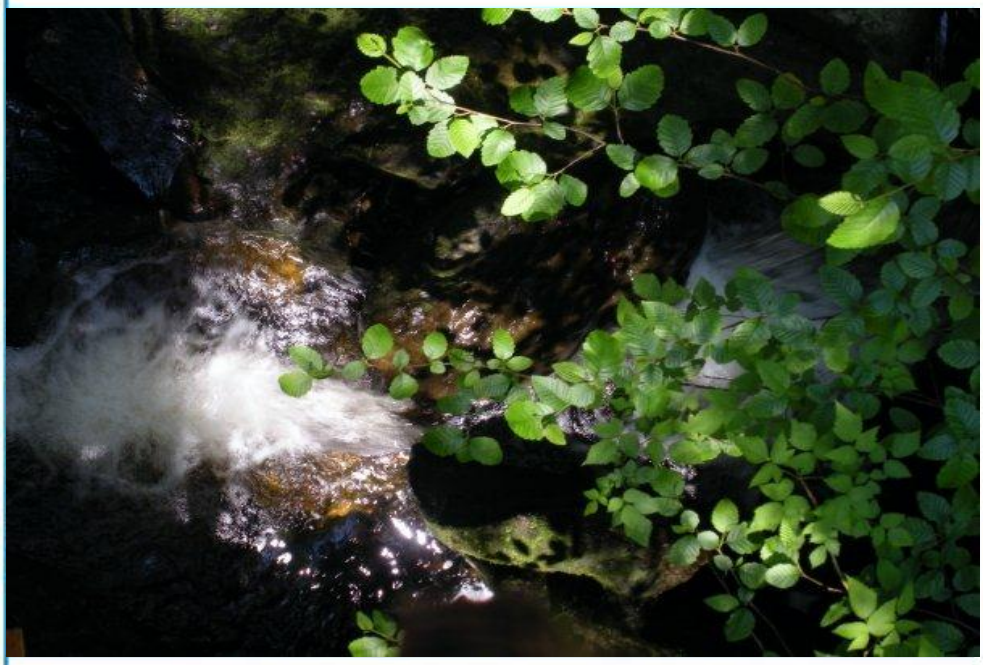
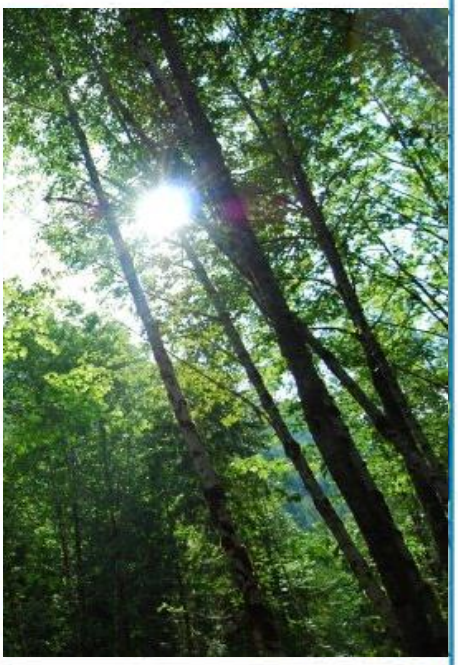
City of North Vancouver
Climate Change Adaptation Plan





October 2013

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1. Introduction

The effects of climate change are already evident in the City of North Vancouver, with measurable changes in temperature, precipitation, and extreme events in recent decades. Without adequate planning and adaptation these changes will have extensive impacts on the liveability of the City.

The City has a strong history of mitigation – preventing or slowing climate change by reducing greenhouse gas (GHG) emissions – but this is only one half of the two-pronged approach needed to address climate change. The other half of a comprehensive climate change strategy is adaptation – making adjustments in our decisions, activities, and thinking to increase our resilience and reduce the impacts of climate change. Even extensive mitigation efforts will not prevent some degree of future climate change. Today's emissions and those already in the atmosphere will continue to affect the climate for many decades to come, and these changes are likely to have substantial impacts if we are not prepared – if we do not adapt.

While many of the City's mitigation measures also help us to prepare for future climate changes, adaptation has not previously been addressed directly. The City of North Vancouver has joined leading cities across Canada and around the world by developing and implementing a Climate Change Adaptation Plan. To achieve this goal the City is participating in ICLEI[1] Canada's Building Adaptive and Resilient Communities (BARC) program (Figure 1). The program's five milestone framework leads cities through the process of developing, implementing, and monitoring a climate adaptation strategy, with a focus on reducing risk throughout the community.

The City has also made the strategic decision to integrate adaptation throughout all City operations, including the 2014 Official Community Plan (OCP) update. By planning for the climate of the future rather than today, and improving the community's environmental, economic, and social capacities to respond to climate change, the most severe impacts can be avoided and the City will be ready to take advantage of new opportunities as they arise.

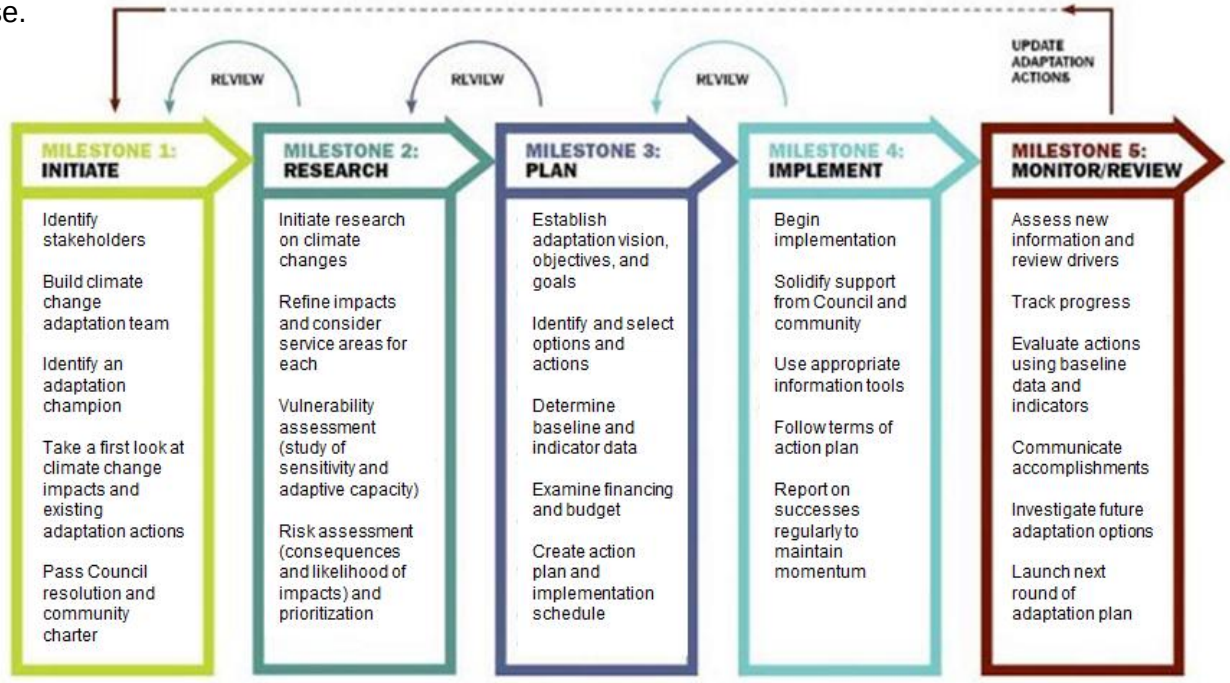

Figure 1: ICLEI Canada five milestone framework for planning and adapting to the impacts of climate change

[1] **International Council for Local Environmental Initiatives**

2. Understanding and Responding to Climate Change

2.1 Climate and Weather

Climate is what you expect. Weather is what you get.

One of the key concepts for understanding climate change is the definition of climate itself and how it differs from weather.

Weather describes the short-term conditions of the atmosphere, including temperature, wind, precipitation, humidity, and cloudiness, and is concerned with the exact conditions at a particular place and time.

e.g. What will the temperature be at 4pm tomorrow?

Climate describes the long-term weather patterns for a particular area and time, usually over a period of at least 30 years. Climate considers what kind of weather to expect for a certain time of year based on what has happened in the past and projections of future change.

e.g. What is the average summer temperature?

Predicting the exact probability of rain five days from now is difficult because atmospheric conditions change so quickly, but predicting the average summer temperature over the next 10 years is much easier. This has allowed climate models to successfully reproduce recent climate changes and to make reliable predictions, giving us a high level of confidence in their projections of the future.

2.2 Causes of Climate Change

For the Earth's temperature to remain steady the amount of energy it gives off must be the same as the energy it receives from the Sun. However, rising GHG concentrations trap extra heat in the Earth's atmosphere, lands, and oceans.

The most obvious effect of this extra heat is the warming of the ocean and atmosphere. Because weather is mainly caused by the transfer of heat in the atmosphere, and warmer air holds more water and energy that fuel large storms, the extra heat also affects all aspects of the world's weather and climate.

Just as weather and climate varies around the world based on latitude, altitude, ocean currents, atmospheric circulation, and the distance from water bodies, the effects of climate change will also vary dramatically from location to location. In general, the world can expect:

- Increasing surface temperatures, with more warming over the continents than over the ocean, and more warming closer to the North and South poles
- Increasing contrast in precipitation between wet and dry regions and between wet and dry seasons, with wet places and seasons becoming wetter, and dry places and seasons becoming drier
- More frequent and intense extreme heat, precipitation, and drought events
- Rising sea levels
- Shrinking Arctic sea ice, continental glaciers, and snow cover

British Columbia and the City of North Vancouver will experience many of these same changes in the coming decades. See *Section 3. Local Climate Change Projections* for more detail on the changes the City has already experienced and those it is likely to see in the future.

2.3 Addressing Climate Change: Mitigation and Adaptation

Weather influences nearly all aspects of the City of North Vancouver's operations, design, and culture. From storm sewer and building design, to parks and environmental management, to festivals and recreation, the region's moderate oceanic climate plays a major role in shaping the City's structure and lifestyle. Because of these strong connections climate change will have a wide range of impacts, some of which will become major threats if we do not address this challenge.

Two separate but related approaches are required to successfully respond to the threat of climate change: Mitigation and Adaptation.

Mitigation is the attempt to prevent climate change by reducing atmospheric greenhouse gas (GHG) concentrations. However, even extensive mitigation will not prevent future climate change because today's GHG emissions and the surplus heat stored in the ocean will continue to affect the climate for many decades to come.

Adaptation involves making adjustments in our decisions, activities, and thinking to increase our resilience and reduce the impacts of climate change, regardless of how much warmer, wetter, and stormier the City becomes.

Adaptation and mitigation are often presented as two distinct courses of action, implying that doing one precludes the other, and that committing to adaptation is an admission of defeat with respect to mitigation. However, both approaches are required to fully address the issue and can complement each other to greatly reduce the consequences of climate change.

Mitigation and adaptation measures are often similar and can offer benefits to the other course of action. When mitigation is done successfully it also reduces the need for adaptation, reducing costs and allowing a greater range of impacts to be addressed. Even with aggressive worldwide mitigation the climate will continue to change for at least the next century because of the climate's slow response to increasing GHG concentrations and the large amount of extra heat trapped in the ocean. With the City already experiencing climate change impacts, and even greater changes projected for the future, extensive adaptation will be needed to minimize risk and maintain the community's high quality of life.

While the threat of negative impacts due to climate change is very real, it is important to remember that adaptation is not only about avoiding catastrophe. Like any other decision making process adaptation is simply about planning for the future based on the best available information to achieve your goals – in this case, to maintain a vibrant and healthy community. The local climate has always been considered in City planning, and including adaptation is simply the recognition that we also need to account for how it is changing and what conditions will be like in the future.

2.4 Resilience and Risk

Judging the success of climate change adaptation can be difficult because it is never over and deals with uncertain future events. Therefore, rather than aiming for a specific endpoint, the goals of adaptation are to increase the City's resilience and to reduce the risks of climate change.

Resilience is the ability to respond to change or disruption while continuing to function and prosper. This includes understanding potential changes, acting to reduce impacts before, during, and after a disturbance, taking advantage of new opportunities, and maintaining the ability to respond to further change.

Risk is a measure of the expected outcome of an uncertain event, and is estimated by multiplying the likelihood of an event by its consequences. Risk is a useful tool when dealing with climate change because of its ability to compare impacts that are very likely to occur (e.g. discomfort and health effects from hotter summers) with rare but highly damaging ones (e.g. major flooding and storm damage), and because of the uncertainty involved in predicting both the future climate and humanity's behaviour.

Humans tend to avoid risk and put a lot of effort and money into reducing it, such as with health, car, and home insurance. However, this has not carried over to climate change. Even on its own, the small chance that climate change will be much worse than expected and cause a major catastrophe supports substantial mitigation and adaptation. Like most preventative measures, the costs of mitigation and adaptation are far lower than the expected consequences from not taking action.

3. Local Climate Change Projections

Table 1: Projected temperature changes for the City of North Vancouver[2]

↑ Temperatures Year-Round Much warmer Summer Highs and Winter Lows	**Average Temperature:** +1.7°C by the 2050s and +2.7°C by the 2080s
	Summer Daytime Highs: +2.5°C by the 2050s and +4.2°C by the 2080s Warmer than Seattle by the 2050s Warmer than San Diego by the 2080s
	Winter Nighttime Lows: +2.7°C by the 2050s and +4.1°C by the 2080s
	High Elevation: Average temperatures at Grouse Mountain have risen 2x as fast as at sea level since 1950

Table 2: Projected precipitation changes for the City of North Vancouver[2]

↑ Annual Total Intensity Wetter Falls and Winters and ↓ Drier Springs and Summers Less Snow	**Annual Average:** ↑ +7% by the 2050s and +8% by the 2080s
	Seasonality (2050s): ↓ Spring: -18% Summer: -15% ↑ Autumn: +64% Winter: +6%
	Snowfall (2050s): ↓ Winter: -36% Spring: -52%
	Intensity: +20% Precipitation on the wettest days of the year by the 2050s

Table 3: Projected changes in extreme weather events for the City of North Vancouver[2]

Extreme Events
Extreme Heat Events: Events that once occurred only every 25 years (+32.4°C) will occur every 8 years by the 2050s – More than 3x as frequently
Extreme Precipitation Events: Events that once occurred only every 25 years (>145mm in 24hr) will occur every 10 years by the 2050s – More than 2.5x as frequently

[2] Climate change projections are based on Murdock et al. (2007) and the Pacific Climate Impacts Consortium Plan2Adapt tool (www.plan2adapt.ca). Historical climate data obtained from Environment Canada.

Historical and projected sea level rise

During the 20th century global mean sea level rose at approximately 1.7 mm/year, however this rate has increased to around 3 mm/year since 1993 (Figure 2). The IPCC (Intergovernmental Panel on Climate Change) estimates a further increase of 18 to 59 cm by the end of the 21st century, while other models show the potential for more than 1m of sea level rise. Given the uncertainty in model projections, and the rapid increase observed in the past decades, BC's provincial government released draft guidelines to be used for evaluating long-term land use planning of 0.5m of global mean sea level rise by 2050, 1.0m by 2100, and 2.0m by 2200 (Table 4; Ausenco Sandwell, 2011; Kerr Wood Leidal, 2011)

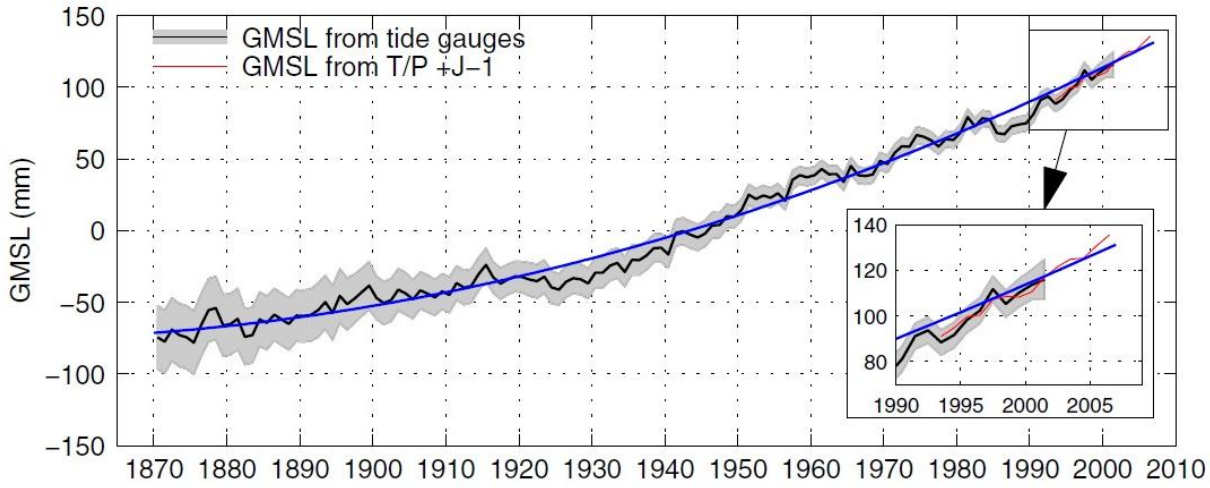

Figure 2: Global mean sea level from 1870 to 2006. (Church et al., 2008)

Table 4 Sea level rise guidelines for evaluating long-term land use planning

Timeframe	Global Sea Level Rise
2050	0.5m
2100	1.0m
2200	2.0m

4. Local Impacts and Benefits of Climate Change

Through consultation with City staff and regional stakeholders, approximately 150 potential climate change impacts were identified, affecting the City's infrastructure, inhabitants, businesses, and environment. Next, vulnerability and risk assessments were used to rank the impacts, and to identify the highest risk impacts to be included in the City's adaptation strategy. This process included an interdepartmental team of City staff and external agencies, and consisted of direct consultations, a vulnerability survey, and a risk assessment workshop.

4.1 Vulnerability and Risk Assessments

Vulnerability Assessment

Vulnerability = Sensitivity ÷ Adaptive Capacity

Vulnerability refers to the susceptibility to adverse effects of climate change (e.g. How susceptible is the drinking water supply to hotter and drier summers and more frequent droughts?). Vulnerability depends on the **sensitivity** to climate change (e.g. How much will the water supply decrease during hotter and drier summers?) and **adaptive capacity** - the ability to respond or adapt - (e.g. How much effort and money would be required to maintain an adequate drinking water supply during drought conditions?).

Increased sensitivity leads to increased vulnerability (e.g. the City's water supply might be highly sensitive to drought – increasing the vulnerability), while increased adaptive capacity leads to decreased vulnerability (e.g. we can adapt relatively easily to drought through water use restrictions and conservation – reducing our vulnerability.

Risk Assessment

Risk = Likelihood x Consequence

Risk is a measure of the expected outcome of an uncertain event, which is estimated by combining the likelihood of an event by the consequence. In the case of climate change there is still some uncertainty around the exact magnitude and variability in the projected changes, as well as the severity of the resulting impacts and our ability to adapt to them. Risk assessment helps to grapple with these uncertainties and allows for the creation of a prioritized list of impacts based on their threat to the City.

The risk assessment looked at the consequence of each impact to six sectors of City operations and quality of life based on the ICLEI Risk Assessment process: Health and Safety, Local Economy and Finance, Community and Lifestyle, Parks and the Environment, Infrastructure and Buildings, and Land Use. The geographic and socio-economic distributions of impacts were also considered, especially where the consequences are expected to fall disproportionately on vulnerable populations.

Timeline

It is important to use a consistent timeline throughout the impact assessment process to accurately frame the likelihood and magnitude of the expected climatic changes and to ensure that the impacts are being compared fairly. The 2050s was chosen as the City's timeframe because it is a common timeframe for climate change projections and is also within the lifespan of most new buildings and infrastructure, making it relevant for decisions being made today.

However, while a timeline of the 2050s is a convenient timeline for initial adaptation planning, it is far too short to fully encompass the nature of the issue. When looking at climate change predictions for any time period, whether it's the 2050s, 2080s, or beyond, it is important to remember that those changes are only the beginning and will continue for decades or centuries to come. Increasing temperatures, storms, and sea level rise does not stop at 2100, and neither can our thinking and planning.

4.2 Assessment Results and Priority Impacts

At each stage in the adaptation planning process lower priority impacts were combined, refined, or removed to create a list of the most pressing impacts the City will experience. All of these high priority impacts are summarized below in Section *6 Adaptation Impacts, Objectives, and Actions*, organized by theme and policy area. A comprehensive list of all impacts that were considered can be found in the ICLEI Milestone 2 report: Climate Changes and Impacts for the City of North Vancouver.

While all of the priority impacts require some form of adaptation, there are several that stand out as presenting the greatest risk to the City of North Vancouver:

1. Flooding and inundation of coastal, creek, and low lying lands due to more intense precipitation and sea level rise

2. Buildings, infrastructure, and development patterns not well adapted to future climate within their lifespans (e.g. undersized storm sewers, excess heat gain and lack of cooling in buildings, roads and buildings built below adequate flood construction levels)

3. Emergency staff and equipment may be inadequate to deal with the higher frequency of emergencies and the increased likelihood of simultaneous emergencies

4. Direct health and safety effects, including heat and cold stress, UV radiation, air quality related respiratory illnesses, storm debris, downed power lines, flood, and land slide related health and injury risks

5. Increasing risk of major transportation disruptions due to flooding of transit hubs, roads, and bridges

6. Vulnerable populations will experience much greater impacts than the general population, which must be addressed to prevent the most severe health and wellbeing consequences

4.3 Climate Change Benefits

The Lower Mainland is comparatively well situated with respect to climate change due to its ocean moderated climate which will mitigate many temperature related impacts and keep average temperatures relatively comfortable for several decades. This room for change prior to substantial negative consequences also provides opportunities for potential benefits of climate change. However, the likelihood and magnitude of these benefits are generally much lower than for the negative impacts identified above.

While food growing conditions may improve, allowing for greater productivity and the introduction of new species and varieties, drier summers will increase watering requirements, and could increase disease pressure as well. Safer road conditions and potentially reduced snow clearing requirements may occur due to higher temperatures and reduced snowfall, but snow may fall in fewer, larger events which would actually require more snow clearing resources. Freeze-thaw weathering of roads and other infrastructure may decrease with increasing winter temperatures, but climate variability could lead to increased weathering as large temperature swings are far more damaging. Finally, there is also the potential for increased tourism and recreational opportunities due to longer, drier summers, however, this effect could be outweighed by the increase in rainfall during the rest of the year and impacts on winter tourism and recreational opportunities.

5. Climate Change Adaptation Strategy

The *Climate Change Adaptation Plan* was developed in tandem with the Official Community Plan (OCP) update to help integrate adaptation into all City operations. The impacts, objectives, and actions are detailed below in Section 6 following the same framework as the OCP, with eight theme areas, plus an additional section related to implementation. Maintaining a consistent organizational structure will make it easier to identify how adaptation applies to all of the City's goals, actions, and operations.

In addition to following the action plan outlined in Section 6, implementation of the adaptation plan will involve the development of a series of accompanying materials to help achieve climate resilience.

First, a catalogue of more specific measures and policy options that could be used to fulfill the objectives and actions laid out in the adaptation plan will be developed. This could include new technologies, policies, funding mechanisms, and other innovative adaptation solutions, as well as references to other cities where they have been successful.

Second, in addition to following the prescribed action plan, activating the public to address climate change adaptation in their own lives will be a key aspect of implementation. Public information materials will be developed to provide guidance for how the public can prepare for climate change and to promote community level adaptation, in addition to ongoing dialogue and consultation.

Finally, the City will develop a monitoring and review process to track our progress and identify new opportunities to reduce climate risks and take advantage of new opportunities. In addition to quantitative indicators and targets, the monitoring program should include regular review of decision making processes to ensure that climate considerations are being included in all City operations and that adequate knowledge and resources are available.

5.1 Adaptation Vision

The City of North Vancouver will remain a vibrant, diverse, and highly resilient community by planning for the climate of the future rather than today, and improving the natural, physical, human, social, cultural, and local economic capacity of the community to respond to the impacts of climate change.

5.2 Overarching Goal

Increase the City's resilience to the physical, social, economic, and environmental impacts of climate change

5.3 Adaptation Guidelines

Climate change adaptation should not simply be seen as a list of preventative actions, but instead as a philosophy to include the changing climate as one more aspect of comprehensive, intelligent planning. Following these guidelines while pursuing explicit adaptation measures, or any other municipal or community actions, will help to improve the City's resilience, and should be seen as an equally vital part of the *Climate Change Adaptation Plan* as the actions listed below in Section 6.

- Commit to climate adaptation as an ongoing process, incorporating the best available science and regularly reviewing the City's vulnerabilities, policies, and adaptation actions
- Integrate climate adaptation throughout City operations, focusing on existing programs and policies rather than developing new initiatives
- Recognize and plan for the needs of vulnerable populations and the disproportionate impacts they will experience
- Protect and restore the natural environment, including air, water, wildlife habitat and ecosystem functions
- Engage the public, community stakeholders, and City staff to reduce climate related risks, increase preparedness, and promote sustainability
- Work cooperatively with regional municipalities and First Nations, government agencies, and community stakeholders
- Give priority to:
    - Adaptation through the responsible planning of complete and compact communities
    - Durable buildings and infrastructure that are adapted to the future climate throughout their expected lifespans
    - Non-structural measures
    - No-regret actions that benefit the community regardless of the amount of future climate change
    - Options which maintain or increase flexibility in future adaptation
    - Actions that also advance mitigation and sustainability efforts

6. Adaptation Objectives, and Actions

6.1 Land Use: Housing, Population & Employment

The City's building stock is a major source of value and a defining characteristic of the community, making reducing its vulnerability to climate change a very high priority and a great opportunity for progress. Much of the City's land is already developed and therefore adaptation measures will focus on redevelopment, retrofitting existing buildings, and shaping the City's land use patterns and infrastructure to prepare for future climate impacts.

The greatest threat to both developed and undeveloped lands will be more frequent and severe flooding due to more intense precipitation, and to a lesser extent, sea level rise and increased storm surge. Reducing the City's flood risk will focus on non-structural solutions, such as hazard land development permit areas (DPAs), regularly updating floodplain maps, restoring wetlands and natural buffers, and the investigation of other innovative policy and land use options. Priorities and a long-term timeline will also be established for structural measures (e.g. dikes) to provide adequate time for capital, engineering, and land use planning.

A second challenge will be preventing new and existing buildings from becoming maladapted to the City's climate during their lifespans. Potential issues could include excessive heat gain and the need for cooling, energy costs and efficiency, and emergency and transportation access. Building bylaws, development guidelines, and zoning regulations will continue to be updated to reflect the newest climate projections and promote higher building standards, and the City will advocate for similar changes to the provincial building code. As redevelopment occurs the City will also look for opportunities to obtain or restore public and natural amenities that increase the City's resilience through density bonusing, development variances, or property purchase. For existing buildings, the City will promote all available energy efficiency and flood protection retrofit programs, and implement its own retrofit programs where possible.

While the City will likely experience significant climate change impacts, most other areas of the world are expected to experience more severe impacts. Because of the well-developed infrastructure, relatively low flood risk due to steep terrain, and temperate climate, the City will be less negatively affected by climate change in comparison to many other regions. This advantage could lead to increasing population and development pressure due to migration from less resilient areas. Responding to these pressures must be done without sacrificing long term resilience, requiring strict building and land use policies, increased municipal and community services, and the preservation of natural capital.

6.1 Land Use: Housing, Population & Employment

Impacts

1.1 Flooding and inundation of public and private property for coastal, creek, and low lying areas due to more intense precipitation, sea level rise, and storm sewer overflow

1.2 New and existing land use planning and building design will become increasingly unsuited to the changing climate, including more frequent climate hazards and increasing need for emergency response

1.3 Increase in population and development pressure due to migration from regions less able to adapt to climate change

Objectives

1.1 Minimize the current and future risks of coastal and upland flooding
1.2 Ensure all new buildings and developments are adapted to the future climate throughout their expected lifespans
1.3 Improve the existing building stock to be better prepared for future climatic conditions
1.4 Pursue development options that increase, rather than decrease, the City's climate resilience

Actions	Action By	Responsibility
1.1 Complete and implement an Integrated Stormwater Management Plan (ISMP) that accounts for future hydrologic and sea level changes within the lifespan of all existing and new infrastructure, buildings, and developments	In Progress Completed by 2016	Engineering
1.2 Prepare and enact Development Permit Area guidelines for properties within hazard prone areas including flood plains, and steep slopes	In Progress	Community Development
1.3 Investigate policy options for reducing flood risk for existing and new infrastructure and residential and commercial developments and buildings	2016	Community Development, Engineering
1.4 Establish priorities and timeline for future structural flood protection measures and capital planning	2015	Community Development, Engineering, Finance
1.5 Establish regular schedule for updating flood maps and risk assessment , with provisions for extra mapping when new information becomes available that will substantially change high risk areas	Ongoing	Engineering
1.6 Continue to strengthen building bylaws and zoning regulations, and advocate for building code changes, regarding energy efficiency, passive design, minimizing heat gain, improving durability, and reducing the urban heat island effect	2017	Community Development
1.7 Promote uptake of energy efficiency and green building incentive programs by maintaining an up to-date-inventory of available and upcoming programs and education opportunities	2014	Environment
1.8 Update development guidelines to include adaptation to future climate conditions	2014	Community Development
1.9 Take advantage of redevelopment to obtain or restore public and natural amenities that increase resilience through density bonusing, variances, or purchase	Ongoing	Community Development

6.2 Transportation, Mobility & Access

The City's somewhat isolated position on the North Shore, steep terrain, and limited east-west connectivity due to existing stream and ravine corridors make it particularly vulnerable to transportation disruptions. The transportation impacts of increased flooding and storms could result in health and safety risks, economic harm, and a decreased quality of life. Reducing these risks will require careful evaluations of the City and regional transportation and transit systems, and long-term planning to accommodate climate change when designing bridges, roads, pathways, and transit hubs and routes. Adaptation considerations should include increasing flood construction levels on the coast and along creek systems, guaranteeing emergency access to new and existing developments, and selecting construction materials that are designed for future temperature and rainfall conditions.

Other options to increase transportation resilience include reducing personal vehicle use through land use planning and supporting transit and active transportation. However, increasing summer temperatures and winter rainfall could impact both transit and active transportation use, and more transit shelters, covered bicycle storage, and access to drinking water will be needed to maintain and increase use and participation. Opportunities for telecommuting should also be explored to reduce energy use and strain on the transportation system, and to increase safety during inclement weather.

2. Transportation, Mobility & Access

Impacts

2.1 Transportation disruptions due to landslide damage and flooding of roads, bridges, and transit hubs and depots, more frequent extreme wind and rain storms, and the disabling of traffic signals by power outages

2.2 Decreased use of transit and active transportation due to discomfort from increased temperatures and precipitation

Objectives

2.1 Minimize the risks and potential transportation disruptions from extreme weather events

2.2 Decrease climate related barriers to active transportation and transit use

Actions	Action By	Responsibility
2.1 Minimize the risk to key transportation assets (e.g. transit hubs and deports, bridges, main thoroughfares) from floods, storms, and landslides through land use and development decisions where possible, and through retrofitting/replacement and structural protection where needed	ISMP – 2014 Ongoing	Engineering, Community Development, Transportation
2.2 Minimize the risk to key transportation assets from power outages by ensuring there are adequate backup power supplies and ventilation systems for electrical equipment	2015	Transportation
2.3 Review emergency access and evacuation routes and their vulnerability to extreme weather and climate change, and ensure adequate access during emergencies for new developments	2015	Community Development, NSEMO
2.4 Develop an inventory of municipal transportation infrastructure (e.g. through Hansen software currently in use) and conduct regular risk assessments when the Transportation Plan is renewed or when new climate change information becomes available	2017	Transportation, Engineering
2.5 Investigate telecommuting options for City staff and large employers for general use and emergency preparedness	2016	HR, IT, Environment
2.6 Review and update the Long-Term Transportation plan to include climate adaptation measures, and establish a regular schedule for updating when new information becomes available	2017	Transportation
2.7 Increase the availability of transit shelters and drinking water access to promote active transportation and transit use during inclement weather	2019	Engineering, Transportation
2.8 Continue to work with Translink and the Provincial government to reduce personal vehicle use and increase the capacity and attractiveness of transit use, active transportation, and other low-carbon mobility options (e.g. equipping buses with energy-efficient air conditioning units for use when there are heat waves)	Ongoing	Transportation, Environment

6.3 Community Wellbeing

The impacts of climate change on physical infrastructure may receive more attention, but this is really just a component of the most important aspect of adaptation: maintaining and improving the health and wellbeing of the community. Climate change could have a wide range of direct and indirect health, safety, and quality of life impacts on the City of North Vancouver that will need to be addressed. The greatest challenge will be reducing the unequal distribution of climate change impacts on vulnerable population, such that no group experiences undue and significant harm. This will require careful identification, engagement, and targeted measures for vulnerable populations, such as the homeless, low income, elderly, isolated, sick, and outdoor workers. For example, more temporary shelter spaces will be needed due to more frequent extreme weather, water access in public spaces will need to be expanded to accommodate higher summer temperatures, and response plans will be required for power outages to identify and protect those most at risk.

The emergency response system must also have the resources and training to respond to more frequent emergencies, and potentially the new hazard of temporary islands isolated by flooding. Encouraging preparedness in the community will also become increasingly important. Coordination with the Fire Department, RCMP, North Shore Emergency Management Office, and Vancouver Coastal Health will also be needed to minimize the direct and indirect health and safety impacts of climate change. These could include heat and cold stress, reduced air quality, storm debris, flooding, fire, landslides, downed power lines, and new disease vectors. Continuing the City's promotion of urban and local agriculture will also become increasingly important as global food production becomes more variable. Like increasing energy efficiency, working to reduce food waste throughout the production, distribution, and consumption should be pursued as a low cost and environmentally friendly method of increasing food security.

Careful planning will also be required to guarantee sufficient funding for emergency response and cleanup, and to minimize the City's liability. This could include increasing maintenance on street trees to reduce storm damage, restrictive covenants on identified hazard lands, well documented emergency triage procedures where lower risk hazards are allowed to be left in place to respond to other emergencies, and enhanced regional and provincial coordination and funding.

3. Community Wellbeing

Impacts

3.1 Emergency staff and equipment may be inadequate to deal with higher frequency of emergencies and the increased likelihood of simultaneous emergencies
3.2 Greater impacts to vulnerable populations due to less ability to afford mitigation and adaptation actions, the inability to move to avoid risks, or more time spent outdoors
3.3 Direct health and safety effects, including heat and cold stress, UV radiation, air quality related respiratory illnesses, storm debris, downed power lines, flood, and land slide related health and injury risks
3.4 Increased emergency response and clean-up costs, and liability when response is delayed or when hazards are left in place for later clean up due to prioritizing simultaneous or larger emergencies
3.5 Increased risk of fire and a longer fire season due to decreased summer precipitation and increased temperatures, leading to increased fire prevention and suppression costs
3.6 Food insecurity due to loss of local arable lands, loss of agricultural diversity, and disruption of the supply chain
3.7 Indirect health effects from the extension in the range of disease vectors and in the environmental survival of pathogens

Objectives

3.1 Reduce the unequal distribution of climate change impacts on vulnerable population, ensuring that no group experiences undue and significant harm
3.2 Minimize the direct and indirect health impacts of climate change on the City
3.3 Increase community food security and resilience to changes in the global food supply
3.4 Maintain or improve current levels of emergency response, prevention, and preparedness
3.5 Minimize the health, safety, financial, and liability risks associated with increased climate related hazards

Actions	Action By	Responsibility
3.1 Identify populations and groups particularly vulnerable to each of the projected climate change impacts and establish a communication strategy to increase awareness, mitigation, and adaptation efforts, and to coordinate emergency response	2016	Community Development
3.2 Work with Vancouver Coastal Health (VCH) and the provincial government to improve access to drinking water, cooling stations, and temporary shelters, and assist high risk populations during extreme weather events	2019	Community Development
3.3 Partner with regional municipalities, VCH, local academic institutions, and the provincial and federal governments to investigate the health impacts of climate change, prepare strategies to prevent climate related health impacts, and conduct public education and engagement to reduce these threats	Ongoing	Community Development
3.4 Reduce the urban heat island effect through building bylaw and zoning changes, and the targeted use of parks and street trees	Ongoing	Engineering, Parks
3.5 Promote and support urban and regional agriculture, and efforts to reduce food waste throughout the production, distribution, and consumption stages	Ongoing	Environment, Community Development
3.6 Increase staff and public climate change education to raise awareness of climate related hazards, risk mitigation and preparedness	Ongoing	Environment
3.7 Continue to support and expand regional cooperation for emergency response, water supply and sewer systems, adaptation measures, and climate related hazard prevention and preparedness	Ongoing	NSEMO
3.8 Investigate and implement measures to reduce climate related hazard risks and improve emergency response, including: -building bylaws; zoning; infrastructure planning; fuel management in parks; and other policy changes	Ongoing	Engineering, Parks and Environment, Community Development, NSEMO

6.4 Natural Environment, Energy & Climate

Coastal erosion, hydrologic changes, and hotter, drier summers will all impact the City's natural ecosystems, leading to habitat loss and degradation, increasing pressure from invasive species, and stress on native species. The City's well established environmental and sustainability programs are well equipped to address these measures simply by incorporating projections of future climate. Adaptation measures could include planting different species that are more tolerant to higher temperatures and drought, and evaluating the impact of climate change on the effectiveness of restoration projects. Flood protection measures will be needed to protect coastal and riparian habitat, particular for coastal lands where development leaves little room for natural ecosystems to move inland with rising sea levels.

Because of the projected slow pace of change, careful monitoring will also be necessary to identify and respond to the environmental impacts of climate change. There will be many opportunities to take advantage of sustainability-adaptation co-benefits as well, such as protecting and restoring coastal and riparian habitat for flood mitigation and habitat protection, and expanding invasive species removal and native species planting to increase the resilience of natural ecosystems to future change.

Climate change could have dramatic impacts on energy use and GHG emission, largely due to increased cooling demand during warmer summers. Without adaptation through modified building codes and land use planning this will put additional strain on the local and provincial electricity systems, increase utility costs for City facilities and private buildings, and increase the environmental effects of energy generation. Reducing the urban heat island effect through careful park and street tree planning offers another opportunity to take advantage of co-benefits to decrease the need for cooling, increase habitat, and improve the streetscape.

4. Natural Environment, Energy & Climate

Impacts

4.1 Habitat loss and ecosystem degradation due to coastal erosion, hydrologic changes, landslides, and hotter, drier summers
4.2 Increased summer energy use, decreased energy security, and stress on utility infrastructure due to higher temperatures and more demand for cooling
4.3 Increased pressure from invasive species and stress on native species from hotter, drier summers

Objectives

4.1 Protect coastal, and riparian habitat by mitigating flood and erosion risks
4.2 Increase energy security and reduce summer energy use by pursuing aggressive conservation efforts and including climate adaptation in building bylaw and zoning policies
4.3 Maintain and improve the long-term health of natural ecosystems and native species

Actions	Action By	Responsibility
4.1 Protect coastal and riparian habitat from flooding, inundation, and erosion using the ISMP, and land use and development decisions where possible, and through structural protection where required	ISMP – 2014 Ongoing	Engineering, Parks and Environment
4.2 Promote energy efficient construction, building design and retrofits through regulation (see Action 1.6), education, and incentive programs	2017	Community Development
4.3 Continue to expand LEC connections and capacity, and investigate the feasibility of adding cooling and alternative energy sources to LEC	Ongoing	LEC
4.4 Coordinate with BC Hydro and other partners to reduce peak loads, reduce energy consumption, and promote the use of alternative energy systems through education and incentive programs	Ongoing	Environment
4.5 Review the Parks and Greenways Strategic Plan, environmental protocols, and development controls and guidelines for opportunities to include adaptation and the protection of ecosystem resilience	2017	Environment
4.6 Map ecosystem composition, diversity, and health to create a baseline for a regular, long term monitoring project to assess and respond to climate related changes	Ongoing	Environment

6.5 Parks, Recreation & Open Space

Parks and recreational spaces are more vulnerable to flooding and inundation than most other land uses because they are largely located in coastal, creek, or low lying areas. The ability of green space to protect developed lands from flooding and erosion also presents one of the greatest opportunities for co-benefits. Seizing opportunities to expand and improve coastal and riparian ecosystems and green spaces can have ecological, recreational, and flood protection benefits. Similarly, parks can be used as part of the stormwater management system to reduce flood risk and to reduce the urban heat island effect.

More frequent inclement weather, including intense precipitation and extreme heat events, will also impact outdoor activity, park use, organized sports, and other events. Providing adequate shelter, indoor recreation programs, and potentially more artificial turf fields may be necessary to maintain and expand the current level of service. Parks maintenance will also have to adapt to the changing conditions, and may require higher costs, different soil management, species selection, and invasive species and pest treatments, and pruning to reduce storm debris risk.

5. Parks, Recreation & Open Space

Impacts

5.1 Flooding, inundation, and erosion of coastal and creek parks and green spaces
5.2 Increased maintenance and replacement costs for urban forests, green spaces and trees due to extreme temperatures, precipitation and wind storms
5.3 Loss of recreational opportunities due to flooding, extreme heat, and discomfort being outdoors

Objectives

5.1 Protect coastal and riparian parks by mitigating flood and erosion risks
5.2 Continue to expand access to recreation opportunities and high quality park and outdoor recreation space
5.3 Take advantage of the adaptation benefits of parks and greenspaces to reduce flood and extreme heat risks

Actions	Action By	Responsibility
5.1 Implement flood and erosion protection measures for parks, trails, and other outdoor recreational spaces - Increased naturalization and vegetation management of coasts and cliffs; using greenspace as flooding buffer zone; structural measures such as rip rap, breakwaters, armouring, and steeper sloped beaches	Ongoing	Engineering, Parks and Environment
5.2 Review and revise the Street Tree Master Plan and Parks Master Plan to including climate adaptation considerations, including: -Soil management; species and location selection; planting, landscaping and wind management techniques; invasive species and pest management; urban heat island effect; and stormwater management	2015	Parks and Environment
5.3 Investigate the need for more artificial turf fields and park shelters and install where needed	2015	Parks and Environment
5.4 Investigate the use of parks and greenspace for stormwater management, flood protection of other lands, and storing rainfall for later irrigation	2015	Parks and Environment

6.6 Arts, Culture & Heritage

Climate change will have widespread impacts around the world, but the local effects of these changes on the art, culture, and heritage of the City are very difficult to predict. The increasing population pressure the City may experience, economic uncertainty, and cultural shifts related to the changing climate could all influence the local community. The strong sense of place on the North Shore is also tied very tightly to the climate and environment and could be affected under extreme climate change.

Engaging the public and art community to produce a cultural response to climate change and wider understanding of its impacts will help to maintain the City's sense of identity and place. This could include public art displays and community forums on sense of place and regional identity, but it will largely be the community that defines how this response is shaped. Adapting the City's many popular outdoor festivals and events to more extreme summer temperatures and winter storms will also be a major priority.

6. Arts, Culture & Heritage

Impacts

6.1 Changing economic and demographic conditions in response to climate change in other regions will affect the local economy and culture

Objectives

6.1 Maintain the City's sense of place, cultural diversity, heritage, and creative community

Actions	Action By	Responsibility
6.1 Support adaptation measures to protect art, cultural, and recreational facilities and installations, and to continue outdoor festivals and other cultural events	Ongoing	Arts Office, Parks and Environment, Facilities

6.7 Employment & Economic Development

The largest economic impacts of climate change will likely arise from direct losses due to flooding, transportation disruptions, and other climate related damage and emergencies. Several major commercial and industrial areas are vulnerable to flooding, including the Harbourside business park. Transportation disruptions related to the flooding of transit hubs and bridges would have also major impacts on the economy of the region. The flood protection measures outlined in the Land Use section above will go a long way to reducing the economic risks of climate change. The other main component will be to apply the same strict land use and building policies that apply residential buildings to commercial properties as well.

The local economy could also likely be affected by regional, national, and global economic change and uncertainty related to climate change. While the local effects of these impacts are difficult to predict, they could include changes in resource use and availability, supply chain disruptions, and increased uncertainty and volatility in the economy. Working to diversify the local economy and increase the number of jobs within the City will increase resilience to economic volatility.

7. Employment & Economic Development

Impacts

7.1 Economic losses and disruptions due to flooding, transportation disruption, and other climate related emergencies
7.2 Economic uncertainty and change in response to climate change in other regions

Objectives

7.1 Increase the City's economic resilience to climate change through economic development, diversification, and regional cooperation to prevent overreliance on any sector, vulnerable supply chain, or transportation route

Actions	Action By	Responsibility
7.1 Work with the Chamber of Commerce and Lower Lonsdale Business Associate to build climate change awareness around vulnerabilities and potential mitigation and adaptation options (e.g emergency preparedness, alternate supply chains, local materials, markets and employment)	Ongoing	Environment, Lands, Business Services
7.2 Seek out opportunities to strengthen the local economy through climate change mitigation and adaption actions (e.g. advertising the City's climate leadership and adaptation actions attract new businesses and customers)	Ongoing	Environment, Lands, Business Services

6.8 Municipal Services & Infrastructure

As with building design and land use planning, there will be an increasing need to consider natural disasters, emergency response, and future climatic conditions during the design, building, and retrofitting of City infrastructure. Ensuring that the storm and sanitary sewer systems are sized appropriately and have adequate drainage and pumping capacity will be vital to minimizing the City's flood risk. Infrastructure design, lifecycle planning, and maintenance will all need to be modified to adjust to higher temperatures, more intense precipitation, and increased weather variability. Keeping an up to date catalogue of new technologies, methods, and climate projections will also help to guide future work.

Because physical infrastructure generally has a long lifespan and plays such an important role in the functioning of the City, climate change considerations should be incorporated into all new installations, retrofits, and repairs. This should include methods of increasing durability and function, meeting changing demands, and being capable of handling more frequent and extreme weather events and emergency situations.

Climate change will also place increasing pressure on Metro Vancouver's potable water supply because of limited reservoir capacity and projections of changing snowmelt conditions and hotter, drier summers. Water conservation measures will need to be expanded throughout the region, including greywater reuse, with a potential need to increase reservoir capacity further in the future.

8. Municipal Services & Infrastructure

Impacts

8.1 Infrastructure planning and design will become increasingly unsuited to the changing climate, including more frequent climate hazards and increasing need for emergency response
8.2 Decreased durability and lifecycle, and more frequent loss of service, for civic infrastructure, property, and utilities, leading to increased maintenance and replacement costs
8.3 Increased risk of summer drought and water shortages due to decreased water supply and increased water use

Objectives

8.1 Ensure all new and retrofitted infrastructure is adapted to future climatic conditions to the end of its expected lifespan
8.2 Maintain or improve service levels related to water supply, sewers, transportation, communication and energy infrastructure

Actions	Action By	Responsibility
8.1 Investigate and apply methods of incorporating climate change considerations into infrastructure design, lifecycle planning, and maintenance that account for the climatic conditions through to the end of the lifespan	2015	Engineering, Facilities, Purchasing, Public Works
8.2 Regularly update infrastructure adaptation measures to account for new climate change information	Ongoing	Engineering, Facilities, Purchasing, Public Works
8.3 Include climate vulnerability and risks (e.g. power outages, capacity limitations, health and safety impacts, road drainage, failure) in infrastructure planning and asset management	Ongoing	Engineering
8.4 Continue to reduce per capita water use through conservation measures, water metering, assessing and fixing leaking infrastructure, encouraging use of rain barrels and other grey water use, and increased watering restriction and enforcement	Ongoing	Environment, Engineering
8.5 Investigate means of increasing greywater reuse in the City and work to overcome regulatory barriers	2015	Environment

6.9 Implementation

Beyond the sector specific actions described above, the City will make a continued effort to incorporate climate change adaptation into all of its policies and operations. Chief among these efforts will be to include long term and future climate considerations into budget, capital, risk management, and operational planning. All new and revised City policies and plans should be screened to look for opportunities to address the impacts of climate change. These efforts will undoubtedly lead to difficult decisions regarding balancing priorities and dealing with uncertainty. Developing consistent and thorough methods to evaluate long term versus short term costs and defining acceptable levels of risk and uncertainty will be a major task that will result in substantial benefits.

Regular monitoring and review of the City's adaptation actions and the state of climate science will be vital to successfully increasing our climate resilience. Climate science, and adaptation technologies and policies are progressing rapidly and it will take a concerted effort to keep up to date on the latest developments and best practices. A consistent format and regular schedule should be established to maintain a catalogue of the latest science and options for adaptation, including technologies, engineering and planning conventions, funding schemes, and engagement techniques. A regular monitoring program will also be established to record how well adaptation is being integrated in all City departments and whether the City is improving on key adaptation indicators.

Adapting municipal operations will be a major step to increasing the community's resilience, but it is only one component of what is needed to reduce the City's and region's vulnerability to climate change. The other major component will be to ongoing engagement and cooperation with community and regional stakeholders, BC Hydro and other utilities, the public, neighbouring municipalities, and First Nations. The public engagement and stakeholder consultations that took place during the plan development stage are only first steps in what must be long-term conversations and relationships.

9. Implementation

Objectives

9.1 Integrate climate adaptation into all City policies and operations
9.2 Regularly monitor and review the current state of climate science, adaptation best practices, and the City's adaptation policies and progress
9.3 Engage with City staff and local, provincial, and federal stakeholders and organizations on adaptation planning and information sharing

Actions	Action By	Responsibility
9.1 Incorporate adaptation considerations into budget, capital, risk management and operational planning to support adaptation measures and increasing resilience	2014	Finance, All (Project Managers)
9.2 Screen all City policies and plans for opportunities to incorporate climate adaptation when being revised or amended, and make necessary changes where appropriate	Ongoing	All
9.3 Continue to investigate adaptation options, including: -public-private partnerships (e.g. Weatherwise Partnership in Toronto); adaptation software (e.g. software developed in Toronto and Seattle); adaptation checklists for capital and other projects (e.g. Victoria); external funding opportunities (e.g. CARIP, FCM Green Municipal Fund, BC Hydro); new and alternative technologies	2016	Environment
9.4 Establish a standard format and location to record climate change information and projections and regularly review and record the current state of climate science (e.g. every two years) and adaptation best practices	2014	Environment, All
9.5 Revise the Adaptation Plan, and related adaptation components of other City policies and plans, on a regular basis (e.g. every three to five years) or when major changes in climate science occur	Ongoing Action by 2019	Environment
9.6 Work with Environment Canada, BC Environment, Squamish Nation, DNV, and DWV to review the adequacy of weather and environmental monitoring on the North Shore to ensure there is long term, high quality data at low and high elevations	Ongoing	Environment
9.7 Maintain record of observed climate related impacts to the City (e.g. infrastructure damage, fallen trees, flood events, liability claims, traffic disruptions) and track change over time	Ongoing	Environment, All
9.8 Continue to pursue regional solutions, information sharing, and joint participation in sustainability organizations and initiatives by collaborating with other municipalities, First Nations, and Metro Vancouver	Ongoing	Environment, All
9.9 Explore and implement engagement and cooperation measures, such as public and staff adaptation awareness campaigns, data sharing, public-private partnerships, workshops, citizen science, and regional and interagency cooperation	Ongoing	Environment

Appendix A: Glossary

Adaptation

Adaptation making adjustments in our decisions, activities and thinking to reduce the negative impacts of observed or expected climate change, or to take advantage of any benefits. Adaptation can include changes to human behaviour, or the natural or built environments.

Adaptive Capacity

Adaptive capacity is the ability to adjust to climate change, including moderating damages, taking advantage of opportunities, and coping with the consequences.
(e.g. *Can the emergency response system adjust to more frequent hazards without major costs and disruption?)*

Climate

Climate is the pattern of variability in atmospheric conditions in a given region over a long period of time, typically decades or longer. In contrast to weather which describes current atmospheric conditions (e.g. temperature, air pressure, humidity, cloudiness, precipitation), climate describes the

Climate Change

Climate change refers to the statistically significant variation in the average or variability of atmospheric conditions (e.g. temperature, humidity, wind speeds, precipitation) that persist over long periods of time, typically decades or longer. This includes shifts in seasonality (e.g. drier summers and wetter winters), diurnal patterns (e.g. nighttime warming faster than daytime), interannual variability (e.g. wetter wet years interspersed with more frequent drought years), changes in extremes (e.g. fewer days with precipitation but heavier rainfall when it does occur), and geographic shifts (e.g. the northward movement of the Pacific storm tracks). Climate change can be caused by natural processes either on the Earth (e.g. volcanic eruptions, changes in the Earth's angle of rotation), or external to the planet (e.g. solar intensity), or by human activity (e.g. greenhouse gas emissions, land use change).

FCL

The minimum Flood Construction Level is height above mean sea level above which the flood risk considered low enough to allow construction. The calculation of the FCL should take into account the higher high water level tide (HHWLT) elevation, an allowance for future sea level rise to a particular time horizon, the estimated storm surge and wave effects associated with the selected design storm, and freeboard. In British Columbia the FCL is required to be calculated using a 1 in 200 year design storm.

ICLEI

The International Council for Local Environmental Initiatives, also known as *ICLEI – Local Governments for Sustainability*, is an association of local governments that promotes environmental sustainability through local initiatives. See http://www.icleicanada.org for more information.

ISMP

An Integrated Stormwater Management Plan is an ecosystem based approach to stormwater management that balances land use planning, stormwater engineering, flood and erosion protection, and environmental protection. In contrast to traditional stormwater practices that focus solely on infrastructure, Integrated Stormwater Management attempts to imitate a natural watershed by increasing infiltration and reducing runoff through careful land use planning, protecting natural lands, and mimicking natural processes.

LEC

The Lonsdale Energy Corporation is a district energy system that provides heating to residential and commercial buildings in the City of North Vancouver. See http://www.cnv.org/City-Services/Lonsdale-Energy for more information.

Mitigation

Mitigation is the attempt to prevent climate change, and by doing so to avoid or lessen its negative impacts. Mitigation typically includes measures to stabilize or reduce atmospheric greenhouse gas concentrations and the prevention or reversal of damaging land use changes.

OCP

The Official Community Plan outlines the City of North Vancouver's long term vision, and is one of the City's most important policy documents. The OCP includes objectives and policies to guide planning and land use decisions, and aims to balance the social, environmental, and economic needs of the community. See http://www.cnv.org/Your-Government/Official-Community-Plan for more information.

Resilience

Resilience is the ability of a social or ecological system to absorb disturbances while retaining the same basic structure and ways of functioning, the same capacity for self-organization and the same capacity to adapt to stress and change. Increased resilience is the objective of adaptation actions.
(e.g. *Can we maintain a comfortable outdoor environment given changing demands, climate, and levels of development?)*

Risk

Risk is a measure of the expected outcome of an uncertain event, which is estimated by combining an event's likelihood by the expected consequence. The concept of risk helps to grapple with uncertainties and allows for the comparison of potential impacts.

Sensitivity

Sensitivity is the degree to which a system is affected by climatic conditions or a specific climate change impact.
(e.g. *How much will landslide risk increase because of higher intensity precipitation?)*

Sustainability

Sustainability is the management of our communities in a way that balances the social, economic and environmental implications of our activities in order to meet the needs of people today without compromising the ability of future generations to meet their own needs.

Vulnerability

Vulnerability refers to the susceptibility of a social or ecological system to adverse effects of climate change, and is a combination of sensitivity and adaptive capacity.
(*How susceptible is the drinking water supply to more frequent droughts?)*

Weather

Weather is the short term, day-to-day condition of the atmosphere, and can be described with respect to heat, moisture, air pressure, cloudiness, wind, sunshine, precipitation, etc.

References

Ausenco Sandwell, 2011. Guidelines for Management of Coastal Flood Hazard Land Use. Report prepared for BC Ministry of Environment.

Church, J. A., N. J. White, L. F. Konikow, C. M. Domingues, J. G. Cogley, E. Rignot, J. M. Gregory, M. R. van den Broeke, A. J. Monaghan, and I. Velicogna, 2011. Revisiting the Earth's sea-level and energy budgets from 1961 to 2008, Geophys. Res. Lett., 38, L18601

Kerr Wood Leidal Associates Ltd, 2011. Coastal Floodplain Mapping – Guidelines and Specifications. Final Report for Ministry of Forests, Lands and Natural Resource Operations (MFLNRO), Victoria, Canada: MFLNRO

Murdock, T.Q., Sobie, S.R., Eckstrand, H.D., Jackson, E. (Submitted) Georgia Basin – Projected Climate Change, Extremes, and Historical Analysis. Pacific Climate Impacts Consortium Report