ul style="list-style-type: none"> Solicited input from the SWG on impact statements, adaptive capacity, and risk prioritization Discussed potential actions to address outstanding risks
1-1 Calls (Staff Working Group)	Departments/Divisions: <ul style="list-style-type: none"> Communications Transportation Asset Management Contaminated Lands Water Services Culture and Recreation Economic Development and Tourism Guelph Library Services Solid Waste Facilities and Energy Management Corporate Health & Safety Wastewater Information Technology Stormwater Parks Planning and Building Services Transit Public Works Emergency Services Equity/Diversity/Inclusion 	November – December 2022	<ul style="list-style-type: none"> One-hour meetings with individual departments to solicit in-depth information about adaptive capacity measures 	<ul style="list-style-type: none"> Discussed the service(s) the department provides to the City and the interconnectivity between departments, adaptive capacity measures already being implemented and any planned actions and associated funding

Activity	Audience	Timing	Description	Purpose/Key Outcomes
1-1 Calls (Partner Working Group)	Partners: <ul style="list-style-type: none"> Grand River Conservation Authority University of Guelph Guelph Junction Railway Alectra Wellington Dufferin Guelph Public Health 	January – February 2023	<ul style="list-style-type: none"> One-hour meetings with individual departments/partner organizations to solicit in-depth information about adaptive capacity measures 	<ul style="list-style-type: none"> Discussed the interactions between partner and City services/assets, adaptive capacity measures already being implemented and any planned actions and associated funding
Stage 4 Memo	<ul style="list-style-type: none"> Steering Committee, Core Project Team, Staff Working Group 	March 2023	<ul style="list-style-type: none"> Stage 4 Memo circulated via email for internal review and comment 	<ul style="list-style-type: none"> Solicited feedback on Stage 4 Actions and Plan Development Memo
Staff Poster Session	All City Staff (60 attendees)	March 2023	<ul style="list-style-type: none"> Internal open house (in-person) with display boards outlining draft actions PDFs of poster boards were circulated to the Steering Committee, Core Project Team, and SWG for review and comment 	<ul style="list-style-type: none"> SWG members presented draft adaptation actions and associated implementation considerations on behalf of their departments City staff provided comments and suggestions to refine the proposed actions
Pop-Up Information Events	General Public (75 engaged)	April 2023	<ul style="list-style-type: none"> Two in-person pop-up information booths April 15: Guelph Farmers' Market April 22: Hanlon Forest Tree Planting event 	<ul style="list-style-type: none"> Draft Climate Adaptation Plan presented to the public Answered questions about the project and the City's climate action efforts
Public Webpage Updated	General Public	April 2023	<ul style="list-style-type: none"> Webpage updated 	<ul style="list-style-type: none"> Provided additional information on work to date and upcoming engagement opportunities
Email Update	Steering Committee, Core Project Team, Staff Working Group, Partner Working Group, Community Organizations	May 2023	<ul style="list-style-type: none"> Draft CAP sent to Partner Working Group and relevant community organizations 	<ul style="list-style-type: none"> Partner Working Group provided a project update, information about engagement opportunities and a condensed version of the Stage 4 Memo Community organizations provided with a project update

A.2 Indigenous Engagement Activities

The following table provides a log of the engagement and communications activities conducted with Indigenous governments throughout the project. All correspondence is from Shelley Lorenz, Project Manager, Environmental Services, City of Guelph, unless noted otherwise.

Table A.5 Indigenous Engagement Activities Summary

Activity	Audience	Timing	Description	Purpose/Key Outcomes
Introductory Email	The Haudenosaunee Confederacy info@hdi.land	Feb.25, 2022	<ul style="list-style-type: none"> Letter via email 	<ul style="list-style-type: none"> The City invited the Haudenosaunee Confederacy to participate in developing the Climate Change Adaption Plan. The City provided details of the project along with timelines.
Introductory Email	Mississaugas of the Credit First Nation (MCFN) MCFN Consultation, Department of Consultation and Accommodation (DOCA) MCFN.Consultation@mncfn.ca Doca.Admin@mncfn.ca	Feb.25, 2022	<ul style="list-style-type: none"> Letter via email 	<ul style="list-style-type: none"> The City invited MCFN to participate in developing the Climate Change Adaption Plan. The City provided details of the project along with timelines.
Introductory Email	Six Nations of the Grand River (SNGR) Robbin Vanstone, Consultation Supervisor, Land and Resources Office, rvanstone@sixnations.ca	Feb.25, 2022	<ul style="list-style-type: none"> Letter via email 	<ul style="list-style-type: none"> The City invited SNGR to participate in developing the Climate Change Adaption Plan. The City provided details of the project along with timelines. SNGR expressed appreciation for inclusion in the initiative and said they are confident they could be an asset to this discussion and that an Indigenous perspective is essential. Robbin cc'd the Wildlife and Stewardship Manager, Bethany Kuntz-Wakefield, as she is knowledgeable from a science perspective.

Activity	Audience	Timing	Description	Purpose/Key Outcomes
Introductory Email	Grand River Métis Council (GRMC) Jennifer Parkinson, President president@grandrivermetis.ca , consultations@metisnation.org	Mar. 9, 2022	<ul style="list-style-type: none"> Letter via email 	<ul style="list-style-type: none"> The City invited the GRMC to participate in developing the Climate Change Adaption Plan. The City provided details of the project along with timelines.
Meeting Invitation Via Email	Six Nations of the Grand River Robbin Vanstone, Consultation Supervisor, Land and Resources Office, rvanstone@sixnations.ca , Bethany Kuntz-Wakefield, Wildlife and Stewardship Manager, wildlife@sixnations.ca	Mar. 10, 2022	<ul style="list-style-type: none"> A virtual meeting invite via email 	<ul style="list-style-type: none"> The City invited SNGR to a virtual meeting on Mar. 10, 2022. The session was recorded and meeting notes were taken.
Follow-up Email	The Haudenosaunee Confederacy info@hdi.land	Mar. 14, 2022	<ul style="list-style-type: none"> Letter via email, follow-up (#2/4) 	<ul style="list-style-type: none"> The City invited the Haudenosaunee Confederacy groups to participate in developing the Climate Change Adaption Plan. The City provided details of the project along with timelines.
Follow-up Email	Mississaugas of the Credit First Nation MCFN Consultation, Department of Consultation and Accommodation (DOCA) MCFN.Consultation@mncfn.ca Doca.Admin@mncfn.ca	Mar. 14, 2022	<ul style="list-style-type: none"> Letter via email, follow-up (#2/3) 	<ul style="list-style-type: none"> The City invited MCFN to participate in developing the Climate Change Adaption Plan. The City provided details of the project along with timelines.
Email Update	Six Nations of the Grand River Robbin Vanstone, Consultation Supervisor, Land and Resources Office, rvanstone@sixnations.ca , Lauren Jones, Laurenjones@sixnations.ca , Bethany Kuntz-Wakefield, Wildlife and Stewardship Manager, wildlife@sixnations.ca	Mar. 23, 2022	<ul style="list-style-type: none"> Email 	<ul style="list-style-type: none"> The City sent SNGR meeting minutes along with PowerPoint from Mar. 10th meeting.

Activity	Audience	Timing	Description	Purpose/Key Outcomes
Follow-up Email	Grand River Métis Council Jennifer Parkinson, President, president@grandrivermetis.ca , consultations@metisnation.org	Mar. 23, 2022	<ul style="list-style-type: none"> Letter via email, follow-up (#2/3) 	<ul style="list-style-type: none"> The City invited GRMC to participate in developing the Climate Change Adaption Plan The City provided details of the project along with timelines.
Follow-up Phone Call	Mississaugas of the Credit First Nation	Mar. 28, 2022	<ul style="list-style-type: none"> Follow-up (#3/3) 	<ul style="list-style-type: none"> Left message. Mark called Shelley back on March 28, 2022. He said they have no immediate need to be included in the consultation. However, he wants to be kept informed as we progress the project.
Follow-up Phone Call	The Haudenosaunee Confederacy 519-445-4222	Mar. 28, 2022	<ul style="list-style-type: none"> Follow-up (#3/4) 	<ul style="list-style-type: none"> Spoke with the receptionist. She confirmed that they had received my email. She said she would re-send the email to her team to see if they had any comments, questions or interest. She said that someone should get back to me in a few days.
Follow-up Email	Grand River Métis Council Jennifer Parkinson, President	Apr. 7, 2022	<ul style="list-style-type: none"> Email 	<ul style="list-style-type: none"> Jennifer apologized for the delayed response. She will forward the information to Council, who will be in touch.
Follow-up Phone Call	The Haudenosaunee Confederacy 519-445-4222	Apr. 13, 2022	<ul style="list-style-type: none"> Follow-up (#4/4) 	<ul style="list-style-type: none"> Spoke with the receptionist. She will re-send the email to her team and follow up at the staff meeting on April 14. Someone will get back to me. (NO FURTHER CONTACT MADE WITH HC. NO ONE GOT BACK.)
Follow-up Email	Grand River Métis Council Jennifer Parkinson, President	Apr. 21, 2022	<ul style="list-style-type: none"> Follow-up (#3/3) 	<ul style="list-style-type: none"> Follow-up (#3/3) Followed-up on Jennifer's email. She said someone would reach out. (NO FURTHER CONTACT MADE WITH GRMC. NO RESPONSE.)
Email Update	Mississaugas of the Credit First Nation mark.laforme@mncfn.ca	Jul. 15, 2022	<ul style="list-style-type: none"> Email 	<ul style="list-style-type: none"> Share the first project status update. This covered Tech Memo 1 (Scope and Planning) and included the Plan vision and objectives.

Activity	Audience	Timing	Description	Purpose/Key Outcomes
Email Update	Six Nations of the Grand River Robbin Vanstone, Consultation Supervisor, Land and Resources Office rvanstone@sixnations.ca Lauren Jones, Laurenjones@sixnations.ca Bethany Kuntz-Wakefield, Wildlife and Stewardship Manager, wildlife@sixnations.ca	Jul. 15, 2022	<ul style="list-style-type: none"> Email 	<ul style="list-style-type: none"> Share the first project status update. This covered Tech Memo 1 (Scope and Planning) and included the Plan vision and objectives.
Follow-up Email	Mississaugas of the Credit First Nation mark.laforme@mncfn.ca	Aug. 8, 2022	<ul style="list-style-type: none"> Email 	<ul style="list-style-type: none"> Follow-up to the July 15, 2022, email.
Follow-up Email	Six Nations of the Grand River Robbin Vanstone, Consultation Supervisor, Land and Resources Office, rvanstone@sixnations.ca , Lauren Jones, Laurenjones@sixnations.ca , Bethany Kuntz-Wakefield, Wildlife and Stewardship Manager, wildlife@sixnations.ca	Aug. 8, 2022	<ul style="list-style-type: none"> Email 	<ul style="list-style-type: none"> Follow-up to the July 15, 2022, email.
Email Update	Mississaugas of the Credit First Nation mark.laforme@mncfn.ca	Nov. 30, 2022	<ul style="list-style-type: none"> Email 	<ul style="list-style-type: none"> Share the second project status update.
Email Update	Six Nations of the Grand River Robbin Vanstone, Consultation Supervisor, Land and Resources Office, rvanstone@sixnations.ca Lauren Jones, Laurenjones@sixnations.ca Bethany Kuntz-Wakefield, Wildlife and Stewardship Manager, wildlife@sixnations.ca	Nov. 30, 2022	<ul style="list-style-type: none"> Email 	<ul style="list-style-type: none"> Share the second project status update.
Follow-up Email	Mississaugas of the Credit First Nation mark.laforme@mncfn.ca	Dec. 15, 2022	<ul style="list-style-type: none"> Email 	<ul style="list-style-type: none"> Follow-up to the Nov. 30, 2022, email.

Activity	Audience	Timing	Description	Purpose/Key Outcomes
Follow-up Email	Six Nations of the Grand River Robbin Vanstone, Consultation Supervisor, Land and Resources Office, rvanstone@sixnations.ca , Lauren Jones, Laurenjones@sixnations.ca Bethany Kuntz-Wakefield, Wildlife and Stewardship Manager, wildlife@sixnations.ca	Dec. 15, 2022	<ul style="list-style-type: none"> Email 	<ul style="list-style-type: none"> Follow-up to the Nov. 30, 2022, email.
Follow-up Email	Mississaugas of the Credit First Nation mark.laforme@mncfn.ca	Jan. 5, 2022	<ul style="list-style-type: none"> Email 	<ul style="list-style-type: none"> Follow-up to the Nov. 30, 2022, email. Mark's response "We have no comments or concerns at this time."
Follow-up Email	Six Nations of the Grand River Lauren Jones, Laurenjones@sixnations.ca Bethany Kuntz-Wakefield, Wildlife and Stewardship Manager, wildlife@sixnations.ca	Jan. 5, 2022	<ul style="list-style-type: none"> Email 	<ul style="list-style-type: none"> Follow-up to the Nov. 30, 2022, email.
Invitation Email	Mississaugas of the Credit First Nation mark.laforme@mncfn.ca	Feb. 3, 2023	<ul style="list-style-type: none"> Email 	<ul style="list-style-type: none"> Message: "I was wondering if you'd be free for a brief phone call to discuss how the City can conceptualize Reconciliation into the City's Climate Adaptation Plan, as our official treaty partner? We would really like your input as to how we can do this."
Follow-up Email	Mississaugas of the Credit First Nation mark.laforme@mncfn.ca	Feb. 17, 2023	<ul style="list-style-type: none"> Email 	<ul style="list-style-type: none"> Message: "I was wondering if you'd be free for a brief phone call? I'd like to learn from you how the City can conceptualize Reconciliation into the City's Climate Adaptation Plan?"
Meeting Via Phone	Mississaugas of the Credit First Nation mark.laforme@mncfn.ca	Feb. 17, 2023	<ul style="list-style-type: none"> Phone call 	<ul style="list-style-type: none"> Shelley shared an update on the project and a brief federal climate adaptation strategy overview. Mark agreed to review Tech Memo 3 and 4, to support the City in identifying how Reconciliation can be conceptualized in the Plan.

Activity	Audience	Timing	Description	Purpose/Key Outcomes
Email Update	Six Nations of the Grand River L RCS@sixnations.ca Bethany Kuntz-Wakefield, wildlife@sixnations.ca ; Lauren Jones, laurenjones@sixnations.ca Peter Graham, petergraham@sixnations.ca	Mar. 24, 2023	<ul style="list-style-type: none"> Email 	<ul style="list-style-type: none"> Shelley shared the third project status update and Tech Memo 3. She asked for feedback and to set up phone call.
Email Update	Mississaugas of the Credit First Nation mark.laforme@mncfn.ca	Mar. 24, 2023	<ul style="list-style-type: none"> Email 	<ul style="list-style-type: none"> Shelley shared the third project status update and Tech Memo 3. She asked for feedback and to set up phone call.
Email Update	Six Nations of the Grand River Peter Graham (L RCS@sixnations.ca)	Apr. 11, 2023	<ul style="list-style-type: none"> Email 	<ul style="list-style-type: none"> Shelley shared Memo 4 (1-page summary). She asked if Peter could review it before April 12 phone call.
Email Update	Mississaugas of the Credit First Nation mark.laforme@mncfn.ca	Apr. 11, 2023	<ul style="list-style-type: none"> Email 	<ul style="list-style-type: none"> Shelley shared Memo 4 (1-page summary). She asked for feedback and to set up a phone call.
Meeting Via Phone	Six Nations of the Grand River Peter Graham (L RCS@sixnations.ca)	Apr. 12, 2023	<ul style="list-style-type: none"> Phone call 	<ul style="list-style-type: none"> Peter would like the opportunity to review the draft report If we are prioritizing recommendations, they would prioritize anything related to the natural environment (e.g., 69, 106, 110, 112, 113, 117) Peter said he will give some more thought to how Reconciliation can tie into the plan Peter wanted to learn more on the salt application pilot project. I told him I'd have the project lead contact him.
Email Update	Mississaugas of the Credit First Nation mark.laforme@mncfn.ca	June 7, 2023	<ul style="list-style-type: none"> Email 	<ul style="list-style-type: none"> Email with the draft Climate Adaptation Plan, and the response to comments for Memos 3 and 4. Asked MCFN to provide comments. Received response from MCFN on June 14, 2023 thanking the City for sharing the draft document. The MCFN has no further comments on the report.

Activity	Audience	Timing	Description	Purpose/Key Outcomes
Email Update	Six Nations of the Grand River Peter Graham (LRCS@sixnations.ca)	June 7, 2023	<ul style="list-style-type: none"> Email 	<ul style="list-style-type: none"> Email with the draft Climate Adaptation Plan, and the response to comments for Memos 3 and 4. Asked SNGR to provide comments. Received comments from SNGR on June 12, 2023, which were incorporated into final report.

Appendix A - Community Organizations Engaged

Community organizations were consulted and informed throughout the process through email updates and email communication. The following is a list of organizations that were engaged, organized by area of interest.

Environmental Groups:

- AIM Environmental Group
- Council of Canadians, Guelph Chapter
- eMerge Guelph Sustainability
- Extinction Rebellion
- For our Kids Guelph
- Green New Deal Guelph
- Guelph Horticultural Society
- Guelph Students for Environmental Change
- Nature Guelph
- Ontario Public Interest Research Group (OPIRG) Guelph
- Ontario Water Consortium
- Our Energy Guelph
- Transition Guelph
- University of Guelph Sustainability Office
- Wellington Water Watcher

Cultural/Socio-economic Groups:

- Compass Community Services
- Family and Children's Services of Guelph and Wellington
- Innovation Guelph
- Guelph Community Foundation
- Guelph Community Health Centre
- Guelph & Wellington Task Force for Poverty Elimination
- Guelph Tool Library
- The People and Information Network (PIN)
- Rural Ontario Institute
- Toward Common Ground
- University of Guelph Institute of Community Engaged Scholarship (CESI)
- United Way Guelph Wellington Dufferin
- 10C Shared Space

Neighbourhood Groups:

- Guelph Neighbourhood Support Coalition
- Brant Avenue Neighbourhood Group
- Grange Hill East Neighbourhood Group
- Kortright Hills Neighbourhood Group
- North Riverside Neighbourhood Group
- Parkwood Gardens Neighbourhood Group
- Two Rivers Neighbourhood Group

Commercial/Industry/Landowners and Developers:

- Business Centre Guelph Wellington
- Downtown Guelph Business Association
- Guelph Chamber of Commerce
- Guelph & District Home Builders' Association

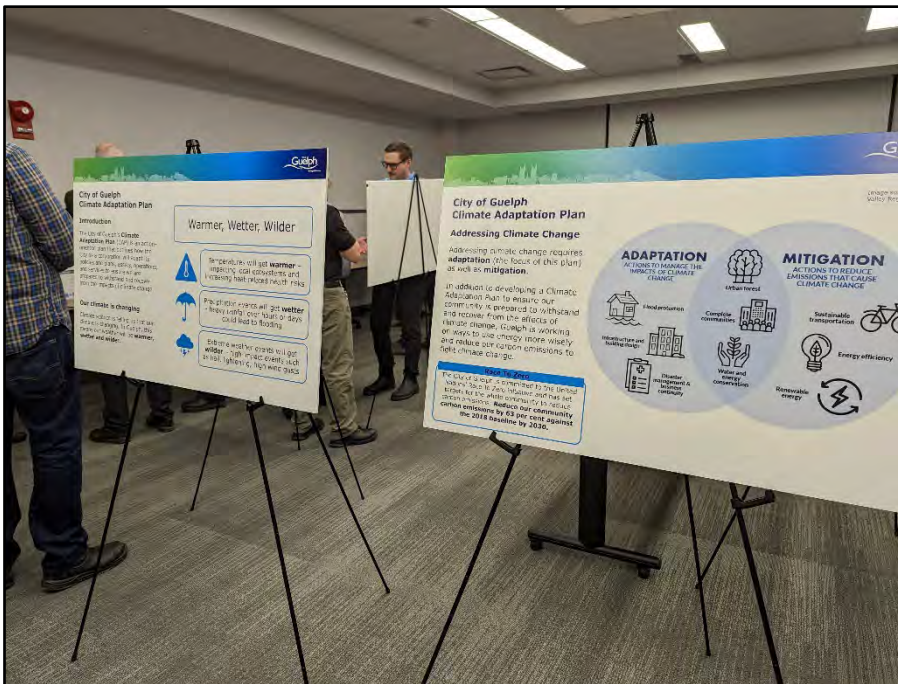
Neighbouring Municipalities:

- City of Cambridge
- City of Kitchener
- City of Waterloo
- Region of Waterloo



LURA Consulting
March 23, 2023

1. Poster Event in City Hall



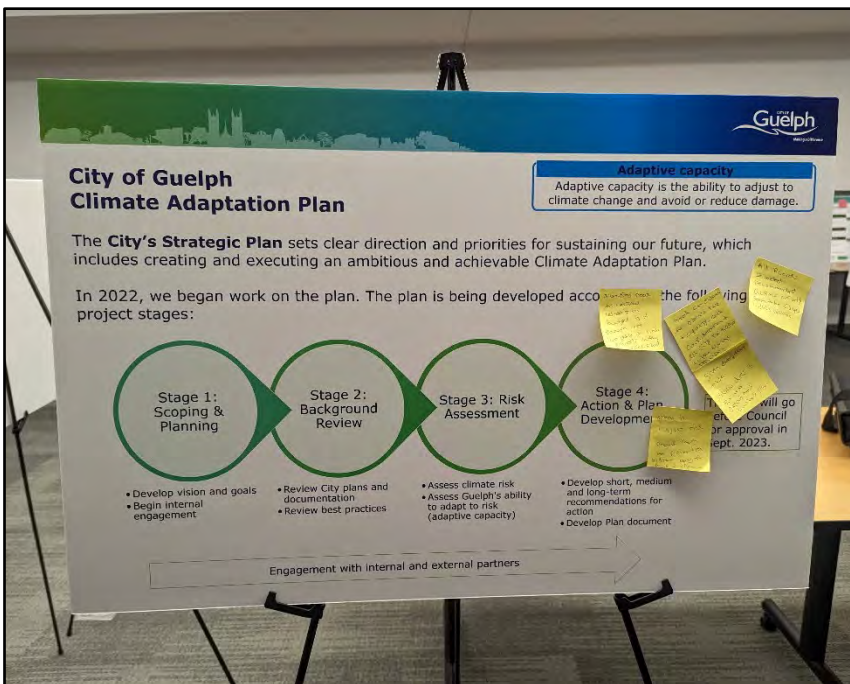
LURA Consulting
March 23, 2023

2. Close up of Introductory Posters



LURA Consulting
March 23, 2023

3. Posters displayed for City Staff



LURA Consulting
March 23, 2023

4. Staff comments on one of the poster boards



Appendix B Climate Hazards, Data, and Likelihood Memo Staff



STAGE 2 - BACKGROUND REVIEW

CITY OF GUELPH CLIMATE ADAPTATION PLAN

Prepared for:
CITY OF GUELPH

Prepared by:
MATRIX SOLUTIONS INC.

Version 1.0
January 2023
Guelph, Ontario

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STAGE 2 - BACKGROUND REVIEW
CITY OF GUELPH CLIMATE ADAPTATION PLAN

Prepared for City of Guelph, January 2023



Melani-Ivy Samson, M.A.Sc., E.I.T.
Water Resources EIT



reviewed by
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DISCLAIMER

Matrix Solutions Inc. certifies that this report is accurate and complete and accords with the information available during the project. Information obtained during the project or provided by third parties is believed to be accurate but is not guaranteed. Matrix Solutions Inc. has exercised reasonable skill, care, and diligence in assessing the information obtained during the preparation of this report.

This report was prepared for City of Guelph. The report may not be relied upon by any other person or entity without the written consent of Matrix Solutions Inc. and of City of Guelph. Any uses of this report by a third party, or any reliance on decisions made based on it, are the responsibility of that party. Matrix Solutions Inc. is not responsible for damages or injuries incurred by any third party, as a result of decisions made or actions taken based on this report.

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1 INTRODUCTION

As part of Stage 2 of the Climate Adaptation Plan (CAP), Matrix Solutions Inc. has prepared a strategic context review of internal and external documents for the City of Guelph (the City), which serves as a high-level preliminary review of how the CAP can build upon current efforts to address climate change, draw from climate adaptation plans developed by other municipalities, and identify where there may be opportunities for budget and funding options. The primary intent of this review is to undertake a preliminary assessment of the City's current coping methods and where they may enhance adaptive capacity. The review includes the identification of current and relevant sources of internal and external information that are consistent with study objectives, while also placing the results of the CAP within the regional geographic context and those already established by the Canadian regulatory and institutional standard of practice.

This Stage 2 memorandum provides a text summary of the documents reviewed and the references serve as a digital library of the most current and relevant documents pertaining to climate change and adaptive capacity in the City of Guelph. The list of strategic context documents and data reviewed was finalized with the Core Project Team. The details of this review include, but are not limited to, adaptation alternatives, existing or documented vulnerability to climate change and associated management, and internal funding with respect to climate change impacts. The review is organized under the following headings: City of Guelph Documents; Climate Data and Risk Studies; Climate Risk Guidelines and Standards; and Other Relevant Documents.

2 CITY OF GUELPH DOCUMENTS

Matrix has reviewed a list of background documents that was established at the onset of the project. Reference to these documents will continue in the next stage of the project as it pertains to risk management and adaptive capacity.

2.1 City Planning

2.1.1 City of Guelph Community Plan, 2019

The Community Plan (City of Guelph n.d.) seeks to shape the City over the next 10 to 20 years through a comprehensive plan that identifies specific priorities relevant to the City. Preparation of the plan involved interviewing and observing the Guelph community over a year to determine key values, which includes environmental stewardship. Pertaining to this value, one of the goals is make “bold, innovative, [and] collaborative” (City of Guelph n.d.) decisions to address and reduce the impacts of climate change. The strategic directions to improve the City's environmental stewardship includes, but are not limited to, protection and sustainment of current resources, becoming a model city for environmental decisions and actions, and preparation for the future (i.e., climate change resiliency). The City is committed to investing

into smart and clean technologies that help improve the resiliency of infrastructure and reduce the City’s carbon footprint.

2.1.2 City of Guelph Strategic Plan, 2019-2023

The Strategic Plan (City of Guelph 2019) builds upon the vision of the Community Plan to strategize actions over the next few years. One of the areas of focus is called “Sustaining our Future.” It references the future CAP (this project), which may include the investment into green infrastructure and increasing the City’s tree canopy. It discusses reducing the City’s carbon footprint to help mitigate climate change through retrofits, advocating for regulation and policy changes, and supporting environmental initiatives and partners. The City aims to plan and grow sustainably by protecting green infrastructure provided by the existing natural heritage system and implementing adaptable green infrastructure in physical areas.

2.1.3 City of Guelph Implementation of the City’s Strategic Plan, 2020

The Implementation of the City’s Strategic Plan (Optimus SBR 2020) summarizes the main pillars of the Strategic Plan, including “Sustaining our Future.” A strategy to review the overall plan includes reviewing the Performance Measurement Framework twice a year to evaluate potential changes required based on progress and/or changes to the environment. The document includes tables that summarize recommended priorities for each strategic pillar. Under the “Sustaining our Future” pillar this includes the CAP (this project), goals to improve sustainability within the City and their associated measures of success, initiatives, suggested implementation priorities, dependencies (i.e., other plans), and funding resources. The summary of the CAP as envisioned in the Strategic Plan is provided in Table 1.

TABLE 1 Strategic Priority - Sustaining Our Future: Climate Adaptation Plan (Optimus SBR 2020)

Item	Description
Expected Outcome	Care for the local environment, respond to climate change and prepare Guelph for a net-zero carbon future
Focus Areas	Create and execute an ambitious and achievable climate adaptation plan
Prioritized Measures of Success	% reduction of climate risk exposure for the City’s built and natural assets
Strategic Initiatives	Develop and implement CAP
Accountabilities and Responsibilities	TBD [<i>Post document: Matrix, LURA, and the City of Guelph</i>]
Suggested Implementation Priorities	
2020	<ul style="list-style-type: none"> Establish a governance approach to developing the plan Identify Guelph’s current state regarding climate risk exposure and develop an inventory of the City’s built and natural assets
2021	<ul style="list-style-type: none"> Prioritize actions and adaptation strategies based on assessed climate risk Review findings and actions with external stakeholders

Item	Description	
2022	<ul style="list-style-type: none"> Refine, finalize, and approve the final CAP with Council Complete Growth Conformity Review 	Implement the recommended actions and adaptation strategies outlined in the plan (to 2023+)
2023+	<ul style="list-style-type: none"> Measure progress and outcomes of implementation Identify action opportunities for continuous improvement and increase the City's resilience to climate change and/or reduce the City's exposure to climate risk 	
Dependencies		
Internal	Corporate Asset Management Plan addresses climate risk, inflow and infiltration strategy, emergency preparedness; and forest management	
External	Climate change risk levels	
Resourcing		
Total \$	\$10 million to \$50 million	
Additional Full-Time Equivalent	4 to 10	
Funded vs. New	Partially funded	

2.1.4 City of Guelph Strategic Plan Progress Report, 2020

The City has provided an online progress report for the Strategic Plan (City of Guelph 2022a) that summarizes its goals, including the “Sustaining our Future” pillar. The key performance indicators provide the progress in the form of the target, results, and brief notes. For instance, the goal to increase renewable energy resources to achieve corporate 100% renewable energy target is 24.4% as of 2019 (with an updated goal of 24.7% by 2021). The scope, schedule, and budget statuses are provided for four strategic initiatives: 1) develop and implement a sustainability city master plan, 2) continue to support the Community Energy Initiative, 3) implement the ISO 50001 Corporate Energy Management System, and 4) develop and implement the CAP.

2.1.5 City of Guelph United Nation Cities Race to Zero Pledge, 2022

As a commitment to the United Nations’ Race to Zero Pledge, the City has set out to first reduce greenhouse gas (GHG) emissions by 63% against the 2018 baseline by 2030, and then become a net-zero carbon community by 2050 (City of Guelph n.d.). A few examples of the ways the City seeks to accomplish this goal is by actively reducing GHG emissions from municipal operations, supporting sustainable transportation, and restoring clean water. The summary pledge summarized ways the City took action in 2021 to reduce GHG emissions, including the City’s energy consumption, cost, and project status related to the Race to Zero Pledge. For example, many projects aimed at energy efficiency are highlighted, such as the City installing 20 electrical vehicle charging stations at a cost of \$252,000 through funding from the federal government, and the installation of LED lighting retrofits at specific facilities. Mitigation measures is the primary focus, with only a few projects directly or indirectly enhancing

resiliency, such as the protection and restoration of urban forests and natural heritage, invasive species management, and water services, among others. There is opportunity to investigate the various funding sources for these projects and verify how they align with the vulnerabilities and risk priorities extending from the CAP project.

The pledge update report also included goals that were consistent with those appearing in some of the City's master plans, namely the Transportation Master Plan, Solid Waste Management Master Plan, and the Wastewater and Biosolids Master Plan. In early 2022, the City approved the 2022 Transportation Master Plan and will begin implementation; there is opportunity to align adaptive capacity components into these individual projects stemming from the Transportation Master Plan. The Solid Waste Management Master Plan advocates for a circular economy (see Smart Cities description) to move toward a zero-waste goal City wide, and solid waste revenues can be redirected to further this initiative. For example, the City has sold \$237,000 of carbon credits from electricity generated through processing from landfills and organics, and these funds are intended to be used toward the net-zero goal for 2050. Another example is to foster a re-envisioned perspective of waste management with a first step of changing the name of the Wastewater Treatment Plant (WWTP) to the Water Resource Recovery Centre.

2.1.6 City of Guelph Community Energy Initiative Update, 2020

Our Energy Guelph published a Community Energy Initiative (CEI) Update to summarize the City's progress on the Pathway to Net Zero Carbon. The Community Energy Plan (OEG 2022) was initiated in 2007 and began implementation in 2010 as the CEI with subsequent update plans that followed. The City recognizes climate change as "one of the most critical global issues of our time" and has aimed to be powered by 100% renewable energy by 2050 for City facilities, fleet, and operations, which also aligns with the City's goal to be a net-zero carbon city by then. The CEI focuses on the idea that the City can generate more energy, use less energy, and use energy wisely.

The City has undertaken a number of initiatives to pursue resiliency through the energy initiative. For instance, the University of Guelph has a thermal energy storage system that generates electricity that is clean, low cost, and off peak. Pertaining to the Pathway to Net Zero, the City sees an opportunity to create revenue by tackling climate change issues and move toward economic self-reliance. It is estimated that an investment of \$3.3 billion could generate \$5.5 billion in benefits, creating an internal rate of return of almost 9%. Overall, the plan aims to promote community prosperity and well-being while aggressively tackling climate change. Specific action items are not listed in the Plan.

2.1.7 Smart City Roadmap, 2022

In the Smart Cities Office Update Report to Council (Our Food Future 2022), Our Food Future Guelph-Wellington has set out goals to create Canada's first circular regional food ecosystem and improve equitability in the form of food availability. The main goals to achieve by 2025 include 50 new circular businesses (i.e., food waste is minimized through reduction or repurposed), an increase of food access by 50%, and repurposing 50% of food waste. Among other actions toward an increased circular food

economy were employing local expertise (e.g., data analysis of food flow) and working with community partners. The Smart City Roadmap also refers to the “2022-2030 Future Focused: A Climate Change Mitigation Plan for the County of Wellington,” which builds upon the existing programmes to reduce GHG emissions and the federal government’s goal to net zero by 2050. The successful application submitted in 2019 to the Smart Cities Challenge references the CEI, and the creation of the City’s Climate Change Office and Sustainability Board who are responsible for prioritizing environmental sustainability and climate adaptation and resilience.

2.1.8 City of Guelph Official Plan Consolidation, 2021

The Official Plan acts as a guideline for development for the City to 2031 (City of Guelph 2021a). The Official Plan acknowledges the impact of climate change and the importance of mitigation and adaptation to increase community resiliency. A few explicit policy ideas the City has included establishing policies and programs to reduce GHG emissions 60% from 2007 levels by 2031, preparing a climate change adaptation strategy (this project) and implementing standards that reduce impacts on public works and infrastructure.

The Official Plan discusses the City’s master plans and their individual update requirements. There is opportunity to collaborate and strategize methods to incorporate climate change resiliency through these master plans. It is mandated that the Wastewater Treatment Master Plan, Solid Waste Management Plan, Downtown Implementation Strategy, and the Official Plan itself (in part or as a whole) be revised at 5-year intervals, so there are frequent opportunities ahead to incorporate climate change initiatives into the master planning process. In fact, a specific goal for downtown Guelph is to promote development that mitigates and adapts to climate change. Furthermore, the Official Plan summarizes the Community Energy Plan (see CEI Update section) and its goal to reduce energy consumption and GHG emissions with the idea that the City can “decouple energy consumption from population growth.” The Official Plan encourages ways to lower the City’s carbon footprint by advancing innovation projects and coordinated efforts.

Pertaining to development, the Official Plan promotes ways to move toward establishing Guelph as a “green city” with mention of low impact development (LID), rainwater harvesting, grey water use, drought-resistant landscaping, etc. It describes the development restrictions within the designated floodplain and rules specific to Special Policy Areas. To move toward increased sustainability, development submissions may be required to complete the City’s sustainability checklist, a district energy feasibility study, a renewable energy feasibility study, a water conservation efficiency study, an energy conservation efficiency study, and a salt management plan (source water protection). For example, development within the Guelph Innovation District is encouraged to be carbon neutral through energy efficiency and using renewable energy resources such as wind, solar, and biomass energy.

Funding is not specific in the Official Plan; however, funding may come from municipal government, other levels of government, or non-governmental funding. There is opportunity to integrate climate change adaptation components into policies and projects as well as aligning common goals between plans and

departments. For instance, the City may use government or non-government funding programs to implement heritage conservation policies and integrate or suggest climate adaptation strategies into conservation projects. Along the same notion, City budgets designated for community improvement projects could incorporate methods to improve its resiliency and vulnerability to climate change.

2.1.9 City of Guelph Natural Heritage Action Plan, 2018

The Natural Heritage Action Plan (NHAP; City of Guelph 2018) recognizes the impacts of climate change and the importance for action. From a natural heritage perspective, there is opportunity to promote healthy and biologically diverse ecosystems as a way of addressing climate change vulnerability. One of the objectives in the plan is to support a natural heritage system in Guelph that is resilient to climate change with the goal of informing actions and decision-making practices by science. For data management, a key distinction in this plan is the recognition of the risks and implications of action and inaction.

Challenges associated with watershed planning which can be extended to the broader context of planning and climate change mitigation include, but are not limited to, staff resources, limited implementation, financial resources, and aligning plans and budgets. It was noted that during budget setting the implementation of subwatershed plans through restoration projects, monitoring programs and adaptive management are not always considered. The NHAP also indicates various opportunities to collaborate across departments including aligning budgets for funding opportunities and creating a centralized and integrated monitoring program that supports the City's natural spaces, water resources and ecosystem services.

The City's intent to create a CAP (this project) is mentioned in this document, and it is emphasized as an important future companion to the NHAP. The creation of a natural asset inventory would be a key aspect for both plans as it would act as a comparative tool for natural heritage items to other infrastructure in terms of climate change vulnerability, budgeting (i.e., by assigning a value associated with the item and its associated ecosystem services and role as a buffer in natural disasters), and savings/revenue opportunities. The Natural Asset Inventory for the City of Guelph has now been completed and a summary will be forthcoming. Aligning with the Official Plan, the NHAP laid out specific priority actions and their respective outcomes, target dates, budget status, and lead divisions. A sample of these action items is provided in Table 2.

TABLE 2 Extraction of Priority Actions from the Natural Heritage Action Plan

Actions	Outcome	Target Dates	Budget Status	Lead Division(s)
Develop a natural asset inventory, inclusive of the natural heritage and water resource system and the ecological goods and services they provide, to facilitate the integration of green infrastructure into the City’s Corporate Asset Management Plan	Guidelines and standards	2020	Proposed through the 2019 capital budget	Asset Management Program
Develop Guelph-specific LID standards for stormwater management to assist development and capital projects in integrating alternative designs for supporting water quality and quantity protection consistent with the MECP LID companion document to the Stormwater Management Planning and Design Manual	Guidelines and standards	2019	Proposed through 2019 capital budget as part of the Stormwater Master Plan update	Infrastructure Engineering

Notes:

MECP - Ontario Ministry of the Environment, Conservation and Parks

Source: City of Guelph (2018)

2.1.10 City of Guelph Corporate Asset Management Plan, 2020

The 2020 Corporate AMP (City of Guelph 2020) is a strategic document that states how the City’s assets are to be managed over a period of time. The Plan describes the characteristics and condition of infrastructure assets, the Levels of Service (LOS) expected from them, planned actions to ensure the assets are providing the expected LOS, and financing strategies to implement the planned actions. The following sections provide a summary of the key components of the Plan. The City has been rapidly advancing the City-wide asset management program since 2016, with the end goal of ensuring that the City makes the best possible decisions regarding its assets. Initiatives have been implemented to increase the knowledge of infrastructure, documenting LOS, managing risks and implementing full lifecycle planning. In the development of its AMP, the City has surpassed compliance to with Ontario Regulation 588/17: Asset Management Planning for Municipal Infrastructure through the 2020 updated of the AMP.

The City has accomplished many of its intended goals and initiatives with the development of its AMP as follows:

- Since 2016 the City has been rapidly advancing their City-wide asset management program. They have advanced their asset management capabilities from “Basic” to “Core,” when measured against the International Infrastructure Management Manual maturity index and are developing a work-plan to move the City to “Intermediate” and “Advanced” categories by 2024.
- The City is taking a leadership role on asset management but integrating AMP data into their budget analysis to help develop the capital budget.

- Developed performance and financial forecasts for 17 asset portfolios.
- Incorporated performance forecasting into the budget process.
- Developed LOS metrics for all asset types. Defined O. Reg. 588/17 mandated LOS for the Core assets (Roads, Bridges, Water, Wastewater and Stormwater) and will continue to define LOS for all asset types while also defining our Community-driven LOS.
- Developed water, wastewater and stormwater risk management framework.
- Inventory and condition assessments have been completed for roads, bridges, sewers, solid waste, wastewater, water facilities, corporate facilities, recreation facilities and structure.
- Developed an Integrated Corridor Model Tool to assist in lifecycle planning for all road network assets. New innovation was recognized by municipalities across the province and won an award in early 2020 through the Ontario Public Works Association.

The 2020 Asset Management Plan does not specifically address the linkages between the effects of climate change and the need to implement climate change adaptation measures; however, the foundational aspects of having the AMP in-place make it possible to further develop and realign the asset management strategy so that it directly accounts for the effects of climate change.

The physical asset systems included in the plan:

- | | | |
|------------------------------------|--------------------------|------------------|
| • Administrative facilities | • Emergency Services | • Stormwater |
| • Corporate vehicles and equipment | • Information technology | • Transit |
| • Culture and recreation | • Parking | • Transportation |
| • Wastewater | • Solid Waste | • Water |

The asset management strategy summarizes planned actions that include non-infrastructure solutions, maintenance activities, renewal/rehabilitation activities, replacement activities, disposal activities and expansion activities. The Strategy also provides a budget analysis that outlines yearly expenditure forecasts for each of the planned actions in the strategy, along with actual expenditures from previous years and yearly revenues.

The City has an infrastructure asset base with a 2020 calculated replacement value of approximately \$4.39 billion, of which approximately \$1.8 billion (32% have below 40% remaining life and will need replacing within the next 10-20 years. These assets will be addressed as priority within the capital budget, with support provided through the Infrastructure Renewal Funding Strategy. The City also has an investment backlog of infrastructure assets that have exceeded their service life, valued at approximately \$292 million

for the City asset portfolio. A lifecycle analysis of all City assets estimated that over the next 25 years an average annual requirement of \$256 million per year was needed for asset replacement, renewal and rehabilitation needs, that took into account an allowance to reduce the existing backlog, plus an annual allowance to cover maintenance and expansion due to projected growth. The average forecast funding value is \$226 million per year and a total of \$5.7 billion over 25 years. This represents an annual funding gap of almost \$30 million per year. Of note, within the next 1-5 years there is almost \$1 billion of assets that are “very poor” or “past due” conditions that may require complete replacement or in requirement of significant renewal efforts to ensure continued long-term performance.

The Plan identifies sustainable funding targets that focus on supporting the renewal and replacement of assets but does not include maintenance or growth funding requirements. Sustainable funding needed includes annual transfers to capital renewal reserve funds for tax and non-tax services, in addition to reliable annual funding from other levels of government. From 2017-2020, sustainability funding for non-tax services have increased by 8%, noting that parking and wastewater has decreased, while stormwater and water have increased. A majority of funding continues to be from federal and provincial gas tax funding programs, generating over \$60 million annually.

2.1.11 City of Guelph Core Asset Management Plan, 2021

The Core Asset Management Plan (AMP; City of Guelph 2021b) is a detailed assessment of the City’s core asset types which comprise more than 80% of the total infrastructure asset base owned and managed by the City of Guelph. These are roads (and related assets such as sidewalks, street lighting and traffic controls), bridges, water services, wastewater services and stormwater management.

From the analysis completed for the 2020 Corporate AMP, the core asset infrastructure is estimated to have a Current Replacement Value (CRV) of \$3,585,760,138 out of a total City asset CRV of \$4,324,685,333. The following table summarizes the estimated CRV for each core asset category.

TABLE 3 Current Replacement Value per Asset Category

Asset Category	2020 CRV	% of Total City Inventory
Roads and Bridges	\$1,222,163,378	28.19%
Water	\$773,972,981	17.85%
Wastewater	\$679,843,708	15.68%
Stormwater	\$852,780,071	19.67%
TOTAL CORE ASSETS	\$3,528,760,138	81.39%
All Other Assets	\$806,925,196	18.61%

The Core AMP does not include a complete climate risk assessment although a key focus is to identify the potential impacts of climate change on City infrastructure and the delivery of services. The plan recognizes that climate change may present direct risks to the physical assets, whereby occurrences such as strong

rainstorms may overload the City stormwater management infrastructure, droughts may negatively affect domestic water supply, and hotter average yearly temperatures may require the installation of more and stronger cooling and ventilation systems for facilities. A brief discussion of climate hazards and potential short-term and long-term effects to each of the core asset groups is provided making this report a foundational reference for the CAP. Completed or in progress climate change adaptation initiatives were collected during the preparation of the Core AMP.

Key findings include:

- **Transportation Assets:** Potential impacts to roads and bridges are addressed. Recent history shows an increased number of freeze-thaw cycles through winter months, whereby moisture in or on the road surface will freeze and melt with each of these events causing pavement surfaces to experience more potholes and cracking. Increased frequency of preventative crack sealing during summer months is identified as possible adaptation method to reduce unplanned work during winter months. Increasing intensity of winter storms may require increased snow and ice control operations, while stronger and more intense rainstorms bring an increase in the risk of flooding. In the latter case roads at low elevations relative to nearby water bodies can be susceptible to flood risk, whereby water may washout the road base structure, or cover the entire roadway surface impacting traffic flow and requiring emergency operations to manage. A formal risk assessment that identifies specific roads or areas prone to potential flooding has not been completed.
- **Water Services:** The City is introducing programs that educate and inform the community on how they can help prepare for potential climate change risks. Mention of the Tier 3 groundwater model that was done by Water Services to assess the impact of climate change. Eight measures are identified, including six programs: environmental monitoring, frozen services, facility and roof inspection, well performance testing, well inspection and rehabilitation, and educational water efficiency.
- **Wastewater Services:** Potential short-term flooding as a result from rainstorms of increasing intensity may create problems with overloading the capacity of the wastewater system and lead to basement flooding. The WWTP may also be at risk, as high intensity storms can lead to increased flows, impacting treatment and potentially placing the City as a compliance risk. Other potential risks may occur where wastewater assets share a corridor with roads, stormwater and water assets, and when these systems are impacted which results in related consequences.
- **Stormwater:** Stormwater systems play a critical role in providing a safe, livable community during extreme weather events. Stormwater systems are integrated with naturally occurring systems, such as wetlands, rivers and lakes. Predicting how the existing stormwater system will manage the effects of changing climate is complicated. Stormwater systems are designed to manage storms up to and including a 100-year event, but more severe and frequent storms and associated risk of flooding and erosion damage would require emergency resources and funding to repair. Resilience strategies are proposed including the oversizing of stormwater sewers, the reduction in the number of hard

surfaces, enhancement of natural surfaces, and consideration of the stormwater system as part of the natural environment.

The commitment to maturing along the asset management cycle and the City’s immediate focus on core assets provides both a source of information to understand adaptive capacity and risk, while representing a mechanism to implement and fund resiliency measures.

2.1.12 City of Guelph Natural Assets Inventory, Condition, Risk and Service Attribution, 2022

City of Guelph Natural Assets Inventory, Condition, Risk and Service Attribution (NAI; Green Analytics and Grounded Solutions 2022) estimated and mapped the City’s natural assets, summarized the current condition of the assets, and identified the hazards to the assets and the level of risk associated with the hazard. The Province of Ontario has mandated all municipalities to create and have in place a comprehensive AMP by July 1, 2025 under O. Reg. 588/17 that would include providing feasible and desirable LOS under climate change conditions. The City’s natural assets inventory consists of three main categories of inventory: (1) street and park tree assets, (2) watercourse feature assets, and (3) terrestrial natural features. As watersheds and natural features do not follow municipal boundaries, a 120 m buffer was provided for terrestrial natural features.

The NAI provided a list of primary hazards to the City’s natural assets and a number of these hazards were viewed with under exacerbated climate change conditions, including flooding, invasive plants and wildlife, erosion and sedimentation, extreme weather events, and drought. The City’s risk score table was used, in which impact was scaled from 1-4 and likelihood was scaled from 1-5 (see Table 6 for the same table used under the Enterprise Risk Management Framework). The risk scores per potential hazards were calculated, normalized, and ranked as shown in Table 4.

TABLE 4 Risk Rating for the Potential Hazards to the Natural Assets

Potential Hazards to Natural Assets	Risk Impact Rating	Risk Likelihood Rating	Risk Score
Extreme weather events	4	4	16
Invasive plants and wildlife	3	5	15
Overuse or inappropriate use	3	5	15
Urban intensification	3	5	15
Shifts in hydrologic regime	3	5	15
Erosion and sedimentation	2	5	10
Native and invasive pests and diseases	2	5	10
During construction impacts	2	5	10
Encroachment	2	5	10
Contamination	2	5	10
Flooding	3	3	9
Drought	2	4	8
Fire	4	2	8

The document also lists twelve (12) main ecological services associated with the natural assets. The NAI described the ecosystem function, associated ecological service(s), and a short description. For example, by implementing or improving the urban heat management, there would be reduced energy consumption, and this would be provided by natural assets providing shade to buildings. The NAI also identified climate change mitigation as an ecological service through carbon sequestration and storage by natural assets. Maps of the assets providing each main ecological service, including climate change mitigation, has been provided by asset type, i.e., upland forest, marsh, etc. It should be noted that the CAP includes more elements to climate change mitigation than what is summarized in the NAI.

2.1.13 City of Guelph Urban Forest Management Plan, 2013-2032

The Urban Forest Management Plan (UFMP; Beacon Environmental 2012) discusses the urban forest as a valuable green infrastructure asset. There is a dedicated climate change section and long-term plan that is broken up into 5-year intervals (Figure 1) to allow for the integration of changing conditions, new findings, and resource availability. The UFMP acknowledges the reality of climate change stressors and discusses the importance of trees and their benefits in all aspects of the community. The UFMP may align well with climate change resiliency goals identified in the City’s CAP. Some examples of the benefits of urban forests vis-à-vis climate change are filtration of air pollution, shade (e.g., extending lifecycle of asphalt), flood control and stormwater management, reduction of local energy use (e.g., trees beside buildings can moderate extreme temperatures), carbon sequestration, improved physical human health (e.g., lower blood pressure and risk of skin cancer), and improved mental health.



FIGURE 1 The Long-term Urban Forest Management Planning Structure

The UFMP goes on to describe trees as a “practical and relatively inexpensive opportunity to both mitigate and adapt to climate changes” and the plan includes its own section on climate change with strategies that are consistent with best practice urban forest management from other Canadian jurisdictions. These strategies include, but are not limited to, planting trees that are tolerant of warmer and drier

summer conditions, developing extreme weather response plans, and moving toward adaptive management by monitoring the responses of different tree species to changing conditions and pests. Other methods of mitigation can be adopted from other municipalities; for instance, the City of Burlington have cabled and braced some of their trees in response to extreme weather.

There is opportunity to translate trees (or 'green infrastructure') as an asset and use them as a comparative tool to 'hard' assets. The City will estimate these values within the natural asset inventory document to incorporate the associated value of their ecosystem services. Though most assets and infrastructure depreciate over time, a unique consideration for trees is that they will appreciate over time. Other municipalities have quantified how much money trees have saved through air pollution control, stormwater management, and residential energy savings; the Town of Oakville has estimated that their 1.9 million trees have saved \$2 million and the Town of Ajax have reported a savings of over \$1 million annually for their 1.4 million trees. The City has not yet completed a comparative study; however, a natural asset study could help drive municipal budgeting and funding to provide collaborative resiliency for the City.

Each recommendation given in the UFMP provides an indication of the lead department, support/partners, cost, funding source (either capital or operating and broken down for 2013-2017, i.e., the first 5-year evaluation stage), priority level, and the related goals. For instance, the UFMP recommends developing a formal urban forest risk management policy with at least two of the City's arborists assigned to obtain formal risk assessment training. Ranked as a medium to high priority, the cost for to implement this recommendation is approximately \$44,000 annually and would be pulled from the operating budget. The UFMP also includes recommendations that may not require additional funding and can be done in house with existing staff resources such as the establishment of a green infrastructure asset valuation.

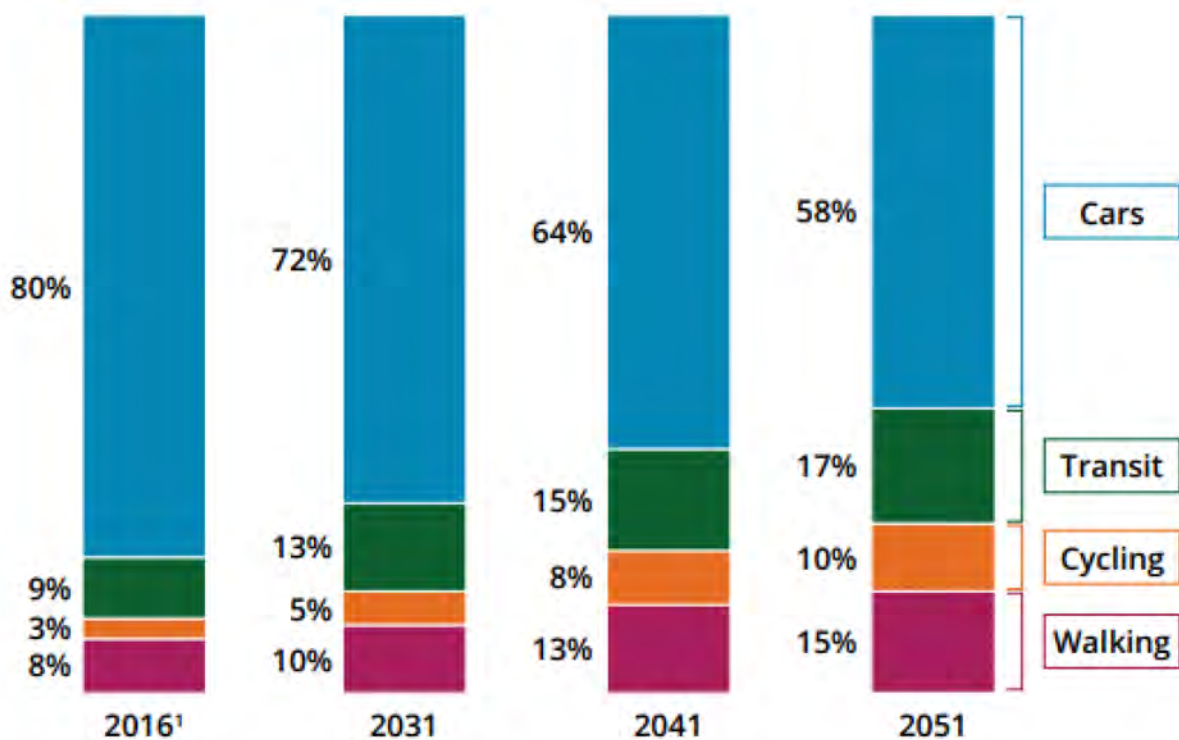
The City has opportunities to fund their goal for increasing canopy cover and diversifying the urban forest. A list of current feasible opportunities is included in Table 5. These funding opportunities include grants and scientific research that may be supported at the federal and/or provincial level. For example, the City provided 300 trees and care booklets to residents in 2011 for tree planting in selective areas through a grant from the TD Green Streets program. Wellington County's Green Legacy Programme has also funded the City with 1,000 seedlings annually for volunteers to plant around Arkell Springs (outside but owned by the City). Finally, the City established a "green infrastructure" capital account with an initial \$100,000 allocation toward urban greening activities.

TABLE 5 Extraction of Funding Opportunities for the City

Organization	Program Name	Opportunity in Guelph	Required Lead and/or Partnerships	Nature of Support
Canadian Tree Fund	Jack Kimmel Grants	Could be pursued in partnership with someone at the University of Guelph to explore success of different species in streetscapes, or success of trees in streetscapes using different soil amendments.	Most suited for an academic lead (e.g., University of Guelph)	Grants (from this registered charitable organization)
Ontario Trillium Foundation	Community Program or Province-Wide Program	City could apply for a grant if they are part of a community collaborative that involves at least one eligible organization (i.e., a registered charitable or non-profit organization) and has a clear benefit to the community.	Non-profit or charitable organization	Community Grants Program (up to \$15K) or Province-Wide Grants Program (over \$15 K; up to about \$100 K)
Trees Canada	TD Green Streets Program	City could obtain funds to for tree planting, inventory, maintenance, and educational activities. Wide range of potential activities.	Municipality	Grants of up to \$15,000 for successful municipalities (from Trees Canada through TD Friends of the Environment Fund). Requires 50% matching funding from another source

2.1.14 City of Guelph Transportation Master Plan, 2022

The *City of Guelph Transportation Master Plan* (TMP; Dillon 2022a) discusses the City’s transportation plan for the next 30 years, with part of the vision that seeks to “[minimize] and even [reverse] transportation impacts on the natural environment.” In terms of sustainability and resiliency, the TMP describes the need to create a more efficient transportation plan for the future that can adapt to changes that include, but are not limited to, climate change, user behaviour changes, and a growing population. Figure 2 demonstrates the modal shift that the City is aiming for within the next 30 years; the City would like to see less cars driven and a gravitation toward walking, cycling, and transit.



¹Source: 2016 Transportation Tomorrow Survey (TTS)

FIGURE 2 Existing and Incremental Targeted Transportation Mode Shares

One of the goals listed in the TMP is to aim for a net-zero carbon footprint in the transportation sector by 2050. To accomplish this goal, the City is looking to pursue these main avenues: reducing the percentage of trips made by cars, updating the downtown parking strategy to reduce car use downtown, and moving to electrify Guelph Transit and City-owned vehicles (covered in the municipal zero emissions vehicle and transit fleet strategy). Policy directions specifically for roads encourage integrating GHG objectives in planning, implementing LID designs, and instating low- or zero-emission vehicle technology. Strategies included in these policy directions include, but are not limited to, aiming for 100% renewable energy usage for all City facilities and fleet operations by 2050, implementing urban design and development standards targeted to reduce climate change impacts, and reducing transportation energy use by 25%.

Note that the TMP also lays out a plan to release a series of master plans (e.g., Pedestrian Master Plan), guidelines (e.g., Multimodal Level of Service Guidelines), and programs/actions (e.g., Active Transportation Program) that will be prepared or continuously updated. Among external plans that will need to align with the TMP, the Source Water Protection Plan and Stormwater Management Master Plan will specifically have to coordinate efforts for LID projects that also act as climate change adaptive capacity measures. The *Transportation System Resilience* paper (TSR; Dillon 2022b) discusses other common

actions that can be integrated to promote “flexible streets” with adaptive capacity to respond to the impacts of climate change, such as managing impermeable pavements, increasing LIDs, and increasing urban tree canopies.

The City also recognizes that it needs to adopt and create resilient transportation through diversity in travel options, route redundancy, and the capability to adapt to changes. The TMP aims to achieve this through both short-term (2022-2031) and long-term (2032-2051) road projects. These retrofit or capital projects were analyzed with a weighting system that includes relative sustainability and affordability scores for each project. Budgeting for these projects is not specific in the TMP; however, it is mentioned that the capital budget is reviewed annually by the City to target the recommended capital projects and continuously move toward the transportation mode shift envisioned by the City. The TSR (Dillon 2022b) discusses the possibility of tying budgeting with transportation objectives rather than project completion as a form of added flexibility and adaptive capacity. The budget is subject to changes depending on the following fluctuations: market prices, property values, external funding, and policy changes to tax and development charge rates.

2.2 Development

2.2.1 City of Guelph Draft Zoning Bylaw, 2021

The zoning bylaw (City of Guelph 2021c) does not explicitly mention climate change mitigation and/or adaptation measures. However, there are some key mandated or recommended measures that align well with adaptive measures, such as floodplains, natural areas, and Wellhead Protection Areas (WHPAs). This includes flood zones labelled as “FL” or a Special Po development in flood prone areas. Similarly, the protection of WHPAs are emphasized. An allotted number of bike parking spots is required for new development. The zoning bylaw also provides recommendations for buffer areas (areas of land consisting of soft landscaping such as grass, flowers, trees and shrubbery) as a measure to manage surface runoff. Finally, there are site-specific measures in place that are planned, and this presents an opportunity to target areas prone to climate change. As planning in municipalities is guided by the Provincial Policy Statement (2020), we note that land use planning is recognized as an important mechanism to prepare for the impacts of a changing climate.

2.2.2 City of Guelph Site Plan Approval Process, 2015

The Site Plan Approval Process (City of Guelph 2015) outlines steps, engineering design criteria, and a checklist for obtaining site plan approval. The document does not explicitly mention climate change; however, it references certain documents that may in time incorporate climate change measures and generally indicate adherence to best management practices. For instance, the design of sewers and watermains are indicated to comply to provincial and municipal guidelines or standards; this allows for changes in future documents that may incorporate upsized sewer requirements, intensity-duration-frequency (IDF) curve changes, etc. Additionally, all applications are subjected to the

necessary approvals by MECP which may incorporate climate change elements. Note that a new site plan approval process is being developed by the City and will launch in 2023.

2.3 Water Servicing

2.3.1 City of Guelph Tier Three Water Quantity Risk Assessment, 2017

A Tier Three Assessment Water Quantity Risk Assessment (Matrix 2017) was completed for municipal drinking water systems of the City of Guelph and the Township of Guelph/Eramosa within the Province of Ontario, Canada. As a requirement under the province's Clean Water Act (Bill 43; Government of Ontario 2021b), the purpose of the Tier Three Assessment was to identify the Water Quantity Threats to municipal drinking water systems where those systems are located within a subwatershed classified as having a Moderate or Significant potential for water quantity stress during a Tier Two Water Quantity Stress Assessment (AquaResource 2009a, 2009b). This work included the following tasks:

- develop the conceptual understanding of the study area
- develop and calibrate a groundwater flow model with sufficient detail to simulate groundwater flow near municipal wells and surface water features
- develop and calibrate a streamflow-generation model to simulate variable streamflow in the area and to estimate groundwater recharge rates in the Study Area
- apply the calibrated surface water and groundwater models to assess the water budget components in the Study Area and near municipal wells
- complete a Local Area Risk Assessment for the municipal wells located in the Study Area to determine if there is a risk that the municipal wells may not be able to meet current or future demands while considering population growth, reduced groundwater recharge due to land development and drought conditions
- identify Significant Water Quantity Threats including consumptive water takings and areas of potential reduced groundwater recharge
- develop, assess, and recommend risk management measures that if implemented would help ensure that the City could meet its future planned water demand requirements considering the cumulative effects of non-municipal water use, future municipal water use, and drought conditions.

The Tier Three Assessment included a Climate Change Assessment (Matrix Solutions, 2018) which evaluated the potential impacts of climate change on groundwater recharge rates and streamflow, and in the resulting impacts to water supply. The results illustrated that under average annual conditions,

groundwater recharge rates supplying the City's water supply aquifers are likely to increase due to higher winter temperatures. However, there remains the potential for climate change to result in extended drought periods which would result in acute stresses to the drinking water supply.

The results of the Tier Three Assessment clearly supported the desired outcomes and approach followed for the development the City's Water Efficiency Strategy (C3 Water and Gauley 2016) which establishes a plan to minimize future water consumption.

2.3.2 City of Guelph Water Efficiency Strategy, 2016

The Water Efficiency Strategy (C3 Water and Gauley 2016) is a guide that sets the City up for reduced water consumption to promote availability for future water supply, especially in the face of unpredictable rainfall and aquifer recharge due to climate change. The implementation of water efficiency programs also helps the City reduce operational costs and GHG emissions. Water conservation and efficiency program alternatives were identified and evaluated to tailor to the City for a 10-year timeframe to meet the goal to reduce daily water consumption by 9,147 cubic metres set by the Water Supply Master Plan. The Water Efficiency Strategy used a weighted evaluation criteria that included a climate change resiliency factor and incorporated the International Water Association/American Water and Wastewater Association Water Audit Method (which uses the Infrastructure Leakage Index) to evaluate and recommend programs suitable for the City.

The City has realized great success in terms of water efficiency. The reductions in residential water consumption are related to a number of efficiency initiatives and there are opportunities to continue improvement. The current reductions can be attributed to changes to the Ontario Buildings Code, more efficient plumbing, public awareness and water efficiency programming (e.g., the Outside Water Use By-Law), and increases to annual water/wastewater user rate prices. For the customer sector (industrial, commercial, and institutional), the City is ahead of plan for meeting its 2038 water use reduction target. There is still opportunity to reduce operating costs for both customers and the City on this front.

If all the water efficiency programs are implemented as recommended between 2016 and 2031, it is estimated that the City could save approximately \$29 million in avoided or delayed infrastructure expansion. Table 6 lists the recommended programs, costs, and savings. The City is anticipated to continue to pursue water efficiency and research programs and have many of these externally funded through grants and partnerships beyond the allocated budget. Note that the Water Efficiency Strategy is projected to be updated in 2022 and the costs in Table 6 will be revised accordingly.

TABLE 6 Summary of the Total Water Efficiency Programs Cost (2016-2031)

Water Efficiency Programs	10 year Program Cost	Program Savings
Direct Water Savings		
Royal Flush Toilet Rebate Program	\$605,000	\$982,800
Blue Built Home Water Efficiency Standards and Rebate Program	\$109,500	\$64,350
Home Visits/Audits	\$122,500	\$301,860
Water Softener Rebate	\$50,000	\$16,380
Multi- Residential Audit Program	\$142,500	\$347,490
Sub-metering Program	\$95,000	\$50,544
Water Smart Business	\$2,225,000	\$7,020,000
Municipal Facility Upgrades	\$602,953	\$1,028,196
Water Loss Management	\$1,595,000	\$18,542,160
Automated Meter Reading Installation	\$760,000	\$261,144
Indirect Water Savings		
Healthy Landscapes Home Visit	\$2,411,000	N/A
Water Efficient Landscaping Incentives	\$330,000	N/A
Public Outreach and Education	\$1,150,000	N/A
Mobile Applications (Water Wagon)	\$140,000	N/A
Drinking Water Promotion	\$150,000	N/A
Outdoor Water Use Programs	\$300,000	N/A
Research		
Water Reuse and Demand Management	\$550,000	N/A
Water Conservation and Rebound Effects Study	\$100,000	N/A
Water/Energy Nexus	\$60,000	N/A
Water Softening Pilot Rebate Study	\$100,000	N/A
Municipal Upgrades Best Practices Study	\$25,000	N/A
Distribution System Pressure Management	\$20,000	\$468,000
Automated Meter Reading Study	\$180,000	N/A
Cooling Tower Audit Research Program	\$120,000	\$70,200
Irrigation Audit (Water Smart Irrigation Professional)	\$27,000	\$138,477
Irrigation System Rebates	\$18,000	\$27,695
Water Efficiency Strategy Implementation	\$3,775,200	N/A
TOTAL	\$3,775,200	\$29,319,296

2.3.3 City of Guelph Water Supply Master Plan Draft, 2021

The Water Supply Master Plan (WSMP; AECOM et al. 2021) provides short-term, mid-term and long-term water supply options to ensure that the City can continue to meet the demands of Guelph’s growing population. The City of Guelph recently updated the 2014 WSMP to assess the municipal water supply sources and identify priorities, including sustainable water supply options, from now until 2041.

When investigating existing and new water supply options, such as new groundwater sources in and outside of the City and local surface water sources, the WSMP considers things like water quality and quantity, climatic conditions, economic factors and any relevant regulations. The WSMP follows the

requirements of Phases 1 & 2 of the Municipal Class Environmental Assessment (MCEA) in accordance with Approach #1 of the Master Plan Process described in the MCEA Manual (amended in 2015) by the Municipal Engineers Association. The WSMP update will be readily updated at approximately five-year intervals.

The WSMP update integrates a number of technical tools and functions already present at the City. The modelling work completed in the project relies on the Tier Three groundwater flow model. The WSMP recommends water conservation and efficiency alternatives to reduce future water demand. The City will follow up with these recommendations by updating its Water Conservation and Efficiency Strategy (Section 2.3.2) where appropriate.

The feedback received through the various engagement tools and activities indicates that there is a continued interest from community members and stakeholders about water supply in Guelph, notably the community identified concerns about the impact of climate change on the water supply. The WSMP re-iterates the results of the Tier Three Water Quantity Risk Assessment (Section 2.3.1), which concluded that climate change is not likely to have an adverse effect on average water supply availability. However, the significant drought conditions similar to those observed in Guelph during the 1960s will stress the water supply.

The WSMP's conclusions relating to additional water supplies and water conservation measures can also be considered as climate adaptation measures, as they ultimately help the City become more resilient to long-term climate stresses and increased water demand.

2.4 Other Servicing

2.4.1 City of Guelph Water and Wastewater Servicing Master Plan, 2008

The Water and Wastewater Servicing Master Plan (WWSMP; Earth Tech 2008) addresses climate change implicitly through capacity/resiliency of infrastructure and providing appropriate distribution and conveyance of water and wastewater respectively for the projected future growth of the City. The WWSMP commits to sustainable growth and will align with the City's Growth Management Study upon its completion. This plan is intended to guide the City until 2031, however, it is acknowledged that the finalized growth study may change priorities and longer maintenance items may extend beyond this timeframe. We note that the City's Growth Management Strategy has been informed by the Shaping Guelph process that included several technical background studies.

The WWSMP evaluated alternative solutions for optimal water and wastewater servicing in the City. The plan indicates the need for Council to properly funded maintenance and replacement of its watermains and sanitary sewers before investing in the infrastructure required for growth. As the basis for a comprehensive AMP, this plan is structured to support decision-making relating to expected service levels, risk mitigation, and infrastructure funding (i.e., rehabilitation and replacements). Pertaining to resiliency, an extract of some of the recommended projects and budgetary estimates is provided in Table 7.

TABLE 7 Extraction of Recommended Project List and Budgetary Items

Years	Estimated Timing	Project Description	Budgetary Estimate	Class EA Schedule
Water Servicing				
0-5	2009-2014	Asset Management	\$500,000	A
8-10	EA/des - 8/9 implement 9-10	Arkell wellfield transmission main (for redundancy, assume 900mm)	\$14,985,000	B
Wastewater Servicing				
0-10	n/a	Asset Management	\$300,000	A
6-25	2016; 2026	Wastewater Master Plan Update	\$600,000	Master Plan EA
0-5	n/a	Wastewater effluent re-use "Purple Pipe" (allowance)	\$5,000,000	A+/B

EA - Environmental Assessment

The WWSMP is currently being updated by the City, with expected completion in 2023.

2.4.2 City of Guelph Wastewater Treatment and Biosolids Master Plan, 2009

The Wastewater Treatment and Biosolids Master Plan (CH2M HILL 2009) addresses capacity at the Guelph WWTP to meet future growth in the City, aligning with projections shown in the Local Growth Management Plan and WSMP. An update is expected to be completed in 2022.

Among other studies that would complement the Master Plan, it was recommended in the Master Plan that a climate change adaptation study specific to the WWTP be conducted (2009 cost estimate of \$35,000). The Master Plan recommends an examination of potential climate change impacts to the WWTP that would warrant emergency planning and adaptation. It is recommended that climate change scenarios specific to Guelph be analyzed that may include, but are not limited to, flooding, inflow and infiltration, and droughts. Low flow conditions are a component of drought periods that pose a threat to the general functionality of WWTPs. The Speed River historically experiences its lowest flows during the summer months. These low flows are expected to increase in frequency as a result of climate change. It is recommended that these efforts be coordinated with the Grand River Conservation Authority (GRCA) who regulate flow augmentation on the Speed River. The GRCA are also conducting climate change investigations under Source Water Protection Planning and these efforts should align with future plans for the Guelph WWTP.

Opportunities that can be pursued include reuse of grey water and water conservation measures. Generally, capital budget funds infrastructure improvement projects. External funding (e.g., the City's Green Municipal Enabling Funds) can also be implemented to pursue innovative ventures, such as a residential grey water pilot study in which 30 new homes are evaluated in terms of performance and cost savings. Note that the alternatives expressed in the Master Plan were partially evaluated on a scale (0, 5, and 10) to receive potential funding.

2.4.3 City of Guelph Stormwater Management Master Plan, 2012

The Stormwater Management Master Plan (SWMMP; AMEC 2012) provides a long-term management plan for stormwater in the City, progressing as a "Water Cycle City" that treats stormwater runoff as a resource instead of a liability. The SWMMP addresses water quality, water quantity, and the natural environment for urban areas as well as the Eramosa and Speed rivers and their tributaries. The SWMMP provided suggestions for maintenance and retrofits that incorporate LID and best management practices.

The SWMMP addresses the impact of climate change on the sewer network: *City of Guelph - Ward One, Frequency Analysis of Maximum Rainfall and IDF Curve Update* (Earth Tech 2007), which referenced literature indicating that a 15% increase in rainfall depth in Canada was projected due to climate change and recommended a continuous update to the IDF curves on a 5-year basis. The SWMMP included a comparison of the currently applied frequency depths (1954-1970) to updated frequency depths (1954-2010) for the City; however, no clear climate change trends were found. Taking both into account, it was assumed that the probability of the return period storms would shift to increase in frequency, e.g., a 5-year storm would become a 2-year. To meet the 5-year capacity sewer standard in the City, a summary of preliminary upgrades was made for the entirety of the City's drainage networks, including the number of sewers impacted and estimated costs. If sewers were expected to meet the 10-year capacity (in a frequency shift under climate change conditions), a general cost estimate for the sewer upgrade would be \$20,000/ha, with the value to be increased to consider inflation. The drainage network was divided into areas of prioritization (low, medium, and high) depending on its performance at both the 5-year and 100-year storm, historic flooding, and the average sewer age. Note that since the publication of this plan, the City has indicated that they have used the IDFCC RCP 4.5 curve to map future infrastructure needs.

Portions of sewer networks and neighbourhoods were identified as high priority for implementation. The SWMMP provides a summary of potential funding sources for stormwater management projects, including general tax base, development charges, stormwater user pay rates (now in effect), grant opportunities, and a combination thereof. In 2012, it was estimated that the total annual maintenance costs for the City's stormwater management facilities, oil/grit chambers, storm sewer system operation, and storm sewer replacement is approximately three times the City's budget for these items. Future budgeting would need to account for these needs, especially in the case that climate change exacerbates conditions.

The SWMMP is currently being updated by Aquafor Beech Ltd. to plan for the next 25 years, with a projected completion date for 2023 (City of Guelph 2022b). Since the publication of the current SWMMP, various erosion memos have been produced with the purpose of restoring creeks and channels to their full capacity in order to manage floods and larger storm events. Additional locations for natural channel restoration and repairs listed in priority sequence will be added to the annual programming for the Engineering Design and Construction group and this list will be reassessed at subsequent Master Plans. There is further opportunity to align current findings to better indicate adaptive capacity for stormwater infrastructure. The SWMMP also indicated that funding for monitoring programs was limited, but there is an opportunity to use funding more efficiently to improve government agency and stakeholder collaboration.

2.5 Emergency

2.5.1 City of Guelph Enterprise Risk Management Framework, 2012

The Enterprise Risk Management Framework (City of Guelph 2012a, City of Guelph 2012b) provides departments with a tool (Microsoft® Excel spreadsheet) to assess and manage risk by strategizing risk priority. Though climate change is not explicitly mentioned, the risk evaluation mirrors a climate change risk evaluation using both impact and likelihood scales to prioritize more severe events that occur at higher frequencies. The risk is evaluated through risk categories (such as service delivery, employees, and reputation), impact and likelihood (Table 8), and impact criteria. Generally, for risks that score 10 or higher (red) in order to have a mitigation plan and the risk status will have to be logged in a risk register. A yellow risk will require action but can be deferred and a green risk will require no action plan.

TABLE 8 Risk Management Framework

Impact Scale	Likelihood Scale				
	1 Rare	2 Unlikely	3 Somewhat Likely	4 Likely	5 Almost Certain
4 - Catastrophic	4	8	12	16	20
3 - Major	3	6	9	12	15
2 - Moderate	2	4	6	8	10
1 - Minor	1	2	3	4	5

Source: City of Guelph 2012a, City of Guelph 2012b

2.5.2 City of Guelph Emergency Response Plan, 2015

The Emergency Response Plan (ERP; City of Guelph 2014) provides staff members and citizens with direction and contact information in the event of an emergency. The ERP is intended to be flexible to account for a variety of emergencies. It indicates that the three most likely community risks to the City are: (1) severe weather (including tornadoes and ice storms), (2) hazardous material releases from fixed or mobile sites, and (3) human health emergencies. The Office of the Fire Marshal and Emergency

Management have required each community to conduct the Hazard Identification and Risk Assessment (HIRA), which is outlined in the next section.

2.5.3 City of Guelph Emergency Management Hazard Identification and Risk Assessment, 2018

The HIRA (OFMEM 2018) is a provincial document that has been designed to help Ontario communities record hazard data, determine the risk level, and provide context for risk assessors and decision makers. The user is guided to list the exposure and vulnerability of the population and infrastructure, identify the likelihood and consequence, and note the capacity and residual risks. For each hazard (e.g., dam failure, geopolitical pressures, food shortage, etc.), the consequences are classified as none, low, medium, and high for the following categories: fatalities, injury/illness, evacuation, psycho-social, support system impact, property damage, critical infrastructure, environmental, economic, and reputational. Weather-related hazards are captured in the HIRA process, including hazards that are an outcome of extreme weather events.

The City of Guelph has completed an Emergency HIRA, which addresses most of the potential hazards outlined in the provincial guidance, reflecting the geography of the City vis-à-vis hazards (e.g., nuclear facilities are not included). Numerous climate-related hazards are addressed in the City's HIRA, such as: drought or low water, extreme temperatures (cold and heat), flood, fog, storms, storm surge, high winds, and winter weather. The consequences or impacts of extreme weather events are also addressed, such as: food contamination, landslides, water quality, dam failure, electrical energy supply and distribution, food shortages, water or wastewater disruption, public transit systems, and road and highway.

The HIRA process represents an important and useful exercise to identify hazards at a high level and provides a useful starting point to gauge the City's Emergency Management Team's perception of climate-related hazards. We note that while the evaluation has merit and should be explored in more detail, in the absence of a corresponding discussion document it provides limited explanation regarding the calculation of risk scores. The HIRA scores are also likely based on historical climate conditions and do not include how climate is projected to change in the future. Cumulative effects are not considered, nor are interdependencies among hazards and/or consequences.

2.6 Other Internal Documents

In addition to the internal documents identified by the research team and confirmed by the Core Working Group, there is a large library of plans and strategies developed by and for the City of Guelph that present additional documents worthy of consideration. We note that the list of plans and strategies on the City's website lists 12 Master Plans and 38 additional plans and strategies. Since climate change is a cross-cutting issue, it can be anticipated that some, if not many, of these other plans and strategies may provide information about climate-related vulnerability and risk, adaptive capacity, and opportunities for funding. Further, initiatives may have numerous internal studies and documents that may help inform the CAP. The City's Growth Management Strategy and Shaping Guelph process includes several technical

background studies, such as a residential intensification analysis, a housing analysis and strategy, a land needs assessment, and an analysis of long-term population and housing growth, among others.

Additional studies may be added to this review, pending further engagement of City staff. We note that the City's Design Manuals may also be a source of information, notably:

- Stormwater Management Practices Planning and City of Guelph Community Urban Design Manual (City of Guelph 2017)
- City of Guelph Development Engineering Manual (City of Guelph Engineering and Transportation Services 2019)
- City of Guelph Linear Infrastructure Standards (City of Guelph 2022c)

2.7 Summary

Overall, the measures captured in these reports are plentiful, and this section has highlighted some of those, or at least has identified plans that represent sources of information where a deeper investigation is warranted. We note that the City's AMP provides significant content for roads and bridges, water, wastewater, and stormwater when it comes to climate risks and adaptation, but for other asset areas additional information will be required. Additional assets are addressed in other plans, with the natural environment addressed in the NHAP (2018) and UFMP 2013-2032 (2012), and water through the Tier Three Water Quantity Risk Assessment (2017), Water Efficiency Strategy (2016), and the WSMP Draft (2021). Among the other plans and reports that offer useful insights include the HIRA (2018) for providing initial risk scores from an emergency management team perspective regarding various climate-related hazards, noting that their assessment does not include future climate change.

Not unexpectedly mention of funding opportunities are scattered, and the main financial source is primarily through the asset management program and budget. There is a shortfall, however, even for the four key asset groups covered through the asset management plans, and financial support for the implementation of plans for other asset groups remains somewhat unclear. Potential financial sources will be explored more closely during Stage 4 when the focus is on recommending appropriate adaptation measures.

3 CLIMATE RISK STUDIES

Climate risk studies that are relevant to the development of the CAP fall into three categories: (1) climate projections that apply to the City of Guelph, including national climate data portals; (2) Climate Change Impacts, Vulnerability and Adaptation studies at the national and provincial level that address issues that apply to municipalities and/or southern Ontario; and (3) CAPs and strategies that have been developed for municipalities that are most relatable to the City of Guelph. A list of comparators is provided in Table 9 that includes, but is not limited to, each comparator's current climate adaption plan. Provincial climate-related policies are addressed in Section 4.

TABLE 9 Comparator List

Tier	Comparator	Climate Adaptation Plans
Single Tier	Barrie	<i>City of Barrie Climate Change Adaptation Strategy (2017)</i>
	Brantford	<i>A Community Climate Change Action Plan for the City of Brantford (2022)</i>
	Chatham-Kent	<i>Chatham-Kent Climate Change Action Plan (in progress)</i>
	Hamilton	<i>Climate Science Report for the City of Hamilton (2021)</i>
	Kingston	<i>Kingston Climate Action Plan (2014); Climate Leadership Plan (in progress)</i>
	Sudbury	<i>Greater Sudbury Community Energy and Emissions Plan (2021)</i>
Lower Tier	Brampton	<i>Our 2040 Energy Transition: Community Energy Emissions Reduction Plan (2020; as part of chapter 1)</i>
	Burlington	<i>Climate Action Plan (2020, to be updated); Climate Resilient Burlington: Climate Change Vulnerability and Risk Assessment (2021)</i>
	Cambridge	<i>City of Cambridge Energy Conservation and Demand Management Plan (2020)</i>
	Kitchener	<i>Kitchener, Changing for Good: Our Corporate Climate Action Plan for Sustainability (2019)</i>
	Mississauga	<i>Climate Change Action Plan (2020)</i>
	Oakville	<i>Town of Oakville Climate Change Strategy Technical Report (2015)</i>
	Waterloo	<i>City of Waterloo Corporate Climate Change Adaptation Plan (2019)</i>
Upper Tier	Halton Region	<i>Climate Change Discussion Paper: Regional Official Plan Review (2020)</i>
	Waterloo Region	<i>Community Climate Change Adaptation Plan for Waterloo Region (2019); Transform WR: Waterloo Region’s Transition to an Equitable, Prosperous, Resilient Low Carbon Community</i>
	Peel Region	<i>Climate Change Master Plan (2019)</i>

3.1 Climate Projections

Localized Climate Projections for Waterloo Region - Final Report (2015)

The Interdisciplinary Centre on Climate Change and the University of Waterloo developed climate change projections for the City of Cambridge, City of Kitchener, City of Waterloo and the Region of Waterloo in 2015 (ICCC and University of Waterloo 2015). Projections compared to a 1981-2010 baseline were developed for a select and limited number of temperature and precipitation variables under three different emission scenarios: net-zero carbon (RCP2.6), aggressive mitigation (RCP4.5), and business-as-usual (RCP8.5) for the 2020s, 2050s and 2080s. The projections developed for this report have informed the climate data used for the CAPs developed for the City and Region of Waterloo. Projections include climate variables where considerable uncertainty applies, such as snowfall and freezing rain where their occurrence is dependent upon a combination of temperature and precipitation and are variables that climate data portals are reluctant to project into the future. As such the projections serve as a useful foundation from which to compare more updated projections drawn from other sources that apply to a wider range of variables, and as a source for future climate conditions of variables typically not addressed in climate data portals.

Climate Science Report for the Climate Change and Health Vulnerability Assessment for Waterloo Region, Wellington County, Dufferin County, and the City of Guelph (2022)

The science report for climate change and health vulnerability assessment (ICLEI Canada 2022) provides climate change projections for a wide range of climate variables (42) that are drawn from the Ontario provincial climate data portal Laboratory of Mathematical Parallel Systems (LAMPS), based at York University. The baseline for projections is 1986-2005, and future projections are provided for three emission scenarios (RCP2.6, RCP4.5 and RCP8.5) for the 2050s and 2080s. Data for Wellington County are directly applicable to the City of Guelph and provide a wider range of future climate projections than the localized climate projections developed for the Waterloo Region. The projections however do not include climate variables where there is high uncertainty, notably freezing rain and snowfall.

Climatedata.ca (currently active)

The Canadian Centre for Climate Services provides two key climate data portals: climatedata.ca (Climatedata.ca 2022) and climateatlas.ca (Climateatlas.ca 2022), and since their launch are widely considered to be the primary source of climate projections in Canada. For the purposes of the Guelph CAP, the climatedata.ca portal is more useful. The climatedata.ca portal provides “modelled” historical climate data back to 1950, and future projections to 2100 on a year-by-year basis. Projections are for three scenarios (RCP2.6, RCP4.5 and RCP8.5), and consider a range of uncertainty by providing “low,” “median,” and “high” values. The “analyze” function also provides additional flexibility to calculate future projections of various climate variables where you can select specific values (e.g., days where heat stress may be a particular health concern, such as when maximum temperatures are above 31°C and nighttime minimum temperature exceeds 21°C). These projections, along with those developed for Waterloo Region and Wellington County above, form the basis of climate projections for the CAP and in the determination of likelihood scores for key climate hazards. The flexibility and wide range of climate data provided in the portal has additional value for future analysis of climate risk for infrastructure assets and components, where specific critical thresholds may be of interest to determine asset failure and performance.

3.2 Climate Change Assessments and Guidance: National and Provincial Level

Canada in a Changing Climate: National Issues Report (2021)

This report (Warren and Lulham 2021) provides high-level context and guidance to municipalities across Canada and is applicable to the process to develop the Guelph CAP, notably:

- Climate change is threatening ageing infrastructure in cities and towns
- Enhancing green infrastructure helps cities and towns adapt to climate change, while increasing the quality of life for residents
- Working together with different groups yields the most successful adaptation outcomes
- Monitoring and evaluation of adaptation is an important and often overlooked step

Guide for Integrating Climate Change Considerations into Municipal Asset Management (2019)

Commissioned by the Federation of Canadian Municipalities under the Municipalities for Climate Innovation Program, the guide (FCM 2019) provides a roadmap that municipalities can use to understand climate change and its implications for municipal services and infrastructure. The intention of the guide is to help municipalities integrate climate change considerations and systematically build climate resiliency into asset management policies, plans and practices. The guide is part of a package of materials, including information briefs and a companion video.

The guide is based on the input and best practices from 11 municipalities across Canada including the City of Guelph. Of note, the City's Strategic Asset Management Policy (2018) was highlighted, including their principles and general framework for asset management. Other highlights included the City's integration of climate-related performance indicators as reflected in the LOS for infrastructure assets across all 17 service areas. Quarterly reporting on key LOS projects and phases is also highlighted.

The report outlines an overall framework that is consistent with the risk assessment approach adopted in the City's CAP and will be a valuable resource for later stages in the CAP process.

Canada in a Changing Climate: Regional Perspectives Report - Ontario (2022)

This report (Douglas and Pearson 2022) was recently released as part of a series of reports covering six regions across Canada, and which provides a 14 year update to the previous Ontario chapter that was released in 2008. Seven key messages are provided:

- Ontario's infrastructure is vulnerable to climate change, noting that due to interdependencies between multiple infrastructure types, climate change and especially extreme weather events can have cascading economic and social impacts.
- Nature-based approaches help address climate change impacts on biodiversity and ecosystem services which are magnified through the cumulative effects of climate change, habitat loss, urbanization, pollution and other threats.
- Adaptive management is key for addressing impacts in the Great Lakes Basin, where the combined effects of climate change, land use changes, and other stressors have negative impacts. Despite mechanisms to address complex governance challenges, adaptation across the Basin remain relatively fragmented, however many communities have embraced adaptive management practices in light of uncertainties in future changes in climate.
- Adaptation improves forest health, carbon storage and biodiversity, noting that changes in drought, pests, fire and wind regimes are of particular concern given the resulting cumulative impacts.
- Climate change brings both threats and opportunities to Ontario agriculture and food systems, such as reductions in summer rainfall, more severe heatwaves, higher frequency of precipitation

extremes, and increased risks from pests and diseases, which are only partially counterbalanced by longer growing seasons and warmer average temperatures.

- Existing human health inequities will be worsened by climate change, and local assessments of climate change vulnerability that include consideration of health equity will provide a foundation for stronger and more widespread adaptation action.
- Progress on adaptation planning and implementation remains limited in Ontario, where the primary focus is still placed on the assessment of risk and vulnerability. Although there are examples of implementation, there is little evidence of adaptation being mainstreamed into decision making broadly. Further, in most jurisdictions systems for monitoring and evaluating adaptation action and effectiveness remain inadequate.

National Adaptation Strategy (2022)

In December 2020, the Government of Canada committed to develop a National Adaptation Strategy (Government of Canada 2022a) with provincial, territorial and municipal governments, Indigenous Peoples, and other key partners. As part of a strengthened climate plan *A Healthy Environment and a Healthy Economy*, the strategy aims to establish a shared vision for climate resilience in Canada. This includes the identification of key priorities for increased collaboration and the establishment of a framework for measuring progress at the national level. The National Adaptation Strategy was released in December 2022, after the Conference of the Parties (COP 27) meetings in Sharm El-Sheikh, Egypt. It was released in conjunction with the *Government of Canada Adaptation Action Plan* (Government of Canada 2022b), which is intended to be an implementation document for the strategy. The action plan outlines 84 actions to advance adaptation throughout the five National Adaptation Strategy systems, and address both immediate and future climate risks to Canada.

Ontario Climate Change Impact Assessment (expected 2023)

In August 2020, the Government of Ontario (Environment, Conservation and Parks) announced that they were commissioning the province's first-ever multi-sector climate change impact assessment. The study, that is expected to be released in 2023, is intended to be based upon the best science and information to understand where and how climate change is likely to affect communities, critical infrastructure, economies and the natural environment, while helping to strengthen the province's resilience to the impacts of climate change.

3.3 Climate Change Adaptation Plans/Strategies - Municipal Level

There is a growing number of municipalities that have developed, or are in the process of developing, climate change adaptation plans and/or strategies across Canada. Many of the plans that have been developed have been completed by municipalities in southern Ontario, including most communities across the Greater Toronto and Hamilton Area. All of the adaptation plans are the outcome of a risk assessment where the process follows the ISO 31000 approach, or variations such as the International

Council for Local Environmental Initiatives (ICLEI) BARC methodology. The plans and/or strategies included in this review were selected because of the municipality's proximity to the City of Guelph, were communities of comparable size and population in southern Ontario, or notable for specific aspects of the risk method adopted that are unique and may be of interest to the process to develop the Guelph CAP.

Generally, each plan and/or strategy was reviewed with respect to the climate hazards considered, the historical climate data presented, and the climate change projections, including emission scenarios and time periods. Each provides insight into the methodology adopted in the vulnerability and risk assessment, whether they follow the ICLEI BARC framework or a variant version, how they prioritized impacts, what high-level adaptation measures were identified, proposed or recommended, the costs and responsibility for these actions, and what steps were needed in support of an implementation strategy. While the intent of this review is not to outline in detail how each plan/strategy addresses these issues, the initial scan will help inform the core research team regarding the process to assess risk, the identification of specific adaptation measures, and steps needed for implementation as the Guelph CAP project moves into Stages 3 and 4.

City of Barrie Climate Change Adaptation Strategy (2017)

Following the ICLEI BARC methodology, this strategy considered both City (Corporate) and Community impacts (City of Barrie 2017). Over 60 climate change impacts were initially identified, and after scoring 28 impacts were brought forward into the planning stage. The climate data analysis is notable for considering snowfall, a variable typically ignored in many plans and strategies. A total of 59 actions were selected as priority "Must Do" for their strategy. Of note snowfall and freezing rain events are considered in their climate analysis, as well as changes in winter rainfall. Recommendations are for cross cutting actions that address seven goals that represent the physical, social, economic, and ecological implications of climate change. Actions are aligned with existing plans, policies and frameworks, with the intent of providing a more sustainable, effective, and efficient use of resources. An implementation schedule is provided, aligning specific actions to lead departments and associated municipal plans/policies/strategies. In addition, potential partners, estimated costs, level of effort, duration, and frequency are provided for each action. Note that the actions outlined in the strategy are "high-level."

City of Barrie Implementation Plan - Climate Change Adaptation Strategy (2018)

The City of Barrie Implementation Plan (City of Barrie 2018) complements their adaptation strategy and takes the City from the planning stages of adaptation to on-the-ground implementation of priority actions. City departments were engaged to identify responsibility, budgets, timelines, supporting tasks, and measurements of success. Action-Specific Action Plans (ASAPs) were then developed which provide detailed implementation guidance for each of the priority actions outlined in the Strategy. The implementation plan is intended to guide ownership, communication, and progress on their adaptation actions. Actions are prioritized into three categories, and those considered to represent "Quick wins" were highlighted. Two other metrics were considered in action review, identifying those that served a mitigation co-benefit function and helped reduce greenhouse gas emissions (e.g., natural infrastructure

that sequesters carbon), and those selected as “People’s Choice,” which were considered as top priority by the community.

Climate Science Report for the City of Hamilton (2021)

The report (ICLEI Canada 2021) provides a summary (cut and paste) of climate variables and projections drawn from the Climate Atlas of Canada and the climatedata.ca portals. This report is indicative of climate science reports done for other municipalities that draw almost exclusively from climate change data portals. Projections are provided for two emission scenarios: moderate GHG concentrations (RCP4.5) resulting from substantial climate change mitigation measures, and the highest GHG concentrations (RCP8.5) resulting from business-as-usual emissions. Rainfall IDF (intensity-duration-frequency) projections are drawn from Western University’s Computerized Tool for the Development of IDF Curves under Climate Change. Variables not included in the data portals (e.g., freezing rain, wind, lake water temperatures and ice coverage) are addressed at a high-level, based on existing studies. General impacts are identified for human health, stormwater management and sewage, tourism and recreation, transportation network, ecosystems and species, buildings and energy systems/power grid, and food and agriculture.

Norfolk County Climate Change Adaptation Plan: Final Report (2021)

The report (Norfolk County 2021) is notable for the clarity and simplicity of the narrative and effective use of graphics. The report addresses eight climate hazards: coastal flooding, inland flooding, windstorms, river flooding, snowstorms, drought, heat waves and cold waves. A total of 18 priority risks are identified and are presented with provisional ranking scores (ranging from moderate to high to very high), pending additional public and stakeholder consultation. Risks and adaptation strategies are aligned with existing actions that represent actions that adapt to climate change. A total of 114 actions are identified, a suggested dollar value estimated (ranging from low to high), and further organized into four implementation categories: planning, process, communication, and physical. Implementation options are considered based on budget considerations and financial resources, specifically (1) fixed annual budget; (2) risk-based approach; and (3) community preferences.

Town of Oakville Climate Change Strategy - Technical Report (2015)

This is one of the earlier climate risk assessments and climate change adaptation plans developed by a municipality (Town of Oakville 2015). The strategy completes Milestones 1 and 2 of the five-milestone process outlined in the ICLEI BARC method. Six climate hazards were considered: (1) temperature, (2) precipitation, (3) high wind, (4) precipitation, thunder and lightning, (5) winter precipitation events, and (6) temperature and air quality. A total of 39 impact statements were identified, and over 400 actions planned, underway or on-going. The study considered vulnerability but did not determine risk of occurrence. Existing plans, practices and protocols are identified that would support specific actions that are considered as mitigation or adaptation response measures.

City of Ottawa Climate Change Vulnerability and Risk Assessment (2022)

This document included recently published climate vulnerability and risk assessment for the City of Ottawa at both the City and community scale (City of Ottawa 2022). While the methodology adopted follows the ICLEI BARC approach broadly, it is notable that it varies by considering and integrating complementing climate risk assessments being conducted for other departments, including water services, public health, and emergency management. Further consideration was given to other risk assessment methodologies used by the City such as corporate risk management and asset management. The assessment was structured around 12 focus areas pertaining to public health and community well-being, infrastructure, natural environment, and the economy. Five climate hazards were addressed: (1) extreme heat, drought and humidity; (2) seasonal variability and change; (3) increased precipitation volume and intensity; (4) extreme weather events; and (5) global climate change. A total of 150 climate impacts were assessed, with 40 impacts identified as priority risks where the impacts have a medium or higher vulnerability and a medium-high or higher risk rating. Of note this assessment places strong emphasis on vulnerable groups, such as older adults, persons with disabilities, persons living in poverty, racialized people, Indigenous people, rural residents, immigrants women and youth. The results of the assessment are intended to be the focus of the next phase of the project - the development of a Climate Resiliency Strategy.

Community Climate Change Adaptation Plan for Waterloo Region (2019)

This is a climate change adaptation plan that is facilitated by the Region of Waterloo, and supported by municipalities, organizations, and community members from across the region (Region of Waterloo 2019). The plan meets the first three Milestones outlined in the ICLEI BARC framework and will be followed by an implementation plan that includes monitoring and review. The plan focuses on four impact areas: (1) health and community; (2) built environment; (3) natural environment and water; and (4) energy and economy. Across these four impact areas 15 objectives are identified, with a total of 36 key actions. Forty impact statements are identified, based on local climate projections developed at the University of Waterloo (2015). Twelve consequence categories were identified, across social, economic and environmental factors. Risk scores were calculated by adding the consequence scores together, and then multiplying these by the likelihood score. Each impact received three risk scores (one for each consequence category) on a scale out of 100, and cumulative risk scores calculated for each impact out of 300. Through a prioritization exercise 14 priority impacts were identified with a risk score of medium or higher. Of note additional impacts were included if they received a single category score of medium or higher, and if they were also identified by subject-matter experts or community members as being of considerable concern. This added five additional impacts for a total of 19 that were prioritized for the action planning stage. Adaptation actions were identified in consideration of guiding principles, goals and objectives for the community CAP.

City of Waterloo Corporate Climate Change Adaptation Plan (2019)

The climate change adaptation plan (The Corporation of the City of Waterloo 2019) outlines how the municipality as a corporation will adapt its assets, operations, and services to the impacts of climate change. The plan focuses on things that the City is responsible for - such as City-owned buildings and

roads, and City-run programs. The plan meets Milestones One, Two and Three of the ICLEI BARC methodology. Thirty-seven actions are identified in the plan, and are rooted into eight goals that reflect high-level intentions that the City will strive toward as it implements the plan:

1. Create conditions to minimize health and safety risks to outdoor workers and community members.
2. Generate awareness of changing climate conditions with staff and the public.
3. Ensure a coordinated response to and recovery from extreme weather events.
4. Consider climate change impacts in the design, construction, and maintenance of built infrastructure.
5. Foster resiliency within the urban forest and natural landscape.
6. Reduce risks associated with heavy rainfall and flooding.
7. Minimize disruption to City services.
8. Integrate climate change adaptation into the City's strategies, plans, policies, procedures, and operations.

An implementation schedule was also developed for the actions to inform who, when, and how they will be implemented, including the scope, lead and supporting divisions, current practice, timelines, and estimated resource needs at a high level.

Risk Assessment Report: Waterloo Region Community Climate Adaptation Plan (2018)

This report provides information on the methodology and results of the Region's risk assessment as it nears completion (ICLEI Canada 2018). The report outlines the likelihood matrix used in the risk assessment. Detailed explanation is provided regarding the methodology adopted in the risk assessment, with emphasis on the calculation of risk assessment scores, and the process to vet these scores with community partners through surveys and workshops. Of note, none of the impacts received an overall risk score of very low, high or very high.

Transform^{WR}: Waterloo Region's Transition to an Equitable, Prosperous, Resilient Low Carbon Community

This report (ClimateActionWR n.d.) is a community-wide response for Waterloo Region to the global climate crisis. It is primarily in response to the 2015 Paris Agreement and driven by the need to reduce global emissions of GHGs to avert the climate crisis. The report outlines a long-term strategy to achieve an 80% reduction of GHGs below 2010 levels at the local level, including local actions to achieve a 30% reduction by 2030. There are six transformative changes that will guide the journey set out in the report to 2050, focusing on (1) most trips are through active transportation, supported by a robust public transit system, (2) vehicles emit zero emissions, (3) commercial and residential buildings no longer use fossil fuels, (4) waste reduction, including redirecting all organic matter away from landfills, (5) a thriving local food system, and (6) the Waterloo Region has leveraged reducing GHG emissions to increase equity, prosperity, and resiliency for all.

The report also places a strong emphasis on equity issues and has been showcased in the recently released document by the ICLEI and Federation of Canadian Municipalities (2022) *Integrating Equity, Diversity and*

Inclusion into Municipal Climate Action. In the absence of other documents that equity, diversity and inclusion (EDI) issues, the two reports represent an important resource for applying such a lens to the CAP process. However, as the response to their call to action is primarily directed at reducing GHG emissions, the notion of resilience is largely attributed as an outcome of implementing mitigation measures. Becoming resilient to the physical risks of climate change is not that evident, and at best indirectly captured in mitigation measures. Applying an equity lens to the CAP process thus requires some additional effort by the project team in order to determine where certain areas and groups across the City may be unfairly exposed or vulnerable to climate hazards, and where adaptation measures need to be adjusted accordingly.

3.4 Summary

Regarding climate data from portals and previous studies, the national climatedata.ca portal is the primary source for climate hazards data, both for the modelled historical baseline and future projections. The portal provides most of the climate data needed to describe future conditions for the nine climate hazards selected for the CAP, and they are largely consistent with secondary sources. The latter includes climate projections developed for Waterloo Region (2015) and for a recently published report for Waterloo Region, Wellington County, Dufferin County and the City of Guelph (2022) that informed a climate change and health vulnerability assessment. Climate vulnerability studies using the Public Infrastructure Engineering Vulnerability Committee (PIEVC) Protocol for public infrastructure across the Greater Toronto and Hamilton Area were used to fill in any data gaps.

National and provincial level climate change assessments were also reviewed in order to situate the CAP process within a broader research and knowledge context. For the most part their key finding and/or recommendations are largely applicable to the issues identified in the various City plans and are consistent with the approach being applied to the CAP process. We note that a Provincially led climate change impacts and adaptation assessment is expected to be released later this year, while the federal government is planning to release a National Adaptation Strategy at the Conference of the Parties (COP) 27 meetings that will be held in November, in Egypt. The strategy may provide some guidance and direction for supporting climate resiliency and adaptation measures, but whether it provides any clarity regarding governance and funding remains to be determined.

The municipal level plans and strategies reviewed provide a plethora of guidance and insights to inform the process to develop the Guelph CAP. We note that the approaches adopted by other municipalities to determine hazards, select historical baseline data, and calculate future climate change projections are consistent with the CAP. There is an important difference, however, insofar as the ICLEI BARC approach tends to be somewhat generic and ubiquitous, notably lacking connectivity to asset management and service delivery. The main strength of these reports is the array of impact statements, albeit at a high level rather than at the infrastructure asset level, and a list of adaptation and resiliency response measures. As such their statements may be useful to the CAP process, but only to a degree, and further care will be needed to produce consequence and risk statements that are meaningful to asset owners and operators.

The studies are less helpful in identifying sources of funding, which may be a reflection that plans and strategies are still early in their development and level of maturity. In general, there is less detail on implementation, including funding sources, and that monitoring and reporting on progress is not yet well developed. We anticipate that a majority of funding for municipal climate change adaptation measures will come from existing tax and non-tax sources, suggesting that the CAP's recommended adaptation measures may reflect a fine-tuning or tweaking of budgets to address assets that are at high risk.

4 CLIMATE RISK GUIDELINES AND STANDARDS

There is a growing literature regarding climate risk guidelines and standards, that are useful resources that have informed and shaped the methodology applied to the City's CAP. As the CAP process unfolds, there will be opportunity to identify and explain how each document has been used (if at all) in the development of the plan. For the purposes of this memo, this section provides a list of documents rather than provide a detailed summary of their content and applicability to the CAP.

- ICLEI BARC Guidance
- PIEVC Protocol and PIEVC High Level Screening Guidance (HLSG)
- ISO 1409X series of adaptation standards:
 - ✦ ISO 14090:2019 Adaptation to climate change - Principles, requirements and guidelines
 - ✦ ISO 14091: 2021 Adaptation to climate change - Guidelines on vulnerability, impacts and risk assessment
 - ✦ ISO 14092:2020 Adaptation to climate change - Requirements and guidance on adaptation planning for local governments and communities
 - ✦ ISO 14093 (under development) Mechanism for financing local adaptation to climate change - Performance-based climate resilience grants - Requirements and guidelines
- ISO 31000 Risk Management
- ISO 55000:2014 Asset management - Overview, principles and terminology

Other Relevant Documents

Similarly, there are numerous documents that apply to the provincial, national, and international level that are not addressed in detail above, but are relevant to the process to develop the CAP. They are listed as follows, without summaries, noting that they may be drawn upon more extensively in the next stages of the process.

- *A Climate Resilience Roadmap for Municipal Infrastructure and Systems.* (Milner et al. 2021)

- *Costing Climate Change Impacts to Public Infrastructure: Assessing the financial impacts of extreme rainfall, extreme heat, and freeze-thaw cycles on public buildings in Ontario* (Afroz et al. 2021)
- *Costing Climate Change Impacts to Public Infrastructure Project Backgrounder and Methodology*
- *Climate-Resilient Buildings and Core Public Infrastructure: An Assessment of Climate Change on Climatic Design Data in Canada* (Park et al. 2021)
- *Indicators of Climate Change in California: Report Summary* (Office of Environmental Health Hazard Assessment 2018)
- *Costing climate change impacts and adaptation for provincial and municipal public infrastructure in Ontario, Deliverable #10 - Final Report* (WSP 2021)
- *Planning and Investing for a Resilient California: A Guidebook for State Agencies* (2016)
- *Indicators of Climate Change in California* (Milanes et al. 2018)
- *Accounting for the Effects of Climate Change Supplementary Green Book Guidance* (Defra 2018)
- *National Building Code of Canada 2015 - Volume 1* (NRC 2015)
- *California Adaptation Planning Guide* (The California Governor’s Office of Emergency Services 2020)
- *Canada’s Top Climate Change Risks* (CCA 2019)
- *State of the Global Climate 2021* (WMO 2022)
- “Annex I: Glossary,” *IPCC Special Report on the Ocean and Cryosphere in a Changing Climate* 2019 (IPCC 2019)
- *Adapting to the Impacts of Climate Change in Canada: an update on the National Adaptation Strategy* (Government of Canada 2021a)
- *Disaster Mitigation and Adaptation Fund Application Guide: Strengthening the Resilience of Canadian Communities* (Infrastructure Canada 2021)
- *Integrating Equity, Diversity and Inclusion into Municipal Climate Action* (ICLEI and FCM 2022)

4.1 Policy Documents

There are numerous policy documents for consideration outside of the City that apply on the provincial level and at a regional scale. Some are more relevant to planning for climate change impacts than others,

noting that they range from policy compliance (e.g., O. Reg. 588/17, that applies to municipal asset management planning) to policy statements that make general reference to climate risks and resiliency (e.g., Provincial Policy Statement). In the latter case such documents are useful by embedding recognition of climate change risks into the policy process but offer few insights or detailed guidance regarding how climate resilience should be achieved. Details for policy documents will be further examined during Stage 4 when adaptation measures are evaluated to internal and external funding opportunities.

- Policy Review of Municipal Stormwater Management in the Light of Climate Change (MOE 2016)
- Stormwater Management Practices Planning and Design Manual (MOE 2003)
- Asset Management Planning for Municipal Infrastructure Regulation, O. Reg. 588/17 (Government of Ontario 2017)
- A Place to Grow: Growth Plan for the Greater Golden Horseshoe (Government of Ontario 2019a)
- Planning Act (Government of Ontario 2019b)
- Municipal Act (Government of Ontario 2022)
- Clean Water Act (Government of Ontario 2021b)
- Environmental Assessment Act (Government of Ontario 2010a)
- Ontario Water Resources Act (Government of Ontario 2021c)
- Water Opportunities and Water Conservation Act (Government of Ontario 2010b)
- Ontario Building Code
- Provincial Policy Statement (MMAH 2020)
- Official Plan, Wellington County (The Corporation of the County of Wellington 2022)
- Ontario Heritage Act (Government of Ontario 2021d)
- Species at Risk Act (Government of Canada 2021b)
- Endangered Species Act (Government of Ontario 2021a)
- Migratory Birds Convention Act (Government of Canada 2017)

4.2 Summary

Climate risk guidelines and standards that shapes the risk assessment framework may provide individual or unique insights that may be helpful in later stages, especially in stage 4 where adaptation measures will be proposed, costs will be estimated, and potential funding sources identified. In the absence of any new funding opportunities outlined in the forthcoming National Adaptation Strategy, we anticipate that the City will continue to be responsible for administering measures that improve the resiliency and adaptive capacity of infrastructure assets and the services that are dependent upon them through their asset management program and other plans currently being implemented. The policy landscape at the national and provincial level is also constantly evolving, although key Acts and guidance can be identified. From a policy perspective we anticipate that O. Reg. 588/17 will continue to be the primary driver behind the CAP process as we move into Stage 4, followed by implementation.

5 CONCLUSIONS AND NEXT STEPS

This strategic context review of internal and external documents for the City of Guelph (the City) provides a high-level preliminary assessment of how the CAP can build upon current efforts to address climate change, draw from climate adaptation plans developed by other municipalities, and identify where there may be opportunities for budget and funding options. The primary intent is to help identify the City's current coping methods and where they may enhance the City's adaptive capacity, and the review has provided the project team a sufficient working knowledge from which to engage staff. The project team reviewed a selection of internal and external documents that will help situate the CAP and the City's current and planned climate-related activities within a broader regional context and those already established by the Canadian regulatory and institutional standard of practice. The documents reviewed across four key areas: (1) City documents, (2) climate change data, risk assessments and adaptation plans, (3) climate risk guidelines and standards, and (4) other relevant material (e.g., policy documents) deemed by the project team that could provide useful insights into municipal adaptation, provided a plethora of information to help guide the CAP process, and evaluate the City's adaptive capacity to future climate hazards.

Overall, the City has a strong suite of plans, strategies and initiatives that address climate-related hazards and are directly or indirectly aimed at reducing the impacts and vulnerability of City assets and their ability to deliver services. The AMP developed by the City provides a strong foundation from which to inform the development of the City's CAP, while other plans regarding the natural environment and water provide additional mechanisms to build climate resiliency. While this is a positive position for the City, more work is needed that will be addressed through the Stage 3 risk workshops to determine the effectiveness of these plans, strategies and initiatives to move the City toward a stronger level of resiliency as climate change and extreme weather events become more pronounced.

The climate data and projections applied to the City's CAP is consistent to other studies and drawn from the national data portal developed by the Canadian Centre for Climate Services, while the risk assessment

framework is consistent with best practice adopted by neighbouring municipalities. We note that the focus on asset management does differentiate the City's CAP from other plans and strategies and represents a unique opportunity to develop a plan that is more meaningful in informing improvements in operations, asset management, and the design of construction of new infrastructure. This is also apparent when applying the equity lens, where the City's CAP presents an opportunity to address EDI issues when implementing measures that enhance adaptive capacity. These measures will likely need to be funded through existing tax and non-tax revenue streams, although additional funding opportunities may materialize as higher orders of government turn their attention to physical risks and adaptation needs.

Now that a desktop review exercise has been completed, a key component after completing the strategic review will be to follow up with selected City staff members and stakeholders to gather information regarding adaptive capacity measures, existing or planned, within their department or area of expertise. This will include reviewing the template entries for applicable strategic content in order to "ground truth" the results and generate a richer understanding of the work, as well as identify any information or additional sources that may have been missed in the review process. It is anticipated that engagement may take place with staff in Environmental Services, Emergency Services, Engineering, Planning and Building Services, Facilities and Energy Management, Economic Development, in addition to external stakeholders from GRCA, WDGPH, local utilities, and the University of Guelph, among others.

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CITY OF GUELPH CLIMATE ADAPTATION PLAN
CLIMATE HAZARDS, DATA, AND LIKELIHOOD

Prepared for:
CITY OF GUELPH

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CITY OF GUELPH CLIMATE CHANGE ADAPTATION PLAN
CLIMATE HAZARDS, DATA AND LIKELIHOOD

Prepared for City of Guelph, October 2022



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Matrix Solutions Inc. certifies that this report is accurate and complete and accords with the information available during the project. Information obtained during the project or provided by third parties is believed to be accurate but is not guaranteed. Matrix Solutions Inc. has exercised reasonable skill, care, and diligence in assessing the information obtained during the preparation of this report.

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1 INTRODUCTION

As part of the strategic context review, climate hazards have been identified that will inform the risk assessment stage as part of the process to develop a Climate Adaptation Plan (CAP) for the City of Guelph (the City). While there tends to be broad consensus regarding what constitutes climate hazards of concern (e.g., drought, heat, floods, etc.), the calculation of how each will change under future climate conditions, and thus impact municipal infrastructure assets and the ability of departments and staff to deliver services, is a complicated procedure. This involves selecting the climate variables or parameters that best illustrate or represent the climate conditions that define and capture a specific hazard, drawing information from climate data portals and published material to identify future changes in these variables relative to past conditions, and then determining how their occurrence (likelihood) will change in the mid-term (30 years) and long-term (60 years) future. We note that while in some cases there are subtle differences in the historical record and future projections, overall, there is a high level of agreement in the climate data and likelihood of occurrence between data portals and CAPs and strategies. The likelihood scores will then be combined with consequence scores to determine the level of risk that the City is facing regarding future climate conditions that can adversely impact infrastructure asset condition and performance and municipal service delivery.

This discussion outlines the steps taken in the process to select climate hazards, climate variables and parameters, climate data (historical baseline and future projections), and the likelihood of occurrence. It is intended to provide a transparent account of how the likelihood scores for each climate hazard are based on credible data and information, and that the projections in occurrence are accurate and defensible. It is noted that the process to calculate future changes in the likelihood of climate hazards is well established and, for the most part, is objective and based on sound science. However, there is much uncertainty regarding climate projections and, in some cases, the likelihood of occurrence involves using expert judgement that can be subjective in nature. Detailed tables of climate information and scoring criteria that were used to inform this discussion, to support the calculation of likelihood scores, and provide transparency to the process are provided in Appendix A. The table may be deemed useful to those wishing to take a deeper dive into the data and can serve as a useful resource for City staff regarding future needs to consider relevant climate information.

In a climate that is becoming warmer, wetter, and wilder, we can expect that changes in likelihood for the future occurrence of climate hazards will generally decrease in the winter season, increase in the spring and summer seasons, and that changes in the frequency and intensity of acute and chronic conditions will become even greater as this century unfolds (depending upon global efforts to mitigate greenhouse gas [GHG] emissions). Changes (or the rate of change) may not be linear or consistent over time, noting that some climate variables, such as snowfall and freezing rain, are driven by both precipitation and temperature conditions, resulting in a trajectory that increases and then decreases by the 2050s or 2080s. It should also be noted that climate model projections do not capture extreme events and conditions very well, even if ranges in uncertainty (e.g., 10th and 90th percentiles) are considered. What could happen in the future then could exceed or amplify the projections of likelihood of occurrence outlined in this report.

Nonetheless, for the purposes of developing a CAP, the likelihood scores should suffice in determining the projected levels of risk.

This report is organized into the following sections:

- selection of climate hazards
- selection of climate variables or parameters
- future climate projections
- likelihood criteria
- likelihood scores
- likelihood justification

Since the purpose of this report is to calculate the likelihood scores of the climate hazards and the associated climate variables and parameters for the purposes of informing the risk workshops, its focus is to communicate the process in a transparent manner, rather than provide a detailed explanation for how the scores are justified. A more detailed explanation in support of likelihood scores on a hazard and climate variable/parameter basis may be provided in the projects final report, pending feedback from the core committee.

2 SELECTION OF CLIMATE HAZARDS

The selection of climate hazards was based on a review of the literature such as other climate risk assessments developed for neighbouring municipalities, CAPs, and national and provincial climate impact risk assessments that make specific reference to southern Ontario or the Greater Toronto and Hamilton Area (GTHA). The climate hazards are also grounded in historical experience in the City, whose residents have encountered a wide range of acute (extreme weather) and chronic (longer term) conditions in weather and climate. A provisional list of proposed climate hazards was provided to the core advisory group. After some discussion, a list of seven hazards was used in the first workshop with the staff working group to identify key climate hazards: drought, extreme cold, extreme heat, freeze/thaw, snow and freezing rain, acute weather events, and flooding. Two new hazards were added to the list by the project team to capture climate conditions that may be a concern for the City's unique situation: winter/spring rainfall and warmer ambient temperatures. The addition of these hazards reflects the fact that they are not adequately captured within the other seven hazards, they involve many interdependencies, and could generate cumulative effects. For example, heavy rainfall events may not reflect winter/spring rainfall, which is seasonal in nature and could recharge groundwater resources and, thus, compensate for declining water resources due to summer drought conditions. Maximum temperatures and heat waves may not capture all of the potential consequences associated with warmer ambient temperatures, such as warmer winters that support the spread of ticks and Lyme disease and higher minimum nighttime temperatures in the summer that are a concern for heat stress mortality among the elderly, young, and immunocompromised.

In brief, the climate hazards can be described as:

- lack of rainfall (drought) over a prolonged period of time, which could compromise water quantity and quality, affect ecosystem health, and, when occurring with hot temperatures and convection storms (and associated lightning), lead to an increase in wildfires
- extreme cold and extreme heat, which could adversely impact municipal infrastructure, especially those exposed to outdoor weather conditions and pose a health risk for staff and residents
- freeze/thaw cycles, which affect thermal conditions of infrastructure assets, and, when coupled with precipitation, exacerbate moisture conditions that can make surfaces slippery, leading to slips, falls, and vehicular accidents
- snow and freezing rain, which can directly damage municipal infrastructure, natural infrastructure, buildings, and people and indirectly by damaging interdependent infrastructure (e.g., power outages), such as energy supply and electricity transmission and distribution
- acute weather events (hail, wind and lightning), which tend to be less frequent but high-impact events; the climate science is highly uncertain for projecting how these hazards will change in the future
- flooding, which can be riverine (fluvial), overland/urban (pluvial), or a combination of the two, caused by intense rainfall events that occur over hours or days
- winter/spring rainfall, which can partially offset the adverse effects from prolonged drought on groundwater quality and quantity
- warmer ambient temperatures, which can affect ecosystem function and exacerbate heat-related health risks

3 SELECTION OF CLIMATE VARIABLES OR PARAMETERS

For the 9 climate hazards there are 23 climate variables/parameters that were initially identified to inform the direction and degree of change (Table 1). Along with climate projections, these were calculated based on climate data derived from provincial and federal data portals, compared and vetted to projections in science and technical reports and CAPs/strategies, Public Infrastructure Engineering Vulnerability Committee (PIEVC) vulnerability assessments applied to public infrastructure across the GTHA, and other sources (Figure 1).

As a starting point, information was extracted from historical data and future climate projections from the climatedata.ca portal. Matrix notes that the historical baseline data is modelled data, rather than actual recorded data (sourced from Environment and Climate Change Canada [ECCC] historical climate record). The Canadian Centre for Climate Services (CCCS) recommends using modelled historical baseline data when using historical data along with future climate projections.

While different historical baselines are used in the literature to inform future climate conditions, we chose the period 1986-2005 to be consistent/comparable with the Wellington, Dufferin, and Guelph health assessment report, which provides detailed health-related climate projections. Future projections were calculated for the 2050s and 2080s under a high emissions scenario (Representative Concentration Pathway [RCP] 8.5). Using the modelled historical data (which goes back to 1950), the historical baseline for the period 1986-2005 represented the average values over this 19-year period. Following international best practice, future projections are based on a 30-year average: 2050s (2035-2065) and 2080s (2065-2095), rather than discrete values (e.g., the number of hot days above 30°C for 2050 or 2080).

Both the historical baseline and future projections were compared to science-technical reports that provided data for Waterloo Region and Wellington County: *Localized Climate Projections for Waterloo Region* (ICCC and University of Waterloo 2015) and the *Science Report for the Wellington, Dufferin and Guelph Climate Change and Health Vulnerability Assessment for Waterloo Region, Wellington County, Dufferin County and the City of Guelph* (ICLEI Canada 2022). The latter analysis drew their data from the Ontario Climate Change Data Portal, developed by Laboratory of Mathematical Parallel Systems (LAMPS), York University. We note that the Waterloo Region projections were used to inform both the *City of Waterloo Corporate Climate Adaptation Plan* (The Corporation of the City of Waterloo 2019) and the *Community Climate Adaptation Plan for Waterloo Region* (Region of Waterloo 2019). In addition, the *Norfolk County Climate Change Adaptation Plan* (Norfolk County 2021) was reviewed to compare climate hazards, climate variables and parameters, the magnitude and direction of change for these variables, and changes in overall likelihood of occurrence. Approximately 90 climate variables or parameters were calculated in these studies.

TABLE 1 Climate Hazards, Variables, and Parameters

Climate Hazard and Description	Climate Variable/Parameter
Drought	
Summer Soil Water Content	Trend in future average summer soil water content (mm)
Period of heat and low precipitation	Average Summer Soil Water Content
	Longest dry period in a year defined as the greatest number of consecutive days with daily precipitation less than 1 mm
	Number of periods with more than five consecutive dry days (less than 1 mm/day)
Extreme Cold	
Number of individual or consecutive cold days	Number of days where $T_{min} < -15^{\circ}C$
Number of frost/ice days	Days below freezing $<0^{\circ}C$
Extreme Heat	
Number of individual or consecutive hot days above a specified heat threshold	Number of days where $T_{max} > 30^{\circ}C$
Freeze/Thaw	
Number of days experiencing freeze/thaw conditions	Freeze-thaw cycles (days with $\pm 0^{\circ}C$)
Snow and Freezing Rain	
Number of days with snow and/or freezing rain conditions	Average percentage change in the number of daily freezing rain events (≥ 1 hour, ≥ 4 hours, ≥ 6 hours)
	Annual mean snowfall (cm)
	Number of days > 5 cm snowfall
Acute Weather Events	
Hail	Number of days with hail particles > 5 mm
Lightning	Lightning strikes per year
High wind gusts	Number of days > 40 km/h
	Number of days > 70 km/h
Flooding	
Heavy rainfall leading in overland and/or riverine flooding	Return levels for maximum 24-hour rainfall (mm)
	Return levels for maximum 5-day rainfall (mm)
	Number of wet days > 20 mm rain
Winter/Spring Rainfall	
Winter rain	Days with rainfall ≥ 25 mm during January-February-March (rain on snow/ground frozen)
Seasonal precipitation	Winter season precipitation
	Spring Season precipitation
Warmer Ambient Temperatures	
	Annual mean temperature ($^{\circ}C$)
	Winter Season mean temperature ($^{\circ}C$)
	Winter minimum temperature ($^{\circ}C$)
	Number of days $> 31^{\circ}C$ and nights $> 20^{\circ}C$

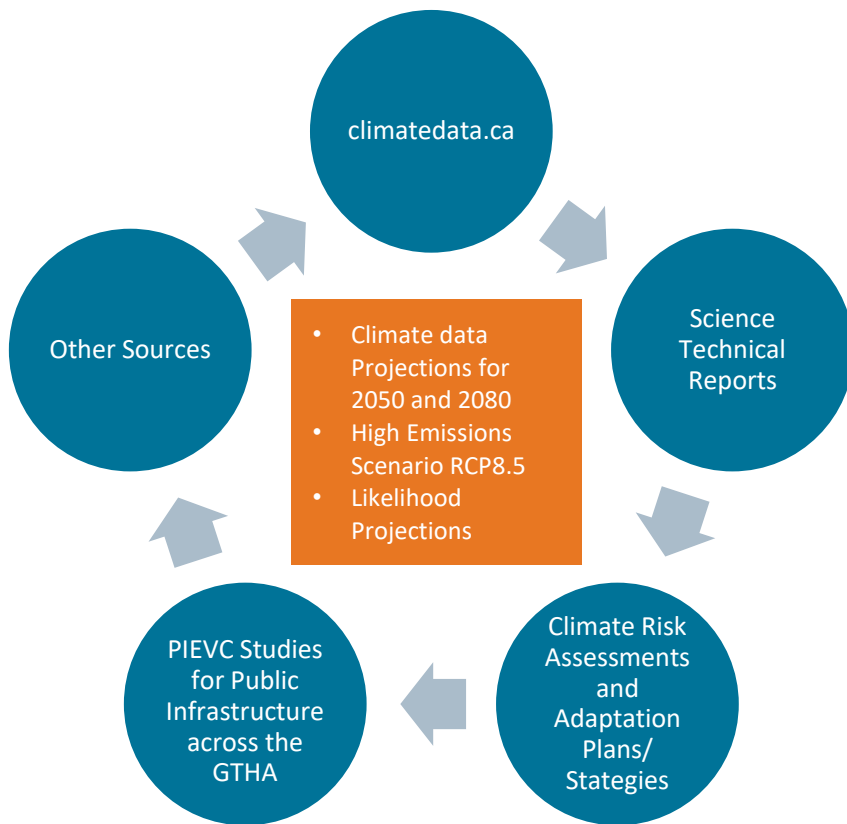


FIGURE 1 Review Process to Determine Climate Variable/Parameter Thresholds/Definitions and Historical Baseline and Future Projections

In addition, seven PIEVC assessments of public infrastructure across the GTHA were reviewed, in order to fill in any information and data gaps for climate variables/parameters, especially where there is great uncertainty and lack of confidence in future climate projections. While some overlap exists with the 90 climate variables and parameters considered in the science-technical reports and climate adaptation plans/strategies, there was a total of 81 different variables collected from the 7 PIEVC assessment reports. The PIEVC assessments were used to inform projections of hail and lightning strikes, and potential changes in likelihood of occurrence.

Lastly, there are a number of data challenges that should be highlighted that helps explain the wide range of climate variables and parameters vis-à-vis the number of climate hazards. Not all climate hazards have a single climate variable/parameter that captures how they will change over time, and in some cases hazards or variables are missed/ignored altogether. In the former case, for example, the number of hot days will be dependent upon the climate threshold selected (e.g., 30°C, 32°C or 40°C), while risk to flooding could be captured by rainfall over different time periods (e.g., 24 hours or over 5 days), or the number of days when rainfall exceeds a specific threshold (e.g., number of wet days >20 m of rain). There is no right or wrong choice in the climate variable or parameter, other than to consider what is the applied convention from other studies or what resonates with City staff who own and operate

infrastructure assets. In the latter case, for example, there is a scarcity of winter precipitation projections in the climatedata.ca portal, where the occurrence of precipitation and temperatures would determine the amount of snowfall and accumulation. Nonetheless, climate variables/parameters could still be considered even where there is a high level of uncertainty and/or combination of conditions that are needed to generate the hazard, and where expert judgement could estimate magnitude and direction. For example, it is widely accepted that freezing rain events could increase in the short to medium future, and then decline over the longer term. Aside from direct projections of freezing rain events, an increased likelihood of occurrence by 2050 would be based on increases in precipitation being the primary factor, with rising minimum temperatures as a secondary factor.

4 FUTURE CLIMATE PROJECTIONS

Climate projections are provided in Appendix A for the wide range of climate variables and parameters, as captured in science-technical reports and CAPs. These projections were used in conjunction with those drawn from the climatedata.ca portal, which are the primary source of information for a majority of likelihood scores. The summary table provides a comprehensive account/record of historical baseline data and future climate projections for the high emissions scenarios (e.g., RCP8.5) and for two future time periods (e.g., 2050 and 2080) for individual reports, noting the actual values, the likelihood of occurrence, and the primary sources, including any secondary sources that supported these projections and scores. A more detailed account of climate information collected for this project is available upon request.

5 LIKELIHOOD CRITERIA

There are various criteria used in the literature to define likelihood. In the Intergovernmental Panel on Climate Change (IPCC) process and PIEVC studies, a seven-point likelihood scale is adopted, but these are rarely referenced in local and regional studies, with the exception of the Regional Municipality of Peel. We also note that in most, if not all, municipal-based CAPs and strategies that adopt the International Council for Local Environmental Initiatives (ICLEI) Building Adaptive and Resilient Cities (BARC) method, likelihood scores are only indirectly revealed through the vulnerability scoring exercise. We found no studies that followed the ICLEI BARC method included likelihood scores that were explicated stated. Consequently, it is left to the reader to directly infer the changes in likelihood for each climate hazard, based on the historical baseline record and the data provided for future climate projections.

ICLEI BARC studies typically follow a five-point rating scale, ranging from rare (1) to almost certain (5) (Table 2).

TABLE 2 Likelihood Criteria and Scoring Recommended by International Council of Local Environmental Initiatives Building Adaptive and Resilient Cities

Likelihood Rating	Recurrent Impact
Almost Certain (5)	Could occur several times per year
Likely (4)	May arise about once per year
Possible (3)	May arise once in 10 years May arise once in 5 years
Unlikely (2)	May arise once in 10 years to 25 years May arise once in 5 years to 10 years
Rare (1)	Unlikely during the next 10+ years Unlikely during the next 25 years

The exception are PIEVC studies where likelihood is a key component of the assessment reporting process, and both historical baseline and future probabilities are typically included in their published reports. However, their scoring criteria is not without flaws, as it is skewed toward the lower probability categories (40% and below) and underestimates differences between higher probabilities (70% and above; Table 3).

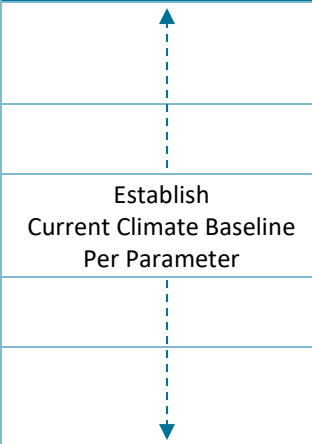
A variation of the ICLEI BARC method is also recommended in the federal Climate Lens Guidance, with differing terms for likelihood rating (e.g., very low to very high) and different time periods for probability (e.g., not likely to will become critical within several years). We note that the probability metric categories vary slightly between municipalities for three of the five categories (as noted above). However, last year Infrastructure Canada commissioned the creation of a climate risk screening guide, based on the original PIEVC Protocol, to be used in future climate risk assessments for new public infrastructure projects required under the Climate Lens Guidance process. The PIEVIC High Level Screening Guide (HLSG) is being promoted as the de facto approach to assess the physical climate risks to public infrastructure. The need for a new approach reflected the need to simplify and clarify the risk assessment methodology used in the original PIEVC Protocol and included a revamp of the likelihood criteria. The new and improved scoring method is described as being appropriate for a screening level assessment, which has applicability to the City CAP, given the focus and consideration of infrastructure assets.

TABLE 3 Public Infrastructure Engineering Vulnerability Committee Likelihood Criteria

PIEVC Probability Scoring Methods		
Score	Method A	Method B (years)
0	Negligible Not Applicable	<0.1% <1 in 1,000
1	Highly Unlikely Improbably	1% 1 in 100
2	Remotely Possible	5% 1 in 20
3	Possible Occasional	10% 1 in 10
4	Somewhat Likely Normal	20% 1 in 5
5	Likely Frequent	40% 1 in 2.5
6	Probably Often	70% 1 in 1.4
7	Highly Probably	>99%

The alternative approach is outlined in the PIEVC HLSG that was released early in 2022. The approach assigns the likelihood to hazard indicators relative to the baseline conditions in the historical period, with the mean conditions projected in the future. The emphasis is on the change in future risk relative to past conditions, rather than calculating probability based on a somewhat arbitrary scale. A five-point scale is also adopted, but the degree of change (and significance in likelihood) is grounded in the current climate baseline, with likelihood scores related to changes from the baseline value (Table 4). For example, any change in future conditions that fall within $\pm 10\%$ of the baseline mean is scored a 3. In cases where likelihood is projected to experience a noticeable change is scored a 2 or a 4 where a 10% to 50% reduction in frequency or intensity relative to the baseline mean occurs, or an increase in frequency or intensity of 10% to 50%, respectively. Similarly, any significant changes will be reflected in likelihood scores of 1 or 5, where there will be a reduction or increase in the frequency or intensity relative to the baseline mean of 50% to 100%. From the perspective of operation planning and asset management, this approach may be more effective in communicating changes in likelihood given that asset owners and operators tend to be influenced by climate conditions and impacts that have occurred most recently.

TABLE 4 Simplified Middle Baseline Likelihood Scoring Approach in the Public Infrastructure Engineering Vulnerability Committee High Level Screening Guide

PIEVC HLSG Probability Scoring			
Likelihood	Middle Baseline Approach	Method	Suggested Rational
1		Likely to occur less frequently than current climate	50% to 100% reduction in frequency or intensity with reference to baseline mean
2			10% to 50% reduction in frequency or intensity with reference to baseline mean
3		Likely to occur as frequently as current climate	Baseline mean conditions or a change in frequency or intensity of $\pm 10\%$ with reference to the baseline mean
4			10% to 50% increase in frequency or intensity with reference to baseline mean
5		Likely to occur more frequently than current climate	50% to 100% increase in frequency or intensity with reference to baseline mean

6 LIKELIHOOD SCORES

Applying the likelihood scoring method outlined in the PIEVC HLSG to the science-based climate projections of 23 climate variables that represent 9 climate hazards, the likelihood scores shown in Table 5 were calculated.

TABLE 5 Likelihood Scorings for the 2050s and 2080s by Climate Hazard Type

Climate Hazard	Likelihood	
	2050s	2080s
Drought	4	5
Extreme Cold	1	1
Extreme Heat	5	5
Freeze/Thaw	2	2
Snow and Freezing Rain	3 for snow 4 for freezing rain Low score of 3	2 for snow 4 for freezing rain Low score of 2
Acute Weather Events	3 for hail and lightning 4 for high wind gusts High score of 4	3 for hail and lightning 4 for high wind gusts High score of 4
Flooding	4	4
Winter/Spring Rainfall	4	4
Warmer Ambient Temperatures	5	5

For the purposes of the upcoming risk assessment of existing infrastructure assets, the likelihood scores for the 2080s will be adopted. This is based on the assumption that existing or legacy infrastructure assets

will have remaining lifecycle expectancies up to another 30 to 60 years depending upon their age and condition, while likelihood scores for 2080s should be considered in cases where new infrastructure is being planned or proposed, where lifecycle expectancy will also extend for another 30 to 60 years, or beyond. We note that likelihood scores are consistent for most climate hazards for 2050 and 2080, although they differ slightly for hazards that are either more rare or difficult to project changes (e.g., snow, freezing rain, and acute weather events). Further discussion and refinement may be necessary as the engagement and assessment process moves toward Stage 4.

7 LIKELIHOOD JUSTIFICATION

A brief justification will be considered for inclusion in the final report on a hazard-by-hazard and climate variable/parameter-by-climate variable/parameter basis. The justification will draw upon the following detailed explanation that draws its recommendations from the climate data tables. For each hazard, a future likelihood score based on the PIEVC HLSG scoring method is provided for 2050 and 2080. A brief general description is provided for each, in addition to the identification of the primary source and any secondary sources that support the recommended score. Actual numbers drawn from the climate data tables are included.

Drought: 4 by 2050; 5 by 2080

- Description: period of heat and low precipitation
- Main metric: Average future summer soil water storage (mm) predicted using water balance model and the Canadian Regional Climate Model – Run 1.
- Primary source: Matrix (2018) report Tier Three Water Quantity Risk Assessment (Climate Change Scenarios)
 - ✦ Under average annual conditions the groundwater recharge rates and streamflow supplying the City’s water supply aquifers are likely to increase due to higher winter temperatures. However, summer drought conditions as demonstrated by periods of higher temperature and evapotranspiration will result in reduced soil moisture resulting in more frequent periods of vegetative stress.

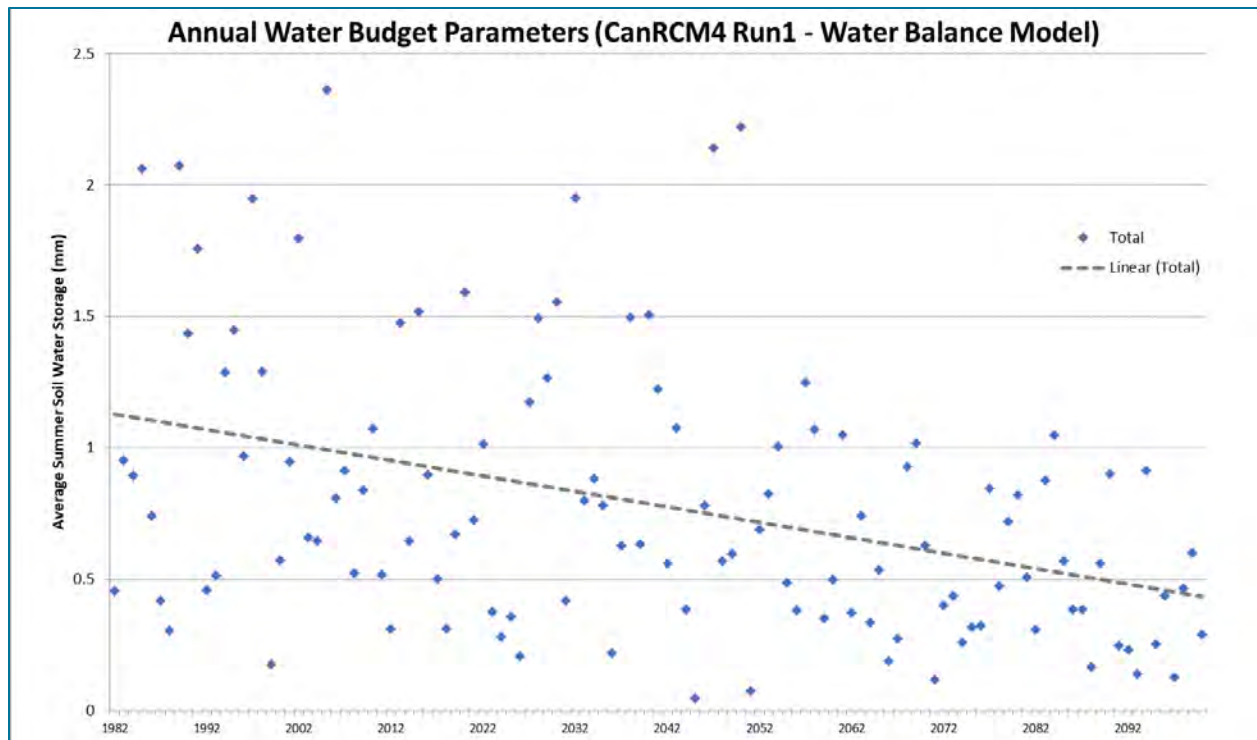


FIGURE 2 Projected Future Average Summer Soil Water Storage (mm)

- Alternative metrics:
 - ✦ Longest dry period in a year defined as the greatest number of consecutive days with daily precipitation less than 1 mm.
 - ✦ Historically, there are as many as 15 days each year when the daily precipitation is less than 1 mm over a 24-hour period.
 - ✦ The likelihood of occurrence is projected to increase to 15.15 days by 2050 and 15.34 days by the 2080s
 - primary: climatedata.ca
 - secondary: health report
 - ✦ Number of periods with more than 5 consecutive dry days (less than 1 mm a day) follows a similar trajectory.
 - ✦ Historically, there are typically 12.25 times a year when there are 5 consecutive days where there is less than 1 mm of precipitation over a 24-hour period
 - ✦ The number of 5-day periods is projected to increase to 12.42 per year by 2050 and drop slightly to 12.23 times per year by 2080s

- primary: climatedata.ca
- secondary: localized projections

Extreme Cold: 1 by 2050s; 1 by 2080s

- Description: number of individual or consecutive cold days; number of frost/ice days
 - Main metric: number of days where the minimum temperature (T_{\min}) $\leq 15^{\circ}\text{C}$
 - Primary source: climatedata.ca
 - Secondary sources: supported by localized projections, health science report, and City of Waterloo Corporate CAP
- ✦ Historically, there are on average 20 to 21 days where the minimum temperature drops below -15°C .
 - ✦ The likelihood of occurrence is projected to decrease dramatically to 5.68 days by 2050 and less than once per year (0.74 days per year) by 2080.
 - ✦ Comparable metrics (e.g., number of frost/ice days $< 0^{\circ}\text{C}$) follow a similar pattern:
 - On average, 150 days/nights of the year the temperature drops below 0°C , and in the future, it is projected that this number will drop to 116 days per year by 2050 and 90 days per year by 2080.

Extreme Heat: 5 by 2050, 5 by 2080

- Description: number of individual or consecutive hot days above a specified heat threshold
 - Main metric: number of days where the maximum temperature (T_{\max}) $> 30^{\circ}\text{C}$
 - Primary source: climatedata.ca
 - Secondary sources: supported by localized projections, health science report, and City of Waterloo Corporate CAP
- ✦ Historically, there are 8.825 days every year above 30°C .
 - ✦ The likelihood of occurrence is projected to increase dramatically to about 38 days/year by 2050 and 67 days by 2080.

Freeze-thaw: 2 by 2050, 2 by 2080

- Description: number of days experiencing freeze/thaw conditions
 - Main metric: freeze-thaw cycles (days with $\pm 0^{\circ}\text{C}$)
 - Primary source: climatedata.ca
 - Secondary sources: supported by localized projections, City of Waterloo Corporate CAP
- ✦ Increases by 2050 and then decreases by 2080 (secondary sources).

- ✦ Historically, there are 70 days where the temperature moves $\pm 0^{\circ}\text{C}$.
- ✦ The likelihood of occurrence is projected to decrease to 61 days by 2050 and further to 52 days by 2080.
- ✦ Anticipate that there will be monthly variability.

Snow and Freezing Rain: overall score of 2

Snow: 3 by 2050, 2 by 2080

- Description: projecting future snow events is fraught with uncertainty due to the combined effects of temperature and precipitation. While it is projected that winter precipitation will increase at a modest level, temperatures are also rapidly becoming warmer. This will likely result in more rain than snow on an annual or seasonal basis, but future changes in snowfall may follow historical trends, which is for declines in snowfall in most winter months with the exception of increases in February. Single storm events can also result in higher levels of snowfall, as the amount of precipitation increases. The Polar Vortex is also an additional factor that can result in extreme cold and precipitation events. As a result, metrics that are provided for snowfall and freezing rain tend to be at a more general level, if at all. The occurrence of snow is also much more frequent than freezing rain, and overall decreases in snowfall will more than offset any initial increase in freezing rain event.
- Primary source: localized climate projections for Waterloo Region
 - ✦ Multiple metrics - Metric 1: Annual mean snowfall (cm) has a historical baseline of 191.4 cm
 - ✦ By 2050 annual mean snowfall (cm) is projected to decrease to 173 cm, and to 123 cm by 2080
 - 3 by 2050, 2 by 2080
 - ✦ Metric 2: Number of days when there is > 5 cm of snowfall has a historical baseline of 11.5 days
 - ✦ By 2050 this drops to 10.3 days and by 2080 it dips to 7.2 days
 - 2 by 2050, 2 by 2080
 - ✦ Secondary source: in the case of annual snowfall comparable to City of Waterloo Corporate CAP

Freezing Rain: 4 by 2050, 4 by 2080

- Primary source: localized climate projections for Waterloo Region
 - ✦ Main metric: average percentage change in the number of daily freezing rain events (≥ 1 hour, ≥ 4 hours, ≥ 6 hours)
 - ✦ By 2050 percentage change will be +40%, and by 2080 +45%

- Secondary source: in the case of freezing rain, comparable to the Waterloo Region Community CAP; also consistent with PIEVC studies

Acute Weather Events: overall 4 by 2050, 4 by 2080

Hail and Lightning: 3 by 2050, 3 by 2080

High Wind Gusts: 4 by 2050, 4 by 2100

- Description: acute weather events include those that are either rare in occurrence (e.g., hail), highly localized (e.g., lightning), or the science is highly uncertain regarding future conditions (e.g., hail, lightning, and high wind gusts). PIEVC studies have not projected any significant changes in the frequency for hail and lightning by 2050 and do not provide any projections to 2080. There is somewhat stronger confidence in an increase in wind gusts, but the projections extend to the end of the century rather than 2050 and 2080 timelines. Overall high wind gusts are likely to occur more frequently than hail.
 - ✦ Metric for hail: number of days with hail particles >5 mm
 - ✦ Metric for lightning: number of lightning strikes per year
- Primary source: PIEVC studies
 - ✦ Metric for wind: number of days >40 km/hour (+10-20% by 2100)
number of days >70 km/hour (+20-40% by 2100)
- Primary source: City of Waterloo Corporate CAP
- Secondary source: Waterloo Region Community CAP

Flooding: 4 by 2050, 4 by 2080

- Description: multiple metrics available for flooding, and we selected three which reflects heavy rainfall leading to overland and/or riverine flooding. Overall consistency, with minor variation, across metrics.
 - ✦ Metric 1: return levels for maximum 24-hour rainfall (mm)
 - Baseline of 39.23 mm, increases to 43.42 mm by 2050, 46.13 mm by 2080
 - ✦ Metric 2: return levels for maximum 5-day rainfall (mm)
 - Baseline of 67.08 mm, increases to 72.51 mm by 2050, 77.59 mm by 2080
 - ✦ Metric 3: number of wet days >20 mm rain
 - Baseline of 6.325 days per year, increases to 7.47 days per year by 2050, 9.03 days per year by 2080

- Primary source: climatedata.ca
- Secondary source: 24-hour and 5-day return levels consistent with Science Report for Climate Change and Health Vulnerability Assessment
- Secondary source: number of wet days >20 mm rain consistent with localized climate projections for Waterloo Region and City of Waterloo Corporate CAP

Winter/Spring Rainfall: 4 by 2050, 4 by 2080

- Description: initially the amount of rainfall during the winter and spring seasons, but also interpreted as rain on snow. Uncertainties due to the combination of warmer temperature and increases in precipitation, resulting in multiple metrics. Note that winter season mean temperature is addressed in the following hazard.
 - ✦ Metric 1: days with rainfall ≥ 25 mm during January to March (rain on snow or frozen ground)
 - Baseline of 0.33 days per year, with minor clear change by 2050
 - ✦ Metric 2: winter season precipitation
 - Baseline of 192.84 mm, increasing to 216.56 mm by 2050, 231.65 mm by 2080
 - ✦ Metric 3: spring season precipitation
 - Baseline of 216.8 mm, increasing to 239.09 mm by 2050, 261.25 by 2080
- Primary source for days with rainfall ≥ 25 mm from PIEVC studies
 - ✦ No secondary sources
- Primary source for winter and spring season precipitation from climatedata.ca
 - ✦ Secondary source: multiple sources - localized climate projections, Science Report for Climate Change and Health, City of Waterloo Corporate CAP

Warmer Ambient Temperatures: 5 by 2050, 5 by 2080

- Description: initially intended to capture two aspects of warmer ambient temperatures not captured in the other temperature-related hazards: (i) warmer winter temperatures that enabled overwintering of ticks, pine beetles and other insects that could lead to human (Lyme disease) and ecosystem (pine beetle infestation) impacts; and (ii) warmer summer nighttime temperatures along with hotter daytime maximum temperatures, resulting in increasing health risk of heat stress.
 - ✦ Metric 1: annual mean temperature

- Baseline of 7.12°C, 10.1°C by 2050, 12.21°C by 2080
- ✦ Metric 2: winter season mean temperature
 - Baseline of -5.3°C, -2.04°C by 2050, 0.34°C by 2080
- ✦ Metric 3: winter minimum temperature
 - Baseline of -9.0°C, -5.42°C by 2050, -2.75°C by 2080
- ✦ Metric 4: number of days >31°C and nights >20°C

Baseline of 0.5, 9.37 by 2050, 27.8 by 2080

- Primary source: for all metrics is climatedata.ca
- Secondary source: multiple sources - for all metrics, comparable to Science Report for Climate Change and Health; mean temperatures: localized climate data, City of Waterloo Corporate CAP; winter minimum temperature: also comparable to Waterloo Region Community CAP

8 REFERENCES

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Appendix A: Climate Data Summary Table

TABLE 1 Climate Data Summary Table														
Climate Hazard and Description	Climate Variable/Parameter	Baseline	Climate Projections		Likelihood		Climate Data Sources							
		1986-2005 or 1981-2010	2050s	2080s	2050s	2080s	climatedata.ca	Localized Climate Projections for Waterloo Region (2015)	Science Report for Climate Change and Health Vulnerability Assessment (2022)	City of Waterloo Corporate Climate Change Adaptation Plan (2019)	Waterloo Region Community Climate Adaptation Plan (2019)	PIEVC	Other	
Drought	Trend in future average summer soil water content (mm)				4	5								P
Period of heat and low precipitation	Longest dry period in a year defined as the greatest number of consecutive days with daily precipitation less than 1 mm	15	15.16	15.35	3	3	P		S					
	Number of periods with more than 5 consecutive dry days (less than 1 mm per day)	12.25	12.42	12.23	3	3	P	S ¹						
Extreme Cold					1	1								
Number of individual or consecutive cold days	Number of days where T _{min} <-15°C	20.65	5.68	0.74	1	1	P	S	S	S				
Number of frost/ice days	Days below freezing <0°C	151.7	116.27	90.13	2	2	P	S	S					
Extreme Heat					5	5								
Number of individual or consecutive hot days above a specified heat threshold	Number of days where T _{max} >30°C	8.825	37.79	67.05	5	5	P	S	S	S				
Freeze/Thaw					2	2								
Number of days experiencing freeze/thaw conditions	Freeze-thaw cycles (days with ±0°C)	70.05	61.39	52.11	2	2	P	S ²		S ²				
Snow and Freezing Rain					3	2								
Number of days with snow and/or freezing rain conditions	Average percentage change in the number of daily freezing rain events (≥1 hour, ≥4 hours, ≥6 hours)		+40%	+45%	4	4		P				S		
	annual mean snowfall (cm)	191.4	173	123.2	3	2		P		S				
	Number of days > 5 cm snowfall	11.5	10.3	7.2	2	2		P						
Acute Weather Events					3	3								
Hail	Number of days with hail particles >5 mm				3	3								P
	Lightning strikes per year				3	3								P
	High Wind Gusts			+10-20% by 2100	3	4					P			
Flooding	Number of days >70 km/hour			+20-40% by 2100	3	4					P	S ³		
	Heavy rainfall leading in overland and/or riverine flooding				4	4								
Return levels for maximum 24-hour rainfall (mm)		39.23	43.42	46.13	4	4	P		S					
	Return levels for maximum 5-day rainfall (mm)	67.08	72.51	77.59	3	4	P		S					
	Number of wet days >20 mm rain	6.325	7.47	9.03	4	4	P	S ⁴		S ⁴				
Winter/Spring Rainfall				4	4	P								
Winter Rain	Days with rainfall ≥25 mm during JFM (rain on snow/ground frozen)	0.33			3	3								P
Seasonal Precipitation	Winter Season Precipitation	192.84	216.56	231.65	4	4	P	S	S	S				
	Spring Season Precipitation	216.8	239.09	261.25	4	4	P	S	S	S				
Warmer Ambient Temperatures				5	5	P								
Annual Mean Temperature (C°)		7.12	10.01	12.21	4	5	P	S	S	S				
	Winter Season Mean Temperature (C°)	-5.3	-2.04	0.34	5	5	P	S	S	S	S ⁵			
	Winter Minimum Temperature (C°)	-9.0	-5.42	-2.75	4	5	P	S	S	S				
	Number of days >31°C and nights >20°C	0.5	9.37	27.8	5	5	P		S					
Notes:														
1 periods of 6 or more consecutive days														
2 increases by 2050, then decreases by 2080														
3 more wind gusts by 2100														
4 days >25 mm rainfall														
5 increases most marked throughout winter														
P - primary source														
S - secondary source														
PIEVC - Public Infrastructure Engineering Vulnerability Committee														
JFM -														
T _{min} - minimum temperature														
T _{max} - maximum temperature														



Appendix C

Risk Assessment and Adaptive Capacity Action Tables

Table C.1a Impact Statements

Climate Hazard	Department/Division	Asset	Original Impact Statement
Acute Weather Events	Engineering and Transportation Services (Transportation and Parking)	Bridges and Structures	High wind gusts causing damage to infrastructure assets and property, resulting in higher costs for repairs and ongoing maintenance.
Acute Weather Events	Engineering and Transportation Services (Transportation and Parking)	Roads, Sidewalks, bike paths/trails	Damage to infrastructure assets from high wind gusts could limit access, thereby impacting emergency services and local businesses.
Acute Weather Events	Engineering and Transportation Services (Transportation and Parking)	Signage, Streetlights, Traffic Controls	High wind gusts could result in instantaneous damage to infrastructure assets, creating unsafe conditions, and resulting in costs for repair and ongoing maintenance.
Acute Weather Events	Fire Services, Paramedic Services	Emergency Buildings	High wind gusts causing damage to infrastructure assets and property, resulting in disruptions of services.
Acute Weather Events	Fire Services, Paramedic Services	Emergency Vehicles	Increased risk of accidents and damage to vehicles, requiring repairs, and reducing asset performance and life expectancy.
Acute Weather Events	Parks (Culture and Recreations)	Buildings	High wind gusts could result in instantaneous damage to infrastructure assets and property, resulting in higher costs for repairs and ongoing maintenance.
Acute Weather Events	Parks (Culture and Recreations)	Library, Culture, Tourism and Community Investment	High wind gusts could result in instantaneous damage to infrastructure assets and property, resulting in higher costs for repairs and ongoing maintenance, and reduced access to amenities.
Acute Weather Events	Parks (Planning Services)	Forests and Plants	High wind gusts damaging trees and limbs, resulting in damage to nearby infrastructure and property, and incurring vegetation replacement costs.
Acute Weather Events	Planning and Building Services (Operations)	Facilities: Commercial, Corporate Administration, Operations	High wind gusts could result in instantaneous damage to infrastructure assets and property, resulting in higher costs for repairs and ongoing maintenance.
Acute Weather Events	Solid Waste Services	Waste Resource Innovation Centre (Facility)	High wind gusts could result in instantaneous damage to infrastructure assets and property, resulting in higher costs for repairs and ongoing maintenance.
Acute Weather Events	Transit	Bus Stops/Shelters	High wind gusts could result in instantaneous damage to infrastructure assets and property, resulting in higher costs for repairs and ongoing maintenance.
Acute Weather Events	Transit	Bus Terminal	High wind gusts could result in instantaneous damage to infrastructure assets and property, resulting in higher costs for repairs and ongoing maintenance.
Acute Weather Events	Transit	Transit Facility	High wind gusts could result in instantaneous damage to infrastructure assets and property, resulting in higher costs for repairs and ongoing maintenance.
Acute Weather Events	Wastewater Services	Water Resource Recovery Centre	High wind gusts could result in instantaneous damage to infrastructure assets and property, resulting in an increase in bypasses and spills, impacting aquatic habitat and service delivery.
Acute Weather Events	Water Services	Arkeel Springs, Water Spring Recharge System	High wind gusts could result in instantaneous damage to the infrastructure assets (well houses, etc.) in the Arkeel Spring Grounds, impacting service delivery.
Acute Weather Events	Water Services	Collector Aqueduct	High wind gusts could result in instantaneous damage to the above-ground infrastructure assets (maintenance accesses) of the aqueduct and/or damage to infrastructure assets located near the aqueduct, impacting service delivery and/or the ability to service and maintain the aqueduct in an emergency.
Acute Weather Events	Water Services	Water Tower	High wind gusts could result in instantaneous damage to infrastructure assets and property, resulting in higher costs for repairs and ongoing maintenance.
Acute Weather Events	Water Services	Water Treatment Plant	High wind gusts could result in instantaneous damage to infrastructure assets and property, resulting in higher costs for repairs and ongoing maintenance.
Drought	Parks (Planning Services)	Forests and Plants	Drought directly impacting the health of forests and plants, and also indirect effects by making them more susceptible to disease, pests, and invasive species, leading to a loss or degradation of associated benefits, such as the loss of recreational opportunities.

Table C.1a Impact Statements

Climate Hazard	Department/Division	Asset	Original Impact Statement
Drought	Parks (Planning Services)	Surface Water	Drought conditions will impact the flow of surface water potential, recharge potential, and aquatic habitat, affecting water supply and reducing the capacity of surface water to assimilate run-off and wastewater effluent.
Drought	Parks (Planning Services)	Wetlands	Drought could directly damage the performance and functioning of wetland ecosystems, make them more susceptible to disease, pests and invasive species, and indirectly impact water recharge and water supply.
Drought	Wastewater Services	Water Resource Recovery Centre	Drought could result in deterioration of water quality from reduced dilution.
Extreme Heat	Engineering and Transportation Services (Contaminated Sites)	Contaminated Lands	Die-back of vegetative cover over contaminated soils, leading to increased risk of erosion and exposure of contaminated soils.
Extreme Heat	Engineering and Transportation Services (Stormwater Services)	Stormwater Infrastructure (Channels, Culvert, Management Ponds, Oil and Grit Separator, Pipe)	Damage to stormwater infrastructure, reducing the functionality of assets and also leading to the deterioration of water quality (e.g., elevated temperatures, algal bloom activity) which, in turn, impacts natural assets in which stormwater drains into.
Extreme Heat	Engineering and Transportation Services (Transportation and Parking)	Parking Garage, Parking	Increase in radiant heat, adding to the urban heat island effect.
Extreme Heat	Engineering and Transportation Services (Transportation and Parking)	Roads, Sidewalks, bike paths/trails	Softening of roads, requiring minor repairs and reduced access.
Extreme Heat	Engineering and Transportation Services (Transportation and Parking)	Signage, Streetlights, Traffic Controls	Indirect impacts caused by heat-related power outages, leading to asset failure and increased safety concerns.
Extreme Heat	Fire Services, Paramedic Services	Emergency Buildings	Increased stress on ancillary assets, reducing performance, requiring repairs and leading to premature replacement.
Extreme Heat	Fire Services, Paramedic Services	Emergency Equipment	Impacts on asset condition and performance, leading to increased individual risk and reduced level of community service.
Extreme Heat	Fire Services, Paramedic Services	Emergency Vehicles	Increased heat-risk exposure, and potential increase in response times.
Extreme Heat	Information Technology	IT Equipment	Extreme heat could damage equipment performance, compromise staff resources, and increase reliance on backup power with consequences for energy use and emissions.
Extreme Heat	Parks (Culture and Recreations)	Buildings	Increased stress on HVAC ancillary assets, reducing performance, compromising thermal comfort, requiring more repairs and leading to premature replacement.
Extreme Heat	Parks (Culture and Recreations)	Library, Culture, Tourism and Community Investment	Higher temperatures could result in increased risk to heat-stress exposure.
Extreme Heat	Parks (Culture and Recreations)	Parks	Extreme heat may damage parks, requiring vegetation replacements.
Extreme Heat	Parks (Culture and Recreations)	Recreation Facility	Higher temperatures could compromise thermal comfort and result in increased risk to heat-stress exposure.
Extreme Heat	Parks (Planning Services)	Forests and Plants	Extreme heat directly impacting the health of forests and plants, and also indirect effects by making them more susceptible to disease, pests, and invasive species, leading to a loss or degradation of associated benefits, increasing the urban heat island effect and worsening air pollution.
Extreme Heat	Parks (Planning Services)	Surface Water	High temperature conditions will impact water quality and habitat potential, as increased water temperature could result in the loss of cool and cold-water dependent species, in addition to impacts to water supply and the capacity of surface water to assimilate run-off and wastewater effluent.
Extreme Heat	Parks (Planning Services)	Wetlands	Extreme heat may directly damage wetland ecosystems, and indirectly impact water recharge and water supply.
Extreme Heat	Planning and Building Services (Operations)	Facilities: Commercial, Corporate Administration, Operations	Higher temperatures could result in increased risk to heat-stress exposure.
Extreme Heat	Planning and Building Services (Operations)	Fleet Vehicles	Higher temperatures could compromise thermal comfort and result in increased risk to heat-stress exposure.

Table C.1a Impact Statements

Climate Hazard	Department/Division	Asset	Original Impact Statement
Extreme Heat	Solid Waste Services	Waste Resource Innovation Centre (Facility)	Higher temperatures could compromise thermal comfort and result in increased risk to heat-stress exposure.
Extreme Heat	Solid Waste Services	Waste Collection Fleet Vehicles	Higher temperatures could compromise thermal comfort and result in increased risk to heat-stress exposure.
Extreme Heat	Transit	Bus: Conventional and Mobility, other vehicles	Extreme heat could increase heat-risk exposure to staff and customers.
Extreme Heat	Transit	Bus Stops/Shelters	Extreme heat could increase heat-risk exposure to staff and customers.
Extreme Heat	Transit	Bus Terminal	Extreme heat could increase heat-risk exposure to customers at stops and shelters.
Extreme Heat	Transit	Transit Facility	Extreme heat could increase heat-risk exposure to customers at Terminal platforms.
Extreme Heat	Wastewater Services	Wastewater Infrastructure (Maintenance Hole, Sanitary Pipe, Siphon, Wastewater Pumping Station)	Extreme heat could damage wastewater infrastructure, and compromise water quality.
Extreme Heat	Wastewater Services	Water Resource Recovery Centre	Higher temperatures could compromise thermal comfort and result in increased risk to heat-stress exposure, and compromise service if effluent is impacted.
Extreme Heat	Water Services	Water Treatment Plant	Higher temperatures could result in increased risk to heat-stress exposure.
Extreme Heat	Water Services	Groundwater Well Station, Pumping Station, Well Station	Extreme heat could damage infrastructure, and compromise water quality.
Flooding	Engineering and Transportation Services (Contaminated Sites)	Contaminated Lands	Increased threat to human health and the environment from the transport of contaminated soils.
Flooding	Engineering and Transportation Services (Stormwater Services)	Stormwater Infrastructure (Channels, Culvert, Management Ponds, Oil and Grit Separator, Pipe)	Risk of flash flooding, leading to direct and indirect damage to buildings and property, and reducing service delivery.
Flooding	Engineering and Transportation Services (Transportation and Parking)	Bridges and Structures	Floods could result in damage to roads, bridges and structures, requiring repairs and increasing maintenance costs for primary and ancillary assets.
Flooding	Engineering and Transportation Services (Transportation and Parking)	Roads, Sidewalks, bike paths/trails	Community-wide economic impacts, due to asset damage and resulting travel delays and restrictions.
Flooding	Fire Services, Paramedic Services	Emergency Buildings	Floods could result in damage to assets, facilities and buildings, requiring repairs and increasing maintenance costs, and reducing levels of functionality and service. <ul style="list-style-type: none"> · 911 dispatch is in the floodplain · Clair Rd backup infrastructure located under the flood elevation
Flooding	Fire Services, Paramedic Services	Emergency Vehicles	Safety concerns leading to an increase in accidents and/or increase in response times.
Flooding	Parks (Culture and Recreations)	Buildings	Risk of flash flooding, leading to direct and indirect damage to buildings and property, resulting in higher costs for repairs and ongoing maintenance.
Flooding	Parks (Culture and Recreations)	Library, Culture, Tourism and Community Investment	Risk of flash flooding, leading to direct and indirect damage to buildings and property, resulting in higher costs for repairs and ongoing maintenance, and reduced access to amenities.
Flooding	Parks (Planning Services)	Forests and Plants	Flooding may directly impact plants and lead to nutrient losses, causing significant and long-lasting damage.
Flooding	Parks (Planning Services)	Surface Water	Flood damages to watercourse and floodplain such as erosion, embankment issues, etc.
Flooding	Planning and Building Services (Operations)	Facilities: Commercial, Corporate Administration, Operations	Flooding could result in instantaneous damage to infrastructure assets and property, resulting in higher costs for repairs and ongoing maintenance.
Flooding	Solid Waste Services	Waste Resource Innovation Centre (Facility)	Risk of flash flooding could result in instantaneous damage to infrastructure assets and property, resulting in higher costs for repair and ongoing maintenance.
Flooding	Transit	Bus Stops/Shelters	Flooding could result in instantaneous damage to infrastructure assets and property, resulting in higher costs for repairs and ongoing maintenance.

Table C.1a Impact Statements

Climate Hazard	Department/Division	Asset	Original Impact Statement
Flooding	Transit	Bus Terminal	Flooding could result in instantaneous damage to infrastructure assets and property, resulting in higher costs for repairs and ongoing maintenance.
Flooding	Transit	Transit Facility	Flooding could result in instantaneous damage to infrastructure assets and property, resulting in higher costs for repairs and ongoing maintenance.
Flooding	Wastewater Services	Water Resource Recovery Centre	Flooding could result in instantaneous damage to infrastructure assets and property, resulting in an increase in bypasses and spills, impacting aquatic habitat and service delivery.
Flooding	Water Services	Arnell Springs, Water Spring Recharge System	Issue with servicing limitations.
Flooding	Water Services	Water Treatment Plant	Issue with servicing limitations.
Warmer Ambient Temperatures	Engineering and Transportation Services (Stormwater Services)	Stormwater Infrastructure (Channels, Culvert, Management Ponds, Oil and Grit Separator, Pipe)	Stormwater infrastructure providing habitat for insects and pests that transmit diseases.
Warmer Ambient Temperatures	Fire Services, Paramedic Services	Emergency Equipment	Increased damage to equipment and reduced water supply, resulting in increased repair costs and decline in service delivery.
Warmer Ambient Temperatures	Information Technology	IT Equipment	Warmer temperatures could damage equipment performance, leading to costly repairs and premature lifecycle replacement.
Warmer Ambient Temperatures	Parks (Culture and Recreations)	Parks	Warmer ambient temperatures could enhance the spread of invasive species, and support habitat that enhances the spread of pests/wildlife and associated diseases.
Warmer Ambient Temperatures	Parks (Culture and Recreations)	Recreation Facility	Warmer ambient temperatures could enhance the spread of invasive species, and support habitat that enhances the spread of pests/wildlife and associated diseases.
Warmer Ambient Temperatures	Parks (Planning Services)	Forests and Plants	Warmer ambient temperatures could enhance the spread of invasive species, and support habitat that enhances the spread of pests/wildlife and associated diseases.
Warmer Ambient Temperatures	Parks (Planning Services)	Surface Water	Rising temperatures may impact water quality and habitat potential, including the loss of cool and cold-water dependent species, in addition to enhancing the prevalence of pests and disease.
Warmer Ambient Temperatures	Parks (Planning Services)	Wetlands	Rising temperatures may result in an increase in the prevalence of invasive species, in addition to pests and wildlife carrying diseases that affect human health.
Warmer Ambient Temperatures	Wastewater Services	Water Resource Recovery Centre	Warmer ambient temperatures could adversely impact temperature dependent processes, lowering treatment efficacy.
Winter/Spring Rainfall	Engineering and Transportation Services (Stormwater Services)	Stormwater Infrastructure (Channels, Culvert, Management Ponds, Oil and Grit Separator, Pipe)	Rising water levels overwhelming stormwater infrastructure, causing flooding and creating unsafe conditions.
Winter/Spring Rainfall	Wastewater Services	Water Resource Recovery Centre	Increased risk of bypasses and spills, lowering water quality and directly impacting aquatic habitat.

Table C.1b Risk Assessment

Department/ Division	Asset Category	Assets	Asset Groups	Hazard	Climate Variable	Likelihood	Individual Risk Rating										Risk Calculation and Adjustment									
							PHYSICAL HUMAN HEALTH	Human Health Ranking	MENTAL HEALTH	Mental Health Ranking	ASSET MANAGEMENT inc. routine maintenance and repair	Asset Management Ranking	ENVIRONMENT	Environment Ranking	COMMUNITY & ECONOMY	Comm. & Econ. Ranking	Physical Human Health Risk	Mental Health Risk	Physical Damage Risk	Environment Risk	Economic Risk	Maximum Risk	Altered based on 1:1s?	Revised Risk	Rationale for Risk Change	
Engineering and Transportation Services	Contaminated Sites	Contaminated Land	Contaminated Land	Acute Weather Events	Number of days with high wind gusts > 40 and 70 km/hr	4	Increased threat to human health from contaminated soils	Med	Stress from threat to human health from contaminated soils	Med	Cost of remediation of contaminated soils.	Med	Potential impact to the environment, wildlife, vegetation and citizens	Med			Moderate	Moderate	Moderate	Moderate	None	Moderate	Yes	High	Expressed this may lead to sediment transfer	
Engineering and Transportation Services	Parking	Parking Garage, Parking	Parking	Extreme Heat	Number of days >30°C	5	Increase in heat exposure, from increase in urban heat island effect	Med	Stress related to heat island effect	Med	Softening of pavement. Minor pavement repairs and methods to ameliorate urban heat island effect.	Med	Contribution to heat-island effect	Low	Disruption to parking access would temporarily redirect traffic and may impact local businesses.	Low	High	High	High	Moderate	Moderate	Moderate	High	No	High	
Engineering and Transportation Services	Parking	Parking Garage, Parking	Parking	Freeze/Thaw	Number of days experiencing freeze/thaw conditions	2	Safety concerns related to slips and falls.	Low	Stress related to slips and falls	Low	May lead to cracks and damages. Salt intrusions may also exacerbate conditions. Repair and maintenance of property damage.	Med	Increased salt application.	Med	May cause minor disruptions.	Low	Low	Low	Moderate	Moderate	Low	Moderate	Moderate	Yes	High	Assuming the same rationale for roads and freeze/thaw can be applied here
Engineering and Transportation Services	Transportation	Bridges and Structures	Bridges and Structures	Acute Weather Events	Number of days with high wind gusts > 40 and 70 km/hr	4	Health and safety concerns relating to asset failure and service loss; driving conditions	High	Limited access to bridge and loss/damage to cultural landmark.	High	Acute events (e.g., wind, lightning) could result in instantaneous damage. Repair and maintenance of damaged bridges.	Med	Deposits of sediments, increased scouring and erosion, damaged components	Med	Disruption to bridge access would temporarily redirect traffic.	Med	High	High	Moderate	Moderate	Moderate	Moderate	High	No	High	
Engineering and Transportation Services	Transportation	Bridges and Structures	Bridges and Structures	Freeze/Thaw	Number of days experiencing freeze/thaw conditions	2	Compromise to damage and driving concerns could be safety concern.	High	Limited access to bridge and loss/damage to cultural landmark. Walking/driving on snow covered bridges could be stressful.	High	Structural damage related to freeze-thaw. Repair and maintenance of damaged bridges.	Low	Increased salt application.	Low	May cause minor disruptions.	Low	Moderate	Moderate	Low	Low	Low	Moderate	Moderate	Yes	High	Assuming the same rationale for roads and freeze/thaw can be applied here
Engineering and Transportation Services	Transportation	Roads, Sidewalks, bike paths/trails	Roads	Extreme Heat	Number of days >30°C	5	Increase in heat exposure, from increase in urban heat island effect	Med	Heat islands will impact mental health - reduced social interactions, stress from heat related illness, possible impacts to capacity to work etc.	Med	Softening of pavement. Minor pavement repairs and methods to ameliorate urban heat island effect.	Med	Contribution to heat-island effect	Low	May cause minor disruptions.	Med	High	High	High	Moderate	High	High	High	No	High	
Engineering and Transportation Services	Transportation	Roads, Sidewalks, bike paths/trails	Roads	Acute Weather Events	Number of days with high wind gusts > 40 and 70 km/hr	4	Safety concerns related to travel conditions.	Med	Limited access.	Med	Acute weather events could result in instantaneous damage. Repair and maintenance of property damage.	High	Increased debris from trees and utilities	Low	Disruption to road access or physical damage would temporarily redirect traffic and may impact local businesses.	High	Moderate	Moderate	High	Moderate	High	High	High	No	High	
Engineering and Transportation Services	Transportation	Roads, Sidewalks, bike paths/trails	Roads	Freeze/Thaw	Number of days experiencing freeze/thaw conditions	2	Safety concerns related to slips and falls, and travel conditions.	High	Limited access. Stress related to slips and falls and driving conditions	High	May lead to cracks and damages. Salt intrusions may also exacerbate conditions. Repair and maintenance of property damage.	Med	Increased salt application.	Med	Disruption to road access would temporarily redirect traffic and may impact local businesses.	Med	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Yes	High	Staff mentioned that though cycles are decreasing, they would like to keep this on their radar
Engineering and Transportation Services	Transportation	Signage, Streetlights, Traffic Controls	Signage	Acute Weather Events	Number of days with high wind gusts > 40 and 70 km/hr	4	Potential safety concerns, including falling infrastructure. Pavement markings could be hidden or rubbed away which could cause safety issues.	Med	Stress related to driving conditions with damaged/missing/falling signs.	Med	Damages to structures. Loss of function associated with power outages. Repair and maintenance of property damage.	High	Debris management	Low	May cause minor disruptions.	Low	Moderate	Moderate	High	Moderate	Moderate	Moderate	High	No	High	
Fire Services, Paramedic Services	Emergency Services	Emergency Buildings	Emergency Buildings	Flooding	Return levels for max 24-hour and 5 day rainfall	4	Safety concerns relating to building occupation and ancillary services. Potential safety concerns with the exiting of the facilities in the flood plain.	Med	Limited access to buildings and issues relating to building ancillary services. Impacts from changes in work environment or loss of belongings.	Med	Floods could result in instantaneous damage. Extensive repair and maintenance of property damage. Increased demand for services	High	Debris enters storm sewers and discharged to waterways	Med	Potential change in levels of service if building is impacted.	High	Moderate	Moderate	High	Moderate	High	High	High	No	High	

Table C.1b Risk Assessment

Department/ Division	Asset Category	Assets	Asset Groups	Hazard	Climate Variable	Likelihood	Individual Risk Rating										Risk Calculation and Adjustment									
							PHYSICAL HUMAN HEALTH	Human Health Ranking	MENTAL HEALTH	Mental Health Ranking	ASSET MANAGEMENT inc. routine maintenance and repair	Asset Management Ranking	ENVIRONMENT	Environment Ranking	COMMUNITY & ECONOMY	Comm. & Econ. Ranking	Physical Human Health Risk	Mental Health Risk	Physical Damage Risk	Environment Risk	Economic Risk	Maximum Risk	Altered based on 1:1s?	Revised Risk	Rationale for Risk Change	
Fire Services, Paramedic Services	Emergency Services	Emergency Buildings	Emergency Buildings	Acute Weather Events	Number of days with high wind gusts > 40 and 70 km/hr	4	Safety concerns relating to building occupation and ancillary services.	Med	Limited access to buildings and issues relating to building ancillary services. Loss of assets or damage to personal belongings due to building impacts may increase stress.	Med	Acute events (e.g., wind, lightning) could result in instantaneous damage. Repair and maintenance of property damage. Increased demand for services.	High	Debris Management	Low	Potential change in levels of service if building is impacted. Impact to critical infrastructure can result in disruption of services (Communications down?, getting emergency vehicles out)	High	Moderate	Moderate	High	Moderate	High	High	No	High		
Fire Services, Paramedic Services	Emergency Services	Emergency Buildings	Emergency Buildings	Extreme Heat	Number of days >30°C	5	Health impacts related to extreme temperature	High	Stress related to extreme temperatures and changes in conditions. Loss of assets or damage to personal belongings due to building impacts may increase stress.	High	Increased stress to buildings systems and infrastructure due to the extreme heat conditions. Potential burst pipes, stress on HVAC. Increased cooling costs. Increased demand for services. Potential increased cost to operate due to length of use, changes in load limit, or to repair, clean or maintain facility.	Med	Increased GHG emissions. Cooling with increase the heat dome in the community. Risk to overloading the powergrid.	Low	Potential change in levels of service if building is impacted.	Med	Very High	Very High	High	Moderate	High	Very High	No	Very High		
Fire Services, Paramedic Services	Emergency Services	Emergency Equipment	Emergency Equipment	Extreme Heat	Number of days >30°C	5	Increased chances of injuries due to equipment impacts/failures. Health and safety concerns when staff are exposed to extreme weather conditions if attending to work outdoors or in non-climate controlled areas.	Med	Stress related to extreme temperatures.	Med	Potential equipment issues (e.g., damage and supply) due to extreme temperatures. Potential equipment issues due to increased use. Potential impact to communications due to failure of equipment. Cost of equipment and repairs. Increased demand for supply and services.	Med	Increased use of equipment could result in more GHG emissions and disposal of equipment, batteries, etc.	Low	Potential change in levels of service to the community if equipment is impacted. Any disruption to the level of service will have reputational impacts.	Med	High	High	High	Moderate	High	High	No	High		
Fire Services, Paramedic Services	Emergency Services	Emergency Vehicles	Emergency Vehicles	Acute Weather Events	Number of days with high wind gusts > 40 and 70 km/hr	4	Safety concerns related to driving conditions and reductions/delays in service delivery.	High	Limited access to services.	High	Damage to vehicle (i.e., accidents). Increased utilization will decrease the asset life. Repair and maintenance of damaged vehicles. Increased demand services. If a specific type of equipment is required then it will have additional costs.	Med			Any changes in normal response could result in a disruption of services. Reputational impacts are also possible.	Med	High	High	Moderate	None	Moderate	High	No	High		
Fire Services, Paramedic Services	Emergency Services	Emergency Vehicles	Emergency Vehicles	Extreme Heat	Number of days >30°C	5	Health impacts related to extreme temperature.	Med	Stress related to extreme temperatures.	Med	Unique challenges from heat and cold. Increased utilization will decrease the asset life. Lower fuel efficiency and fuel costs. Increased demand services. If a specific type of equipment is required then it will have additional costs.	Low	Increased fuel emissions from vehicles running in these conditions.	Low	Any changes in normal response could result in a disruption of services. Reputational impacts are also possible.	Med	High	High	Moderate	Moderate	High	High	No	High		
Fire Services, Paramedic Services	Emergency Services	Emergency Vehicles	Emergency Vehicles	Flooding	Return levels for max 24-hour and 5 day rainfall	4	Safety concerns related to driving conditions and reductions/delays in service delivery.	High	Limited access to services. (Stress from driving in these conditions)	High	Damage to vehicle (i.e., accidents). Additional risk from water damage in these conditions. Increased utilization will decrease the asset life. Repair and maintenance of damaged vehicles. Increased demand services. If a specific type of equipment is required then it will have additional costs.	Med	Debris management; increased emissions from increased use of equipment in these conditions.	Low	Any changes in normal response could result in a disruption of services. Reputational impacts are also possible.	Med	High	High	Moderate	Moderate	Moderate	High	No	High		
Guelph Transit	Transit Services	Bus - Conventional, Bus - Mobility, Transit Vehicle - Other	Vehicles	Extreme Heat	Number of days >30°C	5	Health risk exposure to staff and customers.	High	Limited access to services. Stress to provide services in extreme weather conditions	Med	Lower fuel efficiency and fuel costs.	Low	Increased fuel emissions.	Low	Service disruption.	Low	Very High	High	Moderate	Moderate	Moderate	Very High	No	Very High		
Guelph Transit	Transit Services	Transit	Bus Stops/Shelters	Acute Weather Events	Number of days with high wind gusts > 40 and 70 km/hr	4	Safety concerns for passengers	Med	Safety concerns for passengers	Med	Acute events (e.g., wind, lightning) could result in instantaneous damage. Repair and maintenance of property damage.	High	Debris management	Low	Servicing limitations.	Med	Moderate	Moderate	High	Moderate	Moderate	High	No	High		
Guelph Transit	Transit Services	Transit	Bus Stops/Shelters	Snow and Freezing Rain	Days > 5cm and/or Days with Freezing Rain	2	Safety concerns slips and falls	Med	Stress related to slips and falls	Med	Increased snow loads on roofs may cause property damage. Repair and maintenance of property damage.	Med	Increased salt application.	Low	Servicing limitations.	Low	Moderate	Moderate	Moderate	Low	Low	Moderate	Yes	High	Mentioned efforts to improve shelter from the elements	
Guelph Transit	Transit Services	Transit	Bus Stops/Shelters	Extreme Heat	Number of days >30°C	5	Health impacts related to extreme temperature.	Med	Stress related to extreme temperatures.	High					Potential impact to services. Frustration from residents regarding current provisions for shelter	Med	High	Very High	None	None	High	Very High	No	Very High		
Guelph Transit	Transit Services	Transit	Bus Terminal	Acute Weather Events	Number of days with high wind gusts > 40 and 70 km/hr	4	Safety concerns for passengers	Med	Safety concerns for passengers	Med	Acute events (e.g., wind, lightning) could result in instantaneous damage. Repair and maintenance of property damage.	High	Debris management	Low	Servicing limitations.	Med	Moderate	Moderate	High	Moderate	Moderate	High	No	High		

Table C.1b Risk Assessment

Department/ Division	Asset Category	Assets	Asset Groups	Hazard	Climate Variable	Likelihood	Individual Risk Rating							Risk Calculation and Adjustment											
							PHYSICAL HUMAN HEALTH	Human Health Ranking	MENTAL HEALTH	Mental Health Ranking	ASSET MANAGEMENT inc. routine maintenance and repair	Asset Management Ranking	ENVIRONMENT	Environment Ranking	COMMUNITY & ECONOMY	Comm. & Econ. Ranking	Physical Human Health Risk	Mental Health Risk	Physical Damage Risk	Environment Risk	Economic Risk	Maximum Risk	Altered based on 1:1s?	Revised Risk	Rationale for Risk Change
Guelph Transit	Transit Services	Transit	Bus Terminal	Snow and Freezing Rain	Days > 5cm and/or Days with Freezing Rain	2	Safety concerns slips and falls	Med	Stress related to slips and falls	Med	Increased snow loads on roofs may cause property damage. Repair and maintenance of property damage.	Med	Increased salt application.	Low	Servicing limitations.	Low	Moderate	Moderate	Moderate	Low	Low	Moderate	Yes	High	Mentioned efforts to improve shelter from the elements
Guelph Transit	Transit Services	Transit	Bus Terminal	Extreme Heat	Number of days >30°C	5	Health impacts related to extreme temperature.	Med	Stress related to extreme temperatures.	High					Potential impact to services. Frustration from residents regarding current provisions for shelter	Med	High	Very High	None	None	High	Very High	No	Very High	
Facilities and Energy Management	Transit Services	Transit	Bus Terminal	Extreme Heat		5																		High	
Guelph Transit	Transit Services	Transit Facilities	Buildings	Acute Weather Events	Number of days with high wind gusts > 40 and 70 km/hr	4	Safety concerns relating to building occupation and ancillary services.	Low	Limited access to buildings/services and issues relating to building ancillary services.	Low	Acute events (e.g., wind, lightning) could result in instantaneous damage. Repair and maintenance of property damage.	High	Debris management	Low	Servicing limitations.	Low	Moderate	Moderate	High	Moderate	Moderate	High	No	High	
Guelph Transit	Transit Services	Transit Facilities	Buildings	Extreme Heat	Number of days >30°C	5	Health impacts related to extreme temperature.	High	Stress related to extreme temperatures.	High	Increased cooling costs.	Low	Increased energy consumption - GHG emissions	Low	Potential impact to services.	Low	Very High	Very High	Moderate	Moderate	Moderate	Very High	No	Very High	
Information Technology	Software and Hardware	Equipment	Equipment	Flooding	Return levels for max 24-hour and 5 day rainfall	4	Health and safety concerns when staff are exposed to flooding if attending to work outdoors or in non-climate controlled areas.	Low	Stress related to extreme temperatures and unknown consequences from outages (systems go off-line mostly during non-business hours)	Med	Floods could result in instantaneous damage. Equipment is mostly located above grade, though some are below grade. May have resourcing issues around staffing. Cost of equipment and repairs. Cost of energy and emissions as well as diesel backup and supply.	Med			System outages could impact on City revenue and impact many residents	Med	Moderate	Moderate	Moderate	None	Moderate	Moderate	Yes	High	The equipment is currently stored in the basement and may be damaged in the event of a flood
Information Technology	Software and Hardware	Equipment	Equipment	Extreme Heat	Number of days >30°C	5	Health and safety concerns when staff are exposed to extreme weather conditions if attending to work outdoors or in non-climate controlled areas.	Low	Stress related to extreme temperatures and unknown consequences from outages (systems go off-line mostly during non-business hours)	Low	Potential equipment issues (e.g., damage and supply) due to extreme temperatures. May have resourcing issues around staffing. Cost of equipment and repairs. Cost of energy and emissions as well as diesel backup and supply.	High	Increased use of equipment could result in more GHG emissions and disposal of equipment, batteries, etc.	Low	System outages could impact on City revenue and impact many residents	Med	Moderate	Moderate	Very High	Moderate	High	Very High	No	Very High	
Culture and Recreation	Culture and Recreation	Culture and Recreation	Buildings	Acute Weather Events	Number of days with high wind gusts > 40 and 70 km/hr	4	Safety concerns relating to building occupation and ancillary services.	Low	Limited access to buildings/services and issues relating to building ancillary services.	Low	Acute events (e.g., wind, lightning) could result in instantaneous damage. Repair and maintenance of property damage.	High	Debris management	Low	Servicing limitations.	Low	Moderate	Moderate	High	Moderate	Moderate	High	No	High	
Culture and Recreation	Culture and Recreation	Culture and Recreation	Buildings	Extreme Heat	Number of days >30°C	5	Health impacts related to extreme temperature.	High	Stress related to extreme temperatures.	High	Increased cooling costs.	Low	Increased energy consumption - GHG emissions	Low	Potential impact to services.	Low	Very High	Very High	Moderate	Moderate	Moderate	Very High	No	Very High	
Culture and Recreation	Culture and Recreation	Culture and Recreation	Library, Culture, Tourism and Community Investment	Acute Weather Events	Number of days with high wind gusts > 40 and 70 km/hr	4	Safety issues for access to facilities for program delivery	Low	Health effects of cancelled programs	Low	Acute events (e.g., wind, lightning) could result in instantaneous damage and increased equipment fatigue. Cost of equipment and repairs. Increased demand for supply and services.	High	Acute weather events (e.g., lightning, high wind gusts, hail) may damage or destroy trees	Low	Impacts on tourism, cultural events, and recreational activities.	Low	Moderate	Moderate	High	Moderate	Moderate	High	No	High	
Culture and Recreation	Culture and Recreation	Culture and Recreation	Library, Culture, Tourism and Community Investment	Extreme Heat	Number of days >30°C	5	Health impacts related to extreme temperature.	High	Stress related to limited access to services	Low	Increased cooling costs.	Low	Increased energy consumption - GHG emissions	Low	Impacts on tourism, cultural events, and recreational activities, reputation, impacts to revenue	Med	Very High	Moderate	Moderate	Moderate	High	Very High	No	Very High	
Planning and Building Services	Parks and Planning	Parks and Planning	Parks	Extreme Heat	Number of days >30°C	5	Loss or degradation of urban forest can increase heat island impacts, and worsen air pollution.	Low	Indirect impacts due to park services.	Low	Costs may include vegetation replacement.	Med	Extreme heat may damage parks.	Med	Potential impact to services. Brand/trust impact on City reputation.	Low	Moderate	Moderate	High	High	Moderate	High	No	High	
Planning and Building Services, Parks	Parks and Planning	Parks and Planning	Parks	Acute Weather Events	Number of days with high wind gusts > 40 and 70 km/hr	4	High wind gusts may damage trees or limbs, may cause harm.	Low	Limited access to parks.	Low	Trail damages. Costs may include vegetation and trail replacement.	Med	Acute weather events (e.g., lightning, high wind gusts, hail) may cause instantaneous damage.	Med	Service disruption. Damaged vegetation could hurt the City's image.	Low	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Yes	High	Expressed staffing/equipment issues in the event that many trees are damaged (could be grouped in Forests and Plants)

Table C.1b Risk Assessment

Department/Division	Asset Category	Assets	Asset Groups	Hazard	Climate Variable	Likelihood	Individual Risk Rating								Risk Calculation and Adjustment											
							PHYSICAL HUMAN HEALTH	Human Health Ranking	MENTAL HEALTH	Mental Health Ranking	ASSET MANAGEMENT inc. routine maintenance and repair	Asset Management Ranking	ENVIRONMENT	Environment Ranking	COMMUNITY & ECONOMY	Comm. & Econ. Ranking	Physical Human Health Risk	Mental Health Risk	Physical Damage Risk	Environment Risk	Economic Risk	Maximum Risk	Altered based on 1:1s?	Revised Risk	Rationale for Risk Change	
Planning and Building Services, Parks	Parks and Planning	Parks and Planning	Parks	Warmer Ambient Temperature	Winter season mean temperatures and/or Number of days >31°C and nights >20°C	5	Prevalence of pests/wildlife carrying diseases may increase and impact human health.	Med	Stress related to potential limited access and increase in pests/wildlife carrying diseases.	Low			Issues surrounding species diversity, invasive species, and pests may occur.	High	Education and management of new/known species, pests, and diseases may be warranted.	Low	High	Moderate	None	Very High	Moderate	Very High	No	Very High		
Culture and Recreation	Culture and Recreation	Culture and Recreation	Recreation Facility	Warmer Ambient Temperature	Winter season mean temperatures and/or Number of days >31°C and nights >20°C	5	Prevalence of pest/wildlife carrying diseases may increase and impact human health.	Med	Stress related to potential limited access and increase in pests/wildlife carrying diseases.	Med					Potential reduced revenue of facilities.	Low	High	High	None	None	Moderate	High	No	High		
Culture and Recreation	Culture and Recreation	Culture and Recreation	Recreation Facility	Acute Weather Events	Number of days with high wind gusts > 40 and 70 km/hr	4	Safety concerns relating to facility use and ancillary services.	Low	Limited access to facilities and issues relating to ancillary services.	Low	Acute events (e.g., wind, lightning) could result in instantaneous damage. Repair and maintenance of property damage.	Med	Debris management	Low	Servicing limitations.	Low	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Yes	High	Expressed that they would like to try to maintain their functions as much as possible for wellness (in lieu of their facilities being used as an emergency shelter)
Culture and Recreation	Culture and Recreation	Culture and Recreation	Recreation Facility	Flooding	Return levels for max 24-hour and 5 day rainfall	4	Safety concerns relating to facility use and ancillary services.	Low	Limited access to facilities and issues relating to ancillary services.	Low	Flooding could result in instantaneous damage. Repair and maintenance of property damage.	Med	Debris enters storm sewers and discharged to waterways	Low	Servicing limitations.	Low	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Yes	High	Expressed that they would like to try to maintain their functions as much as possible for wellness (in lieu of their facilities being used as an emergency shelter)
Culture and Recreation	Culture and Recreation	Culture and Recreation	Recreation Facility	Extreme Heat	Number of days >30°C	5	Health impacts related to extreme temperature.	High	Limited access to facilities and associated activities.	Low	Increased cooling costs, if indoors.	Low	Extreme heat may damage facilities.	Low	Brand/trust impact on City reputation.	Low	Very High	Moderate	Moderate	Moderate	Moderate	Moderate	Very High	No	Very High	
Planning and Building Services, Parks	Natural Assets	Natural Heritage	Forest and Plants	Acute Weather Events	Number of days with high wind gusts > 40 and 70 km/hr	4	High wind gusts may damage trees or limbs, may cause harm.	High	Potential impact to mental and emotional well-being. Receive many calls from residents worried about potential falling trees.	High	High wind gusts may damage trees or limbs, resulting in damage to nearby property. Vegetation and tree replacement costs to the City.	High	Acute weather events (e.g., lightning, high wind gusts, hail) may damage or destroy trees	Med	Damage to the City's reputation as the trees are considered valuable natural heritage resources.	Med	High	High	High	Moderate	Moderate	High	No	High		
Planning and Building Services, Parks	Natural Assets	Natural Heritage	Forest and Plants	Flooding	Return levels for max 24-hour and 5 day rainfall	4	Local food supply may be impacted. Flooding may damage trees or limbs, may cause harm.	Med	Citizens will feel a strain on their mental health if plants are dying and local food supply is limited.	Med	Local food production may decrease and supply disrupted. Import substitution for low food production and impact on local farmers/businesses.	Med	Flooding may cause damage to plants and nutrient losses (fertilizer and manure sources). Flooding of ecosystems that are not flood adapted can cause significant and long lasting damage.	High	Local food production may decrease and supply disrupted. Damage to the City's reputation as the trees are considered valuable natural heritage resources.	Med	Moderate	Moderate	Moderate	High	Moderate	High	No	High		
Planning and Building Services, Parks	Natural Assets	Natural Heritage	Forest and Plants	Drought	Average summer soil content (mm)	5	Local food supply may be impacted. Increased drought periods threaten urban forests which mitigate extreme heat.	Med	Citizens will feel a strain on their mental health if plants are dying and local food supply is limited. Increased drought periods threaten urban forests which provide enjoyment and recreation for residents	Med	Import substitution for low food production and impact on local farmers/businesses. Tree replacement costs and large scale ecosystem restoration to the City.	Med	Drought conditions place stresses on urban forests, one of the City's most valuable natural heritage resources. Drought can cause significant die-back and permanently alter forest ecosystems. Drought conditions also make forests more susceptible to disease, pests and invasive species. Loss or degradation of benefits provided by trees (heat island, pollution mitigation etc.), Dryness in the environment will bring fire risk.	High	Damage to the City's reputation as the trees are considered valuable natural heritage resources.	Med	High	High	High	Very High	High	Very High	No	Very High		

Table C.1b Risk Assessment

Department/ Division	Asset Category	Assets	Asset Groups	Hazard	Climate Variable	Likelihood	Individual Risk Rating								Risk Calculation and Adjustment										
							PHYSICAL HUMAN HEALTH	Human Health Ranking	MENTAL HEALTH	Mental Health Ranking	ASSET MANAGEMENT inc. routine maintenance and repair	Asset Management Ranking	ENVIRONMENT	Environment Ranking	COMMUNITY & ECONOMY	Comm. & Econ. Ranking	Physical Human Health Risk	Mental Health Risk	Physical Damage Risk	Environment Risk	Economic Risk	Maximum Risk	Altered based on 1:1s?	Revised Risk	Rationale for Risk Change
Planning and Building Services, Parks	Natural Assets	Natural Heritage	Forest and Plants	Extreme Heat	Number of days >30°C	5	Loss or degradation of urban forest can increase heat island impacts, and worsen air pollution.	Med	Citizens will feel a strain on their mental health if plants are dying and local food supply is limited. Increased dry periods threaten urban forests which provide enjoyment and recreation for residents	Med	Costs may include vegetation replacement and large scare restoration efforts.	Med	Extreme heat may scorch foliage and damage plants, especially younger plantings. Extreme Heat can cause significant die-back and permanently alter forest ecosystems. Extreme Heat conditions also make forests more susceptible to disease, pests and invasive species.	High	Loss or degradation of recreational opportunities.	Med	High	High	High	Very High	High	Very High	No	Very High	
Planning and Building Services, Parks	Natural Assets	Natural Heritage	Forest and Plants	Warmer Ambient Temperature	Winter season mean temperatures and/or Number of days >31°C and nights >20°C	5	Prevalence of pest/wildlife carrying diseases may increase and impact human health.	Med	Stress related to potential increase in pests/wildlife carrying diseases.	Med			Warmer ambient temperatures allow for introduction of invasive species and pests.	High	Widespread damage to the City's urban forests may impact the City's reputation as having rich and vibrant natural heritage resources	High	High	High	None	Very High	Very High	Very High	No	Very High	
Planning and Building Services, Parks	Natural Assets	Natural Heritage	Surface Water	Flooding	Return levels for max 24-hour and 5 day rainfall	4	Safety concerns related to flood.	High	Stress related to sewer back-ups, basement flooding, property damage, etc.	High			Flood damages to watercourse and floodplain such as erosion, embankment issues, etc.	High	Rising water levels could deter residents from normal services and impact City reputation.	Low	High	High	None	High	Moderate	High	No	High	
Planning and Building Services, Parks	Natural Assets	Natural Heritage	Surface Water	Drought	Average summer soil content (mm)	5	Water quality impacts associated with algae and stagnant water.	Low	Recreational activities may be impacted.	Med	Surface water dependent processes may be impacted. Costs related to offset drought conditions, e.g. GRCA releasing more water from upstream dam.	Low	Drought conditions will impact the flow of surface water, recharge potential, and aquatic habitat. Drought can impact water quality and habitat potential. Impacts to water supply and capacity to assimilate run-off and waste water effluent	High	Brand/trust impact on City reputation.	Low	Moderate	High	Moderate	Very High	Moderate	Very High	No	Very High	
Planning and Building Services, Parks	Natural Assets	Natural Heritage	Surface Water	Extreme Heat	Number of days >30°C	5					Extreme evapotranspiration may damage the functionality of the water system	Low	High temperature conditions will impact on water quality and habitat potential. Increased water temperature could result in the loss of cool and cold-water dependent species. Impacts to water supply and capacity to assimilate run-off and waste water effluent	High			None	None	Moderate	Very High	None	Very High	No	Very High	
Planning and Building Services, Parks	Natural Assets	Natural Heritage	Surface Water	Warmer Ambient Temperature	Winter season mean temperatures and/or Number of days >31°C and nights >20°C	5	Prevalence of pests/wildlife carrying diseases may increase and impact human health.	Med	Stress related to potential limited access and increase in pests/wildlife carrying diseases.	Low			Rising temperatures may impact on water quality and habitat potential. Increased water temperature could result in the loss of cool and cold-water dependent species. Issues surrounding pests and diseases may occur	High			High	Moderate	None	Very High	None	Very High	No	Very High	
Planning and Building Services, Parks	Natural Assets	Natural Heritage	Wetlands	Drought	Average summer soil content (mm)	5	Water quality impacts associated with algae and stagnant water.	Low	Mental health implications related to vegetation loss and wildlife.	Low	Costs related to wetland restoration.	Low	Indirect impacts to water sources could occur if critical wetlands are damaged or lost Drought can cause significant die-back and permanently alter wetland ecosystems. Drought conditions also make wetlands more susceptible to disease, pests and invasive species. Impacts to water recharge and water supply.	High	Brand/trust impact on City reputation.	Low	Moderate	Moderate	Moderate	Very High	Moderate	Very High	No	Very High	

Table C.1b Risk Assessment

Department/ Division	Asset Category	Assets	Asset Groups	Hazard	Climate Variable	Likelihood	Individual Risk Rating										Risk Calculation and Adjustment									
							PHYSICAL HUMAN HEALTH	Human Health Ranking	MENTAL HEALTH	Mental Health Ranking	ASSET MANAGEMENT inc. routine maintenance and repair	Asset Management Ranking	ENVIRONMENT	Environment Ranking	COMMUNITY & ECONOMY	Comm. & Econ. Ranking	Physical Human Health Risk	Mental Health Risk	Physical Damage Risk	Environment Risk	Economic Risk	Maximum Risk	Altered based on 1:1s?	Revised Risk	Rationale for Risk Change	
Planning and Building Services, Parks	Natural Assets	Natural Heritage	Wetlands	Extreme Heat	Number of days >30°C	5	Loss or degradation of wetlands can worsen air pollution.	Low	Mental health implications related to vegetation loss.	Low	Costs related to wetland restoration. Costs related to wetland restoration.	Low	Extreme heat may damage vegetation within wetlands. Impacts to water recharge and water supply.	High			Moderate	Moderate	Moderate	Very High	None	Very High	No	Very High		
Planning and Building Services, Parks	Natural Assets	Natural Heritage	Wetlands	Warmer Ambient Temperature	Winter season mean temperatures and/or Number of days >31°C and nights >20°C	5	Prevalence of pests/wildlife carrying diseases may increase and impact human health.	Med	Stress related to potential limited access and increase in pests/wildlife carrying diseases.	Low	Significant costs to control invasive species.	High	Issues surrounding species diversity, invasive species, and pests may occur.	High	Education and management of new/known species, pests, and diseases may be warranted.	Low	High	Moderate	Very High	Very High	Moderate	Very High	No	Very High		
Fire Services, Paramedic Services	Emergency Services	Emergency Equipment	Emergency Equipment	Flooding	Return levels for max 24-hour and 5 day rainfall	4	Safety concerns relating to service provision.	Med	Stress impacts due to increased frequency of use of equipment as a result of increased call volume. Will impact multiple shifts.	Med	Floods could result in instantaneous damage and increased equipment fatigue. Cost of equipment and repairs.	Med	Increased emissions from increased use of equipment in these conditions.	Low	Increased demand for supply and services. Potential change in levels of service to the community if equipment is impacted. Any disruption to the level of service will have reputational impacts.	Med	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Yes	High	Staff expressed and consistent with IT equipment
Facilities and Energy Management	Administrative and Operations Facilities	Commercial Facilities, Corporate Administration Facilities, Operations Facilities	Buildings	Acute Weather Events	Number of days with high wind gusts > 40 and 70 km/hr	4	Safety concerns relating to building occupation and ancillary services.	Low	Limited access to buildings/services and issues relating to building ancillary services.	Low	Acute events (e.g., wind, lightning) could result in instantaneous damage. Repair and maintenance of property damage.	High	Debris management	Low	Servicing limitations.	Low	Moderate	Moderate	High	Moderate	Moderate	Moderate	High	No	High	
Facilities and Energy Management	Administrative and Operations Facilities	Commercial Facilities, Corporate Administration Facilities, Operations Facilities	Buildings	Flooding	Return levels for max 24-hour and 5 day rainfall	4	Safety concerns relating to building occupation and ancillary services.	Low	Limited access to buildings and issues relating to building ancillary services.	Low	Floods could result in instantaneous damage. Repair and maintenance of property damage.	High	Debris enters storm sewers and discharged to waterways	Med	Servicing limitations.	Low	Moderate	Moderate	High	Moderate	Moderate	Moderate	High	No	High	Note: Staff requested to explicitly mention buildings for funding
Facilities and Energy Management	Administrative and Operations Facilities	Commercial Facilities, Corporate Administration Facilities, Operations Facilities	Buildings	Extreme Heat	Number of days >30°C	5	Health impacts related to extreme temperature.	High	Stress related to extreme temperatures.	High	HVAC equipment performance and lifecycle; electrical power outage. Increased cooling costs.	Low	Increased energy consumption - GHG emissions	Low	Potential impact to services.	Low	Very High	Very High	Moderate	Moderate	Moderate	Moderate	Very High	No	Very High	
Solid Waste Services	Solid Waste	Waste Collection	Vehicles	Extreme Heat	Number of days >30°C	5	Health risk exposure to staff.	High	Limited access to services. Stress to provide services in extreme weather conditions	Low	Damage to vehicle (i.e., overheating, extended repair times). Lower fuel efficiency and fuel costs.	Low	Increased fuel emissions, potential process interruptions.	Low	Service disruption.	Low	Very High	Moderate	Moderate	Moderate	Moderate	Moderate	Very High	No	Very High	
Solid Waste Services	Solid Waste	Waste Resource Innovation Centre (Facility)	Buildings	Acute Weather Events	Number of days with high wind gusts > 40 and 70 km/hr	4	Safety concerns relating to building occupation and ancillary services.	Low	Limited access to buildings/services and issues relating to building ancillary services.	Low	Floods could result in instantaneous damage. Repair and maintenance of property damage	High	Potential impact to the environment, wildlife, vegetation and citizens	Low	Servicing limitations, loss of revenue, contract risk re OWPF processing.	Med	Moderate	Moderate	High	Moderate	Moderate	Moderate	High	No	High	
Solid Waste Services	Solid Waste	Waste Resource Innovation Centre (Facility)	Buildings	Extreme Heat	Number of days >30°C	5	Health impacts related to extreme temperature.	High	Stress related to extreme temperatures.	High	Increased cooling costs.	Low	Increased energy consumption - GHG emissions. Potential process interruptions	Low	Potential impact to services.	Low	Very High	Very High	Moderate	Moderate	Moderate	Moderate	Very High	No	Very High	
Stormwater Services	Stormwater	Channels, Culvert, Management Ponds, Oil and Grit Separator, Pipe	Stormwater Infrastructure	Extreme Heat	Number of days >30°C	5					Damages to infrastructure (e.g., OGS). Repair and maintenance of damaged structures.	Low	Water quality implications from damaged structures; function of cooling trenches; discharge into cold water features	Med	Service disruption.	Low	None	None	Moderate	High	Moderate	Moderate	High	No	High	
Facilities and Energy Management	Corporate Vehicle	Equipment	Equipment	Extreme Heat	Number of days >30°C	5	Health and safety concerns when staff are exposed to extreme weather conditions if attending to work outdoors or in non-climate controlled areas.	Low	Stress related to extreme temperatures.	Low	Potential equipment issues (e.g., damage and supply) due to extreme temperatures. Cost of equipment and repairs.	Low	Increased use of equipment could result in more GHG emissions and disposal of equipment, batteries, etc.	Low	Potential impact to services.	Low	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Yes	High	Consistent with plans for IT

Table C.1b Risk Assessment

Department/ Division	Asset Category	Assets	Asset Groups	Hazard	Climate Variable	Likelihood	Individual Risk Rating							Risk Calculation and Adjustment											
							PHYSICAL HUMAN HEALTH	Human Health Ranking	MENTAL HEALTH	Mental Health Ranking	ASSET MANAGEMENT inc. routine maintenance and repair	Asset Management Ranking	ENVIRONMENT	Environment Ranking	COMMUNITY & ECONOMY	Comm. & Econ. Ranking	Physical Human Health Risk	Mental Health Risk	Physical Damage Risk	Environment Risk	Economic Risk	Maximum Risk	Altered based on 1:1s?	Revised Risk	Rationale for Risk Change
Stormwater Services	Stormwater	Channels, Culvert, Management Ponds, Oil and Grit Separator, Pipe	Stormwater Infrastructure	Flooding	Return levels for max 24-hour and 5 day rainfall	4	Safety concerns related to flood. Recreational usage could be dangerous (e.g., lack of fencing).	High	Stress related to sewer back-ups, basement flooding, property damage, etc.; flash flood risk	High	Damages to infrastructure (e.g., OGS, culverts, etc.) and accumulation of debris. Repair and maintenance of damaged structures and clearing debris. Potential upsizing of infrastructure.	Med	Altered pathways associated with debris and damaged structures.	Med	Service disruption.	Med	High	High	Moderate	Moderate	Moderate	High	No	High	
Stormwater Services	Stormwater	Channels, Culvert, Management Ponds, Oil and Grit Separator, Pipe	Stormwater Infrastructure	Warmer Ambient Temperature	Winter season mean temperatures and/or Number of days >31°C and nights >20°C	5	Prevalence of pests carrying diseases may increase and impact human health.	Med	Stress related to potential increase in pests carrying diseases.	Med			Issues surrounding pests may occur.	Med			High	High	None	High	None	High	No	High	
Stormwater Services	Stormwater	Channels, Culvert, Management Ponds, Oil and Grit Separator, Pipe	Stormwater Infrastructure	Winter/Spring Rainfall	Days with rainfall ≥25 mm during Jan - March (rain on snow or frozen ground)	4	Safety concerns related to flooding rising water levels. Recreational usage could be dangerous (e.g., lack of fencing).	High	Stress related to sewer back-ups, basement flooding, property damage, etc.	Low	Damages to infrastructure (e.g., OGS); additional salt loading. Repair and maintenance of damaged structures.	Med	Water quality implications from damaged structures; additional salt loading	Med	Service disruption.	Low	High	Moderate	Moderate	Moderate	Moderate	High	No	High	
Wastewater Services	Wastewater	Maintenance Hole, Sanitary Pipe, Siphon, Wastewater Pumping Station	Wastewater Infrastructure	Extreme Heat	Number of days >30°C	5					Damages to infrastructure. Repair and maintenance of damaged structures.	Low	Water quality implications from damaged structures.	Med	Servicing limitations.	Low	None	None	Moderate	High	Moderate	High	No	High	
Wastewater Services	Wastewater	Water Resource Recovery Centre	Wastewater Treatment Facility	Acute Weather Events	Number of days with high wind gusts > 40 and 70 km/hr	4	Safety concerns relating to building occupation and ancillary services.	Med	Stress related to working conditions.	Med	Acute events (e.g., wind, lightning) could result in instantaneous damage to multiple components. Repair and maintenance of property damage.	High	Potential increase in bypasses and spills. Aquatic animals directly impacted by lower water quality.	High	Servicing limitations. Damage to the facility could impact many residents/businesses.	High	Moderate	Moderate	High	High	High	High	No	High	
Wastewater Services	Wastewater	Water Resource Recovery Centre	Wastewater Treatment Facility	Winter/Spring Rainfall	Days with rainfall ≥25 mm during Jan - March (rain on snow or frozen ground)	4					Stress related to sewer potential bypasses	Low	Increased bypasses and spills. Aquatic animals directly impacted by lower water quality.	High	Servicing limitations.	Low	None	Moderate	None	High	Moderate	High	No	High	
Wastewater Services	Wastewater	Water Resource Recovery Centre	Wastewater Treatment Facility	Warmer Ambient Temperature	Winter season mean temperatures and/or Number of days >31°C and nights >20°C	5	Health impacts related to warmer ambient temperature.	Low	Stress related to warmer ambient temperatures.	Low	Impacts to temperature dependent processes.	Med	Lower treatment efficacy.	Med			Moderate	Moderate	High	High	None	High	No	High	
Wastewater Services	Wastewater	Water Resource Recovery Centre	Wastewater Treatment Facility	Extreme Heat	Number of days >30°C	5	Health impacts related to extreme temperature.	High	Stress related to extreme temperatures.	High	Damages to equipment and instrumentation. Impacts to temperature dependent processes. Increased cooling costs and equipment repairs.	Low	Water quality implications from damaged structures.	Low	Servicing limitations. Damaged reputation if effluent is impacted	Med	Very High	Very High	Moderate	Moderate	High	Very High	No	Very High	
Water Services	Water	Arnell Springs, Water Spring Recharge System	Arnell Springs and Recharge System	Acute Weather Events	Number of days with high wind gusts > 40 and 70 km/hr	4	Impacts to the supply of drinking water.	Med	Large portion of the population would be on no/reduced water supply while the aqueduct was repaired. The City would have to make alternative arrangements to keep a water supply.	Med	Damages to infrastructure. Repair and maintenance of damaged structures.	Med	Damage to Arnell Spring Grounds forest.	Med	Servicing limitations	High	Moderate	Moderate	Moderate	Moderate	High	High	No	High	
Water Services	Water	Arnell Springs, Water Spring Recharge System	Arnell Springs and Recharge System	Flooding	Return levels for max 24-hour and 5 day rainfall	4	Impacts to the supply of drinking water.	Med	Stress related to damaged infrastructure.	Low	Damages to infrastructure. Repair and maintenance of property damage/sedimentation	Med	Water quality implications.	Med	Servicing limitations. Declining trust in servicing provision and could impact many residents	High	Moderate	Moderate	Moderate	Moderate	High	High	No	High	

Table C.1b Risk Assessment

Department/ Division	Asset Category	Assets	Asset Groups	Hazard	Climate Variable	Likelihood	Individual Risk Rating							Risk Calculation and Adjustment											
							PHYSICAL HUMAN HEALTH	Human Health Ranking	MENTAL HEALTH	Mental Health Ranking	ASSET MANAGEMENT inc. routine maintenance and repair	Asset Management Ranking	ENVIRONMENT	Environment Ranking	COMMUNITY & ECONOMY	Comm. & Econ. Ranking	Physical Human Health Risk	Mental Health Risk	Physical Damage Risk	Environment Risk	Economic Risk	Maximum Risk	Altered based on 1:1s?	Revised Risk	Rationale for Risk Change
Water Services	Water	Arkell Springs, Water Spring Recharge System	Arkell Springs and Recharge System	Drought	Average summer soil content (mm)	5	Issues regarding water supply	Med	Stress related to lower or lack of water supply.	Med					External support may be required if water supply cannot be met.	Med	High	High	None	None	High	High		High	
Water Services	Water	Collector Aqueduct	Collector Aqueduct	Acute Weather Events	Number of days with high wind gusts > 40 and 70 km/hr	4	Impacts to the supply of drinking water.	High	Large portion of the population would be on no/reduced water supply while the aqueduct was repaired. The City would have to make alternative arrangements to keep a water supply.	High	Damages to infrastructure and impact to regular O&M. High consequence because the aqueduct supplies the majority of Guelph's drinking water. Repair and maintenance of damaged structures.	High		Debris management	Low		High	High	High	Moderate	Moderate	High	No	High	
Water Services	Water	Collector Aqueduct	Collector Aqueduct	Drought	Average summer soil content (mm)	5	Issues regarding water supply	Med	Stress related to lower or lack of water supply.	Med							High	High	None	None	None	High	No	High	
Water Services	Water	Groundwater Well Station, Pumping Station, Well Station (Inactive)	Well Station	Extreme Heat	Number of days >30°C	5					Damages to infrastructure and power service. Increased cooling costs and equipment repairs.	Low		Water quality implications from damaged structures.	Med	Low	None	None	Moderate	High	Moderate	High	No	High	
Water Services	Water	Groundwater Well Station, Pumping Station, Well Station (Inactive)	Well Station	Drought	Average summer soil content (mm)	5	Issues regarding water supply	Med	Stress related to lower or lack of water supply.	Med	Drought conditions would require increase spend on well maintenance and new water supplies	Low		Cumulative impact of drought and groundwater pumping may effect wetlands and coldwater fisheries	Med	Med	High	High	Moderate	High	High	High	No	High	
Water Services	Water	Water Tower	Water Tower	Acute Weather Events	Number of days with high wind gusts > 40 and 70 km/hr	4	Impacts to the supply and quality of drinking water.	High	Stress on residents if there are water supply issues.	High	Acute events (e.g., wind, lightning) could result in instantaneous damage to multiple components. Repair and maintenance of property damage	High		Debris management	Low	Med	High	High	High	Moderate	Moderate	High	No	High	
Water Services	Water	Water Tower	Water Tower	Drought	Average summer soil content (mm)	5	Issues regarding water supply	Med	Stress related to lower or lack of water supply.	Med						Low	High	High	None	None	Moderate	High	No	High	
Water Services	Water	Water Treatment Plant	Water Treatment Plant	Acute Weather Events	Number of days with high wind gusts > 40 and 70 km/hr	4	Safety concerns relating to building occupation and ancillary services. Impacts to the supply and quality of drinking water.	High	Stress related to working conditions and drinking water quality.	High	Acute events (e.g., wind, lightning) could result in building damage, damage to disinfection systems, PLC system, power outages. Repair and maintenance of property damage	High		Debris management	Low	High	High	High	High	Moderate	High	High	No	High	
Water Services	Water	Water Treatment Plant	Water Treatment Plant	Drought	Average summer soil content (mm)	5	Service to buildings, having no or limited access to water.	Low	Stress related to lower or lack of water supply.	Med							Moderate	High	None	None	None	High	No	High	

Table C.1b Risk Assessment

Department/ Division	Asset Category	Assets	Asset Groups	Hazard	Climate Variable	Likelihood	Individual Risk Rating								Risk Calculation and Adjustment										
							PHYSICAL HUMAN HEALTH	Human Health Ranking	MENTAL HEALTH	Mental Health Ranking	ASSET MANAGEMENT inc. routine maintenance and repair	Asset Management Ranking	ENVIRONMENT	Environment Ranking	COMMUNITY & ECONOMY	Comm. & Econ. Ranking	Physical Human Health Risk	Mental Health Risk	Physical Damage Risk	Environment Risk	Economic Risk	Maximum Risk	Altered based on 1:1s?	Revised Risk	Rationale for Risk Change
Water Services	Water	Water Treatment Plant	Water Treatment Plant	Extreme Heat	Number of days >30°C	5	Health impacts related to extreme temperature.	High	Stress related to extreme temperatures.	High	Damages to equipment and instrumentation. Impacts to temperature dependent processes. Increased cooling costs and equipment repairs.	Low	Water quality implications from damaged structures. Lower treatment efficacy.	Low	Potential impact to services. Brand/trust impact on City reputation.	Low	Very High	Very High	Moderate	Moderate	Moderate	Very High	No	Very High	

Table C.2 Adaptive Capacity Actions (Assets)

Department	Asset Category	Assets	Asset Groups	Hazard	Climate Variable	As Reported by SWG			Adaptive Capacity Actions	
						Current Adaptive Capacity Measures	Planned Adaptive Capacity Measures	Suggested Adaptive Capacity Measures	Existing	Recommended
Engineering and Transportation Services	Contaminated Sites	Contaminated Land	Contaminated Land	Acute Weather Events	Number of days with high wind gusts > 40 and 70 km/hr			<ul style="list-style-type: none"> Mapping sediment transport Implement lessons from BC Contaminated Lands Include Climate change in risk assessment Incorporate climate change component into the prioritization of sites Embed appropriate practices into municipal policies 	<ol style="list-style-type: none"> Continue to complete risk assessments of contaminated lands and prioritize climate resiliency when implementing risk management measures. Liaise with Stormwater to prioritize contaminated site clean ups on lands that can be used for stormwater management purposes (e.g., Bull Frog SWM project). 	<ol style="list-style-type: none"> Apply lessons from other jurisdictions into planning (e.g., BC Contaminated Lands, federal guidelines). Include climate change as part of prioritization of site remediation. Communicate with MECP to prioritize cleanup of brownfield sites.
Engineering and Transportation Services	Parking	Parking Garage, Parking	Parking	Extreme Heat	Number of days >30°C	<ul style="list-style-type: none"> Coordinate improvements with asset management (subsurface works) Pavement condition index through asset management Parking lots and parking garage conditions and ages are documented and queued for maintenance at the appropriate time Adding trees in parks, roadways, residential, commercial and industrial locations Increased street trees, construct LID along transportation corridors. 			<ol style="list-style-type: none"> Continue pavement condition monitoring in collaboration with Asset Management. 	<ol style="list-style-type: none"> Pursue joint venture to create a City-wide urban heat island effect map to pinpoint best locations to apply cooling innovations (e.g., planting trees, LIDs). Investigate areas where permeable pavements and LIDs can be applied.
Engineering and Transportation Services	Parking	Parking Garage, Parking	Parking	Freeze/Thaw	Number of days experiencing freeze/thaw conditions	<ul style="list-style-type: none"> Coordinate improvements with asset management (subsurface works) Pavement condition index through asset management otherwise potholes through Public Works(Kevin would maintain that database) 	<ul style="list-style-type: none"> Looking into permeable pavements, LID, and how to maintain it 		<ol style="list-style-type: none"> Continue pavement condition monitoring in collaboration with Asset Management. Work with equity group to map out vulnerable communities to ensure equitable service delivery. 	<ol style="list-style-type: none"> Investigate areas where permeable pavements and LIDs can be applied.
Engineering and Transportation Services	Transportation	Bridges and Structures	Bridges and Structures	Acute Weather Events	Number of days with high wind gusts > 40 and 70 km/hr	<ul style="list-style-type: none"> Coordinate improvements with asset management (subsurface works) Pavement condition index through asset management otherwise potholes through Public Works(Kevin would maintain that database) Completed Transportation Master Plan update (2022), with actions that include Transportation Demand Management (reducing traffic in peak times), Goods Movement Strategy, Strategic Transportation Planning, Road Safety and Emerging Technology 	Goods Movement Strategy preparing to go to tender. Will include lifecycle analysis, preferred cycling, transit and pedestrian networks, design needs that accommodate LIDs, street trees, emergency service routes and maintenance considerations.	<ul style="list-style-type: none"> Real time data access (app) - ability to plan trip based on weather 	<ol style="list-style-type: none"> Continue pavement condition monitoring in collaboration with Asset Management. Pursue investigation to provide real-time weather conditions for roads and bridges. Work with equity group to map out vulnerable communities to ensure equitable service delivery. Add a climate adaptation lens to the Goods Movement Strategy Communicate with Asset Management to identify priority capital or repair works at a corridor level and provide feedback when those works are completed 	<ol style="list-style-type: none"> Establish communication plan with Emergency Services and Public Works
Engineering and Transportation Services	Transportation	Bridges and Structures	Bridges and Structures	Freeze/Thaw	Number of days experiencing freeze/thaw conditions	<ul style="list-style-type: none"> Coordinate improvements with asset management (subsurface works) Pavement condition index through asset management otherwise potholes through Public Works(Kevin would maintain that database) 	Goods Movement Strategy preparing to go to tender. Will include lifecycle analysis, preferred cycling, transit and pedestrian networks, design needs that accommodate LIDs, street trees, emergency service routes and maintenance considerations.		<ol style="list-style-type: none"> Continue pavement condition monitoring in collaboration with Asset Management. Work with equity group to map out vulnerable communities to ensure equitable service delivery. Add a climate adaptation lens to the Goods Movement Strategy Communicate with Asset Management to identify priority capital or repair works at a corridor level and provide feedback when those works are completed 	
Engineering and Transportation Services	Transportation	Roads, Sidewalks, bike paths/trails	Roads	Extreme Heat	Number of days >30°C	<ul style="list-style-type: none"> Coordinate improvements with asset management (subsurface works) Pavement condition index through asset management Adding trees in parks, roadways, residential, commercial and industrial locations Increased street trees, construct LID along transportation corridors. 	Goods Movement Strategy preparing to go to tender. Will include lifecycle analysis, preferred cycling, transit and pedestrian networks, design needs that accommodate LIDs, street trees, emergency service routes and maintenance considerations.		<ol style="list-style-type: none"> Add a climate adaptation lens to the Goods Movement Strategy 	<ol style="list-style-type: none"> Pursue joint venture to create a City-wide urban heat island effect map to pinpoint best locations to apply cooling innovations (e.g., planting trees, LIDs).
Engineering and Transportation Services	Transportation	Roads, Sidewalks, bike paths/trails	Roads	Acute Weather Events	Number of days with high wind gusts > 40 and 70 km/hr	<ul style="list-style-type: none"> Infrastructure conditions and ages are documented and queued for maintenance and replacement at the appropriate time Established framework and assigned roles to respond to emergency situations. Collaboration with other organizations including GRCA, school boards, hospital. 	<ul style="list-style-type: none"> Goods Movement Strategy preparing to go to tender. Will include lifecycle analysis, preferred cycling, transit and pedestrian networks, design needs that accommodate LIDs, street trees, emergency service routes and maintenance considerations. Climate lens projects coming up (Tijo mentioned): ICIP-GUE-05 Cycling Network Expansion and Enhancements – Adding to existing cycling network 	<ul style="list-style-type: none"> Real time data access (app) - ability to plan trip based on weather 	<ol style="list-style-type: none"> Continue pavement condition monitoring in collaboration with Asset Management. Pursue investigation to provide real-time weather conditions for roads and bridges. Work with equity group to map out vulnerable communities to ensure equitable service delivery. Add a climate adaptation lens to the Goods Movement Strategy Communicate with Asset Management to identify priority capital or repair works at a corridor level and provide feedback when those works are completed Continue Complete Streets Design Guide project that includes consideration for street trees, stormwater management, and low impact development 	<ol style="list-style-type: none"> Establish communication plan with Emergency Services and Public Works
Engineering and Transportation Services	Transportation	Roads, Sidewalks, bike paths/trails	Roads	Freeze/Thaw	Number of days experiencing freeze/thaw conditions	<ul style="list-style-type: none"> Coordinate improvements with asset management (subsurface works) Pavement condition index through asset management otherwise potholes through operations (Kevin would maintain that database) 	<ul style="list-style-type: none"> Goods Movement Strategy preparing to go to tender. Will include lifecycle analysis, preferred cycling, transit and pedestrian networks, design needs that accommodate LIDs, street trees, emergency service routes and maintenance considerations. Looking into permeable pavements, LID, and how to maintain it 	<ul style="list-style-type: none"> Real time data access (app) - ability to plan trip based on weather 	<ol style="list-style-type: none"> Continue pavement condition monitoring in collaboration with Asset Management. Work with equity group to map out vulnerable communities to ensure equitable service delivery. Add a climate adaptation lens to the Goods Movement Strategy Communicate with Asset Management to identify priority capital or repair works at a corridor level and provide feedback when those works are completed 	
Engineering and Transportation Services	Transportation	Signage, Streetlights, Traffic Controls	Signage	Acute Weather Events	Number of days with high wind gusts > 40 and 70 km/hr	<ul style="list-style-type: none"> Signage, streetlights and traffic control conditions and ages are documented and queued for maintenance and replacement at the appropriate time Established framework and assigned roles to respond to emergency situations. Collaboration with other organizations including GRCA, school boards, hospital Have PW staff on standby for repairs to traffic signals due to high winds, etc. but Alectra would also be involved in this. 		<ul style="list-style-type: none"> Real time data access (app) - ability to plan trip based on weather 	<ol style="list-style-type: none"> Pursue investigation to provide real-time weather conditions for roads and bridges. Work with equity group to map out vulnerable communities to ensure equitable service delivery. Continue Complete Streets Design Guide project that includes consideration for street trees, stormwater management, and low impact development 	<ol style="list-style-type: none"> Establish communication plan with Emergency Services and Public Works

Table C.2 Adaptive Capacity Actions (Assets)

Department	Asset Category	Assets	Asset Groups	Hazard	Climate Variable	As Reported by SWG			Adaptive Capacity Actions	
						Current Adaptive Capacity Measures	Planned Adaptive Capacity Measures	Suggested Adaptive Capacity Measures	Existing	Recommended
Fire Services, Paramedic Services	Emergency Services	Emergency Buildings	Emergency Buildings	Flooding	Return levels for max 24-hour and 5 day rainfall	<ul style="list-style-type: none"> Participate in Emergency exercises around flooding Ice storm – used university for assistance - have a Memorandum of Understanding in place with U of G Maintaining the Community Emergency Management Coordinator role (Eric Lucko) Addressing infrastructure capacity issues through changes in infrastructure design guidelines (e.g., sizing sewers for larger storm events) Maintain and increase natural assets (reduction in runoff, increased infiltration) Stormwater infrastructure conditions and ages are documented and queued for maintenance and replacement at the appropriate time. Investing in green infrastructure Watershed planning policies Construct LID along transportation corridors. Established framework and assigned roles to respond to emergency situations 	<ul style="list-style-type: none"> Facility Needs Assessment to be conducted (and Executive Team to review) to address/relocate fire and EMS systems (incl 911 dispatch) that are currently housed below the floodplain (work managed by Facilities) 		<ol style="list-style-type: none"> Work with Facilities to review and address relocation of fire and emergency management systems located below the floodplain. Continue to update and keep current the Memorandum of Understanding with University of Guelph to share assets and resources at times. Pursue building relocation potential outside the floodplain, consider locations with an equity lens. 	<ol style="list-style-type: none"> Establish route and alternate emergency route plans with team (compare with Transit), consider with equity lens. Establish a business continuity plan in case emergency building is compromised and provide alternate/redundant work environment in case the emergency buildings cannot be safely occupied.
Fire Services, Paramedic Services	Emergency Services	Emergency Buildings	Emergency Buildings	Acute Weather Events	Number of days with high wind gusts > 40 and 70 km/hr	<ul style="list-style-type: none"> Emergency exercises Ice storm – used University of Guelph for assistance - have a Memorandum of Understanding in place with U of G. Maintaining the Community Emergency Management Coordinator role (Eric Lucko) Emergency building conditions and ages are documented and queued for maintenance and replacement at the appropriate time Established framework and assigned roles to respond to emergency situations 	<ul style="list-style-type: none"> Collaboration and communication amongst all departments for emergency related matters and inclusion in emergency planning exercises 	<ol style="list-style-type: none"> Itemize emergency building components susceptible to hazard impacts and plan with Asset Management for replacement. Continue to update and keep current the Memorandum of Understanding with University of Guelph to share assets and resources at times. 	<ol style="list-style-type: none"> Establish route and alternate emergency route plans with team (compare with Transit), consider with equity lens. Establish a business continuity plan in case emergency building is compromised and provide alternate/redundant work environment in case the emergency buildings cannot be safely occupied. 	
Fire Services, Paramedic Services	Emergency Services	Emergency Buildings	Emergency Buildings	Extreme Heat	Number of days >30°C	<ul style="list-style-type: none"> Buildings are climate controlled Building conditions and ages are documented and queued for maintenance and replacement at the appropriate time. Corporate H&S heat alert notices and protocols Memorandum of Understanding in place with U of G Transit provides buses as shelter in extreme hot and cold for displaced people in an emergency 		<ol style="list-style-type: none"> Work with Facilities to ensure emergency building heating, ventilation and air conditioning systems are maintained and replaced as per the Asset Management Plan. Staff are aware of heat alerts from Corporate Health and Safety 	<ol style="list-style-type: none"> Consider if additional shade trees are possible around emergency buildings. 	
Fire Services, Paramedic Services	Emergency Services	Emergency Equipment	Emergency Equipment	Extreme Heat	Number of days >30°C	<ul style="list-style-type: none"> Emergency exercises/drills Equipment is stored in climate conditioned or shaded locations Emergency equipment conditions and ages are documented and queued for maintenance and replacement at the appropriate time Have rehab unit that has air conditioning Memorandum of Understanding in place with U of G 	<ul style="list-style-type: none"> Collaboration and communication amongst all departments for emergency related matters and inclusion in emergency planning exercises Back up personnel available 	<ol style="list-style-type: none"> Work with Facilities to ensure emergency building heating, ventilation and air conditioning systems are maintained and replaced as per the Asset Management Plan. Ensure adequate air conditioning in the building and confirm storage temperature requirements of assets. Continue to update and keep current the Memorandum of Understanding with University of Guelph to share assets and resources at times. 	<ol style="list-style-type: none"> Itemize emergency building components susceptible to hazard impacts and plan with Asset Management for replacement. Provide redundant equipment elsewhere or a plan to access equipment in case the assets are damaged. 	
Fire Services, Paramedic Services	Emergency Services	Emergency Vehicles	Emergency Vehicles	Acute Weather Events	Number of days with high wind gusts > 40 and 70 km/hr	<ul style="list-style-type: none"> Emergency vehicles conditions and ages are documented and queued for maintenance and replacement at the appropriate time Memorandum of Understanding in place with U of G 	<ul style="list-style-type: none"> Collaboration and communication amongst all departments for emergency related matters and inclusion in emergency planning exercises Back up personnel available 		<ol style="list-style-type: none"> Establish redundancy plan in case emergency vehicles are compromised. Establish route and alternate emergency route plans with team (compare with Transit), consider with equity lens. 	
Fire Services, Paramedic Services	Emergency Services	Emergency Vehicles	Emergency Vehicles	Extreme Heat	Number of days >30°C	<ul style="list-style-type: none"> Cooling rehab unit (air conditioning system) and water bottles for fire fighters Protocol in place to switch out firefighting team every 20 minutes Heating/cooling apparatus – provide heat into the pump house (extreme cold) Emergency vehicles conditions and ages are documented and queued for maintenance and replacement at the appropriate time. Adding trees in parks, roadways, residential, commercial and industrial locations, which would include parking lots where emergency vehicles are parked. Corporate H&S heat alert notices and protocols Memorandum of Understanding in place with U of G 	<ul style="list-style-type: none"> Collaboration and communication amongst all departments for emergency related matters and inclusion in emergency planning exercises Back up personnel available 	<ol style="list-style-type: none"> Maintain cooling feature in vehicles with adequate hydration available for staff. Provide redundancy in case cooling fails in a vehicle. 	<ol style="list-style-type: none"> Establish redundancy plan in case emergency vehicles are compromised. 	

Table C.2 Adaptive Capacity Actions (Assets)

Department	Asset Category	Assets	Asset Groups	Hazard	Climate Variable	As Reported by SWG			Adaptive Capacity Actions	
						Current Adaptive Capacity Measures	Planned Adaptive Capacity Measures	Suggested Adaptive Capacity Measures	Existing	Recommended
Fire Services, Paramedic Services	Emergency Services	Emergency Vehicles	Emergency Vehicles	Flooding	Return levels for max 24-hour and 5 day rainfall	<ul style="list-style-type: none"> Addressing infrastructure capacity issues through changes in infrastructure design guidelines (e.g., sizing sewers for larger storm events), quantity control facilities Maintain and increase natural assets (reduction in runoff, increased infiltration) Vehicle conditions and ages are documented and queued for maintenance and replacement at the appropriate time. Investing in green infrastructure Watershed planning policies Increased street trees, construct LID along transportation corridors. Established framework and assigned roles to respond to emergency situations 				<ol style="list-style-type: none"> Establish redundancy plan in case emergency vehicles are compromised. Establish route and alternate emergency route plans with team (compare with Transit), consider with equity lens.
Guelph Transit	Transit Services	Bus - Conventional, Bus - Mobility, Transit Vehicle - Other	Vehicles	Extreme Heat	Number of days >30°C	<ul style="list-style-type: none"> These vehicles are climate conditioned Have sitting spares, which are other bus operators that can take over if a bus operator calls in sick. Corporate H&S heat alert. 	<ul style="list-style-type: none"> Climate lens projects coming up (Tijo mentioned): 1. ICIP-GUE-01 Bus Fleet Expansion - Purchase of electric buses 4. ICIP-GUE-04 Bus Fleet Electrification – Purchase of electric buses 	Working with Fleet to expand EV bus line to include mobility buses and supervisor vehicles. Looking at on-route charging stations and the perimeter stations. All season tires changed to winter tires, which is managed by Fleet.	<ol style="list-style-type: none"> Maintain cooling feature in corporate vehicles with adequate hydration available for staff. Provide redundancy in case cooling fails in a vehicle. Continue to convert bus fleet to electric vehicles, collaboration with Fleet. Continue to provide buses as an emergency shelter when requested by Emergency Services. 	
Guelph Transit	Transit Services	Transit	Bus Stops/Shelters	Acute Weather Events	Number of days with high wind gusts > 40 and 70 km/hr	<ul style="list-style-type: none"> Bus shelter repair is managed through a contract Transit has with a third party. Except in the case of a glass hazard, which is managed out of Transit Coordinate bus shelter installation with Transportation Do not pull services during inclement weather (safety issue if leaving people out with no way home) Staff are trained on how to do detours, which may be necessary if there is climate-related damage on a route. 	<ul style="list-style-type: none"> Looking for more amenities for customers to protect them from the elements (2023 - bus shelters in the station being addressed) Real bus time arrival (text message, website) and digital signs next year (solar powered) 	Bike storage at bus shelters (co-benefit)	<ol style="list-style-type: none"> Continue policy and practice of continuing bus service during inclement weather. Continue training staff on how to do route detours. 	<ol style="list-style-type: none"> Investigate and provide adequate shelter for users at popular transit stops, consider equity lens.
Guelph Transit	Transit Services	Transit	Bus Stops/Shelters	Snow and Freezing Rain	Days > 5cm and/or Days with Freezing Rain	<ul style="list-style-type: none"> Asset Management Plan provides schedule for maintenance and replacement of terminals Don't pull service if there's a weather delay since people may be left out in the elements (plan in place to provide service albeit delayed; overtime list and have a plan for what routes to cut first) Bylaw that City needs to clear areas in a given amount of time. Public Works have third party contractor for clearing bus stops and salting 	<ul style="list-style-type: none"> Looking for more amenities for customers to protect them from the elements. Real bus time arrival (text message, website) and digital signs next year (solar powered) 		<ol style="list-style-type: none"> Continue policy and practice of continuing bus service during inclement weather. Continue training staff on how to do route detours. Maintain communications with Public Works under by-law stipulation for snow plowing. 	<ol style="list-style-type: none"> Investigate and provide adequate shelter for users at popular transit stops, consider equity lens.
Guelph Transit	Transit Services	Transit	Bus Stops/Shelters	Extreme Heat	Number of days >30°C	<ul style="list-style-type: none"> Don't pull service if there's a weather delay since people may be left out in the elements (plan in place to provide service albeit delayed; overtime list and have a plan for what routes to cut first) 	<ul style="list-style-type: none"> Looking for more amenities for customers to protect them from the elements (2023 - bus shelters in the station being addressed) Add trees (shade) near bus shelters Add benches 		<ol style="list-style-type: none"> Continue policy and practice of continuing bus service during inclement weather. 	<ol style="list-style-type: none"> Investigate and provide adequate shelter for users at popular transit stops, consider equity lens.
Guelph Transit	Transit Services	Transit	Bus Terminal	Acute Weather Events	Number of days with high wind gusts > 40 and 70 km/hr	<ul style="list-style-type: none"> Asset Management Plan provides schedule for maintenance and replacement of terminals Don't pull service if there's a weather delay since people may be left out in the elements (plan in place to provide service albeit delayed; overtime list and have a plan for what routes to cut first) Bylaw that public works needs to clear areas in a given amount of time 	<ul style="list-style-type: none"> Climate lens projects coming up (Tijo mentioned): 2. ICIP-GUE-02 Guelph Central Station – Terminal upgrade and expansion 3. ICIP-GUE-03 New Guelph Transit Storage Facility - Construction of new transit facility 		<ol style="list-style-type: none"> Continue policy and practice of continuing bus service during inclement weather. Continue training staff on how to do route detours. 	<ol style="list-style-type: none"> Work with Facilities (Facilities to lead, Transit to support) and consider climate change in setting design standards for new south end and downtown bus terminals
Guelph Transit	Transit Services	Transit	Bus Terminal	Snow and Freezing Rain	Days > 5cm and/or Days with Freezing Rain	<ul style="list-style-type: none"> Asset Management Plan provides schedule for maintenance and replacement of terminals 	<ul style="list-style-type: none"> Real bus time arrival (text message, website) and digital signs next year (solar powered) Climate lens projects coming up (Tijo mentioned): 2. ICIP-GUE-02 Guelph Central Station – Terminal upgrade and expansion 3. ICIP-GUE-03 New Guelph Transit Storage Facility - Construction of new transit facility 		<ol style="list-style-type: none"> Continue policy and practice of continuing bus service during inclement weather. Continue training staff on how to do route detours. Maintain communications with Public Works under by-law stipulation for snow plowing. 	<ol style="list-style-type: none"> Work with Facilities (Facilities to lead, Transit to support) and consider climate change in setting design standards for new south end and downtown bus terminals
Guelph Transit	Transit Services	Transit	Bus Terminal	Extreme Heat	Number of days >30°C	<ul style="list-style-type: none"> SOP exists for bus operators if a passenger feels unwell. Asset Management Plan provides schedule for maintenance and replacement of terminals Corporate H&S heat alert. 	<ul style="list-style-type: none"> Add climate control to bus terminal Real bus time arrival (text message, website) and digital signs next year (solar powered) Climate lens projects coming up (Tijo mentioned): -ICIP-GUE-02 Guelph Central Station – Terminal upgrade and expansion -ICIP-GUE-03 New Guelph Transit Storage Facility - Construction of new transit facility 		<ol style="list-style-type: none"> Continue policy and practice of continuing bus service during inclement weather. 	<ol style="list-style-type: none"> Work with Facilities (Facilities to lead, Transit to support) and consider climate change in setting design standards for new south end and downtown bus terminals
Facilities and Energy Management	Transit Services	Transit	Bus Terminal	Extreme Heat						<ol style="list-style-type: none"> Work with Transit (Facilities to lead) and consider climate change in setting design standards for new south end and downtown bus terminals
Guelph Transit	Transit Services	Transit Facilities	Buildings	Acute Weather Events	Number of days with high wind gusts > 40 and 70 km/hr	<ul style="list-style-type: none"> Asset Management Plan provides schedule for maintenance and replacement of terminals 				<ol style="list-style-type: none"> Establish a business continuity plan in case building is compromised, itemize the transit building components, and provide alternate/redundant work environment in case the transit buildings cannot be safely occupied.

Table C.2 Adaptive Capacity Actions (Assets)

Department	Asset Category	Assets	Asset Groups	Hazard	Climate Variable	As Reported by SWG			Adaptive Capacity Actions	
						Current Adaptive Capacity Measures	Planned Adaptive Capacity Measures	Suggested Adaptive Capacity Measures	Existing	Recommended
Guelph Transit	Transit Services	Transit Facilities	Buildings	Extreme Heat	Number of days >30°C	<ul style="list-style-type: none"> These buildings are climate conditioned Corporate H&S heat alert. 			1. Ensure adequate air conditioning in the transit buildings and that staff is aware of alerts from H&S.	1. Establish a business continuity plan in case building is compromised, itemize the transit building components, and provide alternate/redundant work environment in case the transit buildings cannot be safely occupied.
Information Technology	Software and Hardware	Equipment	Equipment	Flooding	Return levels for max 24-hour and 5 day rainfall	<ul style="list-style-type: none"> Protocols in place for all major outages (monitor all systems, after hours calls) Service and maintenance contracts for critical equipment to get spares within 4 hours or sitting on a shelf Have internal IT asset management program (cataloguing, lifecycle planning) Networking and info sharing with surrounding municipalities 	<ul style="list-style-type: none"> Trial exercises slated for 2023 Executive team reviewing planning to address/relocate equipment that are currently housed below the floodplain (initiative managed by Facilities) 		<ol style="list-style-type: none"> Develop and maintain internal Information Technology asset management program. Maintain service and maintenance contracts for critical equipment to store or obtain spares within 4 hours. Conduct trial emergency exercise planned for 2023. Continue to liaise with surrounding municipalities for information sharing and networking. 	<ol style="list-style-type: none"> Create relocation plan for assets and stage the rollout to avoid service disruption. Create an interim plan to protect equipment from flooding at data centers. Formalize emergency plans, understand length (time) of backup power, and have redundant staff available at all hours. Work with Asset Management to include climate change aspect in life cycle analyses in addition to considering industry standards.
Information Technology	Software and Hardware	Equipment	Equipment	Extreme Heat	Number of days >30°C	<ul style="list-style-type: none"> Protocols in place for all major outages (monitor all systems, after hours calls) Service and maintenance contracts for critical equipment to get spares within 4 hours or sitting on a shelf Have internal IT asset management program (cataloguing, lifecycle planning) Networking and info sharing with surrounding municipalities 	<ul style="list-style-type: none"> Trial exercises slated for 2023 		<ol style="list-style-type: none"> Develop and maintain internal Information Technology asset management program. Maintain service and maintenance contracts for critical equipment to store or obtain spares within 4 hours. Conduct trial emergency exercise planned for 2023. Continue to liaise with surrounding municipalities for information sharing and networking. 	<ol style="list-style-type: none"> Formalize emergency plans, understand length (time) of backup power, and have redundant staff available at all hours. Work with Asset Management to include climate change aspect in life cycle analyses in addition to considering industry standards.
Culture and Recreation	Culture and Recreation	Culture and Recreation	Buildings	Acute Weather Events	Number of days with high wind gusts > 40 and 70 km/hr	<ul style="list-style-type: none"> Asset Management Plan provides schedule for maintenance and replacement of buildings Models for resiliency of businesses 		<ul style="list-style-type: none"> Maintain building at code, in alignment with climate change 		1. Itemize culture and recreation buildings components for their resilience to climate hazard impacts and plan with Asset Management for itemization and replacement.
Culture and Recreation	Culture and Recreation	Culture and Recreation	Buildings	Extreme Heat	Number of days >30°C	<ul style="list-style-type: none"> Asset Management Plan provides schedule for maintenance and replacement of buildings Buildings are climate controlled. 			1. Work with Facilities to ensure adequate air conditioning in offices and recreation facilities, continue with routine maintenance on these systems.	1. Itemize culture and recreation buildings components for their resilience to climate hazard impacts and plan with Asset Management for itemization and replacement.
Culture and Recreation	Culture and Recreation	Culture and Recreation	Library, Culture, Tourism and Community Investment	Acute Weather Events	Number of days with high wind gusts > 40 and 70 km/hr	<ul style="list-style-type: none"> Asset Management Plan provides schedule for maintenance and replacement of buildings Discussions around sustainability with new businesses interested in coming to Guelph Creation of Guelph's SMART Cities office 		<ul style="list-style-type: none"> Businesses must maintain their place of business up to the Ontario Building Code and in line with climate adaptation; however, some businesses have less financial capacity and resilience and struggle to meet and upgrade to new standards. The City is looking for a way to support these businesses. 		<ol style="list-style-type: none"> Itemize library building (functioning as a shelter, as needed) components susceptible to hazard impacts and plan with Asset Management for replacement. Design and build new Baker Street library with climate adaptation lens. Periodically review, maintain, and update use of libraries as emergency shelter buildings. Review with an equity lens. This includes co-ordination with the County of Wellington and Emergency Services.
Culture and Recreation	Culture and Recreation	Culture and Recreation	Library, Culture, Tourism and Community Investment	Extreme Heat	Number of days >30°C	<ul style="list-style-type: none"> Asset Management Plan provides schedule for maintenance and replacement of buildings Use of libraries and recreational facilities as heating and cooling centres. Staff trained on protocols for heat-related illnesses 		<ul style="list-style-type: none"> Approach with equity lens in mind Maintain building at code, in alignment with climate change 	<ol style="list-style-type: none"> Work with Facilities to ensure adequate air conditioning in the libraries, continue with routine maintenance on heating, ventilation, and air conditioning systems. Maintain first aid training for staff at libraries, including equity considerations. 	1. Periodically review, maintain, and update use of libraries as emergency shelter buildings. Review with an equity lens. This includes co-ordination with the County of Wellington and Emergency Services.
Parks	Parks	Parks	Parks	Extreme Heat	Number of days >30°C	<ul style="list-style-type: none"> Urban Forest Management Plan which contains guidelines of types of trees to plant, climate adaptations (e.g., planting more southern species) that are still compatible to Guelph. Follow tree planting strategy Tree technical manual - how long to monitor new trees for Tracking asset condition in relation to climate. 		<ul style="list-style-type: none"> Complete plantings also in areas with currently higher ecological value to protect these assets from die off. 	<ol style="list-style-type: none"> Continue to undertake tree planting initiatives Follow the guidelines put forth in the Urban Forest Management Plan (e.g., types of trees to plant, how long to monitor new trees, Tree Planting strategy for Guelph). Develop a sports field strategy including a mowing (and potential irrigation) strategy that accommodates a changing climate, including shared use (e.g., for stormwater management). Carry out the actions specified in the Natural Heritage Action Plan including: 1) Developing a City-wide environmental monitoring program; 2) Producing a status of the Natural Heritage system report; 3) Creating a biodiversity strategy; 4) Developing an Invasive Species Management Plan; and 5) Updating the Natural Assets Inventory. 	<ol style="list-style-type: none"> Expand upon the Natural Assets Inventory to identify vulnerable areas and ways in which to improve the area (similar to corridor fixes for hard infrastructure). Determine if development of a local Guelph climate change model/data portal with maps and data specific to the City's vulnerabilities is a worthwhile City project.
Parks	Parks	Parks	Parks	Acute Weather Events	Number of days with high wind gusts > 40 and 70 km/hr	<ul style="list-style-type: none"> Urban Forest Management Plan which contains guidelines of types of trees to plant, climate adaptations (e.g., planting more southern species) that are still compatible to Guelph. Follow tree planting strategy Tree technical manual - how long to monitor new trees for Tracking asset condition in relation to climate Staff availability (emergency services, too) for damaged tree removal after storm events. 		<ul style="list-style-type: none"> Natural heritage vulnerability, putting it altogether to identify vulnerable areas Determine temperature stuff to inform planting and forestry stewardship Guelph scale climate change model 	<ol style="list-style-type: none"> Continue to undertake tree planting initiatives Follow the guidelines put forth in the Urban Forest Management Plan (e.g., types of trees to plant, how long to monitor new trees, Tree Planting strategy for Guelph). Develop a sports field strategy including a mowing (and potential irrigation) strategy that accommodates a changing climate, including shared use (e.g., for stormwater management). Carry out the actions specified in the Natural Heritage Action Plan including: 1) Developing a City-wide environmental monitoring program; 2) Producing a status of the Natural Heritage system report; 3) Creating a biodiversity strategy; 4) Developing an Invasive Species Management Plan; and 5) Updating the Natural Assets Inventory. 	<ol style="list-style-type: none"> Expand upon the Natural Assets Inventory to identify vulnerable areas and ways in which to improve the area (similar to corridor fixes for hard infrastructure). Determine if development of a local Guelph climate change model/data portal with maps and data specific to the City's vulnerabilities is a worthwhile City project. Create a plan for handling and removal of felled trees within parks and public right-of-ways with Public Works, University of Guelph, and others as necessary Actively update a data log of damages by location and hazard, and work with Parks and Public Works to pinpoint best locations for tree plantings for long-term growth and wind protection of assets.

Table C.2 Adaptive Capacity Actions (Assets)

Department	Asset Category	Assets	Asset Groups	Hazard	Climate Variable	As Reported by SWG			Adaptive Capacity Actions	
						Current Adaptive Capacity Measures	Planned Adaptive Capacity Measures	Suggested Adaptive Capacity Measures	Existing	Recommended
Parks	Parks	Parks	Parks	Warmer Ambient Temperature	Winter season mean temperatures and/or Number of days >31°C and nights >20°C	<ul style="list-style-type: none"> Urban Forest Management Plan which contains guidelines of types of trees to plant, climate adaptations (e.g., planting more southern species) that are still compatible to Guelph. Follow tree planting strategy Tree technical manual - how long to monitor new trees for Tracking asset condition in relation to climate. 		<ul style="list-style-type: none"> Complete plantings also in areas with currently higher ecological value to protect these assets from die off. 	<ol style="list-style-type: none"> Continue to undertake tree planting initiatives Follow the guidelines put forth in the Urban Forest Management Plan (e.g., types of trees to plant, how long to monitor new trees, Tree Planting strategy for Guelph). Develop a sports field strategy including a mowing (and potential irrigation) strategy that accommodates a changing climate, including shared use (e.g., for stormwater management). Carry out the actions specified in the Natural Heritage Action Plan including: 1) Developing a City-wide environmental monitoring program; 2) Producing a status of the Natural Heritage system report; 3) Creating a biodiversity strategy; 4) Developing an Invasive Species Management Plan; and 5) Updating the Natural Assets Inventory. 	<ol style="list-style-type: none"> Expand upon the Natural Assets Inventory to identify vulnerable areas and ways in which to improve the area (similar to corridor fixes for hard infrastructure). Determine if development of a local Guelph climate change model/data portal with maps and data specific to the City's vulnerabilities is a worthwhile City project.
Culture and Recreation	Culture and Recreation	Culture and Recreation	Recreation Facility	Warmer Ambient Temperature	Winter season mean temperatures and/or Number of days >31°C and nights >20°C	<ul style="list-style-type: none"> Facilities are climate controlled. Asset Management Plan provides schedule for maintenance and replacement of facilities Staff trained on protocols for insect-bites 			<ol style="list-style-type: none"> Work with Facilities to ensure adequate air conditioning in offices and recreation facilities, continue with routine maintenance on these systems. Maintain first aid training for staff at recreational facilities, including equity considerations. 	
Culture and Recreation	Culture and Recreation	Culture and Recreation	Recreation Facility	Acute Weather Events	Number of days with high wind gusts > 40 and 70 km/hr	<ul style="list-style-type: none"> Asset Management Plan provides schedule for maintenance and replacement of buildings Use of recreational facilities in emergency situations. Staff trained in standard first aid 			<ol style="list-style-type: none"> Maintain first aid training for staff at recreational facilities, including equity considerations. 	<ol style="list-style-type: none"> Itemize culture and recreation buildings components for their resilience to climate hazard impacts and plan with Asset Management for itemization and replacement. Periodically review, maintain, and update use of recreation facilities as emergency shelter buildings. Review with an equity lens. This includes co-ordination with the County of Wellington and Emergency Services.
Culture and Recreation	Culture and Recreation	Culture and Recreation	Recreation Facility	Flooding	Return levels for max 24-hour and 5 day rainfall	<ul style="list-style-type: none"> Asset Management Plan provides schedule for maintenance and replacement of buildings Use of recreational facilities in emergency situations. Staff trained in standard first aid 		<ul style="list-style-type: none"> Design and upgrade with LID features around the recreation facility. 	<ol style="list-style-type: none"> Maintain first aid training for staff at recreational facilities, including equity considerations. 	<ol style="list-style-type: none"> Itemize culture and recreation buildings components for their resilience to climate hazard impacts and plan with Asset Management for itemization and replacement. Periodically review, maintain, and update use of recreation facilities as emergency shelter buildings. Review with an equity lens. This includes co-ordination with the County of Wellington and Emergency Services. Design and upgrade low impact development features around the culture and recreation facilities.
Culture and Recreation	Culture and Recreation	Culture and Recreation	Recreation Facility	Extreme Heat	Number of days >30°C	<ul style="list-style-type: none"> Asset Management Plan provides schedule for maintenance and replacement of buildings Use of libraries and recreational facilities as heating and cooling centres. Staff trained on protocols for heat-related illnesses 			<ol style="list-style-type: none"> Work with Facilities to ensure adequate air conditioning in offices and recreation facilities, continue with routine maintenance on these systems. Maintain first aid training for staff at recreational facilities, including equity considerations. 	<ol style="list-style-type: none"> Periodically review, maintain, and update use of recreation facilities as emergency shelter buildings. Review with an equity lens. This includes co-ordination with the County of Wellington and Emergency Services.
Planning and Building Services, Parks	Natural Assets	Natural Heritage	Forest and Plants	Acute Weather Events	Number of days with high wind gusts > 40 and 70 km/hr	<ul style="list-style-type: none"> Maintain the Natural Heritage Assets inventory Urban Forest Management Plan which contains guidelines of types of trees to plant, climate adaptations (e.g., planting more southern species) that are still compatible to Guelph. Follow tree planting strategy Tree technical manual - how long to monitor new trees for Tracking asset condition in relation to climate Staff availability (emergency services, too) for damaged tree removal after storm events. 		<ul style="list-style-type: none"> Natural heritage vulnerability, putting it altogether to identify vulnerable areas Guelph scale climate change model 	<ol style="list-style-type: none"> Continue invasive species management (e.g., buckthorn) Complete the climate change-related actions specified in the Natural Heritage Action Plan including: 1) Launch a city-wide environmental monitoring program; 2) Produce a status of the natural heritage system report that measures the effectiveness of our natural heritage policies; 3) Develop an environmental implementation report guideline; and 4) Develop restoration and management plans for City owned/managed natural areas. Implement Guelphs Official Plan Natural Heritage Policies, which seek to protect and restore natural heritage features and areas for the long term. Complete the Sustainable City Master Plan. 	<ol style="list-style-type: none"> When the Environmental Implementation Report guidelines are developed, include actions for responding to climate change, such as providing directions on tree planting, shading watercourses and stormwater features, reducing thermal impacts, and assisted migrations of appropriate species Actively update a data log of damages by location and hazard, and work with Parks and Public Works to pinpoint best locations for tree plantings for long-term growth and wind protection of assets. Maintain a log of trees and vegetation within the floodplain as an additional criteria of the conditions report as part of the Natural Asset Inventory. Coordinate with Asset Management; refer to Tree Technical Manual for any new or replacement trees or vegetation within the floodplain.
Planning and Building Services, Parks	Natural Assets	Natural Heritage	Forest and Plants	Flooding	Return levels for max 24-hour and 5 day rainfall	<ul style="list-style-type: none"> Maintain the Natural Heritage Assets inventory Urban Forest Management Plan which contains guidelines of types of trees to plant, climate adaptations (e.g., planting more southern species) that are still compatible to Guelph. Follow tree planting strategy Tree technical manual - how long to monitor new trees for Tracking asset condition in relation to climate GRCA actively control surface water flows in the watershed. 		<ul style="list-style-type: none"> Natural heritage vulnerability, putting it altogether to identify vulnerable areas Guelph scale climate change model 	<ol style="list-style-type: none"> Complete the climate change-related actions specified in the Natural Heritage Action Plan including: 1) Launch a city-wide environmental monitoring program; 2) Produce a status of the natural heritage system report that measures the effectiveness of our natural heritage policies; 3) Develop an environmental implementation report guideline; and 4) Develop restoration and management plans for City owned/managed natural areas. Implement Guelphs Official Plan Natural Heritage Policies, which seek to protect and restore natural heritage features and areas for the long term. Complete the Sustainable City Master Plan. 	<ol style="list-style-type: none"> When the Environmental Implementation Report guidelines are developed, include actions for responding to climate change, such as providing directions on tree planting, shading watercourses and stormwater features, reducing thermal impacts, and assisted migrations of appropriate species Actively update a data log of damages by location and hazard, and work with Parks and Public Works to pinpoint best locations for tree plantings for long-term growth and wind protection of assets. Maintain a log of trees and vegetation within the floodplain as an additional criteria of the conditions report as part of the Natural Asset Inventory. Coordinate with Asset Management; refer to Tree Technical Manual for any new or replacement trees or vegetation within the floodplain.

Table C.2 Adaptive Capacity Actions (Assets)

Department	Asset Category	Assets	Asset Groups	Hazard	Climate Variable	As Reported by SWG			Adaptive Capacity Actions	
						Current Adaptive Capacity Measures	Planned Adaptive Capacity Measures	Suggested Adaptive Capacity Measures	Existing	Recommended
Planning and Building Services, Parks	Natural Assets	Natural Heritage	Forest and Plants	Drought	Average summer soil content (mm)	<ul style="list-style-type: none"> Maintain the Natural Heritage Assets inventory Urban Forest Management Plan which contains guidelines of types of trees to plant, climate adaptations (e.g., planting more southern species) that are still compatible to Guelph. Follow tree planting strategy Tree technical manual - how long to monitor new trees for Tracking asset condition in relation to climate GRCA actively control surface water flows in the watershed. 		<ul style="list-style-type: none"> Natural heritage vulnerability, putting it altogether to identify vulnerable areas Guelph scale climate change model 	<ol style="list-style-type: none"> Continue to undertake tree planting initiatives Continue invasive species management (e.g., buckthorn) Complete the climate change-related actions specified in the Natural Heritage Action Plan including: 1) Launch a city-wide environmental monitoring program; 2) Produce a status of the natural heritage system report that measures the effectiveness of our natural heritage policies; 3) Develop an environmental implementation report guideline; and 4) Develop restoration and management plans for City owned/managed natural areas. Implement Guelphs Official Plan Natural Heritage Policies, which seek to protect and restore natural heritage features and areas for the long term. Complete the Sustainable City Master Plan. 	<ol style="list-style-type: none"> When the Environmental Implementation Report guidelines are developed, include actions for responding to climate change, such as providing directions on tree planting, shading watercourses and stormwater features, reducing thermal impacts, and assisted migrations of appropriate species Actively update a data log of damages by location and hazard, and work with Parks and Public Works to pinpoint best locations for tree plantings for long-term growth and wind protection of assets. Maintain a log of trees and vegetation within the floodplain as an additional criteria of the conditions report as part of the Natural Asset Inventory. Coordinate with Asset Management; refer to Tree Technical Manual for any new or replacement trees or vegetation within the floodplain.
Planning and Building Services, Parks	Natural Assets	Natural Heritage	Forest and Plants	Extreme Heat	Number of days >30°C	<ul style="list-style-type: none"> Maintain the Natural Heritage Assets inventory Urban Forest Management Plan which contains guidelines of types of trees to plant, climate adaptations (e.g., planting more southern species) that are still compatible to Guelph. Follow tree planting strategy Tree technical manual - how long to monitor new trees for Tracking asset condition in relation to climate 		<ul style="list-style-type: none"> Natural heritage vulnerability, putting it altogether to identify vulnerable areas Guelph scale climate change model 	<ol style="list-style-type: none"> Continue to undertake tree planting initiatives Continue invasive species management (e.g., buckthorn) Carry out the actions specified in the Natural Heritage Action Plan including: 1) Developing a City-wide environmental monitoring program; 2) Producing a status of the Natural Heritage system report; 3) Creating a biodiversity strategy; 4) Developing an Invasive Species Management Plan; and 5) Updating the Natural Assets Inventory. Implement Guelphs Official Plan Natural Heritage Policies, which seek to protect and restore natural heritage features and areas for the long term. Complete the Sustainable City Master Plan. 	<ol style="list-style-type: none"> When the Environmental Implementation Report guidelines are developed, include actions for responding to climate change, such as providing directions on tree planting, shading watercourses and stormwater features, reducing thermal impacts, and assisted migrations of appropriate species Actively update a data log of damages by location and hazard, and work with Parks and Public Works to pinpoint best locations for tree plantings for long-term growth and wind protection of assets. Maintain a log of trees and vegetation within the floodplain as an additional criteria of the conditions report as part of the Natural Asset Inventory. Coordinate with Asset Management; refer to Tree Technical Manual for any new or replacement trees or vegetation within the floodplain.
Planning and Building Services, Parks	Natural Assets	Natural Heritage	Forest and Plants	Warmer Ambient Temperature	Winter season mean temperatures and/or Number of days >31°C and nights >20°C	<ul style="list-style-type: none"> Maintain the Natural Heritage Assets inventory Urban Forest Management Plan which contains guidelines of types of trees to plant, climate adaptations (e.g., planting more southern species) that are still compatible to Guelph. Follow tree planting strategy Tree technical manual - how long to monitor new trees for Tracking asset condition in relation to climate 		<ul style="list-style-type: none"> Natural heritage vulnerability, putting it altogether to identify vulnerable areas Guelph scale climate change model 	<ol style="list-style-type: none"> Continue to undertake tree planting initiatives Continue invasive species management (e.g., buckthorn) Carry out the actions specified in the Natural Heritage Action Plan including: 1) Developing a City-wide environmental monitoring program; 2) Producing a status of the Natural Heritage system report; 3) Creating a biodiversity strategy; 4) Developing an Invasive Species Management Plan; and 5) Updating the Natural Assets Inventory. Implement Guelphs Official Plan Natural Heritage Policies, which seek to protect and restore natural heritage features and areas for the long term. Complete the Sustainable City Master Plan. 	<ol style="list-style-type: none"> When the Environmental Implementation Report guidelines are developed, include actions for responding to climate change, such as providing directions on tree planting, shading watercourses and stormwater features, reducing thermal impacts, and assisted migrations of appropriate species Actively update a data log of damages by location and hazard, and work with Parks and Public Works to pinpoint best locations for tree plantings for long-term growth and wind protection of assets. Maintain a log of trees and vegetation within the floodplain as an additional criteria of the conditions report as part of the Natural Asset Inventory. Coordinate with Asset Management; refer to Tree Technical Manual for any new or replacement trees or vegetation within the floodplain.
Planning and Building Services, Parks	Natural Assets	Natural Heritage	Surface Water	Flooding	Return levels for max 24-hour and 5 day rainfall	<ul style="list-style-type: none"> GRCA regulates Speed River flows Increasing Guelph's tree canopy to 40% Following the Urban Forest Management Plan Stormwater infrastructure maintained as per the Asset Management Plan, new storm sewers have design capacity that considers climate change. 	<ul style="list-style-type: none"> Complete the Goods Movement Strategy; new designs should consider LIDs 	<ul style="list-style-type: none"> Natural heritage vulnerability, putting it altogether to identify vulnerable areas Guelph scale climate change model 	<ol style="list-style-type: none"> Update and keep current the Memorandum of Understanding with GRCA Complete the climate change-related actions specified in the Natural Heritage Action Plan including: 1) Launch a city-wide environmental monitoring program; 2) Produce a status of the natural heritage system report that measures the effectiveness of our natural heritage policies; 3) Develop an environmental implementation report guideline; and 4) Develop restoration and management plans for City owned/managed natural areas. Implement Guelphs Official Plan Natural Heritage Policies, which seek to protect and restore natural heritage features and areas for the long term. Complete the Sustainable City Master Plan. 	<ol style="list-style-type: none"> Update the Environmental Impact Study (EIS) Guidelines to clarify that thermal impacts to surface water features are to be assessed as part of the stormwater quality and quantity controls. When the Environmental Implementation Report guidelines are developed, include actions for responding to climate change, such as providing directions on tree planting, shading watercourses and stormwater features, reducing thermal impacts, and assisted migrations of appropriate species. Ensure that the identification of vulnerable areas and opportunities for adapting to climate change are identified and incorporated throughout the completion of the Natural Heritage Action Plan.
Planning and Building Services, Parks	Natural Assets	Natural Heritage	Surface Water	Drought	Average summer soil content (mm)	<ul style="list-style-type: none"> GRCA regulates Speed River flows Water services water taking from the Eramosa River at the Arkell Spring Grounds has a minimum flow rate such that the water taking does not have deleterious impacts on aquatic biota. GRCA's Low Water Response Program monitors river flows and sets actions dependent on flow and precipitation. 		<ul style="list-style-type: none"> Natural heritage vulnerability, putting it altogether to identify vulnerable areas Guelph scale climate change model 	<ol style="list-style-type: none"> Complete the climate change-related actions specified in the Natural Heritage Action Plan including: 1) Launch a city-wide environmental monitoring program; 2) Produce a status of the natural heritage system report that measures the effectiveness of our natural heritage policies; 3) Develop an environmental implementation report guideline; and 4) Develop restoration and management plans for City owned/managed natural areas. Implement Guelphs Official Plan Natural Heritage Policies, which seek to protect and restore natural heritage features and areas for the long term. Complete the Sustainable City Master Plan. 	<ol style="list-style-type: none"> Update the Environmental Impact Study (EIS) Guidelines to clarify that thermal impacts to surface water features are to be assessed as part of the stormwater quality and quantity controls. When the Environmental Implementation Report guidelines are developed, include actions for responding to climate change, such as providing directions on tree planting, shading watercourses and stormwater features, reducing thermal impacts, and assisted migrations of appropriate species. Ensure that the identification of vulnerable areas and opportunities for adapting to climate change are identified and incorporated throughout the completion of the Natural Heritage Action Plan.
Planning and Building Services, Parks	Natural Assets	Natural Heritage	Surface Water	Extreme Heat	Number of days >30°C	<ul style="list-style-type: none"> Maintain the Natural Heritage Assets inventory Urban Forest Management Plan which contains guidelines of types of trees to plant, climate adaptations (e.g., planting more southern species) that are still compatible to Guelph. Follow tree planting strategy Tree technical manual - how long to monitor new trees for Tracking asset condition in relation to climate 	<ul style="list-style-type: none"> Additional plantings near water courses to provide shade to keep the water cooler during times of extreme heat 		<ol style="list-style-type: none"> Complete the climate change-related actions specified in the Natural Heritage Action Plan including: 1) Launch a city-wide environmental monitoring program; 2) Produce a status of the natural heritage system report that measures the effectiveness of our natural heritage policies; 3) Develop an environmental implementation report guideline; and 4) Develop restoration and management plans for City owned/managed natural areas. Implement Guelphs Official Plan Natural Heritage Policies, which seek to protect and restore natural heritage features and areas for the long term. Complete the Sustainable City Master Plan. 	<ol style="list-style-type: none"> Update the Environmental Impact Study (EIS) Guidelines to clarify that thermal impacts to surface water features are to be assessed as part of the stormwater quality and quantity controls. When the Environmental Implementation Report guidelines are developed, include actions for responding to climate change, such as providing directions on tree planting, shading watercourses and stormwater features, reducing thermal impacts, and assisted migrations of appropriate species. Ensure that the identification of vulnerable areas and opportunities for adapting to climate change are identified and incorporated throughout the completion of the Natural Heritage Action Plan.

Table C.2 Adaptive Capacity Actions (Assets)

Department	Asset Category	Assets	Asset Groups	Hazard	Climate Variable	As Reported by SWG			Adaptive Capacity Actions	
						Current Adaptive Capacity Measures	Planned Adaptive Capacity Measures	Suggested Adaptive Capacity Measures	Existing	Recommended
Planning and Building Services, Parks	Natural Assets	Natural Heritage	Surface Water	Warmer Ambient Temperature	Winter season mean temperatures and/or Number of days >31°C and nights >20°C	<ul style="list-style-type: none"> Maintain the Natural Heritage Assets inventory Urban Forest Management Plan which contains guidelines of types of trees to plant, climate adaptations (e.g., planting more southern species) that are still compatible to Guelph. Follow tree planting strategy Tree technical manual - how long to monitor new trees for Tracking asset condition in relation to climate 	<ul style="list-style-type: none"> Additional plantings near water courses to provide shade to keep the water cooler during times of extreme heat 		<ol style="list-style-type: none"> Update and keep current the Memorandum of Understanding with GRCA Complete the climate change-related actions specified in the Natural Heritage Action Plan including: 1) Launch a city-wide environmental monitoring program; 2) Produce a status of the natural heritage system report that measures the effectiveness of our natural heritage policies; 3) Develop an environmental implementation report guideline; and 4) Develop restoration and management plans for City owned/managed natural areas. Implement Guelphs Official Plan Natural Heritage Policies, which seek to protect and restore natural heritage features and areas for the long term. Complete the Sustainable City Master Plan. 	<ol style="list-style-type: none"> Update the Environmental Impact Study (EIS) Guidelines to clarify that thermal impacts to surface water features are to be assessed as part of the stormwater quality and quantity controls. When the Environmental Implementation Report guidelines are developed, include actions for responding to climate change, such as providing directions on tree planting, shading watercourses and stormwater features, reducing thermal impacts, and assisted migrations of appropriate species Ensure that the identification of vulnerable areas and opportunities for adapting to climate change are identified and incorporated throughout the completion of the Natural Heritage Action Plan. Conduct an assessment of aquatic biota once every 5 to 10 years to determine if the warmer ambient temperatures are affecting the species and health of the aquatic biota.
Planning and Building Services, Parks	Natural Assets	Natural Heritage	Wetlands	Drought	Average summer soil content (mm)	<ul style="list-style-type: none"> GRCA regulates Speed River flows Water services water taking from the Eramosa River at the Arkell Spring Grounds has a minimum flow rate such that the water taking does not have deleterious impacts on aquatic biota. GRCA's Low Water Response Program monitors river flows and sets actions dependent on flow and precipitation. 		<ul style="list-style-type: none"> Natural heritage vulnerability, putting it altogether to identify vulnerable areas Guelph scale climate change model 	<ol style="list-style-type: none"> Complete the climate change-related actions specified in the Natural Heritage Action Plan including: 1) Launch a city-wide environmental monitoring program; 2) Produce a status of the natural heritage system report that measures the effectiveness of our natural heritage policies; 3) Develop an environmental implementation report guideline; and 4) Develop restoration and management plans for City owned/managed natural areas. Implement Guelphs Official Plan Natural Heritage Policies, which seek to protect and restore natural heritage features and areas for the long term. Complete the Sustainable City Master Plan. 	<ol style="list-style-type: none"> Update the Environmental Impact Study (EIS) Guidelines to clarify that thermal impacts to surface water features are to be assessed as part of the stormwater quality and quantity controls. When the Environmental Implementation Report guidelines are developed, include actions for responding to climate change, such as providing directions on tree planting, shading watercourses and stormwater features, reducing thermal impacts, and assisted migrations of appropriate species. Ensure that the identification of vulnerable areas and opportunities for adapting to climate change are identified and incorporated throughout the completion of the Natural Heritage Action Plan.
Planning and Building Services, Parks	Natural Assets	Natural Heritage	Wetlands	Extreme Heat	Number of days >30°C	<ul style="list-style-type: none"> Maintain the Natural Heritage Assets inventory Urban Forest Management Plan which contains guidelines of types of trees to plant, climate adaptations (e.g., planting more southern species) that are still compatible to Guelph. Follow tree planting strategy Tree technical manual - how long to monitor new trees for Tracking asset condition in relation to climate 	<ul style="list-style-type: none"> Additional plantings near water courses to provide shade to keep the water cooler during times of extreme heat 		<ol style="list-style-type: none"> Complete the climate change-related actions specified in the Natural Heritage Action Plan including: 1) Launch a city-wide environmental monitoring program; 2) Produce a status of the natural heritage system report that measures the effectiveness of our natural heritage policies; 3) Develop an environmental implementation report guideline; and 4) Develop restoration and management plans for City owned/managed natural areas. Implement Guelphs Official Plan Natural Heritage Policies, which seek to protect and restore natural heritage features and areas for the long term. Complete the Sustainable City Master Plan. 	<ol style="list-style-type: none"> Update the Environmental Impact Study (EIS) Guidelines to clarify that thermal impacts to surface water features are to be assessed as part of the stormwater quality and quantity controls. When the Environmental Implementation Report guidelines are developed, include actions for responding to climate change, such as providing directions on tree planting, shading watercourses and stormwater features, reducing thermal impacts, and assisted migrations of appropriate species. Ensure that the identification of vulnerable areas and opportunities for adapting to climate change are identified and incorporated throughout the completion of the Natural Heritage Action Plan.
Planning and Building Services, Parks	Natural Assets	Natural Heritage	Wetlands	Warmer Ambient Temperature	Winter season mean temperatures and/or Number of days >31°C and nights >20°C	<ul style="list-style-type: none"> Maintain the Natural Heritage Assets inventory Urban Forest Management Plan which contains guidelines of types of trees to plant, climate adaptations (e.g., planting more southern species) that are still compatible to Guelph. Follow tree planting strategy Tree technical manual - how long to monitor new trees for Tracking asset condition in relation to climate 	<ul style="list-style-type: none"> Additional plantings near water courses to provide shade to keep the water cooler during times of extreme heat 		<ol style="list-style-type: none"> Complete the climate change-related actions specified in the Natural Heritage Action Plan including: 1) Launch a city-wide environmental monitoring program; 2) Produce a status of the natural heritage system report that measures the effectiveness of our natural heritage policies; 3) Develop an environmental implementation report guideline; and 4) Develop restoration and management plans for City owned/managed natural areas. Implement Guelphs Official Plan Natural Heritage Policies, which seek to protect and restore natural heritage features and areas for the long term. Complete the Sustainable City Master Plan. 	<ol style="list-style-type: none"> Update the Environmental Impact Study (EIS) Guidelines to clarify that thermal impacts to surface water features are to be assessed as part of the stormwater quality and quantity controls. When the Environmental Implementation Report guidelines are developed, include actions for responding to climate change, such as providing directions on tree planting, shading watercourses and stormwater features, reducing thermal impacts, and assisted migrations of appropriate species Ensure that the identification of vulnerable areas and opportunities for adapting to climate change are identified and incorporated throughout the completion of the Natural Heritage Action Plan. Conduct an assessment of aquatic biota once every 5 to 10 years to determine if the warmer ambient temperatures are affecting the species and health of the aquatic biota.
Fire Services, Paramedic Services	Emergency Services	Emergency Equipment	Emergency Equipment	Flooding	Return levels for max 24-hour and 5 day rainfall			<ul style="list-style-type: none"> Review and address relocation of fire and EMS systems located below the floodplain. 	<ol style="list-style-type: none"> Work with Facilities to review and address relocation of fire and emergency management systems located below the floodplain. 	<ol style="list-style-type: none"> Itemize emergency building components susceptible to hazard impacts and plan with Asset Management for replacement.
Facilities and Energy Management	Administrative and Operations Facilities	Commercial Facilities, Corporate Administration Facilities, Operations Facilities	Buildings	Acute Weather Events	Number of days with high wind gusts > 40 and 70 km/hr	<ul style="list-style-type: none"> Asset Management Plan informed by Building Condition Assessments (BCAs) provides schedule for maintenance and replacement of buildings Memorandum of Understanding with U of G, assist in e.g., ice storm. 		<ul style="list-style-type: none"> The recommendations from the CAP could help with decision making process for capital spending 	<ol style="list-style-type: none"> Maintain the Building Condition Assessments to inform Asset Management Plan and renewal planning. 	<ol style="list-style-type: none"> Itemize corporate buildings components susceptible to hazard impacts and plan with asset management for replacement. Complete a Facility Needs Assessment for all critical infrastructure to determine if a backup source of power available is required and available for on site. Establish redundancy plan for power for critical buildings (e.g., diesel available if grid goes down)

Table C.2 Adaptive Capacity Actions (Assets)

Department	Asset Category	Assets	Asset Groups	Hazard	Climate Variable	As Reported by SWG			Adaptive Capacity Actions	
						Current Adaptive Capacity Measures	Planned Adaptive Capacity Measures	Suggested Adaptive Capacity Measures	Existing	Recommended
Facilities and Energy Management	Administrative and Operations Facilities	Commercial Facilities, Corporate Administration Facilities, Operations Facilities	Buildings	Flooding	Return levels for max 24-hour and 5 day rainfall	<ul style="list-style-type: none"> Addressing infrastructure capacity issues through changes in infrastructure design guidelines (e.g., sizing sewers for larger storm events) Maintain and increase natural assets (reduction in runoff, increased infiltration) Stormwater infrastructure conditions and ages are documented and queued for maintenance and replacement at the appropriate time. Investing in green infrastructure Watershed planning policies Construct LID along transportation corridors Public Works and Community Emergency Management Coordinator currently discussing the City's flood response process. 	<ul style="list-style-type: none"> Facility Needs Assessment to be conducted (and Executive Team to review) to address/relocate fire and EMS systems (incl 911 dispatch) that are currently housed below the floodplain (Clair Road EMS basement) (work managed by Facilities) 	<ul style="list-style-type: none"> The recommendations from the CAP could help with decision making process for capital spending 	<ol style="list-style-type: none"> Maintain the Building Condition Assessments to inform Asset Management Plan and renewal planning. Complete a Facility Needs Assessment to consider relocation of fire and emergency management systems located below the floodplain. 	<ol style="list-style-type: none"> Itemize corporate buildings components susceptible to hazard impacts and plan with asset management for replacement. Complete a Facility Needs Assessment for all critical infrastructure to determine if a backup source of power available is required and available for on site. Establish redundancy plan for power for critical buildings (e.g., diesel available if grid goes down)
Facilities and Energy Management	Administrative and Operations Facilities	Commercial Facilities, Corporate Administration Facilities, Operations Facilities	Buildings	Extreme Heat	Number of days >30°C	<ul style="list-style-type: none"> Sufficient buffer in the design of air conditioning/heater - air conditioning for buildings currently sized at 99th percentile O&M to HVAC systems 		<ul style="list-style-type: none"> The recommendations from the CAP could help with decision making process for capital spending 	<ol style="list-style-type: none"> Set new building designs and building upgrades to consider climate change and air conditioning needs (e.g., air conditioning and heating sized at 99th percentile to provide sufficient buffer). Maintain the Building Condition Assessments to inform Asset Management Plan and renewal planning. 	<ol style="list-style-type: none"> Ensure adequate air conditioning in the corporate buildings and confirm storage temperature requirements of assets. Consider managing air conditioning through smart monitoring and forecasting to minimize impacts on existing equipment.
Solid Waste Services	Solid Waste	Waste Collection	Vehicles	Extreme Heat	Number of days >30°C	<ul style="list-style-type: none"> Loaders are air conditioned and fully automated Process is frequency audited for efficiency Solid waste management plan (award winning) Will suspend yard waste pick up if temperature is too hot (since this is a manual pick up) Corporate H&S protocols for heat days 		<ul style="list-style-type: none"> Put a plan around yard waste – will need to suspend services because vehicles not air conditioned well (based on heat stress guidelines) Working on data – piloted picture grabbing 	<ol style="list-style-type: none"> Maintain cooling feature in waste collection fleet vehicles with adequate hydration available for staff. Provide vehicle redundancy in case cooling fails in a vehicle. 	<ol style="list-style-type: none"> Create a formal protocol for yard waste pick up during the summer.
Solid Waste Services	Solid Waste	Waste Resource Innovation Centre (Facility)	Buildings	Acute Weather Events	Number of days with high wind gusts > 40 and 70 km/hr	<ul style="list-style-type: none"> Asset Management Plan provides schedule for maintenance and replacement of building Solid waste management plan (award winning) Conducted a tornado emergency planning exercise 		<ul style="list-style-type: none"> From Tornado exercise – need to add shelters to MERF and establish lightening protocols 	<ol style="list-style-type: none"> Maintain and review as necessary lightning protocols for Waste Resource Innovation Centre (Facility). 	<ol style="list-style-type: none"> Itemize Waste Resource Innovation Centre (Facility) components susceptible to hazard impacts and plan with asset management for replacement. Add inclement weather shelters to the facility.
Solid Waste Services	Solid Waste	Waste Resource Innovation Centre (Facility)	Buildings	Extreme Heat	Number of days >30°C	<ul style="list-style-type: none"> Solid waste management plan (award winning) Protocols to prevent fires in the transfer station include: Infrared cameras to detect hotspots, 1 day residence time for solids so that there isn't a large inventory stored, education for residents around fireworks (work with Communications and Compliance and Performance groups), pool chemicals, batteries, will shut down facility if heat becomes too high. Asset Management Plan provides schedule for maintenance and replacement of building Corporate H&S protocols for heat days 			<ol style="list-style-type: none"> Ensure staff are abiding by Corporate Health and Safety protocols for heat days. Ensure fire suppression equipment are maintained 	<ol style="list-style-type: none"> Liaise with the fire department on a mock transfer station fire scenario Conduct emergency exercise drills and include Public Works in the drills.
Stormwater Services	Stormwater	Channels, Culvert, Management Ponds, Oil and Grit Separator, Pipe	Stormwater Infrastructure	Extreme Heat	Number of days >30°C	<ul style="list-style-type: none"> Urban Forest Management Plan, Natural Heritage Asset Inventory - maintain and increase natural assets within the City Public Works conducts inspection and maintenance of stormwater ponds (annually), cleaning of OGS and selected storm sewer sections. Consultant conducts environmental monitoring to assist in improving the performance of SWM facilities Asset Management Plan for replacement of stormwater infrastructure 			<ol style="list-style-type: none"> Continue working with Public Works on the storm sewer infrastructure maintenance program. 	<ol style="list-style-type: none"> Develop a scheduled and proactive storm sewer maintenance program with Public Works. Storm sewer flushing is minimally done in locations that typically have complaints, but if the entire system was scheduled for flushing there would be a considerable increase in the capacity of the storm sewer system. Meet and establish specific catch basins that should be priority cleared after a large snowfall as part of a larger pollution and preventative maintenance program. Conduct a storm sewer condition assessment. The storm sewer condition is largely unknown, especially in the older sections of Guelph (which are also typically home to the more vulnerable population)
Facilities and Energy Management	Corporate Vehicles and Equipment	Equipment	Equipment	Extreme Heat	Number of days >30°C					<ol style="list-style-type: none"> Work collaboratively with Fleet to provide redundant vehicles elsewhere or a plan to access vehicles in case of damage.
Stormwater Services	Stormwater	Channels, Culvert, Management Ponds, Oil and Grit Separator, Pipe	Stormwater Infrastructure	Flooding	Return levels for max 24-hour and 5 day rainfall	<ul style="list-style-type: none"> Master plan looking to define stormwater as a utility Rebate program – stormwater service fee, rebate and credit programs for private (rain gardens, infiltration galleries, rainwater harvesting, rain barrels, bioretention etc.) LIDs, roof downspout disconnections, storm sewer upgrades and diversions, quantity control facilities, upgrading selected SWMFs, grading modifications Updated IDF curve to consider climate change for infrastructure 17 special areas for capacity considerations Removal of sediment from infrastructure Urban Forest Management Plan, Natural Heritage Asset Inventory - maintain and increase natural assets within the City Public Works conducts inspection and maintenance of stormwater ponds (annually), cleaning of OGS and selected storm sewer sections. Consultant conducts environmental monitoring to assist in improving the performance of SWM facilities Asset Management Plan for replacement of stormwater infrastructure 	<ul style="list-style-type: none"> New Stormwater Master Plan will size pipes based on 2050 climate change scenario Moving towards treatment train approach according to ministry's guidelines, treating at source 	<ul style="list-style-type: none"> Can't keep up with demand about raingardens and tree planting - more funding/resources? Salt management action plan, heated sidewalks, allow infiltrative methods there 	<ol style="list-style-type: none"> Investigate ways in which Guelph can create its own climate change model/data portal with maps and data specific to the City's vulnerabilities. Continue infrastructure upsizing to accommodate IDF curve updates and align the timing with other infrastructure work Continue incentive programs for private rainwater harvesting and rain barrels. Conduct a storm sewer condition assessment. The storm sewer condition is largely unknown, especially in the older sections of Guelph (which are also typically home to the more vulnerable population) 	<ol style="list-style-type: none"> Consider equity when prioritizing stormwater project and conducting storm sewer condition assessments. Expand upon rebate program for private rainwater harvesting, rain barrels, downspout disconnect. Develop a scheduled and proactive storm sewer maintenance program with Public Works. Storm sewer flushing is minimally done in locations that typically have complaints, but if the entire system was scheduled for flushing there would be a considerable increase in the capacity of the storm sewer system. Meet and establish specific catch basins that should be priority cleared after a large snowfall as part of a larger pollution and preventative maintenance program. Implement the recommended actions from the forthcoming Stormwater Management Master Plan. Of note, this includes the restoration of erosion sites, construction of new stormwater facilities and retrofitting of existing stormwater facilities.

Table C.2 Adaptive Capacity Actions (Assets)

Department	Asset Category	Assets	Asset Groups	Hazard	Climate Variable	As Reported by SWG			Adaptive Capacity Actions	
						Current Adaptive Capacity Measures	Planned Adaptive Capacity Measures	Suggested Adaptive Capacity Measures	Existing	Recommended
Stormwater Services	Stormwater	Channels, Culvert, Management Ponds, Oil and Grit Separator, Pipe	Stormwater Infrastructure	Warmer Ambient Temperature	Winter season mean temperatures and/or Number of days >31°C and nights >20°C	<ul style="list-style-type: none"> Urban Forest Management Plan, Natural Heritage Asset Inventory - maintain and increase natural assets within the City Consultant conducts environmental monitoring to assist in improving the performance of SWM facilities Increased street trees, construct LID along transportation corridors. Investing in green infrastructure WDGPH has a mosquito larvicide program 			<ol style="list-style-type: none"> Consider and incorporate Low Impact Development (LIDs) in the Stormwater and Transportation Master Plans Communicate with WDGPH to ensure continuation of mosquito larvicide programming. 	
Stormwater Services	Stormwater	Channels, Culvert, Management Ponds, Oil and Grit Separator, Pipe	Stormwater Infrastructure	Winter/Spring Rainfall	Days with rainfall ≥25 mm during Jan - March (rain on snow or frozen ground)	<ul style="list-style-type: none"> Master plan looking to define stormwater as a utility Rebate program – stormwater service fee, rebate and credit programs for private (rain gardens, infiltration galleries, rainwater harvesting, rain barrels, bioretention etc.) LIDs, roof downspout disconnections, storm sewer upgrades and diversions, quantity control facilities, upgrading selected SWMFs, grading modifications Updated IDF curve to consider climate change for infrastructure 17 special areas for capacity considerations Removal of sediment from infrastructure Urban Forest Management Plan, Natural Heritage Asset Inventory - maintain and increase natural assets within the City Public Works conducts inspection and maintenance of stormwater ponds (annually), cleaning of OGS and selected storm sewer sections. Consultant conducts environmental monitoring to assist in improving the performance of SWM facilities Asset Management Plan for replacement of stormwater infrastructure 	<ul style="list-style-type: none"> Can't keep up with demand about raingardens and tree planting - more funding/resources? Salt management action plan, heated sidewalks, allow infiltrative methods there 	<ol style="list-style-type: none"> Investigate ways in which Guelph can create its own climate change model/data portal with maps and data specific to the City's vulnerabilities. Continue incentive programs for private rainwater harvesting and rain barrels. Continue infrastructure upsizing to accommodate IDF curve updates and align the timing with other infrastructure work. 	<ol style="list-style-type: none"> Develop a scheduled and proactive storm sewer maintenance program with Public Works. Storm sewer flushing is minimally done in locations that typically have complaints, but if the entire system was scheduled for flushing there would be a considerable increase in the capacity of the storm sewer system. Meet and establish specific catch basins that should be priority cleared after a large snowfall as part of a larger pollution and preventative maintenance program. Expand upon rebate program for private rainwater harvesting, rain barrels, downspout disconnect. Implement the recommended actions from the forthcoming Stormwater Management Master Plan. Of note, this includes the restoration of erosion sites, construction of new stormwater facilities and retrofitting of existing stormwater facilities. 	
Wastewater Services	Wastewater	Maintenance Hole, Sanitary Pipe, Siphon, Wastewater Pumping Station	Wastewater Infrastructure	Extreme Heat	Number of days >30°C	<ul style="list-style-type: none"> Sanitary sewer line is buried and therefore less susceptible to heat Back up pumps available for replacement Asset Management Plan to determine schedule for equipment repair and replacement. 			<ol style="list-style-type: none"> Add permanent flow meters in the collection system, as specified in the Linear Water/Wastewater Master Plan. Continue to work with Asset Management to identify sanitary sewer infrastructure requiring upgrades and replacement. 	
Wastewater Services	Wastewater	Water Resource Recovery Centre	Wastewater Treatment Facility	Acute Weather Events	Number of days with high wind gusts > 40 and 70 km/hr	<ul style="list-style-type: none"> Monitor and track storm events to prepare. WWTP has diesel to provide back up power in the event of a power outage. Asset Management Plan with Building Condition Assessment to determine schedule for building repair and replacement. 			<ol style="list-style-type: none"> Itemize Water Resource Recovery Centre components susceptible to hazard impacts and plan with asset management for replacement. 	
Wastewater Services	Wastewater	Water Resource Recovery Centre	Wastewater Treatment Facility	Winter/Spring Rainfall	Days with rainfall ≥25 mm during Jan - March (rain on snow or frozen ground)	<ul style="list-style-type: none"> Go to step flow protocols and the WWTP when there are heavy rain events Monitor and track storm events to prepare. CCTV camera of sanitary sewer is a large annual program. Proactively meeting with industry – BOD reduction at source Working with Rezatec (and Asset Management Group) to assess and prioritize sanitary sewer for replacement. Nine to ten temporary flow meters installed throughout the sanitary system to assess system flows. Optimization program with GRCA (assimilative capacity) and achieving better than ECA-limits for effluent quality. 	<ul style="list-style-type: none"> High river, water flows backwards – 4 times in 10 years (putting in a backflow valve for 2023) Inflow/Infiltration (I/I) is the key issue. Updating design standard for new sanitary sewer infrastructure to accommodate. 	<ul style="list-style-type: none"> Permanent flow meters would be beneficial Need additional staff during rain events to open up manholes to track I/I during storm events. 	<ol style="list-style-type: none"> Continue to liaise with Grand River Conservation Authority on Speed River flows and assimilative capacity. Install backflow prevention at outfall to Speed River. 	<ol style="list-style-type: none"> Itemize Water Resource Recovery Centre components susceptible to hazard impacts and plan with asset management for replacement.
Wastewater Services	Wastewater	Water Resource Recovery Centre	Wastewater Treatment Facility	Warmer Ambient Temperature	Winter season mean temperatures and/or Number of days >31°C and nights >20°C	<ul style="list-style-type: none"> Proactively meeting with industry – BOD reduction at source Optimization program with GRCA (assimilative capacity) and achieving better than ECA-limits for effluent quality. 			<ol style="list-style-type: none"> Continue to optimize treatment process as ambient temperatures change (increase). Continue to liaise with Grand River Conservation Authority on Speed River flows and assimilative capacity. 	
Wastewater Services	Wastewater	Water Resource Recovery Centre	Wastewater Treatment Facility	Extreme Heat	Number of days >30°C	<ul style="list-style-type: none"> Proactively meeting with industry – BOD reduction at source Optimization program with GRCA (assimilative capacity) and achieving better than ECA-limits for effluent quality. WWTP has diesel to provide back up power in the event of a power outage (brown out). Asset Management Plan with Building Condition Assessment to determine schedule for building repair and replacement. 			<ol style="list-style-type: none"> Continue to optimize treatment process as ambient temperatures change (increase). Continue to liaise with Grand River Conservation Authority on Speed River flows and assimilative capacity. Continue to provide backup power (diesel generator) at the Water Resource Recovery Centre in the event of a power outage. 	<ol style="list-style-type: none"> Itemize Water Resource Recovery Centre components susceptible to hazard impacts and plan with asset management for replacement.
Water Services	Water	Arkell Springs, Water Spring Recharge System	Arkell Springs and Recharge System	Acute Weather Events	Number of days with high wind gusts > 40 and 70 km/hr	<ul style="list-style-type: none"> Requirement of DWQMS to conduct a risk assessment for all of water services infrastructure – reviewed each year SCADA system provides real-time updates. Local systems continue to log if SCADA goes down. Back up power available on site for pumping wells. Glen Collectors and aqueduct are gravity systems. Access to the site actively maintained by Water Services and Public Works Forest is actively managed and maintained by Water Services (contracting to a third party) 	<ul style="list-style-type: none"> Provide redundancy for the aqueduct such that a portion of the water flows immediately to the south end of the City rather than to Woods. 		<ol style="list-style-type: none"> Continue assessing risk as per the Drinking Water Quality Management System 	<ol style="list-style-type: none"> Establish plan with Public Works if additional assistance is needed to clear route to the Arkell Spring Grounds Consider redundancy in aqueduct to direct some portion of flow to southern area of the City.

Table C.2 Adaptive Capacity Actions (Assets)

Department	Asset Category	Assets	Asset Groups	Hazard	Climate Variable	As Reported by SWG			Adaptive Capacity Actions	
						Current Adaptive Capacity Measures	Planned Adaptive Capacity Measures	Suggested Adaptive Capacity Measures	Existing	Recommended
Water Services	Water	Arkell Springs, Water Spring Recharge System	Arkell Springs and Recharge System	Flooding	Return levels for max 24-hour and 5 day rainfall	<ul style="list-style-type: none"> Requirement of DWQMS to conduct a risk assessment for all of water services infrastructure – reviewed each year SCADA system provides real-time updates. Local systems continue to log if SCADA goes down. Back up power available on site for pumping wells. Glen Collectors and aqueduct are gravity systems. Access to the site actively maintained by Water Services and Public Works Woods provides adequate disinfection, but feed from Arkell Spring Grounds can be diverted if a spike in turbidity is seen from that source. 	<ul style="list-style-type: none"> Provide redundancy for the aqueduct such that a portion of the water flows immediately to the south end of the City rather than to Woods. 		1. Continue assessing risk as per the Drinking Water Quality Management System	<ol style="list-style-type: none"> Establish plan with Public Works if additional assistance is needed to clear route to the Arkell Spring Grounds Consider redundancy in aqueduct to direct some portion of flow to southern area of the City.
Water Services	Water	Arkell Springs, Water Spring Recharge System	Arkell Springs and Recharge System	Drought	Average summer soil content (mm)	<ul style="list-style-type: none"> Water takings from the Eramosa River (to supplement Glen Collector flows) are eliminated based on river flows in order to protect biota. Water Efficiency Strategy is in place, includes programs including the Outside Water Use Program (OWUP) to reduce water demand in the City. Large water meter program in place to understand and have better certainty in water takings from industrial large water users. AMR (Automated Meter Reading) technology in place to understand flows throughout the distribution system. Annual program (using third party consultant) to monitor water mains for leaks. 	<ul style="list-style-type: none"> Drought Response Operational Plan to be completed in 2023 Integrated water management strategy project (one water strategy involving water, wastewater, stormwater) beginning in 2023. 		<ol style="list-style-type: none"> Work with Compliance and Performance to continue implementing the Water Efficiency Strategy programming, with periodic updates to programming offered, and evaluate its effectiveness at reducing water demand in the City. Work with Compliance and Performance to establish an Integrated Water Management Strategy for Guelph. The strategy should look at water re-use opportunities from wastewater and stormwater for non-potable uses (industry, vehicle washing, fire suppression, etc.) Work with Compliance and Performance to complete a Drought Response Operational Plan for the City. Continue the water meter program. 	<ol style="list-style-type: none"> Update the Automated Meter Reading technology to inform and account for water within each City district.
Water Services	Water	Collector Aqueduct	Collector Aqueduct	Acute Weather Events	Number of days with high wind gusts > 40 and 70 km/hr	<ul style="list-style-type: none"> Requirement of DWQMS to conduct a risk assessment for all of water services infrastructure – reviewed each year SCADA system provides real-time updates. Local systems continue to log if SCADA goes down. Back up power available on site for pumping wells. Glen Collectors and aqueduct are gravity systems. Access to the site actively maintained by Water Services and Public Works Forest is actively managed and maintained by Water Services (contracting to a third party) 	<ul style="list-style-type: none"> Provide redundancy for the aqueduct such that a portion of the water flows immediately to the south end of the City rather than to Woods. 		1. Continue assessing risk as per the Drinking Water Quality Management System	<ol style="list-style-type: none"> Establish plan with Public Works if additional assistance is needed to clear route to the Arkell Spring Grounds Consider redundancy in aqueduct to direct some portion of flow to southern area of the City.
Water Services	Water	Collector Aqueduct	Collector Aqueduct	Drought	Average summer soil content (mm)	<ul style="list-style-type: none"> Water takings from the Eramosa River (to supplement Glen Collector flows) are eliminated based on river flows in order to protect biota. Water Efficiency Strategy is in place, includes programs including the Outside Water Use Program (OWUP) to reduce water demand in the City. Large water meter program in place to understand and have better certainty in water takings from industrial large water users. AMR (Automated Meter Reading) technology in place to understand flows throughout the distribution system. Annual program (using third party consultant) to monitor water mains for leaks. 	<ul style="list-style-type: none"> Drought Response Operational Plan to be completed in 2023 Integrated water management strategy project (one water strategy involving water, wastewater, stormwater) beginning in 2023. 		<ol style="list-style-type: none"> Work with Compliance and Performance to continue implementing the Water Efficiency Strategy programming, with periodic updates to programming offered, and evaluate its effectiveness at reducing water demand in the City. Work with Compliance and Performance to establish an Integrated Water Management Strategy for Guelph. The strategy should look at water re-use opportunities from wastewater and stormwater for non-potable uses (industry, vehicle washing, fire suppression, etc.) Work with Compliance and Performance to complete a Drought Response Operational Plan for the City. Continue the water meter program. 	<ol style="list-style-type: none"> Update the Automated Meter Reading technology to inform and account for water within each City district.
Water Services	Water	Groundwater Well Station, Pumping Station, Well Station (Inactive)	Well Station	Extreme Heat	Number of days >30°C	<ul style="list-style-type: none"> Back up pumps available for replacement SCADA system provides real-time updates. Local systems continue to log if SCADA goes down. Back up diesel power available at most well stations. Asset Management Plan to determine schedule for equipment repair and replacement. 			<ol style="list-style-type: none"> Continue to stock backup equipment in the event of equipment failure. Continue assessing risk as per the Drinking Water Quality Management System 	
Water Services	Water	Groundwater Well Station, Pumping Station, Well Station (Inactive)	Well Station	Drought	Average summer soil content (mm)	<ul style="list-style-type: none"> Water Efficiency Strategy is in place, includes programs including the Outside Water Use Program (OWUP) to reduce water demand in the City. Large water meter program in place to understand and have better certainty in water takings from industrial large water users. AMR (Automated Meter Reading) technology in place to understand flows throughout the distribution system. Annual program (using third party consultant) to monitor water mains for leaks. 	<ul style="list-style-type: none"> Drought Response Operational Plan to be completed in 2023 Integrated water management strategy project (one water strategy involving water, wastewater, stormwater) beginning in 2023. 		<ol style="list-style-type: none"> Work with Compliance and Performance to continue implementing the Water Efficiency Strategy programming, with periodic updates to programming offered, and evaluate its effectiveness at reducing water demand in the City. Work with Compliance and Performance to establish an Integrated Water Management Strategy for Guelph. The strategy should look at water re-use opportunities from wastewater and stormwater for non-potable uses (industry, vehicle washing, fire suppression, etc.) Work with Compliance and Performance to complete a Drought Response Operational Plan for the City. Continue the water meter program. 	<ol style="list-style-type: none"> Update the Automated Meter Reading technology to inform and account for water within each City district.
Water Services	Water	Water Tower	Water Tower	Acute Weather Events	Number of days with high wind gusts > 40 and 70 km/hr	<ul style="list-style-type: none"> Monitor and track storm events to prepare. Asset Management Plan to determine schedule for repair and replacement. SCADA system provides real-time updates. Local systems continue to log if SCADA goes down. Redundancy is built into the system and water can be re-routed in the drinking water zone if required. Requirement of DWQMS to conduct a risk assessment for all of water services infrastructure – reviewed each year 			<ol style="list-style-type: none"> Continue to review and update as necessary emergency plan to include the loss of Woods Station or a water storage facility. Review redundancy planning for all water storage facilities. Continue assessing risk as per the Drinking Water Quality Management System 	

Table C.2 Adaptive Capacity Actions (Assets)

Department	Asset Category	Assets	Asset Groups	Hazard	Climate Variable	As Reported by SWG			Adaptive Capacity Actions	
						Current Adaptive Capacity Measures	Planned Adaptive Capacity Measures	Suggested Adaptive Capacity Measures	Existing	Recommended
Water Services	Water	Water Tower	Water Tower	Drought	Average summer soil content (mm)	<ul style="list-style-type: none"> Water Efficiency Strategy is in place, includes programs including the Outside Water Use Program (OWUP) to reduce water demand in the City. Large water meter program in place to understand and have better certainty in water takings from industrial large water users. AMR (Automated Meter Reading) technology in place to understand flows throughout the distribution system. Annual program (using third party consultant) to monitor water mains for leaks. 	<ul style="list-style-type: none"> Drought Response Operational Plan to be completed in 2023 Integrated water management strategy project (one water strategy involving water, wastewater, stormwater) beginning in 2023. 		<ol style="list-style-type: none"> Work with Compliance and Performance to continue implementing the Water Efficiency Strategy programming, with periodic updates to programming offered, and evaluate its effectiveness at reducing water demand in the City. Work with Compliance and Performance to establish an Integrated Water Management Strategy for Guelph. The strategy should look at water re-use opportunities from wastewater and stormwater for non-potable uses (industry, vehicle washing, fire suppression, etc.) Work with Compliance and Performance to complete a Drought Response Operational Plan for the City. Continue the water meter program. 	<ol style="list-style-type: none"> Update the Automated Meter Reading technology to inform and account for water within each City district.
Water Services	Water	Water Treatment Plant	Water Treatment Plant	Acute Weather Events	Number of days with high wind gusts > 40 and 70 km/hr	<ul style="list-style-type: none"> Monitor and track storm events to prepare. Asset Management Plan to determine schedule for building repair and replacement. Back up power available on site SCADA system provides real-time updates. Local systems continue to log if SCADA goes down. Redundancy is built into the system and water can be re-routed in the drinking water zone if required. Requirement of DWQMS to conduct a risk assessment for all of water services infrastructure – reviewed each year 	<ul style="list-style-type: none"> Woods Building design to include climate adaptation measures 		<ol style="list-style-type: none"> Continue to review and update as necessary emergency plan to include the loss of Woods Station or a water storage facility. Continue to consider climate adaptation measures in the design of the Woods WTP upgrade. Continue assessing risk as per the Drinking Water Quality Management System 	
Water Services	Water	Water Treatment Plant	Water Treatment Plant	Drought	Average summer soil content (mm)	<ul style="list-style-type: none"> Water Efficiency Strategy is in place, includes programs including the Outside Water Use Program (OWUP) to reduce water demand in the City. Large water meter program in place to understand and have better certainty in water takings from industrial large water users. AMR (Automated Meter Reading) technology in place to understand flows throughout the distribution system. Annual program (using third party consultant) to monitor water mains for leaks. 	<ul style="list-style-type: none"> Drought Response Operational Plan to be completed in 2023 Integrated water management strategy project (one water strategy involving water, wastewater, stormwater) beginning in 2023. 		<ol style="list-style-type: none"> Continue implementing the Water Efficiency Strategy programming, with periodic updates to programming offered, and evaluate its effectiveness at reducing water demand in the City. Establish an Integrated Water Management Strategy for Guelph. The strategy should look at water re-use opportunities from wastewater and stormwater for non-potable uses (industry, vehicle washing, fire suppression, etc.) Complete a Drought Response Operational Plan for the City. Update the AMR technology to inform and account for water within each City district. Continue the water meter program. 	<ol style="list-style-type: none"> Update the Automated Meter Reading technology to inform and account for water within each City district.
Water Services	Water	Water Treatment Plant	Water Treatment Plant	Extreme Heat	Number of days >30°C	<ul style="list-style-type: none"> Water Treatment Plant building is climate controlled. Asset Management Plan to determine schedule for building repair and replacement. Back up power available on site (brown out) SCADA system provides real-time updates. Local systems continue to log if SCADA goes down. Redundancy is built into the system and water can be re-routed in the drinking water zone if required. 	<ul style="list-style-type: none"> Woods Building design to include climate adaptation measures 		<ol style="list-style-type: none"> Continue to review and update as necessary emergency plan to include the loss of Woods Station or a water storage facility. Continue to consider climate adaptation measures in the design of the Woods WTP upgrade. Continue assessing risk as per the Drinking Water Quality Management System 	

Table C.3 Adaptive Capacity Actions (Services)

Department	Hazard	As Reported by SWG		Adaptive Capacity Actions	
		Current Adaptive Capacity Measures	Suggested Adaptive Capacity Measures	Existing	Recommended
Equity, Diversity and Inclusion	All Hazards	<ul style="list-style-type: none"> Community Engagement and Communications (Master Plan in the works) – current adaptive capacity – who to currently consult Large Community Plan meeting for different groups 	<ul style="list-style-type: none"> Continue to enhance partnerships Collaborate with departments to provide services to residents or that work on equity Accessibility at emergency service locations (Service dog accommodations, Medications and narcotics availability) <ul style="list-style-type: none"> Hold a tours every 3 years? To review and update facility Sending list of actions (and prioritization) to First Nations for review Community consultation (more with Sustainability Master Plan) Frequency with which we meet with the groups and discuss emergency preparedness More staffing to review development applications Education is important Support agency to have a specific person to go call in the event of an emergency 	<ol style="list-style-type: none"> Continue to follow and adopt the Community Engagement and Communications Plan, and coordinate community consultation with the Sustainability Master Plan Continue to enhance partnerships with Partner Working Group Continue involvement with emergency shelter support 	<ol style="list-style-type: none"> Identify a specific person in the City that community support agencies can contact in the event of an emergency Establish regular meetings with the Community Emergency Management Coordinator, Red Cross, and County of Wellington Work with City Departments to apply a equity, diversity, and inclusion lens when planning and prioritizing services or infrastructure upgrades/replacements. Establish a formal means of communication.
Health & Safety	All Hazards	<ul style="list-style-type: none"> Thermal stress policy (breaks and refreshments; they own the policy) <ul style="list-style-type: none"> Distribute this to managers (onus from hereon on managers) Policy snapshot (updated annually) Humid x gets to 24, no work Education material from 2016 regarding working outside in the heat Heat Stress awareness tool poster Track all incidents but no formal policy Involved in fire drills 	<ul style="list-style-type: none"> Formalize incident tracking 	<ol style="list-style-type: none"> Staff are aware of heat alerts from Corporate Health & Safety. Dedicated Health & Safety Specialists for Environmental Services (Water Services, Wastewater and Solid Waste), Public Works, Parks, and Transit. Update thermal stress policies as appropriate. Continue to be a member of the Fire Services Joint Health & Safety committee, and involved in fire drills. 	<ol style="list-style-type: none"> Develop cold stress policy, policy for staff working outside in high winds, flooding, and update as needed heat stress policy. Communicate these to all departments. Formalize incident tracking including identifying root cause. Flag those that are weather related.
Health & Safety	Freeze/Thaw	<ul style="list-style-type: none"> Document slips, trips, fall from same level, and fall from high Track all incidents but no formal policy 		<ol style="list-style-type: none"> Dedicated Health & Safety Specialists for Environmental Services (Water Services, Wastewater and Solid Waste), Public Works, Parks, and Transit. Continue to be a member of the Fire Services Joint Health & Safety committee, and involved in fire drills. 	<ol style="list-style-type: none"> Develop cold stress policy, policy for staff working outside in high winds, flooding, and update as needed heat stress policy. Communicate these to all departments. Formalize incident tracking including identifying root cause. Flag those that are weather related.
Health & Safety	All Hazards	<ul style="list-style-type: none"> Track all incidents but no formal policy 	<ul style="list-style-type: none"> Have to be aware of the tornados because of the flatness 	<ol style="list-style-type: none"> Staff are aware of heat alerts from Corporate Health & Safety. Dedicated Health & Safety Specialists for Environmental Services (Water Services, Wastewater and Solid Waste), Public Works, Parks, and Transit. Update thermal stress policies as appropriate. Continue to be a member of the Fire Services Joint Health & Safety committee, and involved in fire drills. 	<ol style="list-style-type: none"> Develop cold stress policy, policy for staff working outside in high winds, flooding, and update as needed heat stress policy. Communicate these to all departments. Formalize incident tracking including identifying root cause. Flag those that are weather related.
Communications	All Hazards	<ul style="list-style-type: none"> Rely on online platform for communication Severe weather emergency response test 	<ul style="list-style-type: none"> Need plan in case communications isn't available CAP would need to provide the budget for an online/website push 	<ol style="list-style-type: none"> Leverage appropriate communications tactics during climate related events Continue involvement in the Emergency Operations Group. Consider how to use communications to weave in climate change adaptation and mitigation messaging and make connections across the Corporation. Continue to follow and adopt the Community Engagement and Communications Plan, and coordinate community consultation with the Sustainability Master Plan. 	<ol style="list-style-type: none"> Establish business continuity plan in case communications are not available. Establish emergency internal and external communications that include digital and broadcast media in multiple languages, as well as American Sign Language. Develop a list of support agencies to contact during an emergency to accelerate assistance to those in need. Create a plan outlining how and when these agencies will be contacted efficiently.

Table C.3 Adaptive Capacity Actions (Services)

Department	Hazard	As Reported by SWG		Adaptive Capacity Actions	
		Current Adaptive Capacity Measures	Suggested Adaptive Capacity Measures	Existing	Recommended
Asset Management	All Hazards	<ul style="list-style-type: none"> Hired Rezatec (company out of England) – takes history of breaks, combine with weather conditions and soil type to advise when to replace Performance rating for each asset and send recommended priority lists to PMs (Facilities, Engineering – capital works, Operations) Building Condition Assessments (Facilities) inform Asset Management Plan and renewal planning. 	<ul style="list-style-type: none"> Include climate change in current planning/formula in asset state assessment (Quentin suggested to follow FAO for guidance) Reducing the scope and increasing frequency may be best way to handle budgets 	<ol style="list-style-type: none"> Continue performance condition assessment and level of service reviews on all assets. Work with project managers to recommend priority lists for upgrades and replacement Update the Natural Assets Inventory Continue to pursue venture with Rezatec to take into account history of breaks, combine with weather conditions, and soil type to order to advise when to replace infrastructure. Continue performance rating for each asset and send recommended priority lists to PMs (Facilities, Engineering – capital works, Operations). 	<ol style="list-style-type: none"> Establish a regular communication plan between all departments with assets and the Asset Management Group to keep up to date on asset upgrades/replacements. Include climate change in current planning/formula in asset state assessment (e.g., follow Municipal Finance Officers' Association for guidance) Asset Management to take on the role of monitoring progress on implementing actions recommended in the City's Climate Adaptation Plan and updating this Plan every five years. Determine if development of a local Guelph climate change model/data portal with maps and data specific to the City's vulnerabilities is a worthwhile City project.
Facilities	All Hazards	<ul style="list-style-type: none"> Corporate energy lens. Collaboration with new facilities to incorporate renewable energy etc. Diesel generators available and supply power if grid goes down. For new facilities, one of the factors in site selection is to consider climate related risks (i.e., not in floodplain) Setting design standards from Enercan document Building Condition Assessments (Facilities) inform Asset Management Plan and renewal planning. 	<ul style="list-style-type: none"> Must complete Facility Needs Assessment for all critical infrastructure so that it becomes standard to have a backup source of power available on site. 	<ol style="list-style-type: none"> Set new building designs and building upgrades to consider climate change and air conditioning needs (e.g., incorporate renewable energy, air conditioning and heating sized at 99th percentile to provide sufficient buffer). Diesel generators available to supply power if grid goes down. 	<ol style="list-style-type: none"> Complete a Facility Needs Assessment for all critical infrastructure to determine if a backup source of power available is required and available for on site. Establish redundancy plan for power for critical buildings (e.g., diesel available if grid goes down). Work with the appropriate department to ensure adequate air conditioning in all City-owned buildings (e.g., offices, recreation facilities, libraries) and continue with routine maintenance on these systems.
Public Works	Snow and Freezing Rain	<ul style="list-style-type: none"> Conduct minor road repairs, pothole repairs Conduct road inspections (as mandated by O.Reg 239/02) Conduct all plowing operations, including maintenance of 132 City-owned laneways for priority plowing (e.g., access to water production wells). If receive a call from a transit operator, PW will adjust their plowing route to accommodate. PW have a sidewalk crew to plow sidewalks. Priority sidewalks have an EDI lens and also include schools and seniors residents Conducting pilot project in conjunction with U of G to optimize salt application during winter. Conduct year round road inspections 	<ul style="list-style-type: none"> Need to establish regular interaction between Public Works and Asset Management Group. AMG is not aware of roads that repeatedly have issues and need repairs, they require this information to better inform the Asset Management Plan and schedule replacements and upgrades at optimal times. Require more staffing to be more efficient. Currently have more equipment than staff. 	<ol style="list-style-type: none"> Continue conducting minor road repairs Continue conducting road inspection (O.Reg 239/02) Continue conducting pilot project in conjunction with the University of Guelph to optimize salt application during winter. Continue to plan plowing (road and sidewalk) routes with equity lens, in addition to schools and seniors. 	
Public Works	All Hazards	<ul style="list-style-type: none"> Maintenance of storm sewer system on a Level of Service agreement with Engineering. This includes catch basin cleaning, sewer flushing, manhole repairs, culvert cleaning, stormwater management pond inspection and maintenance (annually, 130 ponds) Set up traffic control for emergency situations for EMS and have SOPs for this. Have PW staff on standby for repairs to traffic signals due to high winds, etc. but Alectra would also be involved in this. 	<ul style="list-style-type: none"> Storm sewer maintenance program is largely reactive. This should be scheduled and proactive. Storm sewer flushing is minimally done in locations that typically have complaints, but if the entire system was scheduled for flushing there would be a considerable increase in the capacity of the storm sewer system The storm sewer condition is largely unknown, especially in the older sections of Guelph (which are also typically home to the more vulnerable population) PW are not part of other department's emergency exercise drills. Recommend to include this department in the future. 	<ol style="list-style-type: none"> Maintain Level of Service agreement with Engineering to conduct storm sewer system maintenance and inspections. Continue to set up traffic control in emergency situations for emergency management systems. Continue to have Public Works workers on standby for inclement weather based on forecasting. Continue to send out alerts on Guelphs alert system from the Community Emergency Management Coordinator 	<ol style="list-style-type: none"> Involvement of Public Works department in emergency drills led by other departments Develop a formal storm sewer maintenance program with Engineering (Stormwater)

Table C.3 Adaptive Capacity Actions (Services)

Department	Hazard	As Reported by SWG		Adaptive Capacity Actions	
		Current Adaptive Capacity Measures	Suggested Adaptive Capacity Measures	Existing	Recommended
Solid Waste	None	<ul style="list-style-type: none"> • 4-season audits (the cleaner the streams, the better). Automated cart collection with camera makes it easier to identify contamination. • Circular economy around recyclables - this will soon be taken on by the province and not the municipality. • Farm to Fork supply chain mapping completed. Creating opportunities upstream to avoid food waste. • Can accommodate some additional organics if there is a power out with associated food spoilage. Overflow goes to landfilling. 	<ul style="list-style-type: none"> • Opportunities for downtown business association to manage their own waste streams in an effort to get better quality in these waste streams. 	1. Grow the circular economy by creating and implementing the Circular Economy Framework.	
Solid Waste	Acute Weather Events	<ul style="list-style-type: none"> • Cart system (heavier) makes it better on windy days, with less garbage blown around. 			1. Improve communication to the community to manage windy days. Carts must be heavier or kept them inside.
Water Services	Drought				<ol style="list-style-type: none"> 1. Participate in the Water Managers Working Group with GRCA, other municipalities in the watershed 2. Continue the Sourcewater Protection Program.
Water Services	Freeze/Thaw				1. Sourcewater Protection group to work with Public Works to consider alternative means of de-icing instead of salt use
Emergency Services	All Hazards				<ol style="list-style-type: none"> 1. Participate in regular emergency exercises with Wellington County, with whom paramedic services are shared and police services work closely together. 2. Continue to communicate with Transit for times when bus is needed for warmth or cooling for displaced people in an emergency.
All Departments	All Hazards			<ol style="list-style-type: none"> 1. City managers to prioritize staff retention recognizing that the knowledge of staff is one of the City's best assets in an emergency situation. 2. Engage Mississaugas of the Credit First Nations (MCFN) and Six Nations of the Grand River (SNGR) in the City's pre-consultation process. 	
CAOs Office	All Hazards			<ol style="list-style-type: none"> 1. Maintain the Community Emergency Management Coordinator role for the City 2. Grow the circular economy by creating and implementing the Circular Economy Framework 	
Parks	Extreme Heat Warmer Ambient Temperature				1. Consider planting additional shade trees around City-owned buildings (offices, emergency buildings, recreation centres, etc.)
Compliance and Performance	Drought			1. Complete a Drought Response Operational Plan for the City	
Compliance and Performance	Drought			1. Continue implementing the Water Efficiency Strategy programming, with periodic updates to programming offered, and evaluate its effectiveness at reducing water demand in the City.	
Compliance and Performance	All Hazards			1. Establish an Integrated Water Management Strategy for Guelph. The strategy should look at water re-use opportunities from wastewater and stormwater for non-potable uses (industry, vehicle washing, fire suppression, etc.)	
Economic Development	All Hazards	<ul style="list-style-type: none"> • Infrastructure construction could impact tourism - they have models for resiliency of businesses • They can help control what businesses come in – align with environmental goals 		1. Continue to play an active role in supporting new businesses and industries to Guelph that align with the City's sustainability and resiliency goals	

Table C.4 Prioritization

#	Actions	Basis	Existing (/Planned) or Recommended	Asset(s) Addressed	Climate Hazard(s)	Managing Department (Prime Task Leader)	Impacted/Benefitting Departments and External Groups	Applicable PWG Actions	Prioritization (score 1 3)					
									Risk Rating	Ease of Implementation	Social Benefit	Risk Benefit	Priority Score	Overall Priority Rank
1	Work with Facilities to ensure adequate air conditioning in offices and recreation facilities, continue with routine maintenance on these systems.	Asset	Existing	Recreation Facility	Extreme Heat Warmer Ambient Temperature	Facilities Culture and Recreation	Culture and Recreation Asset Management Facilities Red Cross	Red Cross	20	3	3	3	9	180
2	Develop a sports field strategy including a mowing (and potential irrigation) strategy that accommodates a changing climate, including shared use (e.g., for stormwater management).	Asset	Existing	Parks Forest and Plants	All Hazards	Parks	Planning Public Works Asset Management	N/A	20	3	3	3	9	180
3	Implement Guelphs Official Plan Natural Heritage Policies, which seek to protect and restore natural heritage features and areas for the long term.	Asset	Existing	Parks Forest and Plants	All Hazards	Planning	Parks Public Works Asset Management	N/A	20	3	3	3	9	180
4	Complete the Sustainable City Master Plan.	Asset	Existing	Parks Forest and Plants	All Hazards	Planning	Parks Public Works Asset Management All PWG	All	20	3	3	3	9	180
5	Continue performance condition assessment and level of service reviews on all assets. Work with project managers to recommend priority lists for upgrades and replacement.	Asset	Existing	All	All Hazards	Asset Management	All Departments	N/A	20	3	3	3	9	180
6	Continue to undertake tree planting initiatives.	Asset	Existing	Parks Forest and Plants	All Hazards	Parks	Planning Public Works Asset Management University of Guelph	University of Guelph	20	3	3	3	9	180
7	Follow the guidelines put forth in the Urban Forest Management Plan (e.g., types of trees to plant, how long to monitor new trees, Tree Planting strategy for Guelph).	Asset	Existing	Parks Forest and Plants	All Hazards	Parks	Planning Public Works Asset Management	N/A	20	3	3	3	9	180

Table C.4 Prioritization

#	Actions	Basis	Existing (/Planned) or Recommended	Asset(s) Addressed	Climate Hazard(s)	Managing Department (Prime Task Leader)	Impacted/Benefitting Departments and External Groups	Applicable PWG Actions	Prioritization (score 1 3)					
									Risk Rating	Ease of Implementation	Social Benefit	Risk Benefit	Priority Score	Overall Priority Rank
8	Continue assessing risk as per the Drinking Water Quality Management System.	Asset	Existing	<ul style="list-style-type: none"> • Arkell Springs, Water Spring Recharge System • Collector Aqueduct • Groundwater Well Station, Pumping Station, Well Station (Inactive) • Water Tower • Water Treatment Plant 	All Hazards	Water Services	Asset Management	N/A	20	3	3	3	9	180
9	Continue Source Water Protection program.	Asset	Existing	<ul style="list-style-type: none"> • Arkell Springs, Water Spring Recharge System • Collector Aqueduct • Groundwater Well Station, Pumping Station, Well Station (Inactive) • Water Tower • Water Treatment Plant 	All Hazards	Water Services	Asset Management	N/A	20	3	3	3	9	180
10	Work with the appropriate department to ensure adequate air conditioning in all City-owned buildings (e.g., offices, recreation facilities, libraries) and continue with routine maintenance on these systems.	Asset	Existing	City-Owned Buildings	Extreme Heat	Facilities	All Departments	N/A	20	3	3	3	9	180
11	Continue to stock backup equipment in the event of equipment failure.	Asset	Existing	<ul style="list-style-type: none"> • Groundwater Well Station, Pumping Station, Well Station (Inactive) • Water Tower • Water Treatment Plant 	Extreme Heat	Water Services	Asset Management	N/A	20	3	3	3	9	180
12	Continue performance rating for each asset and send recommended priority lists to PMs.	Asset	Existing	All Assets	All Hazards	Asset Management	All Departments	N/A	20	3	3	3	9	180
13	Complete the climate change-related actions specified in the Natural Heritage Action Plan including: 1) Launch a city-wide environmental monitoring program; 2) Produce a status of the natural heritage system report that measures the effectiveness of our natural heritage policies; 3) Develop an environmental implementation report guideline; and 4) Develop restoration and management plans for City owned/managed natural areas.	Asset	Existing	Parks Forest and Plants	All Hazards	Planning	Parks Public Works Asset Management	N/A	20	3	3	3	9	180

Table C.4 Prioritization

#	Actions	Basis	Existing (/Planned) or Recommended	Asset(s) Addressed	Climate Hazard(s)	Managing Department (Prime Task Leader)	Impacted/Benefitting Departments and External Groups	Applicable PWG Actions	Prioritization (score 1 3)					
									Risk Rating	Ease of Implementation	Social Benefit	Risk Benefit	Priority Score	Overall Priority Rank
14	Continue to convert bus fleet to electric vehicles, collaboration with Transit.	Asset	Existing	Bus - Conventional, Bus - Mobility, Transit Vehicle - Other	All Hazards	Fleet	Transit Asset Management	N/A	20	3	3	3	9	180
15	Work with Facilities to ensure adequate air conditioning in the libraries, continue with routine maintenance on heating, ventilation, and air conditioning systems.	Asset	Existing	Library, Culture, Tourism and Community Investment	Extreme Heat Warmer Ambient Temperature	Facilities Guelph Public Library	Guelph Public Library Asset Management Emergency Services Facilities County of Wellington Red Cross	County of Wellington Red Cross	20	3	2	3	8	160
16	Maintain cooling feature and changeover to winter tires in corporate vehicles and buses. Provide redundancy.	Asset	Existing	Bus - Conventional, Bus - Mobility, Transit Vehicle - Other	Extreme Heat	Fleet	Transit Asset Management	N/A	20	3	3	2	8	160
17	Continue to provide backup power (diesel generator) at the Water Resource Recovery Centre in then event of a power outage.	Asset	Existing	Water Resource Recovery Centre	Extreme Heat Acute Weather Events	Wastewater	Asset Management Grand River Conservation Authority	N/A	20	3	3	2	8	160
18	Maintain the Building Condition Assessments to inform Asset Management Plan and renewal planning.	Asset	Existing	All	All Hazards	Asset Management	All Departments	N/A	20	3	2	3	8	160
19	Develop and maintain internal Information Technology asset management program.	Asset	Existing	Software and Hardware	All Hazards	Information Technology	Asset Management Communications	N/A	20	3	3	2	8	160
20	Maintain service and maintenance contracts for critical equipment to store or obtain spares within 4 hours.	Asset	Existing	Software and Hardware	All Hazards	Information Technology	Asset Management Communications	N/A	20	2	3	3	8	160
21	Continue invasive species management (e.g., buckthorn).	Asset	Existing	Parks Forest and Plants	All Hazards	Parks	Planning Public Works Asset Management Wellington Dufferin Guelph Public Health	WDGPH	20	3	2	3	8	160

Table C.4 Prioritization

#	Actions	Basis	Existing (/Planned) or Recommended	Asset(s) Addressed	Climate Hazard(s)	Managing Department (Prime Task Leader)	Impacted/Benefitting Departments and External Groups	Applicable PWG Actions	Prioritization (score 1 3)					
									Risk Rating	Ease of Implementation	Social Benefit	Risk Benefit	Priority Score	Overall Priority Rank
22	Backup generators available to supply power if grid goes down.	Asset	Existing	Corporate Equipment Infrastructure	All Hazards	Facilities	All Departments	N/A	20	3	2	3	8	160
23	Establish a regular communication plan between all departments with assets and the Asset Management Group to keep up to date on asset upgrades/replacements.	Asset	Recommended	All	All Hazards	Asset Management	All Departments	N/A	20	3	2	3	8	160
24	Periodically review, maintain, and update use of recreation facilities as emergency shelter buildings. Review with an equity lens. This includes co-ordination with the County of Wellington, WDGPH, and Emergency Services.	Asset	Recommended	Recreation Facility	Extreme Heat Acute Weather Events Flooding	Culture and Recreation	Asset Management Equity, Diversity and Inclusion Emergency Services County of Wellington Red Cross WDGPH	County of Wellington Red Cross WDGPH	20	3	3	2	8	160
25	Formalize emergency plans, understand length (time) of backup power, and have redundant staff available at all hours	Asset	Recommended	Software and Hardware	Extreme Heat Flooding	Information Technology	Asset Management Communications All PWG	All	20	3	3	2	8	160
26	Liaise with the fire department on a mock transfer station fire scenario.	Asset	Recommended	Waste Resource Innovation Centre (Facility)	Extreme Heat	Solid Waste	Asset Management Health & Safety Emergency Services	N/A	20	3	2	3	8	160
27	Involvement of Public Works department in emergency drills led by other departments	Asset	Recommended	All Assets	All Hazards	Public Works	All Departments	N/A	20	3	2	3	8	160
28	Conduct emergency exercise drills and include Public Works. Recommend to include this department in the future.	Asset	Recommended	Waste Resource Innovation Centre (Facility)	All Hazards	Solid Waste	Emergency Services Public Works Asset Management	N/A	20	3	2	3	8	160
29	Pursue venture to create a City-wide urban heat island effect map.	Asset	Recommended	<ul style="list-style-type: none"> • Parks • Parking Garage, Parking • Roads, Sidewalks, bike paths/trails 	Warmer Ambient Temperature Extreme Heat	Engineering (Transportation)	Planning Parks Asset Management Health & Safety Engineering (Stormwater) Wellington County Housing	Wellington County Housing	20	2	3	3	8	160

Table C.4 Prioritization

#	Actions	Basis	Existing (/Planned) or Recommended	Asset(s) Addressed	Climate Hazard(s)	Managing Department (Prime Task Leader)	Impacted/Benefitting Departments and External Groups	Applicable PWG Actions	Prioritization (score 1 3)					
									Risk Rating	Ease of Implementation	Social Benefit	Risk Benefit	Priority Score	Overall Priority Rank
30	Work with Transit (Facilities to lead) and consider climate change in setting design standards for new south end and downtown bus terminals.	Asset	Recommended	Bus Terminal	Extreme Heat	Facilities	Transit Asset Management	N/A	20	2	3	3	8	160
31	Continue to pursue venture with Rezatec to take into account history of breaks, combine with weather conditions, and soil type to order to advise when to replace infrastructure.	Asset	Existing	Storm pipe Water mains Sanitary pipe	Freeze/Thaw Flooding	Water Services	Engineering (Stormwater) Wastewater Asset Management	N/A	16	3	3	3	9	144
32	Continue to update and keep current the Memorandum of Understanding with University of Guelph to share assets and resources at times.	Asset	Existing	<ul style="list-style-type: none"> Emergency Buildings Emergency Equipment Emergency Vehicles 	Extreme Heat Acute Weather Events Flooding	Emergency Services	Asset Management University of Guelph	University of Guelph	20	3	2	2	7	140
33	Work with Facilities to ensure emergency building heating, ventilation and air conditioning systems are maintained and replaced as per the Asset Management Plan.	Asset	Existing	Emergency Buildings	Extreme Heat	Emergency Services	Emergency Services Asset Management Facilities	N/A	20	3	1	3	7	140
34	Set new building designs and building upgrades to consider climate change and air conditioning needs (e.g., incorporate renewable energy, air conditioning and heating sized at 99th percentile to provide sufficient buffer).	Asset	Existing	Commercial Facilities, Corporate Administration Facilities, Operations Facilities	Extreme Heat	Facilities	Administrative and Operations Asset Management Health & Safety	N/A	20	2	2	3	7	140
35	Ensure adequate air conditioning in the transit buildings and that staff is aware of alerts from Health & Safety.	Asset	Existing	Transit Facilities	Extreme Heat	Transit	Asset Management	N/A	20	3	1	3	7	140
36	Continue to review and update as necessary emergency plan to include the loss of Woods Station or a water storage facility.	Asset	Existing	Water Treatment Plant	Extreme Heat Acute Weather Events	Water Services	All Departments	N/A	20	2	3	2	7	140
37	Conduct trial emergency exercise planned for 2023.	Asset	Existing	Software and Hardware	All Hazards	Information Technology	Asset Management Communications	N/A	20	3	2	2	7	140

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#	Actions	Basis	Existing (/Planned) or Recommended	Asset(s) Addressed	Climate Hazard(s)	Managing Department (Prime Task Leader)	Impacted/Benefitting Departments and External Groups	Applicable PWG Actions	Prioritization (score 1 3)					
									Risk Rating	Ease of Implementation	Social Benefit	Risk Benefit	Priority Score	Overall Priority Rank
38	Continue to liaise with surrounding municipalities for information sharing and networking.	Asset	Existing	Software and Hardware	All Hazards	Information Technology	Asset Management Communications County of Wellington Region of Waterloo	County of Wellington Region of Waterloo	20	3	2	2	7	140
39	Continue to liaise with Grand River Conservation Authority on Speed River flows and assimilative capacity.	Asset	Existing	Water Resource Recovery Centre	Winter/Spring Rainfall Flooding	Wastewater	Asset Management Grand River Conservation Authority	GRCA	20	3	2	2	7	140
40	Update the Natural Assets Inventory.	Asset	Existing	Forest and Plants	All Hazards	Asset Management	All Departments	N/A	20	3	2	2	7	140
41	Complete a Facility Needs Assessment to consider relocation of fire and emergency management systems located below the floodplain.	Asset	Existing	All	All Hazards	Facilities	All Departments	N/A	20	2	2	3	7	140
42	Include climate change in current planning/formula in asset state assessment (e.g., follow Municipal Finance Officers' Association for guidance)	Asset	Recommended	All	All Hazards	Asset Management	All Departments	N/A	20	2	2	3	7	140
43	Periodically review, maintain, and update use of libraries as emergency shelter buildings. Review with an equity lens. This includes co-ordination with the County of Wellington, WDGPH, and Emergency Services.	Asset	Recommended	Library, Culture, Tourism and Community Investment	Extreme Heat Acute Weather Events Flooding	Guelph Public Library	Asset Management Equity, Diversity and Inclusion Emergency Services County of Wellington Red Cross WDGPH	County of Wellington Red Cross WDGPH	20	3	2	2	7	140
44	Ensure adequate air conditioning in the corporate buildings and confirm storage temperature requirements of assets. Consider managing air conditioning through smart monitoring and forecasting to minimize impacts on existing equipment.	Asset	Recommended	Corporate Equipment	Extreme Heat	Facilities	Administrative and Operations Asset Management Health & Safety	N/A	20	3	2	2	7	140
45	Update the Environmental Impact Study (EIS) Guidelines to clarify that thermal impacts to surface water features are to be assessed as part of the stormwater quality and quantity controls.	Asset	Recommended	<ul style="list-style-type: none"> • Surface Water • Wetlands 	Drought Extreme Heat Warmer Ambient Temperature Flooding	Planning	Parks Asset Management Public Works	N/A	20	3	2	2	7	140

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#	Actions	Basis	Existing (/Planned) or Recommended	Asset(s) Addressed	Climate Hazard(s)	Managing Department (Prime Task Leader)	Impacted/Benefitting Departments and External Groups	Applicable PWG Actions	Prioritization (score 1 3)					
									Risk Rating	Ease of Implementation	Social Benefit	Risk Benefit	Priority Score	Overall Priority Rank
46	Establish a business continuity plan in case building is compromised, itemize the transit building components, and provide alternate/redundant work environment in case the transit buildings cannot be safely occupied.	Asset	Recommended	Transit Facilities	Extreme Heat Acute Weather Events	Transit	Asset Management	N/A	20	2	3	2	7	140
47	Itemize Water Resource Recovery Centre components susceptible to hazard impacts and plan with Asset Management for replacement.	Asset	Recommended	Water Resource Recovery Centre	Extreme Heat Acute Weather Events	Wastewater	Asset Management Public Works	N/A	20	3	2	2	7	140
48	When the Environmental Implementation Report guidelines are developed, include actions for responding to climate change, such as providing directions on tree planting, shading watercourses and stormwater features, reducing thermal impacts, and assisted migrations of appropriate species	Asset	Recommended	All	All Hazards	Planning	Asset Management Parks Public Works Facilities Stormwater Grand River Conservation Authority	GRCA University of Guelph	20	2	3	2	7	140
49	Work with Asset Management to include climate change aspect in life cycle analyses in addition to considering industry standards.	Asset	Recommended	Software and Hardware	Extreme Heat Flooding	Information Technology	Asset Management Communications	N/A	20	2	3	2	7	140
50	Investigate and provide adequate shelter for users at popular transit stops, consider equity lens.	Asset	Recommended	Bus Stops/Shelters	Extreme Heat Acute Weather Events Snow and Freezing Rain	Transit	Asset Management Public Works Engineering (Transportation)	N/A	20	2	3	2	7	140
51	Source Water Protection group to work with Public Works to consider alternative means of de-icing instead of salt use.	Asset	Recommended	<ul style="list-style-type: none"> • Arkell Springs, Water Spring Recharge System • Collector Aqueduct • Groundwater Well Station, Pumping Station, Well Station (Inactive) • Water Treatment Plant 	All Hazards	Water Services	Asset Management Public Works	N/A	20	2	2	3	7	140
52	Continue to work with Asset Management to identify sanitary sewer infrastructure requiring upgrades and replacement.	Asset	Existing	Water Resource Recovery Centre Maintenance Hole, Sanitary Pipe, Siphon, Wastewater Pumping Station	All Hazards	Wastewater	Asset Management	N/A	15	3	3	3	9	135
53	Continue working with Public Works on the storm sewer infrastructure maintenance program.	Asset	Existing	Channels, Culvert, Management Ponds, Oil and Grit Separator, Pipe	Winter/Spring Rainfall	Engineering (Stormwater)	Asset Management Public Works Engineering (Transportation)	N/A	16	3	3	2	8	128

Table C.4 Prioritization

#	Actions	Basis	Existing (/Planned) or Recommended	Asset(s) Addressed	Climate Hazard(s)	Managing Department (Prime Task Leader)	Impacted/Benefitting Departments and External Groups	Applicable PWG Actions	Prioritization (score 1 3)					
									Risk Rating	Ease of Implementation	Social Benefit	Risk Benefit	Priority Score	Overall Priority Rank
54	Add a climate adaptation lens to the Goods Movement Strategy	Asset	Existing	<ul style="list-style-type: none"> Bridges and Structures Roads, Sidewalks, bike paths/trails Signage, Streetlights, Traffic Controls 	Acute Weather Events	Engineering (Transportation)	Economic Development Asset Management Public Works Transit Emergency Services	N/A	16	3	3	2	8	128
55	Continue pavement condition monitoring in collaboration with Engineering (Transportation).	Asset	Existing	<ul style="list-style-type: none"> Bridges and Structures Roads, Sidewalks, bike paths/trails Parking Garage, Parking 	Acute Weather Events Extreme Heat Freeze/Thaw	Asset Management	Engineering (Transportation) Public Works	N/A	16	3	2	3	8	128
56	Communicate with Engineering (Transportation) to identify priority capital or repair works at a corridor level and provide feedback when those works are completed.	Asset	Existing	<ul style="list-style-type: none"> Bridges and Structures Roads, Sidewalks, bike paths/trails 	Acute Weather Events Freeze/Thaw	Asset Management	Engineering (Transportation) Public Works Transit Alectra Enbridge Gas Guelph Junction Railway CN Rail Metrolinx	Alectra Enbridge Gas Guelph Junction Railway CN Rail Metrolinx	16	3	2	3	8	128
57	Pursue investigation to provide real-time weather conditions for roads and bridges.	Asset	Existing	<ul style="list-style-type: none"> Bridges and Structures Roads, Sidewalks, bike paths/trails Signage, Streetlights, Traffic Controls 	Acute Weather Events	Engineering (Transportation, Design and Construction)	Emergency Services Public Works Asset Management Public Works Transit	N/A	16	2	3	3	8	128
58	Conduct minor road repairs.	Asset	Existing	Roads, Sidewalks, bike paths/trails	Snow and Freezing Rain	Public Works	Asset Management Engineering (Transportation) Transit Emergency Services Health & Safety Economic Development	N/A	16	3	3	2	8	128
59	Conduct road inspections.	Asset	Existing	Roads, Sidewalks, bike paths/trails	Snow and Freezing Rain	Public Works	Asset Management Engineering (Transportation) Transit Emergency Services Health & Safety Economic Development	N/A	16	3	3	2	8	128
60	Maintain Level of Service agreement with Engineering (Stormwater) to conduct storm sewer treatment system maintenance and inspections.	Asset	Existing	Channels, Culvert, Management Ponds, Oil and Grit Separator, Pipe	Flooding	Public Works	Engineering (Stormwater) Asset Management Health & Safety	N/A	16	3	2	3	8	128
61	Consider developing an updated municipal heat response plan with support from Wellington Dufferin Guelph Public Health.	Asset	Recommended	All	Extreme Heat	Health & Safety	All departments WDGPH	WDGPH	N/A	2	3	2	7	N/A

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									Risk Rating	Ease of Implementation	Social Benefit	Risk Benefit	Priority Score	Overall Priority Rank
62	Develop a scheduled and proactive storm sewer maintenance program with Public Works, which includes flushing, inspections, catch basin clearing, etc.	Asset	Recommended	Channels, Culvert, Management Ponds, Oil and Grit Separator, Pipe	Winter/Spring Rainfall	Engineering (Stormwater)	Asset Management Public Works Engineering (Transportation)	N/A	16	3	3	2	8	128
63	Establish communication plan with Emergency Services and Public Works.	Asset	Recommended	<ul style="list-style-type: none"> Bridges and Structures Roads, Sidewalks, bike paths/trails Signage, Streetlights, Traffic Controls Emergency Buildings 	Acute Weather Events Flooding	Engineering (Transportation)	Emergency Services Public Works Asset Management Transit	N/A	16	3	2	3	8	128
64	Maintain a log of trees and vegetation within the floodplain as an additional criteria of the conditions report as part of the Natural Asset Inventory. Coordinate with Asset Management; refer to Tree Technical Manual for any new or replacement trees or vegetation within the floodplain.	Asset	Recommended	Forest and Plants	Flooding	Parks	Asset Management Engineering (Stormwater) University of Guelph	University of Guelph	16	3	2	3	8	128
65	Consider equity when prioritizing stormwater project and conducting storm sewer condition assessments.	Asset	Recommended	Channels, Culvert, Management Ponds, Oil and Grit Separator, Pipe	Flooding	Engineering (Stormwater)	Asset Management Public Works Equity, Diversity and Inclusion Wastewater Wellington County Housing	Wellington County Housing	16	2	3	3	8	128
66	Conduct a storm sewer condition assessment. The storm sewer condition is largely unknown, especially in the older sections of Guelph (which are also typically home to the more vulnerable population)	Asset	Recommended	Channels, Culvert, Management Ponds, Oil and Grit Separator, Pipe	Flooding Warmer Ambient Temperature Winter/Spring Rainfall	Asset Management	Engineering (Stormwater) Public Works Wastewater Water Services Planning Parks	N/A	16	2	3	3	8	128
67	Communicate with Wellington Dufferin Guelph Public Health (WDGPH) to ensure continuation of mosquito larvicide programming.	Asset	Existing	Channels, Culvert, Management Ponds, Oil and Grit Separator, Pipe	Warmer Ambient Temperature	Engineering (Stormwater)	Public Works Engineering (Transportation) Compliance and Performance Wellington Dufferin Guelph Public Health Planning Parks Water Services	WDGPH	15	3	3	2	8	120
68	Continue implementing the Water Efficiency Strategy programming, with periodic updates to programming offered, and evaluate its effectiveness at reducing water demand in the City.	Asset	Existing	<ul style="list-style-type: none"> Arkell Springs, Water Spring Recharge System Collector Aqueduct Groundwater Well Station, Pumping Station, Well Station (Inactive) Water Tower Water Treatment Plant 	Drought	Compliance and Performance	Water Services Wastewater Stormwater Communications Grand River Conservation Authority	GRCA	15	3	3	2	8	120

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#	Actions	Basis	Existing (/Planned) or Recommended	Asset(s) Addressed	Climate Hazard(s)	Managing Department (Prime Task Leader)	Impacted/Benefitting Departments and External Groups	Applicable PWG Actions	Prioritization (score 1 3)					
									Risk Rating	Ease of Implementation	Social Benefit	Risk Benefit	Priority Score	Overall Priority Rank
69	Complete a Drought Response Operational Plan for the City	Asset	Planned	<ul style="list-style-type: none"> • Arkell Springs, Water Spring Recharge System • Collector Aqueduct • Groundwater Well Station, Pumping Station, Well Station (Inactive) • Water Tower • Water Treatment Plant 	Drought	Compliance and Performance	Water Services Communications Grand River Conservation Authority	GRCA	15	3	3	2	8	120
70	Establish an Integrated Water Management Strategy for Guelph. The strategy should look at water re-use opportunities from wastewater and stormwater for non-potable uses (industry, vehicle washing, fire suppression, etc.)	Asset	Planned	<ul style="list-style-type: none"> • Arkell Springs, Water Spring Recharge System • Collector Aqueduct • Groundwater Well Station, Pumping Station, Well Station (Inactive) • Water Tower • Water Treatment Plant 	Drought	Compliance and Performance	Water Services Wastewater Stormwater Solid Waste	N/A	15	3	3	2	8	120
71	Staff are aware of heat alerts from Corporate Health & Safety.	Asset	Existing	Emergency Buildings	Extreme Heat	Health & Safety	Emergency Services Wellington Dufferin Guelph Public Health	WDGPH	20	3	1	2	6	120
72	Ensure staff are abiding by Corporate Health & Safety protocols for heat days.	Asset	Existing	Waste Resource Innovation Centre (Facility)	Extreme Heat	Solid Waste	Health & Safety	N/A	20	3	1	2	6	120
73	Maintain cooling feature in waste collection fleet vehicles with adequate hydration available for staff. Provide vehicle redundancy.	Asset	Existing	Waste Collection Fleet Vehicles	Extreme Heat	Solid Waste	Fleet Asset Management Health & Safety	N/A	20	3	1	2	6	120
74	Continue to have Public Works workers on standby for inclement weather based on forecasting.	Asset	Existing	All	All Hazards	Public Works	All Departments	N/A	20	2	2	2	6	120
75	Continue conducting pilot project with the University of Guelph to optimize salt application during winter.	Asset	Existing	Roads, Sidewalks, bike paths/trails	Snow and Freezing Rain	Public Works	Asset Management Water Services Engineering (Stormwater) Emergency Services University of Guelph	University of Guelph	20	3	1	2	6	120

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									Risk Rating	Ease of Implementation	Social Benefit	Risk Benefit	Priority Score	Overall Priority Rank
76	Ensure fire suppression equipment are maintained.	Asset	Existing	Waste Resource Innovation Centre (Facility)	Extreme Heat	Solid Waste	Asset Management Health & Safety Emergency Services	N/A	20	3	1	2	6	120
77	Determine if development of a local Guelph climate change model/data portal with maps and data specific to the City's vulnerabilities is a worthwhile City project.	Asset	Recommended	All	All Hazards	Asset Management	Parks Public Works Facilities Stormwater Planning Contaminated Sites WDGPH	N/A	20	1	3	2	6	120
78	Create a formal protocol for yard waste pick up during the summer.	Asset	Recommended	Waste Collection Fleet Vehicles	Extreme Heat	Solid Waste	Asset Management Health & Safety	N/A	20	3	1	2	6	120
79	Consider planting additional shade trees around City-owned emergency buildings.	Asset	Recommended	Emergency Buildings	Extreme Heat	Parks	Emergency Services Asset Management	N/A	20	2	2	2	6	120
80	Complete a Facility Needs Assessment for all critical infrastructure to determine if a backup source of power available is required and available for on site. Establish redundancy plan for power for critical buildings (e.g., diesel available if grid goes down).	Asset	Recommended	All	All Hazards	Facilities	All Departments	N/A	20	2	2	2	6	120
81	Work collaboratively with Facilities and Energy Management to provide redundant vehicles elsewhere or a plan to access vehicles in case of damage.	Asset	Recommended	Corporate Equipment	Extreme Heat	Fleet	Facilities and Energy Management Asset Management	N/A	20	2	1	3	6	120
82	Conduct an assessment of aquatic biota once every 5 to 10 years to determine if the warmer ambient temperatures are affecting the species and health of the aquatic biota.	Asset	Recommended	Surface Water	Warmer Ambient Temperature	Parks	Planning	N/A	20	2	2	2	6	120
83	Ensure that the identification of vulnerable areas and opportunities for adapting to climate change are identified and incorporated throughout the completion of the Natural Heritage Action Plan.	Asset	Recommended	<ul style="list-style-type: none"> • Parks • Forest and Plants 	Warmer Ambient Temperature Extreme Heat Acute Weather Events	Planning	Parks Asset Management Public Works	N/A	20	2	2	2	6	120

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									Risk Rating	Ease of Implementation	Social Benefit	Risk Benefit	Priority Score	Overall Priority Rank
84	Work with equity group to map out vulnerable communities to ensure equitable service delivery.	Asset	Existing	<ul style="list-style-type: none"> Bridges and Structures Roads, Sidewalks, bike paths/trails Signage, Streetlights, Traffic Controls Emergency Buildings Emergency Vehicles 	Acute Weather Events Flooding	Engineering (Transportation)	Asset Management Public Works Transit Equity Emergency Services Wellington County Housing WDGPH	Wellington County Housing WDGPH	16	2	3	2	7	112
85	Update and keep current the Memorandum of Understanding with GRCA.	Asset	Existing	<ul style="list-style-type: none"> Forest and Plants Surface Water 	Flooding	Parks	Planning Parks Compliance and Performance Public Works Grand River Conservation Authority	GRCA	16	3	2	2	7	112
86	Continue inflow and infiltration investigation program. Explore means to add resources during rain events to investigate flows within the system.	Asset	Existing	Water Resource Recovery Centre	Winter/Spring Rainfall	Wastewater	Asset Management Public Works	N/A	16	2	3	2	7	112
87	Continue Complete Streets Design Guide project that includes consideration for street trees, stormwater management, and LIDs.	Asset	Existing	<ul style="list-style-type: none"> Roads, Sidewalks, bike paths/trails Signage, Streetlights, Traffic Controls 	Acute Weather Events	Engineering (Transportation)	Asset Management Engineering (Stormwater) Parks Public Works Transit	N/A	16	2	3	2	7	112
88	Continue infrastructure upsizing to accommodate IDF curve updates and align the timing with the timing of other infrastructure work	Asset	Existing	Channels, Culvert, Management Ponds, Oil and Grit Separator, Pipe	Flooding Winter/Spring Rainfall	Engineering (Stormwater)	Asset Management Public Works Planning Water Services Wastewater	N/A	16	1	3	3	7	112
89	Continue to optimize treatment process as ambient temperatures change (increase).	Asset	Existing	Water Resource Recovery Centre	Winter/Spring Rainfall	Wastewater	Asset Management Public Works	N/A	16	3	2	2	7	112
90	Itemize library building (functioning as a shelter, as needed) components susceptible to hazard impacts and plan with Asset Management for replacement.	Asset	Recommended	Library, Culture, Tourism and Community Investment	Acute Weather Events	Guelph Public Library	Culture and Recreation Asset Management Emergency Services County of Wellington	County of Wellington	16	3	2	2	7	112
91	Establish route and alternate emergency route plans with team (compare with Transit) and consider with equity lens	Asset	Recommended	Emergency Vehicles	Acute Weather Events Flooding	Emergency Services	Transit Wellington County Housing	Wellington County Housing	16	3	2	2	7	112

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									Risk Rating	Ease of Implementation	Social Benefit	Risk Benefit	Priority Score	Overall Priority Rank
92	Itemize emergency building components susceptible to hazard impacts and plan with Asset Management for replacement.	Asset	Recommended	Emergency Buildings	Acute Weather Events	Emergency Services	Asset Management	N/A	16	3	2	2	7	112
93	Itemize corporate building components susceptible to hazard impacts and plan for replacement with Asset Management.	Asset	Recommended	Commercial Facilities, Corporate Administration Facilities, Operations Facilities	Acute Weather Events Flooding	Facilities	Administrative and Operations Asset Management	N/A	16	3	2	2	7	112
94	Create a plan for handling and removal of felled trees within parks and public right-of-ways with Public Works, University of Guelph, and others as necessary.	Asset	Recommended	<ul style="list-style-type: none"> Forest and Plants Parks 	Acute Weather Events	Parks	Emergency Services Asset Management Public Works Emergency Services University of Guelph	University of Guelph	16	3	2	2	7	112
95	Itemize Waste Resource Innovation Centre (Facility) components susceptible to hazard impacts and plan for replacement with Asset Management.	Asset	Recommended	Waste Resource Innovation Centre (Facility)	Acute Weather Events	Solid Waste	Asset Management	N/A	16	3	2	2	7	112
96	Develop a storm sewer maintenance program.	Asset	Recommended	Channels, Culvert, Management Ponds, Oil and Grit Separator, Pipe	Flooding Extreme Heat	Engineering (Stormwater)	Public Works Asset Management Health & Safety Wastewater	N/A	16	2	2	3	7	112
97	Install backflow prevention at outfall to Speed River.	Asset	Recommended	Water Resource Recovery Centre	Winter/Spring Rainfall Flooding	Wastewater	Asset Management Grand River Conservation Authority	GRCA	16	3	2	2	7	112
98	Implement the recommended actions from the forthcoming Stormwater Management Master Plan (e.g., restoration of erosion sites, constructing new and retrofitting stormwater facilities).	Asset	Recommended	Channels, Culvert, Management Ponds, Oil and Grit Separator, Pipe	Flooding Winter/Spring Rainfall	Engineering (Stormwater)	Asset Management Public Works Engineering (Transportation) Compliance and Performance Planning Parks Wastewater Water Services	N/A	16	1	3	3	7	112
99	Consider redundancy in aqueduct to direct some portion of flow to southern area of the City.	Asset	Recommended	<ul style="list-style-type: none"> Arkell Springs, Water Spring Recharge System Collector Aqueduct Groundwater Well Station, Pumping Station, Well Station (Inactive) 	All Hazards	Water Services	Asset Management	N/A	16	1	3	3	7	112

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									Risk Rating	Ease of Implementation	Social Benefit	Risk Benefit	Priority Score	Overall Priority Rank
100	Ensure adequate air conditioning in the building and confirm storage temperature requirements of assets.	Asset	Existing	Emergency Equipment	Extreme Heat	Emergency Services	Asset Management Facilities	N/A	15	3	1	3	7	105
101	Add permanent flow meters in the collection system, as specified in the Linear Water/Wastewater Master Plan.	Asset	Existing	Maintenance Hole, Sanitary Pipe, Siphon, Wastewater Pumping Station	Extreme Heat	Wastewater	Asset Management Public Works	N/A	15	2	3	2	7	105
102	Liaise with Engineering (Stormwater) to prioritize contaminated site clean ups on lands that can be used for stormwater management purposes (e.g., Bull Frog SWM project).	Asset	Existing	Contaminated Land	Acute Weather Events	Engineering (Contaminated Sites)	Asset Management Public Works Parks Engineering (Stormwater)	N/A	12	3	3	2	8	96
103	Itemize culture and recreation buildings components for their resilience to climate hazard impacts and plan with Asset Management for itemization and replacement.	Asset	Recommended	Recreation Facility	Extreme Heat Acute Weather Events Flooding	Culture and Recreation	Asset Management Facilities	N/A	12	3	3	2	8	96
104	Maintain and update as necessary lightning protocols for Waste Resource Innovation Centre (Facility).	Asset	Existing	Waste Resource Innovation Centre (Facility)	Acute Weather Events	Solid Waste	Asset Management Emergency Services Health & Safety	N/A	16	3	1	2	6	96
105	Include direction to consider and incorporate LIDs in the Stormwater and Transportation Master Plans.	Asset	Existing	<ul style="list-style-type: none"> Forest and Plants Channels, Culvert, Management Ponds, Oil and Grit Separator, Pipe 	Flooding Warmer Ambient Temperature Winter/Spring Rainfall	Engineering (Stormwater) Engineering (Transportation)	Asset Management Public Works Engineering (Transportation) Compliance and Performance Planning Parks Wastewater	N/A	16	2	2	2	6	96
106	Pursue building relocation potential outside the floodplain, consider locations with an equity lens.	Asset	Existing	Emergency Buildings	Flooding	Emergency Services	Asset Management Equity, Diversity and Inclusion	N/A	16	1	2	3	6	96
107	Establish a business continuity plan in case emergency building is compromised and provide alternate/redundant work environment in case the emergency buildings cannot be safely occupied.	Asset	Recommended	Emergency Buildings	Acute Weather Events	Emergency Services	Asset Management County of Wellington Red Cross	County of Wellington Red Cross	16	2	2	2	6	96

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									Risk Rating	Ease of Implementation	Social Benefit	Risk Benefit	Priority Score	Overall Priority Rank
108	Establish redundancy plan in case emergency vehicles are compromised.	Asset	Recommended	Emergency Vehicles	Acute Weather Events Flooding	Emergency Services	Asset Management	N/A	16	3	1	2	6	96
109	Establish plan with Public Works if additional assistance is needed to clear route to the Arkell Spring Grounds.	Asset	Recommended	<ul style="list-style-type: none"> • Arkell Springs, Water Spring Recharge System • Collector Aqueduct 	Acute Weather Events Flooding	Water Services	Public Works	N/A	16	3	1	2	6	96
110	Review redundancy planning for all water storage facilities.	Asset	Recommended	Water Tower	Acute Weather Events	Water Services	Asset Management	N/A	16	2	2	2	6	96
111	Actively update a data log of damages by location and hazard, and work with Public Works to pinpoint best locations for tree plantings for long-term growth and wind protection of assets.	Asset	Recommended	<ul style="list-style-type: none"> • Parks • Forest and Plants 	Acute Weather Events	Parks	Planning Public Works Asset Management University of Guelph	University of Guelph	16	2	2	2	6	96
112	Maintain cooling feature in vehicles with adequate hydration available for staff. Provide redundancy in case cooling fails in a vehicle.	Asset	Existing	Emergency Vehicles	Extreme Heat	Emergency Services	Asset Management	N/A	15	3	1	2	6	90
113	Provide redundant equipment elsewhere or a plan to access equipment in case the assets are damaged.	Asset	Recommended	Emergency Equipment	Extreme Heat	Emergency Services	Asset Management	N/A	15	2	1	3	6	90
114	Update the Automated Meter Reading technology to inform and account for water within each City district.	Asset	Recommended	<ul style="list-style-type: none"> • Arkell Springs, Water Spring Recharge System • Collector Aqueduct • Groundwater Well Station, Pumping Station, Well Station (Inactive) • Water Tower • Water Treatment Plant 	Drought	Water Services	Asset Management	N/A	15	2	2	2	6	90

Table C.4 Prioritization

#	Actions	Basis	Existing (/Planned) or Recommended	Asset(s) Addressed	Climate Hazard(s)	Managing Department (Prime Task Leader)	Impacted/Benefitting Departments and External Groups	Applicable PWG Actions	Prioritization (score 1 3)					
									Risk Rating	Ease of Implementation	Social Benefit	Risk Benefit	Priority Score	Overall Priority Rank
115	Create relocation plan for assets and stage the rollout to avoid service disruption. Create an interim plan to protect equipment from flooding at data centers.	Asset	Recommended	Software and Hardware	Flooding	Information Technology	Asset Management Communications	N/A	12	2	3	2	7	84
116	Continue to consider climate adaptation measures in the design of the Woods WTP upgrade.	Asset	Existing	Water Treatment Plant	Acute Weather Events	Water Services	Asset Management Facilities	N/A	16	1	2	2	5	80
117	Add inclement weather shelters to the facility.	Asset	Recommended	Waste Resource Innovation Centre (Facility)	Acute Weather Events	Solid Waste	Emergency Services Asset Management Health & Safety	N/A	16	2	1	2	5	80
118	Design and build new Baker Street library with climate adaptation lens.	Asset	Recommended	Library, Culture, Tourism and Community Investment	Acute Weather Events	Guelph Public Library	Culture and Recreation Asset Management	N/A	16	1	2	2	5	80
119	Continue the water meter program.	Asset	Existing	<ul style="list-style-type: none"> • Arkell Springs, Water Spring Recharge System • Collector Aqueduct • Groundwater Well Station, Pumping Station, Well Station (Inactive) • Water Tower • Water Treatment Plant 	Drought	Water Services	Asset Management	N/A	15	3	1	1	5	75
120	Continue completing risk assessments of contaminated lands and prioritize climate resiliency when implementing risk management measures.	Asset	Existing	Contaminated Land	Acute Weather Events	Engineering (Contaminated Sites)	Asset Management Public Works Parks Engineering (Stormwater)	N/A	12	3	2	1	6	72
121	Apply lessons from other jurisdictions into planning (e.g., BC Contaminated Lands, federal guidelines).	Asset	Recommended	Contaminated Land	Acute Weather Events	Engineering (Contaminated Sites)	Asset Management Public Works Engineering (Stormwater) Parks	N/A	12	3	2	1	6	72

Table C.4 Prioritization

#	Actions	Basis	Existing (/Planned) or Recommended	Asset(s) Addressed	Climate Hazard(s)	Managing Department (Prime Task Leader)	Impacted/Benefitting Departments and External Groups	Applicable PWG Actions	Prioritization (score 1 3)					
									Risk Rating	Ease of Implementation	Social Benefit	Risk Benefit	Priority Score	Overall Priority Rank
122	Include climate change as part of prioritization of site remediation.	Asset	Recommended	Contaminated Land	Acute Weather Events	Engineering (Contaminated Sites)	Asset Management Public Works Engineering (Stormwater) Parks	N/A	12	3	2	1	6	72
123	Communicate with MECP to prioritize cleanup of brownfield sites.	Asset	Recommended	Contaminated Land	Acute Weather Events	Engineering (Contaminated Sites)	Asset Management Public Works Parks Engineering (Stormwater)	N/A	12	2	2	2	6	72
124	Work with Parks to design and upgrade low impact development features around the culture and recreation facilities.	Asset	Recommended	Recreation Facility	Flooding	Culture and Recreation	Culture and Recreation Parks Asset Management Engineering (Stormwater)	N/A	12	2	2	2	6	72
125	Maintain communications with Public Works under by-law stipulation for snow plowing.	Asset	Existing	<ul style="list-style-type: none"> • Bus Stops/Shelters • Bus Terminal 	Snow and Freezing Rain	Transit	Asset Management Public Works	N/A	6	3	3	2	8	48
126	Investigate areas where permeable pavements and low impact development can be applied.	Asset	Recommended	Parking Garage, Parking	Freeze/Thaw Extreme Heat	Engineering (Transportation)	Asset Management Engineering (Stormwater) Public Works	N/A	6	2	2	2	6	36
127	Investigate updating the Property Standards By-law to including providing cooling facilities to maintain ambient temperatures below a maximum temperature, (in addition to the existing provision of providing heating facilities to maintain a minimum temperature)	Service	Recommended	N/A	Extreme Heat	Operations	Planning and Business Services Wellington Dufferin Guelph Public Health	Wellington Dufferin Guelph Public Health	N/A	2	3	2	7	N/A
128	Continue to plan plowing (road and sidewalk) routes with equity lens, in addition to schools and seniors.	Service	Existing	Roads, Sidewalks, bike paths/trails	Snow	Public Works	Engineering (Transportation) Emergency Services Asset Management Wellington Catholic District School Board Upper Grand District School Board Guelph General Hospital	Wellington Catholic District School Board Upper Grand District School Board Guelph General Hospital	N/A	3	3	3	9	N/A
129	Continue to provide buses as an emergency shelter when requested by Emergency Services.	Service	Existing	Bus - Conventional, Bus - Mobility, Transit Vehicle - Other	All Hazards	Transit	Emergency Services Fleet Asset Management County of Wellington Red Cross	County of Wellington Red Cross	N/A	3	3	3	9	N/A

Table C.4 Prioritization

#	Actions	Basis	Existing (/Planned) or Recommended	Asset(s) Addressed	Climate Hazard(s)	Managing Department (Prime Task Leader)	Impacted/Benefitting Departments and External Groups	Applicable PWG Actions	Prioritization (score 1 3)					
									Risk Rating	Ease of Implementation	Social Benefit	Risk Benefit	Priority Score	Overall Priority Rank
130	Continue policy and practice of continuing bus service during inclement weather.	Service	Existing	Bus - Conventional, Bus - Mobility, Transit Vehicle - Other	Extreme Heat Acute Weather Events Snow and Freezing Rain	Transit	Emergency Services Fleet Asset Management	N/A	N/A	3	3	3	9	N/A
131	Continue training staff on how to do route detours.	Service	Existing	Bus - Conventional, Bus - Mobility, Transit Vehicle - Other	Extreme Heat Acute Weather Events Snow and Freezing Rain	Transit	Emergency Services Asset Management Fleet	N/A	N/A	3	3	3	9	N/A
132	Continue involvement in the Emergency Operations Group.	Service	Existing	All	All Hazards	Communications	All Departments	N/A	N/A	3	3	3	9	N/A
133	Consider how to use communications to weave in climate change adaptation and mitigation messaging and make connections across the Corporation.	Service	Existing	All	All Hazards	Communications	All Departments	N/A	N/A	3	3	3	9	N/A
134	Continue involvement with emergency shelter support.	Service	Existing	All	All Hazards	Equity, Diversity and Inclusion	All Departments County of Wellington Red Cross	County of Wellington Red Cross	N/A	3	3	3	9	N/A
135	Continue to send out alerts on Guelphs alert system from the Community Emergency Management Coordinator.	Service	Existing	All	All Hazards	Public Works	All Departments	N/A	N/A	3	3	3	9	N/A
136	Establish emergency internal and external communications that include digital and broadcast media in multiple languages, as well as American Sign Language.	Service	Recommended	All	All Hazards	Communications	All Departments County of Wellington Red Cross	County of Wellington Red Cross	N/A	3	3	3	9	N/A
137	Develop a list of support agencies to contact during an emergency to accelerate assistance to those in need. Create a plan outlining how and when these agencies will be contacted efficiently.	Service	Recommended	All	All Hazards	Communications	All Departments County of Wellington Red Cross	County of Wellington Red Cross	N/A	3	3	3	9	N/A

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#	Actions	Basis	Existing (/Planned) or Recommended	Asset(s) Addressed	Climate Hazard(s)	Managing Department (Prime Task Leader)	Impacted/Benefitting Departments and External Groups	Applicable PWG Actions	Prioritization (score 1 3)					
									Risk Rating	Ease of Implementation	Social Benefit	Risk Benefit	Priority Score	Overall Priority Rank
138	Establish regular meetings with the Community Emergency Management Coordinator, Red Cross, WDGPH, and County of Wellington.	Service	Recommended	All	All Hazards	Equity, Diversity and Inclusion	All Departments County of Wellington Red Cross WDGPH	County of Wellington Red Cross WDGPH	N/A	3	3	3	9	N/A
139	Asset Management to take on the role of monitoring progress on implementing actions recommended in the City's Climate Adaptation Plan and updating this Plan every five years.	Service	Recommended	All	All Hazards	Asset Management	All Departments	N/A	N/A	3	3	3	9	N/A
140	Engage Mississaugas of the Credit First Nations (MCFN) and Six Nations of the Grand River (SNGR) in the City's pre-consultation process.	Service	Recommended	All	All Hazards	All Departments	All Departments Mississaugas of the Credit First Nations Six Nations of the Grand River	MCFN SNGR	N/A	3	3	3	9	N/A
141	Form an internal climate change working group, to be led by Asset Management, as per the Asset Management Plan recommendations	Service	Recommended	All	Asset Management	Asset Management	All Departments	N/A	N/A	3	3	3	9	N/A
142	Continue to play an active role in supporting new businesses and industries to Guelph that align with the City's sustainability and resiliency goals	Service	Existing	All	All Hazards	Economic Development	All Departments	N/A	N/A	3	3	2	8	N/A
143	Continue to be a member of the Fire Services Joint Health & Safety committee, and involved in fire drills.	Service	Existing	All	All Hazards	Health & Safety	All Departments	N/A	N/A	3	2	3	8	N/A
144	Continue incentive programs for private rainwater harvesting and rain barrels.	Service	Existing	Channels, Culvert, Management Ponds, Oil and Grit Separator, Pipe	Flooding Winter/Spring Rainfall	Engineering (Stormwater)	Asset Management Compliance and Performance Planning	N/A	N/A	3	3	2	8	N/A
145	Establish business continuity plan in case communications are not available.	Service	Recommended	All	All Hazards	Communications	All Departments All PWG	All	N/A	3	3	2	8	N/A

Table C.4 Prioritization

#	Actions	Basis	Existing (/Planned) or Recommended	Asset(s) Addressed	Climate Hazard(s)	Managing Department (Prime Task Leader)	Impacted/Benefitting Departments and External Groups	Applicable PWG Actions	Prioritization (score 1 3)					
									Risk Rating	Ease of Implementation	Social Benefit	Risk Benefit	Priority Score	Overall Priority Rank
146	Work with City Departments to apply an equity, diversity, and inclusion lens when planning and prioritizing services or infrastructure upgrades/replacements. Establish a formal means of communication.	Service	Recommended	All	All Hazards	Equity, Diversity and Inclusion	All Departments	N/A	N/A	3	3	2	8	N/A
147	Continue to follow and adopt the Community Engagement and Communications Plan, and coordinate community consultation with the Sustainability Master Plan.	Service	Existing	All	All Hazards	Communications	All Departments All PWG	All	N/A	3	3	1	7	N/A
148	Leverage appropriate communications tactics during climate related events	Service	Existing	All	All Hazards	Communications	All Departments All PWG	All	N/A	3	2	2	7	N/A
149	Continue to enhance partnerships with Partner Working Group	Service	Existing	All	All Hazards	Equity, Diversity and Inclusion	All PWG	All	N/A	3	2	2	7	N/A
150	Maintain first aid training for staff at library, including equity considerations.	Service	Existing	Library, Culture, Tourism and Community Investment	Extreme Heat Acute Weather Events Flooding	Guelph Public Library	Asset Management Equity, Diversity and Inclusion Emergency Services County of Wellington Red Cross	County of Wellington Red Cross	N/A	3	2	2	7	N/A
151	Maintain first aid training for staff at recreational facilities, including equity considerations.	Service	Existing	Recreation Facility	Extreme Heat Acute Weather Events Flooding	Culture and Recreation	Asset Management Equity, Diversity and Inclusion Emergency Services County of Wellington Red Cross	County of Wellington Red Cross	N/A	3	2	2	7	N/A
152	Continue to set up traffic control in emergency situations for emergency management systems.	Service	Existing	Roads, Sidewalks, bike paths/trails	All Hazards	Public Works	Engineering (Transportation) Transit Asset Management	N/A	N/A	3	2	2	7	N/A
153	Update thermal stress policies as appropriate.	Service	Existing	All	All Hazards	Health & Safety	All Departments	N/A	N/A	3	2	2	7	N/A

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#	Actions	Basis	Existing (/Planned) or Recommended	Asset(s) Addressed	Climate Hazard(s)	Managing Department (Prime Task Leader)	Impacted/Benefitting Departments and External Groups	Applicable PWG Actions	Prioritization (score 1 3)					
									Risk Rating	Ease of Implementation	Social Benefit	Risk Benefit	Priority Score	Overall Priority Rank
154	Grow the circular economy by creating and implementing the Circular Economy Framework.	Service	Existing	Library, Culture, Tourism and Community Investment	Acute Weather Events	CAO's Office	Solid Waste County of Wellington	County of Wellington	N/A	2	3	2	7	N/A
155	Dedicated Health & Safety Specialists for Environmental Services (Water Services, Wastewater and Solid Waste), Public Works, Parks, and Transit.	Service	Existing	All	All Hazards	Health & Safety	All Departments	N/A	N/A	3	2	2	7	N/A
156	Identify a specific person in the City that community support agencies can contact in the event of an emergency	Service	Recommended	None	All Hazards	Equity, Diversity and Inclusion	All Departments	N/A	N/A	2	3	2	7	N/A
157	Participate in regular emergency exercises with Wellington County, with whom paramedic services are shared and police services work closely together.	Service	Recommended	All	All Hazards	Emergency Services	Emergency Services Equity, Diversity and Inclusion County of Wellington	County of Wellington	N/A	3	2	2	7	N/A
158	Participate in the Water Managers Working Group with GRCA and other municipalities in the watershed.	Service	Recommended	Natural Heritage System	Drought	Water Services	Wastewater Grand River Conservation Authority	GRCA	N/A	3	2	2	7	N/A
159	Expand upon rebate program for private rainwater harvesting, rain barrels, downspout disconnect.	Service	Recommended	Channels, Culvert, Management Ponds, Oil and Grit Separator, Pipe	Winter/Spring Rainfall Flooding	Compliance and Performance	Engineering (Stormwater) Asset Management Public Works Communications	N/A	N/A	3	2	2	7	N/A
160	Improve communication to the community to manage windy days. Carts must be heavier or kept them inside.	Service	Recommended	Waste Collection Service	Acute Weather Events	Solid Waste	Communications	N/A	N/A	3	2	2	7	N/A
161	Develop cold stress policy, policy for staff working outside in high winds, flooding, and update as needed heat stress policy. Communicate these to all departments.	Service	Recommended	All	Extreme Heat	Health & Safety	All Departments	N/A	N/A	2	2	2	6	N/A

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#	Actions	Basis	Existing (/Planned) or Recommended	Asset(s) Addressed	Climate Hazard(s)	Managing Department (Prime Task Leader)	Impacted/Benefitting Departments and External Groups	Applicable PWG Actions	Prioritization (score 1 3)					
									Risk Rating	Ease of Implementation	Social Benefit	Risk Benefit	Priority Score	Overall Priority Rank
162	City managers to prioritize staff retention recognizing that the knowledge of staff is one of the City's best assets in an emergency situation.	Service	Recommended	All	All Hazards	All Departments	All Departments	N/A	N/A	2	2	2	6	N/A
163	Formalize incident tracking including identifying root cause. Flag those that are weather related.	Service	Recommended	All	All Hazards	Health & Safety	All Departments	N/A	N/A	2	1	2	5	N/A

Table C.5 Implementation

#	Actions	Managing Department (Prime Task Leader)	Impacted/Benefitting Departments and External Groups	Applicable PWG Actions	Implementation				Example Key Performance Indicator(s) (KPI)
					Capital, O&M, or Planning/ Policy	Schedule	Estimated Resources	Goal Alignment	
1	Work with Facilities to ensure adequate air conditioning in offices and recreation facilities, continue with routine maintenance on these systems.	Facilities Culture and Recreation	Culture and Recreation Asset Management Facilities Red Cross	Red Cross	O&M	On-going	\$	Environment & Health Infrastructure Safety Equity	<ul style="list-style-type: none"> • Number of air conditioning units in good condition. • Percentage of spaces with air conditioning. • Percentage of AC units in need of repair and/or replacement (reverse KPI); amount of time to repair and/or replace AC units
2	Develop a sports field strategy including a mowing (and potential irrigation) strategy that accommodates a changing climate, including shared use (e.g., for stormwater management).	Parks	Planning Public Works Asset Management	N/A	Planning	Short-term	\$	Environment & Health Infrastructure Safety Equity	<ul style="list-style-type: none"> • Development of a sports field strategy that includes climate change.
3	Implement Guelphs Official Plan Natural Heritage Policies, which seek to protect and restore natural heritage features and areas for the long term.	Planning	Parks Public Works Asset Management	N/A	Planning	Short-term	\$	Environment & Health Safety	<ul style="list-style-type: none"> • Number of protected and restored natural heritage features. • Area of protected and restored natural heritage features.
4	Complete the Sustainable City Master Plan.	Planning	Parks Public Works Asset Management All PWG	All	Policy	On-going	\$	Environment & Health Infrastructure Economy Safety Equity	<ul style="list-style-type: none"> • Completion of the Sustainable City Master Plan.
5	Continue performance condition assessment and level of service reviews on all assets. Work with project managers to recommend priority lists for upgrades and replacement.	Asset Management	All Departments	N/A	Capital	On-going	\$\$	Environment & Health Infrastructure Safety Equity	<ul style="list-style-type: none"> • Number of assets with an up-to-date condition assessment and level of service review • Number/percentage of assets where climate-related risks have been incorporated into their condition assessment and review of LOS
6	Continue to undertake tree planting initiatives.	Parks	Planning Public Works Asset Management University of Guelph	University of Guelph	Capital	On-going	\$\$	Environment & Health Infrastructure Safety Equity	<ul style="list-style-type: none"> • Number of trees planted. • Percentage canopy cover.
7	Follow the guidelines put forth in the Urban Forest Management Plan (e.g., types of trees to plant, how long to monitor new trees, Tree Planting strategy for Guelph).	Parks	Planning Public Works Asset Management	N/A	Planning	On-going	\$\$	Environment & Health Infrastructure Safety Equity	<ul style="list-style-type: none"> • Number of trees planted in accordance with the Urban Forest Management Plan.

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#	Actions	Managing Department (Prime Task Leader)	Impacted/Benefitting Departments and External Groups	Applicable PWG Actions	Implementation				Example Key Performance Indicator(s) (KPI)
					Capital, O&M, or Planning/ Policy	Schedule	Estimated Resources	Goal Alignment	
8	Continue assessing risk as per the Drinking Water Quality Management System.	Water Services	Asset Management	N/A	Policy	On-going	\$\$	Infrastructure Economy	<ul style="list-style-type: none"> Average risk status as dictated by the Drinking Water Quality Management System. Conducting annual risk assessment.
9	Continue Source Water Protection program.	Water Services	Asset Management	N/A	Capital	On-going	\$\$	Environment & Health Infrastructure Economy	<ul style="list-style-type: none"> Continuation of the Source Water Protection program.
10	Work with the appropriate department to ensure adequate air conditioning in all City-owned buildings (e.g., offices, recreation facilities, libraries) and continue with routine maintenance on these systems.	Facilities	All Departments	N/A	On-going	On-going	\$\$	Infrastructure Safety	<ul style="list-style-type: none"> Number of air conditioning units in good condition. Percentage of spaces with air conditioning.
11	Continue to stock backup equipment in the event of equipment failure.	Water Services	Asset Management	N/A	O&M	On-going	\$\$	Infrastructure Safety	<ul style="list-style-type: none"> Number of assets with backup equipment readily available.
12	Continue performance rating for each asset and send recommended priority lists to PMs.	Asset Management	All Departments	N/A	Capital	On-going	\$\$	Environment & Health Infrastructure Safety	<ul style="list-style-type: none"> Completion of list of asset performance rating and prioritization.
13	Complete the climate change-related actions specified in the Natural Heritage Action Plan including: 1) Launch a city-wide environmental monitoring program; 2) Produce a status of the natural heritage system report that measures the effectiveness of our natural heritage policies; 3) Develop an environmental implementation report guideline; and 4) Develop restoration and management plans for City owned/managed natural areas.	Planning	Parks Public Works Asset Management	N/A	Capital	Short-term to Medium- term	\$	Environment & Health Safety	<ul style="list-style-type: none"> Launch of the city-wide environmental monitoring program. Production of the natural heritage system report. Development of an environmental implementation report guideline. Develop restoration and management plans for City owned/managed natural areas.
14	Continue to convert bus fleet to electric vehicles, collaboration with Transit.	Fleet	Transit Asset Management	N/A	Capital	Short-term to Medium- term	\$\$\$	Environment & Health Safety	<ul style="list-style-type: none"> Number of electric vehicles.

Table C.5 Implementation

#	Actions	Managing Department (Prime Task Leader)	Impacted/Benefitting Departments and External Groups	Applicable PWG Actions	Implementation				Example Key Performance Indicator(s) (KPI)
					Capital, O&M, or Planning/ Policy	Schedule	Estimated Resources	Goal Alignment	
15	Work with Facilities to ensure adequate air conditioning in the libraries, continue with routine maintenance on heating, ventilation, and air conditioning systems.	Facilities Guelph Public Library	Guelph Public Library Asset Management Emergency Services Facilities County of Wellington Red Cross	County of Wellington Red Cross	O&M	On-going	\$	Environment & Health Infrastructure Safety Equity	<ul style="list-style-type: none"> Number of air conditioning units in good condition. Percentage of spaces with air conditioning. Percentage of AC units in need of repair and/or replacement (reverse KPI); amount of time to repair and/or replace AC units
16	Maintain cooling feature and changeover to winter tires in corporate vehicles and buses. Provide redundancy.	Fleet	Transit Asset Management	N/A	O&M	On-going	\$	Environment & Health Safety Equity	<ul style="list-style-type: none"> Number of vehicles with adequate cooling feature. Number of corporate vehicles and buses with winter tires. Number of vehicular accidents during the winter season. Percentage of vehicles available for alternative use.
17	Continue to provide backup power (diesel generator) at the Water Resource Recovery Centre in then event of a power outage.	Wastewater	Asset Management Grand River Conservation Authority	N/A	O&M	On-going	\$	Environment & Health Infrastructure Safety	<ul style="list-style-type: none"> Provision of diesel generator.
18	Maintain the Building Condition Assessments to inform Asset Management Plan and renewal planning.	Asset Management	All Departments	N/A	Capital	On-going	\$ to \$\$	Environment & Health Infrastructure Safety Equity	<ul style="list-style-type: none"> Number of buildings with up-to-date building condition assessments that consider climate-related risks (e.g., conducted within the last 2 years).
19	Develop and maintain internal Information Technology asset management program.	Information Technology	Asset Management Communications	N/A		On-going	\$\$	Infrastructure Safety	<ul style="list-style-type: none"> Formalization of an internal IT asset management program.
20	Maintain service and maintenance contracts for critical equipment to store or obtain spares within 4 hours.	Information Technology	Asset Management Communications	N/A		On-going	\$\$	Infrastructure Economy Safety	<ul style="list-style-type: none"> Number of key assets with maintenance contracts. Number of key assets with spares readily available within 4 hours.
21	Continue invasive species management (e.g., buckthorn).	Parks	Planning Public Works Asset Management Wellington Dufferin Guelph Public Health	WDGPH	Capital	On-going	\$\$	Environment & Health	<ul style="list-style-type: none"> Population of recorded invasive species.

Table C.5 Implementation

#	Actions	Managing Department (Prime Task Leader)	Impacted/Benefitting Departments and External Groups	Applicable PWG Actions	Implementation				Example Key Performance Indicator(s) (KPI)
					Capital, O&M, or Planning/ Policy	Schedule	Estimated Resources	Goal Alignment	
22	Backup generators available to supply power if grid goes down.	Facilities	All Departments	N/A	Capital	On-going	\$\$	Infrastructure Safety	<ul style="list-style-type: none"> • Number of diesel generators available. • Average outage time. • Area with redundant power readily available.
23	Establish a regular communication plan between all departments with assets and the Asset Management Group to keep up to date on asset upgrades/replacements.	Asset Management	All Departments	N/A	Policy	On-going	\$	Infrastructure Economy Safety	<ul style="list-style-type: none"> • Apply learnings from CAP across all departments with infrastructure assets regarding decisions on asset upgrades/replacements.
24	Periodically review, maintain, and update use of recreation facilities as emergency shelter buildings. Review with an equity lens. This includes co-ordination with the County of Wellington, WDGPH, and Emergency Services.	Culture and Recreation	Asset Management Equity, Diversity and Inclusion Emergency Services County of Wellington Red Cross WDGPH	County of Wellington Red Cross WDGPH	Planning	On-going	\$	Environment & Health Infrastructure Safety Equity	<ul style="list-style-type: none"> • Develop and apply a protocol to review recreational facilities as emergency shelter buildings, taking into account climate-related risks and equity concerns • Percentage of recreation facilities where the protocol for climate-related risks and equity concerns have been applied • The percentage of recreation facilities where onsite evaluations have been completed, regarding climate-related risks and equity concerns
25	Formalize emergency plans, understand length (time) of backup power, and have redundant staff available at all hours	Information Technology	Asset Management Communications All PWG	All	Planning	Short-term	\$	Infrastructure Economy Safety	<ul style="list-style-type: none"> • Completion of formalized emergency plans. • Percentage of emergency response plans that consider climate-related risks. • Incorporation of climate-related risks into emergency Standard Operating Procedures. • Completed assessment of back-up power requirements for critical assets and services. • Number of table top emergency response exercises that take into account extreme weather.
26	Liaise with the fire department on a mock transfer station fire scenario.	Solid Waste	Asset Management Health & Safety Emergency Services	N/A	Planning	Short-term	\$	Environment & Health Infrastructure Safety	<ul style="list-style-type: none"> • Establish procedure with fire department for a mock transfer station fire scenario. • Number of areas with an adequate procedure in place.
27	Involvement of Public Works department in emergency drills led by other departments	Public Works	All Departments	N/A	Planning	Short-term	\$	Environment & Health Infrastructure Safety Equity	<ul style="list-style-type: none"> • Number of emergency drills conducted. • Number of employees participating in emergency drills.

Table C.5 Implementation

#	Actions	Managing Department (Prime Task Leader)	Impacted/Benefitting Departments and External Groups	Applicable PWG Actions	Implementation				Example Key Performance Indicator(s) (KPI)
					Capital, O&M, or Planning/ Policy	Schedule	Estimated Resources	Goal Alignment	
28	Conduct emergency exercise drills and include Public Works. Recommend to include this department in the future.	Solid Waste	Emergency Services Public Works Asset Management	N/A	Planning	Short-term	\$	Infrastructure Safety	<ul style="list-style-type: none"> • Number of emergency drills conducted. • Number of employees participating in emergency drills.
29	Pursue venture to create a City-wide urban heat island effect map.	Engineering (Transportation)	Planning Parks Asset Management Health & Safety Engineering (Stormwater) Wellington County Housing	Wellington County Housing	Capital	Medium-term	\$\$	Environment & Health Infrastructure Equity	<ul style="list-style-type: none"> • Commission new work to generate a City-wide urban heat island effect map. • Number of planning documents (i.e., Master Plans) that integrate the urban heat island effect map.
30	Work with Transit (Facilities to lead) and consider climate change in setting design standards for new south end and downtown bus terminals.	Facilities	Transit Asset Management	N/A	Capital	Short-term	\$\$\$	Environment & Health Infrastructure Equity	<ul style="list-style-type: none"> • Incorporation of climate change into the design standards for the new south end bus terminal. • Incorporation of climate change into the design standards for the new downtown bus terminal.
31	Continue to pursue venture with Rezatec to take into account history of breaks, combine with weather conditions, and soil type to order to advise when to replace infrastructure.	Water Services	Engineering (Stormwater) Wastewater Asset Management	N/A	Capital	Short-term	\$\$	Environment & Health Infrastructure Safety	<ul style="list-style-type: none"> • Length (km) of infrastructure requiring maintenance and replacement. • Completion of city wide assessment.
32	Continue to update and keep current the Memorandum of Understanding with University of Guelph to share assets and resources at times.	Emergency Services	Asset Management University of Guelph	University of Guelph	On-going	Short-term	\$	Environment & Health Infrastructure Safety	<ul style="list-style-type: none"> • Up-to-date Memorandum of Understanding with University of Guelph.
33	Work with Facilities to ensure emergency building heating, ventilation and air conditioning systems are maintained and replaced as per the Asset Management Plan.	Emergency Services	Emergency Services Asset Management Facilities	N/A	O&M	On-going	\$	Environment & Health Infrastructure Safety	<ul style="list-style-type: none"> • Percentage of systems that are considered maintained satisfactorily.
34	Set new building designs and building upgrades to consider climate change and air conditioning needs (e.g., incorporate renewable energy, air conditioning and heating sized at 99th percentile to provide sufficient buffer).	Facilities	Administrative and Operations Asset Management Health & Safety	N/A	Planning	Short-term	\$	Infrastructure Safety	<ul style="list-style-type: none"> • Number of new designs and upgrades that incorporate climate change. • Number of new designs and upgrades that consider air conditioning needs.

Table C.5 Implementation

#	Actions	Managing Department (Prime Task Leader)	Impacted/Benefitting Departments and External Groups	Applicable PWG Actions	Implementation				Example Key Performance Indicator(s) (KPI)
					Capital, O&M, or Planning/ Policy	Schedule	Estimated Resources	Goal Alignment	
35	Ensure adequate air conditioning in the transit buildings and that staff is aware of alerts from Health & Safety.	Transit	Asset Management	N/A	O&M	On-going	\$	Environment & Health Safety Equity	<ul style="list-style-type: none"> Percentage of adequately air conditioned rooms over number of rooms with an air conditioning recommendation. Percentage of alerts sent to staff over extreme heat events.
36	Continue to review and update as necessary emergency plan to include the loss of Woods Station or a water storage facility.	Water Services	All Departments	N/A	Planning	Short-term	\$	Infrastructure Safety	<ul style="list-style-type: none"> Establish a regular review of the emergency plan.
37	Conduct trial emergency exercise planned for 2023.	Information Technology	Asset Management Communications	N/A	Planning	Short-term	\$	Environment & Health Infrastructure Safety	<ul style="list-style-type: none"> Completion of the trial emergency exercise.
38	Continue to liaise with surrounding municipalities for information sharing and networking.	Information Technology	Asset Management Communications County of Wellington Region of Waterloo	County of Wellington Region of Waterloo	Planning	On-going	\$	Infrastructure Safety	<ul style="list-style-type: none"> Communication with surrounding municipalities for information sharing and networking.
39	Continue to liaise with Grand River Conservation Authority on Speed River flows and assimilative capacity.	Wastewater	Asset Management Grand River Conservation Authority	GRCA	Planning	On-going	\$	Environment & Health Infrastructure Economy Safety	<ul style="list-style-type: none"> Regular correspondence with GRCA on Speed River flows and assimilative capacity.
40	Update the Natural Assets Inventory.	Asset Management	All Departments	N/A	Capital	Medium-term	\$	Environment & Health Infrastructure Safety	<ul style="list-style-type: none"> Up-to-date Natural Assets Inventory.
41	Complete a Facility Needs Assessment to consider relocation of fire and emergency management systems located below the floodplain.	Facilities	All Departments	N/A	Capital	Planned Short-term	\$\$	Infrastructure Safety	<ul style="list-style-type: none"> Completion of a Facility Needs Assessment.

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42	Include climate change in current planning/formula in asset state assessment (e.g., follow Municipal Finance Officers' Association for guidance)	Asset Management	All Departments	N/A	Capital	Short-term	\$	Environment & Health Infrastructure Safety	<ul style="list-style-type: none"> Inclusion of the formula into the asset state assessment.
43	Periodically review, maintain, and update use of libraries as emergency shelter buildings. Review with an equity lens. This includes co-ordination with the County of Wellington, WDGPH, and Emergency Services.	Guelph Public Library	Asset Management Equity, Diversity and Inclusion Emergency Services County of Wellington Red Cross WDGPH	County of Wellington Red Cross WDGPH	Planning	On-going	\$	Environment & Health Infrastructure Safety Equity	<ul style="list-style-type: none"> Initiate a tour of facilities to review its usage as an emergency shelter and establish frequency of review. Establish list of minimum criteria to ensure equity lens is applied.
44	Ensure adequate air conditioning in the corporate buildings and confirm storage temperature requirements of assets. Consider managing air conditioning through smart monitoring and forecasting to minimize impacts on existing equipment.	Facilities	Administrative and Operations Asset Management Health & Safety	N/A	O&M	Short-term	\$	Environment & Health Infrastructure Safety	<ul style="list-style-type: none"> Percentage of systems that are considered maintained satisfactorily. Number of systems equipped with smart monitoring and forecasting.
45	Update the Environmental Impact Study (EIS) Guidelines to clarify that thermal impacts to surface water features are to be assessed as part of the stormwater quality and quantity controls.	Planning	Parks Asset Management Public Works	N/A	Planning	Short-term	\$	Environment & Health Infrastructure	<ul style="list-style-type: none"> Update of the EIS to provide clarity on thermal impacts to surface water features.
46	Establish a business continuity plan in case building is compromised, itemize the transit building components, and provide alternate/redundant work environment in case the transit buildings cannot be safely occupied.	Transit	Asset Management	N/A	Planning	Short-term to Medium- term	\$	Infrastructure Equity	<ul style="list-style-type: none"> Establish a business continuity plan. Completion of an itemized list of assets within the building.
47	Itemize Water Resource Recovery Centre components susceptible to hazard impacts and plan with Asset Management for replacement.	Wastewater	Asset Management Public Works	N/A	Planning	Short-term	\$	Infrastructure Safety	<ul style="list-style-type: none"> Completion of an itemized list of assets within the building. Percentage of items in good working condition.
48	When the Environmental Implementation Report guidelines are developed, include actions for responding to climate change, such as providing directions on tree planting, shading watercourses and stormwater features, reducing thermal impacts, and assisted migrations of appropriate species	Planning	Asset Management Parks Public Works Facilities Stormwater Grand River Conservation Authority University of Guelph	GRCA University of Guelph	Capital	Short-term to Medium- term	\$	Environment & Health Infrastructure Economy Safety	<ul style="list-style-type: none"> Number of actions implemented from the Environmental Implementation Report related to climate change.

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49	Work with Asset Management to include climate change aspect in life cycle analyses in addition to considering industry standards.	Information Technology	Asset Management Communications	N/A	Planning	Medium-term	\$\$	Infrastructure Economy Safety	<ul style="list-style-type: none"> Number of assets that include climate change in the life cycle analyses.
50	Investigate and provide adequate shelter for users at popular transit stops, consider equity lens.	Transit	Asset Management Public Works Engineering (Transportation)	N/A	Capital	Short-term	\$\$	Environment & Health Infrastructure Equity	<ul style="list-style-type: none"> Number of shelters in place (shelters per squared km).
51	Source Water Protection group to work with Public Works to consider alternative means of de-icing instead of salt use.	Water Services	Asset Management Public Works	N/A	Capital	Short-term to Medium-term	\$\$	Environment & Health Economy Safety	<ul style="list-style-type: none"> Amount (kg) of salt application.
52	Continue to work with Asset Management to identify sanitary sewer infrastructure requiring upgrades and replacement.	Wastewater	Asset Management	N/A	Planning	On-going	\$	Environment & Health Infrastructure Safety	<ul style="list-style-type: none"> Length (km) of sanitary sewer infrastructure requiring upgrades and replacement.
53	Continue working with Public Works on the storm sewer infrastructure maintenance program.	Engineering (Stormwater)	Asset Management Public Works Engineering (Transportation)	N/A	O&M	Short-term	\$	Environment & Health Infrastructure Safety Equity	<ul style="list-style-type: none"> Create a system to continuously update the maintenance catalogue and inform Asset Management. Percentage of storm sewers that meet a climate change design standard
54	Add a climate adaptation lens to the Goods Movement Strategy	Engineering (Transportation)	Economic Development Asset Management Public Works Transit Emergency Services	N/A	Planning	Short-term	\$	Economy Equity	<ul style="list-style-type: none"> Addition of climate adaptation to the Goods Movement Strategy document.
55	Continue pavement condition monitoring in collaboration with Engineering (Transportation).	Asset Management	Engineering (Transportation) Public Works	N/A	O&M	On-going	\$	Infrastructure Economy Safety Equity	<ul style="list-style-type: none"> Number of logs in collaboration with Asset Management regarding pavement condition. Number of pavement projects scoped.

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					Capital, O&M, or Planning/ Policy	Schedule	Estimated Resources	Goal Alignment	
56	Communicate with Engineering (Transportation) to identify priority capital or repair works at a corridor level and provide feedback when those works are completed.	Asset Management	Engineering (Transportation) Public Works Transit Alectra Enbridge Gas Guelph Junction Railway CN Rail Metrolinx	Alectra Enbridge Gas Guelph Junction Railway CN Rail Metrolinx	O&M	On-going	\$	Infrastructure Economy Safety Equity	<ul style="list-style-type: none"> Percentage of completed work reported to Asset Management. Number of regular meetings to discuss priority capital and repair works at a corridor level.
57	Pursue investigation to provide real-time weather conditions for roads and bridges.	Engineering (Transportation, Design and Construction)	Emergency Services Public Works Asset Management Public Works Transit	N/A	Capital	Medium-term	\$\$	Environment & Health Safety Equity	<ul style="list-style-type: none"> Pursue and finalize study/project to provide real-time weather conditions for roads and bridges. Length of roads/bridges with real-time weather conditions coverage.
58	Conduct minor road repairs.	Public Works	Asset Management Engineering (Transportation) Transit Emergency Services Health & Safety Economic Development	N/A	O&M	On-going	\$\$	Infrastructure Safety	<ul style="list-style-type: none"> Length of roads with minor repairs implemented.
59	Conduct road inspections.	Public Works	Asset Management Engineering (Transportation) Transit Emergency Services Health & Safety Economic Development	N/A	O&M	On-going	\$\$	Infrastructure Safety	<ul style="list-style-type: none"> Length of road inspections conducted.
60	Maintain Level of Service agreement with Engineering (Stormwater) to conduct storm sewer treatment system maintenance and inspections.	Public Works	Engineering (Stormwater) Asset Management Health & Safety	N/A	Planning	On-going	\$\$	Infrastructure Safety	<ul style="list-style-type: none"> Confirm Level of Service agreement is active. Length of storm sewer that is maintained and inspected.
61	Consider developing an updated municipal heat response plan with support from Wellington Dufferin Guelph Public Health.	Health & Safety	All Departments WDGPH	WDGPH	Planning	Short-term	\$	Environment & Health Safety Equity	<ul style="list-style-type: none"> Completion of response plan update.
62	Develop a scheduled and proactive storm sewer maintenance program with Public Works, which includes flushing, inspections, catch basin clearing, etc.	Engineering (Stormwater)	Asset Management Public Works Engineering (Transportation)	N/A	Planning	Short-term	\$	Environment & Health Infrastructure Safety Equity	<ul style="list-style-type: none"> % of storm sewers inspected and cleared on an annual basis % of storm sewers that meet higher climate change standards Establishment of a climate-related storm sewer maintenance program

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#	Actions	Managing Department (Prime Task Leader)	Impacted/Benefitting Departments and External Groups	Applicable PWG Actions	Implementation				Example Key Performance Indicator(s) (KPI)
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63	Establish communication plan with Emergency Services and Public Works.	Engineering (Transportation)	Emergency Services Public Works Asset Management Transit	N/A	Planning	Short-term	\$	Environment & Health Infrastructure Safety	<ul style="list-style-type: none"> • Inclusion of extreme weather in emergency response plan
64	Maintain a log of trees and vegetation within the floodplain as an additional criteria of the conditions report as part of the Natural Asset Inventory. Coordinate with Asset Management; refer to Tree Technical Manual for any new or replacement trees or vegetation within the floodplain.	Parks	Asset Management Engineering (Stormwater) University of Guelph	University of Guelph	Capital	Medium-term	\$	Environment & Health Infrastructure	<ul style="list-style-type: none"> • Establish minimum frequency of updates for log of trees and vegetation. • Number of trees planted that are confirmed to be appropriate for the floodplain. • Percentage of vegetative restoration within the floodplain
65	Consider equity when prioritizing stormwater project and conducting storm sewer condition assessments.	Engineering (Stormwater)	Asset Management Public Works Equity, Diversity and Inclusion Wastewater Wellington County Housing	Wellington County Housing	Capital	Short-term	\$\$	Infrastructure Safety Equity	<ul style="list-style-type: none"> • Establish list of minimum criteria to ensure equity lens is applied when conducting storm sewer condition assessments and prioritizing stormwater projects.
66	Conduct a storm sewer condition assessment. The storm sewer condition is largely unknown, especially in the older sections of Guelph (which are also typically home to the more vulnerable population)	Asset Management	Engineering (Stormwater) Public Works Wastewater Water Services Planning Parks	N/A	O&M	Short term	\$\$	Environment & Health Infrastructure Safety Equity	<ul style="list-style-type: none"> • Length of storm sewer assessed.
67	Communicate with Wellington Dufferin Guelph Public Health (WDGPH) to ensure continuation of mosquito larvicide programming.	Engineering (Stormwater)	Public Works Engineering (Transportation) Compliance and Performance Wellington Dufferin Guelph Public Health Planning Parks Water Services	WDGPH	Planning	On-going	\$	Environment & Health Safety Equity	<ul style="list-style-type: none"> • Number of joint public facing awareness campaigns.
68	Continue implementing the Water Efficiency Strategy programming, with periodic updates to programming offered, and evaluate its effectiveness at reducing water demand in the City.	Compliance and Performance	Water Services Wastewater Stormwater Communications Grand River Conservation Authority	GRCA	Capital	Short-term	\$\$\$	Environment & Health Infrastructure Economy Safety Equity	<ul style="list-style-type: none"> • Measure of water demand (L/person).

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69	Complete a Drought Response Operational Plan for the City	Compliance and Performance	Water Services Communications Grand River Conservation Authority	GRCA	Capital	Short-term	\$	Environment & Health Infrastructure Economy Safety Equity	<ul style="list-style-type: none"> Completion of an Operational Drought Response Plan
70	Establish an Integrated Water Management Strategy for Guelph. The strategy should look at water re-use opportunities from wastewater and stormwater for non-potable uses (industry, vehicle washing, fire suppression, etc.)	Compliance and Performance	Water Services Wastewater Stormwater Solid Waste	N/A	Capital	Short-term	\$\$ to \$\$\$	Environment & Health Infrastructure Economy Safety Equity	<ul style="list-style-type: none"> Estimated reuse of water (L). Number of places offering reusable water.
71	Staff are aware of heat alerts from Corporate Health & Safety.	Health & Safety	Emergency Services Wellington Dufferin Guelph Public Health	WDGPH	Policy	On-going	\$	Environment & Health Safety	<ul style="list-style-type: none"> Percentage of staff receiving training for heat alerts and/or who receive heat alert notifications (e.g., text message or emails). Percentage of staff that can work from home, if necessary.
72	Ensure staff are abiding by Corporate Health & Safety protocols for heat days.	Solid Waste	Health & Safety	N/A	Policy	On-going	\$	Environment & Health Safety	<ul style="list-style-type: none"> Number of staff working under heat advisory days. Number of staff that are sent alerts for heat days.
73	Maintain cooling feature in waste collection fleet vehicles with adequate hydration available for staff. Provide vehicle redundancy.	Solid Waste	Fleet Asset Management Health & Safety	N/A	O&M	On-going	\$	Environment & Health	<ul style="list-style-type: none"> Number of waste collection fleet vehicles with cooling feature. Number of redundant vehicles available with cooling feature.
74	Continue to have Public Works workers on standby for inclement weather based on forecasting.	Public Works	All Departments	N/A	Capital	On-going	\$\$	Economy Safety Equity	<ul style="list-style-type: none"> Number of workers available on standby.
75	Continue conducting pilot project with the University of Guelph to optimize salt application during winter.	Public Works	Asset Management Water Services Engineering (Stormwater) Emergency Services University of Guelph	University of Guelph	Capital	Short-term to Medium- term	\$\$	Environment & Health Infrastructure	<ul style="list-style-type: none"> Completion of pilot project. Implementation of project findings into maintenance documents.

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76	Ensure fire suppression equipment are maintained.	Solid Waste	Asset Management Health & Safety Emergency Services	N/A	O&M	On-going	\$\$	Environment & Health Infrastructure Safety	<ul style="list-style-type: none"> Number of fire suppression equipment in good condition.
77	Determine if development of a local Guelph climate change model/data portal with maps and data specific to the City's vulnerabilities is a worthwhile City project.	Asset Management	Parks Public Works Facilities Stormwater Planning Contaminated Sites WDGPH	N/A	Capital	Short-term to Medium- term	\$	Environment & Health Infrastructure Economy Safety	<ul style="list-style-type: none"> Scope out work to initiate climate change model/data portal.
78	Create a formal protocol for yard waste pick up during the summer.	Solid Waste	Asset Management Health & Safety	N/A	Planning	Short-term	\$	Environment & Health	<ul style="list-style-type: none"> Creation of yard waste pick up protocol for the summer. Frequency of pick ups. Approximate yard pick up load.
79	Consider planting additional shade trees around City-owned emergency buildings.	Parks	Emergency Services Asset Management	N/A	Capital	Short-term to Medium- term	\$ to \$\$	Environment & Health Infrastructure	<ul style="list-style-type: none"> Number of trees planted around City-owned emergency buildings.
80	Complete a Facility Needs Assessment for all critical infrastructure to determine if a backup source of power available is required and available for on site. Establish redundancy plan for power for critical buildings (e.g., diesel available if grid goes down).	Facilities	All Departments	N/A	Capital	On-going	\$\$	Infrastructure Safety	<ul style="list-style-type: none"> Completion of Facility Needs Assessment for all critical infrastructure. Creation of redundancy plan for power for critical buildings.
81	Work collaboratively with Facilities to provide redundant vehicles elsewhere or a plan to access vehicles in case of damage.	Fleet	Facilities and Energy Management Asset Management	N/A	Planning	Short-term	\$\$	Infrastructure Economy Safety	<ul style="list-style-type: none"> Number of redundant vehicles available.
82	Conduct an assessment of aquatic biota once every 5 to 10 years to determine if the warmer ambient temperatures are affecting the species and health of the aquatic biota.	Parks	Planning	N/A	Capital	Medium- term	\$\$	Environment & Health Infrastructure	<ul style="list-style-type: none"> Confirmation of up to date assessment of aquatic biota. Average health level of aquatic biota.

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83	Ensure that the identification of vulnerable areas and opportunities for adapting to climate change are identified and incorporated throughout the completion of the Natural Heritage Action Plan.	Planning	Parks Asset Management Public Works	N/A	Capital	On-going	\$\$	Environment & Health Infrastructure	<ul style="list-style-type: none"> • Identification of vulnerable areas completed. • Incorporation of climate change adaptation in the Natural Heritage Action Plan.
84	Work with equity group to map out vulnerable communities to ensure equitable service delivery.	Engineering (Transportation)	Asset Management Public Works Transit Equity Emergency Services Wellington County Housing WDGPH	Wellington County Housing WDGPH	Planning	Short-term	\$	Environment & Health Infrastructure Equity	<ul style="list-style-type: none"> • Creation of vulnerable communities map. • Number of planning documents (e.g., Master Plans) that integrate a map of vulnerable communities.
85	Update and keep current the Memorandum of Understanding with GRCA.	Parks	Planning Parks Compliance and Performance Public Works Grand River Conservation Authority	GRCA	Planning	On-going	\$	Environment & Health Infrastructure Safety	<ul style="list-style-type: none"> • Establish an annual review of the Memorandum of Understanding with GRCA.
86	Continue inflow and infiltration investigation program. Explore means to add resources during rain events to investigate flows within the system.	Wastewater	Asset Management Public Works	N/A	Capital	On-going	\$	Infrastructure Safety Equity	<ul style="list-style-type: none"> • Estimate of "leaky" pipes (km).
87	Continue Complete Streets Design Guide project that includes consideration for street trees, stormwater management, and LIDs.	Engineering (Transportation)	Asset Management Engineering (Stormwater) Parks Public Works Transit	N/A	Capital	On-going	\$\$	Environment & Health Infrastructure Safety Equity	<ul style="list-style-type: none"> • Length of complete streets implemented. • Percentage of street trees surviving. • Length of roads with LID and SWM components.
88	Continue infrastructure upsizing to accommodate IDF curve updates and align the timing with the timing of other infrastructure work	Engineering (Stormwater)	Asset Management Public Works Planning Water Services Wastewater	N/A	Capital	On-going	\$\$\$	Environment & Health Infrastructure Economy Safety Equity	<ul style="list-style-type: none"> • Length of infrastructure updated.
89	Continue to optimize treatment process as ambient temperatures change (increase).	Wastewater	Asset Management Public Works	N/A	Capital	On-going	\$\$\$	Environment & Health Infrastructure	<ul style="list-style-type: none"> • Continued optimization of treatment process.

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90	Itemize library building (functioning as a shelter, as needed) components susceptible to hazard impacts and plan with Asset Management for replacement.	Guelph Public Library	Culture and Recreation Asset Management Emergency Services County of Wellington	County of Wellington	Planning	Short-term	\$	Environment & Health Infrastructure Safety Equity	<ul style="list-style-type: none"> • Create list of components with associated resilience level. • Percentage of updated and/or replaced items with a low resilience rating.
91	Establish route and alternate emergency route plans with team (compare with Transit) and consider with equity lens	Emergency Services	Transit Wellington County Housing	Wellington County Housing	Planning	Short-term	\$	Environment & Health Safety	<ul style="list-style-type: none"> • Establishment of emergency routes throughout the City with an equity lens.
92	Itemize emergency building components susceptible to hazard impacts and plan with Asset Management for replacement.	Emergency Services	Asset Management	N/A	Capital	Short-term to Medium- term	\$	Environment & Health Infrastructure Safety	<ul style="list-style-type: none"> • Create list of components with associated resilience level. • Percentage of updated and/or replaced items with a low resilience rating.
93	Itemize corporate building components susceptible to hazard impacts and plan for replacement with Asset Management.	Facilities	Administrative and Operations Asset Management	N/A	Planning	Medium- term	\$	Infrastructure Safety	<ul style="list-style-type: none"> • Create list of components with associated resilience level. • Percentage of updated and/or replaced items with a low resilience rating.
94	Create a plan for handling and removal of felled trees within parks and public right-of-ways with Public Works, University of Guelph, and others as necessary.	Parks	Emergency Services Asset Management Public Works Emergency Services University of Guelph	University of Guelph	Planning	Short-term	\$	Environment & Health Infrastructure Economy Safety	<ul style="list-style-type: none"> • Create a collaborative plan between Public Works, University of Guelph, and others as necessary. • Average removal time of felled trees.
95	Itemize Waste Resource Innovation Centre (Facility) components susceptible to hazard impacts and plan for replacement with Asset Management.	Solid Waste	Asset Management	N/A	Planning	Short-term	\$	Infrastructure Safety	<ul style="list-style-type: none"> • Create list of components with associated resilience level. • Percentage of updated and/or replaced items with a low resilience rating.
96	Develop a storm sewer maintenance program.	Engineering (Stormwater)	Public Works Asset Management Health & Safety Wastewater	N/A	O&M	Short-term	\$\$	Environment & Health Infrastructure Economy Safety	<ul style="list-style-type: none"> • Create or update a storm sewer maintenance program in collaboration with Public Works and Asset Management. • Number of items addressed in the storm sewer maintenance program.

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97	Install backflow prevention at outfall to Speed River.	Wastewater	Asset Management Grand River Conservation Authority	GRCA	Capital	Short-term to Medium- term	\$\$	Environment & Health Infrastructure Safety	<ul style="list-style-type: none"> Installation of backflow prevention at outfall to Speed River.
98	Implement the recommended actions from the forthcoming Stormwater Management Master Plan (e.g., restoration of erosion sites, constructing new and retrofiting stormwater facilities).	Engineering (Stormwater)	Asset Management Public Works Engineering (Transportation) Compliance and Performance Planning Parks Wastewater Water Services	N/A	Capital	Short to Long term	\$\$\$	Environment & Health Infrastructure Safety Equity	<ul style="list-style-type: none"> Number of actions implemented from the Stormwater Management Master Plan.
99	Consider redundancy in aqueduct to direct some portion of flow to southern area of the City.	Water Services	Asset Management	N/A	Capital	Medium- term	\$\$\$	Infrastructure Safety	<ul style="list-style-type: none"> Area of the City with redundant source of water.
100	Ensure adequate air conditioning in the building and confirm storage temperature requirements of assets.	Emergency Services	Asset Management Facilities	N/A	O&M	On-going	\$	Environment & Health Infrastructure Safety	<ul style="list-style-type: none"> Percentage of systems that are considered maintained satisfactorily. Percentage of building with adequate air conditioning available.
101	Add permanent flow meters in the collection system, as specified in the Linear Water/Wastewater Master Plan.	Wastewater	Asset Management Public Works	N/A	Capital	Medium- term	\$	Infrastructure Economy Safety Equity	<ul style="list-style-type: none"> Addition of flow meters as specified in the Linear Water/Wastewater Master Plan.
102	Liaise with Engineering (Stormwater) to prioritize contaminated site clean ups on lands that can be used for stormwater management purposes (e.g., Bull Frog SWM project).	Engineering (Contaminated Sites)	Asset Management Public Works Parks Engineering (Stormwater)	N/A	Existing	On-going	\$	Environment & Health Infrastructure Economy Equity Safety	<ul style="list-style-type: none"> Area of contaminated lands safely repurposed for stormwater management purposes.
103	Itemize culture and recreation buildings components for their resilience to climate hazard impacts and plan with Asset Management for itemization and replacement.	Culture and Recreation	Asset Management Facilities	N/A	Planning	Short-term	\$	Infrastructure Safety Equity	<ul style="list-style-type: none"> Completion of an inventory of culture and recreation building assets and components and their risk to climate-related hazards Percentage of updated and/or replaced items with a low resilience rating.

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104	Maintain and update as necessary lightning protocols for Waste Resource Innovation Centre (Facility).	Solid Waste	Asset Management Emergency Services Health & Safety	N/A	Planning	Short-term	\$	Environment & Health Safety	<ul style="list-style-type: none"> • Ensurance that the lightning protocol is up-to-date.
105	Include direction to consider and incorporate LIDs in the Stormwater and Transportation Master Plans.	Engineering (Stormwater) Engineering (Transportation)	Asset Management Public Works Engineering (Transportation) Compliance and Performance Planning Parks Wastewater	N/A	Capital	Medium-term	\$\$	Environment & Health Infrastructure	<ul style="list-style-type: none"> • Inclusion of more information regarding LIDs in the Stormwater Master Plan with respect to climate adaptation. • Inclusion of more information regarding LIDs in the Transportation Master Plan with respect to climate adaptation. • Number of LIDs implemented.
106	Pursue building relocation potential outside the floodplain, consider locations with an equity lens.	Emergency Services	Asset Management Equity, Diversity and Inclusion	N/A	Capital	Planned Long-term	\$\$\$	Environment & Health Infrastructure Safety Equity	<ul style="list-style-type: none"> • Establish plan to relocate building outside the floodplain.
107	Establish a business continuity plan in case emergency building is compromised and provide alternate/redundant work environment in case the emergency buildings cannot be safely occupied.	Emergency Services	Asset Management County of Wellington Red Cross	County of Wellington Red Cross	Planning	Short-term to Medium-term	\$	Environment & Health Infrastructure Safety	<ul style="list-style-type: none"> • Establish a business continuity plan. • Number of employees with an alternative workspace available in the event of an emergency.
108	Establish redundancy plan in case emergency vehicles are compromised.	Emergency Services	Asset Management	N/A	Planning	Short-term	\$	Environment & Health Safety	<ul style="list-style-type: none"> • Number of redundant vehicles available.
109	Establish plan with Public Works if additional assistance is needed to clear route to the Arkell Spring Grounds.	Water Services	Public Works	N/A	Planning	Short-term	\$	Infrastructure Safety	<ul style="list-style-type: none"> • Establishment of plan with Public Works to clear route to the Arkell Spring Grounds.
110	Review redundancy planning for all water storage facilities.	Water Services	Asset Management	N/A	Planning	Short-term	\$	Infrastructure Safety	<ul style="list-style-type: none"> • Number of water storage facilities with a redundancy plan.

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111	Actively update a data log of damages by location and hazard, and work with Public Works to pinpoint best locations for tree plantings for long-term growth and wind protection of assets.	Parks	Planning Public Works Asset Management University of Guelph	University of Guelph	Capital	Short-term to Medium- term	\$\$	Environment & Health Infrastructure	<ul style="list-style-type: none"> Percentage of City with a tree canopy. Number of new trees planted. Frequency of data log update.
112	Maintain cooling feature in vehicles with adequate hydration available for staff. Provide redundancy in case cooling fails in a vehicle.	Emergency Services	Asset Management	N/A	O&M	On-going	\$	Environment & Health Safety	<ul style="list-style-type: none"> Number of emergency vehicles with cooling feature. Number of redundant vehicles available with cooling feature.
113	Provide redundant equipment elsewhere or a plan to access equipment in case the assets are damaged.	Emergency Services	Asset Management	N/A	Capital	Medium- term	\$\$	Environment & Health Infrastructure Safety Equity	<ul style="list-style-type: none"> Number of redundant equipment available. Establishment of plan to access equipment, as necessary.
114	Update the Automated Meter Reading technology to inform and account for water within each City district.	Water Services	Asset Management	N/A	Capital	Short-term to Medium- term	\$\$	Infrastructure Economy	<ul style="list-style-type: none"> Update of the Automated Meter Reading technology.
115	Create relocation plan for assets and stage the rollout to avoid service disruption. Create an interim plan to protect equipment from flooding at data centers.	Information Technology	Asset Management Communications	N/A	Planning	Short-term	\$\$	Infrastructure Economy Safety	<ul style="list-style-type: none"> Creation of relocation plan. Creation of interim plan to protect equipment.
116	Continue to consider climate adaptation measures in the design of the Woods WTP upgrade.	Water Services	Asset Management Facilities	N/A	Capital	Short-term	\$\$\$	Infrastructure Safety	<ul style="list-style-type: none"> Incorporation of the climate adaptation measures in the design of the Woods WTP upgrade.
117	Add inclement weather shelters to the facility.	Solid Waste	Emergency Services Asset Management Health & Safety	N/A	Capital	Medium- term	\$ to \$\$	Environment & Health Infrastructure	<ul style="list-style-type: none"> Number of weather shelters available.

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118	Design and build new Baker Street library with climate adaptation lens.	Guelph Public Library	Culture and Recreation Asset Management	N/A	Capital	Short-term to Medium- term	\$\$\$	Infrastructure	<ul style="list-style-type: none"> Incorporation of climate change into building design. Number of elements incorporating climate adaptation.
119	Continue the water meter program.	Water Services	Asset Management	N/A	Capital	On-going	\$\$ to \$\$\$	Infrastructure Economy	<ul style="list-style-type: none"> Continuation of the water meter program.
120	Continue completing risk assessments of contaminated lands and prioritize climate resiliency when implementing risk management measures.	Engineering (Contaminated Sites)	Asset Management Public Works Parks Engineering (Stormwater)	N/A	Existing	On-going	\$\$	Environment & Health Infrastructure Economy Safety	<ul style="list-style-type: none"> Number of risk assessments completed with a climate change lens for prioritization.
121	Apply lessons from other jurisdictions into planning (e.g., BC Contaminated Lands, federal guidelines).	Engineering (Contaminated Sites)	Asset Management Public Works Engineering (Stormwater) Parks	N/A	Planning	Short-term	\$	Environment & Health Economy	<ul style="list-style-type: none"> Incorporation of new lessons learned from other documents into the main planning document.
122	Include climate change as part of prioritization of site remediation.	Engineering (Contaminated Sites)	Asset Management Public Works Engineering (Stormwater) Parks	N/A	Planning	Short-term	\$	Environment & Health Economy	<ul style="list-style-type: none"> Incorporation of climate change into the planning documents. Number of sites assessed with climate change in mind.
123	Communicate with MECP to prioritize cleanup of brownfield sites.	Engineering (Contaminated Sites)	Asset Management Public Works Parks Engineering (Stormwater)	N/A	Planning	Short-term	\$	Environment & Health Infrastructure Economy Safety	<ul style="list-style-type: none"> Number of brownfield sites reported to MECP.
124	Work with Parks to design and upgrade low impact development features around the culture and recreation facilities.	Culture and Recreation	Culture and Recreation Parks Asset Management Engineering (Stormwater)	N/A	Capital	Medium- term	\$\$	Infrastructure	<ul style="list-style-type: none"> Number of LIDs implemented.

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125	Maintain communications with Public Works under by-law stipulation for snow plowing.	Transit	Asset Management Public Works	N/A	Planning	On-going	\$	Environment & Health Safety Equity	<ul style="list-style-type: none"> • Estimated delays (time) due to unplowed streets. • Number of complaints received during a snow event
126	Investigate areas where permeable pavements and low impact development can be applied.	Engineering (Transportation)	Asset Management Engineering (Stormwater) Public Works	N/A	Capital	Short-term	\$ to \$\$	Environment & Health Infrastructure	<ul style="list-style-type: none"> • Completion of assessment for appropriate areas for permeable pavements and LIDs. • Area of permeable pavements implemented. • Number of LIDs implemented.
127	Investigate updating the Property Standards By-law to including providing cooling facilities to maintain ambient temperatures below a maximum temperature, (in addition to the existing provision of providing heating facilities to maintain a minimum temperature)	Public Works (Operations)	Planning and Business Services Wellington Dufferin Guelph Public Health	Wellington Dufferin Guelph Public Health	Planning	Short-term to Medium-term	\$	Environment & Health Safety Equity	<ul style="list-style-type: none"> • Number of heat related illnesses reported
128	Continue to plan plowing (road and sidewalk) routes with equity lens, in addition to schools and seniors.	Public Works	Engineering (Transportation) Emergency Services Asset Management Wellington Catholic District School Board Upper Grand District School Board Guelph General Hospital	Wellington Catholic District School Board Upper Grand District School Board Guelph General Hospital	Planning	On-going	\$	Infrastructure Safety Equity	<ul style="list-style-type: none"> • Establish equity criteria applicable to plowing and incorporate into planning documents.
129	Continue to provide buses as an emergency shelter when requested by Emergency Services.	Transit	Emergency Services Fleet Asset Management County of Wellington Red Cross	County of Wellington Red Cross	Planning	On-going	\$	Environment & Health Infrastructure Equity	<ul style="list-style-type: none"> • Number of buses available as an emergency shelter. • Average response time after request for bus as an emergency shelter.
130	Continue policy and practice of continuing bus service during inclement weather.	Transit	Emergency Services Fleet Asset Management	N/A	Policy	On-going	\$	Environment & Health Infrastructure Equity	<ul style="list-style-type: none"> • Up-to-date bus service policy during inclement weather.
131	Continue training staff on how to do route detours.	Transit	Emergency Services Asset Management Fleet	N/A	Capital	On-going	\$	Environment & Health Infrastructure Equity	<ul style="list-style-type: none"> • Number of staff trained in route detours.

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132	Continue involvement in the Emergency Operations Group.	Communications	All Departments	N/A	Planning	On-going	\$	Safety Equity	<ul style="list-style-type: none"> Attendance to meetings or regular correspondence with the Emergency Operations Group.
133	Consider how to use communications to weave in climate change adaptation and mitigation messaging and make connections across the Corporation.	Communications	All Departments	N/A	Planning	On-going	\$	Economy Safety Equity	<ul style="list-style-type: none"> Number of communications with climate change adaptation and mitigation messaging.
134	Continue involvement with emergency shelter support.	Equity, Diversity and Inclusion	All Departments County of Wellington Red Cross	County of Wellington Red Cross	Policy	On-going	\$	Environment & Health Infrastructure Safety Equity	<ul style="list-style-type: none"> Capacity (number of people) of emergency shelters throughout the City.
135	Continue to send out alerts on Guelphs alert system from the Community Emergency Management Coordinator.	Public Works	All Departments	N/A	O&M	On-going	\$	Environment & Health Economy Safety Equity	<ul style="list-style-type: none"> Number of alerts sent from the Community Emergency Management Coordinator.
136	Establish emergency internal and external communications that include digital and broadcast media in multiple languages, as well as American Sign Language.	Communications	All Departments County of Wellington Red Cross	County of Wellington Red Cross	Capital	On-going	\$	Infrastructure Safety Equity	<ul style="list-style-type: none"> Percentage of population that receive messaging in their first language (in accordance with census). Number of languages included in messaging.
137	Develop a list of support agencies to contact during an emergency to accelerate assistance to those in need. Create a plan outlining how and when these agencies will be contacted efficiently.	Communications	All Departments County of Wellington Red Cross	County of Wellington Red Cross	Capital	On-going	\$	Infrastructure Safety Equity	<ul style="list-style-type: none"> Completion of list of support agencies and plan to contact these agencies efficiently.
138	Establish regular meetings with the Community Emergency Management Coordinator, Red Cross, WDGPH, and County of Wellington.	Equity, Diversity and Inclusion	All Departments County of Wellington Red Cross WDGPH	County of Wellington Red Cross WDGPH	Planning	Short-term	\$	Environment & Health Economy Safety Equity	<ul style="list-style-type: none"> Attendance of regular meetings with the Community Emergency Management Coordinator, Red Cross, and County of Wellington.

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139	Asset Management to take on the role of monitoring progress on implementing actions recommended in the City's Climate Adaptation Plan and updating this Plan every five years.	Asset Management	All Departments	N/A	Capital	Short-term	\$	Environment & Health Infrastructure Safety Equity	<ul style="list-style-type: none"> • Update of the CAP. • Continued monitoring and implementation of actions in CAP.
140	Engage Mississaugas of the Credit First Nations (MCFN) and Six Nations of the Grand River (SNGR) in the City's pre-consultation process.	All Departments	All Departments Mississaugas of the Credit First Nations Six Nations of the Grand River	MCFN SNGR	Policy	Short-term	\$	Environment & Health Equity	<ul style="list-style-type: none"> • Number of projects that engage MCGN and SNGR in the City's pre-consultation process.
141	Form an internal climate change working group, to be led by Asset Management, as per the Asset Management Plan recommendations	Asset Management	All Departments	N/A	Planning	Short-term	\$	Environment & Health Infrastructure Safety Equity	<ul style="list-style-type: none"> • Number of meetings held by the climate change working group.
142	Continue to play an active role in supporting new businesses and industries to Guelph that align with the City's sustainability and resiliency goals	Economic Development	All Departments	N/A	Planning	On-going	\$	Economy Safety Equity	<ul style="list-style-type: none"> • Percentage of businesses and industries committing to the City's sustainability and resiliency goals.
143	Continue to be a member of the Fire Services Joint Health & Safety committee, and involved in fire drills.	Health & Safety	All Departments	N/A	Planning	On-going	\$	Environment & Health Safety	<ul style="list-style-type: none"> • Continued membership in the Fire Services Joint Health & Safety committee. • Number of fire drills participated in.
144	Continue incentive programs for private rainwater harvesting and rain barrels.	Engineering (Stormwater)	Asset Management Compliance and Performance Planning	N/A	Capital	On-going	\$\$	Environment & Health Infrastructure Equity	<ul style="list-style-type: none"> • Number of rainwater harvesting units and rain barrels sold.
145	Establish business continuity plan in case communications are not available.	Communications	All Departments All PWG	All	Planning	Short-term	\$	Economy Safety Equity	<ul style="list-style-type: none"> • Percentage of BCPs that consider climate-related risks

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146	Work with City Departments to apply an equity, diversity, and inclusion lens when planning and prioritizing services or infrastructure upgrades/replacements. Establish a formal means of communication.	Equity, Diversity and Inclusion	All Departments	N/A	Planning	Short-term	\$	Environment & Health Economy Safety Equity	<ul style="list-style-type: none"> Number of plans and services confirming an EDI consideration. Establishment of a formal means of communication
147	Continue to follow and adopt the Community Engagement and Communications Plan, and coordinate community consultation with the Sustainability Master Plan.	Communications	All Departments All PWG	All	Policy	On-going	\$	Environment & Health Infrastructure Economy Safety Equity	<ul style="list-style-type: none"> Continued adoption of the Community Engagement and Communications Plan. Continued consultation with the Sustainability Master Plan.
148	Leverage appropriate communications tactics during climate related events	Communications	All Departments All PWG	All	O&M	On-going	\$	Safety Equity	<ul style="list-style-type: none"> Strategies in place to target communications during climate related events.
149	Continue to enhance partnerships with Partner Working Group	Equity, Diversity and Inclusion	All PWG	All	Policy	On-going	\$	Environment & Health Infrastructure Economy Safety Equity	<ul style="list-style-type: none"> Number of touchpoints with the Partner Working Group.
150	Maintain first aid training for staff at library, including equity considerations.	Guelph Public Library	Asset Management Equity, Diversity and Inclusion Emergency Services County of Wellington Red Cross	County of Wellington Red Cross	O&M	On-going	\$	Environment & Health Safety Equity	<ul style="list-style-type: none"> Number of staff with first aid training. Ensure equity components are integrated in first aid training.
151	Maintain first aid training for staff at recreational facilities, including equity considerations.	Culture and Recreation	Asset Management Equity, Diversity and Inclusion Emergency Services County of Wellington Red Cross	County of Wellington Red Cross	O&M	On-going	\$	Environment & Health Safety Equity	<ul style="list-style-type: none"> Number of staff with first aid training. Ensure equity components are integrated in first aid training.
152	Continue to set up traffic control in emergency situations for emergency management systems.	Public Works	Engineering (Transportation) Transit Asset Management	N/A	O&M	On-going	\$	Environment & Health Infrastructure Safety	<ul style="list-style-type: none"> Average response time in establishing traffic control in emergency situations.

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153	Update thermal stress policies as appropriate.	Health & Safety	All Departments	N/A	Policy	On-going	\$	Environment & Health Safety	<ul style="list-style-type: none"> Up-to-date thermal stress policies.
154	Grow the circular economy by creating and implementing the Circular Economy Framework.	CAO's Office	Solid Waste County of Wellington	County of Wellington	Capital	On-going	\$\$	Environment & Health Economy Safety Equity	<ul style="list-style-type: none"> Investment (\$) in the Circular Economy Framework. Budget allocated for resiliency in the food stream.
155	Dedicated Health & Safety Specialists for Environmental Services (Water Services, Wastewater and Solid Waste), Public Works, Parks, and Transit.	Health & Safety	All Departments	N/A	Capital	On-going	\$\$	Environment & Health Safety	<ul style="list-style-type: none"> Number of departments with a dedicated Health & Safety Specialist.
156	Identify a specific person in the City that community support agencies can contact in the event of an emergency	Equity, Diversity and Inclusion	All Departments	N/A	Policy	On-going	\$	Environment & Health Safety Equity	<ul style="list-style-type: none"> Assign emergency contact for community support agencies.
157	Participate in regular emergency exercises with Wellington County, with whom paramedic services are shared and police services work closely together.	Emergency Services	Emergency Services Equity, Diversity and Inclusion County of Wellington	County of Wellington	Planning	On-going	\$	Environment & Health Safety	<ul style="list-style-type: none"> Number of emergency exercises conducted with Wellington County.
158	Participate in the Water Managers Working Group with GRCA and other municipalities in the watershed.	Water Services	Wastewater Grand River Conservation Authority	GRCA	Planning	Short-term	\$	Environment & Health Infrastructure Safety	<ul style="list-style-type: none"> Number of meetings/communication with the Water Managers Working Group with GRCA.
159	Expand upon rebate program for private rainwater harvesting, rain barrels, downspout disconnect.	Compliance and Performance	Engineering (Stormwater) Asset Management Public Works Communications	N/A	Capital	Medium-term	\$	Environment & Health Infrastructure Equity	<ul style="list-style-type: none"> Number of rainwater harvesting units and rain barrels sold. Percentage of downspouts disconnected.

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160	Improve communication to the community to manage windy days. Carts must be heavier or kept them inside.	Solid Waste	Communications	N/A	Planning	Short term	\$	Economic Safety	<ul style="list-style-type: none"> Number of cart replacements or complaints.
161	Develop cold stress policy, policy for staff working outside in high winds, flooding, and update as needed heat stress policy. Communicate these to all departments.	Health & Safety	All Departments	N/A	Policy	Short-term	\$	Environment & Health Safety	<ul style="list-style-type: none"> Completion of policy for staff working in extreme weather conditions. Percentage of alerts sent to staff for weather events (i.e., goal of at least one alert per event).
162	City managers to prioritize staff retention recognizing that the knowledge of staff is one of the City's best assets in an emergency situation.	All Departments	All Departments	N/A	Policy	On-going	\$\$	Environment & Health Safety	<ul style="list-style-type: none"> Percentage of staff retention annually.
163	Formalize incident tracking including identifying root cause. Flag those that are weather related.	Health & Safety	All Departments	N/A	Capital	On-going	\$	Environment & Health Safety	<ul style="list-style-type: none"> Number of incidents that are weather related.