City of Surrey

Climate Adaptation Strategy

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Climate Adaptation Strategy

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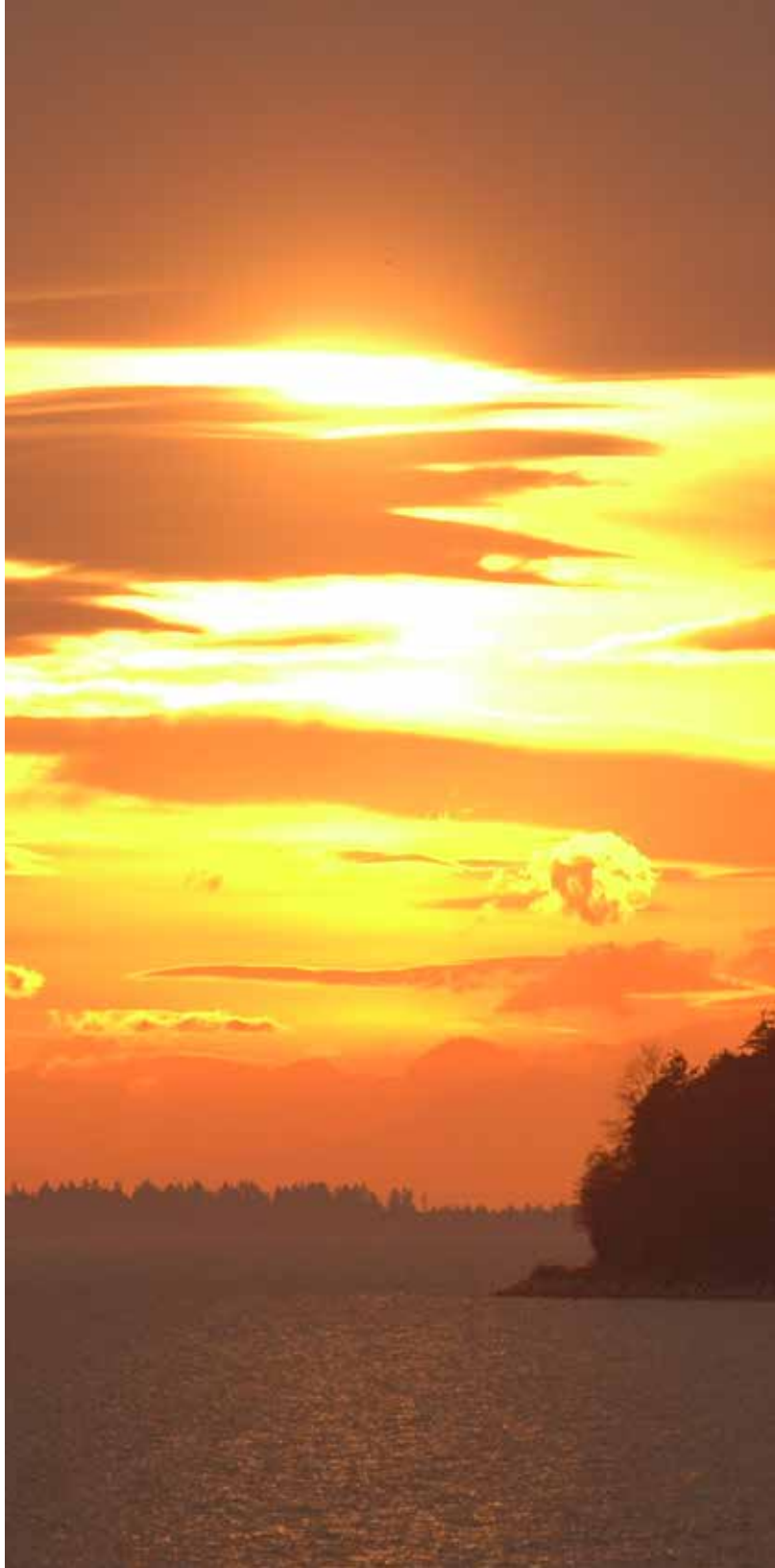

EXECUTIVE SUMMARY

As we move forward in the 21st century, the impacts from global climate change are becoming evident, and challenging all levels of government to look to the future and develop more resilient communities. Ensuring Surrey is resilient in the face of unavoidable climate change impacts is critical to maintaining community well-being, environmental health and a vibrant local economy over the long-term. With direction from Surrey's Sustainability Charter, this Climate Adaptation Strategy has been developed using a five-milestone planning framework from the International Council for Local Environmental Initiatives (ICLEI-Canada – Local Governments for Sustainability).

Through the adaptation planning process, a risk assessment identified medium to high level risks in areas related to drainage and flooding, tree mortality and ecosystem change, energy security, and agricultural viability in Surrey. In response to these impacts, cross-departmental working groups have developed 91 actions to increase resilience in six sectors:

- Flood Management and Drainage
- Infrastructure
- Ecosystems and Natural Areas
- Urban Trees and Landscaping
- Human Health and Safety, and
- Agriculture and Food Security

Many of Surrey's existing policies and practices support community resilience, and position the City to respond proactively to new challenges posed by climate change. The actions identified within the Climate Adaptation Strategy build upon our existing adaptive capacity and provide direction for the City to further strengthen our existing policies, develop new programs or practices where gaps exist, work collaboratively with key partners and senior levels of government, and undertake the research necessary to ensure we are making the best decisions within the right time frames.

The Strategy ensures that the City is doing what needs to be done, in a timely and cost effective way, based on the best available science and information. As our knowledge evolves, so will this Strategy. The Strategy further recognizes the critical role that senior levels of government will play in helping cities adapt to a changing climate, and identifies where the City will lead and where we will need assistance.

Taking action is more than just preparing for uncertainty and stranger weather. A community that is resilient to climate change has a localized economy, strong and healthy ecosystems, tight-knit neighbourhoods, and a strong social fabric; it is walkable, energy efficient, and can thrive through disruptions such as rising energy and food prices or a natural disaster. Through proactive action in Surrey, we can achieve these goals and simultaneously realize a host of community benefits, including economic development, community health and wellness, and the continued development of a strong and liveable City over the decades to come.

Acknowledgements

CITY OF SURREY STAFF

The Climate Adaptation Strategy was coordinated and written by the City's Sustainability Office: Maggie Baynham (Sustainability Coordinator), Ruth Legg (Sustainability Intern), and Polly Ng (Sustainability Intern), with oversight from Anna Mathewson (Sustainability Manager).
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A large number of City Staff participated in cross-departmental working groups to define the adaptation actions:

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GUIDANCE AND SUPPORT

ICLEI Canada: Local Governments for Sustainability provided a strategy development framework and ongoing support as part of their Building Adaptive and Resilient Communities (BARC) program. Six other local governments in British Columbia were simultaneously participating in the BARC program, and shared experiences and support throughout the process.

STAKEHOLDER CONTRIBUTIONS

The following organizations provided input and valuable feedback:
BC Healthy Communities, BC Landscape and Nursery Association, Diamond Head Consulting, Fraser Health, Golder Sustainable Communities , Metro Vancouver, Nicomekl Enhancement Society, Options BC, SFU Adaptation to Climate Change Team, Surrey School Board, Surrey Environmental Partners, Village Surrey

Acronyms

BCLNA: BC Landscape and Nursery Association
BCSLA: BC Society of Landscape Architects
CEEP: Community Energy and Emissions Plan
CMO: City Manager's Office
DPA: Development Permit Area
ED: Economic Development
F&T: Finance and Technology
GHG: Greenhouse gas
IPCC: Intergovernmental Panel on Climate Change
ISMP: Integrated Stormwater Management Plan
NCP: Neighbourhood Concept Plan
OCP: Official Community Plan
PCIC: Pacific Climate Impacts Consortium
PRC: Parks, Recreation and Culture
P&D: Planning and Development
SLR: Sea Level Rise
SO: Sustainability Office

INTRODUCTION

CHANGING CLIMATE, CHANGING CITIES

The global climate is rapidly changing, and the need for communities to respond has never been greater. Leading scientists have pronounced the warming of the world's climate as "unequivocal" and point to mounting evidence, including rising average air and ocean temperatures, sea level rise, changing precipitation patterns and extensive melting of icecaps and glaciers worldwide. Post-industrial human activities and the release of greenhouse gas (GHG) emissions into the atmosphere are the primary drivers of these changes. Human-caused GHG emissions increased by an unprecedented 70% between 1970 and 2004 and are likely to continue their upward trend over the coming decades.

Local governments have a unique interest and opportunity in planning for a changing climate. Municipalities will bear the greatest impacts and are best situated to proactively respond to affected services at the local level. Over the coming decades, communities will need to contend with the challenges of extreme weather events, rising sea levels, infrastructure failures, food and water shortages, increasing energy costs, and community health issues caused or exacerbated by climate change. The specific impacts for each community vary, and will depend on geography, the concentration of people and assets that are exposed to climatic risks, and the resources and willingness of the community to plan for and adapt to expected changes.

Preparing for climate change early on will help local governments to build resilient communities, reduce risks, and take advantage of opportunities. Municipal decision-makers are generally well positioned to take action because of several key factors:

Mandate — Local governments' legislative mandate includes many services that will be directly impacted by climate change—from infrastructure and utilities, to parks and recreation. Adapting to new climate conditions is crucial for continuing to deliver high quality municipal services.

Local Scale — As the level of government closest to community-scale circumstances, local governments are well placed to identify unique vulnerabilities to climate change and to prepare a response tailored to a City's needs.

Managing Risk — Proactive climate change adaptation planning can bolster a City's existing risk management by anticipating and mitigating future risks, as well as identifying and making the most of potential benefits.

Fiscal Responsibility — The cost of climate change for Canada is expected to be $21-43 billion, or 0.8-1% of GDP per year by 2050, depending on global efforts to curb emissions, and economic and population growth . Adaptation can significantly reduce these costs, and is a fiscally prudent measure given the extent of municipal services affected by climate change.

WHAT IS CLIMATE CHANGE ADAPTATION?

The projected impacts of climate change will have far-reaching consequences for our economies, our ecosystems and our social well-being. Adaptation is about ensuring our communities are resilient in the face of these changes.

Adaptation strategies are diverse and they may occur through changes to individual behaviour, business practices, infrastructure management, or standards and regulation, as illustrated in Table 1. Communities may adapt in anticipation of future changes, or may act in response to experienced impacts.

> Adaptation is defined as the initiatives or measures to reduce the vulnerability of human and natural systems to the actual or anticipated effects of climate change (IPCC, 2007).

Being proactive and integrating climate considerations into local government processes and decision-making allows for greater flexibility and helps to significantly reduce the cost of anticipated climate impacts. In addition to choosing adaptation strategies that represent a value for money or effort, actions that provide win-win outcomes and support broader sustainability goals should take higher priority. Many adaptation actions are aimed at maintaining healthy ecosystems, fostering regional self-sufficiency, and supporting vulnerable populations. Implementation of adaptation strategies as outlined in this document should maximize co-benefits in areas such as:

Employment — increased jobs in key sectors (e.g. agriculture, energy, green buildings);

Energy — reduced energy costs for residents and businesses;

Air and water quality — improved through healthy ecosystem services and protected natural areas;

Liveability — enhanced with improved services (e.g. drainage; tree replacements), access to green space, and security for vulnerable populations (e.g. energy efficient housing; emergency services).

Table 1. Types of Adaptation

Type	Example
Anticipatory	Diversifying how rainfall is accommodated by using rainwater storage, permeable surfaces and enlarging drainage pipes during their replacement cycle
Reactive	Undertaking major drainage infrastructure upgrades after damage caused by heavy precipitation events
Supply Side	Building water reservoirs or using rain barrels to collect rainwater
Demand Side	Water-metering to support water conservation
Top Down	Changing national or provincial standards, such as Building Codes, to address changes in climate
Bottom Up	Developing community by-laws to regulate building construction, and increasing areas of permeable surfaces to minimize pressure on storm water systems
Autonomous	Changing the timing and species planted by farmers based on observed weather changes
Planned	Changing water resource allocation to ensure biodiversity protection, agriculture and drinking water needs are met

[Modified from the Canadian Communities' Guidebook for Adaptation to Climate Change]

INTEGRATING ADAPTATION WITH MITIGATION

The relative stability of the earth's climate over the last 10,000 years has allowed human civilization to flourish; however, human activities have increased the concentration of greenhouse gas (GHG) emissions in the atmosphere to levels not seen for at least 650,000 years. These heat-trapping gases are contributing to a rise in global temperatures, disrupting natural and physical systems upon which our health and prosperity depend. The 2007 International Panel on Climate Change (IPCC) report concluded that a temperature increase of 1 to 2°C "poses significant threats" to global ecological systems. In order to keep global temperatures from increasing beyond 2°C, global emissions need to peak before 2015 and see a 50-85% reduction below 2000 levels by 2050. For a summary of climate change science and the greenhouse effect, see Surrey's Community Climate Action Strategy overview document.

Unfortunately, the persistence of GHGs in the atmosphere means that we will experience and must prepare for some climate change impacts, regardless of global efforts to reduce GHG emissions over the coming decades. As noted in the Community Climate Action Strategy overview document, ***taking action on climate change therefore requires both mitigation and adaptation.*** Mitigation is aimed at reducing the production of greenhouse gas emissions to slow and limit the effects of climate change. Adaptation, on the other hand, seeks to minimize the inevitable impacts on our natural and human systems. Each is critical: without mitigation or a reduction in GHG emissions, no amount of adaptation will prepare us for the debilitating global effects on water, food production, biodiversity and human health. It is therefore essential that mitigation take place to "avoid the unmanageable", while adaptation concurrently aims to "manage the unavoidable."

The Cost of Climate Change

Commissioned by the British Government and authored by former World Bank Chief Economist Nicholas Stern, the 2007 *Economics of Climate Change* report estimates the annual cost of reducing GHG emissions to a safe level to be 1% of global GDP by 2050.

The report also estimates the cost of climate change impacts to be equivalent to a 20% reduction in consumption per capita if no action were taken. Stern concluded that "the benefits of strong, early action on climate change outweigh the costs".

Adaptation and mitigation can have positive mutual benefits, but require careful planning to ensure strategies do not undermine each other. For example, numerous options are available to address increasing summer temperatures. To keep people cool, one adaptation strategy would be to increase the availability and installations of air conditioning systems; however, the added energy demand resulting from this adaptation measure would be in conflict with the mitigation objective of decreasing greenhouse gas emissions. By contrast, increasing tree canopy, vegetative cover, and green roofs in the City also have a cooling effect, and act to make buildings more energy efficient. In this way, the latter option is supportive of both mitigation and adaptation goals.

To maximize beneficial linkages between adaptation and mitigation, the City developed a *Community Energy and Emissions Plan* in tandem with the *Climate Adaptation Strategy*, and which together comprise Surrey's *Community Climate Action Strategy*. The *Community Energy and Emissions Plan* identifies actions to reduce emissions in five sectors: land use, transportation, buildings, district energy, and solid waste.

A number of mutually reinforcing actions have been identified within Surrey's *Climate Adaptation Strategy* and Surrey's *Community Energy and Emissions Plan*, and are summarized in Table 2 on page 86. The linkages that simultaneously increase resilience to climate change impacts and reduce GHG emissions can be categorized into four areas:

- ***Ecosystem Protection, Hazard Avoidance, Compact Land Use:*** Focusing growth into dense urban land uses allows for the protection of green space which can strengthen the resilience of ecosystems and improve storm water management. Directing growth away from hazardous areas (e.g. floodplains) also reduces exposure to impacts from climate change. Compact, transit-oriented communities reduce transportation and building GHGs.

- ***Ecosystem Health, Carbon Sequestration:*** Healthy trees and ecosystems increase resilience to climate impacts such as increased rainfall and warmer summer temperatures. They also play an important climate change mitigation role by absorbing carbon from the atmosphere.

- **Heat Management, Passive Solar Design:** Many passive solar strategies designed to improve thermal performance and reduce GHGs (e.g. trees, reduced asphalt, insulation and green roofs) also help reduce the urban heat island effect and moderate health risks during heat waves.

- **Community-Based Energy Systems, Self-sufficiency:** Reduced snow pack and increased variability in precipitation patterns will periodically reduce hydro electric supply. Extreme storm events, too, can reduce natural gas and gasoline supplies and increase costs. Investing in community-based energy systems such as district energy, as well as local, renewable energy supplies such as geo-exchange or biomass increases resilience to fluctuating costs and supply of global markets, while reducing GHG emissions.

  In addition, more frequent intense weather events including floods, droughts and storms have the potential to temporarily or permanently disrupt global supply chains with cost implications for imported commodities, particularly food and energy. Increasing self-sufficiency and efficiency in these areas increases resilience in the local economy and reduces GHG emissions associated with transportation.

Reducing GHG emissions and preparing for the impacts of climate change are both critical components of climate action, and can have positive mutual benefits with careful planning. Table 2 summarizes the mutually reinforcing strategy areas that have been identified within Surrey's Climate Adaptation Strategy and Surrey's Community Energy and Emissions Plan. Together, these two plans comprise Surrey's Community Climate Action Strategy and reinforce the City's broader efforts toward establishing Surrey as a prosperous and resilient 21st century urban centre.

ADAPTATION IN CONTEXT

SURREY'S VISION

Our Community, the City of Surrey, will be resilient in the face of a changing climate. Through bold leadership and careful forethought, Surrey will take timely action to reduce the risks of climate change and thereby minimize social, environmental, and economic costs in the future. In partnership with key stakeholders, and through the integration of adaptation in City policy, Surrey will remain a vibrant, flexible, and prosperous community for centuries to come.

OVERARCHING GOALS

- Minimize risks and vulnerabilities to climate change impacts;
- Maximize adaptation co-benefits to achieve multiple sustainability goals;
- Integrate climate change considerations into ongoing business decisions;
- Build on existing City initiatives to make best use of existing resources;
- Ensure financial means are in place to take critical action where necessary;
- Partner with key stakeholders to take coordinated and prioritized action;
- Build adaptive capacity to respond effectively to climate change impacts over time;
- Increase awareness among the public and City staff to build support for adaptation;
- Pursue continual learning to ensure actions remain relevant and based on best practice.

To assist the City in dealing with climate change uncertainties, an adaptive management approach will be employed. Adaptive management is the process of putting in place small, flexible, incremental changes. This approach is based on regular monitoring and revision of plans using information available at the time, rather than relying on one-off, large-scale treatments. Adaptive management leaves scope for decisions about actions to be reviewed in the future, as improved information becomes available about the nature of climate change risks. The adaptive management approach helps address the challenges of uncertainty that are inherent within climate change planning, while maintaining the ability for Surrey to strengthen its risk mitigation should it become apparent that it is under-adapting to one or more climate change risks.

POLICY CONTEXT

In September 2008, Surrey City Council unanimously adopted the *Sustainability Charter*, a comprehensive framework for implementing a progressive, 50-year vision for a Sustainable City. The City has been working to achieve its vision since 2008, including progress towards its commitments on climate change. In particular, the Charter commits the City to a climate change action plan (EN11), and includes action on both mitigation and adaptation:

EN11: Surrey's Commitment to the Climate Change Action Plan

The City will undertake the following actions to reduce the causes of climate change and to mitigate potential impacts:

1. Develop strategies and take actions to achieve the goals of BC's Climate Action Charter, to which Surrey is a signatory;

2. Expedite the completion of the five milestones in the Federation of Canadian Municipalities' (FCM) Partners for Climate Protection process; and

3. Create an adaptation strategy to deal with the unavoidable impacts of climate change.

Surrey's *Community Energy and Emissions Plan (CEEP)* complements the Adaptation Strategy. The City of Surrey's Sustainability Office has coordinated the input of community members, stakeholders, City Council and City staff to create a plan to reduce energy use and greenhouse gas emissions in key sectors across the community. The goal of the CEEP is to establish Surrey as a model community in the areas of energy supply, reliability, sustainability and climate responsibility. The CEEP encourages local job creation and community re-investment; promotes vibrant, healthy neighbourhoods; and helps residents and businesses proactively address anticipated energy cost increases.

As part of the *Climate Adaptation Strategy*, Surrey has taken part in the Building Adaptive and Resilient Communities (BARC) initiative offered by the International Council for Local Environmental Initiatives (ICLEI Canada – Local Governments for Sustainability). The collaboration offers participating cities the opportunity to plan for anticipated impacts related to local and regional climate change. Participating cities worked in peer groups with facilitation, support, and direction from ICLEI Canada staff. Locally, other collaborators include: Metro Vancouver, the City of Vancouver, the Corporation of Delta and the City of North Vancouver.

ICLEI – Local Governments for Sustainability

ICLEI is an international non-profit, with a local chapter in Canada. It has established itself as a leading organization and expert in climate change planning, specializing in easy-to-use frameworks that allow local governments to develop their own custom-made plans. In 2012, the City of Surrey completed ICLEI's 5 milestone process for Corporate GHG reduction as part of ICLEI's Partners for Climate Protection (PCP) program offered in partnership with the Federation of Canadian Municipalities.

With the initiation of the Climate Adaptation Strategy, Surrey was part of the first 'cohort' to participate in ICLEI's adaptation program. Choosing to partner with ICLEI on this initiative enabled the City to cost-effectively develop a strategy tailored to Surrey's needs, and work collaboratively with other municipalities in this emerging field.

PLANNING PROCESS

The planning process began with the ICLEI collaborative in 2011, following approval by Surrey City Council in February 2011 (Council Report No.R028). Facilitated by ICLEI, the City of Surrey is following a five-milestone approach to climate change adaptation: initiate, research, plan, implement and monitor. The five-milestone process is outlined in ICLEI's *Changing Climate, Changing Communities: Guide and Workbook for Municipal Climate Adaptation*.

The Initiate Phase includes identifying stakeholders, building an adaptation team, and communicating with stakeholders.

The Research Phase involves recording climatic changes, identifying impacts, conducting vulnerability and risk assessments, and engaging stakeholders.

The Plan Phase includes setting an adaptation vision, goals, targets and objectives, identifying and assessing options, finalizing actions and establishing indicators.

Following the approval of the Adaptation Strategy, City staff will move to the **Implement** and **Monitor/Review Phases**, which include identifying implementation tools and initiating actions, engaging and communicating with residents and stakeholders, tracking progress and effectiveness of actions, and revisiting and revising the strategy as necessary.

Figure 1: ICLEI's 5 Milestone Planning Process

Milestone 1: Initiate

Build an Adaptation Team

An Adaptation Advisory Team representing multiple City departments was established at the outset of the process and guided the development of the Adaptation Strategy at every stage. Team members defined the overarching vision and goals, and helped to identify climate change impacts, review risk assessment outcomes, and evaluate adaptation options. They also contributed feedback and direction on staff engagement, provided a cross-sectoral perspective, and served as champions, raising interest and awareness within their respective departments.

Milestone 2: Research

Identify and Evaluate Impacts

Climate change projections were obtained from the Pacific Climate Impacts Consortium, BC Ministry of Environment reports and other credible and scientific sources. Following background research and interviews with City staff, a set of 18 impact statements were developed to describe the key ways in which Surrey would be affected by projected climatic changes.

A vulnerability and risk assessment was conducted for each impact statement to determine the areas in which the City should focus its effort. The vulnerability component of the assessment considered each service area's sensitivity and adaptive capacity. The risk component assessed the likelihood of an impact occurring over the short and long term, and the consequences of the impact for public safety, the local economy and private property, regionally important infrastructure, environmental quality, and City government

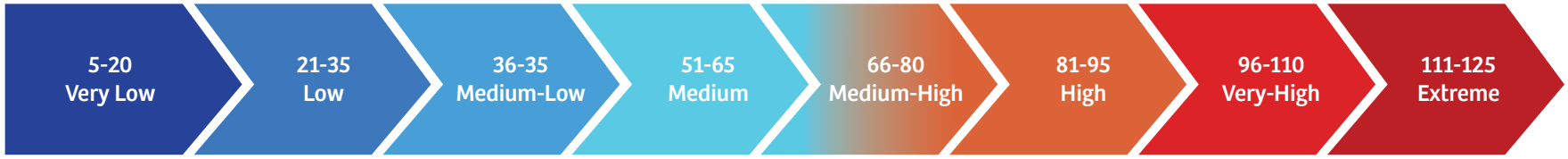
Sensitivity: The degree to which a system is affected, either adversely or beneficially, by climate-related stimuli.

Adaptive Capacity: The ability of the built, natural and social systems to adjust to climate change, to moderate potential damages, to take advantage of opportunities, or to cope with the consequences. (IPCC, 2001)

operations. Over 30 staff from multiple departments were brought together to conduct the assessment in a workshop-style format. The resulting risk ratings were then reviewed by the Adaptation Advisory Team to ensure consistency between scores. See Appendix D for details on the risk assessment methodology and outcomes.

None of the impacts were calculated to be 'very high' or 'extreme' risk (see: Figure 2). Climate impacts that were assigned a low risk rating were removed and the remaining 14 were brought forward to be addressed in the strategy development phase. Given that some actions may require little effort or could have valuable ancillary benefits, impacts with a medium-low or medium risk rating were included in the strategy development phase. The level of risk assigned to each impact was later used to help prioritize adaptation strategies.

Figure 2. Risk Rating Spectrum



Risk Assessment Summary for 14 Climate Impacts:

High Risk

- Increase in frequency and duration of flooding within low lying floodplains due to reduced system drainage resulting from sea level rise (SLR) and more intensive precipitation events
- Reduced subsurface drainage in some floodplain areas due to seepage and/or rising water table associated with SLR and more intensive precipitation events
- Increased probability that existing sea dykes will be overtopped due to a combination of SLR, subsidence, and storm surge and wind setup resulting from significant weather events

Medium-High Risk

- Increased tree mortality rate and change in urban forest composition due to increase in hot weather, decreased summer precipitation, and increased winter precipitation leading to more saturated soils in lowlands
- Impacts on the viability of agricultural crops and other vegetation in floodplain areas, due to saltwater intrusion associated with SLR
- Change in streams' ecological composition due to increased summer temperatures and changing precipitation regimes altering stream base flow

Note: More context on these impacts and how they relate to different sectors is provided in the 'Sector Review and Actions' section.

Medium Risk

- Increased risk of Fraser River freshet flooding due to changing temperature and precipitation regime in the Fraser River Basin, and SLR raising Fraser River water levels
- Agricultural irrigation (river and well) demand exceeds supply due to increased temperatures, decreased summer rainfall, and increased agricultural growing due to increased growing degree days
- Increased heat stress and other health ailments due to increase in heat advisory days
- Increased energy costs and energy insecurity due to increased cooling load and changing temperatures and precipitation regimes in BC electrical grid supply areas, impacting seasonal availability of hydroelectric power

Medium-Low Risk

- Increased maintenance costs and premature failure of underground infrastructure due to saltwater intrusion
- Increased risk of urban interface fires (eg. forest fires and fires in other natural areas due to increased temperatures and drier summers)
- Loss of tidal mudflats and marshland ecosystems on seaward-side of dykes due to increased wave action and erosion associated with SLR and existing dyke positions
- Increased human health impacts including greater spread of pathogens due to warmer, wetter winter climate

Milestone 3: Plan

Developing and Prioritizing Strategies

Following the risk assessment, cross-departmental staff teams met regularly and developed overarching goals and actions to address the climate impacts identified for different sectors. The six working groups were:

- Flood Management and Drainage
- Infrastructure
- Ecosystems and Natural Areas
- Urban Trees and Landscaping
- Agriculture and Food Security
- Human Health and Safety

Once a refined list of actions was developed by each working group, the feasibility of implementing each action was evaluated based on criteria related to cost, ancillary benefits, urgency, political acceptability, and capacity. The feasibility outcomes were then mapped against the sectors' risk ratings to give a priority level (see Appendix E for full description of the prioritization methodology). The Advisory Team then used the prioritization ratings to identify 11 actions for immediate implementation. The expertise of external stakeholders was engaged at critical points throughout the process through one-on-one interviews and targeted workshops.

CLIMATE SCIENCE AND PROJECTED IMPACTS

CHANGES GLOBAL TO LOCAL

At the international scale, global climate change is tracked and assessed by the Intergovernmental Panel on Climate Change (IPCC), an organization committed to providing a current, scientific and technical perspective. Leading scientists from around the globe who contribute to the IPCC agree that the Earth's climate is changing and that the chief cause of this change is human activity. Impacts at the global scale are already being experienced around the world—including increased annual temperatures, increased rate of glacier melt, more extreme weather events, increased flooding, and more pervasive droughts.

While climate change is global, the local impacts in different regions of the world vary widely. Here in Surrey, rising average temperatures and more frequent and intense rainfall events have already been observed, and are expected to continue on that trajectory. In British Columbia, the University of Victoria's Pacific Climate Impacts Consortium (PCIC) delivers high quality climate data, analysis and interpretation to local governments and other stakeholders. The City of Surrey also collects extensive weather data which assists the City in corroborating projections, undertaking finer-grained analyses and recognizing emerging trends. Climate projections and historic weather trends must now be considered together in decision-making since historic weather is no longer an accurate predictor of future climate.

Despite ever-improving data and projections, uncertainty is inherent in projecting climate change. The future climate hinges on how the global community responds to the task of drastically reducing GHG emissions over the coming years; as a result, differing GHG emissions scenarios play into a wide range of plausible climate outcomes. Moreover, scientists will always have an imperfect understanding of the climate system and will constantly be challenged to capture it in models; the promise of better data will always be around the corner and should not deter timely, effective and appropriate action. Following the precautionary principle, and using tools such as adaptive management, the City will strive to make the best decisions based on the best available science.

See Appendix C for a detailed table of climate projections in Metro Vancouver and Surrey.

Temperature

By the 2050s, Metro Vancouver is projected to have summer temperatures that are 1.4°C to 2.8°C warmer (see Figure 3) and winter temperatures that are 0.8°C to 2.7°C warmer, with an average increase of 1.7°C year-round. Projections show changes in variables related to temperature including increased growing degree days, cooling degree days, and frost free periods, along with decreased heating degree days and precipitation as snow. Analysis of historic weather data shows Surrey has experienced statistically significant changes in all these variables between 1960 and 2000 (Figure 4).

Extreme temperatures are also anticipated to increase; extremely hot days which historically occur every 10 years (exceeding 32°C - 35°C) are projected to occur over twice as often by the 2050s in Metro Vancouver. Results from specialized high resolution models indicate that the daytime summer high temperatures can be expected to be warmer than present-day San Diego by the 2050s in a high-warming scenario, and by the 2080s in a lower-warming scenario.

Projected mean temperatures such as Figure 3 are based on a set of 30 commonly used Global Climate Models (GCMs).

Figure 3. Metro Vancouver Mean Summer Temperature Projection (Source: PCIC, Plan2Adapt Tool (2013))

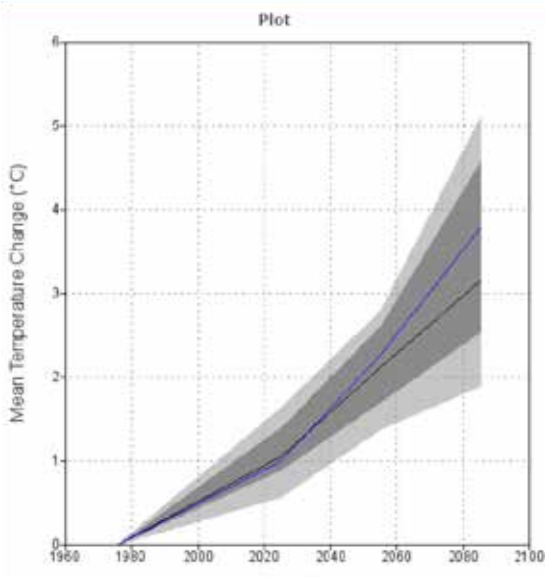
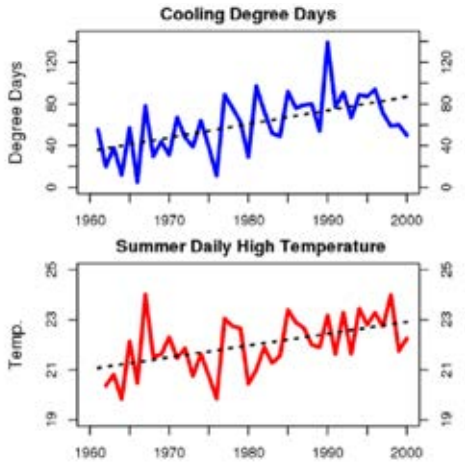


Figure 4. Surrey Newton Historic Temperature-Based Trends (Source: PCIC, 2012)



Precipitation and Wind

Changes to precipitation patterns exhibit a wider range than temperature projections, with wetter winters and drier summers generally anticipated. By mid-century, Metro Vancouver is expected to see somewhere between a -4% and +15% change in winter precipitation, with the median scenario projecting a 6% increase (Figure 5). The median projection for summer precipitation is a 15% decrease, with a range of -25% to +3% (Figure 6). The amount of precipitation falling during "very wet days" (95th percentile, currently 28mm) is projected to increase by 21% in Metro Vancouver, while precipitation during "extremely wet days" (99th percentile, currently 44mm) is projected to increase by 28% in Metro Vancouver by the 2050s. Extreme precipitation events (with 3-hour duration) that in the past would occur once every 10 years, are projected to occur on average three times as often in the future.

A recent precipitation trend analysis looking at hourly rainfall data in Surrey from 1965 to 2011 showed statistically significant changes in rainfall patterns across 19 indicators. The historic analysis showed that Surrey is experiencing increases in both the frequency and intensity of moderate and heavy precipitation events. The analysis also showed that the most significant changes in intense rainfall have occurred over the past two decades; however, short-term trends are susceptible to influence from effects due to natural variability such as the Pacific Decadal Oscillation. More detailed modelling and analysis is necessary to complement the climate models and develop Surrey-specific design standards.

In Metro Vancouver, projections for wind speed return periods are varied, with occurrences projected up to 2.7 times as often or as seldom as 0.2 as often as in the past.

Figure 5. Metro Vancouver Summer Precipitation Projection (Source: PCIC, Plan2Adapt Tool (2013)

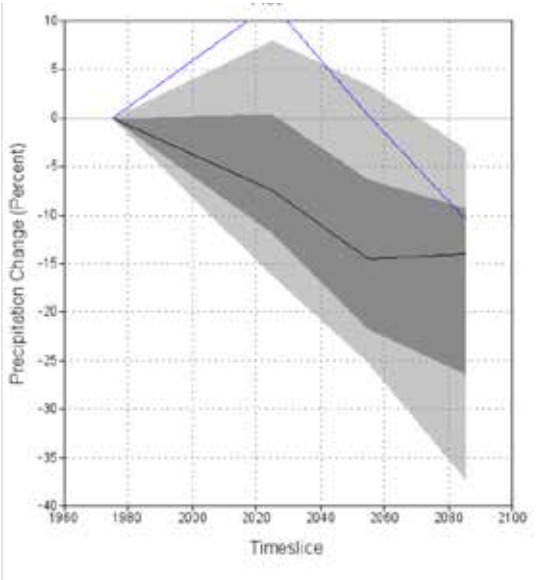
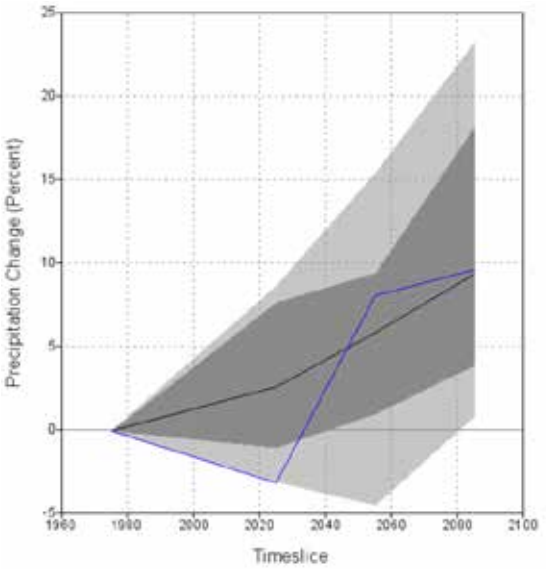


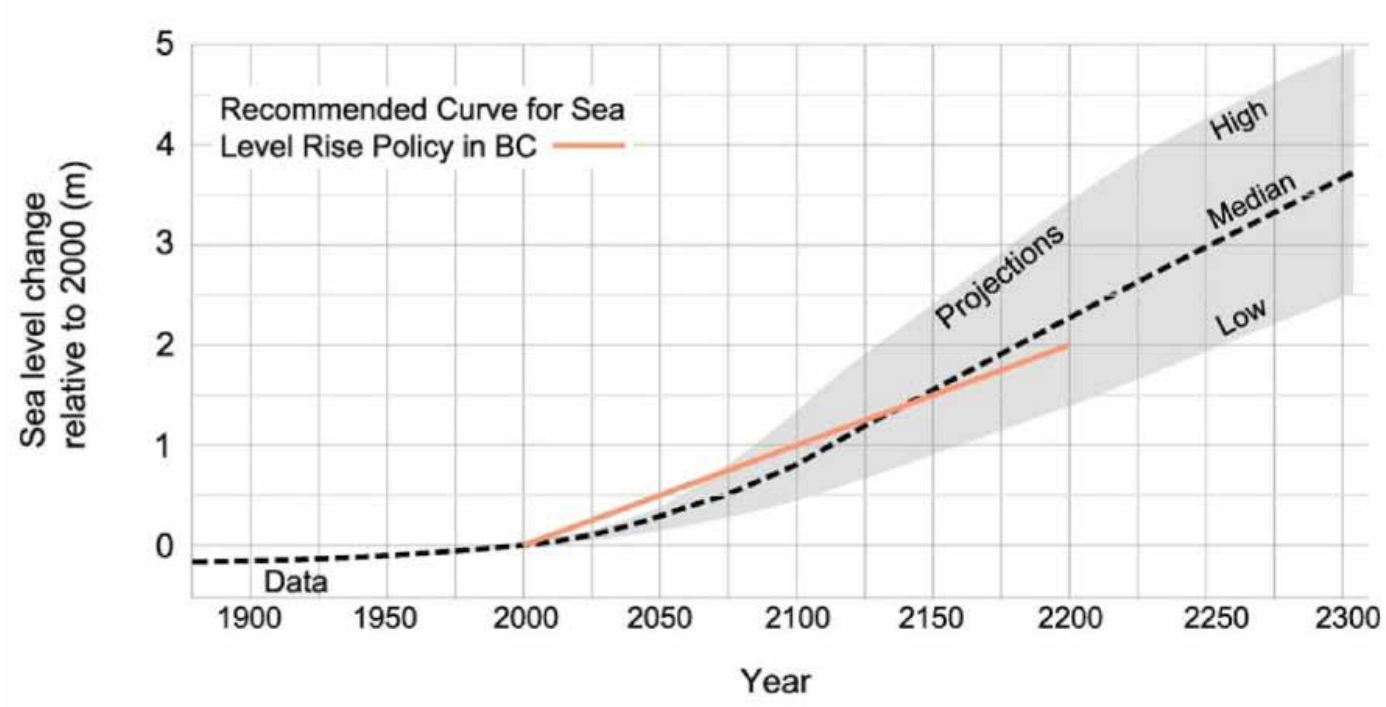
Figure 6. Metro Vancouver Winter Precipitation Projection (Source: PCIC, Plan2Adapt Tool (2013)



Sea Level Rise

Global Sea Level Rise (SLR) is due to the ocean's thermal expansion and glacial melt, both products of increasing global temperatures. Sea levels have been rising at approximately 3.1mm per year in recent years, but this is expected to accelerate substantially with climate change in coming decades.

Figure 7: Sea Level Rise Guidelines for British Columbia (Source: BC Ministry of Environment Sea Dike Guidelines)



The BC Ministry of Environment has recommended planning for 1m of SLR by 2100 and 2m by 2200 (Figure 7). Using the provincial information as a baseline, the City has further investigated the rate of SLR and subsidence within the community. Subsidence is variable throughout the lowlands of Surrey; however, for the purposes of detailed impact work an average value of 0.225mm/year was assumed recognizing the need for more advanced assessments on this item. Combining the effects of rising seas and subsidence, Surrey is projected to see a net SLR increase of 1.195m (2010 base) by 2100. Further studies are being undertaken to better understand the combined effects of SLR with heavy precipitation events, storm surge, wave effects and wind events in Surrey.

SECTOR REVIEW AND ACTIONS

From the City's efforts to define and protect its Green Infrastructure Network and biodiversity corridors, to the successful implementation of the Strategic Plan for Lowlands Flood Control, many of the City's past and current actions are contributing to its ability to effectively anticipate and respond to climate change. The 91 adaptation actions identified in this section seek to formalize and build upon the City's existing adaptive capacity.

In the following section, key cross-cutting actions are identified, with the remaining adaptation actions organized under six sectoral areas:

- Flood management and drainage;
- Infrastructure;
- Ecosystems and natural areas;
- Urban trees and landscaping;
- Agriculture and food security; and
- Human health and safety.

Each section is prefaced by a description of the ‘current state’, which provides background information on the sector’s existing strengths, stresses and adaptive capacity.

The ‘potential impacts’ subsection provides information on how that sector is likely to be affected by climate change, and the outcomes from the risk assessment are summarized.

The goals for each area were developed by staff working groups and adjusted based on stakeholder feedback, where applicable.

The immediate implementation actions were identified by the staff Advisory Team following a prioritization process that considered each action’s feasability and risk rating, as described in Appendix E.

Details relevant to the implementation of each action, including the supporting City departments, related policy tools, relative costs, and spheres of influence can be found in Appendix A.

Cross-Cutting Actions

The following three actions cut across all sectors of adaptation and are central to building a resilient community through policy integration, education, and community engagement.

	Adaptation Action	City Lead
CC-1.1	Review City policies and by-laws to identify those practices that support resilience, and reinforce their implementation and enforcement.	CMO
CC-1.2	Integrate climate change education and awareness into existing programs and communications, and develop new education initiatives where gaps exist for Surrey residents, businesses, and City Staff.	CMO
CC-1.3	Engage residents and businesses on ways they can adapt or otherwise prepare for climate change impacts (e.g. promote sustainable drainage techniques, plant appropriate tree species, emergency preparedness).	CMO

City Department Acronyms: *P&D: Planning and Development; PRC: Parks, Recreation and Culture; CMO: City Manager's Office; ED: Economic Development*

Immediate Implementation

FLOOD MANAGEMENT AND DRAINAGE

Current State

Flooding can occur in Surrey due to rainfall, snowmelt, rain on snow events, high tide events, or some combination of these conditions. With over 8,500 hectares of land within an existing floodplain area, the City of Surrey has developed a comprehensive system to manage drainage and flood risk issues within the community. There are four floodplains within Surrey: the Fraser River, Nicomekl/Serpentine, Campbell River and Boundary Bay floodplains, together controlled by over 100km of dykes, 30 drainage pump stations, two sea dams, and 170 flood boxes. This system not only defends municipal infrastructure, but controls flooding for private and senior government lands and assets including significant agricultural land, highways, port and railway facilities, and the community's water, sewer, energy and telecommunication utilities.

B.C. Ministry of Environment provides province-wide guidelines for dyke crest elevations and building flood construction levels. The City of Surrey is responsible for maintaining the dyking system on the Fraser River, Crescent Beach, and most of the dykes along the Serpentine and Nicomekl Rivers except for Colebrook and Mud Bay Dyking District Areas. In addition, the City is accountable for the community-wide drainage system which includes over 1,100km of ditches and over 1,700km of storm sewers, with an average useful life of 70% remaining on this infrastructure.

The Fraser River is susceptible to freshet flooding each spring, where melted snowpack overwhelms the river's conveyance capacity and floods its banks. The flood of 1948 breached over a dozen dyking systems in the Fraser Valley, damaged or destroyed 2,300 homes, caused the evacuation of 16,000 people and cost over $150 million (2010 dollars) in damage and recovery. Another significant flood occurred in 1972. While flooding of this magnitude has since been avoided, peak snow conditions have posed significant flood risk numerous times since, including 1974, 1999, 2007, and 2011. The Nickomekl and Serpentine river basins are prone to flooding from extreme precipitation events and runoff from the uplands, strong Westerly winds, and high tide events. Prompted by persistent flooding in Surrey's agricultural land and increasing impacts from upstream development, the City invested $40 million over 10 years to upgrade drainage and flood infrastructure as part of the *Strategic Plan for Lowlands Flood Control*, beginning in 1997. The City has seen significant improvements to flood impacts in the lowlands since implementing the Strategic Plan.

In addition to infrastructure, the City has a number of policies in place to help limit the risk of flooding and extent of damage from flood events. While the City has long had a practice of limiting development within the lowlands, in 2008 Council endorsed the *Development within the Nicomekl and Serpentine River Floodplains* policy, which formally restricts development within the Serpentine/Nicomekl 200-year floodplain. The Surrey Zoning By-law provides floodproofing regulations, including community-specific policies for flood-prone areas. Stormwater management is embedded in land use decisions through the development of Integrated Stormwater Management Plans and through incorporation into Neighbourhood Concept Plans. In addition, the City's drainage infrastructure has retained open streams as the foundation of the stormwater network since the adoption of the *Natural Drainage Policy* in 1979.

In the case of a major flooding event, the Surrey Emergency Program is prepared to support evacuation, if necessary.

Climate Change Impacts

If unaddressed, climate change is anticipated to significantly increase the risk of flooding in Surrey in a number of different ways. First, protective infrastructure such as sea dams and dykes are more likely to be breached with sea level rise, particularly in combination with more intense storm surges. Second, sea level rise and more frequent and intensive precipitation events may increase the frequency and duration of flooding in flood plain areas due to more frequent and intensive precipitation events. Third, sea level rise may cause local water tables to rise, increasing the risk of surface pooling and flooding. The degree of risk is less certain regarding Fraser River freshet flooding, given the intricate dynamics of changing snowpack, rising temperatures, and shifting precipitation patterns.

Some flooding and drainage impacts are already being experienced in Surrey due to climate change. For example, the combination of sea level rise, subsidence, and high winter tides has led to a rising water table and increasing drainage problems in Crescent Beach. The City's *2009 Crescent Beach Climate Change Adaptation Study* analyzed these issues and outlined a servicing strategy with a cost of $25 to $30 million. The first component of the servicing strategy, the replacement of the Maple Drainage Pump Station, was completed in 2013.

There are four categories of response that can be considered in addressing sea level rise: accommodate, protect, retreat or avoid. Accommodating impacts means a certain level of flooding will be anticipated and accepted, and can involve flood proofing at the building level (e.g. elevated building construction) or developing a sophisticated emergency response system. Protection is a structural response which may involve the construction of dykes, sea walls, or natural buffers, such as wetlands, to provide a physical barrier to flooding. Retreating involves decommissioning or moving existing development back from the hazard over time. Finally, avoidance entails restricting new development from locating in flood prone areas and can be undertaken in conjunction with the other options.

In 2011, the Province released a draft report entitled *Climate Change Adaptation Guidelines for Sea Dikes and Coastal Flood Hazard Land Use*, which advised planning for 1.2m of sea level rise by 2100, and increased the recommended flood

construction level from 3.6m to 6.2m. In 2012, a second report was released by the Province that estimated the cost of upgrading flood protection infrastructure for sea level rise at $9.5 billion across Metro Vancouver, with $1.6 billion of that cost for infrastructure within Surrey. The City articulated some concern regarding this estimate, including the proportion of the cost dedicated to seismic upgrading, and the low probability of the combined effects (e.g. high tide, storm surge. wind set up) that informed the new recommended standards (CR#5225-17). The City is currently undertaking more detailed analysis to model and map sea level rise impacts with more locally contextual information and a greater level of accuracy. Given the regional nature of the impacts and the tremendous expense entailed, the Fraser Basin Council recently initiated a planning process to develop a Regional Flood Management Strategy that considers different flood management options in collaboration with regional stakeholders and the provincial and federal governments.

Risk Assessment Results

Climate Impact Statements	Risk
Increased probability that existing sea dykes will be overtopped due to a combination of sea level rise, subsidence, and storm surge and wind setup resulting from significant weather events	High
Increase in frequency and duration of flooding within low lying floodplains due to reduced system drainage resulting from sea level rise and more intensive precipitation events	High
Reduced subsurface drainage in some floodplain areas due to seepage and/or rising water table associated with sea level rise and more intensive precipitation events	High
Increased risk of Fraser River freshet flooding due to changing temperature and precipitation regime in the Fraser River Basin, and SLR raising Fraser River water levels	Medium

Overarching Goals and Prioritized Actions

Two key goals have been identified to address impacts and increase resilience for flood management and drainage in Surrey:

1. Reach Consensus on a Regional Approach to Flood Management
2. Update Planning and Development Standards for Floodplains

Goal 1: Reach Consensus on a Regional Approach to Flood Management		
	Adaptation Action	**City Lead**
FL-1.1	Support the development of the Regional Flood Management Strategy in coordination with senior levels of government, other municipalities, and key stakeholders	Engineering
FL-1.2	Participate in a detailed cost-benefit analysis to assess alternative options for accommodating sea level rise and coastal climate change impacts	Engineering
FL-1.3	Encourage senior levels of government to proactively commit the capital investment for flood protection infrastructure	Engineering

Immediate Implementation

Goal 2: Update Planning and Development Standards for Floodplains		
	Adaptation Action	**City Lead**
FL-2.1	Conduct detailed analysis on Surrey-specific climate impacts, including the timelines and extent of sea level rise and its related effects on flood construction levels and floodplain designations	Engineering
FL-2.2	Develop drainage and flood control strategies based on cost-benefit analyses and site-specific needs	Engineering
FL-2.3	Incorporate climate change into the City's Integrated Stormwater Management Plans (ISMPs) and other efforts to integrate land use planning and stormwater management	Engineering
FL-2.4	Review and revise regulatory By-Laws and design standards to account for and minimize the impacts of climate change	P&D

City Department Acronyms: *P&D: Planning and Development; PRC: Parks, Recreation and Culture; CMO: City Manager's Office; ED: Economic Development*

Immediate Implementation

INFRASTRUCTURE

Current State

The City of Surrey is responsible for providing and maintaining billions of dollars worth of infrastructure across the City. Capital works are funded through transportation levies, utility fees, Development Cost Charges, and tax revenue, as outlined in *The City of Surrey's 10-Year Servicing Plan*. Major infrastructure assets include:

- Drinking water system: pipes, service connections, pump stations, valves and fire hydrants
- Sanitary sewer systems: pipes, manholes, service connections and pump stations
- Drainage system: pipes, manholes, natural channels, ditches, detention ponds, sea dams, flood boxes, pump stations, and dykes
- Transportation systems: roads, active transportation networks, bridges, streetlights, traffic signals, and signage
- District energy systems: thermal energy generation systems, pipes, service connections, and energy transfer stations
- Buildings: civic facilities such as community and recreation centres
- Green Infrastructure Network: parks, streams, biodiversity corridors, hubs and sites

In many cases, the delivery of services occurs in cooperation with other organizations; for example, Metro Vancouver is responsible for managing the drinking water reservoirs, filtration plants, and water mains, as well as regional sewer trunks and wastewater treatment plants. Similarly, many players are involved in the delivery of the regional transportation system within Surrey's borders, including the Province, TransLink, Port Metro Vancouver, and CN, CP, BNSF and Southern Railways. BC Hydro and Fortis BC have traditionally delivered the vast majority of energy needs to Surrey residents; however, the City has recently established a district energy utility, Surrey City Energy.

In addition to delivering community infrastructure, the City plays an important role in providing and enforcing building regulations from the BC Building Code and the City's Buildings By-Law. In 2012, building permits for over $1 billion of development were approved in Surrey; the extent and scope of development in Surrey represent an opportunity to ensure a resilient building stock for the community.

Climate Change Impacts

Climate change has the potential to impact municipal infrastructure in a number of significant ways, with financial and safety implications for the community. In potentially disastrous incidents, infrastructure may sustain damage from extreme weather events such as wind storms, temperature extremes, heavy rain and flooding. In these instances, inadequate design or vulnerable locations may be coalescing factors that result in losses. While today's infrastructure has been carefully designed to account for historic climate extremes, it can no longer be assumed that the past will accurately represent future weather patterns. Without accounting for climate change, our built environment is vulnerable to weather events beyond what it has been designed to withstand.

Infrastructure may also be vulnerable to more gradually changing conditions, such as inundation from sea level rise or changes in the availability of water or energy. These changes may increase the operating and maintenance costs or reduce the lifespan of infrastructure. In some cases, climate impacts in the global marketplace may cause interruptions to the supply chain and have implications for the bottom line. Demand-induced effects must also be taken into consideration, such as increased pressure on water or energy resources during summer heat waves.

Adapting municipal infrastructure to climate change can take many forms, from physical interventions or structural improvements, to the relocation of assets to more secure locations. Financial and policy changes may also be needed, such as more comprehensive insurance or more thorough health and safety response plans in the event of infrastructure failure. Demand-side management programs to reduce water or energy usage may be implemented to reduce the pressure on service delivery. Complementing or replacing traditional "grey" infrastructure with "green" infrastructure can increase resilience to extreme precipitation and temperatures, as well as realize a host of other community benefits. In addition to increasing capacity to manage stormwater runoff and reduce ambient temperatures, green infrastructure can improve air quality and health, lower energy demand, increase carbon storage, and provide wildlife habitat and recreational space.

Surrey's most acute risks with respect to infrastructure are posed by the inadequacy of current flood protection and existing drainage systems to accommodate future sea level rise. Given the gravity and regional nature of this issue, it is addressed in more detail in its own section (see page 37). The degree of risk for the balance of Surrey's infrastructure was deemed relatively low for a combination of reasons, including:

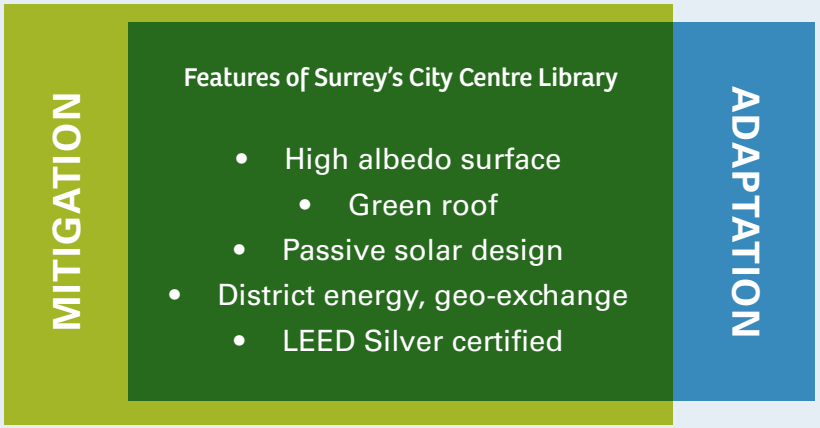
- **Limited exposure of infrastructure to climate impacts.** The City restricts new development in the floodplain, which has led to relatively little City infrastructure being exposed to flooding.
- **Mid-term replacement cycles for infrastructure.** As a fairly young City, much of Surrey's infrastructure has yet to reach the end of its service life. Fifty percent of Surrey's drainage mains will not require replacement for another 35 to 50 years, with the balance needing replacement in the latter half of the century. Given the range of uncertainty with respect to short- and mid-term precipitation projections, a longer time horizon for pipe replacement enables the City to observe trends, utilize enhanced climate projections, and develop infrastructure plans that will better accommodate climate impacts.
- **Existing investment in the City's Green Infrastructure Network.** Surrey's 1979 *Natural Drainage Policy* established a commitment to keep creeks open, and to maintain a naturalized drainage system, where feasible. This tradition continues today with the increasing incorporation of bioswales in street design and the identification and protection of Surrey's Green Infrastructure Network (GIN). The development of Integrated Stormwater Management Plans for each of the City's watersheds further embeds stormwater management and infrastructure planning into land use decisions.
- **Emerging capacity to adapt.** Surrey is likely to experience growing climate impacts in the decades to come, but has also demonstrated an ability to identify, plan for, and finance infrastructure improvements in response to changing circumstances. *The Strategic Plan for Lowland Flood Control* was established to provide standard drainage criteria for the Serpentine, Nicomekl lowlands. It was implemented over 10 years and has effectively controlled the incidents of flooding in the Serpentine and Nicomekl floodplains. More recently, the Adaptation Study and servicing plan developed for Crescent Beach responds to drainage issues exacerbated by sea level rise.

Despite these strengths, the City will need to focus on climate change considerations and how they impact infrastructure investments, in order to protect the community's assets for decades to come.

Opportunities in Energy: Addressing both sides of the climate change coin

Like other types of infrastructure, our energy system has the potential to be impacted by shifting climate norms as well as an increase in extreme weather events. Hydropower generation may lose capacity because of a declining snow pack and reduced summer precipitation. At the same time, the demand for air conditioning may increase due to rising summer temperatures. These impacts may add to the rising energy costs our communities are already facing.

While adapting the Province's energy supply falls outside the City's responsibility, there are many actions that can be taken to increase energy security and at the same time help to reduce the community's greenhouse gas (GHG) emissions. These actions include reducing energy demand through conservation and efficiencies, and exploring opportunities for more localized and renewable energy supplies to help protect the community against Provincial or global energy shortfalls. To achieve these goals, the City has also initiated the development of District Energy (DE) systems in City Centre, which will use a centralized energy source to deliver heating, and in some cases cooling, to neighbouring buildings. Using a central energy source increases energy efficiency, and makes it easier to switch between different fuel types, such as natural gas, geo-exchange, biomass, or sewer-heat recovery. Increased efficiency and the opportunity to use renewable, low-carbon fuels will help to reduce the City's GHG emissions, while the increased flexibility and use of local energy sources will provide Surrey with a more resilient energy system that can respond to the price and availability of different energy sources.



Surrey's new City Centre Library is a great example of a building that possesses both adaptive as well as GHG reduction features, including:

- A green roof and light coloured exterior that absorbs less heat and reduces the urban heat island effect, thereby minimizing the need for mechanical cooling
- A passive solar design that reduces energy demands and energy costs
- A geoexchange district energy system that reduces GHG emissions, lowers energy costs, and reduces reliance on external energy supply

Risk Assessment Results

Climate Impact Statements	Risk
Increased probability that existing sea dykes will be overtopped due to a combination of sea level rise, subsidence, and storm surge and wind setup resulting from significant weather events	High
Increase in frequency and duration of flooding within low lying floodplains due to reduced system drainage resulting from sea level rise and more intensive precipitation events	High
Increasing energy costs and energy insecurity due to the combination of increased cooling demand and changing temperature and precipitation regimes affecting the seasonal availability of hydroelectric power in BC	Medium
Damages and/or increased maintenance costs to structures and infrastructure (underground and at-grade) due to more variable and extreme weather patterns and sea level rise	Medium - Low
Domestic water demand exceeds supply due to increased temperatures and decreased summer rainfall	Low

Overarching Goals and Prioritized Actions

Three key goals have been identified to address impacts and increase resilience for Surrey's infrastructure:

1. Deliver Proactive Climate Analysis and Management Practices for City Infrastructure
2. Support the Design of Climate-Resilient Buildings in Surrey
3. Advance Energy Self-Sufficiency Within the Community

Goal 1: Deliver Proactive Climate Analysis and Management Practices for City Infrastructure		
	Adaptation Action	**City Lead**
IN-1.1	Enhance data collection and monitoring for climate impacts in Surrey (e.g. storm events, precipitation patterns, subsidence rates, changes in water quality, etc.)	Engineering
IN-1.2	Regularly review design requirements to ensure that they adequately account for expected weather conditions due to climate change	Engineering
IN-1.3	Assess existing City infrastructure and utilities for vulnerability to climate change	Engineering
IN-1.4	Integrate climate change into the 10 year capital and servicing plans of relevant departments	Engineering; PRC
IN-1.5	Continue to minimize the inflow and infiltration of stormwater into the sanitary sewer system in an effort to reduce the risk of sanitary sewer overflows	Engineering
IN-1.6	Monitor and manage species composition and selection to enhance resilience of Surrey's Green Infrastructure Network	PRC

Immediate Implementation

Goal 2: Support the Design of Climate-Resilient Buildings in Surrey		
	Adaptation Action	**City Lead**
IN-2.1	Advance energy efficiency in new construction and building retrofits	P&D
IN-2.2	Increase education and awareness on energy efficiency opportunities among City staff and developers	P&D
IN-2.3	Encourage the Province to ensure the BC Building Code adequately reflects and accounts for current and projected climate (i.e. increased winter precipitation, storm events and increased summer temperatures)	CMO
IN-2.4	Incorporate guidelines for water conservation in new and existing development	P&D

Goal 3: Advance Energy Self-Sufficiency Within the Community		
	Adaptation Action	**City Lead**
IN-3.1	Continue to expand on district energy systems in City Centre and support the development of district energy outside the current service areas	Engineering
IN-3.2	Establish a requirement for development over a certain size to complete an energy study that identifies energy efficiency and generation opportunities	P&D
IN-3.3	Explore opportunities to support local development of distributed energy systems and renewable energy sources (e.g. solar hot water, biomass, etc.)	CMO
IN-3.4	Encourage the Province to establish programs that incent homeowners to invest in renewable energy generation	CMO

City Department Acronyms: *P&D: Planning and Development; PRC: Parks, Recreation and Culture; CMO: City Manager's Office; ED: Economic Development*

ECOSYSTEMS AND NATURAL AREAS

Current State

The City of Surrey is fortunate to be located within rich and diverse natural surroundings. Sixty percent of Surrey's parkland inventory is now classified as natural area. This includes all types of green space, from dedicated urban forest, riparian areas, wetland, bogs, marshes, grasslands, and fields, to forested areas in parks, greenbelts, and boulevards. Surrey's green network also includes regionally important natural areas such as Surrey Bend Regional Park and Tynehead Regional Park, neighbourhood-scale sites such as Port Kells Park and Redwood Park, and countless forested backyards, urban parks, and agricultural fields. Natural areas help sustain clean water, recharge groundwater, maintain clean air, and support healthy plant, fish and wildlife communities. In terms of the services it provides, this "green infrastructure" is just as essential as the network of roads that move goods and people, or the agricultural landscape that provides food and other products.

The ongoing challenge with managing the City's natural assets is finding a workable balance between environmental protection of natural areas and access to these same lands for the benefit and well being of Surrey residents and visitors. A number of factors related to the rapid development and urbanization of Surrey can place stress on ecosystems. Population growth increases the demand for and use of Surrey's natural areas and many are now bordered by residential, commercial and industrial developments. Ongoing issues with managing natural areas include: illegal dumping of waste and refuse in parklands; blazing of unauthorized trails; inappropriate use of and damage to trails; spread of invasive species; damage to waterways that threatens surrounding ecology; and management of tree and fire hazards. These ongoing pressures can both degrade natural areas and contribute to conflicts over use.

The City has a number of planning processes and tools for addressing its challenges in balancing protection and access to natural areas. These include:

- Natural Area Management Plan;
- Ecosystem Management Study;
- Biodiversity Conservation Strategy;
- Community Wildfire Protection Plan;
- Integrated Stormwater Management Plans;
- Erosion and Sediment Control By-law;
- Integrated Pest Management Policy & Pesticide By-law;
- Stormwater Drainage Regulation and Changes By-law; and
- Official Community Plan.

Climate Change Impacts

Several climate change factors are projected to impact Surrey's ecosystems and natural areas, including an increase in average temperatures and extreme heat events, decreasing summer precipitation, and increasing winter precipitation (leading to more frequently saturated soils). These factors are anticipated to result in an increasing tree mortality rate as well as changes to ecosystem composition. Different tree species, and even different seed stock within species, have varying adaptive capacities, or ability to cope with a quickly changing climate. While hardwoods appear to be less affected by climate change, many conifer species in BC are expected to lose a large portion of their suitable habitat. As already seen in other parts of British Columbia, tree species are becoming more vulnerable to pests, such as the Mountain Pine Beetle.

An increased tree mortality rate in Surrey would have a series of associated environmental and socio-economic risks. Less canopy cover will likely result in lowered air quality and an increased urban heat island effect. Other ecosystem services may also be diminished by the loss of trees, such as water filtration, slope stability, removal of airborne particles and gases, and stormwater retention. To mitigate increasing tree mortality, the City will need to anticipate the suitable species and management requirements for the City's projected climate.

In addition to tree impacts, many critical ecosystems in Surrey are expected to be significantly affected by climate change. Changes to the base flow of local streams, as well as shifts to their ecological composition, are anticipated due to increased summer temperatures and changing precipitation patterns. Sea level rise and increased wave action and erosion will likely cause "coastal squeeze", or a loss of tidal mudflats and marshland ecosystems that are trapped on the seaward side of dykes and are unable to naturally adapt by migrating inland. These ecosystem impacts have important implications for biodiversity health; for example, salmon are very sensitive to water temperature change and may be negatively impacted by increased stream temperatures, with cascading repercussions for other species.

Risk Assessment Results

Climate Impact Statements	Risk
Increased tree mortality rate and change in urban forest composition due to increase in hot weather, decreased summer precipitation, and increased winter precipitation leading to more saturated soils in lowlands	Medium - High
Change in streams' ecological composition due to increased summer temperatures and changing precipitation regimes altering stream base flow and water quality	Medium - High
Loss of tidal mudflats and marshland ecosystems on seaward side of dykes due to increased wave action and erosion associated with sea level rise and existing dyke positions	Medium - High
Impacts on the viability of agricultural crops and other vegetation in floodplain areas, due to saltwater intrusion and flooding associated with sea level rise	Medium - High

Overarching Goals and Prioritized Actions

Four key goals have been identified to address impacts and increase resilience for Surrey's ecosystems and natural areas:

1. Optimize Space for Habitat and Species Migration
2. Actively Manage Ecological Assets
3. Support Viability of Highly Sensitive Ecosystems
4. Protect Ecosystem Services Through Development

Goal 1: Optimize Space for Habitat and Species Migration		
	Adaptation Action	**City Lead**
EC-1.1	Improve the quantity and quality of the City's habitat to enable species migration and resilience through the implementation of the Biodiversity Conservation Strategy	PRC
EC-1.2	Strategically acquire a diverse representation of ecosystem types as part of Surrey's parks and natural areas	PRC
EC-1.3	Reduce habitat fragmentation by using and protecting a comprehensive network of corridors and larger natural areas (hubs and sites)	PRC
EC-1.4	Increase public awareness, capacity, and the use of planning tools (e.g. voluntary conservation easements) to create higher habitat values on private property.	P&D

Goal 2: Actively Manage City's Ecological Assets		
	Adaptation Action	**City Lead**
EC-2.1	Increase active management of City controlled natural areas (e.g. removal of invasive species), and encourage more active management of natural areas on Provincial, Regional, non-profit and privately owned lands.	PRC
EC-2.2	Implement evolving best practices for ecosystem management in a changing climate	PRC
EC-2.3	Consider assisted migration for species whose dispersion rate is unable to keep pace with climate change (e.g. planting tree species historically suited to more Southern climates)	PRC
EC-2.4	Increase tree risk management to minimize damage and liability from dead or dying trees	PRC
EC-2.5	Partner with key organizations and the private sector to limit the sale of invasive species and promote adaptable species at local nurseries	PRC
EC-2.6	Incorporate climate change messaging in environmental education efforts, and continue to engage the public in stewardship initiatives	PRC

Goal 3: Support Viability of Highly Sensitive Ecosystems		
Riparian Areas		
	Adaptation Actions	**City Lead**
EC-3.1	Apply Surrey standards for streamside setbacks to accommodate potential erosion and optimize ecological health	P&D
EC-3.2	Establish Development Permit Area Guidelines for sensitive ecosystems	P&D
EC-3.3	Implement strategies to maintain stream flow affected by changing temperature and precipitation patterns	Engineering
Intertidal Areas		
	Adaptation Actions	**City Lead**
EC-3.4	Promote the development of regional cost/benefit analyses of sea level rise and flood management options that considers ecological values and protection of property and infrastructure	Engineering
EC-3.5	Evaluate options for installing physical interventions to support ecosystems (e.g. construction of a breakwater)	Engineering

Goal 4: Protect Ecosystem Services through Development		
	Adaptation Action	**City Lead**
EC-4.1	Incorporate climate change into the City's Integrated Stormwater Management Plans (ISMPs) and other efforts to integrate land use planning and stormwater management	Engineering
EC-4.2	Provide direction to developers on suitable vegetative species and development features that enhance habitat values	P&D
EC-4.3	Host workshops for the City's staff, management and Council on 'green' development features and their effectiveness in protecting ecosystem services	P&D
EC-4.4	Review landscape design guidelines to ensure they support habitat values	P&D

City Department Acronyms: *P&D: Planning and Development; PRC: Parks, Recreation and Culture; CMO: City Manager's Office; ED: Economic Development*

URBAN TREES AND LANDSCAPING

Current State

The City of Surrey values its urban trees for the quality of life they bring to residents as well as the many benefits and ecosystem services they provide. A number of policies are in place to protect and enhance the urban landscape, including the Tree Protection By-law, which outlines requirements for tree preservation and replacement on private property. The City also engages residents and schools through the Surrey Nature Centre, the ReLeaf Tree Planting Program, ReLeaf Days, Environmental Extravaganza, Party for the Planet – Earth Day, Arbor Day, and by providing public education on watering, pruning and other aspects of tree care.

A number of existing challenges face the City regarding shade trees and urban landscaping. As a fast growing community, development is displacing many mature trees. As well, densification, important for achieving many of the City's climate mitigation and liveability goals, makes it difficult to give newly planted trees the space they require to grow into healthy, fully grown trees. Practices are evolving to accommodate more trees in dense new neighbourhoods, such as the use of structural soil to allow more space for root development.

Warmer, drier summers are already placing increased stress on young trees. In 2001, the City watered its newly planted trees for 14-16 weeks of the year, for up to four years. In 2010, newly planted trees required water for 16-18 weeks of the year, and trees required watering for up to eight years. This has added considerable cost in terms of staff time and water resources for the City.

Climate Change Impacts

As a result of climate change, urban trees will be impacted by hotter, drier summers, and soil saturation may increase during winter months. A primary concern is that the species that currently thrive in Surrey may not be suitable for the future local climate. The projected rate of climatic change may make it very difficult for existing species to adapt, or for southern species to migrate north. A key challenge for the City will be to anticipate a range of tree species that may be suited to Surrey's future climate and to maintain species diversity to ensure resilience across a range of possible future climates.

Urban trees, or shade trees, include those on public lands such as streets, boulevards, and urban parks, as well as trees on private property. Street trees are considered unique from Surrey's natural areas due to the differing management considerations; however, they do provide important contributions to habitat and ecosystem values.

The current issue of prolonged watering requirements for newly planted trees will persist, with costs increasing for replanting and maintenance. Minimizing tree mortality through diversified species and adequate space and soil quality will help to offset these rising costs. With increasing tree mortality, valuable habitat may be lost, air and water quality may decline, and there may be a greater risk of hazards from trees near homes and roads. Ensuring a healthy urban landscape is critical for a number of Surrey's objectives, including enhancing liveability and the public realm, increasing biodiversity, and maintaining clean air and water. Sustaining our urban trees will also become increasingly important for other components of climate action in Surrey, such as managing stormwater, reducing the urban heat island effect, and maximizing building efficiency.

Risk Assessment Results

Climate Impact Statement	Risk
Increased tree mortality rate and change in urban forest composition due to increase in hot weather, decreased summer precipitation, and increased winter precipitation leading to more saturated soils in lowlands	Medium - High

Overarching Goals and Prioritized Actions

Three key goals have been identified to address impacts and increase resilience for Surrey's urban trees and landscaping:

1. Provide the Required Growing Environment to Sustain Trees
2. Plant Appropriate Species
3. Increase Tree Maintenance Management

Goal 1: Provide the Required Growing Environment to Sustain Trees		
	Adaptation Action	**City Lead**
TR-1.1	Utilize City by-laws, standards, and permitting processes to ensure adequate canopy, root crown and root growth space is provided for trees to mature to optimal size on public and private property	P&D
TR-1.2	Utilize City by-laws, standards, and permitting processes to optimize soil conditions for shade trees on public and private property (e.g. soil quality, quantity and moisture content)	P&D

Immediate Implementation

Goal 2: Plant Appropriate Species		
	Adaptation Action	**City Lead**
TR-2.1	Select tree species and planting stock from provenances that will be well adapted to Surrey's future climate projections, particularly with respect to temperature and drought increases	PRC
TR-2.2	Monitor survival rate of trees planted on public property to confirm species suitability over time	PRC
TR-2.3	Increase the species diversity of shade trees on public and private property	PRC
TR-2.4	Develop an educational resource that encourages residents to plant trees which enhance species diversity (e.g. an annual "feature tree" pamphlet)	P&D

Immediate Implementation

Goal 3: Increase Tree Maintenance Management		
	Adaptation Action	**City Lead**
TR-3.1	Increase tree replacement and maintenance activities (such as watering) to sustain trees, as necessary	PRC
TR-3.2	Anticipate a growing need for tree risk assessments and abatement due to tree decline and mortality	PRC
TR-3.3	Undertake a Pest Threat Assessment to better understand the risks to trees and ecosystems posed by changing disease vectors and invasive species	PRC
TR-3.4	Explore a requirement for local residents to water boulevard trees during summer months	PRC

City Department Acronyms: *P&D: Planning and Development; PRC: Parks, Recreation and Culture; CMO: City Manager's Office; ED: Economic Development*

AGRICULTURE AND FOOD SECURITY

Current State

A mild climate and some of the most fertile soils in the country make the agricultural industry a unique and critical sector within Metro Vancouver. Over one-third of the City's land is designated for agriculture within the Agricultural Land Reserve (ALR); agriculture also contributes significantly to the City's economy and regional food security. Approximately 3,300 people or 1.6% of Surrey's labour force are employed in agriculture, with most farms being family owned. The 2011 Census of Agriculture reports that Surrey's total farm receipts, a measure of agriculture sales, total over $167 million.

Surrey's farmers face numerous challenges in the operation of their farms, many of which Surrey's *Agriculture Protection and Enhancement Strategy* seeks to address. Farm businesses, regardless of size, are experiencing increasing input costs and pressure from global commodity prices, and are continually competing with inexpensive imports.

Financial returns are low, with most farm operators relying on a second, off-farm income. As a result, it is difficult and often undesirable for young farmers to enter the sector, and the average age of B.C.'s farmers is increasing. Access to irrigation water is also a pressing concern, with limited options for expansion. Surface water licences for the Nicomekl, Serpentine, and Campbell Rivers are currently oversubscribed, with all available licences allocated by the Province. Much of the groundwater in Surrey is of marginal quality and not easily available to farms. Potable water is only available to farmers for residential use, as the water network was not designed for irrigation purposes. Other existing issues for farmers include ensuring appropriate drainage and effectively managing salt water intrusion in areas adjacent to Boundary Bay and Mud Bay.

Climate Change Impacts

Drainage and flooding pose some of the greatest risks to farmers in Surrey, with the potential for crop and livestock losses, soil salinization, and a loss of agricultural land due to permanent inundation. Wetter winters and increased weather variability may lead to soil saturation, more frequent flooding, increased nutrient leaching, interruptions to planting and harvesting, and increased pressure on drainage infrastructure and management. Addressing these issues through increased pumping or other infrastructure improvements could be costly to the City.

Warmer temperatures and extreme precipitation events may increase the risk of food-borne pathogens, such as *E.coli*. In addition, higher temperatures may increase the winter survival rates and the number of pest cycles experienced each year, with new pests and diseases being introduced. Pollination may be delayed or prevented due to pests and diseases, and may be interrupted by increasing precipitation and weather variability. Challenges with accessing irrigation are also likely to become more pronounced with warmer, drier summers, leading to water stress and a decline in the productivity and quality of crops and livestock.

Climate change research predicts that BC will experience increasing agricultural capability and a broader range of suitable crops in the short term. In the long term, however, climate change will likely increase uncertainty and the costs of weather damage for BC's agricultural operations. A switch to new high-value crops may be challenged by exposure to pests, soil salinization, limited irrigation access, and inconsistent productivity, quality, and prices in global markets due to weather fluctuations.

It is estimated that 40 to 50% of the food consumed in BC is currently imported. Extreme weather and deteriorating agricultural conditions internationally will likely increase the costs of production and lead to a greater demand for local food products. For example, a significant portion of imported food comes from California, which has experienced severe drought in recent years with implications for food production. This makes a strong case for building a well-adapted and increasingly self-sufficient agricultural sector that hedges its investments through diversified products and growing methods. Locally, more frequent extreme weather events such as storms, winds and heat may increase farm building maintenance costs, the risk of crop and livestock losses, and increase costs for cooling and ventilation. The sum of these changes will mean increased management complexity for the agricultural sector in Surrey.

Risk Assessment Results

Climate Impact Statements	Risk
Increase in frequency and duration of flooding within low lying floodplains due to reduced system drainage resulting from sea level rise and more intensive precipitation events	High
Reduced subsurface drainage in some floodplain areas due to seepage and/or rising water table associated with sea level rise and more intensive precipitation events	High
Increased probability that existing sea dykes will be overtopped due to a combination of sea level rise, subsidence, and storm surge and wind setup resulting from significant weather events	High
Impacts on the viability of agricultural crops and other vegetation in floodplain areas, due to saltwater intrusion and flooding associated with sea level rise	Medium - High
Agricultural irrigation (river & well) demand exceeds supply due to increased temperatures, decreased summer rainfall, and increased agricultural growing due to increased growing degree days	Medium

Overarching Goals and Prioritized Actions

Four key goals have been identified to address impacts and increase resilience for food security and agriculture in Surrey:

1. Provide Appropriate Infrastructure for Agricultural Viability
2. Encourage Greater Diversity in Local Products and Growing Methods
3. Increase Food Self-Sufficiency in the City and Region
4. Help Farmers Build Capacity to Adapt

Goal 1: Provide the Required Growing Environment to Sustain Trees		
	Adaptation Action	**City Lead**
AG-1.1	Continue to improve lowland drainage and flood management infrastructure in keeping with the Lowland Flood Control Strategic Plan	Engineering
AG-1.2	Work with all levels of government to evaluate long-term flood management options in response to sea level rise impacts with considerations for agricultural vulnerability	Engineering
AG-1.3	Continue to enhance rainwater storage and stormwater management in all areas of Surrey, including agricultural areas	Engineering
AG-1.4	Investigate ways of improving access to an adequate and safe water supply for food production and processing purposes	Engineering

Immediate Implementation

Goal 2: Encourage Greater Diversity in Local Products and Growing Methods		
	Adaptation Action	**City Lead**
AG-2.1	Continue to work closely with the Federal Department of Fisheries and Oceans to protect fish habitat within the City	Engineering
AG-2.2	Work with key partners to help maintain and grow the food processing industry in Surrey	P&D
AG-2.3	Encourage local research to help identify resilient agricultural practices (e.g. mapping crop varieties to future climate scenarios; integrated pest management strategies, etc.)	CMO
AG-2.4	Support farmers and other key partners to pursue innovative agricultural practices (e.g. vertical farming) within and beyond designated agricultural lands	P&D
AG-2.5	Encourage farmers to diversify crop selection and choose adaptable varieties (e.g. less dependent on irrigation, more resistant to saline soils)	P&D

Goal 3: Increase Food Self-sufficiency in the City and Region		
	Adaptation Action	**City Lead**
AG-3.1	Continue to support residents' direct access to local food through farm gate sales and partnerships with farmers' markets	P&D
AG-3.2	Increase opportunities for residents to produce their own food (e.g. support community gardens; review parcel size requirements for backyard chickens)	CMO
AG-3.3	Maximize the use of public and private urban landscape features, terraces, and rooftops for food production (e.g. edible landscaping guidelines for new strata developments)	P&D
AG-3.4	Encourage local research on the types and quantity of crops needed to increase self-sufficiency	CMO
AG-3.5	Encourage the restoration of pollinator-friendly habitat and housing of apiaries on private and public lands, where practical	P&D
AG-3.6	Investigate the feasibility of a farm incubator program to ensure new farmers are able to enter the industry	P&D
AG-3.7	Collaborate with others to reduce the quantity of food that is wasted at each stage in the supply chain (e.g. finding markets for food that is not perfectly symmetrical or aesthetically conventional)	CMO

Goal 4: Help Farmers Build Capacity to Adapt		
	Adaptation Action	**City Lead**
AG-4.1	Review and update Surrey's Agricultural Plan to account for climate change impacts	P&D
AG-4.2	Manage urban-rural interface relations as agricultural practices change and adapt	P&D
AG-4.3	Explore and support best practices from other global communities that currently face challenges our agricultural system may face in the future (e.g. innovative dyking technologies, growing practices in warmer/dryer climates, etc.)	CMO
AG-4.4	Consider an agriculture co-ordinator position to help build capacity for the development of agriculture and sustainable food systems within the City	P&D

City Department Acronyms: *P&D: Planning and Development; PRC: Parks, Recreation and Culture; CMO: City Manager's Office; ED: Economic Development*

HUMAN HEALTH AND SAFETY

Current State

The health and wellbeing of Surrey residents is central to creating a strong and vibrant community. While health care formally falls into the jurisdiction of the Provincial Government and the Fraser Health Authority, many of the City's actions contribute to the health and safety of citizens. For example, providing recreational facilities, planning for walkable neighbourhoods, ensuring public access to natural areas, developing guidelines for construction on steep slopes, and the delivery of natural disaster emergency response all falls within the City's realm of responsibilities.

Climate change has the potential to modify environmental factors, and as a result, increase the level of exposure or risk for certain climate-sensitive health concerns. Environmental factors, however, are only one piece of the puzzle: the social determinants of health act as key indicators for whether a population is predisposed to health issues. The social determinants of health include income, social support networks, education levels, employment status, child development opportunities, gender, and culture. For example, populations most vulnerable to climate-related health impacts include the young and old, low income individuals, people who are socially isolated, and those with pre-existing conditions. An emphasis on improving the socio-economic status of individuals can lead to positive outcomes for health, as well as other aspects of community well-being.

To this end, the City of Surrey has a number of policies and initiatives in place to not only support our most vulnerable populations, but create a more inclusive, resilient and vibrant City for everyone. These include:

- Plan for the Social Well-Being of Surrey Residents (Social Plan)
- Poverty Reduction Plan
- Child and Youth Friendly City Strategy
- Master Plan for Housing the Homeless
- Crime Reduction Strategy
- Learning for Life Strategy

The City works with a diverse set of community groups, non-profit organizations, government agencies and service providers to continually improve the health and safety of Surrey residents.

Climate Change Impacts

Changing temperatures, rainfall patterns and storm events have the potential to affect health and safety in a myriad of ways; however, community members without the means, abilities or social networks to respond to climate impacts are likely to be most affected by altered conditions. In Surrey, health and safety will likely be affected by climate change in four primary ways: 1) rising temperatures and extreme heat, 2) the spread of communicable diseases, 3) the increase of flood and storm events, and 4) the expansion of urban-interface fire risks.

Heat Waves: Extreme heat events are already affecting health outcomes in Metro Vancouver. An eight-day heat wave in 2009 saw temperatures above 34°C and contributed to approximately 156 excess deaths recorded in the Fraser and Vancouver Coastal Health Authorities. There is a high level of certainty in climate projections that an increase in the frequency and intensity of heat waves will lead to additional deaths and illnesses due to hot weather and heat stress. Vulnerable populations include individuals who are: older and home-bound, very young, socially isolated (low income, homeless, living alone), living in densely populated areas, unable to access air conditioning, in heat-exposed occupations, taking certain medications, having pre-existing medical conditions, vigorous exercisers, or tourists.

While other areas of B.C. and Canada may regularly see temperatures of this magnitude, Metro Vancouver residents are acclimatized to a relatively narrow band of temperatures and very few homes are equipped with air conditioning, which can lead to heighted vulnerability. As urbanization and densities increase within Surrey, ensuring an urban design that minimizes the urban heat island effect will be imperative. In the case of heat waves that pose a human health threat, Fraser Health and Environment Canada are responsible for issuing heat alerts. An Extreme Heat-Wave Advisory issued by Vancouver Coastal Health and Fraser Health, in coordination with Environment Canada, is meant to trigger municipal heat response plans. In 2011, Health Canada's Climate Change and Health Office funded a joint *Extreme Heat Response Plan* for the City of Surrey and White Rock, which is currently in draft form.

Infectious Disease: Climate change will likely contribute to shifts in the patterns of infectious disease occurrence and spread in B.C. (data is unavailable for the city scale). Water-borne diseases will likely increase as a result of increased precipitation and flooding, while respiratory pathogens may become less seasonal. Food-borne illnesses will likely rise due to increases in the average summer temperature. Some vectors of human disease (e.g. moquitoes and

ticks) could acquire an expanded geographic range, increased reproductive or biting rates, and shortened pathogen incubation periods as a result of higher average temperatures and rainfall. New fungal pathogens are also expected to develop due to a warmer and wetter climate. Evidence of climate affecting the incidence of disease is emerging; for instance, Cryptococcus gattii, a fungal pathogen previously found in the tropics has become prevalent on Vancouver Island since 1999, with 28 diagnosed cases per 1 million island residents and a 4.5% fatality rate.

Fraser Health and the BC Centre for Disease Control (BCCDC) currently monitors changing conditions and collects surveillance data on communicable diseases—tracking what disease strains are circulating regionally and in relation to strains in other parts of the world. While Fraser Health does not have a formal climate change adaptation plan, its existing programs create adaptive capacity. For example, Fraser Health and the BCCDC have a program for monitoring the potential spread of West Nile virus. Transmitted by mosquitoes, West Nile virus will likely become more prevalent in the wetter, warmer winters expected with climate change.

Flood and Storm Events: Flooding poses a very real and growing risk in Surrey, as discussed on page 37. While storm and wind events are more difficult to project, there is some evidence that the region will experience an increase in the number and intensity of storms, with implications for public safety. These events may result in downed power lines and more power outages, falling trees and debris, severed transportation routes and limited access to goods and services, inundation from flood waters, and degraded water quality. Emergency access and evacuation may pose a challenge in some scenarios, due to limited North-South transportation routes across the Serpentine-Nicomekl lowlands and limited street connectivity in some areas of the City. In these instances, the most resilient and resourceful communities are those with a strong social support network, able to support the most vulnerable individuals throughout the disaster.

The Surrey Fire Service is responsible for implementing the Emergency Program in the case of disasters, including flood and storm events. The exact response, including the number and location of reception centres and evacuation orders, is dependent on the nature of the situation. Information and instructions are disseminated to residents by radio. Part of the response includes the Emergency Social Services Program, which is run by volunteers and provides support, services, and supplies such as food, clothing, shelter, and blankets. The City also runs a Neighbourhood Emergency Preparedness Program that delivers workshops to help neighbourhood groups formalize their network and develop response plans.

Urban-Wildland Interface Fire: The current risk of urban-wildland interface fire in Surrey is relatively low, chiefly due to the dominant low-risk forest type (deciduous stands) and frequent rainfall year-round. Over the past twenty years there have been no recorded large-scale fires within Surrey's park natural areas. However, the risk of wildfires is likely to increase with warmer, drier temperatures and increasing tree mortalities. As a case in point, fall of 2012 was one of the driest periods on record in the coastal region, and led to 265 wildfires—one of which occurred in a wet floodplain area that would normally have been an area of low fire risk.

The magnitude of the risk posed by climate change will depend on development patterns, tree planting and building practices, and the ecosystem health and maintenance measures within urban-wildland interface areas. Roughly 60% of Surrey's parks are managed natural areas, though unmaintained wildlands also exist along Hydro right of ways and other sites across the City. Many natural areas are adjacent to important structures that are at risk should a natural area fire occur. In 2013, the City completed a *Community Wildfire Protection Plan* that identifies areas at high risk of wildfires, acknowledges the importance of climate change in managing wildfire risk in the future, and recommends the plan be reviewed every five years. Wildfires are the joint responsibility of the local fire department and the Province's Wildfire Management Branch. In the case of disasters such as wildfires, the City has an Emergency Program in place that outlines response and evacuation procedures.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Risk Assessment Results

Climate Impact Statements	Risk
Increased probability that existing sea dykes will be overtopped due to a combination of sea level rise, subsidence, and storm surge and wind setup resulting from significant weather events.	High
Increased human health impacts including greater spread of pathogens due to warmer, wetter winter climate	Medium
Increased risk of urban interface fires (e.g. forest fires and fires in other natural areas) due to increased temperature and drier summers	Medium - Low
Increased heat stress and other health ailments due to increase in heat advisory days	Medium - Low

Overarching Goals and Prioritized Actions

Four key goals have been identified to address impacts and increase resilience for health and safety in Surrey:

1. Collaborate with Key Partners on Improving Population Health
2. Minimize the Urban Heat Island Effect
3. Minimize Risks from Urban-Wildland Interface Fire
4. Build Emergency Response Capacity at the City

Goal 1: Collaborate with Key Partners on Improving Population Health		
	Adaptation Action	**City Lead**
HS-1.1	Continue to collaborate with community organizations and service agencies to improve the socio-economic conditions and health outcomes of vulnerable populations	P&D
HS-1.2	Encourage health agencies and research institutions to anticipate, monitor and reduce the impact of climate change on the spread of infectious disease	CMO
HS-1.3	Work with key partners to integrate climate change messaging into communication materials related to public health and safety	CMO
HS-1.4	Work with health agencies to better identify and respond to the needs of vulnerable populations specific to climate-related health risks	P&D

Goal 2: Minimize the Urban Heat Island Effect		
	Adaptation Action	**City Lead**
HS-2.1	Ensure sufficient space and adequate soil medium for shade trees in urban areas	P&D
HS-2.2	Encourage development to incorporate passive building design features that keep buildings cool while reducing reliance on air conditioning	P&D
HS-2.3	Utilize landscaping and site design to increase green space and strategically cool buildings and the urban environment	P&D
HS-2.4	Explore opportunities for green roofs and walls on institutional, commercial, industrial and large residential development	P&D
HS-2.5	Engage vulnerable neighbourhoods in programs that keep indoor and outdoor environments cool (e.g. energy retrofit programs, tree planting and water fountain installations)	CMO
HS-2.6	Reduce the impacts of surface parking lots by increasing canopy coverage and the use of alternative paving surfaces	P&D
HS-2.7	Increase the use of high albedo (i.e. light coloured, reflective) surfaces on buildings and pavings	P&D

Immediate Implementation

Goal 3: Minimize Risks from Urban-wildland Interface Fire		
	Adaptation Action	**City Lead**
HS-3.1	Implement the City of Surrey Community Wildfire Protection Plan, and monitor changes to fire risk over time as a result of climate change	PRC
HS-3.2	Enforce "Firesmart" guidelines for developments within 100m of moderate or high risk wildfires	PRC
HS-3.3	Provide "Firesmart" education to the Surrey public, targeting residents in close proximity to areas of high and moderate risk of wildfire	Fire Department

Goal 4: Build Emergency Preparedness Capacity at the City		
	Adaptation Action	**City Lead**
HS-4.1	Continue to build community capacity to respond effectively in an emergency (i.e. neighbours helping neighbours)	Fire Department
HS-4.2	Review and support implementation of the Surrey-White Rock Extreme Heat Response Plan in the case of heat advisories	Fire Department
HS-4.3	Look at gaps in emergency prevention and response, taking into account climate change impacts	Fire Department
HS-4.4	Ensure emergency response capacity keeps pace with the need for services, given increasing climate impacts	Fire Department

City Department Acronyms: *P&D: Planning and Development; PRC: Parks, Recreation and Culture; CMO: City Manager's Office; ED: Economic Development*

Immediate Implementation

SUMMARY OF ADAPTATION AND MITIGATION LINKAGES

Reducing GHG emissions and preparing for the impacts of climate change are both critical components of climate action, and can have positive mutual benefits with careful planning. Table 2 summarizes the mutually reinforcing strategy areas that have been identified within Surrey's Climate Adaptation Strategy and Surrey's Community Energy and Emissions Plan. Together, these two plans comprise Surrey's Community Climate Action Strategy and reinforce the City's broader efforts toward establishing Surrey as a prosperous and resilient 21st century urban centre.

Table 2: Mitigation and Adaptation Strategy Linkages

Climate Adaptation Strategy Goals by Sector	Ecosystem Protection, Hazard Avoidance, Compact Land Use	Ecosystem Health, Carbon Sequestration	Heat Management, Passive Solar Design	Community Energy Supply, Self-Sufficiency
Cross-Cutting Actions				
Reinforce the implementation and enforcement of City policies and By-laws that support resilience				
Educate and Engage Surrey Residents and Staff on Climate Impacts and Solutions				
Flood Management and Drainage				
Reach Consensus on a Regional Approach to Flood Management	✓			
Update Planning and Development Guidelines for Floodplains	✓			
Infrastructure				
Deliver Proactive Climate Analysis and Management Practices for City Infrastructure		✓		
Support the Design of Climate-Resilient Buildings in Surrey			✓	✓
Advance Energy Self-Sufficiency Within the Community				✓

Ecosystems and Natural Areas				
Optimize Space for Habitat and Species Migration	✓	✓		
Actively Manage City's Ecological Assets	✓	✓		
Support Viability of Highly Sensitive Ecosystems	✓	✓		
Protect Ecosystem Services Through Development	✓	✓		
Urban Trees and Landscaping				
Provide the Required Growing Environment to Sustain Trees		✓	✓	
Plant Appropriate Species		✓	✓	
Increase Tree Maintenance Management		✓	✓	

Table 2 (continued)

Climate Adaptation Strategy Goals by Sector	Ecosystem Protection, Hazard Avoidance, Compact Land Use	Ecosystem Health, Carbon Sequestration	Heat Management, Passive Solar Design	Community Energy Supply, Self-Sufficiency
Agriculture and Food Security				
Provide Appropriate Infrastructure for Agricultural Viability				✓
Encourage Greater Diversity in Local Products and Growing Methods				✓
Increase Food Self-Sufficiency in the City and Region				✓
Help Farmers Build Capacity to Adapt				✓
Human Health and Safety				
Collaborate with Key Partners on Improving Population Health				✓
Minimize the Urban Heat Island Effect			✓	
Minimize Risks from Urban-Wildland Interface Fire	✓			
Build Emergency Response Capacity at the City				✓

IMPLEMENTATION AND MONITORING

The Climate Adaptation Strategy identifies 91 actions to help Surrey prepare for and respond to the impacts of climate change. Many of the actions are cross-sectoral, in that they help build the City's adaptive capacity in more than one area. Effort has been made to minimize potential conflicts or trade-offs between actions (e.g. habitat vs. agricultural protection); however, more exploration and analysis may be required to resolve these issues in the implementation of some actions. As a relatively new and rapidly evolving issue, the *Climate Adaptation Strategy* will be a living document to be revisited regularly and updated as necessary.

ROLES AND RESPONSIBILITIES

Each adaptation action has been assigned a lead City department responsible for implementation; however, not all actions are within the jurisdiction of the City to carry out. Indeed, the role of senior governments in helping cities adapt to climate change will be critical. In these cases, City staff may collaborate with other stakeholders and look to other levels of government to implement or partner on certain actions. To clarify the sphere of influence and align with the structure of Surrey's Sustainability Charter, each action has been categorized as either: corporate operations, municipal jurisdiction, or influencing others in Appendix A.

For the actions that fall within the realm of corporate operations or municipal jurisdiction, actions may be tied into departmental plans and budgeting processes. The lead department will work with the other supporting departments, using identified planning and policy tools, with an emphasis on the priority actions highlighted for immediate implementation. The full list of actions with other implementation considerations including supporting departments, policy tools, and relative cost can be found in Appendix A.

PRIORITY ACTIONS FOR IMMEDIATE IMPLEMENTATION

Of the 91 actions developed for the Climate Adaptation Strategy, 11 actions have been distinguished as immediate priorities for the City to pursue. These actions were chosen by the staff Advisory Team following the prioritization process (see Appendix E) and were considered based on urgency, ease of implementation, and representation across a spectrum of issues. The adaptation actions for immediate implementation are:

Adaptation Actions for Immediate Implementation	
CC-1.1	Review City policies and by-laws to identify those practices that support resilience, and reinforce their implementation and enforcement
CC-1.2	Integrate climate change education and awareness into existing programs and communications, and develop new education initiatives where gaps exist for Surrey residents and City Staff
FL-1.1	Support the development of a Regional Flood Management Strategy in coordination with senior levels of government, other municipalities, and key stakeholders
FL-2.1	Conduct detailed analysis on Surrey-specific climate impacts, including the timelines and extent of sea level rise and its related effects on flood construction levels and floodplain designations
IN-1.1	Enhance data collection and monitoring for climate impacts in Surrey (e.g. storm events, precipitation patterns, subsidence rates, changes in water quality, etc.)
EC-1.1	Improve the quantity and quality of the City's habitat to enable species migration and resilience through the implementation of the Biodiversity Conservation Strategy
TR-1.1	Utilize City by-laws, standards, and permitting processes to ensure adequate canopy, root crown and root growth space is provided for trees to mature to optimal size on public and private property
TR-2.1	Select tree species and planting stock from provenances that will be well adapted to Surrey's future climate projections, particularly with respect to temperature and drought conditions
AG-1.2	Work with all levels of government to evaluate long-term flood management options in response to sea level rise impacts with considerations for agricultural viability
HS-2.2	Encourage development to incorporate passive building design features that keep buildings cool while reducing reliance on air conditioning
HS-4.1	Continue to build community capacity to respond effectively in an emergency (i.e. neighbours helping neighbours)

TARGETS, INDICATORS AND MONITORING

To ensure the successful implementation of the Adaptation Strategy, a series of indicators have been proposed to track progress over time (Appendix B) that are aligned with existing reporting efforts. The City's Sustainability Office will collect the data to establish a baseline and monitor progress of these metrics. Surrey staff will convene as needed to review progress on the adaptation actions and assess the indicator data as it is collected and as trends emerge.

Finally, the climate impact statements and actions will be integrated into the City's Enterprise Risk Management (ERM) Framework, where they can be strategically managed by the department responsible. The ERM is a structured and continuous process that engages departments across the organization to identify and respond to risks that threaten the achievement of the City's objectives. By prioritizing and monitoring risks, their consideration is strategically embedded into management functions. The development of the *Climate Adaptation Strategy* takes a risk-based approach (including a risk assessment, the development of actions, prioritization and the development of indicators), and can therefore be seamlessly integrated into the City's ERM. The ERM's online platform allows "risk owners" to track the implementation of actions, monitor any changes to risks, and report this information out in a timely and consistent manner.

CONCLUSION

As the impacts of climate change become increasingly tangible, all levels of government have a responsibility to ensure our communities are resilient and adaptable. By taking informed and proactive action, the City of Surrey is positioned to make the right decisions within the timeframes necessary, using the best available science and knowledge. The actions identified within the Climate Adaptation Strategy provide a blueprint for City staff and stakeholders that will help ensure Surrey continues to grow into a vibrant and livable community for decades to come. Together, with the Community Energy and Emissions Plan (CEEP), the City of Surrey's comprehensive Climate Action Strategy is preparing our community for a new future.

APPENDIX A: IMPLEMENTATION

P&D	Planning and Development
PRC	Parks, Recreation and Culture
CMO	City Manager's Office
ED	Economic Development
F&T	Finance and Technology

$	< $75,000
$$	$75 - 300,000
$$$	$300-500,000
$$$$	$500,000 - $1 million
$$$$$	>$1 million

Cross Cutting Actions

	Adaptation Action	Sphere of Influence	City Lead	Support	Tools	Cost
CC-1.1	Review City policies and by-laws to identify those practices that support resilience, and reinforce their implementation and enforcement.	Municipal Jurisdiction	CMO	All		$
CC-1.2	Integrate climate change education and awareness into existing programs and communications, and support the development of new education initiatives where gaps exist for Surrey residents and City Staff	Municipal Jurisdiction	CMO	All		$$
CC-1.3	Engage citizens on ways they can adapt their households or otherwise prepare for climate change impacts (e.g. promote sustainable drainage techniques, plant appropriate tree species, emergency preparedness)	Municipal Jurisdiction	CMO	All		$$

Immediate Implementation

Flood Management and Drainage

Goal 1: Coordinate with all Levels of Government and Key Stakeholders on Regional Flood Management						
	Adaptation Action	**Sphere of Influence**	**City Lead**	**Support**	**Tools**	**Cost**
FL-1.1	Support the development of a Regional Flood Management Strategy in coordination with senior levels of government, other municipalities, and key stakeholders	Municipal Jurisdiction	Eng	CMO; P&D		$$
FL-1.2	Participate in a detailed cost-benefit analysis to assess alternative options for accommodating sea level rise and coastal climate change impacts	Municipal Jurisdiction	Eng	CMO; P&D		$$
FL-1.3	Encourage senior levels of government to proactively commit the capital investment for flood protection infrastructure	Influencing Others	Eng	CMO; P&D		$

Immediate Implementation

Goal 2: Update Planning and Development Standards for Floodplains						
	Adaptation Action	**Sphere of Influence**	**City Lead**	**Support**	**Tools**	**Cost**
FL-2.1	Conduct detailed analysis on Surrey-specific climate impacts, including the timelines and extent of sea level rise and its related effects on flood construction levels and floodplain designations	Municipal Jurisdiction	Eng	P&D; CMO		$$$$
FL-2.2	Develop drainage and flood strategies based on cost-benefit analyses and site-specific needs	Municipal Jurisdiction	Eng	P&D; CMO	OCP (DPAs); NCPs, ISMPs; By-Laws	$$$$
FL-2.3	Incorporate climate change into the City's Integrated Stormwater Management Plans (ISMPs) and other efforts to integrate land use planning and stormwater management	Municipal Jurisdiction	Eng	P&D; CMO	OCP (DPAs); NCPs; ISMPs	$
FL-2.4	Review and revise regulatory and design standards to account for and minimize the impacts of climate change	Municipal Jurisdiction	P&D	Eng; CMO	OCP (DPAs); NCPs; ISMPs; By-Laws	$

Immediate Implementation

Infrastructure

Goal 1: Deliver Proactive Climate Analysis and Management Practices for City Infrastructure						
	Adaptation Action	**Sphere of Influence**	**City Lead**	**Support**	**Tools**	**Cost**
IN-1.1	Enhance data collection and monitoring for climate impacts in Surrey (e.g. storm events, precipitation patterns, subsidence rates, changes in water quality, etc.)	Corporate Operations	Eng	P&D; PRC	Monitoring equipment	$$
IN-1.2	Regularly review design requirements to ensure that they adequately account for expected weather conditions due to climate change	Corporate Operations	Eng	PRC	Engineering Design Criteria; Park Design Standards	$
IN-1.3	Assess existing City infrastructure and utilities for vulnerability to climate change	Corporate Operations	Eng			$$
IN-1.4	Integrate climate change into the 10 year capital and servicing plans of relevant departments	Corporate Operations	Eng; PRC	CMO		$
IN-1.5	Continue to minimize the inflow and infiltration of stormwater into the sanitary sewer system in an effort to reduce the risk of sanitary sewer overflows	Municipal Jurisdiction	Eng	P&D	Engineering Design Criteria	$$
IN-1.6	Monitor and manage species composition and selection to enhance resilience of Surrey's Green Infrastructure Network	Municipal Jurisdiction	PRC	Eng	Biodiversity Conservation Strategy	$

Goal 2: Support The Design of Climate-Resilient Buildings in Surrey						
	Adaptation Action	**Sphere of Influence**	**City Lead**	**Support**	**Tools**	**Cost**
IN-2.1	Advance energy efficiency in new construction and building retrofits	Municipal Jurisdiction	P&D	CMO; Eng	CEEP; District Energy By-law; OCP; Design Guidelines; Sustainable Development Checklist	$$
IN-2.2	Increase education and awareness on energy efficiency opportunities among City staff and developers	Corporate Operations	P&D	CMO; Eng		$
IN-2.3	Encourage the Province to ensure the BC Building Code adequately reflects and accounts for current and projected climate (i.e. increased winter precipitation, storm events and increased summer temperatures)	Influencing Others	CMO	P&D; Eng		$
IN-2.4	Ensure incorporation of guidelines for water conservation in new and re-development	Municipal Jurisdiction	P&D	Eng	DPAs; Design Guidelines; Sustainable Development Checklist	$

Goal 3: Advance Energy Self-Sufficiency within the Community						
	Adaptation Action	**Sphere of Influence**	**City Lead**	**Support**	**Tools**	**Cost**
IN-3.1	Continue to expand on district energy systems in City Centre and support the development of district energy outside the current service areas	Municipal Jurisdiction	Eng	P&D	District Energy By-Law; Community Energy and Emissions Plan	$$$$$
IN-3.2	Establish a requirement for development over a certain size to complete an energy study that identifies energy efficiency and generation opportunities	Municipal Jurisdiction	P&D	Eng	CEEP; OCP (Zoning)	$
IN-3.3	Explore opportunities to support local development of distributed energy systems and renewable energy sources (e.g. solar hot water, biomass, etc.)	Influencing Others	CMO	P&D; Eng	Community Energy and Emissions Plan	$
IN-3.4	Encourage the Province to establish programs that incent homeowners to invest in renewable energy generation	Influencing Others	CMO	P&D; Eng	DPAs; Design Guidelines; Sustainable Development Checklist	$

Ecosystems and Natural Areas

Goal 1: Optimize Space for Habitat and Species Migration						
	Adaptation Action	**Sphere of Influence**	**City Lead**	**Support**	**Tools**	**Cost**
EC-1.1	Improve the quantity and quality of habitat across the City to enable species migration and resilience through the implementatin of the Biodiversity Conservation Strategy	Municipal Jurisdiction	PRC	P&D; Eng	Ecosystem Management Study; Biodiversity Conservation Strategy; Park Natural Areas Strategic Management Plan; PRC Strategic Management Plan	$$
EC-1.2	Strategically acquire a diverse representation of ecosystem types as part of Surrey's parks and natural areas	Municipal Jurisdiction	PRC	P&D; Eng	Biodiversity Conservation Strategy; Park Natural Areas Strategic Management Plan; PRC Strategic Management Plan	$$
EC-1.3	Reduce habitat fragmentation by using and protecting a comprehensive network of corridors and larger natural areas (hubs and sites)	Municipal Jurisdiction	PRC	P&D; Eng	Ecosystem Management Study; Biodiversity Conservation Strategy; Park Natural Areas Strategic Management Plan	$
EC-1.4	Increase public awareness, capacity, and the use of planning tools (e.g. voluntary conservation easements) to create higher habitat values on private property.	Influencing Others	P&D	PRC; Eng	Biodiversity Conservation Strategy; Ecosystems Management Study	$

Immediate Implementation

Goal 2: Actively Manage City's Ecological Assets						
	Adaptation Action	**Sphere of Influence**	**City Lead**	**Support**	**Tools**	**Cost**
EC-2.1	Increase active management of City controlled natural areas (e.g. removal of invasive species), as necessary and encourage more active management of natural areas on Provincial, Regional and non-profit and privately owned lands.	Corporate Operations	PRC	P&D; Eng	Biodiversity Conservation Strategy; Park Natural Area Strategic Management Plan	$$$
EC-2.2	Implement evolving best practices for ecosystem management in a changing climate	Corporate Operations	PRC	Eng	Ecosystem Management Study; Biodiversity Conservation Strategy; Park Natural Areas Strategic Management Plan	$$
EC-2.3	Consider assisted migration for species whose dispersion rate is unable to keep pace with climate change (e.g. planting tree species historically suited to more Southern climates)	Corporate Operations	PRC	P&D; Eng	Biodiversity Conservation Strategy; Park Natural Area Strategic Management Plan	$$

Goal 2: Actively Manage City's Ecological Assets (continued)						
	Adaptation Action	**Sphere of Influence**	**City Lead**	**Support**	**Tools**	**Cost**
EC-2.4	Increase tree risk management to minimize damage and liability from dead or dying trees	Municipal Jurisdiction	PRC	F&T; Eng	Tree Removal Policy	$$
EC-2.5	Partner with key organizations and the private sector to limit the sale of invasive species and promote adaptable species at local nurseries	Influencing Others	PRC	CMO; Eng; P&D	Park Natural Area Strategic Management Plan	$
EC-2.6	Incorporate climate change messaging in environmental education efforts, and continue to engage the public in stewardship initiatives	Municipal Jurisdiction	PRC	Eng	High School Urban Forestry Program; SHaRP Program; Coho Crew; SNAP Program, etc.	$

Goal 3: Support Viability of Highly Sensitive Ecosystems						
	Adaptation Action	**Sphere of Influence**	**City Lead**	**Support**	**Tools**	**Cost**
Riparian Areas						
EC-3.1	Apply Surrey standards for streamside setbacks to accommodate potential erosion and optimize ecological health	Municipal Jurisdiction	P&D	PRC; Eng	OCP/DPAs; NCPs	$
EC-3.2	Establish Development Permit Area Guidelines for sensitive ecosystems	Municipal Jurisdiction	P&D	PRC; Eng	OCP/DPAs	$
EC-3.3	Implement strategies to maintain stream flow affected by changing temperature and precipitation patterns	Corporate Operations	Eng	PRC; P&D	ISMPs	$$$$
Intertidal Areas						
EC-3.4	Promote the development of a regional cost/benefit analysis of sea level rise and flood management options that considers ecological values and protection of property and infrastructure	Municipal Jurisdiction	Eng	P&D		$$$
EC-3.5	Evaluate options for installing physical interventions to support ecosystems (e.g. construction of a breakwater)	Municipal Jurisdiction	Eng	P&D		$$

Goal 4: Protect Ecosystem Services through Development						
	Adaptation Action	Sphere of Influence	City Lead	Support	Tools	Cost
EC-4.1	Incorporate climate change into the City's Integrated Stormwater Management Plans (ISMPs) and other efforts to integrate land use planning and stormwater management	Municipal Jurisdiction	Eng	P&D	NCPs; OCP Guidelines; ISMPs	$
EC-4.2	Provide direction to developers on suitable vegetative species and development features that enhance habitat values	Municipal Jurisdiction	P&D	Eng; PRC	NCPs; OCP Guidelines	$
EC-4.3	Host workshops for the City's staff, management and Council on 'green' development features and their effectiveness in protecting ecosystem services	Corporate Operations	P&D	CMO; Eng	NCPs; OCP Guidelines	$
EC-4.4	Review landscape design guidelines to ensure they support habitat values	Municipal Jurisdiction	P&D	PRC; Eng	NCPs; OCP Guidelines	$

Urban Trees and Landscaping

Goal 1: Provide the Required Growing Environment to Sustain Trees						
	Adaptation Action	**Sphere of Influence**	**City Lead**	**Support**	**Tools**	**Cost**
TR-1.1	Utilize City by-laws, standards, and permitting processes to ensure adequate canopy, root crown and root growth space is provided for trees to mature to optimal size on public and private property	Municipal Jurisdiction	P&D	Eng; PRC	Park Construction Standards, Engineering Design Criteria, NCPs, Tree Protection By-law, BCSLA & BCLNA Landscape Standards, ISMPs	$$
TR-1.2	Utilize City By-laws, standards, and permitting processes to optimize soil conditions for shade trees on public and private property (e.g. soil quality, quantity and moisture content)	Municipal Jurisdiction	P&D	Eng; PRC	Park Construction Standards, Engineering Design Criteria, NCPs, Tree Protection By-law, BCSLA & BCLNA Landscape Standards, ISMPs	$

Immediate Implementation

Goal 2: Plant Appropriate Species						
	Adaptation Action	**Sphere of Influence**	**City Lead**	**Support**	**Tools**	**Cost**
TR-2.1	Select tree species and planting stock from provenances that will be well adapted to Surrey's future climate projections, particularly with respect to temperature and drought increases	Municipal Jurisdiction	PRC	P&D; Eng	Park Construction Standards, Tree Protection By-law	$
TR-2.2	Monitor survival rate of trees planted on public property to confirm species suitability over time	Corporate Operations	PRC	P&D; Eng		$
TR-2.3	Increase the species diversity of shade trees on public and private property	Corporate Operations	PRC	Eng; P&D	Park Construction Standards, Shade Tree Strategic Management Plan, Tree Protection By-law	$
TR-2.4	Develop an educational resource that encourages residents to plant trees which enhance species diversity (e.g. an annual "feature tree" pamphlet)	Municipal Jurisdiction	P&D	PRC		$

Immediate Implementation

Goal 3: Increase Tree Maintenance Management						
	Adaptation Action	**Sphere of Influence**	**City Lead**	**Support**	**Tools**	**Cost**
TR-3.1	Increase tree replacement and maintenance activities (such as watering) to sustain trees, as necessary	Corporate Operations	PRC	P&D	Tree Protection By-law	$$$
TR-3.2	Anticipate a growing need for tree risk assessments and abatement due to tree decline and mortality	Municipal Jurisdiction	PRC	F&T; P&D		$$
TR-3.3	Undertake a Pest Threat Assessment to better understand the risks to trees and ecosystems posed by changing disease vectors and invasive species	Corporate Operations	PRC	P&D		$
TR-3.4	Explore a requirement for local residents to water boulevard trees during summer months	Municipal Jurisdiction	PRC	P&D; Legal Services		$

Agriculture and Food Security

Goal 1: Provide Appropriate Infrastructure for Agricultural Viability						
	Adaptation Action	**Sphere of Influence**	**City Lead**	**Support**	**Tools**	**Cost**
AG-1.1	Continue to improve lowland drainage and flood management infrastructure in keeping with the Lowland Flood Control Strategic Plan	Municipal Jurisdiction	Eng	P&D	Agricultural Strategy; Lowland Flood Control Strategic Plan; Agri-Food Regional Development Subsidiary Agreement (ARDSA)	$$$$$
AG-1.2	Work with all levels of government to evaluate long-term flood management options in response to sea level rise impacts with considerations for agricultural vulnerability	Municipal Jurisdiction	Eng	P&D	BC Flood Construction Guidelines	$$
AG-1.3	Continue to enhance rainwater storage and stormwater management in all areas of Surrey, including agricultural areas	Municipal Jurisdiction	Eng	P&D	OCP; NCPs; ISMPs; Engineering Design Criteria	$$
AG-1.4	Investigate ways of improving access to an adequate and safe water supply for food production and processing purposes	Influencing Others	Eng	P&D	Agricultural Strategy	$

Immediate Implementation

Goal 2: Encourage Greater Diversity in Local Products and Growing Methods						
	Adaptation Action	**Sphere of Influence**	**City Lead**	**Support**	**Tools**	**Cost**
AG-2.1	Continue to work closely with the federal Department of Fisheries and Oceans to protect fish habitat within the City	Municipal Jurisdiction	Eng	PRC	Biodiversity Conservation Strategy	$$
AG-2.2	Work with key partners to help maintain and grow the food processing industry in Surrey	Influencing Others	P&D	ED	Agricultural Strategy; Economic Development Strategy; Zoning By-law; NCPs; OCP	$
AG-2.3	Encourage local research to help identify resilient agricultural practices (e.g. mapping crop varieties to future climate scenarios; integrated pest management strategies, etc.)	Influencing Others	CMO	P&D	Agricultural strategy	$
AG-2.4	Support farmers and other key partners to pursue innovative agricultural practices (e.g. vertical farming) within and beyond designated agricultural lands	Influencing Others	P&D	ED	Agricultural Strategy; Economic Development Strategy	$
AG-2.5	Encourage farmers to diversify crop selection and choose adaptable varieties (e.g. less dependent on irrigation, more resistant to saline soils)	Influencing Others	P&D	Eng	Agricultural Strategy	$

Goal 3: Increase Food Self-Sufficiency in the City and Region						
	Adaptation Action	Sphere of Influence	City Lead	Support	Tools	Cost
AG-3.1	Continue to support residents' direct access to local food through farm gate sales and partnerships with farmers' markets	Municipal Jurisdiction	P&D	CMO; ED	Agricultural Strategy	$
AG-3.2	Increase opportunities for citizens to produce their own food (e.g. support community gardens; review parcel size requirements for backyard chickens)	Municipal Jurisdiction	CMO	P&D; PRC	Zoning By-law	$
AG-3.3	Maximize the use of public and private urban landscape features, terraces, and rooftops for food production (e.g. edible landscaping guidelines for new strata developments)	Municipal Jurisdiction	P&D	PRC; Eng	Zoning By-law; OCP; NCPs; Design Guidelines	$
AG-3.4	Encourage local research on the types and quantity of crops needed to increase self-sufficiency	Influencing Others	CMO			$
AG-3.5	Encourage the restoration of pollinator-friendly habitat and the housing of apiaries on private and public lands, where practical	Influencing Others	P&D		Biodiversity Conservation Strategy	$
AG-3.6	Investigate the feasibility of a farm incubator program to ensure new farmers are able to enter the industry	Influencing Others	P&D	PRC; ED	Agricultural Strategy	$$
AG-3.7	Collaborate with others to reduce the quantity of food that is wasted at each stage in the supply chain (e.g. finding markets for food that is not perfectly symmetrical or aesthetically conventional)	Influencing Others	CMO	P&D; PRC; Eng	Surrey Waste Reduction Strategy	$

Goal 4: Help Farmers Build Capacity to Adapt						
	Adaptation Action	**Sphere of Influence**	**City Lead**	**Support**	**Tools**	**Cost**
AG-4.1	Review and update Surrey's Agricultural Plan to account for climate change impacts	Municipal Jurisdiction	P&D	Eng		$
AG-4.2	Manage urban-rural interface relations as agricultural practices change and adapt	Municipal Jurisdiction	P&D		OCP, DPAs, Zoning By-law	$
AG-4.3	Explore and support best practices from other global communities that currently face challenges our agricultural system may face in the future (e.g. innovative dyking technologies, growing practices in warmer/ dryer climates, etc.)	Influencing Others	CMO	P&D		$
AG-4.4	Consider an agriculture co-ordinator position to help build capacity for the development of agriculture and sustainable food systems within the City	Municipal Jurisdiction	P&D		Agricultural Plan	$

Human Health and Safety

Goal 1: Collaborate with Key Partners on Improving Population Health						
	Adaptation Action	**Sphere of Influence**	**City Lead**	**Support**	**Tools**	**Cost**
HS-1.1	Continue to collaborate with community organizations and service agencies to improve the socio-economic conditions and health outcomes of vulnerable populations	Municipal Jurisdiction	P&D	PRC; CMO; Eng; Crime Reduction; Libraries	Social Plan; Poverty Reduction Plan; Child and Youth Friendly City Strategy; Master Plan for Housing the Homeless	$
HS-1.2	Encourage health agencies and research institutions to anticipate, monitor and reduce the impact of climate change on the spread of infectious disease	Influencing Others	CMO	P&D; PRC; Eng		$
HS-1.3	Work with key partners to integrate climate change messaging into communication materials related to public health and safety	Influencing Others	CMO	P&D, PRC; Fire; Eng		$
HS-1.4	Work with health agencies to better identify and respond to the needs of vulnerable populations specific to climate-related health risks	Influencing Others	P&D	PRC; Fire	Surrey Emergency Social Services Program; Social Plan	$

Goal 2: Minimize the Urban Heat Island Effect						
	Adaptation Action	**Sphere of Influence**	**City Lead**	**Support**	**Tools**	**Cost**
HS-2.1	Ensure sufficient space and adequate soil medium for shade trees in urban areas	Municipal Jurisdiction	P&D	PRC; Eng	Park Construction Standards, Engineering Design Criteria, NCPs	$
HS-2.2	Encourage development to incorporate passive building design features that keep buildings cool while reducing reliance on air conditioning	Municipal Jurisdiction	P&D	CMO; Eng	OCP (DPAs), NCPs (Design Guidelines), Sustainable Development Checklist; CEEP	$
HS-2.3	Utilize landscaping and site design to increase green space and strategically cool buildings and the urban environment	Municipal Jurisdiction	P&D	PRC	NCPs, DPAs, Landscaping Design Guidelines, Sustainable Development Checklist	$

Immediate Implementation

Goal 2: Minimize the Urban Heat Island Effect (Cont'd)						
	Adaptation Action	**Sphere of Influence**	**City Lead**	**Support**	**Tools**	**Cost**
HS-2.4	Explore opportunities for green roofs and walls on institutional, commercial, industrial and large residential development	Municipal Jurisdiction	P&D	CMO; PRC; Eng	Sustainable Development Checklist; By-Laws	$
HS-2.5	Engage vulnerable neighbourhoods in programs that keep indoor and outdoor environments cool (e.g. energy retrofit programs, tree planting and water fountain installations)	Municipal Jurisdiction	CMO	P&D; Eng; PRC		$
HS-2.6	Reduce the impacts of surface parking lots by increasing canopy coverage and the use of alternative paving surfaces	Municipal Jurisdiction	P&D	Eng	OCP (DPAs)	$
HS-2.7	Increase the use of high albedo (i.e. light coloured, reflective) surfaces on buildings and pavings	Municipal Jurisdiction	P&D	PRC; Eng	OCP (DPAs); NCPs (Design Guidelines); Sustainable Development Checklist	$

Goal 3: Minimize Risks from Urban-wildland Interface Fire							
	Adaptation Action	**Sphere of Influence**	**City Lead**	**Support**	**Tools**	**Cost**	**Priority**
HS-3.1	Implement the City of Surrey Community Wildfire Protection Plan, and monitor changes to fire risk over time as a result of climate change	Municipal Jurisdiction	PRC	P&D; Fire		$	Medium
HS-3.2	Enforce "Firesmart" guidelines for developments within 100m of moderate or high risk wildfires	Municipal Jurisdiction	PRC	P&D; Fire	NCPs, DPAs	$	Medium
HS-3.3	Provide "Firesmart" education to the Surrey public, targeting residents in close proximity to areas of high and moderate risk of wildfire	Municipal Jurisdiction	Fire	PRC		$	Low

Goal 4: Build Emergency Preparedness Capacity at the City							
	Adaptation Action	**Sphere of Influence**	**City Lead**	**Support**	**Tools**	**Cost**	**Priority**
HS-4.1	Continue to build community capacity to respond effectively in an emergency (i.e. neighbours helping neighbours)	Municipal Jurisdiction	Fire	All	Neighbourhood Emergency Preparedness Program; Surrey Emergency Program	$$	Medium
HS-4.2	Review and support implementation of the Surrey-White Rock Extreme Heat Response Plan in the case of heat advisories	Municipal Jurisdiction	Fire	F&T; P&D	Surrey-White Rock Extreme Heat Response Plan; Surrey Emergency Program	$	Medium
HS-4.3	Look at gaps in emergency prevention and response, taking into account climate change impacts	Corporate Operations	Fire	F&T; All	Surrey Emergency Program	$	Medium
HS-4.4	Ensure emergency response capacity keeps pace with the need for services, given increasing climate impacts	Corporate Operations	Fire	F&T; All	Surrey Emergency Program	$	Low

APPENDIX B:
PROPOSED INDICATORS

Flood Management and Drainage

Goal	Proposed Indicator	Related Plan or Source	Department
Coordinate with all levels of government and key stakeholders on regional flood management	Value of regional and City-owned assets in unprotected coastal flood-prone areas		Engineering; Planning
Update planning and development standards for floodplains	Number of days/incidents of dykes breached per year		Engineering
	Percentage (or total) population residing in floodplain areas		Engineering; Planning
	Number of high tides greater than Xm/year		Engineering
	Number of rainfall events with a return period greater than 2 years		Engineering

Infrastructure

Goal	Proposed Indicator	Related Plan or Source	Department
Deliver proactive climate analysis and management practices for City infrastructure	Number of sanitary sewer overflows per year		Engineering
	Total losses (dollar value) due to weather related events incurred by the City		Risk Management
Support the design of climate-resilient buildings in Surrey	Energy use from community buildings	Sustainability Dashboard	Sustainability
	Daily water consumption per capita (in winter months)	Sustainability Dashboard	Sustainability
	Number and/or cost of insurance claims from extreme weather events in the community		
	Number of new certified green buildings	Sustainability Dashboard	Sustainability
Advance energy self-sufficiency within the community	Total floor space connected to district energy system		Engineering

Ecosystems and Natural Areas

Goal	Proposed Indicator	Related Plan or Source	Department
Optimize space for habitat and species migration	Proportion of Green Infrastructure Network established	Biodiversity Conservation Strategy	Planning; Engineering; Parks
	Proportion of Surrey's land base with vegetative coverage, by type	Sustainability Dashboard, Biodiversity Conservation Strategy	Planning; Engineering; Parks
Actively manage ecological assets	Proportion of invasive alien plant species compared to native plant species	Biodiversity Conservation Strategy	Engineering; Parks
	Management strategies and action plans for species at risk	Biodiversity Conservation Strategy	Engineering; Parks
Support viability of highly sensitive ecosystems	Total area of protected riparian zones		Planning; Engineering; Parks

Urban Trees and Landscaping

Goal	Proposed Indicator	Related Plan or Source	Department
Provide required growing environment to sustain trees	Mortality rate of trees in public inventory		Parks
	Tree canopy coverage	Surrey Tree Canopy Study	Planning; Parks
Plant appropriate species	Number of species exceeding 10% of total tree inventory; Number of genii exceeding 15% of total tree inventory		Parks
	Total number of tree species and genii in the public tree inventory		Parks
	Mortality rate of trees, by species		Parks
Increase tree maintenance management	Dollars expended on abatement per year		Parks
Improve public understanding of climate change impacts	Ratio trees planted to trees removed on private property	Sustainability Dashboard	Planning
	Tree canopy coverage on private property		Planning

Agriculture and Food Security

Goal	Proposed Indicator	Related Plan or Source	Department
Provide appropriate infrastructure for agricultural viability	Number of flooding events that exceed standards set by Agri-Food Regional Development Subsidiary Agreement (ARDSA)	Lowlands Flood Control Project	Engineering
Encourage greater diversity in local product and growing methods	Total number of food products grown in Surrey	Agriculture Strategy; Agricultural Plan	Sustainability; Planning
	Gross revenue from processing and/or number of processing facilities	Agriculture Strategy	Sustainability; Planning
Increase food self-sufficiency in the City and region	Gross annual farm receipts	Sustainability Dashboard	Planning
	Total land in food production	Sustainability Dashboard	Sustainability
	Number of Community Garden Plots	Sustainability Dashboard	Sustainability

Human Health and Safety

Goal	Proposed Indicator	Related Plan or Source	Department
Collaborate with key partners on improving population health	Incidence of West Nile Virus (humans and birds)	BC Centre for Disease Control's WNV Surveillance Data	Sustainability
Minimize the urban heat island effect	Tree canopy coverage in urban areas	Surrey Tree Canopy Study	Planning
Minimize risk from urban-wildland interface fires	Number of wildfires per year	Community Wildfire Protection Plan	Fire Department; Parks
	Number of households within 100m of areas that are rated at moderate to high risk of wildfires	Community Wildfire Protection Plan	Parks
Build emergency preparedness capacity at the City	Number of neighbourhoods participating in the Neighbourhood Emergency Preparedness Program	Neighbourhood Emergency Preparedness Program	Fire Department

APPENDIX C:
DETAILED CLIMATE PROJECTIONS

Climatic Change	Variable	Historical Baseline	Projected Climatic Change		
			2020s	2050s	2080s
Temperature	Mean Annual Temperature	1961-1990	+1°C (+ 0.5°C to 1.4°C)	+1.7 °C (+1.0 °C to +2.5 °C)	+2.7 °C (+1.5 °C to +4.1 °C)
	Extremely Hot Days	1971-2000	By 2050s: 5-, 10-, and 25-year return period events occur 2.4, 2.8, and 3.2 times as often as in the past, respectively		
	Heating Degree Days (deg-days <18°C)*	1961-1990	-334 deg-days (-479 to -171 deg-days)	-589 deg-days (-853 to -360 deg-days)	-919 deg-days (-1344 to -520 deg-days)
	Cooling Degree Days (deg-days <18°C)*	1961-1990	-	+142% to +597%	+329% to +1043%
	Growing Degree Days (deg-days >5°C)*	1961-1990	+225 deg-days (+104 to +314 deg-days)	+415 deg-days (+250 to +609 deg-days)	+680 deg-days (+373 to +1072 deg-days)
	Frost Free Days	1961-1990	+13 days (+6 to +21 days)	+22 days (+14 to +33 days)	+33 days (+19 to +47 days)
Precipitation	Mean Annual Precipitation	1961-1990	+4% (-2% to +8%)	+7% (-2% to +11%)	+8% (+1% to +18%)
	Winter Precipitation	1961-1990	+3% (-3 to +9%)	+6% (-4 to +15%)	+9% (+1 to +23%)
	Summer Precipitation	1961-1990	-7% (-16 to +8%)	-15% (-25 to +3%)	-14% (-37 to -3%)
	Peak Precipitation: Intensity	1971-2000	By 2050s: Amount of precipitation on 'very wet days' (>95th percentile) to increase by 21%; 'extremely wet days) (>99th percentile) to increase by 28%		
	Peak Precipitation: Frequency	1971-2000	By 2050s: 5-, 10-, and 25-year daily precipitation return periods occur 1.6, 1.9, and 2.5 times as often as in the past, respectively		
	Winter Precipitation as Snow	1961-1990	-22% (-42% to -5%)	-36% (-56% to -19%)	-52% (-74% to -26%)
Sea Level Rise (SLR)	Sea Level Rise (Surrey)	-	Surrey is currently experiencing +3.1mm of SLR plus 0.225mm of subsidence per year		1.2m by 2100 (including subsidence)

**Degree-days measure the accumulation of degrees (temperature) above or below a stated baseline. For example, with a baseline of 5°C (the minimum temperature conducive to vegetative growth), a day with an average temperature of 10°C would have a value of 5 growing degree days. Growing degree days are often used to measure the potential for agricultural productivity; heating degree days are used to assess the energy demand required for heating buildings on cold days (< 18°C); cooling degree days are used to assess the energy demand required for cooling buildings on hot days (> 18°C).*

APPENDIX D: RISK ASSESSMENT METHODOLOGY AND OUTCOMES

ICLEI's Milestone 3 (Plan) involved a vulnerability and risk assessment to determine the areas in which the City should focus effort. Vulnerability describes how susceptible a service area (e.g. water utility) is to the impacts of climate change and is a function of the service area's sensitivity and adaptive capacity; that is, how sensitive the service area is to existing and future climatic stresses and how effectively it can accommodate and adjust to impacts. Key determinants of adaptive capacity include economic resources, level of technology, available information and skills, social capital, and the efficacy of existing institutions.

The sensitivity and adaptive capacity scores were mapped on a matrix (Table 3) to give the resulting vulnerability rating. The impacts to which Surrey was least vulnerable (V1) were removed, and 15 of the original 18 climate impacts were carried forward to the risk assessment.

Table 3: Vulnerability Matrix (Source: ICLEI's Adaptation Tool)

			Sensitivity				
			Low →				High
			S1	S2	S3	S4	S5
Adaptive Capacity	Low	AC1	V2	V2	V4	V5	V5
		AC2	V2	V2	V3	V4	V5
		AC3	V2	V2	V3	V4	V4
		AC4	V1	V2	V2	V3	V3
	High	AC5	V1	V1	V2	V3	V3

Surrey's risk assessment evaluated the probability of an impact occurring and multiplied this likelihood by the consequences, should it occur. The likelihood of a climate impact was considered as either a recurrent risk, such as flooding or heat waves, or a single event, such as permanent inundation due to sea level rise. The likelihood rating considered the chances of events occurring in the near term and over the next 50 years. The potential consequences were estimated across five dimensions: public safety, local economy and private property, regionally important infrastructure, environmental quality, and City government.

The likelihood and consequence scores were multiplied to give the resulting risk rating. None of the impacts were calculated to be 'very high' or 'extreme' risk. Climate impacts that were assigned a low risk rating (< 35) were removed and the remaining 14 were brought forward to be addressed in the strategy development phase. Given that some actions may require little effort or could have valuable ancillary benefits, impacts with a medium-low or medium risk rating were included in the strategy development phase. The level of risk assigned to each impact was later used to help prioritize adaptation strategies. See Table 4 for the scoring results from the risk assessment outcomes.

Figure 8. Risk Rating

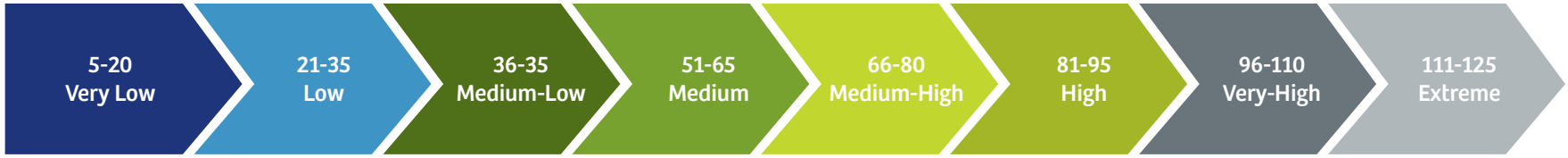

Table 4: Risk Assessment Scoring and Results

Potential Resulting Impact from Climate Change Condition	Likelihood	Consequence	Risk
Increase in Temperature			
Increased tree mortality rate and change in urban forest composition due to increase in hot weather, decreased summer precipitation, and increased winter precipitation leading to more saturated soils in lowlands	5	16	80 (medium-high)
Change in streams' ecological composition due to increased summer temperatures and changing precipitation regimes altering stream base flow and water quality	5	14	70 (medium-high)
Increased risk of Fraser River freshet flooding due to changing temperature and precipitation regime in the Fraser River Basin, and sea level rise raising Fraser river water levels	4	16	64 (medium)
Agricultural irrigation (river & well) demand exceeds supply due to increased temperatures, decreased summer rainfall, and increased agricultural growing due to increased growing degree days	5	12	60 (medium)
Increased human health impacts including greater spread of pathogens due to warmer, wetter winter climate	4	15	56 (medium)
Increasing energy costs and energy insecurity due to the combination of an increased cooling load and changing temperature and precipitation regimes affecting the seasonal availability of hydroelectric power in BC	4	14	56 (medium)
Increased risk of urban interface fires (e.g. forest fires and fires in other natural areas) due to increased temperature and drier summers	3	13	39 (medium-low)
Increased heat stress and other health ailments due to increase in heat advisory days	5	10	50 (medium-low)
Domestic water demand exceeds supply due to increased temperatures and decreased summer rainfall	2	11	22 (low)

Increase in Winter Precipitation			
Drainage system flooding in floodplain areas due to reduced gravity drainage associated with sea level rise and more intensive precipitation events	5	19	95 (high)
Reduced soil drainage in floodplain areas due to seepage and rising water tables associated with sea level rise and heavier winter rainfall	5	18	90 (high)
Increased tree mortality rate and change in urban forest composition due to increase in hot weather, decreased summer precipitation, and increased winter precipitation leading to more saturated soils in lowlands	5	16	80 (medium-high)
Increased risk of Fraser River freshet flooding due to changing temperature and precipitation regime in the Fraser River Basin, and sea level rise raising Fraser river water levels	3	16	64 (medium)
Increased human health impacts including greater spread of pathogens due to warmer, wetter winter climate	4	15	56 (medium)
Decrease in Summer Precipitation			
Increased tree mortality rate and change in urban forest composition due to increase in hot weather, decreased summer precipitation, and increased winter precipitation leading to more saturated soils in lowlands	5	16	80 (medium-high)
Change in streams' ecological composition due to increased summer temperatures and changing precipitation regimes altering stream base flow and water quality	5	14	70 (medium-high)
Agricultural irrigation (river & well) demand exceeds supply due to increased temperatures, decreased summer rainfall, and increased agricultural growing due to increased growing degree days	5	12	60 (medium)

Increasing energy costs and energy insecurity due to the combination of an increased cooling load and changing temperature and precipitation regimes affecting the seasonal availability of hydroelectric power in BC	4	14	56 (medium)
Increased risk of urban interface fires (e.g. forest fires and fires in other natural areas) due to increased temperature and drier summers	3	13	39 (medium-low)
Domestic water demand exceeds supply due to increased temperatures and decreased summer rainfall	2	11	22 (low)
Increase in Sea Level and Storm Events			
Drainage system flooding in floodplain areas due to reduced gravity drainage associated with sea level rise and more intensive precipitation events	5	19	95 (high)
Reduced soil drainage in floodplain areas due to seepage and rising water tables associated with sea level rise and heavier winter rainfall	5	18	90 (high)
Flooding and/or permanent inundation of floodplains due to rising seas and more intense storm surges breaching sea dams and/or dykes	5	19	95 (high)
Impacts on the viability of agricultural crops and other vegetation in floodplain areas, due to saltwater intrusion and flooding associated with sea level rise	4	19	76 (medium-high)
Loss of tidal mudflats and marshland ecosystems on seaward side of dykes due to increased wave action and erosion associated with sea level rise and existing dyke positions	5	14	70 (medium-high)
Damages and/or increased maintenance costs to structures and infrastructure (underground and at-grade) due to more variable and extreme weather patterns and sea level rise	3	12	36 (medium-low)

APPENDIX E:
PRIORITIZATION FRAMEWORK

Once a refined list of adaptation actions was developed, each option was assessed using a modified evaluation framework from Natural Resources Canada and University of British Columbia's *Canadian Communities' Guidebook for Adaptation to Climate Change*. Table 5 summarizes the evaluation framework, which includes criteria related to cost, ancillary benefits, political acceptability, and capacity. Actions that are easier or more feasible to implement receive a higher score under the following criteria.

Table 5: Evaluation Framework for Assessing Feasibility of Potential Actions

Criteria	1 (Low)	2 (Medium)	3 (High)
Mitigation Co-benefit	Results in increased GHG emissions	Would not affect GHG emissions	Results in reduced GHG emissions
Implementation Cost	Cost is high	Cost is moderate	Cost is low
Operating and Maintenance Cost	Cost is high	Cost is moderate	Cost is low
Urgency	Impacts are likely to occur in the longer term	Impacts are beginning to occur or are likely to occur in the near to mid-term	Impacts are already occurring
Ancillary Benefits	Will contribute little or not at all to other community goals	Will contribute somewhat to other community goals	Will contribute significantly to other community goals
Window of Opportunity	There is no window of opportunity currently	A window of opportunity could be created	A window of opportunity exists to implement
Political Acceptability	Likely to be politically contentious	Likely to require political direction	Likely to be easily politically supported
Funding Sources	Funding is required but has not been identified	Funding is required and likely to be secured	Funding is available (or not required)
Capacity	Current capacity is insufficient and gaps not easily addressed	Gaps exist but could be addressed	Current capacity is sufficient

The results of the evaluation provided a feasibility rating, and were projected against the risk rating for the climate impact that each action was intended to address. For example, the action "Provide Fire Smart education to residents" is in response to an increased risk of urban-interface fires, which has a risk rating of 2, or Medium-Low. This methodology results in a priority level, as illustrated in Table 6. Through this process, proposed actions that emerged as higher priority were those that were developed to address high risk and urgent impacts and/or those that could be implemented relatively easily and often aligned with other City goals and priorities.

Table 6: Prioritization Framework

		Risk Rating				
		Low Risk	Medium-Low Risk	Medium Risk	Medium-High Risk	High Risk
Feasibility Rating	1	Low Priority	Low Priority	Low Priority	Medium Priority	Medium Priority
	2	Low Priority	Medium Priority	Medium Priority	Medium Priority	High Priority
	3	Medium Priority	Medium Priority	High Priority	High Priority	High Priority

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