City of Vancouver

Climate Change Adaptation Strategy

The Sustainability Group
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Contents

Executive Summary

Global mitigation efforts are underway to curb greenhouse gas emissions, but unless concerted action happens soon, further and more extreme changes may become unavoidable. Scientists project that Vancouver will experience increased annual precipitation and temperatures, with hotter, drier summers. More intense and frequent rain and wind storms are anticipated, and sea level rise will pose a significant challenge by mid-century. Adaptation refers to actions taken to respond to the impacts of climate change by taking advantage of opportunities, or reducing the associated risks.

There is significant overlap between climate change adaptation, mitigation and sustainability measures including those designed to improve greenspace, foster urban agriculture and facilitate improvements in buildings and urban infrastructure. Adaptation more explicitly engages a wider range of issues, particularly emergency management, health and the needs of vulnerable populations in a changing climate. Many existing City actions are already forwarding adaptation, and the focus of the Climate Change Adaptation Strategy is to build on these actions and propose new 'no regret' actions –those that benefit the community regardless of the extent of climate change we eventually experience.

Strategy development began last spring and loosely followed the ICLEI "Changing Climate, Changing Communities" guide. The first step included working with the Pacific Climate Impacts Consortium at UVic to acquire a detailed understanding of anticipated changes to the regional climate. Using these climate projections, impacts to the City were identified through interviews with general managers and working group meetings. Impacts were prioritized through a risk and vulnerability assessment, and adaptation actions were devised and evaluated through staff workshops. The Adaptation Steering Committee provided final review and comment on the Strategy. Implementation of the Strategy will be the responsibility of department staff with coordination and support from the Sustainability Group.

The Strategy includes primary and supporting actions which are all detailed in a matrix in Appendix A, including accountability and priority. Proposed actions were evaluated based on their effectiveness; overlap with sustainability and mitigation goals; cost-benefit ratio; and time horizon for anticipated impacts. They are prioritized into the categories of 'must do', 'monitor' and 'investigate further', with capital planning cycle integration for 'must do' items.

Primary adaptation actions focus on incorporating adaptation as a consideration or key driver into existing and planned projects. They include:

- Completing a comprehensive Integrated Stormwater Management Plan and continuing with sewer separation;
- Completing a coastal flood risk assessment;
- Amending flood-proofing policies;
- Completing an urban forest management plan;
- Including climate change adaptation measures in the next Vancouver Building Bylaw update;

- Developing a back-up power policy; and
- Implementing water conservation actions.

The Strategy is a living document and will continue to be revised and updated as climate change science and adaptation practice evolve. As this is the first Adaptation Strategy for Vancouver, many of the proposed actions focus on increasing our understanding of coming challenges and integrating climate change into planning, design and emergency management.

Introduction

Climate change is clearly supported by both observed trends and peer reviewed scientific research. Some climate change is now inevitable and there is evidence the world over that changes are already taking place. Global mitigation efforts are underway to curb greenhouse gas emissions, but unless concerted action happens soon, further and more extreme changes may become unavoidable. Preparing for these changes –adapting to climate change –is a warranted and complementary strategy. The City of Vancouver is a recognized leader in climate change mitigation, and adding adaptation to our business will ensure that we can continue to meet City goals cost effectively over time.

Scientists project that Vancouver will experience increased annual precipitation and temperatures, with hotter, drier summers. More intense and frequent rain and wind storms are anticipated and sea level rise will pose a significant challenge by mid-century. These changes mean an increasing risk of overland and coastal flooding, damage from storms and overheating during summer highs. Without action, these risks threaten a wide spectrum of City goals from economic prosperity to liveability.

Vancouver is joining a group of leading cities in Europe, Australia and the United States that have developed and implemented climate change adaptation actions. Vancouver's Adaptation Strategy is a priority action in both the Greenest City Plan and the Corporate Strategic Business Plan. The City joined the ICLEI Climate Change Adaptation Initiative pilot in late 2010 along with a cohort of local and regional governments across Canada. Participants work through ICLEI's five milestone methodology with the goal of developing and implementing a climate change adaptation strategy over two years.

This Adaptation Strategy focuses on understanding the climate impacts today and how they are expected to change in the coming century. It provides a framework for identifying and prioritizing vulnerabilities and risks and then exploring measures to reduce the risk imposed by climate impacts. It will guide development of policies and programs to build resiliency into everyday operations and short and long-term infrastructure investments. Accountability for the actions lies primarily with the City but also with external partners. We need to maintain or enhance the infrastructure, programs and services that make Vancouver one of the most liveable cities in the world, even as storms worsen and sea levels increase.

The Strategy is a living document and will continue to be revised and updated as climate change science and adaptation practice evolves. As this is the first Adaptation Strategy for Vancouver, many of the proposed actions focus on increasing our understanding of coming challenges and integrating climate change into planning, design and emergency management. Successive iterations of the Strategy will yield more detailed actions.

Many adaptation activities are already in place at the City driven by the need to manage observed climate changes, or to meet sustainability imperatives such as water conservation. This Strategy takes a "no regrets" approach to climate policy by identifying actions that build on these existing activities to improve community resiliency and generate benefits whether the extent of anticipated climate change materializes or not.

The Strategy begins with an overview and context for adaptation in Vancouver including adaptation basics and Vancouver's future climate (chapters one to three). Chapter four focuses on understanding the impacts and the cross-cutting issues they represent. Chapter five identifies the primary and supporting actions with a companion comprehensive action matrix located in Appendix A. A brief description of plan implementation and maintenance procedures conclude the plan.

Vision, Principles and Goals:

Strategy Vision: To ensure that Vancouver remains a liveable and resilient city, maintaining its values, character and charm in the face of climate change.

Guiding Principles:

- Use the best science available at the time of planning and review regularly.
- Promote flexible and adaptive management approaches that leave a range of future options available.
- Give priority to adaptation strategies that build on existing programs or policies and provide co-benefits with mitigation and sustainability goals.
- Aim for integration into department business, "mainstreaming", versus entirely new-staffed projects.
- Establish and maintain strong networks with First Nations and other levels of government as well as with partners such as the Port, the Board of Trade and the Vancouver Economic Commission.
- Adaptation efforts should be mindful of, and include, planning to meet the unique needs and conditions of people who are most vulnerable.

Goals:

Development and implementation of this strategy will:

- Increase the resilience of City infrastructure, programs and services to anticipated local climate change impacts.
- Promote and facilitate the incorporation of climate change information into City business.
- Improve awareness, knowledge, skills and resources of City staff.
- Enhance opportunities for coordination and cooperation through the development of networks and partnerships.

Chapter 1: Adaptation in Vancouver

1.1 Mitigation and Adaptation:

Climate Change mitigation refers to the ongoing attempts to prevent significant climate change through the reductions of greenhouse gases in the atmosphere. The City of Vancouver has been a leader in mitigation for over a decade. In 1990, the Clouds of Change task force was created by Council to study issues related to atmospheric change. One of their recommendations was to study adaptive measures and begin planning long-term measure to adapt to possible consequences of climate change.

In 2003, the Cool Vancouver task force connected government, industry, citizens and non-government organizations working toward the common goal of reducing greenhouse gas emissions in Vancouver.

The Greenest City Action Team, charged with making Vancouver the greenest city in the world by 2020, was formed in 2009. The resulting Greenest City Plan, released in July, 2011, includes mitigation actions and an action directing development of an adaptation strategy under the Climate Leadership goal.

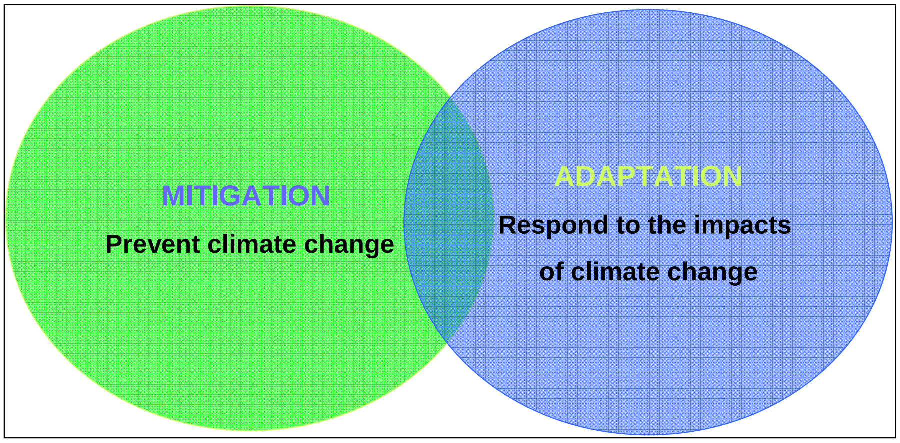

Figure 1: Mitigation and Adaptation to Climate Change

The City of Vancouver's mitigation commitment is to reduce greenhouse gas emissions in the community by 33% below 2007 levels by 2020. The reduction pathways identified include energy efficient buildings, district energy, transportation and vehicle changes, reduced landfill waste and clean electricity.

Adaptation refers to actions taken to respond to the impacts of climate change by taking advantage of opportunities or reducing the associated risks. Examples of adaptation actions include modifications of coastal development to account for sea level rise, provision of heat refuges during heat waves, planting hardy or suitable plants and dealing with increases in beach erosion.

Mitigation and adaptation are not mutually exclusive, with many actions contributing to both goals. Examples include water conservation and effective building envelopes which reduce GHGs now, but also mitigate the effects of extended hotter, drier weather in the future. Sustainability goals in general, as detailed in the Greenest City Plan, have extensive overlap with adaptation and mitigation actions. Integration of the Adaptation Strategy with Greenest City Plan actions was completed in development of this strategy.

1.2 Role of local government in adaptation

It is widely recognized that adaptation is most effective at the regional and community scale. Exposure to hazards, vulnerability, adaptive capacity and risk are all place-based in nature and many of the impacts anticipated from climate change will affect the services and infrastructure for which local governments have the primary responsibility. Local governments also have many of the tools necessary for adaptation such as planning, codes, standards and emergency response.

Local governments also invest in capital projects and programs that are expected to serve the City over many decades. Given current replacement rates, new buildings will account for an equal or greater fraction of building stock within climate change timeframes. The cost of no action, both from a future retrofit and public safety perspective, could be much higher than proactively planning infrastructure to be resilient to future climate.

The cost to build a new house, bridge or transmission line that is adapted to climate change for its lifecycle will only add 0% to 5% to construction costs which is significantly cheaper than restoring infrastructure post damage, retrofitting, rebuilding or an increased lifetime maintenance bill.[1] Economic value at risk from climate change was estimated at between 1% and 12% of GDP by 2030 for various global locations. The same study found that between 40% and 68% of these losses could be averted through adaptation measures for which economic benefits outweigh costs[2]. The National Round Table on the Environment and the Economy completed a cost benefit analysis of implementing proactive adaptation actions versus dealing with the consequences when they occur. They concluded that adaptation was a cost effective way of dealing with many climate change impacts[3]. According to a recent University of Waterloo research project, climate change adaptation is “simply good and smart business for Canada”[4].

Local governments have a duty of care to their citizens to ensure development decisions do not create the potential for unmanageable exposure to hazards. They also have a special

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[1] Climate Change Adaptation Project, 2012. Climate Change Adaptation: A Priorities Plan for Canada.
[2] Economics of Climate Adaptation Working Group, 2009. Shaping Climate-Resilient Development: a framework for decision-making.
[3] National Round Table on the Environment and the Economy. 2012. Paying the Price: The Economic Impacts of Climate Change for Canada.
[4] See footnote 1

responsibility to those members of society who are more vulnerable to impacts from climate change.

To adapt to climate change, local governments will have to alter their traditional regulatory and design regimes to incorporate future projections into decision-making. Many North American cities are well on their way to doing this and Vancouver's efforts start here.

1.3 Adaptation Definitions:

Adaptation: In human systems, adaptation is the process of adjustment to actual or expected climate and its effects, in order to moderate harm or exploit beneficial opportunities[5]. Adaptation is a function of Vulnerability and Risk.

Vulnerability: is the degree to which a system is susceptible to, or unable to cope with a particular climate change impact. It is a function of the character, magnitude and rate of climate variation to which a system is exposed; its sensitivity and its adaptive capacity[6].
Vulnerability = Exposure X Sensitivity X Adaptive Capacity

Exposure and Sensitivity: are almost inseparable properties of a system (or community). A coastal community like Vancouver is *exposed* to sea level rise while an Okanagan community may be *exposed* to drought. Sensitivity is the degree to which the system is affected. At the municipal level, ICLEI suggests assessing sensitivity by considering existing stresses that make a department sensitive and how much the performance or function of an area may be affected by a climate change impact.

Adaptive Capacity: is similar to, or closely related to, a host of other commonly used concepts, including adaptability, coping ability, management capacity, stability, flexibility and resilience. The determinants of adaptive capacity are the forces that influence the ability of the system to adapt such as managerial ability; access to financial, technological and information resources; infrastructure; institutional environment; political influence; kinship networks, etc. Adaptive capacity is context-specific and varies from community to community and among social groups and individuals, and over time[7].

Vulnerability Assessment: The process to prioritize climate change risks focusing on where we are the most susceptible. Vulnerability is a key determinant of potential impacts and disasters. For example, a heat wave can have very different impacts on distinctive populations depending on their vulnerability.

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[5] Intergovernmental Panel on Climate Change (IPCC), 2011.
[6] IPCC, 2001
[7] Smit, Barry and Johanna Wandel. 2006. Adaptation, adaptive capacity and vulnerability. Global Environmental Change 16. 282-292

Climate Change Risk: is a combined function of the probability of a hazard (an event with the potential to cause harm, e.g. floods, droughts) occurring and the magnitude or severity of its potential consequences (injury, damage, loss of habitat etc.)[8].
RISK = Likelihood (probability) X Consequence

Risk Assessment: The process to prioritize climate change risks focusing on the potential consequences of an impact.

Disaster Risk Management: Improving the understanding of disaster risk; fostering disaster risk reduction and transfer; and promoting continuous improvement in disaster preparedness, response, and recovery practices, with the explicit purpose of increasing human security, well-being, quality of life, resilience, and sustainable development[9].

Resilience: Resilience is the ability of a system and its component parts to anticipate, absorb, accommodate, or recover from the effects of a hazardous event in a timely and efficient manner, including ensuring the preservation, restoration, or improvement of its essential basic structures and functions[10].

8 Brooks, Nick 2003. Vulnerability, risk and adaptation: A conceptual framework. Tyndall Centre for Cliamte Change Research. Working Paper 38.
[9] IPCC, 2011
[10] IPCC, 2011

Chapter 2: Methodology

2.1 Overview

In 2008, ICLEI Canada, with support from Natural Resources Canada, embarked on a pilot project that guided three Canadian municipalities (Delta, BC; Greater Sudbury, ON and St. John's, NL) through an American adaptation process developed by ICLEI-USA and the University of Washington. The pilot project identified the needs of Canadian municipalities, the gaps in Canadian resources available to them and future steps for municipal adaptation planning. These lessons were integral in development of a Canadian-specific guidebook: ICLEI Canada's *Changing Climate, Changing Communities: Guide and Workbook for Municipal Climate Adaptation.*

As participants in the ICLEI Adaptation Initiative, Vancouver followed the five-milestone methodology outlined in the aforementioned guidebook. The purpose of the methodology is to convey a holistic, straightforward approach for municipalities to investigate climate change impacts and devise strategies for addressing these impacts.

There are generally two recognized approaches to adaptation planning: impact assessment and vulnerability assessment. Impact assessments are described as top down; working from the identification of anticipated impacts. Vulnerability assessments are bottom up; identifying areas where the community is sensitive and exposed to change. Both vulnerability and impact assessments can sit comfortably within a broad risk assessment framework –a systematic methodology to identify, assess, communicate and manage risks. The ICLEI milestones follow a risk assessment format.

The Five ICLEI Milestones are: Initiate, Research, Plan, Implement and Monitor/Iterate. Figure 2 below outlines the main questions addressed in each milestone. Note that this Strategy is a result of Milestones one to three. Milestones 4 and 5 follow adoption of the Strategy.

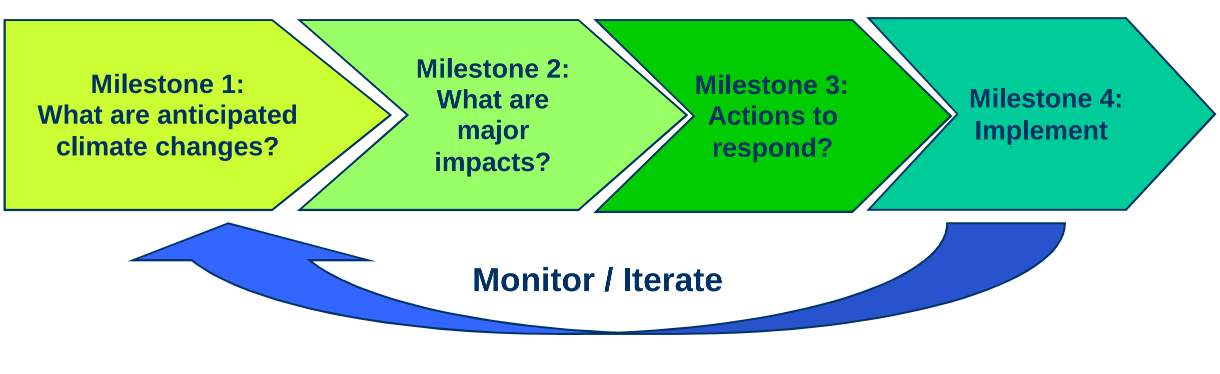


Figure 2: ICLEI Adaptation Initiative Milestones

2.2: The Adaptation Team:

Deputy City Manager, Sadhu Johnston, played an important role as Adaptation Champion. He helped solidify awareness and commitment to adaptation planning within the organization and communicated our work to external stakeholders and partners. City Engineer, Peter Judd, our executive sponsor, was also integral as an avid supporter of preparing for the impacts of climate change and ensuring resilient infrastructure over time.

An inter-departmental working group on adaptation was established in 2008 when initial investigation was completed. The group was re-convened in 2011 to support work on the ICLEI adaptation process. The Adaptation Working Group completed many of the worksheets and tasks associated with the milestones and provided a link back to their respective departments. A sea level rise working group and adaptation steering committee were both established late in the planning process as the need arose. Many staff members were involved throughout the adaptation planning process from identifying impacts to prioritizing and reviewing actions.

2.3: Vancouver Process

Figure 3 below outlines the main actions carried out in the adaptation planning process.

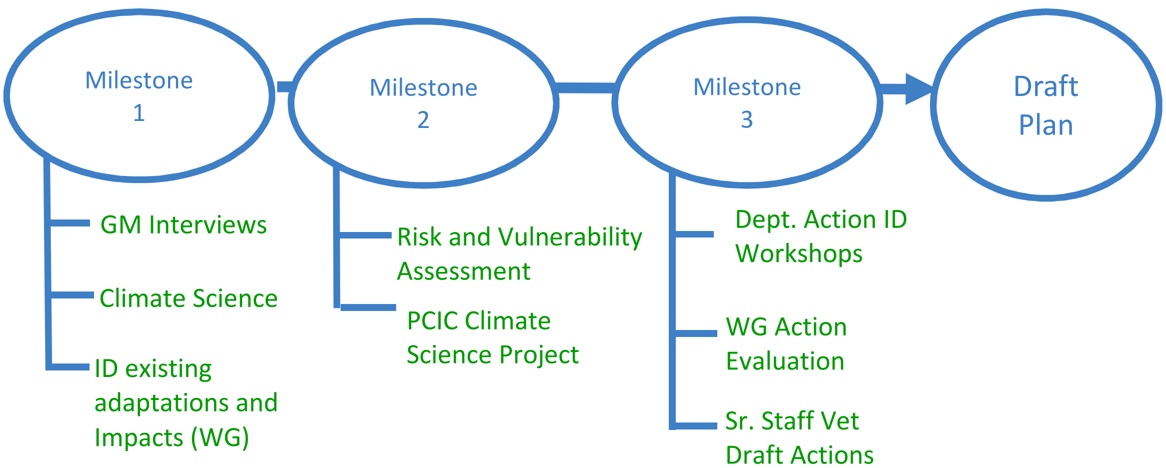


Figure 3: The City of Vancouver's Adaptation Planning Process

In Milestone one, general managers from across the organization were interviewed to introduce them to the planning effort and garner their initial feedback on impacts and department specific actions. Research on anticipated changes to climate variables (rain, wind, temperature) was presented as a basis for impact identification by the GMs and subsequently by the working group. Milestone one also included a scan of existing policies, programs, plans and bylaws to identify existing adaptation actions and opportunities to include adaptation considerations.

Milestone two focused on the risk and vulnerability assessments which were completed by the working group (see section 2.4). Starting with over 80 identified impacts, the assessments prioritized the list to just over twenty key impacts. In collaboration with ICLEI and PCIC, the

Georgia Basin Adaptation Initiative participants commissioned a study of regional climate science to support adaptation planning.

Identification and prioritization of adaptation actions dominated milestone three. Departmental workshops focused on brainstorming actions to respond to, or minimize the risk imposed by impacts affecting the department. Workshops included a mapping exercise to identify assets vulnerable to sea level rise and voting to categorize actions from low hanging fruit to complex. In order to focus detail on appropriate actions, the working group evaluated all actions against a set of criteria (see section 2.5). Iterations of review ensured departments were involved throughout the process.

2.4 Strategy Development

The vulnerability and risk assessments were the primary tool used in Strategy development. The assessments focused this round of adaptation planning on those impacts that we are the most susceptible to, and that will have the greatest consequences. Please refer to Appendix B for more detailed information from the vulnerability and risk assessment.

2.4.1 Vulnerability Assessment

Vulnerability refers to the susceptibility of a given service area to harm arising from climate change impacts. It is a function of a department's sensitivity to climate change and its capacity to adapt to impacts with little to no cost or disruption. Medium and high vulnerability impacts are moved on to the risk assessment.

Vulnerability = Sensitivity X Adaptive Capacity

Sensitivity
To conduct a sensitivity assessment, Vancouver's Adaptation Working Group looked at each identified impact and assessed how the functionality of the primary department would be affected if the impact were to occur. Vancouver decided to look at the sensitivity of the primary department between now and 2080. Sensitivity was ranked on a scale of 1 to 5.

Adaptive Capacity
Inherent to the analysis of adaptive capacity is the assumption that certain systems can accommodate changes in climate with minimal disruption or additional cost. Those systems which cannot accommodate changes have a low adaptive capacity.

In order to measure Vancouver's adaptive capacity, impacts were assessed based on the cost and amount of staff intervention that would be needed to adapt. Engineering was most frequently identified as having low adaptive capacity; a direct reflection of how built infrastructure is generally unable to accommodate major changes in climate without additional costs and potentially significant disruptions.

Given sensitivity and adaptive capacity, vulnerability is ranked as follows.

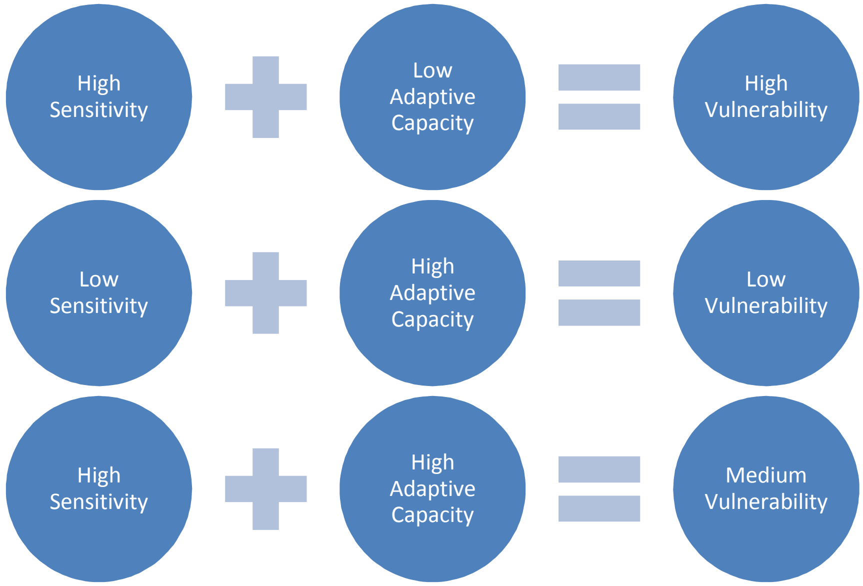


Figure 4: Vulnerability Calculations

2.4.2 Risk Assessment

Likelihood

Consequence

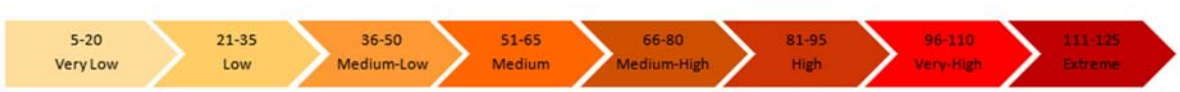


Figure 5: Risk assessment ranking scale

2.5 Evaluation of Adaptation Actions

Workshops were held with staff across the organization to brainstorm actions to prepare for, or reduce risks from, the prioritized impacts. Workshop participants then reviewed a consolidated list of potential actions before the working group evaluated them. Criteria from the Canadian Communities' Guidebook for Adaptation to Climate Change were used to rank the actions. The criteria and ranking descriptions are listed below.

Table 1: Adaptation action evaluation criteria

Category	Criteria	1 (low)	2 (medium)	3 (high)
Sustainability	Mitigation co-benefits	Result in increased GHG emissions	Would not affect GHG emissions	Would reduce greenhouse gas emissions
	Equity	Benefits to few people	Benefits to many people	Significant benefits to many people
	Implementation Cost	Cost is high relative to cost of inaction	Cost is moderate relative to cost of inaction	Cost is low relative to cost of inaction
Effectiveness	Robustness	Effective for a narrow range of plausible future scenarios	Effective across many plausible future scenarios	Effective across a wide range of plausible future scenarios
Risk and Uncertainty	Urgency	Risks are likely to occur in the longer term	Impacts are likely in the near to mid term	Impacts are already occurring
Opportunity	Ancillary benefits	Will contribute little of not at all to other City goals and programs	will contribute somewhat to other City goals and programs	will contribute significantly to other City goals and programs
	No Regret	Will have little or no benefit if climate change impacts do not occur	Will have some benefits regardless of actual climate change impacts	Will result in significant benefits regardless of actual climate change impacts
	Window of Opportunity	There is no window currently	A window of opportunity could be created	A window of opportunity exists to implement
Implementation	Funding Sources	External funding sources are required but have not been identified	External funding sources are required and likely to be secured	Funding is available externally or internally
	Institutional	Implementation	Implementation	Implementation

		requires coordination with, or action by other jurisdictions	requires external approval	is within local control

Actions with low scores were discussed and most often discarded. Others were ranked into the following categories: “must do”, “monitor” or “investigate further”. Must do actions are those that have a high benefit to cost ratio and those with a short time horizon until impacts are likely to be observed. In consultation with staff, must do actions were further prioritized by date of the capital planning cycle they will be implemented by. Actions that are tagged as “monitor” are actions that have good benefit to cost ratio but given long timelines until anticipated impacts, it makes sense to wait to implement these actions until certain thresholds of climate change are observed. Lastly, “investigate further” are actions where the benefit to cost ratio is unclear and more consideration is required.

Must Do	Actions relating to climate impacts already being observed or that have a life safety component and actions with a high benefit to cost ratio.
Monitor	Actions relating to impacts that will be observed in the long term and that have a high benefit to cost ratio. Actions will be implemented when specific climate thresholds are surpassed
Investigate Further	Actions relating to impacts that will be observed in the long term and where the cost-benefit ratio is unknown.

Chapter 3: Climate Change Science

Our climate includes natural year-to-year fluctuations such as El Niño / La Niña and decadal cycles such as the Pacific Decadal Oscillation. Climate change is the trend information that remains once the fluctuations of these natural cycles is removed. Historical observations reveal the trends while global and regional climate models provide insight into anticipated future climate.

Climate is expected to change both in terms of annual and seasonal averages and in the frequency, intensity, duration and timing of extreme events. In B.C, 2011 was 0.51°C warmer than 1951-1980 average values, and was ranked the ninth warmest year since 1880, with nine of the ten warmest years on record occurring since year 2000[11]. In terms of extreme events, a 3-hour heavy rainfall event that occurred on average once every 25 years in the past is projected to occur five and a half times more frequently by 2050.

[11] Pacific Climate Impacts Consortium and IPCC

3.1 Global Climate Change

The Intergovernmental Panel on Climate Change released its first Special Report on Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation (SREX) on March 28th, 2012. The following are conclusions from the report.

- Warming of the climate system is unequivocal, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice and rising global average sea level.
- There is high agreement and much evidence that with current climate change mitigation policies and related sustainable development practices, global GHG emissions will continue to grow over the next few decades
- Observational evidence from all continents and most oceans shows that many natural systems are being affected by regional climate changes, particularly temperature increases.

The IPCC rates the likelihood of projected trends for the 21st century as follows:

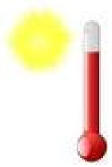
- Virtually certain (>99% likelihood) that decreases in frequency and magnitude of cold extremes will occur.
- 1 in 20 year extreme daily temperature (exceeded once between 1981 and 2000) is likely (>66% likelihood) to become a 1 in 2 or 1 in 5 year event.
- Very likely (>90% likelihood) that mean sea level rise will contribute to upward trends in extreme coastal high water levels in the future.
- Likely that the frequency of heavy precipitation or the proportion of total rainfall from heavy events will increase.
- 1 in 20 year annual maximum daily precipitation amount is likely to become a 1 in 5 to 1 in 15 year event by the end of the century.

3.2 Regional and Local Climate Change

3.2.1 Overview:

The Pacific Climate Impacts Consortium (PCIC) at the University of Victoria completed a study of regional projections for all Georgia Basin ICLEI Adaptation Initiative participants. Basic data from the study are included in this chapter with more detail available in the full report. A general study finding was that projected change by the 2050s appears modest while by the 2080s projected change describes a future climate that is almost unrecognizable in comparison to historical climate.

Table 2: Snapshot of projected changes in climate for Vancouver

Climate Variable	Summary of Change	Snapshot of Anticipated Changes
	 Increase in average annual precipitation with a decrease in the summer.	**Averages[1]:** Increase of 6% and 9% in winter and decrease of 15% and 14% in the summer by the 2050s and 2080s respectively. **Wet days[2, 3]:** By the 2050s, precipitation during extremely wet days is expected to increase 28% relative to the baseline period (1971-2000). **Extreme events[3, 4]:** by the 2050s, a daily rainfall event that occurred once every 25 years in the past is expected to occur almost 2.5 times as frequently.
	 Increase in average annual temperature with most notable change in night-time lows.	**Averages[1]**: Annual increase of 1.7°C by the 2050s and 2.7°C by the 2080s. **Warm days**: Summer days above approx. 24°C are projected to occur more than twice as frequently in the 2050s than during the baseline period 1971-2000. **Extreme events**: in the 2050s, an extreme heat event that occurred once every 25 years in the past is expected to occur over 3 times as frequently.
	 Rising Seas	**Averages**: The Province of B.C. recommends using 0.5m global mean sea level increase to 2050, 1.0m to 2100 and 2.0m to 2200. There is a wide range of projections for sea level rise by 2100 from 45cm to over 2m. **Extreme events**: Sea level rise will cause problems when experienced together with storm surge. Detailed storm surge projections are not available.
		An increase in extreme events is projected including windstorms and heavy rainfall.

1 Average change based on 30 Global Climate Model projections. For range of uncertainty around the average see www.Plan2Adapt.ca
2 With precipitation above the 99th percentile of wet days in the past.
3 Average change based on eight regional climate model projections.

The following climate variables were modelled by PCIC for the region. They are all described against a 1961-1990 baseline unless otherwise stated.

Precipitation as Snow: Vancouver's drinking water comes from mountain reservoirs and the snowpack melt and rainfall that supply them. April 1 snowpack has decreased on average by 25% in BC over the past 50 years with some sites experiencing a 50% reduction[12].

Precipitation as snow is projected to decrease in the areas of Metro Vancouver that are important for water supply. Reductions will be evident by the 2050s and precipitation as snow is projected almost to disappear by 2080.

Growing Degree Days: Growing degree days (GDD) are an important indicator of opportunities for agriculture but may also increase the risk of invasive species spread. They are determined by the accumulation of degrees over 5°C per day. Annual GDDs are a sum of degrees accumulated this way for each day of the year. Regionally, modeled GDDs are projected to increase by approximately one to two thirds in the 2050s and to as much as double by the 2080s from a baseline of approximately 1700 degree days.

Annual Heating and Cooling degree days: Heating and cooling degree days are useful indicators of energy demands required for heating and cooling. HVAC systems, general building design, district energy systems and other energy infrastructure all rely on this information. An approximate 25% and 35% reduction by the 2050s and 2080s respectively in heating degree-days signals a significant reduction in cold season energy requirements.

As temperatures climb, cooling degree days increase. From a historical baseline of only 55 cooling degree-days annually in Metro Vancouver, projected increases range from at least double by the 2050s to as much as a factor of 10 increase by the 2080s. Alternatives to vast application of air conditioning will need promotion in order to avoid adaptation that increases greenhouse gas emissions.

Summer day-time high temps: Projected increases in summer day-time high temperatures indicate a summer climate by the 2050s between that of present-day Seattle and San Diego.

Frost Free Period: Freeze-thaw can be hard on vegetation and infrastructure alike. The frost free period in the urban parts of the study area are already quite high with the majority of the year (roughly 200 days/year) frost free on average during the 1961-1990 period. Projections indicate a new normal by the 2080s of virtually frost free conditions.

Fraser River Hydrology: The portion of the Fraser contiguous with Vancouver is tidally dominated. Nevertheless, changes in runoff timing and the seasonal distribution of runoff could have implications for water availability and habitat. By the 2050s winter and spring flows are projected to increase by 56% to 85% and 37% to 56% respectively and summer flow to decrease by 13% to 23% for the Fraser- Hope hydrometric station. The mean annual peak flow is projected to occur about 10 days earlier.[13]

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[12] http://pacificclimate.org/sites/default/files/publications/Rodenhuis.ClimateOverview.Mar2009.pdf

[13] (PCIC Update Vol V Number 3. Spring 2012).

3.2.2 Extremes:

The head of climate monitoring and attribution at the U.K's Hadley centre for Climate Change, explains that for every 1 degree Celsius rise in temperature, the amount of moisture that the atmosphere can contain rises by 7% or more. "The upshot is that overall rainfall increases only 2% to 3% per degree of warming, where extreme rainfall increases 6% to 7%"[14]. In basic terms, this is due to the large-scale energy balance of the planet. With extra moisture in the atmosphere, when precipitation does occur, it's more likely to be in bigger events.

Current observations support an increase in storm intensity. Toronto recently initiated a program to improve storm drains after experiencing eight extreme storms (more than 1 in 25 year intensity) between 1986 and 2006. The Insurance Bureau of Canada states that severe storm-related water damage has doubled since 1992 to 44% of claims.[15]

PCIC used eight Regional Climate Models (RCMs) to project changes in extremes. The projected change from the 1971-2000 baseline period is projected for the 2050s (2041-2070) in all cases. In the case of warm days (Table 3, first row), the ratio can be interpreted as warm days occurring 2.2 times as frequently by the 2050s.

Extreme precipitation is projected to increase for all the precipitation indices. The percent of annual total precipitation that falls during events that are larger than the 95th percentile of events in the past is projected to increase by about 21% on average (Table 3, row 2). Percent of annual total precipitation falling during events larger than the 99th percentile of past events is projected to increase by 28% on average (Table 3, row3).

Table 3: Summary of projected annual changes in 2050 from the 1971-2000 baseline for all eight RCM runs and all months except for warm days which are given for summer and heaviest precipitation days indicated for September.

Index	Units	Min	Average	Max
Warm Days: 90th percentile temperatures for each day of the year relative to the baseline.	Ratio	1.8	2.2	3.0
Very wet day precipitation: 95th percentile of all rain days.	% change	2	21	43
Extremely wet day precipitation: 99th percentile of all rain days.	% change	-23	28	92
Heaviest precipitation day in September: average of max. precip. on a September day averaged over the baseline period.	% change	-10	25%	47%

[14] Carey, John. June 28, 2011. Storm Warnings: Extreme Weather is a product of Climate Change. Scienftific American.

[15] (PICS newsletter Nov. 29)

3.2.3 Return Periods:

RCM Projections were also used to provide an estimate of how return periods are expected to change by 2050. A return period (or recurrence interval) is an estimate of the interval of time between events (earthquakes, floods) of a certain intensity of size. The table below shows the ratio of future to past return periods. For example, the median value of 5.8 for the 25th return period for 3 hourly precipitation (highlighted) indicates that an event that occurred every 25 years during the past (4% chance of occurring each year) is expected to occur almost six times more frequently by 2050.

In Metro Vancouver, 5-, 10-, and 25- year return period daytime high hot events are projected to occur 2.4, 2.8, and 3.2 times as often, respectively. Return periods for wet events are projected to occur 1.6, 1.9, and 2.5 times as often, respectively.

Table 4: Return period projections (regional median)

Variable	Period	5	10	25
Daily Temperature	Lower bound	0.3	0.1	<.1
	Projected change	2.4	2.8	3.2
	Upper bound	2.5	3.06	4.3
Daily Precipitation	Lower bound	0.7	0.4	0.1
	Projected change	1.6	1.9	2.5
	Upper bound	1.7	2.2	3.1
3-hourly Precipitation	Lower bound	0.7	0.4	0.2
	Projected change	2.5	3.5	5.5
	Upper bound	2.6	3.6	5.8
3-hourly Wind Speed	Lower bound	0.2	0.1	<.1
	Projected change	0.8	0.9	1.1
	Upper bound	1.9	2.4	3.3

3.2.4 Sea Level Rise

Sea level rise is a direct impact of climate change that is caused when warmer temperatures trigger both melting of continental glaciers and ice caps and the thermal expansion of oceans. At the regional and local scale, sea level will also be affected by local ocean and weather characteristics such as salinity, wind and currents, and by the vertical movement of the land due to geological processes (subsidence and uplift).

During the last century sea level rose by almost 8” (20 cm). What is most notable is that the rate of rise is increasing rapidly, almost doubling in the last three decades[16]. Based on present and expected increases in emissions in the near future, sea levels are expected to rise at accelerating rates into the next century. Close monitoring and measurement over the last fifteen years has shown that the present trend is close to, or above, the upper envelope of global scenarios.

[16] Englander, John. 2010. Sea Level Rise and Coastal Property: Potential Impacts on Values This Decade. www.johnenglander.net

Projections for sea level cover a range, with greater weighting in the middle, as in most probability curves. Moderate projections for global average sea level rise this century are approximately 3 feet (1 m), but a few recent papers have raised the upper limit to 6 feet (2 m). Such forecasts are regularly revised and have generally moved upward over the last decade as the extent of melting in Greenland and Antarctica increased[17]. Jurisdictions around the world are using various sea level rise figures in planning to the end of the 21st century. The New Zealand Ministry of Environment is suggesting a 0.8m increase in areas where impacts will have high consequences. The U.S Army Corps uses 1m and 1.5m for low and high scenarios respectively; the Delta Committee of the Netherlands uses a range from 0.55m to 1.2m and the Lowe Study for the U.K released 2.5m as the upper limit of scenarios by 2100.

In May, 2011 the BC Ministry of Environment released draft guidelines providing sea level rise figures for use in evaluation of existing dikes, flood-proofing requirements and long term land use and planning issues. In formulating the guidelines, the Province created a sea level change envelope reflecting the ranges of the most recent peer reviewed scientific projections. They chose a median curve as the basis for defining policy in BC that translates to the figures in table 5 below.

Table 5: BC Ministry of Environment sea level rise planning figures

Development Timeframe	Global increase in mean sea level	Regional SLR
Lifespan to Year 2050	0.5 m	To be developed on a site specific basis.
Lifespan to Year 2100	1.0 m	
Lifespan to year 2200	2.0 m	

[17] Same as above

Chapter 4: Impacts and Issues

Anticipated changes to climate variables, as described in Chapter 3, will cause impacts felt across City departments. An example of a climate change impact is increased street flooding caused by increases in intensity and duration of rainfall. Impacts share common overarching themes that are briefly discussed in this chapter to help decision-makers, working on these policy areas, identify climate risks and opportunities.

4.1 Impacts

From Chapter 3, the most relevant climate change impacts Vancouver will experience are:

- Flooding and/or inundation due to sea level rise;
- Overland flooding due to increased frequency and intensity of precipitation;
- Damage from increased frequency and intensity of wind and rain storms; and
- Health impacts from more days of extreme warm temperatures and heat waves.

Overall changes in climate trends such as warmer, drier summers and more extreme events will also cause impacts. See table 6 below for all the prioritized impacts.

Several Vancouver characteristics standout as significant vulnerabilities to climate change which in turn drive adaptation priorities.

- Lower income households; the homeless and those housed in poor quality housing are particularly vulnerable to climate change and natural hazards due to where they live within cities, the lack of reliable basic services, and their shortage of resources to deal with disruption.
- Low-lying coastal and Fraser-fronting areas include significant infrastructure, neighbourhoods, ecosystems and are central to Vancouver's aesthetic and amenity-centred charm.

Table 6 summarizes the impacts that were prioritized through the vulnerability and risk assessments. Impacts are organized by the expected climate change (high level impact in the case of sea level rise). The general changes category includes impacts felt from a collection of the other climate changes.

Table 6: Summary of Impacts

1.0 Increase in intensity and frequency of heavy rain events
1.1. Increased surface water flooding from ponding of rainfall in low lying areas or heavy rainfall overcoming the capacity of the drainage system
1.2. Increase in number of combined sewer overflows
1.3. Increases in sewer back-ups in combined sewer areas due to high rainfall volume in sewer system
1.4. increase in landslide risk affecting public infrastructure and private property
2.0 Sea Level Rise
2.1. Increased flooding and storm surge damage along the coast and Fraser River as sea levels rise and storms are more frequent.

2.2. Increased damage to coastline structures from storm surge, flooding and salt water intrusion
2.3. Reduced gravity drainage of existing drainage system as sea levels rise, resulting in more frequent flooding of low areas near storm sewer outfalls.
2.4. Increase in shoreline erosion affecting natural environments and public amenities such as parks, trails and access to the water
3.0 Increased frequency and intensity of storms and weather extremes
3.1. Increased safety and health risks for vulnerable populations including water ingress, mould and loss of housing for poorly housed and health risks to the homeless.
3.2. Increased public safety risk on streets due to damage to infrastructure and trees
3.3. Increased resources required to respond and clean-up during and following storm events
3.4. Natural disaster and related emergency management and response capacity may need to cater to more frequent, simultaneous and extreme disasters as well as the associated cascading effects.
4.0 Hotter, drier summers with more heat waves.
4.1. Increased health and safety risks to vulnerable populations during extreme heat events
4.2. Water supply shortages
4.3. Increasing vectors for disease and respiratory illness are expected health impacts from increasing temperatures
5.0 General Changes
5.1 New and Existing Buildings may be maladapted as the climate changes in terms of water ingress, wind, durability, rain on snow loads, increasing heat waves etc.
5.2 Decrease in durability and lifecycle of infrastructure leading to increased maintenance and replacement requirements.
5.3 Increase in impacts to urban forests, green spaces and trees from temperature extremes and wind storms resulting in increased maintenance and replacement costs

4.2 Cross-cutting Issues

The following discussion briefly touches on the issues common to many climate change impacts, highlighting focus areas for adaptation planning.

4.2.1 Infrastructure

Infrastructure assets provide a significant opportunity for adaptation. They have long operational lifetimes, meaning they will be exposed to both current and future climate. Infrastructure in Canada is relatively vulnerable to climate change as it is aging and over-used with population and development pressures increasing associated expectations for service.

Weathering of infrastructure can occur via biological (mould), chemical (corrosion), thermal (freeze-thaw) or mechanical agents (wind-driven rain); all of which will be affected by climate change. Damage to infrastructure from extreme weather events tends to increase dramatically above critical thresholds. Environment Canada reported that a 25% increase in peak wind gust can generate a 650% increase in building damage claims[18].

Aside from direct changes to weather conditions, climate change will also affect patterns of supply and consumer demand. For example, higher summer temperatures may increase demand for transportation to beaches and mountains, while increased severe weather may affect supply chains and resources that infrastructure and repair companies rely on.

Maladapted infrastructure will have indirect impacts in the way of asset management costs, insurance claims and negative effects on reputation. A Vancouver rainstorm in 2010 resulted in 173 filed claims with the City and a 2005 rainstorm in Toronto ranks as the second largest insurance payout in Canadian history. An Ontario-specific study predicted the following increases in insured losses due to rainfall related water damage: 13%, 20% and 30% for the 2020s, 2050s and 2080s respectively[19].

Table 7: Major City infrastructure

Sector	Infrastructure Involved (CoV)	Infrastructure involved (other jurisdictions)	Other players
Sewer	Pump stations, separate and combined sewer system	Waste water treatment, sewer trunks,	Metro Van
Built Infrastructure and Buildings	Civic facilities, non-market housing, regulation of building	Commercial, residential, industrial, institutional etc.	Many
Energy	SEFC District Energy	Production, transmission, storage, natural gas and fuel systems etc.	Fortis, BC Hydro, Other
Transportation	Street signs signals etc., roads, bridges, bike lanes	Buses, rail, ferries, airports, ports, highways	MetroVan Port, Vancouver Airport Authority, Translink, CN and CP Rail, Province of BC
Water	Distribution system, water access locations, Dedicated Fire Protection System (DFPS)	Filtration plant, reservoirs, Trunk mains,	Metro Van
Tele-communications		Phone, internet, cable etc.	Telus, Rogers, etc.

[18] Auld, Heather and MacIver, Don. 2007. Changing Weather Patterns, Uncertainty and Infrastructure Risks: Emerging Adaptation Requirements. Environment Canada.
19 Cheng et al. 2012. Cliamte Change and Heavy Rainfall-Related Water Damage Insurance Claims and Losses in Ontario, Canada. Journal of Water Resource and Protection, 2012, 4, 49-62.

4.2.2 Human Health and Welfare

Environmental Health Services at the BC Centre for Disease Control provided the list of potential impacts of local climate change on health shown in table 8 below.

Table 8: Potential health impacts from anticipated local changes in climate.

Direct Impacts	Climate Mediated Impacts	Indirect Impacts
Morbidity and mortality from heat related illness	Health impacts from biotic changes including new plants and insects	Refugees or climate related conflict
Injury from falling debris and damaged infrastructure during storms	Increases in the occurrence of mould, especially in low quality housing as a result of increasing precipitation and flooding	Power reliability may be affected as well as use patterns
Occupational health impacts for outdoor workers due to increases in extreme weather	Exacerbated allergies and respiratory illness as air pollution worsens with increasing temperatures.	

While changes to water quality are generally a concern in other jurisdictions, the new Seymour-Capilano filtration plan has the capacity to deal with increased source temperature and turbidity.

It is well established that the urban poor are particularly vulnerable to climate change and natural hazards due to where they live within cities with respect to both location and quality of housing, and the lack of reliable basic services[20]. Children, the elderly, and those with existing health conditions are also likely to be more vulnerable to health impacts.

Although heat stress may appear less threatening in BC compared to the rest of the country, much of the BC population is less acclimatized to temperatures above 30 °C. Non-respiratory emergency room visits in Vancouver currently increase with high summer temperatures and are expected to rise further with an aging population.

Airborne pollutants cause wheezing, asthma attacks and impaired lung function, and are associated with increased respiratory illness, stroke, and heart attack[21]. The National Roundtable on the Environment and the Economy reported that poorer air quality resulting from higher temperatures will lead to more hospital visits and millions of dollars in costs to local health care systems for Canada’s four major cities – Toronto, Montreal, Vancouver and Calgary.

[20] World Bank. 2011. Climate Change, Disaster Risk and the Urban Poor.
[21] Health Canada. 2011. Adapting to Extreme Heat Events

4.2.3 Habitat, Parks and Greenspace

The preservation and expansion of trees and greenspaces in Vancouver contributes to both climate change mitigation and adaptation. Vegetation absorbs carbon, helps keep the city cooler in the summer and increases the amount of groundwater recharge, thereby lowering flood risk.

Urban structures such as asphalt and buildings absorb more solar energy than grass and trees increasing the local temperature –a phenomenon known as the urban heat island effect. Vegetation in the downtown helps decrease this effect, providing a safer environment health wise and lowering the need for air conditioning. Models have shown areas like airports with a high proportion of pavement can be almost 9°C warmer than areas with heavy vegetation cover such as parks.

Parks and greenspace can also play an important role in decreasing the impacts or occurrence of flooding from heavy rainfall or storm surge. Parks can be used for detention and infiltration of stormwater or as containment areas for heavy storm surge.

Beyond the number of trees and greenspaces in the City, the health of the urban ecosystems is paramount. Climate change is predicted to exacerbate undesirable agents of rapid change such as invasive pests or indigenous pests which are opportunistic to new environmental stress. Monitoring is essential to ward off major problems before they exceed our ability to control them.

Habitats found within the urban landscapes are often characterized as habitat islands within a sea or buildings. Climate change will exacerbate the implications of habitat isolation necessitating a renewed effort to increase habitat connectivity.

The Stanley Park Management Plan includes considerations for climate change such as 'wind-proofing', appropriate site selection / planting practices, species selection and pest monitoring. These considerations will need to be applied to other urban greenspaces and trees including development landscape plans, street trees and trees on private property.

4.2.4 Economy

Climate change can be thought of as a pervasive economic shock that will potentially affect all sectors of the economy[22]. Both goods movement and local business are likely to be affected by climate change and associated sea level rise with the potential to compromise Vancouver's and the Province's economy. It is important to consider the economic advantages climate change

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[22] Dobes, Leo. 2012. Adaptation to Climate Change: Formulating Policy under Uncertainty. Centre for Climate Economics and Policy, The Australian National University.

may provide as well. Warmer summers may attract more tourists and longer growing seasons allow for new agriculture crops in the region.

The National Round Table on the Environment and the Economy (NRTEE) found that world-wide greenhouse gas emissions and subsequent climate change impacts could, in turn, have an economic impact on Canada of $5 billion annually by 2020 and between $21 and $43 billion annually by 2050. Specific to BC by the 2050s, timber supply impacts could range from $2 billion to $17 billion annually and flooding damages to coastal dwellings could cost between $1 billion to $8 billion per year. The report concluded that ignoring climate change now will cost us more in the long run and that adaptation is a cost-effective way to alleviate many of the impacts of climate change[23]. An international cost benefit study echoed the NRTEE findings, reporting that between 40% and 68% of the loss in GDP expected to 2030 (under severe climate change scenarios) could be averted through adaptation measures for which economic benefits outweigh their costs[24].

Traditionally, risk has been dealt with through insurance. The Insurance Bureau of Canada recently observed that the number and severity of storms is having a negative effect on the industry. They reported that, while historically most insurance claims were related to fire and theft, half of every dollar now paid out by insurance companies is for water damage related to extreme weather events[25]. Insurance costs may rise and become difficult to obtain in risk areas or following repeat events.

Community risks are business risks as they depend on local services and infrastructure to run their businesses. Businesses are already on the frontline of climate change with bottom lines increasingly at risk due to weather and climate phenomena. Impacts to businesses from climate change can be categorized into physical and operational impacts such as decreased availability or increased price of critical materials; regulatory and legal risks such as new land use zoning or building changes; financing risks such as access to capital for businesses at high risk to climate change; market changes; and reputational risks[26]. It will be imperative for businesses to demonstrate a commitment to adaptation, raise awareness and collaborate through new forms of public-private partnerships to tackle the most complex challenges of adaptation[27].

[23] National Round Table on the Environment and the Economy. 2012. Paying the Price: The Economic Impacts of Climate Change for Canada.
[24] Economics of Climate Adaptation Working Group, 2009. Shaping Climate-Resilient Development: a framework for decision-making.
[25] SFU Adaptation to Climate Change Team. 2012. Briefing Paper for Decision Makers: Climate Change Adaptation and Water Governance.
[26] UN Environment Programme. June, 2011. Adapting for a Green Economy: Companies, Communities and Climate Change.
[27] National Round Table on the Environment and the Economy. 2012. Facing the Elements: Building Business Resilience in a Changing Climate.

4.2.5 Coastal Zone

Thirty eight percent of the Canadian population lives within 20km of a coast or great lake shoreline[28]. Coastal areas are exceptionally vulnerable to sea level rise given that they are home to concentrated populations, economic centres and valuable ecosystems. Coastal industry remains integral to the transportation and transfer of goods.

A 2008 OECD report ranked Vancouver 15th out of 136 large port cities in terms of the value of assets exposed to sea level rise[29]. BTA Works, the research arm of a local architecture firm, found that industrial lands, historic areas and the public realm would be affected disproportionally in a 5m sea level rise scenario. Conversion of these industrial lands to residential areas is likely to increase the consequences of a flood. The National Round Table on the Environment and the Economy predicted sea level rise to cause between $2.1billion and $7.6billion in damages by 2050 for BC (primarily Metro Vancouver) based on a sea level rise of 0.28m to 0.85m by 2100. They estimate that $25 billion worth of real estate (not including City infrastructure) would be heavily impacted with the cost of sufficient protective measures such as earth dikes or seawalls estimated to range from $255 million to $510 million (2011 dollars).

Recognized adaptation responses to sea level rise can be grouped into four broad categories as follows:

- Protect: Protect the coastline through structural mechanisms such as dikes and seawalls.
- Accommodate: Increase flood construction levels, add covenants for liability reduction and retrofit existing buildings.
- Planned Retreat: withdraw, relocate or abandon private or public assets due to coastal hazard.
- Avoid: identify future 'no build' zones or use land acquisition or restriction tools such as land trusts.

The United Kingdom is a leader in coastal flood risk management. Planning follows three broad steps: preliminary flood risk assessment; flood hazard mapping; and adoption of a flood risk management plan aimed at prevention, protection and preparedness.

[28] Arlington Group Planning and Architecture Inc. 2012. Draft Sea Level Rise Primer.
[29] OECD. Ranking of the world's cities most exposed to coastal flooding today and in the future.

Chapter 5: Actions

The action chapter is organized by anticipated climate change or direct impact (sea level rise). A suite of adaptation actions are identified for each section, ranging from low cost and easy to implement, to larger, more complex projects. Response strategies identified as **primary actions** represent the key projects that will help the city adapt to climate change. **Supporting actions** represent application of an adaptation lens to existing actions or generally lower cost/ smaller scope activities. Where there are no primary actions to address a climate change, only a suite of supporting actions are introduced.

Primary actions, supporting actions and more detailed actions are listed with accountability and timing information in a comprehensive Adaptation Action Matrix found in Appendix A. The matrix is organized by impacts under the same section headings as the chapter below.

No-regret actions are the focus –those that build on existing plans and actions and provide community benefits regardless of the extent of climate change experienced. Each objective is achieved through a combination of different actions which act together. These portfolios of actions generally include measures from the following four categories:

- modifying policies, plans, procedures, standards (e.g. by-laws, development plans, operating practices, codes) ;
- building new or upgrading infrastructure ;
- improving community awareness and education ; and
- varying/diversifying existing actions (e.g. diversifying energy supplies, diversifying plantings) .

The actions in the Strategy largely focus on areas where the City can take independent action. To this end we completed an early scan of suggested adaptation actions to ascertain whether they fell within the City's jurisdiction/responsibility or not. Some actions signal necessary collaboration with the regional and provincial governments, and it is recognized that local adaptation is reliant on close ties and joint actions with other levels of government, neighbours, the private sector and community groups. Staff will continue to collaborate on projects and push for regional coordination on adaptation issues.

1.0 Increase in intensity and frequency of heavy rain events.

Impacts: Increased surface water flooding, sewer back-ups and combined sewer overflows due to heavy rainfall.

What this could mean: On September 19th, 2010 Vancouver's heavy rainfall resulted in 173 filed claims against the City and 23 other reports of flooding related incidents from citizens. The second most expensive national natural disaster was Toronto's 2005 downpour with damages exceeding $500 million[30]. Rainfall related water damage losses are expected to continue

[30] Kessler. 2011. Stormwater Strategies: Cities Prepare Aging Infrastructure for Climate Change.

increasing (20% by 2050 in Eastern Canada) as is the volume of untreated wastewater entering waterbodies via combined sewer overflows (CSO). These climate change impacts have far-reaching social, environmental and economic implications.

Objective 1.1: Minimize rainfall related flooding and associated consequences.
The City will take advantage of the following opportunities to reduce rainfall related risks:

- Decreasing the proportion of stormwater entering the sewer infrastructure through application of stormwater management techniques.
- Increasing the capacity of the storm sewer through sewer separation.
- Accounting for climate change in system design.

1.1.1 Primary Action: Complete and implement a citywide Integrated Stormwater Management Plan

Applying stormwater management techniques where possible can reduce peak discharges and generally reduce the flow loading on storm sewer infrastructure, thereby increasing resilience to heavier and more frequent storm events. Stormwater management approaches are categorized into:

- Planning and design approaches such as limits to impermeable surfaces;
- Runoff storage and conveyance such as using pocket parks for street runoff, re-routing stormwater to waterbodies, or non-potable water storage/use; and
- Infiltration and detention practices such as green roofs, street infiltration bulges or downspout rock pits.

Stormwater management techniques often include green infrastructure (bioswales, green roofs, rain barrels) which provide a host of co-benefits with other City goals. For example, green roofs reduce energy and keep cities cooler, reducing CSOs means less pathogens enter the waterways, and recycling stormwater contributes to water conservation goals. The City is mandated through the Liquid Waste Management Plan to complete an Integrated Stormwater Management Plan (ISMP) for all watersheds in the City by the end of 2014. The Citywide, cross-departmental ISMP will address options for stormwater (rainfall) management on both public and private property. The ISMP will recommend changes to policy, design practices, standards and bylaws to facilitate implementation.

1.1.2: Primary Action: Separate the sanitary and stormwater sewers (In Progress)

Separating the sanitary and stormwater sewers substantially mitigates the risk of CSOs and private property sewer back-ups. Separating the systems also provides more capacity in the storm sewer for handling anticipated increases in heavy rainfall volumes.

The City is legislated to complete system separation by 2050. Currently, high risk areas, or areas where residents have experienced more frequent sewer backups, are targeted for priority separation. Separation of private side connections is not mandated and will require a closer look to ensure the added resilience of separated pipes is not negated at the property line.

Supporting Actions:

- Explore options for increasing replacement of private side combined sewer connections with separated connections in advance of City-side separation.
- Prepare runoff control guidelines for private property as required by Metro Vancouver in coming years.
- Add larger catch basins or increase number in critical locations.
- Evaluate and recommend opportunities for stormwater detention, infiltration or storage during park re-design and in new parks.
- Incorporate rainfall projections and new IDF curves in sewer and street design.
- Increase public awareness of catch basin functionality and basement flooding mitigation.

2.0 Sea Level Rise

Impacts: Increased flooding, storm surge damage, saltwater intrusion and erosion to the coastline. Impacts to gravity drainage of low lying storm sewers and potential impacts to groundwater levels.

What this could mean: Climate change is imposing increasing threats along coasts, both from rising sea levels and increased intensity and frequency of storms. Based on present and expected increases in emissions in the near future, sea levels are expected to rise at accelerating rates into the next century.

A local study used assessment values to estimate that $25 billion worth of real estate (not including City infrastructure) is at risk from sea level rise in Vancouver by the end of the century. Industrial lands, historic areas and the public realm are affected disproportionately[31]. The federal Round Table on the Environment and the Economy suggest the annual national costs of coastal flooding damage could be as high as $8 billion dollars in coming decades.

Objective 2.1: Increase the resilience of Vancouver's infrastructure and assets to coastal flooding and erosion.

Sea level rise adaptation options include protecting our coastlines with defences, accommodating higher water levels by elevating infrastructure, avoiding flood prone areas by focusing development elsewhere, and retreating via land acquisition etc. Choosing among options is a complex task that starts with a clear risk assessment detailing the magnitude and frequency of coastal flooding, identifying vulnerabilities and quantifying potential damages and losses. The City endeavours to find solutions that minimize the financial, social and environmental impacts of future flooding while ensuring near-shore amenities, access, views and other benefits are maintained. A city-wide sea level adaptation response will provide high-

[31] Keenan, Eileen and Yan, Andrew. 2011. The Local Effects of Global Climate Change in the City of Vancouver: A Community Toolkit and Atlas.

level direction to navigate through the complex issues and make civic investments without creating undue hardships in the short term.

While the risk assessment is being completed, the City's interim flood construction levels need to be revised, and associated Flood-proofing policies amended to provide certainty. Policies will be revisited and updated upon completion of the City-wide sea level rise response strategy.

2.1.1. Primary Action: Complete a coastal flood risk assessment and develop a City-wide sea level rise adaptation response.

Strategic planning for sea level rise is complex given the uncertainty associated with the rate of water level rise and changes in storm frequency, the environmental and financial implications of engineering solutions, and the long timeline for fundraising and implementing such unique capital projects. It took 30 years for the United Kingdom and the Netherlands to add new storm protection after a disastrous coastal storm in 1953. While we are not expecting observable impacts from sea level rise for some time, we need to start thinking about options now. A comprehensive risk assessment is a recognized best practice and first step toward planning actions to mitigate the risks posed by sea level rise.

Continuing to coordinate with other municipalities regionally, with other levels of Government, and with partners such as Port MetroVancouver will be integral to maintaining the economic vibrancy of the region.

The flood risk assessment will include the following general phases of work:

- Phase 1: Flood hazard mapping/modeling
- Phase 2: Vulnerability Assessment
- Phase 3: Consequence Analysis
- Phase 4: Risk Management Options / Trade-off Analysis

Risk assessment outputs will support development of a city-wide sea level rise adaptation response that will address new infrastructure needs, erosion protection considerations, land use regulation changes and plans for amenities such as beaches and the seawall.

2.1.2. Primary Action: Update City Flood-proofing policies including Flood Construction Levels.

While numerous municipalities in the lower mainland maintain many kilometers of dikes, the City of Vancouver has relied on other tools such as flood construction levels (FCLs) and setbacks. City flood-proofing policies establish these elevations and setbacks by flood prone area. The last amendment to the policies in 2007 flagged the need for future updates to incorporate new sea level rise information.

The BC Ministry of Environment released new guidelines outlining incorporation of sea level rise into FCL calculations in May, 2011. The City encouraged an interim increase of 1m to existing FCLs while undertaking a study to apply guideline methodology to specific coastline types.

Amending the flood-proofing policies will increase the flood resilience of new development and maintain the potential for a range of adaptation solutions in the future. Increasing the awareness of builders and developers with respect to flood-proofing methods and considerations will be an important complement to policy amendment.

Supporting Actions:

- Continue to coordinate with other regional municipalities and other levels of government to ensure a regional approach to coastal flood management.
- Leverage opportunities to evaluate strategic near-shore open space planning for inundation and containment areas and saltwater resilient plantings.
- Initiate a flood-proofing awareness campaign among builders and developers.
- Monitor low-lying storm sewer capacity and functionality and continue to add back-up power and storage tanks to existing stormwater pumps.
- Monitor groundwater for increasing levels. Consider associated impacts in coastal development design.

3.0 Increased frequency and Intensity of storms and weather extremes

Impacts: Increased public safety and health risks; increased resources required to respond and recover following events.

What this could mean: In addition to earthquakes, the top hazards identified by emergency management in 2009 are weather related events, namely wind storms, blizzards, freezing rain/ice storms and rainstorms. The 2006 Vancouver windstorm cost the City approximately $10 million in forest restoration, repairs, slope stabilization and planning. Following the August 2005 rainstorm in Toronto, the City spent over $40 million to bring the City's infrastructure back into service. Storms can be bothersome to many in terms of service disruptions but can be lethal to vulnerable populations including the sick, elderly, young, homeless and low-income community members. Enhancing resilience now will be cost effective in terms of damages avoided in the long term.

Many of the actions in this chapter and the action matrix (Appendix A) help build resilience to extreme events. The following actions focus on safety and health risks to vulnerable populations and response and recovery capacity.

Objective 3.2: Increase Vancouver's capacity to respond to extreme weather events and recover effectively.

The City's emergency management and response capacity will need to cater to more frequent, simultaneous and extreme disasters. This includes dealing with their cascading effects such as power outages and road closures. Many existing emergency management and response practices at the City can be expanded to cover extreme weather events. It will also be important to continue monitoring resources including staff, their training and equipment, and City contingency and insurance budgets to ensure they are evolving to meet new and possibly escalating needs.

3.2.1 Primary Action: Develop a policy for back-up power and assess departments for shortfalls.

A key cascading effect of stormy weather is power outages which may in turn cause health impacts and service/ business disruption. At the peak of the 2006 windstorm, BC Hydro reported that over 250,000 customers were without power.

City infrastructure and facilities are often crucial during extreme event response such as community centres providing relief, fire halls, the works yards, traffic signals and some street lighting. Other City facilities and infrastructure may require back-up power to maintain basic services (such as stormwater sewer pumps).

One litre of generator diesel provides about 3 to 3.5 Kilowat hours of power. To retain basic function in a community centre for one hour would therefore require 30 to 50L of fuel. Increased severe weather may also affect fuel supply chains and resources that infrastructure and repair companies rely on.

Identifying where investment in back-up power is integral to public safety, storm response and recovery will build City resilience to extreme events. A comprehensive look at backup power for public buildings and infrastructure includes determining best methods of meeting the power needs and ensuring fuel supply during storms.

The following steps for policy development are recommended:

- Identify and prioritize buildings and infrastructure for back-up power over and above life safety requirements.
- Compare the costs and benefits of mobile generators versus generators built into facilities.
- Plan for fuel supply and emergency fuel movement from both outside providers and city sources.

Supporting Actions:

- Continue adding back-up power to key traffic signals
- Complete planning for response to windstorms, rainstorms and flooding.
- Activate plans and the EOC when events are forecast or occur.
- Consider continuity of supply of key response resources such as plywood.
- Support the Events Risk Assessment Task Force in ensuring events in the City are safe and resilient to inclement weather.
- Broaden ‘Team Vancouver Emergency Response’ volunteer urban search and rescue to aid with extreme event response such as park patrol during heat waves.

Objective 3.1: Reduce safety and health risks for the homeless and low-income population due to inclement weather.

Added shelter capacity exists now in the form of extreme weather response shelters that operate when specific, provincially mandated criteria are met. These criteria and the associated funding need to be expanded to keep up with the increase in frequency and intensity of extreme weather. The local low-income population is generally more vulnerable to extreme weather given their housing conditions, limited mobility, and lack of insurance and savings. Health risks from mould and inclement weather are priorities within this section while heat related risks are detailed in section 4 below.

Supporting Actions:

- Engage with Metro Vancouver to request at the regional level that the extreme weather shelter criteria and funding be expanded.
- Partner with VCH to initiate an education campaign on mould; how to identify and address it.
- Ensure instances of mould are included in the new online rental database.

4.0 Hotter, drier summers

Impacts: water supply shortages in late summer, increasing respiratory illness, health and safety risks for vulnerable populations.

What this could mean: During extreme heat events, health risks from direct impacts such as heat stroke increase, and many people with underlying health conditions will experience a worsening of their condition. The heat wave in 2009 in Vancouver caused an estimated 122 ‘excess deaths’ and many emergency room visits. Vancouverites are generally less acclimatized to high temperatures and therefore have a lower threshold for health effects. Vulnerable populations such as older adults, infants and children, those with chronic illness and socially disadvantaged communities are also at higher risk.

The North Shore snowpack has decreased by over 20% in the last fifty years and is predicted to be almost non-existent by the year 2080. An increase in annual rainfall will help offset the decrease in source water for our drinking reservoirs but longer, drier summers may result in late summer water supply pressure.

Objective 4.1: Minimize per capita water consumption.

The Greenest City Action Plan includes a target of reducing per capita water consumption by 33% below 2006 levels.

4.1.1 Primary Action: Water Conservation (In Progress)

Water conservation actions in the Greenest City Action Plan include water metering and enhanced water education, incentives and conservation programs.

Objective 4.2: Minimize morbidity and mortality during heat waves

4.1.2 Primary Action: Support the Extreme Hot Weather Committee in completion of Phase II of planning and expand the hot weather preparedness work program.

The City's Extreme Hot Weather Committee completed Phase I of planning in 2011, including development of a heat alert and a 'Be Cool' communication campaign. The second phase of work is focused on actions to minimize impacts of heat on health, especially within vulnerable populations. Leveraging and adding support to the existing work program will ensure Vancouver matches the efforts of other Canadian cities in planning for heat.

The following are some of the short and midterm actions and tasks under the extreme hot weather preparedness work program:

- Increase resources to support an expanded program including additional staff time from Sustainability.
- Complete urban heat island effect mapping. Coordinate with parks on targeting green space and trees in hot areas.
- Work with the Coastal Communities at Risk research group on vulnerable population mapping.
- Develop policies for cool refuges and cooling capacity in civic facilities. Assess cooling capacity of facilities within identified hot spots and prioritize for early policy implementation.
- Research and explore options for transporting those in need to cool facilities during heat events.
- Explore the potential for cooling rooms in non-market housing
- Continue to expand public access to drinking water (GCAP).

5.0 Overall Changes

Impacts: Maladapted buildings; decrease in durability and lifecycle of infrastructure; increase in impacts to urban forests, green spaces and trees; changing pests, vectors for disease and air quality.

What this could mean: The combination of more frequent extreme events and increases in annual temperature and precipitation will have impacts on both the built and natural environment.

There is a significant opportunity to improve future resilience of infrastructure by incorporating climate change information into design today. Environment Canada states that within the timeframe of climate change impacts being felt, new building will account for an equal or greater fraction of the building stock (assuming a 1-1.5% replacement rate).

Buildings may be maladapted to hotter temperatures, susceptible to damage during extreme weather and encounter new durability challenges. The Urban Heat Island Effect (UHIE) refers to urban areas being significantly warmer than their surrounding areas due to more heat retentive materials, surface heat radiation being blocked by buildings and lack of evapotranspiration (through lack of vegetation). The Urban heat island will worsen as temperatures climb. Damage to buildings from extreme weather events tends to increase dramatically above critical threshold (e.g. 25% increase in peak wind gust can generate 650% increase in building claims).

Trees, parks and greenspaces provide innumerable co-benefits such as climate change mitigation through carbon uptake, shade provision, moderation of surface flooding, habitat and outdoor amenities. Ensuring trees reach the size and vigour required to start providing these benefits is essential and may be challenged by added climate change stressors such as drought, higher peak winds and new pests and invasive species.

Objective 5.1: Increase resilience of the built environment to future climate conditions.

5.1.1. Primary Action: Continue to include climate change adaptation measures in the next Vancouver Building Bylaw (VBBL) update and explore associated zoning changes.

The building bylaw includes climate related design loads based on historical observation as well as numerous measures to ensure weather resilience in our wet Vancouver climate. Looking ahead to heavier rain events, more wind and hotter summers will require consideration of new building measures to ensure continued resilience.

Buildings may be maladapted to hotter temperatures, susceptible to damage during extreme weather and encounter new durability challenges. The Urban Heat Island Effect whereby highly urbanized areas experience higher temperatures will exacerbate summer cooling loads. Envelope integrity may also be adversely affected by increasing wind and rain loads and higher ambient moisture levels.

Recent Canadian adaptation reports call for action by the Federal and Provincial governments in collaboration with the insurance industry to research design practices that are cost effective and promote climate adaptation. Building durability and disaster resilience are suggested as themes for upcoming building code renewals. Ahead of national and provincial action, there are several opportunities to partner on adaptation incorporation in the next VBBL. The Institute for Catastrophic Loss Reduction has recently worked with Ontario builders to recommend code modifications for a changing climate and are eager to repeat their process elsewhere. More data is required on localized parameters related to design loads such as wind uplift pressure. The Pacific Climate Impacts Consortium at the University of Victoria are eager to continue our existing collaboration.

The following are adaptation measures to be evaluated and/or incorporated into the building bylaw:

- Use of reflective surfaces
- Buildings are better equipped to manage heat gain (passive guidelines)
- Development in fire interface areas (near parks and woodlands)
- Construction safety (high winds)
- Continue to lobby homeowners protection office for broader acceptance of green roofs.
- Overflow mechanisms in roof design with route plan for flood water and/or oversize roof drainage system.
- Emergency management plans / evacuation plans for buildings → combine flood hazard with seismic.
- Gray water use and rainwater capture for toilet flushing and garden use.

Supporting Actions:

- Incorporate climate change as an asset management and infrastructure design consideration.
- Collaborate with Cascadia Region Urban Sustainability Directors Network to investigate asset management approaches to planning for climate change.
- Continue to collaborate with Metro Vancouver on updated Intensity Duration Frequency (IDF) curves.
- Identify training and implementation opportunities within engineering with the Public Infrastructure Engineering Vulnerability Committee (PIEVC - Engineers Canada).

Objective 5.2: Increase the long-term health and vigour of urban forests, green spaces and trees.

Public and private trees were a focus of the access to nature goal in the greenest city plan given the vast array of benefits they provide. Growing healthy, long lasting trees requires consideration of the future climate as well as appropriate siting, planting and maintenance. Trees contribute to adaptation by:

- Intercepting and filtering stormwater runoff to prevent flooding and improve water quality
- Absorbing pollutants to clean the air
- Providing wind-breaks to protect buildings from damage
- Regulating urban heat island effects through shading and evaporation

Some co-benefits with other goals include:

- Lower cooling demand for electricity
- Directly sequester carbon
- Wildlife habitat
- Increased property value and liveability

5.2.1 Primary Action: Support development of a comprehensive Urban Forest Management Plan that focuses on growing successful trees in urban areas.

Through the Greenest City Action Plan we have committed to planting 150,000 trees. An Urban Forest Management Plan will identify the issues and values most important to the community and provides a roadmap for investing in and maintaining our urban forest to 2020 and beyond. It will ensure that species selected and locations for planting targeted, maximize civic investment and ensure longevity. It will explicitly address climate change impacts to trees and greenspaces as well as ensuring we take full advantage of their potential to support City adaptation.

A multi-department process led by arboriculture and park professionals is needed. The Forest Management plan should gather baseline data and provide direction on development of standards and guidelines that address:

- Preparing for challenges facing our urban forest in the 21st century including a changing climate.
- Increasing canopy cover citywide as a measure to help mitigate climate change. Map canopy coverage with land use, identify tree deficient areas and work to add tree space and appropriate soils management to remedy the deficit.
    - Hot spot and vulnerable population mapping can be overlayed with canopy coverage to target certain areas for shade provision.
- Organizational changes that raise the profile of trees and facilitate improved integration of trees into urban design.
- Minimize the negative impacts of new or existing trees.
- Soil management: volume and make-up (loss of heritage soils).
- Educate an expert team across departments to champion trees and provide oversight.
- Develop an Urban Forest Operations Program (Maintenance standards and budgets.)

Supporting Actions:

- Promote public awareness of the critical role of urban forests in coping with climate change.
- Continue pest and invasive species monitoring programs with climate change as an added stressor.
- Establish funding levels adequate enough to reinstitute systematic pruning.
- Ensure species and location selection criteria in the GCAP planting strategy, landscape guidelines and in the replacement tree list in the Protection of Tree Bylaw reflect future climate projections and any Urban Heat Island Effect mapping.

6.0 Organizational adaptive capacity

Objective 6.1: Incorporate adaptation considerations in City business.

Climate change is an overarching issue that poses an additional risk or benefit to the way we do business. Successful adaptation will require moving beyond this strategy to incorporation of climate change in risk management and project planning across departments.

Regular updates to climate science will be shared throughout the organization for consideration in design and planning. Mapping flood hazard, urban heat island effect, tree canopy, landslide risk areas etc. provides a powerful baseline of information. Seattle and Toronto have both developed and applied software programs to support mainstreaming climate change that can be evaluated for potential use in Vancouver. Collaborating with municipalities and other partners regionally will ensure we support regional resilience and continued economic vibrancy.

Supporting Actions:

- Continue to collaborate regionally with First Nations, Metro Vancouver and other municipalities.
- Investigate best practices in 'mainstreaming' adaptation. Consider both internal software programs and external communication / checklists.
- Complete mapping to support climate change adaptation with co-benefits for other applications.
- Complete a communication strategy, including community engagement, for Climate Change Adaptation, especially sea level rise.

Chapter 6: Plan Implementation and Maintenance Process

6.1: Implementation

The departments and divisions identified as accountable for actions in the Strategy will be responsible for implementation. The Sustainability Group will provide coordination among departments, deliver on specific actions and support departments in their implementation of actions. Where significant new actions are proposed, the need for an implementation plan and timeline will be evaluated.

Implementation through existing programs and planning
The effectiveness of Strategy implementation is dependent on incorporation of outlined actions into existing plans, policies and programs. Key vehicles for adaptation incorporation are the following:

Greenest City Action Plan: Many of the actions promoted for sustainability of the City have co-benefits with climate change adaptation. Adaptation provides either an added driver, as with water conservation, or an added consideration as is the case with the tree planting strategies.

Integrated Stormwater Management Plan: Improved management of stormwater will ensure continued functioning of the sewer system under heavier storm conditions. Vancouver has significant opportunities to enhance innovative management approaches from impervious surface policies to street design. The Integrated Stormwater Management Plan will provide cross-departmental recommendations to take advantage of these opportunities.

Urban Forest Management Plan: Long living, vigorous trees are necessary to pay back the cost of getting them to a size at which they start to provide significant benefits in terms of carbon uptake, infiltration, shade provision and water diversion. To grow successful trees in urban areas demands proper soil management, species selection, location and maintenance. Climate change intensifies the need for high standards of tree management and the incorporation of future climate considerations.

***Vancouver Building By-law update 2017*:** Working with the building and academic community to explore best methods for incorporating changing climate loads into the building code will support a more resilient building stock in the coming decades.

Sewer Separation Strategy: Separating the storm and sanitary sewers will reduce the risk of combined sewer overflows and private side sewer back-ups. The existing approach of prioritizing high risk areas for early separation ensures resilience ahead of significant shifts in storm profiles.

Extreme Hot Weather Committee: The committee, in partnership with Vancouver Coastal Health developed a heat alert and Be Cool campaign in phase I of planning. Phase II of the project can be expanded to explore and implement many of the best practices and programs for heat that are being pursued by municipalities across North America.

6.2: Method and schedule for updating the Plan

Our global and local understanding of climate change and its impacts, costs and potential actions continues to evolve. Modeled projections continue to become increasingly sophisticated and inputs change providing new ranges of anticipated temperature, precipitation etc. The City of Vancouver intends to review and evaluate the Strategy annually and to update it every five years from the date of initial Strategy adoption. This cycle may be accelerated to less than five years based on the following triggers:

- A significant climate change impact is experienced; and, or
- Senior government action or policy triggers the need to respond (e.g. as with Provincial Sea Level Rise Guidelines).

Annual Evaluation:
Climate Programs staff in the Sustainability Group will be responsible for evaluating the Strategy and staying current with climate science. Sustainability staff will also participate in regional and provincial adaptation forums and partner with external stakeholders to pool resources and ensure adaptation across sectors and jurisdictions.

The annual review and subsequent progress report will include:

- Summary of any observed changes in climate or impacts that occurred;
- Review of successful actions implemented;
- Review barriers and amend actions to enable successful implementation;
- Re-evaluation of timelines as information on impacts and funding is updated;
- Review of other planning programs or initiatives that provide a window of opportunity for climate adaptation actions or that may be impacted by climate change; and

- Identification of potential new funding options.

5-Year Update:
It is not the intent of the update process to develop a new plan. The update will be guided by the elements below:

- The update process will be carried out by a Climate Change Adaptation Team appointed by the Deputy City Manager and coordinated by Sustainability Group staff. At least one member of the original Strategy development team should be included.
- The most recent regional information on climate science will be a key input to the planning process.
- A scan of impacts identified and prioritized in the original plan will be analysed for gaps arising from new climate science or observed impacts. New actions to mitigate these impacts will be detailed.
- Existing action timelines will be reviewed to ensure thresholds have not been surpassed triggering an acceleration of action implementation.
- All actions will be reviewed and revised to account for actions completed, dropped or changed and to account for changes in risk or to leverage new programs, policies or plans.
- Inserting indicators to measure adaptation progress will be considered.
- The draft update will be reviewed by the appropriate departments prior to a final plan update being presented to Council for adoption.

Appendix A: Detailed Action Matrix

Column Explanation:

- The 'Funding' column identifies whether this is a capital or operating budget intensive action. In many cases, budget is not secured.
- The 'Priority' column includes must do actions with capital plan date delivery (Action by X) and actions in the monitor and investigate further categories as described in section 2.5 of the Strategy.
- The 'Effort' column includes Small (S), Medium (M) and Large (L) projects/actions and identifies those included in the Greenest City Action Plan (GCAP)

1.0 Increase in intensity and frequency of heavy rain events

Significant Impacts
1.1. Increased surface water flooding from ponding of rainfall in low lying areas or heavy rainfall overcoming the capacity of the drainage system
1.2. Increase in number of combined sewer overflows
1.3. Increases in sewer back-ups in combined sewer areas due to high rainfall volume in sewer system
1.4. increase in landslide risk affecting public infrastructure and private property

1.1 Increased surface water flooding				
ACTION	**Funding**	**Priority**	**Accountability**	**Effort**
Include rainfall/stormwater management recommendations in the ISMP including: planning and design; runoff storage and conveyance practices; infiltration and filtration practices.	Capital	Action by 2014	Engineering: sewers and streets; Parks; CSG; Sustainability	L
Within ISMP: Recommend stormwater management opportunities identified during large site rezoning work that are transferable to other types of development.	Operating	Action by 2014	Engineering: sewers and streets; Parks; CSG; Sustainability	L

Within ISMP: Resolve barriers that constrain streets draining to parks.	Operating	Action by 2017	Engineering: sewers and streets; Parks; CSG; Sustainability	S
Within SMP: Evaluate and provide bylaw revisions for impermeable surface allowance. Recommendations for improved enforcement.	Operating	Action by 2014	Engineering: sewers and streets; Parks; CSG; Sustainability	L
Within ISMP: Increase the use of infiltration /detention bulges on streets where appropriate.	Capital	Action by 2014	Engineering: sewers, streets	L
Evaluate and recommend opportunities for stormwater detention or storage during park redesign and in new parks. Implement and evaluate this approach during Phase one of Hastings Park.	Operating and Capital	Action by 2014 (Hastings Park) by 2017 (Trout Lk)	Parks	S
GCAP: Encourage water retention on private sites, e.g. rock pits in one and two family dwellings.	GCAP (In Progress)	Action by 2014	Engineering, CSG: CBO, development services	GCAP
Use best available climate model information and continue to monitor changing Enviro. Can. and Metro Van. IDF curves as design and monitoring input for stormwater system.	Operating	Action by 2014	Engineering: sewers and streets	S
Initiate a pilot flood risk assessment in a catchment area identified in coordination with risk management. Identify risk areas and complete a flowpath evaluation to determine correct sizing, curb design, inlet capacity and number of catch basins required.	Capital	Action by 2020	Eng.: streets, sewers; Risk Management	M
Increase catch basin maintenance in areas identified as high risk for street flooding.	Operating	Ongoing	Eng.: Sewers	S
Implement permeability Pilot projects to test and communicate the opportunities for detention and/or infiltration.	Capital	Ongoing	Eng.: sewers and streets	S
Raise awareness of public involvement in keeping C.Bs clean.	Operating	Ongoing	Corporate Comm.; Eng.: Solid waste	S

Increase existing storm pump station capacity	Capital	Monitor	Eng.: sewers and streets; Parks	M-L
Develop and implement a process to release information bulletin/social media/online information to alert public to check C.Bs when heavy rain is forecast.	Operating	Investigate Further	Corporate Communications Eng.: sewers and streets	M
Examine whether turf fields are meeting community needs during rainy months or if additional artificial covers are needed.	Operating	Investigate Further	Parks	S
Assess feasibility of dewatering spot flooding with fire and rescue equipment	Operating	Investigate Further	Fire and Rescue; Eng.: Sewers	S
Implement comprehensive software (311, Hansen, GIS) to map recorded street flooding incidents.	Capital and Operating	Investigate Further	Engineering	M
1.2 Increased CSO				
Complete sewer separation	Capital (In progress)	Ongoing to 2050	Eng.: Sewers	L
Eliminate CSOs at Crowe and Burrard	Capital (secured)	Action by 2014	Eng. Sewers, Finance	L
Strategic application of stormwater management techniques in combined sewer areas	Capital	Action by 2017	Eng.: sewers and streets; Finance, CSG, Parks	L
Re-route stormwater to waterbodies including daylighted creeks.Opportunities include Tatlow, Lost Lagoon, Renfrew Ravine	Capital	Action by 2014 (Jericho) and ongoing	Eng.: Sewers, Parks	M-L
1.3 Increased liability claims against the city from major rain events, especially private property sewer back-ups				
Provide incentives and/or subsidies for faster replacement (to separated) of private side combined sewer connections ahead of City-side separation.	Capital	Action by 2017	Eng.: Sewers	M-L
Lobby insurance industry to provide discount to properties with separated plumbing in separated areas.	Operating	Action by 2017	Risk Management	M
Through the building or plumbing bylaw, require backwater valves after multiple backups in combined areas.	Operating	Investigate Further	CSG, Eng.: Sewers	S-M

Use tax notices and website to provide information on minimizing risk of sewer back-ups, such as the ICLR handbook on reducing basement flooding.	Operating	Investigate further	Eng.: Sewers and Risk Mgt.	S
1.4 Increase in landslide risk affecting public infrastructure and private property				
Map and prioritize highest risk slopes and create action plans including: - Planting, percolation, vegetation best practices, anchors, retaining walls, deepwater infiltration or purchase property, etc.	Capital	Action by 2017	Land Survey, GIS, Parks	M
Evaluate tools such as bylaw, covenant, property use, landscape plans etc. to hold property owners in identified risk areas to higher standards.	Operating	Action by 2017	CSG: Development Services	M

2.0 Sea Level Rise

Significant Impacts
2.1. Increased flooding and storm surge damage along the coast and Fraser River as sea levels rise and storms are more frequent.
2.2. Reduced gravity drainage of existing drainage system as sea levels rise, resulting in more frequent flooding of low areas near storm sewer outfalls.
2.3. Increase in shoreline erosion affecting natural environments and public amenities such as parks, trails and access to the water

2.1 Increased flooding and storm surge damage along the coast and Fraser River as sea level rises and storms are more frequent				
ACTION	**Funding**	**Timing**	**Accountability**	**Effort**
Undertake a detailed Flood Risk Assessment to quantitatively analyze risk and evaluate risk mitigation options (Use up-coming BC Primer and Costing study as inputs).	Capital	Action by 2014	Sustainability, Engineering, CSG: CBO, Planning	L
Use Risk Assessment information to develop and implement a City-wide Sea Level Response with decision	Operating	Action by 2017	Sustainability, Engineering, CSG: CBO, Planning	L

points and actions detailed over a timeline.				
Acquire LIDAR mapping to support Flood Risk Assessment as well as the Urban Forest and Integrated Stormwater Management Plans.	Capital	Action by 2014	IT, Land Survey, Sustainability	M
Amend flood-proofing policies	Operating	Action by 2014	Sustainability, CSG: CBO, Dev. Services	M
Evaluate need for, and develop, flood preparedness plans, evacuation plans and flood alerts	Operating	Action by 2020	Emergency Management	M
Coordinate with other municipalities through the Fraser Basin Council and with the Province of BC to ensure a regional approach.	Operating	In Progress Action by 2014	Sustainability	S
Initiate Flood-proofing awareness campaign among builders/developers including information on storage of hazardous materials, mechanical equipment and resilient building measures.	Capital	Action by 2017	CSG: CBO, Dev. Services; Communications; Fire and Rescue; Environmental Protection; UDI	S-M
Hold a competition to highlight adaptation options for sea level rise	Operating and Capital	Action by 2017	Sustainability	S
Address the influence of tide and changes to groundwater on existing buildings.	Operating	Action by 2017	CSG: CBO	M
Initiate a Sea Level Rise Working group to recommend next steps for City-wide strategic approach to sea level rise.	Operating	In Progress	Sustainability	S
Evaluate opportunities to increase road grades in risk areas when nearby development or during road replacement.	Operating	In Progress	Engineering; CSG: planning, dev. Services; Sustainability	M-L
Adjust park / beach plantings to ensure resilience to saltwater.	Operating	Monitor	Parks	S
Train and delegate staff member to review/assess BC Storm Surge website and alert departments when hazard identified.	Operating	Investigate Further	Emergency Management	S
Increase groundwater monitoring to track water table rise and salinity.	Capital	Investigate Further	Engineering	M
Evaluate and recommend utility of the Greenshores	Operating	Investigate	CSG: Development Services,	S

Coastal Development Rating System.		Further	Planning	
Research and report on beach storm surge education/awareness and/or signage (e.g. flag system)	Operating	Investigate Further	Parks, communications	S
When pipes are up for replacement in low lying areas consider material resilience to corrosion from saltwater.	Capital	Investigate Further	Engineering	S-M
2.3 Reduced gravity drainage capacity of existing drainage system as sea levels rise, resulting in more frequent flooding of low areas near storm sewer outfalls.				
Continue to install back-up power to storm pump stations and increase system storage.	Capital	In Progress Action by 2020	Eng.: Sewers	M
Identify and prioritize new pump stations in low areas where higher water levels will necessitate stormwater pumping.	Capital	Monitor	Eng.: Sewers	L
Add backwater valves on outfalls to prevent saltwater intrusion and backup.	Capital	Monitor	Eng.: Sewers	M
Evaluate and recommend whether road closure procedures currently used for ice and snow could be applied for flooding.	Operating	Investigate Further	Eng.: streets, sewers; CSG: CBO	S
2.4 Increase in shoreline erosion affecting natural environments and public amenities such as parks, trails and access to the water				
Address Vancouver's coastal open spaces in City-wide sea level rise response (**see 2.1**). Consider: • increased naturalization; Greenshores sustainable shoreline development approach; rip rap, rock groyne and seawall durability; new armouring, breakwaters, steeper sloped beaches; accept loss and replace in lower risk areas; and use excavation materials to reinforce shoreline or stable substrate below sand.	Capital and Operating	Action by 2020	Parks, Engineering, CSG: CBO (private property issues)	L
Leverage opportunities to evaluate strategic open space planning for inundation and containment areas in near	Operating and Capital	Monitor - As Master Plans	Parks, CSG: Planning	S

shore greenspaces.		arise		
Increase budget for scaling and vegetation management of cliffs.	Capital	Monitor	Parks, Engineering, CSG: CBO	M
Increase maintenance budget for existing rock groynes and beaches (sand import, log debris, dredging).	Capital	Monitor	Parks, Engineering	M
Increase awareness among staff about increasing shoreline erosion and appropriate control practices.	Operating	Investigate Further	Parks, Engineering, CSG: CBO	S

3.0 Increased frequency and intensity of storms and weather extremes

Significant Impacts
3.1. Increased safety and health risks for vulnerable populations including water ingress, mould and loss of housing for poorly housed and health risks to the homeless.
3.2. Increased public safety risk on streets due to damage to infrastructure and trees
3.3. Increased resources required to respond and clean-up during and following storm events
3.4. Natural disaster and related emergency management and response capacity may need to cater to more frequent, simultaneous and extreme disasters as well as the associated cascading effects.

3.1 Increased safety and health risks for vulnerable populations including water ingress, mould and loss of housing for poorly housed and health risks to the homeless.				
ACTION	**Funding**	**Timing**	**Accountability**	**Effort**
Send letter requesting Metro Vancouver ask the Province to expand criteria and Provincial funding so that extreme weather response shelters can support more frequent openings.	Require external partner	Action by 2014	CSG: Social development, Parks	S
Ensure instances of mould are included in the online rental database being developed.	Operating	In Progress Action by 2014	Inspections and Licenses	S
Partner with VCH to initiate an education and awareness campaign for social housing operators on mould; how to	No funding source	Investigate Further	Sustainability, Communications, CSG:	M

identify and address it.	identified		License and Inspections	
3.2 Increased public safety risk on streets due to damage to infrastructure				
Continue pole replacement and the transition to more resilient hangers and signs.	Existing Capital	In Progress Action by 2020	Engineering: Streets	M
Continue to add back up power and grounding to traffic signals.	Capital	Ongoing Action by 2020	Engineering	M
Implement a review and update of service levels with recommendations to council on appropriate levels and priorities.	Operating	Investigate Further	Eng.: Asset Management and streets	M
3.3 Increased resources required to respond and clean-up during and following storm events				
Complete an Initial Response Guideline (IRG) for intense rain and wind storms and flooding.	Operating	Action by 2014	Emergency Management	M
Activate IRGs and EOC when storm or flooding occurs. Use EOC to coordinate imminent planning in preparation for a forecast weather event and monitor / plan response. May trigger need for increased funding.	Operating and Capital	Action by 2014	Emergency Management	M
Develop a risk-based approach to apply contingency budget for new and existing facilities in the anticipation of more intense events causing damage.	Capital	Investigate Further	Finance, Real Estate and Facilities Management	M
Budget for increases to insurance costs in the short term. In the long term work with the insurance community to develop appropriate risk reduction coverage that address climate change insurance costs for CoV.	Capital	Investigate Further	Risk Management, finance, Real Estate and Facilities Management	M
3.4 Natural disaster and related emergency management and response capacity may need to cater to more frequent, simultaneous and extreme disasters as well as the associated cascading effects.				
Develop a policy for facility back-up power and assess departments for gaps in back-up power.	Capital	Action by 2020	Engineering / Real Estate and Facilities Management	M-L
Evaluate and learn from HRVA work done by the Integrated Partnership for Regional Emergency Management in Metro Vancouver.	Operating	Action by 2014	Emergency Management	S
Support delivery of a special events risk assessment	Operating	In Progress	Existing task force	S-M

Advanced Planning Unit. Consider heat and wind as factors in assessment.		Action by 2014		
Broaden 'Team Vancouver Emergency Response' volunteer urban search and rescue to aid with extreme event response. Wide response functions including flooding response, heat alert patrols, park post-storm clean up etc.	Operating	Investigate Further	Emergency Management, Vancouver Fire & Rescue Services	L
Prioritizing several of the highest ranked risks in the HRVA, assess critical infrastructure and lifelines for resilience. Follow New Zealand lifeline study example.	Operating	Investigate Further	Emergency Management	M

4.0 Hotter, drier summers

Significant Impacts
4.1. Increased health and safety risks to vulnerable populations during extreme heat events
4.2. Water supply shortages

4.1 Increased health and safety risks to vulnerable populations during extreme heat events				
ACTION	**Funding**	**Timing**	**Accountability**	**Effort**
Support existing Extreme Hot Weather Committee in completion of Phase II of planning	Operating and capital	In Progress Action by 2020	Emergency Management, CSG: Soc. Dev., Sustainability	L
Develop an approach / policy to address cool refuges and/or cooling capacity of civic facilities. Use hot spot and vulnerable population mapping.	Operating	Action by 2020	Real Estate and Facilities Management, engineering, CSG: social development	M
Complete mapping for areas vulnerable to heat extremes.	External partnership	In Progress Action by 2014	IT, academic partnership	S
Assess potential for cooling rooms in non-market housing.	Capital	Action by 2015	CSG: Social Development, Real Estate and Facilities Management	M-L
Use UHIE and vulnerability mapping overlays to target locations for additional green spaces, parks	Capital	Action by 2015	Parks	S

and trees.				
Continue to expand public access to drinking water.	GCAP - Capital	In Progress Action by 2014	Engineering – Water, Parks, Real Estate and Facilities Management	GCAP
Monitor C.Bs in combined areas for increases in odour. Anticipate increases in response.	Operating	In Progress Monitor	Sewers	S
Partner with VCH to undertake a climate change health vulnerability analysis as per Health Canada	Capital and external partnership	Investigate Further	Sustainability and Emergency Management	M
Explore implementation of Buddy system / Block captains building on existing programs. Can be used for other impacts e.g. cleaning catch basins, checking on isolated neighbours during heat waves, etc.	External partners (e.g. Vantage Point Neighbourhood Helpers Outreach Program)	Investigate Further	CSG, Engineering	M
4.2 Water supply shortages in late summer could drive expensive ad hoc capital upgrades and source expansion.				
Implement Greenest City Action Plan Clean Water actions to reduce water use: water metering, water conservation, system leakage reduction and lawn sprinkling enforcement projects.	GCAP - Capital	In Progress Action by 2014	Water	GCAP
Identify areas such as medians and pilot zero irrigation / use of rainwater.	Operating	Action by 2017	Parks / Engineering	M

5.0 General Changes

Significant Impacts
5.1 New and Existing Buildings may be maladapted as the climate changes in terms of water ingress, wind, durability, rain on snow loads, increasing heat waves etc.
5.2 Decrease in durability and lifecycle of infrastructure leading to increased maintenance and replacement requirements.
5.3 Increase in impacts to urban forests, green spaces and trees from temperature extremes and wind storms resulting in increased maintenance and replacement costs

5.4. Increasing vectors for disease and respiratory illness are expected health impacts from increasing temperatures

5.1 New and Existing Buildings may be maladapted as the climate changes in terms of water ingress, wind, durability, rain on snow loads, increasing heat waves etc.				
ACTION	**Funding**	**Timing**	**Accountability**	**Effort**
Consider policy and VBBL changes to address the following: • urban heat effect mitigation; changing climate loads; heat loads, increasing cooling degree days; development in the fire interface areas; appropriate weather protection guidelines; roof drainage; gray water and rainwater capture for toilets/garden use.	Operating	Action by 2017	Sustainability, CBO, Dev. Services	L
Issue a bulletin on construction safety with changes in storms and wind increases. Include a sentence in building bylaw for construction on considering climate change in construction safety plan.	Operating	Action by 2014	CBO	S
Continue to lobby homeowner protection office for broad acceptance of green roofs.	Operating	In Progress Action by 2017	Sustainability, CBO	S
Emergency management plans – evacuation plans for buildings including seismic and flooding.	Operating	Investigate further	CBO	M
5.2 Decrease in durability and lifecycle of infrastructure leading to increased maintenance and replacement requirements.				
Work with partners from other levels of government, and with USDN Cascadia to investigate and apply methods of incorporating climate change considerations into infrastructure lifecycle planning and maintenance monitoring. Include how to track, record and evaluate impacts on infrastructure.	Partner	Action by 2020	Sustainability, Eng.: asset management, streets	M
Develop a policy for regularly updating best practices to reflect new climate change projections in infrastructure	Operating	Action by 2014	Sustainability, Engineering	S

design and repair.				
Low lying pump stations may require increased maintenance	Capital	Monitor	Eng.: Sewers	S
Apply the PIEVC protocol for infrastructure vulnerability where screening level risk assessment indicates high risk.	Capital	Investigate Further	Engineering	M
Support forensic studies to determine climate thresholds.	Capital	Investigate Further	Engineering	M
5.3 Increase in impacts to urban forests, green spaces and trees from temperature extremes and wind storms resulting in increased maintenance and replacement costs.				
Ensure the Urban Forest Management Plan details corporate knowledge and best practices and addresses issues related to: • climate change; soil management; long term tree health as priority in development review / public realm planning; organizational changes that will facilitate improved integration of trees into urban design; plant/tree hardiness; and prevention and management techniques for invasive species and pests	Capital and operating	Action by 2014	Parks, Sustainability, CSG, Real Estate and Facilities Management	L
Map canopy cover and identify tree deficit and greenspace deficit areas. Initiate a program to address these areas through development and planning.	Capital and operating	Action by 2017	Parks, CSG	L
Ensure species and location selection criteria for the Planting Strategies developed under the GCAP consider the best available climate projections and any information or mapping related to Urban Heat Island Effect.	Operating	In Progress Action by 2014 and ongoing	Parks	S
Re-evaluate zero based budget for street and park tree maintenance in urban forest management plan.	Capital	Action by 2014	Parks	M
Review replacement tree list in Protection of Tree Bylaw	Operating	Action By 2017	Parks, CSG	S

and the Water Wise Landscape Guidelines plant list to ensure all species are resilient to climate projections.				
Apply wind management techniques used in Stanley Park in other locations such as Jericho Park and the Renfrew Ravine.	Capital	Action by 2020	Parks	M
Record failures in street tree inventory comments section and learn from climate related trends.	Operating	Ongoing Action by 2014	Parks	S
Explore and evaluate options for the storage and reuse of winter rainwater for summer irrigation. Use Van Dusen gardens as pilot / education opportunity.	No funding source identified	Action by 2017	Parks	
Increase artificial turf use	Capital	Investigate Further	Parks	S
5.4. Increasing vectors for disease and respiratory illness are expected health impacts from increasing temperatures				
Partner with VCH, Health Canada and local academic institutions to continue learning about impacts to human and ecological health.	Operating	Investigate Further	Sustainability, Parks, CSG	M

6.0 Increasing Adaptive Capacity within the Organization

ACTION	Funding	Timing	Accountability	Effort
Explore options for incorporating adaptation considerations into budget, capital and operational planning. Evaluate and consider acquiring adaptation software developed in Toronto or Seattle. Assess Victoria's adaptation checklist for capital projects.	Operating and Capital	Action by 2014	Sustainability	M
Create a central location for climate change projections. Internal website with links to Plan2Adapt, other resources etc.?	Operating and Capital	Action by 2014	Sustainability	M
Establish policy to revise climate change information every 5 years and review Adaptation Strategy.	Operating	Action by 2014	Sustainability	S

Initiate a staff outreach campaign to disseminate climate information and provide meaningful ways to incorporate it in daily work.	Operating	Action by 2014	Sustainability	M
Engage Business: Work with the VEC and Board of Trade to build awareness so businesses can analyze their vulnerability to climate change and take action	Operating	In Progress Action by 2014	Sustainability	M
Engage regionally with other municipalities and First Nations on sea level rise and adaptation planning.	Operating	In Progress Action by 2014	Sustainability	S
Engage Public: Use existing projects and new planning (forest plan, ISMP, mitigation) to raise awareness on adaptation at the City and homeowner scale (rain gardens, private side connections, shade trees).	Capital	Action by 2017	Sustainability and communications	M
Establish a public-private partnership action group for extreme weather resilience like the Weatherwise Partnership in Toronto. Goal is ensuring overall increase in infrastructure resilience.	Operating and Partnership	Investigate Further	Sustainability	L
Investigate checklist development for Developers re. Climate hazards and climate wise development (see Halifax example).	Operating	Investigate further	Sustainability and CSG: Development Services	S
Investigate opportunities for structuring DCLs and CACs to support adaptation work such as raising the seawall or re-designing parks to help mitigate the effects of storm surge.	Operating	Investigate Further	Sustainability, Planning, Engineering, Parks	M

Appendix B – Vulnerability and Risk Assessment Details

The table below includes all impact statements that were assessed for vulnerability and risk. Resulting priority impacts are those addressed directly in the Strategy.

Table 9: All impact statements identified at the beginning of the planning process.

Climatic Change	Impact Statement	Primary Service Area
Increase in temperature	Water supply shortages felt in late summer due to a decreased spring snow pack and higher summer temps influencing greater draw downs and evaporation could result in increased costs for water and imperative conservation measures	Engineering -Water
	Higher bacterial re-growth in water distribution system due to increased water temperatures could affect water quality and increase treatment costs	Engineering -Water
	Increased corrosion rate of water distribution system due to increased water temperatures	Engineering -Water
	Reduction in water supply in late summer may affect fire fighting capacity	Fire and Rescue Services
	Increased maintenance, staffing and refurbishment costs associated with community facilities with air conditioning and outdoor pools, etc. due to an increase in user demand during warmer summer weather	Parks and Recreation
	Community facilities without air conditioning or outdoor pools, etc. could see decline in users during summer daytimes resulting in loss of revenue	Parks and Recreation
	Increased health and safety risks to vulnerable populations during extreme heat events	CSG - social dev
	Decrease in pavement durability and performance with hotter temperatures	Engineering - Streets
	Decreased comfort spending time in the public realm where cover and shade are not available	CSG - Planning
	Decrease in outdoor worker productivity as there are more frequent hot days	Engineering General
	Parks may require more capital spending on watering during warmer summers. Conservation measures will have to be considered	Parks and Recreation
	Increased drought stress on green space plants and trees (including street trees) leading to increased watering costs and/or replacement	Parks and Recreation
	Emergency staff and equipment may be inadequate to deal with previously uncommon emergencies (e.g. forest fire)	Emergency Management

	Mechanical systems in Civic facilities may have shorter lifespan due to increased annual use	Facility Design and Management
	New and existing buildings may be maladapted as the climate changes in terms of water ingress, wind durability, rain on snow loads, etc.	CBO and L&I
	Increasing impacts to aesthetics, public health and management costs associated with new or increasing spread of invasive species and animal and insect pests. E.g. More algal blooms, more mosquitoes in catch basins, etc.	Parks and Recreation
	Increase in ozone-related health impacts as ozone increases with increasing temperature	VCH
Increase in precipitation	Increased surface water flooding from ponding of rainfall in low lying areas or heavy rainfall overcoming the capacity of drainage system	Engineering - Sewers
	Increase in number of combined sewer overflows	Engineering - Sewers
	Increased building roof / skylight leakage and collapse with more extreme events such as rain on snow	Development Services - Building
	Increased water ingress, mould occurrences and storm related damage to temporary or low cost buildings resulting in secondary impacts to health and potentially increasing homelessness	CBO and L&I
	Increase in delays of construction and damaged/rotting construction material.	CBO and L&I
	Increases in private property sewer back-ups in combined sewer areas due to high rainfall volume in sewer system. Secondary impacts to health, insurability of citizens and City reputation and service excellence	Engineering - Sewers
	Increased safety and health risks for vulnerable populations including those in lower quality housing, homeless population and seniors	CSG - social dev
	Reduced revenue due to decrease in attendance at winter/spring/fall outdoor cultural events, especially day-of event ticket sales	CSG - Cultural Services
	Increase in landslide risk affecting public infrastructure and private property	Engineering General
	Higher cost or lower standard associated with snow clearing in the near term with potentially large snowfalls	Finance and Administration
	Increase in worker health and safety needs and occupational health costs due to heavy rainfall, ice events, and generally poor weather working conditions	HR
	Decrease in outdoor worker productivity	All Depts generally
	Increased maintenance costs and shorter lifecycle of civic facilities from weathering and heavier use of mechanical systems	Facility Design and Management
	Decreased comfort spending time in the public realm	CSG - Planning
	Increased maintenance costs and decrease in use of	Parks and Recreation

	playing fields	
	New and existing buildings may be maladapted as the climate changes in terms of water ingress, wind durability, rain on snow loads, etc.	CBO and L&I
	Construction practices may be maladapted to changing climate with resulting risks to public safety and loss of assets	Development Services - Building
	Increased volume of third party liability claims against the city from major rain events, financial loss where City negligent, damage to City owned properties, reputational damage from the perspective of the public	Risk Management
	Increased costs for response actions and clean-up after heavy rain events	Finance and Administration
Increase in sea level	Increased flooding along the Coast and Fraser River as sea level rises and the storm surge and waves breach height of land	Engineering General
	Increased damage to structures (seawalls) and shoreline resulting in greater discontinuity of use	Engineering General
	Reduced gravity drainage of the existing drainage system, resulting in more frequent flooding of the False Creek low areas and Southlands	Engineering - Sewers
	Saltwater intrusion in built up areas affecting the longevity of underground infrastructure	Engineering General
	Saltwater intrusion may foul fresh water wells or lead to water quality issues	Engineering -Water
	VPD facilities may not support emergency operations (low lying areas and lack of emergency power)	Police
	Liability issues in flood risk areas without restrictive covenants	Risk Management
	Increase in environmental refugees from surrounding areas increasing population stress on resources and development	CSG - Planning
	Increase in shoreline erosion affecting natural environment and public amenities such as parks, trails and access to the water	Parks and Recreation
	Saltwater intrusion at sanitary sewer pump stations will increase risk of corrosion and decrease in design life.	Engineering - Sewers
	Gradual inundation of low lying areas of land along the Coast or Fraser River	CSG - Planning
	Increased cost and difficulty acquiring insurance for private and public property owners in high risk areas	Risk Management
	Rising groundwater levels in coastal regions resulting in ponding and drainage problems	Engineering General
Decrease in freshwater levels	Decrease in reservoir levels in the summer due to smaller winter snowpack and reliance on rainwater only	Engineering -Water
	Deleterious effects on species in area streams	Parks and Recreation
Increased	Increased public safety risk from the effects of more	Engineering General

frequency and severity of extreme weather events	intense storms on infrastructure, especially streets.	
	Decrease in durability of water distribution system and declining water quality due to increased turbidity due to landslides, etc. at source	Engineering -Water
	Increase in duration and occurrence of power outages causing secondary impacts to all service areas where back-up power has not been installed	All Depts generally
	Construction practices may be maladapted to changing climate with resulting risks to public safety and loss of assets	CBO and L&I
	Increased safety and health risks for vulnerable populations including water ingress, mould and loss of housing for those in low quality housing and health risks for the homeless	CSG - social dev
	Increase in temporary shelter turnaways as extreme weather events increase	CSG - social dev
	Increased Occupational Health requirements and costs due to heavy rainfall, ice events, and generally poor weather working conditions.	HR
	Increase in staff absenteeism during events when staff are most needed to respond	Emergency Management
	Increase in impacts to urban forests, green spaces and trees from temperature extremes and wind storms resulting in increased maintenance and replacement costs and changes to aesthetics and use	Parks and Recreation
	Increased maintenance and repair costs, response action costs and clean-up costs following storm events	Engineering General
	Decrease in durability and lifecycle of infrastructure leading to increased maintenance and replacement requirements. This includes changes to pavement durability, Civic facilities, signage and traffic signals, underground infrastructure, etc.	Engineering General
	Emergency staff and equipment may be inadequate to deal with previously uncommon emergencies (e.g. forest fire)	Emergency Management
	Decrease in emergency staff ability to reach work sites.	Emergency Management
	Increased damage to civic facilities requiring timely repair	Facility Design and Management
	Civic non-market housing is generally older stock with less resilient building envelope and is likely to incur damage	Facility Design and Management
	New and existing buildings may be maladapted as the climate changes in terms of water ingress, wind durability, rain on snow loads, etc.	CBO and L&I
	Increased volume of 3rd party liability claims from wind/snow storms, etc. , financial loss where City	Risk Management

	negligent, damage to City owned properties, reputational damage from the perspective of the public.	
	Increased risk to public safety for outdoor events	CSG - Cultural Services
	More frequent and more extreme natural disasters may tax emergency response capacity	Emergency Management
All climatic changes	Changed aesthetic experience in parks due to increased plant and tree loss	Parks and Recreation

Table 10: Examples of impacts where high vulnerability was identified

Impact	Sensitivity Rating	Adaptive Capacity Rating	Vulnerability
Increased health and safety risks to vulnerable populations during extreme heat events	S4	AC3	V4
Increased surface water flooding from ponding of rainfall in low lying areas or heavy rainfall overcoming the capacity of drainage system	S4	AC3	V4
Increases in private property sewer back-ups in combined sewer areas due to high rainfall volume in the sewer system	S4	AC2	V4
Increased flooding along the Coast and Fraser River as sea level rises and the storm surge and waves breach height of land	S4	AC2	V4

k Assessment

	Consequence Rating					Consequence Total /25	Likelihood Rating /5	Risk Score /125
	Public Safety	*Local Economy and Growth*	*Community and Lifestyle*	*Environment and Sustainability*	*Public Administration*			
felt in ecreased gher ng l t in r and	1	2	3	2	2	15	3	**45**
fety risks ns during	4	1	1	1	1	8	4	**32**
flooding in low fall of	2	2	2	2	2	10	5	**50**
ombined	2	2	2	3	2	11	4	**44**

Risk Assessment Results:
According to the risk results, all impacts are within the low to medium range, with the majority being medium-low and medium risks. No high risk impacts were identified given the rating matrix shown in table 11 above. Those impacts identified as a medium risk included:

- Increased damage to structures (seawalls) and shoreline resulting in greater discontinuity of use
- Increase in shoreline erosion affecting natural environment and public amenities such as parks, trails and access to the water
- Increase in impacts to urban forests, green spaces and trees from temperature extremes and wind storms resulting in increased maintenance and replacement costs and changes to aesthetics and use
- Increased flooding along the Coast and Fraser River as sea level rises and the storm surge and waves breach height of land
- Decrease in durability and lifecycle of infrastructure leading to increased maintenance and replacement requirements. This includes changes to pavement durability, Civic facilities, signage and traffic signals, underground infrastructure, etc.
- New and existing buildings may be maladapted as the climate changes in terms of water ingress, wind durability, rain on snow loads, etc.
- More frequent and more extreme natural disasters may tax emergency response capacity

Appendix C –Climate Model Projections for the Lower Mainland

The following tables provide more detail on the projected climate changes for the lower mainland. All information is provided by the Pacific Climate Impacts Consortium in their June, 2012 report titled: Georgia Basin: Projected Climate Change, Extremes and Historical Analysis.

Temperature and Precipitation Summary:

Table 12: Projected future change compared to 1961-1990 baseline for both regional districts according to the www.Plan2Adapt.ca ensemble (accessed June 2012). The median and range are based on 30 projections from 15 Global Climate Models for each of the A2 and B1 emissions scenarios. The range is the 10th to 90th percentile of the 30 projections.

Variable	Future period	Metro Vancouver		Capital Regional District	
		Median	Range	Median	Range
Annual Temperature	2050s	+1.7°C	+1.0°C to +2.6°C	+1.6°C	+1.0°C to +2.3°C
	2080s	+2.7°C	+1.5°C to +4.2°C	+2.5°C	+1.4°C to +3.9°C
Summer Temperature	2050s	+2.1°C	+1.4°C to +2.8°C	+2.0°C	+1.3°C to +2.6°C
	2080s	+3.2°C	+2.0°C to +5.0°C	+3.0°C	+1.8°C to +4.6°C
Winter Temperature	2050s	+1.6°C	+0.8°C to +2.7°C	+1.5°C	+0.8°C to +2.4°C
	2080s	+2.3°C	+1.2°C to +4.1°C	+2.2°C	+1.0°C to +3.7°C
Annual Precipitation	2050s	+7%	-2% to +11%	+6%	-2% to +12%
	2080s	+8%	1% to +18%	+8%	-1% to +19%
Summer Precipitation	2050s	-15%	-25% to +5%	-18%	-30% to +1%
	2080s	-14%	-38% to -2%	-20%	-46% to +1%
Winter Precipitation	2050s	+6%	-5% to +16%	+5%	-5% to +17%
	2080s	+9%	+1% to +24%	+9%	-2% to +23%

For comparison with the projections averaged over the GCMs (above), table 13 and 14 provide figures and averages for the 2050s for the eight regional climate models (RCMs) relative to a baseline period of 1971 – 2000. There is significant disagreement between models in the direction of change for some seasons; an indication to plan for both directions.

Table 13: Summary of projected changes for regional average 2050s temperature (°C) **in Metro Vancouver.**

GCM-RCM	Winter	Spring	Summer	Fall	Annual
cgcm3-crcm	2.6	2.6	2.1	2.2	2.4

cgcm3-rcm3	2.9	4.0	2.2	-0.5	2.2
cgcm3-wrfg	2.6	2.9	2.1	-0.3	1.8
ccsm-crcm	3.0	3.2	3.0	2.4	2.9
ccsm-mm5i	2.4	3.9	1.7	-0.2	2.0
ccsm-wrfg	3.1	4.1	2.2	-0.4	2.3
hadcm3-hrm3	2.4	2.6	3.5	2.2	2.7
gfdl-rcm3	2.3	3.5	1.4	-0.8	1.7
average	2.7	3.3	2.3	0.6	2.2

Table 14: Summary of projected changes for regional average 2050s precipitation (%) **in Metro Vancouver.**

GCM-RCM	Winter	Spring	Summer	Fall	Annual
cgcm3-crcm	31	18	-1	22	17
cgcm3-rcm3	33	-22	11	82	26
cgcm3-wrfg	37	-3	24	92	37
ccsm-crcm	-16	-11	-11	37	0
ccsm-mm5i	-40	-52	11	114	8
ccsm-wrfg	-14	-50	7	92	8
hadcm3-hrm3	17	-14	-15	30	3
gfdl-rcm3	-13	-11	5	41	6
average	4	-18	4	64	13

Table 15: Summary of Metro Vancouver region average projected changes from each of the three high resolution projections for 2050s and 2080s (CGM3, HadCM3, HadGEM -see full report for detail). Variables are temperature (T), precipitation (P), precipitation as snow (PAS), growing degree days (GDD), heating degree days (HDD), cooling degree days (CDD), night-time low temperature (Tmin), daytime high temperature (Tmax), and frost free period (FFP).

Var-iable	Season	Units	1961-1990	2050s			2080s		
				CGCM3	HadCM3	HadGEM	CGCM3	HadCM3	HadGEM
T	Winter	°C	2.2	2.7	0.8	2.3	4.0	0.9	4.0
T	Summer	°C	15.3	2.3	2.5	5.2	3.8	3.6	7.0
T	Annual	°C	8.5	2.5	1.8	3.8	3.8	2.6	5.6
Tmax	Summer	°C	20.2	2.4	2.5	5.2	4.2	3.6	7.0
Tmin	January	°C	-1.1	3.8	0.1	2.7	5.5	0.1	4.1
P	Winter	mm	882	72	26	-37	81	3	-29
P	Summer	mm	246	2	-57	-106	-24	-52	-118
P	Annual	mm	2381	250	-2	-85	356	60	69
PAS	Annual	mm	277	-167	-87	-170	-216	-110	-228
GDD	Annual	Days	1716	646	535	1158	1092	803	1710
HDD	Annual	Days	3524	-820	-560	-1097	-1221	-777	-1522

CDD	Annual	Days	55	78	100	329	181	208	575
FFP	Annual	Days	200	81	37	71	120	51	102
P	Winter	%	100	8	3	-4	9	0	-3
P	Summer	%	100	1	-23	-43	-10	-21	-48
P	Annual	%	100	11	0	-4	15	3	3
PAS	Annual	%	100	-60	-31	-61	-78	-40	-82
GDD	Annual	%	100	38	31	67	64	47	100
HDD	Annual	%	100	-23	-16	-31	-35	-22	-43
CDD	Annual	%	100	142	181	597	329	377	1043
FFP	Annual	%	100	41	18	35	60	25	51

Extremes

Projected future changes and historical climatology of extremes are provided for five indices that are a subset of the standard set of indices of extremes called CLIMDEX[32].

1. Warm days - TX90p: occurrence of summer maximum temperature > 90p
    a. Measures 90th percentile temperatures relative to each day of the summer (June-Aug.)
2. Very wet day precipitation - R95pTOT: annual total precipitation when > 95p
3. Extremely wet day precipitation - R99pTOT: annual total precipitation when > 99p
    a. Measures amount of rain when daily precipitation exceeds the 95th (R95pTOT) and 99th percentile of all rain days.
4. Heaviest precipitation day - RX1day: annual average of monthly maximum 1-day precipitation.
5. Heaviest 5-day precipitation - RX5day: annual average of monthly maximum consecutive 5-day precipitation
    a. Measures the maximum precipitation during a single day or 5 consecutive day period. Each month is computed separately and the annual average of all months is reported.

Table 16: Summary of projected changes for regional averages of CLIMDEX indices of extremes in Metro Vancouver. TX90p is for the summer (June-July-August) season and the other variables are annual.

GCM-RCM	TX90p (ratio)	R95pTOT (%)	R99pTOT (%)	RX1day (%)	RX5day (%)
cgcm3-crcm	2.0	32	70	14	8
cgcm3-rcm3	2.2	22	20	8	5
cgcm3-wrfg	1.8	43	92	15	13

[32] (Klein Tank et al. 2009)

ccsm-crcm	2.7	7	-17	-2	-2
ccsm-mm5i	2.0	15	28	1	2
ccsm-wrfg	2.0	31	57	5	2
hadcm3-hrm3	3.0	14	-3	3	0
gfdl-rcm3	1.9	2	-23	0	3
average	2.2	21	28	5	4

Return Periods:
The return periods correspond to the maximum or minimum events so rare that they are expected to occur only once every 5, 10, or 25 years on average. These may also be interpreted as the events with a 20%, 10%, and 4% chance of occurring each year, respectively. The following changes show the projected change in return periods expressed as a ratio of frequency of occurrence in the past. For example, an average ratio of 2 for a 25 year return period would mean that we expect an event that only occurred once every 25 years in the past is expected to occur twice as frequently by 2050.

Table 17: Summary of projected regional median change in future frequency of occurrence of historical 5, 10, and 25-year daily temperature **return period events, expressed as a ratio of frequency of occurrence in past for Metro Vancouver.**

GCM-RCM	Lower bound			Return period			Upper Bound		
	5	10	25	5	10	25	5	10	25
cgcm3-crcm	0.4	0.3	<.1	2.2	1.9	0.8	2.2	1.9	2.5
cgcm3-rcm3	0.4	0.2	<.1	2.8	3.0	2.5	2.8	3.0	3.3
cgcm3-wrfg	0.4	0.1	<.1	0.9	0.9	1.3	1.7	2.2	3.2
ccsm-crcm	0.2	0.1	<.1	3.1	4.4	6.4	3.1	4.4	6.4
ccsm-mm5i	0.2	<.1	<.1	2.2	1.7	1.0	2.2	1.8	2.9
ccsm-wrfg	0.3	0.2	<.1	2.1	1.8	0.3	2.1	2.0	2.6
hadcm3-hrm3	0.1	<.1	<.1	3.3	4.8	6.9	3.3	4.8	6.9
gfdl-rcm3	0.3	0.1	<.1	2.9	4.2	6.4	2.9	4.2	6.4
average	0.3	0.1	<.1	2.4	2.8	3.2	2.5	3.0	4.3

Table 18: Summary of projected regional median change in future frequency of occurrence of historical 5, 10, and 25-year daily precipitation **return period events, expressed as a ratio of frequency of occurrence in past for Metro Vancouver.**

GCM-RCM	Lower bound			Return period			Upper Bound		
	5	10	25	5	10	25	5	10	25
cgcm3-crcm	0.6	0.1	<.1	2.3	2.5	2.3	2.3	2.5	2.9
cgcm3-rcm3	0.8	0.6	0.3	1.0	0.9	0.5	1.1	1.3	1.7
cgcm3-wrfg	0.8	0.6	0.2	2.8	3.7	4.9	2.8	3.7	4.9
ccsm-crcm	0.7	0.5	0.1	0.7	0.5	0.2	1.2	1.2	1.4
ccsm-mm5i	0.7	0.3	<.1	1.5	1.9	2.4	1.6	1.9	2.4
ccsm-wrfg	0.7	0.2	<.1	2.2	3.0	4.6	2.2	3.0	4.6
hadcm3-hrm3	0.3	0.2	0.2	0.8	1.3	2.4	1.4	2.1	3.9
gfdl-rcm3	0.7	0.4	<.1	1.1	1.6	3.0	1.2	1.6	3.0

average	0.7	0.4	0.1	1.6	1.9	2.5	1.7	2.2	3.1

Table 19: Summary of projected regional median change in future frequency of occurrence of historical 5, 10, and 25-year 3-hourly precipitation **return period events, expressed as a ratio of frequency of occurrence in past for Metro Vancouver.**

GCM-RCM	Lower bound			Return period			Upper Bound		
	5	10	25	5	10	25	5	10	25
cgcm3-crcm	0.8	0.4	<.1	1.9	2.4	3.5	2.2	3.1	4.8
cgcm3-rcm3	0.6	0.2	0.2	2.1	2.5	2.5	2.1	2.5	3.3
cgcm3-wrfg	0.7	0.3	<.1	2.9	3.3	2.9	2.9	3.3	2.9
ccsm-crcm	0.9	0.6	0.2	2.9	4.8	9.3	2.9	4.8	9.3
ccsm-mm5i	0.6	0.3	<.1	2.5	3.2	4.4	2.6	3.2	4.4
ccsm-wrfg	0.6	0.2	0.2	4.2	7.1	15.	4.2	7.1	15.
hadcm3-hrm3	0.6	0.1	0.1	2.2	2.9	4.6	2.2	2.9	4.6
gfdl-rcm3	0.9	0.7	0.5	1.6	1.6	1.0	1.6	1.6	1.7
average	0.7	0.4	0.2	2.5	3.5	5.5	2.6	3.6	5.8

Table 20: Summary of projected regional median change in future frequency of occurrence of historical 5, 10, and 25-year 3-hourly wind speed **return period events, expressed as a ratio of frequency of occurrence in past for Metro Vancouver**.

GCM-RCM	Lower bound			Return period			Upper Bound		
	5	10	25	5	10	25	5	10	25
cgcm3-crcm	0.3	0.1	<.1	1.9	2.2	2.6	1.9	2.2	2.8
cgcm3-rcm3	0.1	<.1	<.1	0.7	1.0	1.9	2.3	3.2	6.1
cgcm3-wrfg	<.1	<.1	<.1	<.1	<.1	<.1	1.6	1.9	3.0
ccsm-crcm	0.3	0.2	<.1	2.1	2.7	3.3	2.1	2.7	3.3
ccsm-mm5i	0.4	0.2	<.1	0.5	0.3	0.2	1.6	2.0	2.9
ccsm-wrfg	<.1	<.1	<.1	<.1	<.1	<.1	1.8	2.2	2.7
hadcm3-hrm3	0.3	0.2	<.1	0.5	0.3	<.1	1.8	1.9	2.7
gfdl-rcm3	0.3	<.1	<.1	0.7	0.6	0.5	2.3	2.9	3.1
average	0.2	0.1	<.1	0.8	0.9	1.1	1.9	2.4	3.3

Appendix D – Adaptation Challenges and Responses

Knowledge about future climate –particularly local impacts of global climate change trends –is incomplete. Given the timelines for planning and implementing change, and the understanding that being proactive will yield benefits and alleviate future costs, decision makers will have no option but to make policy and investment choices under uncertainty. The following are examples of some of the adaptation planning challenges and recognized options for responding to them.

Challenge	Tools / Responses
Uncertainty: There are various sources of uncertainty in the information we rely on to plan for climate change including: - the uncertainty introduced as models attempt to model natural processes - unknown socio-economic changes that will influence our vulnerability through time. - how future impacts will relate to each other and compound each other. **Data availability:** data inputs traditionally used for planning at the municipal scale may not be available. - gaps in knowledge at the scale of precise local impacts - models work best with long-term trends over large areas. **Timelines:** Decision 'lifetimes' interact with the nature and timing of the climate change variable to which the decision is sensitive. For example, a new building has a short lead-time in terms of design and permitting but long consequences meaning it will experience a significant degree of climate change. **Choosing Actions**: When choosing between adaptation investments decision-makers face a bewildering array of potential adaptation measures, each with its own costs and benefits, often requiring phased implementation. Traditional business case templates may not apply.	**Low regret actions:** Measures that provide benefits under current climate and a range of future climate change scenarios. Many of these low-regrets strategies produce ***co-benefits***, in that they address other City goals such as mitigation, sustainability, human well-being etc. **Robust decision making approaches.** Identify decisions that are robust across the range of future possibilities, even if they are not precisely optimal for any and may be more costly to implement. **Flexible Design**: Build for conditions now or for the next few decades but ensure designs show cost effective modifications for future conditions. **Flexible decision pathways:** Identify a wide range of options suitable for different extents of change over timeframes. Recognize that we may require an incremental approach for pragmatic reasons (interaction with existing infrastructure) with the opportunity to learn and re-orient as the future unfolds. **Nested decisions:** Incremental and short term decisions will need to be embedded within longer-term plans with key decision points or signposts identified for reappraisal over time. **Adaptive management**: Adaptation efforts

	benefit form an iterative or adaptive management approach due to the complexity, uncertainties and long time frame associated with climate change. **Scenario Planning:** Combinations of structured decision-making with scenario planning for different future socio-economic and climate realities can prove useful for strategic decision-making. **Vulnerability and Risk assessments**: Assessments help prioritize impacts. **Risk Management Approaches**: traditional risk management approaches from the natural hazard field provide frameworks for action synthesis.

A recent global survey on urban adaptation challenges found the following trend.
"In general, cities throughout the world report that they are having difficulty obtaining financial resources, allocating staff time, communicating the nature of the program, generating interest among political officials and business, mainstreaming, and gaining the commitment of local elected officials and government departments. Two additional global trends are that most cities believe their national governments have limited understanding of the challenges they are facing, and most have limited access to financial support from local, regional, national, and international sources."[33]

[33] Carmin, JoAnn, Nikhil Nadkarni, and Christopher Rhie. 2012. Progress and Challenges in Urban Climate Adaptation Planning: Results of a Global Survey. Cambridge, MA: MIT.

Appendix E - Potential Adaptation Indicators

Objective 1.1: Minimize rainfall related flooding and associated consequences.
Potential Indicators:

- Number and or cost of insurance claims related to water incurred loses.
- Number of combined sewer overflows
- Percentage of permeable ground to total ground coverage

Objective 2.1: Increase the resilience of Vancouver's infrastructure and assets to coastal flooding and erosion.
Potential Indicators:

- Percentage of the population in unprotected coastal flood prone areas
- Value of City assets in unprotected coastal flood prone areas
- Changes to salinity of groundwater

Objective 3.2: Increase Vancouver's capacity to respond to extreme weather events and recover effectively.
Potential Indicators:

- Total losses (in dollars) due to weather-related events incurred by the municipality.
- Number of times the EOC is triggered for weather-related events
- Proportion of key municipal facilities with back-up power sufficient to remain functional over and above life safety requirements.

Objective 3.1: Reduce safety and health risks for the homeless and low-income population due to inclement weather.

- Proportion of excess shelter beds during extreme weather
- Number of times extreme weather shelters are triggered annually
- Number of cases of mould reported in online rental database

Objective 4.1: **Minimize morbidity and mortality during heat waves.**

- Heat related hospitalizations / mortalities
- Capacity of cooling centers
- Average distance to cooling centres from known hot spots / vulnerable population location
- Average temperature at assigned community hotspots
- Proportion of shade coverage (canopy cover)
- Number of new fountains in known hotspots

Objective 4.2: Minimize per capita water consumption

- Water usage per capita
- Number of new grey water usage initiatives

Objective 5.1: **Increase resilience of the built environment to future climate conditions**

- Proportion of building permits issues that have LEED certificiation
- Proportion of buildings with green or cool roofs

Objective 5.2: **Increase the long-term health and vigour of urban forests, green spaces and trees.**

- Tree canopy coverage / total terrestrial area of the City of Vancouver
- Average increase/decrease in green space and trees (GCAP)
- Proximity of residents on average to natural areas (GCAP)

Objective 6.1: **Incorporate adaptation considerations in City business**

- Number of climate-related public-private partnerships
- Number of adaptation projects or actions implemented per year
- Number of staff aware of climate projections