Climate Change Adaptation Strategy

2018 Update and Action Plan

11/6/2018
City of Vancouver
Sustainability Group

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Executive Summary

This is the second iteration of the nationally leading Climate Change Adaptation Strategy that aims to prepare Vancouver for a new normal in terms of climate. Proactively planning for change allows for a greater variety of implementation options, harnessing windows of opportunity and lower costs.

The October, 2018 Intergovernmental Panel on Climate Change (IPCC) special report[1] stated that "Limiting global warming to 1.5°C would require rapid, far-reaching and unprecedented changes in all aspects of society…" Mitigation efforts (such as those in the Renewable City Action Plan) are more important than ever to limit the extent of climate change we experience. At the same time, the imperative to prepare for current and anticipated changes and to expect the unexpected continues to increase.

The impacts of a changing climate are being observed globally and locally. Since development of the first Adaptation Strategy in 2011, Vancouverites have experienced extreme rainfall causing street flooding, king tide storm surge flooding causing coastline areas like Kitsilano Pool to flood, longer dry spells in the summer, hotter summer weather, tree die-offs, and increasing incidence of air quality issues due to wildfires outside the region.

Projections from global climate models for the 2050s in Vancouver (relative to the baseline time period 1971-2000) signal a worsening of what has been observed: hotter, drier summers; warmer, wetter winters and sea level rise. Extreme events such as extreme rain and heatwaves are anticipated to increase in frequency and intensity, the growing season will become extended and streamflow will change in peak flow timing and volume.

These projections translate to a range of impacts such as: increased risk of health and safety impacts for frontline communities including people in lower quality housing, isolated seniors and the homeless population; new and existing buildings being maladapted in terms of thermal comfort, water ingress, durability etc.; increased loss of trees and vegetation; and increased street, property and shoreline flooding. Limited benefits are expected such as longer growing seasons and lower winter heating bills.

Strong initial steps have been taken in Vancouver to prepare for the impacts of climate change but continued momentum is needed. The 2012 Climate Change Adaptation Strategy is responsible for driving the implementation of over 50

[1] IPCC, 2018: Global Warming of 1.5°C, an IPCC special report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty.

actions across the city, increasing our preparedness for climate change. Beyond specific Strategy actions, consideration of adaptation to climate change has been incorporated in diverse projects ranging from the technical detail of new wharf designs to climate resilience principles in community plans.

Achievements from the 2012 Strategy include the internationally recognized Coastal Flood Risk Assessment, changes in the way we design and approach drainage, and an Urban Forest Action Plan that targets high temperature and high heat vulnerability neighbourhoods for tree planning.

The 2018 Adaptation Strategy update is based on the same guiding principles and goals as the previous strategy. Guiding principles are:

- Use the best, most up-to date science available (evidence-based)
- Promote flexible and adaptive management approaches that leave a range of future options available. (adaptable)
- Give priority to adaptation strategies that build on existing programs or policies and provide co-benefits with other community priorities. (integrated)
- Collaborate with community partners (relevant and transparent)
- Mainstream adaptation into day-to-day City business (comprehensive)
- Prioritize equitable outcomes – (equitable or fair)

The 2018 Strategy includes a new set of priority and supporting actions and several new focus areas. As the field of adaptation matures, practitioners are recognizing that successful implementation requires enabling factors that reach beyond an action plan. Adaptation is not a one-off effort but requires building the capacity within a given organization and community to continue learning, collaborating and innovating over years. Actions are now split into Core Actions and Enabling Actions. Other focus areas are: better integration with other city work via co-benefits and earlier identification of overlap, and focusing more explicitly on equity.

The Strategy relies on a diversity of existing City and community strategies and plans that aim to improve the overall resilience of the city to shocks and stresses, and to address inequities and systemic vulnerabilities that challenge resilience. Of particular note in this regard is the Resilient Vancouver Strategy under development in 2018. The impacts caused by climate change (dealt with in this Strategy) are one of many types of shocks and stresses Vancouver will face in coming decades. The Resilience Strategy deals with broader resilience-building within the city and works in unison with this Strategy to improve Vancouver's ability to prepare for, respond and recover from shocks and stresses. This Strategy refers often to work underway on the broader Resilient Vancouver front.

The Strategy is composed of 5 core action areas and 17 enabling actions that address adaptation efforts until the next update in 2023. Core actions build on

the work started in 2012 and are divided into five action areas: climate resilient buildings, climate robust infrastructure, vigorous and healthy natural areas, connected and prepared communities and coastline preparedness. In many instances good adaptation work is already planned or underway instigated by a different driver such as sustainability, resilience or risk management.

The table below outlines the Core action areas and where the foci are. Those categorized as 'enhance planned action' have had good success over the last 6 years and have many actions planned that support adaptation. New action needed denotes that these action areas include a fair number of new actions.

Action Area	**Action Category**	**Focus of Attention**
Climate Robust Infrastructure	Enhance planned action	- Improve understanding of water flow in the city and integrate management (Rain City Strategy and Integrated Utility Management Planning). - Increase use of green infrastructure where appropriate - 'Fit for purpose' approach to water end use - Resilient Vancouver Critical Infrastructure project
Climate Resilient Buildings	New action needed	'future proofing' the building stock - New: Building requirements and design options to improve climate resilience - Existing: Upcoming Deep Retrofit Strategy supports co-benefits to enhance resilience - Thermal comfort and hotter summers
Connected and Prepared Communities	New action needed	- Health and safety during heat waves in non-market housing and surrounding neighbourhoods. - Address wildfire smoke events - Support continuation and scaling up of community resilience-building programs such as Resilient Neighbourhoods Pilot Program
Coastal Preparedness	Enhance planned action	- Floodplain development regulations and guidelines - Engagement and design competition - Conceptual design for adaptation approaches for the Fraser River - Study of Climate change impacts to waterfront parks and open spaces.

Healthy and vigorous natural assets	Enhance planned action	- Support implementation of the UFS actions for climate change. - Move UF maintenance from a reactive to a proactive standard of excellence - Soil preservation - Water quality

Introduction

In 2016, the Global Economic Forum rated failure of climate mitigation and adaptation as the highest global risk above water crises and large-scale involuntary migration. A high risk was again evaluated in 2018 with environment-related risks occupying 3 out of the top 5 spots. Street flooding during heavy rains and hot summer days are not new challenges in Vancouver, and we have strategies for responding to them. However, climate change will shift the frequency, intensity, and timing of these events, and what we now consider an extreme event will become the new normal. As well, new impacts are being experienced, such as longer summer dry periods, sea level rise, and poor summer air quality.

The October, 2018 Intergovernmental Panel on Climate Change (IPCC) special report[2] stated that "Limiting global warming to 1.5°C would require rapid, far-reaching and unprecedented changes in all aspects of society…". One of the key messages of the report is that we are already seeing changes such as increased extreme weather, diminishing Arctic sea ice, sea level rise etc., as a result of the 1°C temperature rise over pre-industrial levels. Limiting temperature rise to 1.5°C through climate change mitigation efforts such as energy efficient buildings and low carbon transportation options is more important than ever. Preparing communities for the coming changes in climate, especially those communities that are predisposed to greater impacts due to systemic vulnerabilities and inequities (frontline communities) has also become more imperative.

Vancouver's Greenest City Action Plan and Renewable City Action Plan are two examples of initiatives working to reduce the city's contribution to global climate change. These initiatives will change how we build, heat, and power buildings, as well as change how we get around. These actions will reduce our GHGs. The Renewable City Action Plan targets a transition to 100% renewable energy and an 80% reduction in carbon pollution by 2050. Regardless of our excellent work on climate change mitigation, globally we are locked in to a certain extent of climate change already. The Intergovernmental Panel on Climate Change's (IPCC) most optimistic future emissions scenario only has us leveling out to current concentrations by 2100. The scenario felt to best represent business as usual shows extreme increases in GHG concentrations associated with major changes to the climate.

The City of Vancouver formalized a plan to prepare and adapt to climate change in the Climate Change Adaptation Strategy adopted by City Council in 2012. The Strategy vision focuses on a livable and prosperous city in the face of increasing

[2] IPCC, 2018: Global Warming of 1.5°C, an IPCC special report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty.

climate disruptions and stresses. All nine priority actions are underway or completed and most supporting actions have been initiated and are ongoing or are complete.

Continuous learning and re-navigation is essential for adaptation planning given the underpinning of uncertainty and extended time lines prevalent with many climate drivers and impacts. What follows is an update to the 2012 Climate Change Adaptation Strategy based on new climate science, advances the City of Vancouver has made to date, a changing policy landscape at many scales, and best practices applied in peer cities. The refreshed Strategy includes a new action plan with actions to be initiated between 2018 and the next refresh in 2023.

In Vancouver - since the last iteration of the Strategy - we have experienced king tide flooding, heavy rainfall related street flooding and drier than normal summers with consistent air pollution advisories due to forest fires burning outside the region. On the positive side, adaptation is now being implemented by cities and partners around the region, including Metro Vancouver.

Compared to the state of practice in 2011 when the first plan was developed, climate change adaptation planning is now well established at the local government level. Surveys of both Canadian[3] and American[4] government adaptation practitioners as well as the recent Auditor General's report on BC's climate adaptation progress, report that while plans and methods abound, more 'doing' and capacity building is the necessary next step. These assessments include recommendations such as taking an integrated approach and mainstreaming adaptation into existing tools and planning. Successful adaptation also requires governments to establish a continuous learning and implementing cycle and governance that supports good mainstreaming and integration.

This Adaptation Strategy focuses on both the direct actions that will improve the climate resilience of city infrastructure, buildings, green spaces and communities but also on the actions required to build capacity and enable continued integration of adaptation into daily business and decision-making. In other words - not just the "what" but also the "how" – institutionalizing the capacity to do adaptation planning.

[3] [1] Adams, S. et. al. 2016. Regional Governance for Climate Action. Institute for Sustainable Communities. [2] http://icleicanada.org/images/Making_Strides_on_Community_Adaptation_Final.pdf [3]
[4] Vogel, J. et. Al. 2016. Climate Adaptation The State of Practice in U.S. Communities. The Kresge Foundation [4] http://www.bcauditor.com/pubs/2018/managing-climate-change-risks-independent-audit

Changes since 2012

Vancouver's Climate Context

Since the first Adaptation Strategy was adopted in 2012, Vancouver has experienced several climate-related shocks and numerous stresses. A few examples include:

- In December 2012 a 1 in 50 year return period storm coincided with one of the highest tides of the year (King Tide). Rare flooding occurred along the coastline including seawater inundating Kitsilano Pool and the Jericho Sailing Centre. The levels reached by the water during this flood event are a foreshadowing of where every day high tide levels may be in the future with sea level rise.
- On July 5th, 2015, very high levels of fine particles were measured in Metro Vancouver air due to smoke from wildfires outside the region. Fine particulate matter reached 300ug/m^3. Normal levels are less than 15ug/m^3. In total, wildfire smoke degraded air quality for 8 days during the summer of 2015. Again in the summer of 2017, wildfire smoke and hot weather resulted in an unprecedented total of 19 days of advisories in Metro Vancouver including the longest continuous advisory since the advisory system started in the 1970s. The BC Centre for Disease Control (BCCDC) collected data illustrating some of the health impacts associated with increased air pollution. Daily doctor visits for asthma and prescriptions filled for Ventolin (asthma relief medication) increased to far above average numbers coincidental with the poor air quality days. In August of 2018, wildfires in B.C. again blanketed the lower mainland in smoke with significant health impacts reported among populations more sensitive to heat impacts.
- Drought predominated 3 of the last 4 summers. 2015 was the most significant drought of recent memory with very dry and extremely dry conditions on the South Coast between the end of June and end of August. In 2017 we experienced a delayed drought from the beginning of August to mid-October and in 2018 very dry conditions prevailed between the end of July and beginning of September.
- On August 29th, 2015 a rain and windstorm caused the single largest power outage in BC Hydro's history affecting half of their customers. Power remained out for several days for many residents of Metro Vancouver.
- Social and non-market housing operators in the lower mainland, including the City of Vancouver, are reporting increasing thermal comfort complaints from overheating in buildings. In response, a collective effort lead by BC Housing is underway to revisit heat preparedness and develop a response in areas exposed to high urban heat island effect (UHIE) and housing high percentages of populations more sensitive to heat impacts.

Local Climate Change Projections

The IPCC released new Representative Concentration Pathways (RCPs) in 2013. The IPCC RCPs describe four future scenarios for greenhouse gas emissions for the purposes of application in climate research and modeling.

Pacific Climate Impacts Consortium (PCIC) at the University of Victoria downscaled climate data for Vancouver using 12 climate models. The projected changes illustrate the difference between the 2041 to 2070 (2050s) time range and the baseline time range (1971-2000) based on the average of all 12 climate models. The models followed the IPCC emissions scenario RCP8.5 – internationally recognized as the "business as usual" greenhouse gas emissions scenario. Recent commitments, including the 2015 COP21 Paris Agreement correspond with the RCP 2.6 scenario. This scenario requires substantial and sustained reductions of GHG emissions that we are not yet seeing (extensive adoption of biofuels and vegetarianism along with carbon capture and storage). It is prudent to plan for RCP8.5 until global mitigation actions begin to catch up with commitments.

In the future, Vancouver is likely to experience ongoing changes to its climate including an annual average increase in temperature totaling a 2.9°C increase by the 2050's, and a higher intensity and frequency of extreme events. Unfortunately the projections continue to worsen –compared to the projections used in the 2012 Strategy, the annual average temperature by the 2050's is a degree higher and the extremes are projected to be even more extreme.

- **Hotter, Drier summers**: It is anticipated that there will be more than a doubling in the summer days above 25°C to about 43 days per year in the 2050's. Days above 30°C that happen once a year now will happen 12 times per year. The hottest days will be about 4°C hotter. Summers will have an average 19% decrease in precipitation and 23% increase in consecutive dry days. Summer temperatures are expected to drive greater cooling requirements to 250 degree days per year by 2050 which is, for example, about 25% more than Portland, Oregon's historical average.

- **Warmer, wetter winters**: The 2050's will see a modest increase in winter precipitation with the largest increase of 12% coming in the fall. However, extreme rainfall events are expected to become increasingly common and intense with 33% more rain on very wet days and 63% more rain on extremely wet days. Rare rain events that occur an average of 1 in every 20 years now are projected to increase in intensity by 36%. The coldest winter nights will become almost 5 degrees warmer. For our region's water supply watersheds as a whole, the April 1st snowpack is projected to decrease by 58%.

- **Sea Level Rise**: Projections for sea level rise vary widely after the year 2050 from 60cm over current levels to more than 6m over current levels. The Province of BC currently recommends using 0.5m for planning to 2050, 1m to 2100 and 2m to 2200. The provincial recommendations are expected to be updated in 2022 based on the most current IPCC report.

Review of Impacts

The table below provides a reminder of some of the anticipated impacts Vancouver may face as a result of the projected climate changes discussed above.

Table 1. Examples of climate change impacts to the city of Vancouver

	Hotter, Drier Summers (incl higher frequency and intensity of heat waves)	**Warmer, wetter winters (incl. higher frequency and intensity of rain and storms)**	**Sea Level Rise**
Human systems (community)	- Increased health and safety risks, especially to frontline communities during extreme heat events and air quality events - Water supply shortages felt in late summer due to a decreased spring snow pack and higher summer temps could result in increased costs for water and imperative conservation measures - Decreased thermal comfort in buildings in the summer due to lack of air conditioning or increasing electricity costs with air conditioning	- Increased health and safety risks for frontline communities including those in lower quality housing, homeless population and seniors - Increases in private property sewer back-ups in combined sewer areas due to high rainfall volume in sewer system - Increased costs for response actions and clean-up after heavy rain events - *Reduced energy use to heat buildings	- Increased flooding along the Coast and Fraser River as sea level rises and the storm surge and waves breach height of land - Gradual inundation of low lying land along the coast and the Fraser River. - Increasing costs of flood insurance where available for floodplain areas.
Natural Systems	- Increased tree loss, especially newly planted trees due to drought. - Changing invasive plants and pests affecting existing ecosystems and the services they provide. - Water quality affected by temperature and increased combined sewer overflow from heavy rain events.	- 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	- Increase in shoreline erosion affecting natural environment and public amenities such as parks, trails and access to the water - Shoreline habitat squeeze resulting from rising water and hard infrastructure solutions (dikes)
Built Environment (Buildings and Infrastructure)	- New and existing buildings may be maladapted as the climate changes in terms of thermal comfort, water ingress, wind durability, rain on snow loads, etc. - Increasing stress on green infrastructure in the summer time	- increased duration and occurrence of power outages causing cascading impacts - Increased surface water flooding from ponding of rainfall in low lying areas or heavy rainfall overcoming the capacity of drainage system - Increase in landslide risk affecting public infrastructure and private property - Increased volume of third party liability claims against the city from major rain events	- Increased damage to structures (seawalls) and shoreline resulting in greater discontinuity of use - Reduced gravity drainage of the existing drainage system, resulting in more frequent - Saltwater intrusion in built up areas affecting the longevity of underground infrastructure and pump stations

Changing Policy Landscape

Vancouver's 2012 Climate Change Adaptation Strategy was an internationally recognized forerunner in municipal adaptation. In six years, the landscape has quickly evolved to one in which adaptation is increasingly a focus of all levels of government. Related changes have also been initiated in the Canadian insurance industry and municipal bond market.

Internationally, the Paris Agreement, signed in 2015, strengthened the adaptation pillar of climate change calling for stronger adaptation commitments from governments and transparent mechanisms to assess adaptation progress. The UN Sustainable Development Goals, 2015, include taking urgent action to combat *climate change and its impacts*. The 2017 UN New Urban Agenda which directs efforts around urbanization for a wide range of actors also includes measures to increase climate change adaptation efforts.

The Pan-Canadian Framework on Clean Growth and Climate Change was developed in 2015 with a focus on resilient infrastructure; building design and development; health impacts from climate change; and areas particularly vulnerable to climate change such as the coasts. The objective of the Framework is to help Canadians understand the impacts climate change has on their quality of life and assist them to develop the necessary tools to adapt effectively.

The BC Government published the BC Climate Leadership Plan in 2016 which included mandating 10 year adaptation plans for public sector operations and supporting more resilient infrastructure. In 2018 the Auditor General's report on BC's adaptation efforts was released with a failing grade and strong recommendations for supporting local government adaptation efforts. The three biggest climate hazards for BC were identified as flood, wildfire and drought.

Metro Vancouver is developing a Climate 2050 Strategic Plan (summer 2018) that sets out a 30 year vision and goals for Metro Vancouver's climate policy and actions. The 'issues area roadmap' includes three issue areas relating to adapting to climate change: Nature and Ecosystems; Infrastructure; and Health, Safety and Emergency Management. Land use, growth management, and agriculture cut across mitigation and adaptation themes.

The Insurance Industry in Canada has not historically issued residential overland flood insurance – flooding from extreme rainfall, or a river or ocean flooding dry land. Sewer back-ups have generally been covered. With heavier rainfall, changing freshet timing, and sea level rise, the insurance industry has recently started issuing flood insurance. As this field matures, it can be expected to have far reaching implications for adaptation actions.

Mark Carney, chair of the Financial Stability Board (an international body that monitors and makes recommendations on the global financial system), established the Task Force on Climate-related Financial Disclosure in 2015. With Michael Bloomberg at the helm, the task force is gaining momentum internationally with a dialogue on how to make smart financial decisions given risks of both climate change and a transition to a low carbon world.

In Vancouver

Vancouver is recognized internationally for efforts in sustainability implemented through the Greenest City Action Plan (GCAP) and for climate action (both adaptation and mitigation). The City's next step – the Renewable City Strategy - outlines the path to reach the city's ambitious target to reduce greenhouse gas emissions by at least 80% below 2007 levels before 2050 and derive 100% of energy used in Vancouver from renewable sources before 2050.

This Adaptation Strategy specifically addresses how the City can better offer services, build and maintain infrastructure, and design programs and policies that take advantage of, or prepare for, high risk anticipated climate impacts. The Strategy relies on a diversity of existing City and community strategies and plans that aim to improve the overall resilience of the community to shocks and stresses, and to address inequities and systemic vulnerabilities that challenge resilience.

Of particular note is that Vancouver joined the 100Resilient Cities program in 2016. A Chief Resilience Officer was hired and is in the process of creating a Resilient Vancouver Strategy. The shocks and stresses caused by climate change (dealt with in this document) are one of many types of shocks and stresses Vancouver will face in coming decades. The Resilient Vancouver Strategy deals with broader resilience-building within the City and community and works in unison with this Strategy to improve Vancouver's ability to prepare for, respond and recover from hazards/shocks. The Adaptation Strategy is intrinsically linked to a web of programs and plans that exist or are under development. Governance supporting institutionalization of climate change adaptation will ensure it is embedded as a foundational consideration, integrated across plans.

Figure 1. Example of the integration of various Vancouver Plans and Programs (by Kari Dow)

Guiding Principles

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, most up-to date science available (evidence-based)
- Promote flexible and adaptive management approaches that leave a range of future options available. (adaptable)
- Give priority to adaptation strategies that build on existing programs or policies and provide co-benefits with other community priorities. (integrated)
- Collaborate with community partners (relevant and transparent)
- Mainstream adaptation into day-to-day City business (comprehensive)
- Prioritize equitable outcomes – (equitable or fair)

Goals:

Development and implementation of this strategy will:

- Integrate a climate change adaptation lens into local policies, strategies and planning
- Improve climate resilience of built systems, natural systems and human systems.
- Improve awareness, knowledge, skills and resources of City staff – enhancing capacity for transformative change.

- Enhance opportunities for coordination and cooperation through the development of networks and partnerships.

Objectives:

- Maximize climate resilience of infrastructure and buildings
- With a focus on equity, minimize the health and safety impacts of climate change on communities and maximize their preparedness
- Maximize the health and vigour of natural systems in the face of climate change
- Develop shoreline resilience to sea level rise and storm surge
- Maximize enabling factors within the organization that build adaptive capacity.

Achievements (But There Is More to Do)

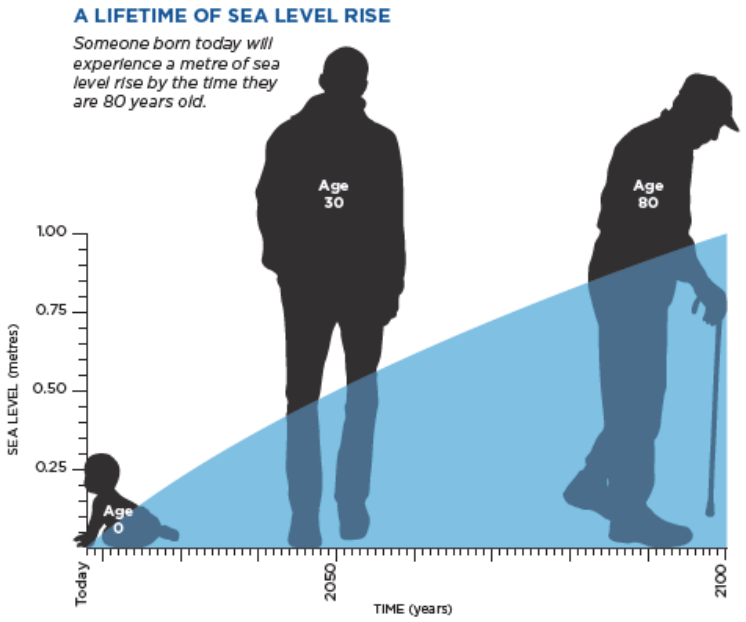
Strong initial steps have been taken in Vancouver to prepare for the impacts of climate change but continued momentum is needed. In 2012 we prioritized action on over 20 impacts through a vulnerability and risk assessment. The impacts can be simplified as follows: impacts from flooding (from rain, river and storm surge), heatwaves, drought and storms on Vancouverites health and safety; the capacity of communities and the City to respond and recover; the economy; and the built and natural environments (see Table 1). The current review showed that the same high risk climate change impacts apply to Vancouver with the addition of air quality concerns during the summer.

The Adaptation Strategy will continue to be a living document updated regularly to ensure actions are appropriate to the dynamic context of evolving science, a growing city, shifting practices and changing risk and vulnerability profiles.

The 2012 Adaptation Strategy is responsible for, or became the main driver of, the implementation of over 50 actions across the city, increasing our preparedness for climate change. Beyond specific Strategy actions, consideration of adaptation to climate change has been incorporated in diverse projects ranging from the technical detail of new wharf designs to climate resilience principles in community plans. Slowly but steadily over the last six years, the knowledge and capacity to include adaptation in day to day work (mainstreaming) is increasing, but there is still far more we can do.

Some highlights of our progress to date:

Coastal flood risk assessment (CFRA)



Vancouver is not alone in facing the challenge of sea level rise and coastal flooding. According to the United Nations, about 40% of the world's population lives within 100 kilometres of the coast today. As a result, coastal cities and communities all over the world are increasingly vulnerable to flooding and shoreline erosion.

Vancouver's sea level rise program, a first program of its kind in Canada, is a multi-phase undertaking to determine the risk and vulnerability of Vancouver to future sea level rise and storm surge scenarios. Trying to anticipate the hazards of future flooding is a complex and technically challenging undertaking. Our sea level rise program first modelled different sea level rise scenarios with a corresponding range of potential storm surge events (i.e., different intensities of storms) for different periods in the future. This work helped us to better understand our flood risks and associated vulnerabilities.

The Fraser River shoreline, which runs from Boundary Road in the east to Musqueam in the west, was identified as the most vulnerable area. Low lying areas around Jericho and Locarno beaches followed, along with some areas in the Port of Vancouver, which are under the jurisdiction of Port Metro Vancouver.

In the next phase of our sea level rise work, a variety of potential solutions, or adaptation options, were investigated at a high level for each of the flood hazard zones.

Future project phases will start rolling out in 2018/2019, and will refine emerging options with the public and local communities, experts and staff. This work will be undertaken through a design challenge process focused on the Fraser River shoreline and False Creek, as the two largest flood-vulnerable areas in the City. There will be multiple opportunities for the public to shape this work. Although the timelines might appear long, Vancouver is taking action now on a number of

fronts through community planning, capital planning, and City operations and maintenance work. This includes:

- Incorporating flood-resilient design standards into the Vancouver Building By-law for flood hazard areas
- Regulating sub-division and development in at-risk areas to avoid increasing coastal flooding vulnerability
- Minimizing the construction of City-owned critical infrastructure in at-risk areas
- Raising the physical height of City utilities (e.g., roads, water, sewer) during regularly planned infrastructure renewal projects

Rainwater Management

Vancouver is known for its rainfall. The 2012 Strategy prioritized developing a citywide Integrated Rainwater Management Plan (IRMP) with an adaptation lens. This initial work snowballed into changes in sewers design and the creation of a new “Green Infrastructure” team with additional staff working on a Rain City Strategy to better align grey and green drainage infrastructure and increase the implementation of green infrastructure.

- An example of a joint initiative between Planning, Engineering and the Park Board is the enhanced boulevard and public space treatment for 63rd Avenue and Yukon Street. The boulevard on 63rd Avenue and Yukon Street was identified in the Marpole Community Plan as an opportunity to increase access to green space, enhance rainwater management, and improve neighbourhood amenities. The project is capturing, cleaning and infiltrating rainwater from the surrounding streets, showcasing new trees, rain gardens,

new sidewalks, seating plazas, bike racks, and a drinking water fountain. As part of this project, City staff are developing new design standards for rainwater inlets, bio-retention planting palettes and internal, inter-departmental processes for the design process. The project will construct engineered rain gardens that will receive water from a large area of the adjacent street and allow it to recharge the local groundwater.

- Vancouver was one of the first municipalities to integrate climate change projections into the intensity, duration, frequency (IDF) curves used to appropriately design and size stormwater management systems. The standard available curves are based on historical data while systems built today will experience quite different precipitation patterns including increased frequency and intensity of heavy rainfall. Vancouver's curves were both updated to reflect current data but also future-cast to take into account precipitation projections to the 2050s and beyond.

- Adopt a catch basin: In October, 2017 Vancouver launched an Adopt a Catch Basin Program to empower Vancouver residents to adopt and name one or more of the City's 45,000 catch basins and keep it free of leaves, debris and litter. The goal of 1000 adoptions was achieved within 3 weeks with a current count of over 600 volunteers. Phase 2 will be launched in September, 2018 with great ambitions; the goal is to reach 5000 adoptions by December 31st, 2018. The key message of the program is to help protect the environment and minimize flooding to support a healthy, vibrant and clean Vancouver. A lighthearted naming contest engaged the public and resulted in winning names: Draino McDrainface, Drain Wetsky, and Make Vancouver Grate Again.

Urban Forest Strategy and Equity

Another priority action of the 2012 Adaptation Strategy was the development and implementation of the Urban Forest Strategy (UFS). The initial Strategy was presented to Council in 2014 with an action plan endorsed in May, 2018. The plan includes a range of actions to improve the urban heat island effect and ensure appropriate robust plantings and preventative maintenance recognizing climate impacts.

- An early quick start of the UFS was a change to the Protection of Trees Bylaw extending conditions where permits are required for tree removal on private property. This was an important action in support of increasing city-wide canopy cover.
- A good example of an equitable solution is the action plan's target neighbourhoods for doubling tree density. Health Canada funded a project by SFU to identify where high population vulnerability to heat intersects with areas of high surface and air temperatures. Three neighbourhoods were identified for priority tree planting – those with low tree density, high heat and high vulnerability to heat.

Building on Our Approach - New Focus

Enabling Actions

The 2012 Climate Adaptation Strategy focused on applying climate science to understand what the local high-risk impacts were, and what actions the City could take to begin to prepare for and/or mitigate the risk. The focus was on what we could do. As the field of adaptation matures, practitioners are recognizing that successful implementation requires enabling factors that reach beyond an action plan. Adaptation is not a one-off effort but requires building the capacity within a given organization and community to continue learning, collaborating and innovating over years. It is necessary to focus on" how" we do things to ensure that the "what" is meaningful and systems-oriented.

Changing the way we do things can take time and occur on a variety of non-linear pathways. Climate adaptation is relatively new to municipalities and even more novel to other organizations. City staff involved in developing the Adaptation Strategy described successful adaptation as when the word "adaptation" is obsolete and climate-related shocks and stresses are a normal day-to-day consideration across government and community.

The adaptation community is increasingly referring to transformational adaptation versus incremental adaptation given the current lackluster movement on the global climate change mitigation front. The 2012 Strategy included many incremental actions (doing things better with existing logic) such as choosing different tree species to plant or continuing to separate the sewer system. Bridging to more transformational adaptation requires reframing problems and practices to understand them from a new or different perspective. For example, reconsidering the coastline as potentially hazardous or using a fit-for-use lens in water supply management.

A clear example of moving from incremental to transformational adaptation is poised to take place in Vancouver as we move from traditional grey infrastructure solutions to fully integrated grey and green infrastructure combinations, through the Rain City Strategy. This shift requires more than implementing rain gardens and infiltration bulges within the existing drainage system. It necessitates a new way of thinking about, and modeling water flow in the city. New working partnerships, staff capacity and early resources are needed to create the setting for a successful shift.

To move from incremental change to transformational adaptation, foundational or enabling elements include: the capacity for systemic inquiry, leadership, and learning from practice; and governance systems that emphasize integration, flexibility, monitoring, continual learning and knowledge sharing[5] [6]

[5] The International Institute for Sustainable Development and the University of Winnipeg, 2017. Building a Climate Resilient City: Transformational Adaptation.

The diagram below, based on New Zealand and Portland, Oregon's adaptation plans, clearly shows that the core functions of adaptation, "the what"–assessing risk and vulnerability, planning, implementation and evaluation require strong enabling factors. It also shows "the how", such as: information, leadership, building capacity and continual learning. Working on these two areas in parallel will support taking a more integrated, system-wide approach navigating toward more innovative ways of city building.

Integration

Resilience has many different definitions ranging from personal resilience to material resilience. The Rockefeller 100 Resilient Cities program defines resilience as "the capacity of individuals, communities, institutions, businesses, and systems within a city to survive, adapt, and grow no matter what kinds of chronic stresses and acute shocks they experience."

The term "shocks and stresses" is used to encompass both one-off events such as earthquakes and ongoing stressors, such as poverty. While this Strategy focuses on climate-related shocks and stresses, integration with the Resilient Vancouver Strategy (under development as of fall 2018) offers opportunities for co-benefits and synergies that increase City and community resilience in general.

[6] UKCIP: https://www.ukcip.org.uk/

In addition to close integration with the Resilient Vancouver Strategy, low carbon resilience (LCR) must be a focus moving forward. LCR refers to climate change strategies that integrate and achieve co-benefits between carbon pollution reduction (mitigation) and planning designed to reduce vulnerability to climate change impacts (adaptation)"[7].

In Vancouver, planning leads for both functions work together to identify opportunities to achieve low carbon adaptation and to ensure mitigation efforts don't lead to greater climate change risk. Co-beneficial actions such as installing heat pumps for heating and cooling, heat recovery ventilators important for improving energy efficiency and improving indoor air quality, and increasing the health and area of natural assets are prioritized. Through greater coordination and mainstreaming, adaptation and mitigation will become foundational considerations across City work.

Social, economic and environmental sustainability plans and policies are all linked to the vision and guiding principles of this Strategy. Civic decision-making will benefit from increased integration and identification of projects that have 'triple word scores' - that is, contribute toward multiple city goals and values. Wherever possible, core and enabling actions in this Strategy promote work taking place under other 'banners' that contribute to climate resilience. During implementation, all actions should be integrated with other city initiatives where possible. In fall of 2018, interdepartmental staff are working on recommendations to best make this switch to integration.

Equity in Climate Adaptation

While equality is the equal provision of services to all, equity is about providing equal access to opportunity and services or equal possession of basic needs, based on equal outcomes. In the climate change context, being part of a frontline community or equity seeking population should not translate to less resilience to climate change.

Climate change shocks and stresses do not affect all groups in the community equally. Frontline communities, those that have been affected by systemic vulnerabilities and inequities (racialized communities/people of colour, lower income communities, immigrant and refugee communities, people with disabilities and older adults) are often at greater risk from the impacts of climate change and often have the fewest resources to respond. Those with existing health issues, young children and pregnant women can also be at increased risk to extreme events and poor air quality.

[7] ACT, 2016. Low Carbon Resilience: Transformative Climate Change Planning for Canada.

There are many Vancouver strategies that focus on alleviating the underlying conditions that make frontline communities more vulnerable to climate impacts. These are more important than ever to support increased resilience across the community. In this Strategy, there is a focus on actions that reduce risk and enhance resilience for frontline communities. Staff reviewed all recommended actions with an equity lens asking: do they enhance positive action that creates more equitable outcomes by meeting the needs and/or removing barriers, or do they increase or maintain inequitable outcomes. If the latter, what could be done to shift them toward more equitable outcomes?

Adaptation Action Plan

How The Plan Was Refreshed:

In order to review and update the plan, two phases of work were carried out: Review and Gap Analysis, and New Action Planning. The review phase included reviewing best practices in adaptation globally, speaking with international colleagues and identifying areas where we could strengthen our approach. With these gaps in hand, interviews were carried out with staff accountable for implementing the 2012 Strategy actions and with new action area staff. Interviews focused on further development of the gap analysis: actions completed, actions underway or planned, barriers to implementation, and assessment of identified gaps and potential actions to fill them.

The original risk and vulnerability assessment and impact statements were reviewed but not repeated. Action planning occurred across a variety of engagement styles including: a workshop with cross-departmental staff, one on one interviews and meetings with staff, and working with partners such as BC Housing and Vancouver Coastal Health. Actions that are ongoing from 2012 are not listed here.

There are many existing City strategies, plans, programs and policies that include measures of adaptation, support adaptation or require an adaptation lens. In moving toward a more climate resilient, livable and vibrant city it is impossible to consider these as mutually exclusive but rather a network of interrelated initiatives that can be easily integrated where co-benefits exist. In the following section that lists actions, the main initiatives that inform, support and integrate with the adaptation action areas are listed at the top of the section under “Integrate with”.

Core Function Actions

Core function actions are the “what”. They are actions we can take to continue to move toward climate resilient services, infrastructure and neighbourhoods. They are divided into 6 categories: Climate Robust Infrastructure, Climate Resilient buildings, Healthy and Vigorous Natural Areas, Prepared and Connected Communities, and Coastline Preparedness. Priority Actions are presented below with priority and supporting actions found in Appendix A – Compendium of Adaptation Actions.

Climate Robust Infrastructure

Infrastructure designed today will service significantly different conditions during its service life. Given the uncertainty associated with climate change, it makes sense to design infrastructure to be robust and be able to do well across a range of future scenarios. PCIC has clearly shown that even with uncertainty, designing with a range of futures in mind is still closer to future conditions than using historical data. A move toward holistic integrated infrastructure systems planning

that is tied more closely to planning will also enhance overall systems resilience through redundancy and diversity. Asset management must consider new risks.

Integrate with:
Critical Infrastructure Interdependency Analysis (Resilient Vancouver and Risk Management)
Rain City Strategy
Engineering Integrated Utility Planning
Resilient Vancouver Strategy

Specific Objectives:

- Plan infrastructure to be robust across a range of future climate scenarios
- Minimize unintended rainfall related flooding and consequences

Priority Actions:

- Complete integrated modeling of water in the city (pipe system, surface water and groundwater). Prioritize watersheds to be modeled to support city objectives such as Combined Sewer Overflow elimination, Rain City Strategy, growth planning and preliminary watershed assessments. Leverage modeling to complete overland flood route mapping and take an integrated approach to drainage systems including public realm, grey and green rainwater infrastructure systems, coastal flood protection, and parks.

- Complete comprehensive information gathering to support system modeling, catchment prioritization, and early implementation of the most effective, resilient water management actions (Rain City and Integrated Utility Management Planning). Early investment will ensure an option analysis of new approaches to servicing is timely.

- Utilize the piped system, green infrastructure and other rainfall storage strategies to attenuate water from catchments that drain into floodplain areas prone to coastal flooding. The aim is to reduce stormwater draining to low lying areas to mitigate peak flows and total flow volume at the runoff source. This will result in the appropriate timing and investment of stormwater pumping facilities.

- Continue water conservation and efficiency actions; develop regulations to support the use of alternative water sources including groundwater, graywater and blackwater for non-potable demand. The ‘fit for purpose’ approach to water end use will reduce pressure on the regional supply and delivery of treated drinking water.

- Undertake a drainage study for low-lying Southlands area to include an assessment of the existing dike network and pump station and recommend improvements for the drainage system as needed.

- Support the Resilient Vancouver development and implementation of an approach to define and analyze Critical Infrastructure. To: identify priority assets to risk manage, define a criticality framework and approach, and evaluate and test the approach.

Climate Resilient Buildings

Buildings are often one of the main focuses of climate change mitigation action due to their high emissions. New buildings are designed to ever higher energy efficiency goals and seismic standards but we are just starting to consider what design elements increase climate resilience and general resilience for inhabitants. Our aim is to have the correct building stock in the future. This includes consideration of materials and systems but also the climate information used in design, the passive survivability of the building if the power is interrupted, back-up power, and how the building caters to community connections and sheltering in place. Retrofits of existing buildings can provide opportunities for co-beneficial climate adaptation upgrades.

Integrate with:
Green Buildings programs such as Zero Emissions Building Plan
Resilient Buildings – Resilient Vancouver Strategy Staff Working Group (seismic focus)
Renewable City Strategy
MBAR (BC Housing led Mobilizing Climate Adaptation and Resilience in Buildings Design and Renovations in BC)
Hey Neighbour Program

Specific Objectives:

- Design robust built form to do well in a range of climates while providing co-benefits such as seismic resilience, energy efficiency, accessibility, and supporting health and well-being.

Priority Actions*:*

- The upcoming deep retrofit strategy (renewable buildings 2050) supports enhanced built form resilience across the board in a number of important ways: low carbon cooling, improved envelopes and insulation, seismic upgrades, and lowering fire risk as a secondary impact during events as gas is not present in most homes. A potential barrier to improving resilience is the regulatory structure, including requirements and process for existing buildings (i.e. renovations).
    - Adjust requirements and process for existing buildings to support enhancement of resilience.

- Currently various CSA standards related to climate change hazards and buildings are under review for revision including: (electrical code,

fenestration, durability of buildings and new basement flood protection). The National Research Council (NRC) is also developing guidelines for the following: flood risk reduction in existing residential communities, corrosion in a changing climate, building envelope systems in wind driven rain, and a database of building material properties in varying climate conditions. They are also completing a climate load update for the 2020 model national building code.

  - Evaluate and integrate where possible the new standards and guidelines. Adopt the new climate loads into the VBBL when available.

- The Zero Emissions Building Plan requires new large buildings to show they will meet new limits on energy use, heating demand, and emissions. In addition, buildings planned without active cooling must show they meet new limits on overheating, reducing overheating in worst case spaces by 90% or more.
  - New buildings are increasingly being designed with active cooling due to market demand, and many new buildings are being designed using heat pumps to meet the City's emissions limits for new buildings. Heat pumps present an opportunity for all new buildings to provide active cooling at little or no incremental cost while also providing energy efficiency benefits, especially when the size of heating and cooling loads is minimized. The City will explore ways to encourage the use of heat pumps, and to reduce cooling demand, in new construction;
  - City staff will work with industry partners to refine and enhance the limits on overheating, and to develop more detailed guidance for industry, with the objective of maintaining year-round comfort in new buildings;
  - The City's Energy Modelling Guidelines have been updated to reflect recent weather (1984-2014), and staff will work with UBC on the "Designing climate resilient MURBS" project to explore using future projected weather data for building design and modelling. Staff will review the outputs of this project and develop recommendations on using future projections in building policy or by-law;
  - As part of the Zero Emissions Building Plan, staff will explore opportunities to use operational data from recently constructed buildings to inform future updates to building policy or by-law.

- Continue as an active partner in the BC Housing led Mobilizing Climate Adaptation and Resilience in Buildings Design and Renovations in BC (MBAR) project.

  - Building on phase 1 of the project, undertake a study and report on potential building requirements and design options to 'future-proof'

buildings. Include MBAR outputs in improvement of structure and process for existing buildings.

- This project looks at resilience in the face of a wide range of possible shocks, such as mitigating the impacts of wildfires, power outages, heat waves, or other shocks to normal building operations. Staff will review the outputs of this project and develop recommendation for potential updates to building policy or by-law.

Healthy and vigorous natural areas and green space

Our natural systems are garnering increasing focus given the ecosystem services they provide, including a role in climate change adaptation and mitigation. Natural assets can significantly reduce the urban heat island effect and they play a part in reducing stormwater runoff. Natural systems can also be used to help mitigate the impacts of climate change such as storm surge or provide detention areas for floodwaters. They are also threatened by more extreme weather, increased impacts to forest health and coastal squeeze.

Integrate with:
Urban Forest Strategy – 2014 and Action update 2018
Rain City Strategy - 2019
Biodiversity Strategy - 2016
Living Systems Strategy (2019-2020)
Coastal Flood Risk Assessment (2012-2018)
Bird Strategy -2015
Rewilding Vancouver - 2014
VanPlay – Vancouver Parks and Rec. Master Plan 2019

Specific Objectives:

- Enhance the long term health and vigor of blue spaces, green spaces, trees and biodiversity.
- Increase the canopy cover in the city.
- Improve water quality of local waters.

Priority Actions:

- Support implementation and integration across departments of the UFS actions for climate change:
    - Action 14: Update tree selection guidelines to reflect the City's goals for climate adaptation, rainwater management, food production, biodiversity and reconciliation.
    - Action 8: Double the street tree canopy in the DTES, Marpole and FCF and other priority neighbourhoods with below average urban forest cover.
    - Actions 16 – 19 Plant trees to support green infrastructure and reduce climate change impacts.

    - Action 32: Update integrated pest management policies to address current and future threats to Vancouver's urban forest
    - Action 33: Work with Vancouver Fire and Rescue Services to update procedures for preventing, minimizing and controlling wildfire in urban forests.

- Develop policy and practices that facilitate soil preservation or is preferential to the reuse of naturally produced topsoils from offsite locations.

- Complete the Planning Department's in progress Living Systems Strategy which will include measures for integrating climate change actions into city planning and development.

- Develop a policy to guide a Park Board climate risk and opportunities-based approach to waterfront planning & design. The policy will be reviewed regularly and address up to date climate & water level projections, adaptable design, green infrastructure based protective measures and a variety of climate change related risks.

Prepared, Connected Communities

Climate change impacts will affect neighbourhoods and people differently and to various levels of severity but everyone benefits from connections and preparedness. Isolated seniors, young children, those already affected by illness or those with low means to recover from an event are more vulnerable. Social cohesion and connections within a community have been shown to be important for a number of wellness factors, including resilience.

Integrate with:
- Healthy City Strategy
- Resilient Vancouver Strategy
- Equity Framework (Poverty Reduction Strategy)
- Resilient Neighbourhoods Pilot Program
- Hey Neighbour program
- Housing and Homelessness Strategy – 2011
- Disaster Support Hub Initiative
- Business and Employer Emergency Preparedness program (BEEP)
- Vancouver Volunteer Corps
- Neighbourhood Emergency Preparedness Program

Specific Objective:

- With a focus on equity, minimize the negative health and safety impacts of climate change on communities and maximize their preparedness

Priority Actions:

- Work with partners VCH, BC Housing, social housing providers and others to develop short term and longer term strategies for health and safety during heat waves in non-market housing and the surrounding neighbourhoods.
    - Complete project with NGO Evergreen to engage non-market housing providers and tenants, and seniors groups to begin understanding how best the City can provide support during heat waves and poor air quality events.

- Across disciplines, address mitigating the Urban Heat Island Effect – street and building design, vegetation and trees, green roofs, access to drinking water. As in the Urban Forest Strategy, prioritize neighbourhoods for UHIE mitigation activities that have high surface and air temperature and frontline communities.

- Refresh personal preparedness communication and programming away from a focus just on earthquakes to a message of what you can do to be more self-sufficient, prepared and resilient across a range of shocks.

- Support climate resilience lens and climate adaptation activities in Resilient Neighbourhood Pilot Program. Support continuation and scaling-up of this program and programs like it that focus on neighbourhood resilience through social connections (i.e. Hey Neighbour).

- Address wildfire smoke events through proactive planning for communications, filtered air assessment and pilot clean air shelters, and worker safety. Work with VCH on the co-benefits of filtered air for wildfire events and TRAP – traffic related air pollution.

- Integrate with the Resilient Vancouver work on facilities to begin a cross-disciplinary conversation about using our facilities and community centres to collectively support people in increasing and different ways – extreme weather, heat, poor air quality etc. Continue to engage regional partners to this end as well.

- Work with the Province, Metro Vancouver and other partners to complete work necessary to integrate effective food system climate change adaptation strategies within City policies and strategies

Coastline Preparedness

Vancouver, like other coastal cities around the world, will experience sea level rise over the coming decades and centuries due to climate change. With one metre of sea level rise and a major storm surge event (0.2% AEP or 1/500 year storm surge event), approximately 13 sq. km of land and buildings valued at $7B (2013 land value assessment) is vulnerable to flooding in Vancouver. To protect vulnerable areas it is

estimated that approximately $1 billion of flood management infrastructure will be needed in Vancouver by 2100.

The Coastal Flood Risk Assessment (CFRA) program was recommended as the top priority action of the 2012 Climate Change Adaptation Plan. The three phases of the CFRA program have been completed and provide the City with a comprehensive understanding of our flood risk and vulnerability as well as high-level adaptation approaches that may be considered for various parts of the City. The next phases of work will focus on public engagement, and designing and implementing adaptation options using the tools and information gained through the CFRA program.

Although the timelines might appear long, Vancouver is taking action now on a number of fronts through community planning, capital planning, and City operations and maintenance work. This includes:

- Incorporating flood-resilient design standards into the Vancouver Building By-law for flood hazard areas
- Regulating sub-division and development in at-risk areas to avoid increasing coastal flooding vulnerability;
- Minimizing the construction of City-owned critical infrastructure in at-risk areas;
- Raising the physical height of City utilities (e.g., roads, water, sewer) during regularly planned infrastructure renewal projects;
- Developing and implementing a flood monitoring and warning system.

Integrate with:
Greenest City Action Plan
Biodiversity Strategy
Resilient City Strategy

Priority Actions:

- Amend the Zoning and Development By-law to ensure that flood plain development is done in a manner that protects people, property, and the natural environment from the consequences of flood hazards and enables future flood management infrastructure.

- Host a city-wide sea level rise engagement and design competition to raise awareness and support for the design and implementation of holistic flood management infrastructure.

- Complete conceptual design of preferred adaptation approaches for the Fraser River shoreline.

- Complete a study of climate change impacts, including **coastal processes** related to sediment transport, water chemistry and erosion, and sea level rise, for Vancouver Parks and Open Space. The study should identify the current state, trends, and projections as well as

informative global adaptation case studies. This document should be updated every 5yrs and inform all site planning and design.

Enabling Function Actions

Enabling actions are those that support mainstreaming climate change into day to day City work, decisions and investments. They also support continuous improvement and capacity building within the organization to ensure climate change adaptation continues to improve and evolve in the city.

Below is a summary of the focus areas for the enabling actions. All actions can be found in Appendix A.

On the mainstreaming front, the City is working with CPA and the City of Toronto on disclosing climate-risk related finances. Beginning to assess major capital projects against known climate hazards and risks is a key next step. The Engineering Project Management Office is spearheading a new asset management framework and it is essential that climate risks are inputted as a base consideration. Opportunities to include climate resilience as a foundation in land use planning and development will be pursued.

Capacity building and knowledge sharing with respect to climate change adaptation need to be enhanced at the City. A City Learn course will be developed to instruct staff on the basics of climate risk and vulnerability assessment methods and more tools will be shared across the organization. The hope is that job descriptions and departmental champions will emerge.

Coordination and availability of data and information for planning and decision-making also needs to be improved as does the way we work together across silos to deliver co-benefits and capture windows of opportunity to increase climate resilience.

Plan Monitoring and Reporting

A more recent trend in adaptation is to measure progress and success. Vancouver's 2012 adaptation plan included possible indicators in the appendices and was monitored for implementation progress but not for actual outcomes toward a more climate resilient city. Adaptation to climate change is tricky to measure for a number of reasons, including that it is hard to define success –is it an outcome that can be achieved or an ongoing set of processes? Time horizons to understand whether actions have reduced risk can be very long (as with sea level rise) during which baseline conditions change. Counterfactual indicators are common but difficult to measure and inaccurate; dollars of flood damage prevented compared to not taking the action. Adaptation indicators are also

frequently proxy measures as measuring the true goal is impossible and it is challenging to tell when measures have negative unintended consequences[8].

There are various types of indicators from those that measure inputs to those that measure efficiency of a project or process. The focus of the indicators below is to build a program over time that begins to give us a sense if we are moving in the right direction and becoming more climate resilient. Another set of indicators worthwhile to monitor over time are explanatory indicators, or those that support why we are doing this work. For example, how many days of air quality alerts there are each summer.

There are a range of existing indicators measured across the City already and more to come through the Resilient Vancouver Strategy, Rain City Strategy, GCAP refresh and others. Many of these provide, or will provide indications of how well we are doing on adaptation. For example, the Rain City Strategy will include targets for infiltrating or detaining rain water. A preliminary list of indicators and targets are listed in Appendix B. If they are existing indicators as marked, they will be measured on the existing basis. If new indicators, they will be measured twice per Adaptation Strategy review cycle (5 years). Staff aim to return to finalize indicators following completion of the aforementioned plans which are under development at the time of writing. Strategy implementation progress reporting will continue to be included in the GCAP annual update.

Plan Implementation and Review

The Adaptation Strategy will be implemented throughout many City of Vancouver departments. Sustainability staff will continue to track and support implementation.

The review cycle for the Strategy should be in step with the IPCC reporting with some time lag for downscaled projections to be completed as an input. The next IPCC AR6 report is due to be completed by mid-2022 with the synthesis report published early in 2023. A 5 year review cycle of the Adaptation Strategy and Action Plan is proposed with the next one due to Council by the end of 2023.

As deemed necessary, only the Action Plan portion of the Strategy need be updated at the 5 year cycle. It is recommended that once every 10 – 15 years, the complete risk and vulnerability assessment be completed.

[8] USDN Indicators Guidebook

Appendix A: Climate Change Adaptation Action Compendium

Priority actions are highlighted and appear at the beginning of the tables.

CORE ACTIONS

Robust Infrastructure

Action #	Action Description	Project Lead	Timeline
I.1	Complete integrated modeling of water in the city (pipe system, surface water and groundwater). Prioritize watersheds to be modeled to support city objectives such as Combined Sewer Overflow elimination, Rain City Strategy, growth planning and preliminary watershed assessments. Leverage modeling to complete overland flood route mapping and take an integrated approach to drainage systems including public realm, grey and green rainwater infrastructure systems, coastal flood protection, and parks.	Eng. IUP	ongoing
I.2	Complete comprehensive information gathering to support system modeling, catchment prioritization, and early implementation of the most effective, resilient water management actions. Early investment will ensure an option analysis of new approaches to servicing is timely.	Eng. IUP	2020
I.3	Utilize the piped system, green infrastructure and other rainfall storage strategies to attenuate water from catchments that drain into floodplain areas prone to coastal flooding. The aim is to reduce stormwater draining to low lying areas to mitigate peak flows and total flow volume at the runoff source. This will result in the appropriate timing and investment of stormwater pumping facilities.	Eng. IUP	ongoing
I.4	Continue water conservation and efficiency actions; develop regulations to support the usage of alternative water sources including groundwater, graywater and blackwater for non-potable demand. The 'fit for purpose' approach to water end use will reduce pressure on the regional supply and delivery of treated drinking water.	Eng. Water	2023
I.5	Undertake a drainage study for low-lying Southlands area to include an assessment of the	Eng.	2020

	existing dike network and pump station and recommend improvements for the drainage system as needed.	Sewers	
I.6	Support the Resilient Vancouver team development and implementation of an approach to define and analyze Critical Infrastructure. To: identify priority assets to risk manage, define a criticality framework and approach, and evaluate and test the approach.	CRO and RM	2020
I.7	Increase City departments' capability to manage a business disruption. Complete list of department critical services and develop tools, templates for departments to own and prepare their critical services for continuity of operations	RM	2023
I.8	Develop a groundwater management strategy and/or protection plan	Eng. Water	2023
I.9	Update the private side standards for stormwater retention, detention and reuse to reflect 2100 precipitation projections (IDF curve), and 2050 growth and climate scenarios.	Eng. IUP	2020
I.10	Continue the sewer separation program to support Combined Sewer Overflows Elimination.	Eng.	ongoing
I.11	Investigate and implement pervious pavement where appropriate.	Eng. Streets	ongoing
I.12	Develop regulation for non-potable reuse in the Vancouver Plumbing Code	Eng. Water	2020
I.13	Complete landslide risk identification and mitigation (from 2012 plan)	SUS	2020
I.14	Add climate change and resiliency considerations to utility design standards and specifications. Continue to build and specify guidelines as standards are updated	Eng.	2018 ongoing
I.15	When completed investigate and adopt appropriate elements of NRC's updated design climate data for reference by codes and standards	Eng.	2020
I.16	Support application of the Envision climate risk section to the two pilot projects and propose any improvements to the scope/deployment of Envision.	Eng.	2020
I.17	When completed investigate and adopt appropriate elements of NRC's guidelines for the adaptation of existing roads to climate change	Eng.	2020
I.18	Complete the Coastal Sanitary Pump Station System Resiliency Upgrade Project	Eng.	2023

*Eng. IUP - Integrated Utility Planning new department
CRO - Resilient Vancouver Strategy group
RM - Risk Management

Resilient Buildings

B.1	Within the upcoming deep retrofit strategy (Renewable Buildings 2050) adjust requirements and process for existing buildings to support enhancement of resilience to climate and other hazards.	SUS	2020
B.2	Evaluate and integrate where possible the new CSA standards and NRC guidelines for buildings related to climate change hazards in the VBBL where possible, including new climate loads.	SUS	2023
B.3	Continue to incorporate new summer normals related to active cooling and thermal comfort in building policy and bylaws: encourage heat pumps, reduce cooling demand in new blg, detailed thermal comfort guidance, exploration of future weather data for building design and modelling, etc.	SUS	2023
B.4	Build on phase 1 of the MBAR project with a study and report on potential building requirements and design options to “future-proof” buildings. Review outputs and develop recommendations for potential updates to building policy or by-law.	SUS	2023
B.5	Streamline heat pump permitting process and provide clarity on requirements.	SUS	2020
B.6	Consider updating the VBBL to cap the amount of summer solar heat gain in residential units.	SUS	2023
B.7	Research opportunities within existing buildings to require consideration of solar heat gain.	PDS	2023
B.8	Work with partners to research opportunities to include thermal comfort as part of certified rental building program and also work to increase the capacity of landlords to address thermal comfort in their buildings.	SUS Eng. Water	2023
B.9	Include climate resilience indicators and considerations, including solar heat gain, in Urban Design’s Resilient Neighbourhood Design Framework (Resilient Vancouver).	PDS (UD), CRO	2020
B.10	Track cooling energy demand intensity in new construction applications, and explore including limits in building policy and by-law	SUS	2021
B.11	Explore opportunities to refine and enhance limits on overheating, and to develop guidance for industry.	SUS	2019
B.12	Review future climate data and develop recommendations for use in building policy or by-law.	SUS	2019
B.13	Explore opportunities to use measured building data to inform updates to building policy or by-law.	SUS	ongoing
B.14	Review results of BC Housing MBAR project and develop recommendations for use in building policy or by-law.	SUS	2021
B.15	Introduce requirements for, or facilitate an increase in application of green roofs.	Building	2020
B.16	Provide guidance and clarify permit requirements for the installation of electrochromic glass. Work with planning and building staff to ensure a shared understanding and support.	SUS	2021

B.17	Include resilience checklist in large site rezoning. Evaluate and move toward more guidelines and standards.	SUS	2018
B.18	When available, incorporate the new Canadian Standards Association standard for residential basement flooding into building inspections and new building checklists for planning and development	SUS	2020

Healthy and Vigorous Natural Areas and Green Space

NA.1	Support implementation and integration across departments of the UFS Action Plan, especially those actions for climate resilience: 8,14,16,32,34.	PB	2023
NA.2	Develop policy and practices that facilitate soil preservation or is preferential to the reuse of naturally produced topsoils from offsite locations.	PB	2023
NA.3	Complete the Planning Department's in progress Living Systems Strategy which will include measures for integrating climate change actions into city planning and development.	PDS	2020
NA.4	Develop a policy to guide a Park Board climate risk and opportunities-based approach to waterfront planning & design. The policy will be reviewed regularly and address up to date climate & water level projections, adaptable design, green infrastructure based protective measures and a variety of climate change related risks	PB	2023
NA.5	Continuous improvement on Stanley Park Fire Preparedness and Fire Fuel Management programs	PB	ongoing
NA.6	Move Urban Forest maintenance from a reactive to a proactive standard for excellence	PB	2020
NA.7	Collaborate with and support DTES BIAs and community stewardship of street trees in line with the Urban Forest Action Plan action of doubling the street canopy in this area.	PB,PDS, Eng.	ongoing
NA.8	False Creek Water Quality Working Group lead Master Planning for False Creek with a focus on water quality outcomes.	Env. Serv.	2023
NA.9	Build on the False Creek management focused working group to advance knowledge and monitoring of marine waters related to pollution, hydraulics and ocean acidification	SUS	2023
NA.10	Develop a factsheet on UHIE for staff and developers. Develop communication that focuses on the economic and co-benefits of trees.	Comms., PDS	2020
NA.11	Monitor and report out on environmental aspects of new Large Sustainable Sites Policy	SUS	2023

NA.12	Expand forest naturalization projects in areas such as Everett Crowley Park as recommended in the BDS and UFS.	PB	ongoing

Prepared, Connected Communities

C.1	Work with partners VCH, Evergreen, social housing providers and others to develop short term and longer term strategies for health and safety during heat waves in non-market housing and the surrounding neighbourhoods.	SUS, ACCS	2020
C.2	Address mitigation of UHIE across disciplines prioritizing neighbourhoods with high temperature and frontline communities.	PDS	ongoing
C.3	Refresh personal preparedness communication and programming away from a focus just on earthquakes to a message of what you can do to be more self-sufficient, prepared and resilient across a range of shocks	OEM	2020
C.4	Support climate resilience lens and climate adaptation activities in Resilient Neighbourhood Pilot Program. Support continuation and scaling-up of this program and programs like it that focus on neighbourhood resilience through social connections (i.e. Hey Neighbour).	CRO, SUS	2020
C.5	Address wildfire smoke events through proactive planning for communications, filtered air assessment and pilot clean air shelters, and worker safety	ACCS, REFM, SUS	ongoing
C.6	Integrate with the Resilient Vancouver work on facilities to begin a cross-disciplinary conversation about using our facilities and community centres to collectively support people in increasing and different ways – extreme weather, heat, poor air quality etc. Continue to engage regional partners to this end as well.	CRO, SUS, PB, ACCS	2020
C.7	Work with the Province, Metro Vancouver and other partners to complete work necessary to integrate effective food system climate change adaptation strategies within City policies and strategies	SUS, ACCS	
C.8	Re-establish the Extreme Heat Planning Committee. First order of business: reassess triggers and thresholds for Extreme Heat Initial Response Guideline (IRG) to add more levels of triggers and actions and include poor air quality events to address potential public alert fatigue	OEM, SUS	ongoing
C.9	Improve information available for homeowners in terms of preparing for various types of	Comms,	2020

	flooding	Eng.	
C.10	Develop planning, response, and recovery tools and resources for Disaster Support Hubs and increase public awareness of these sites. Expand range of facilities beyond solely Vancouver Park Board and Vancouver Public Library facilities.	CRO	2020
C.11	Complete an assessment of non-market housing buildings with the goal of identifying short and long term cooling options. Address air filtration where possible.	ACCS, REFM	2020
C.12	Develop public facing material push ahead of wildfires addressing both fire risk in Stanley Park and air quality risks and related mitigation efforts.	Comms, SUS	2019
C.13	Choose several pilot cooling facilities to be designated clean air shelters for use during poor air quality events during the summer. Evaluate how they are used and program needs moving forward	SUS, REFM	2019
C.14	Continue to add public access to water fountains and where appropriate other water related cooling such as misting stations and VFRS ad hoc cooling.	Eng.	ongoing
C.15	Design public spaces and bike routes with natural or built shade.	PB, Eng.	ongoing
C.16	Continue with adopt a catch basin program – increasing participation each year	Eng.	ongoing
C.17	Support the development of a Train the Trainer program for community to advance engagement around climate and seismic resilience within neighbourhoods and with harder-to-reach groups.	CRO, SUS	2020
C.18	Ensure heat mapping data from the 2015 SFU project and floodplain mapping data is included in the Risk Profiler tool being developed for Resilient Vancouver by Natural Resources Canada.	SUS	2020

*ACCS – Arts, Culture and Community Services

Coastline Preparedness

S.1	Amend the Zoning and Development By-law to ensure that flood plain development is done in a manner that protects people, property, and the natural environment from the consequences of flood hazards and enables future flood management infrastructure.	SUS, Planning	2020
S.2	Host a city-wide sea level rise engagement and design competition to raise awareness and	SUS	2021

	support for the design and implementation of holistic flood management infrastructure.		
S.3	Complete conceptual design of preferred adaptation approaches for the Fraser River shoreline.	PDS, SUS, Eng.	2021
S.4	Complete a study of climate change impacts, including **coastal processes** related to sediment transport, water chemistry and erosion, and sea level rise, for Vancouver Parks and Open Space	PB	2023
	Citywide Actions	PB	ongoing
S.5	As part of the City Wide Plan, support the development of flood management and adaptation policy and planning to improve coastal preparedness at a City scale.	SUS, PDS	2020
S.6	Continue to collaborate with Musqueam, Squamish and Tsleil-Waututh on governance, studies, communications & engagement related to adaptation and coastal preparedness.	SUS, Eng., PB	ongoing
S.7	Develop bylaws, regulations and policies to guide the design of engineered shoreline flood protection such that it is adaptable and built to a consistent performance standard	Eng.	2020
S.8	Develop a long-term funding strategy to support implementation of coastal flood protection.	SUS, Finance	2020
	Zone Specific Actions:		
S.9	Using the tools from CFRA III initiate public engagement on sea level rise and adaptation approaches for the Kitsilano flood hazard zone.	SUS	2023
S.11	Support adaptation approaches for the Waterfront Road flood hazard zone in coordination with broader planning of the Central Waterfront area..	Eng.	ongoing
S.12	Support adaptation and resilience design as part of planning for the St Paul's hospital precinct.	SUS, PDS, Eng.	ongoing
S.13	Jericho Beach pier design and renewal to improve access to disabled sailors and accommodate sea level rise.	PB	Design: 2019
S.14	Support the design and development of the North East False Creek shoreline from Science World, including the decking south of Science World, to the western Concord site to	PDS, PB,	2023

	incorporate flexible flood management design.	Eng, SUS	
S.15	Work with Provincial and Regional partners to plan and implement Phase 2 of Vancouver's sea level monitoring program.	SUS	2020
S.16	Develop a flood hazard response plan for the Fraser River	OEM, SUS	2023
S.17	Cambie Sheet Pile wall design and replacement as part of the development of South East False Creek.	Eng.	2023
C.18	Stanley Park Seawall adaptation pilot projects **as funding is made available**	PB, Eng, SUS	2023

ENABLING ACTIONS

Mainstreaming

	Finance		
E.1	Begin incorporating climate-related financial disclosure in City financial planning in 2019. Work with partners like the City of Toronto and CPA Canada in their TCFD Guidance for Cities project.	Finance	2020
E.2	After several years of climate-related financial disclosure explore adding a specific climate assessment to large capital plan projects.	Finance	2021
E.3	Incorporate a scan of major projects against hazard and risk mapping to identify where staff risk experts should be involved early in the project	Finance, SUS, CRO	2023
	Project Management		
E.4	Add climate change considerations to the sustainability addendum of the engineering project management framework	Eng. PMO	2020
E.5	Support application of the Envision climate risk section to the two pilot projects and propose any improvements to the scope/deployment of envision	Eng. PMO,	2020

		SUS	
	Asset Management		
E.6	Add climate projections and information to multi-hazards risk assessment in the new engineering asset management framework	Eng. PMO,	2020
	Planning		
E.7	Continue to develop the Resilient Neighbourhood Design Framework	PDS (UD), CRO	2020
E.8	Incorporate climate change adaptation as a foundational element in the upcoming City Plan	PDS	2023
E.9	Work with planners to increase understanding of new floodproofing guidelines and related zoning regulation changes.	PDS, SUS	2020
E.10	Integrate spatial hazard and utility planning as a foundational element of land use planning by including it as a core element in job descriptions	PDS, Eng.,	2023

Capacity building and knowledge sharing

E.11	Develop City Learn course to share climate risk and vulnerability assessment methods	SUS	2020

Data and Information

E.12	Hazard mapping available for staff and for public. Message out more broadly about existing staff map layers and ensure climate related hazards and associated projections are included in the Risk Profiler tool under development for the Resilient Vancouver Strategy.	CRO SUS, GIS,	2020
E.13	Support Resilient Vancouver team in identifying and implementing mechanisms to better coordinate and update all hazard information and data for hazard planning across the City.	CRO, SUS, OEM	2023
E.14	Make climate projections widely available across the city. Increase knowledge of the projections and engage staff with respect to other climate projections and tools that would be useful.	Comms,, SUS	2023
E.15	Develop and maintain a database of climate change adaptation funding available from different levels of governments and funders. Include major local adaptation research	SUS	2020

	projects (MEOPAR, MBAR)		

Governance, Leadership, Partnerships

E.16	Collaborate with Resilient Vancouver Strategy team to support an exploration of distributed leadership models to improve governance of resilience, natural hazard management and climate change adaptation.	SUS, CRO	2023
E.17	Continue to work with partners and expand networks. Collaborate with VCH on a forum for regional adaptation practitioners and with the Resilient Vancouver Strategy team on a regional hub for practitioners.	SUS, CRO	2023

Appendix B: Plan Measurement

Objective	Measurement Component or Indicator	Reporting Frequency
Minimize rainfall related flooding and consequences	Adopt upcoming Rain City Strategy indicators and targets where appropriate	Reported with Rain City Strategy Report @ 5 year Strategy review cycle
	Indicator: Number of claims against the city for flood damage Target: To be set at next review	Report @ 5 year Strategy review cycle
Design robust built form to do well in a range of climates while providing co-benefits such as seismic resilience, energy efficiency, accessibility and supporting health and well-being.	Indicator: Floor area of newly permitted buildings that are near zero emissions Target: ZEB target of 100% floor area in newly permitted buildings near-zero-emissions by 2030	Report @ 5 year Strategy review cycle
Increase resilience to coastal and riverine flooding	Indicator: number of residents and prop owners engaged or receiving applicable information from the City	
	Indicator: % of coastal projects using SLR information and adaptation actions Indicator: rate of new development employing flood proofing measures in floodplain areas	
Enhance the long term health and vigour of green spaces, trees and biodiversity	Indicator: Increase the canopy cover in the city.	Measured with targets through the Greenest City action plan annually Report @ 5 year Strategy review cycle
	Indicator: Street tree density in neighbourhoods with higher measured heat	Measured with target through the Urban Forest Action Plan

	and vulnerability to heat.	Report @ 5 year Strategy review cycle
With a focus on equity, minimize the health and safety impacts of climate change on communities and maximize their preparedness	Indicator: social support network size	Measured with targets through the Healthy City Strategy. Report @ 5 year Strategy review cycle
	Indicator: Excess deaths or hospitalizations due to heat	As available from BC Centre for Disease Control or Vancouver Coastal Health Report @ 5 year Strategy review cycle
	Indicator: Percentage of City and BC Housing owned non-market housing with access to a cool room during summer months.	Report @ 5 year Strategy review cycle
	Indicator: Number of public water fountains	Report @ 5 year Strategy review cycle
	Indictor: Number of City facilities open to the public that provide a MERV 13 or higher standard of air filtration during summer months.	Report @ 5 year Strategy review cycle
Continue maximizing adaptation knowledge and mainstreaming across the organization.	Indicator: Number of staff that have taken the adaptation CityLearn course (to be developed)	Report @ 5 year Strategy review cycle
	Number of City staff involved in a climate change risk assessment through the Infrastructure Canada Lens or Envision system.	Report @ 5 year Strategy review cycle
Explanatory Indicators	number of summer days annually with a	To the extent possible use

	special weather statement (heat-related) or heat alert	Emergency Management's Information System, VanORCA, to track and report. Partner with OEM and Environment and Climate Change Canada where information is needed. Report @ 5 year Strategy review cycle.
	number of summer days annually with a special weather statement (smoke-related) or air quality advisory or both	
	Number of days annually with a special weather statement or alert for heavy rainfall	
	Number of street tree or park trees lost to a climate related impact (wind, drought, snow load, etc.)	Report @ 5 year Strategy review cycle
Progress Indicator	% of action items in the Adaptation Strategy that have been initiated.	Report annually with GCAP updates