Climate Change Adaptation Strategy

Acting Now for a Resilient Future

July 2017

DISTRICT OF NORTH VANCOUVER

The purpose of the Climate Change Adaptation Strategy is to coordinate and integrate District initiatives that support climate change adaptation and to incorporate adaptation considerations and longer-term thinking throughout all District activities. In doing so, the strategy will provide an opportunity to not only enhance the District's adaptive capacity and resiliency, but also reduce the long-term costs and impacts associated with climate change.

Executive Summary

Changes to precipitation and temperature and the increasing frequency and severity of extreme events are already affecting the District of North Vancouver. Taking proactive action to adjust to and prepare for anticipated changes will reduce losses, improve environmental health, and provide a host of community benefits.

Climate Change in the District

Since 1980, temperatures have increased by approximately 1.2°C, and precipitation has increased slightly. In recent years, the District has endured a number of extreme climate-related events that resulted in economic, environmental, and societal costs to the community. From 2014 to 2017, the District witnessed several events, including:

- record-setting summer temperatures, including multiple heat-wave warnings
- extreme drought conditions and unusually low snowfall amounts that reduced reservoir levels
- large regional wildfires, which resulted in poor air quality
- intense rainfall events that caused debris flooding and damaged private and public property
- unusually low snowfall levels that reduced reservoir levels and affected winter recreation opportunities

4 Types of Changes

Four major types of climatic changes are projected for the 2050s, relative to a 1980s baseline.

1. Temperature change

- average annual temperatures are projected to increase by approximately 2.9°C
- the average number of hot summer days (above 30°C) is expected to increase from 2 to 13 days per year
- the temperature of extreme hot days, expected to happen once every 20 years (a 5% chance of occurring any year), is projected to increase from 33°C to 38°C

2. Precipitation change

- average annual precipitation is projected to increase by approximately 5% overall but to decrease by 18% in summer
- precipitation is projected to fall in increasingly extreme events, with 33% more precipitation falling on very wet days (the wettest 5% of days) and 58% more precipitation falling on extremely wet days (the wettest 1% of days)
- snowpacks are projected to decrease by an average of 89%

3. Extreme weather

- changes in extremes of precipitation and temperature are projected
- wind projections are highly uncertain

4. Sea level rise

- changes in sea level are difficult to predict

Climate models are inherently uncertain, and, although they will improve, they are likely to continue to project a range of plausible futures.

Taking Action

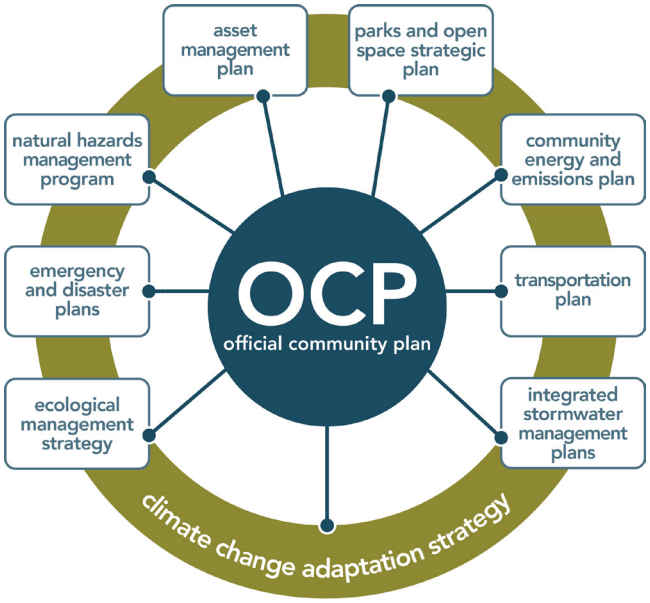
Adapting to climate change is a politically mandated direction for many levels of government, but it also makes good sense from a business, environmental, and societal perspective. Adapting proactively will not only help prepare the corporation and the community for ongoing challenges, it will also benefit municipal finances, improve environmental health, and provide a host of community benefits such as enriched public spaces and enhanced community well-being.

The District recognizes adaptation as an opportunity to increase resiliency by reducing long-term costs through risk-based asset management, proactive environmental management and protection, and enhanced public safety systems. A resilient community can continue to function amid change, and is therefore less vulnerable.

As with many other proactive measures, investing in climate change adaptation may be costly at the outset, but it is usually the most cost-effective option over time.

This Climate Change Adaptation Strategy focuses on adaptation objectives and actions. The goals of this strategy are to:

- pragmatically build upon District activities that are already occurring (related and unrelated to climate) that can help prepare the corporation and community for climate challenges
- identify new initiatives that could be developed to further strengthen the District's adaptation efforts
- bring a range of staff and community members together to collaborate on a strategy that addresses the multidisciplinary challenges posed by climate change



Ongoing Work

The purpose of the Climate Change Adaptation Strategy is to coordinate and integrate District initiatives and to incorporate adaptation considerations and longer-term thinking throughout all District activities. In doing so, this strategy will provide an opportunity to enhance the District's adaptive capacity and resiliency and reduce the long-term costs and impacts associated with climate change.

The concept of adaptation is not new to the District of North Vancouver. The District has already been working on many initiatives that support climate change adaptation. This work is ongoing and includes, but is not limited to, the following list.

- risk assessments for natural hazards (e.g., landslides and debris flows, wildfires, earthquakes, and floods)
- hazard-specific management plans and implementation strategies (e.g., the Maplewood Flood Risk Management Strategy and the Community Wildfire Protection Plan)
- Hazard and Environment Development Permit Areas to ensure new development and major renovations consider hazards and environmental protection
- long-term (40 to 50 years) asset management framework
- Geotech-on-Demand program that provides one-on-one qualified professional consulting advice to property owners concerned about slope or creek hazards on their property
- progressive development standards for buildings, infrastructure, and utilities (e.g., flood construction levels to enhance flood protection, and new Intensity Duration Frequency curves based on climate change projections)
- emergency response and recovery training for staff

12 Action Objectives and Required Actions of the Climate Change Adaptation Strategy

Action Objective 1: Strengthen the capacity to respond to and recover from extreme weather events and provide continuity of essential municipal services

RA 1.1: Complete Continuity of Operations plans to ensure delivery of priority services

RA 1.2: Develop and implement additional technological tools to assist in situational awareness and emergency response communication

RA 1.3: Provide targeted training for clerks to ensure emergency service requests and concerns are responded to in a timely manner

Action Objective 2: Ensure critical municipal functions are served by robust power systems and alternatives are provided where systems are vulnerable

RA 2.1: Identify critical functions that are vulnerable to power outages and further develop priority response and power restoration protocols

RA 2.2: Invest in backup power equipment for critical functions and develop a fueling strategy

Action Objective 3: Increase the resiliency of municipal assets to extreme weather, events, changes in precipitation and temperature, and sea level rise

RA 3.1: Complete the Integrated Stormwater Management Plan and implement recommendations to maintain watershed health and reduce the impacts of extreme runoff

RA 3.2: Update the Community Wildfire Protection Plan and implement recommendations to reduce wildfire risk and strengthen the capacity to respond

RA 3.3: Identify eco-assets, conduct risk assessment under climate change conditions, and include these in the Asset Management Plan

RA 3.4: Implement recommendations in the Debris Geohazard Risk and Risk Control Assessment for debris flood/flow creeks by integrating them into the Asset Management Plan

Action Objective 4: Support residents in proactively managing privately owned property to adapt to temperature and precipitation changes, more frequent and severe extreme weather, and sea level rise

RA 4.1: Review and strengthen building and development policies to require the consideration of climate change over the life cycle of a structure

RA 4.2: Develop and implement an education and incentive program to encourage more resilient choices for the design, maintenance, and renewal of private development

Action Objective 5: Support the long-term health of natural forest ecosystems and fire disturbance regimes

RA 5.1: Proactively manage all District-owned forested areas to increase forest resilience, health, and structure and reduce other natural hazards

Action Objective 6: Reduce the spread of invasive organisms

RA 6.1: Implement the Invasive Plant Management Strategy to manage harmful invasive plants on public and private land

Action Objective 7: Restore and protect existing native biodiversity

RA 7.1: Within a Biodiversity Conservation Strategy, generate area-specific guidelines to acquire sensitive areas, restore existing lands with native species, and increase connectivity between biodiversity hubs

Action Objective 8: Preserve and enhance the viability of ecologically sensitive areas and critical habitat along the foreshore

RA 8.1: Create and implement a Coastal Hazard Development Permit Area to protect people, property, and foreshore ecosystems from coastal impacts

Action Objective 9: Reduce potable water consumption

RA 9.1: Develop and implement programs for rainwater and grey water collection and recycling

Action Objective 10: Provide alternative water sources for emergency response

RA 10.1: Plan for the distribution of alternative potable water supply during an emergency

Action Objective 11: Upgrade preparedness and response to heat waves and poor air quality

RA 11.1: Create more opportunities for heat refuge areas

RA 11.2: Seek opportunities for interagency coordination to minimize adverse health impacts to staff, responders, and the public during heat waves and air quality advisories

Action Objective 12: Support the implementation of adaptation actions

RA 12.1: Assign specific indicators for each adaptation action to help monitor progress

RA 12.2: Integrate Required Actions into existing plans and decision-making processes to increase the likelihood of completion

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A Message from Mayor Richard Walton

On behalf of North Vancouver District Council, it is my pleasure to present our initial Climate Change Adaptation Strategy. This District-specific approach to adapting to climate change combines the latest science with regional best practices and applies these to our unique geography. As we prepare for and respond to climate change, this strategy will guide us in building resiliency throughout our organization and community.

If recent years are any indication, the impact of changing climatic patterns on our community will be varied. With prolonged, heavy rainfall and winter flooding, and with summer heat and drought, we are already experiencing the effects of a changing climate in the District. Severe weather-related events are happening more frequently, causing costly municipal response and putting our environment, property, infrastructure, health, and economy at risk. Our Climate Change Adaptation Strategy takes a proactive approach to reducing that risk and protecting the things we, as a community, value.

In addition to fulfilling commitments made in our Official Community Plan, this strategy also supports other key District programs and plans, including the Transportation Plan, Asset Management Plan, and Parks and Open Spaces Strategic Plan. It provides us with the structure to coordinate our efforts at integrating climate change adaptation into our existing policies and programs. As our scientific knowledge evolves, so will our strategy, allowing us to manage future climate change challenges efficiently.

The District is a leader in taking action on environmental and public safety issues and has done a considerable amount of work to adapt to our changing climate, particularly regarding flood, landslide, and wildfire risk reduction. There is, however, more to do.

As a corporation, we will continue to reduce our greenhouse gas emissions and do our part to slow future climate change. We will respond to the impacts we experience today and prepare for those we expect in the years ahead. To ensure a more resilient future we must act now. This Climate Change Adaptation Strategy will help us prepare for the challenges to come.

Acknowledgements

Leadership from Mayor Walton, Council, and the Executive Management Team supported the entire planning process and greatly contributed to the success of the Climate Change Adaptation Strategy. The District of North Vancouver would like to thank everyone who was involved in the development of this strategy and recognize the following individuals for their commitment to advancing climate change adaptation in the District:

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Purpose

The purpose of the Climate Change Adaptation Strategy is to coordinate and integrate District initiatives that support climate change adaptation and to incorporate adaptation considerations and longer-term thinking throughout all District activities. In doing so, the strategy will provide an opportunity to not only enhance the District's adaptive capacity and resiliency, but also reduce the long-term costs and impacts associated with climate change.

With progressive leadership from Mayor Walton and Council, the District has a strong tradition of taking action on environmental and public safety issues. While a considerable amount of work has already been done to help the District adapt to climate change, the knowledge gained through this adaptation planning process has elevated the importance of this work, and new actions have been proposed where the District can further strengthen its efforts.

This strategy's adaptation actions and implementation plans put the District in a position of readiness. The District is proud of its commitment to prepare the corporation and community for future climate-related challenges.

1 Introduction

"Adaptation is both possible and cost-effective"

—National Round Table on the Environment and the Economy, 2011

We Must Adapt

With access to high-quality services, an abundance of local and regional parks, and beautiful mountain and ocean vistas, the District of North Vancouver is recognized as one of the best places to live in North America. A key component of this livability is the District's mild climate: the summers are warm, but not too hot, and the winters are invigorating without being frustratingly extreme. However, the District's climate is changing. The impacts of climate are already affecting many of the features that make this region so livable, and these impacts are expected to increase over the next 40 years.

In recent years, the District has seen extreme rainfall damage infrastructure, severe droughts degrade the environment, and landslides threaten public safety. While these individual events cannot be directly attributed to climate change, climate change has increased the frequency of these types of events and has made them more severe when they do occur. Taking proactive action to adjust to and prepare for changes is critical to protect the District's economy, environment, and residents as well as the identity and livability of the community.

Taking action on climate change requires two simultaneous approaches: mitigation and adaptation. Mitigation prevents future climate change from happening through actions that reduce greenhouse gas (GHG) emissions. It is often regarded as the only true solution to climate change because it addresses the root cause. Mitigation is necessary to ensure that impacts do not become too severe, but adaptation is also necessary. Adaptation manages the consequences of climate change through actions that prepare for and respond to climate-related challenges and takes advantage of potential benefits of climate change. No matter how focused we are on mitigation, GHGs already in the atmosphere will result in further climate change, and adaptation is necessary to deal with these inevitable impacts.

The Science of Climate Change

The science to support climate change (often referred to as global warming) is unequivocal.[1] Although year-to-year weather conditions vary, temperatures have exhibited a clear and steady upward trend over the last 150 years, and precipitation patterns have also changed. Recent, human-caused climate change has resulted in unprecedented weather and climate across the world.

Human activities and the subsequent release of greenhouse gas emissions (GHGs) are the primary drivers of recent climate change. GHGs are compounds (such as carbon dioxide, water vapour, and methane) that trap heat in the atmosphere, warming the planet through a natural process called the "greenhouse effect."

For thousands of years, this process has maintained a favorable temperature for the proliferation of ecosystems and human civilization. However, recent human activities, such as the conversion of forests to cities and agriculture and the burning of fossil fuels for energy production, has increased concentrations of GHGs in the atmosphere. This has trapped more heat in the atmosphere, enhancing the greenhouse effect and causing climatic changes such as increased temperatures, shifted precipitation patterns, intensified storms, and sea level rise.

1 Intergovernmental Panel on Climate Change (IPCC). (2013). Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Retrieved from: www.climatechange2013.org

Extreme Weather and Climate Change

The difference between weather and climate is time. Weather refers to atmospheric conditions over a short period of time—minutes to weeks. Climate is how the atmosphere behaves over relatively long periods of time (e.g., 30 years or more). Thus, climate change refers to changes in long-term weather. This includes both averages and extremes.

Extreme weather is defined as a meteorological event that is beyond the normal range of activity.[2] Windstorms, heat waves, and droughts are classified as extreme weather events. Because these events are due to a combination of different factors, including natural variability, an individual weather event cannot be solely attributed to climate change. However, scientists have demonstrated that climate change has led to an increase in the frequency and intensity of many of these types of events over time.

Increases in extreme or unusual events are a greater challenge to plan for than general shifts in overall average temperatures or precipitation amounts. Extreme events are also more uncertain by nature, and harder to model.

2 ICLEI Canada. (2012). Changing Climate, Changing Communities: Guide and Workbook for Municipal Climate Change Adaptation. Retrieved from: www.icleicanada.org/resources/item/3-changingclimate-changing-communities

Adaptation Is an Opportunity

Adapting to climate change is a politically mandated direction for many levels of government, but it also makes good sense from a business, environmental, and societal perspective. Adapting proactively will not only help prepare the corporation and the community for ongoing challenges, it will also benefit municipal finances, improve environmental health, and provide a host of community benefits such as enriched public spaces and enhanced community well-being. The District recognizes adaptation as an opportunity to increase resiliency by reducing long-term costs through risk-based asset management, proactive environmental management and protection, and enhanced public safety systems.

A host of plans identify adaptation as a critical response to climate change. These include international agreements (e.g., the Paris Agreement[3] and the Sendai Framework for Action); provincial strategies (e.g., BC's Climate Leadership Plan) and local plans (e.g., the District's Official Community Plan and Corporate Plan). The District is working with other municipalities in the Lower Mainland on adaptation initiatives via a variety of working groups, such as Fraser Basin Council's Joint Program Committee (which focuses on preparing an integrated response to sea level rise), and is collaborating with the City of North Vancouver on integrated stormwater management. The District has joined leading cities around the world in developing and implementing a Climate Change Adaptation Strategy to integrate efforts between departments and across all levels of government.

3 United Nations. (2015). The Paris Agreement. Retrieved from: http://unfccc.int/paris_agreement/items/9485.php

Our Goals

The goals of this Climate Change Adaptation Strategy are to:

- pragmatically build upon District activities that are already occurring (related and unrelated to climate) that can help prepare the corporation and community for climate challenges
- identify new initiatives that could be developed to further strengthen the District's adaptation efforts
- bring a range of staff and community members together to collaborate on a strategy that addresses the multidisciplinary challenges posed by climate change

Climate change affects all areas of work, requiring a collaborative, multidisciplinary approach to the development of this strategy. An interdepartmental Climate Change Adaptation Team consisting of representatives from nine different District departments guided the development of the strategy. Interdepartmental working groups identified climate change challenges and solutions, which helped to bridge any gaps between departments that would otherwise have been missed. An internationally recognized municipal planning process—ICLEI Canada's Building Adaptive and Resilient Communities (BARC) program[4]—was used to facilitate the planning process.

It is imperative that the District take action to reduce the economic, environmental, and social consequences of climate change. Without immediate climate action and adequate long-term planning, these changes will intensify and have significant—and potentially irreversible—impacts.

4 ICLEI Canada. (2012). Changing Climate, Changing Communities: Guide and Workbook for Municipal Climate Change Adaptation. Retrieved from: www.icleicanada.org/resources/item/3-changingclimate-changing-communities

The Approach

Mitigation and adaptation are the two primary strategies for addressing climate change. Mitigation focuses on reducing GHGs to prevent future climate change from happening, either by reducing emissions (e.g., driving less) or improving earth's natural ability to sequester GHGs (e.g., planting trees). Adaptation focuses on preparing for and responding to the impacts posed by climate change, which includes taking advantage of any potential positive impacts (figure 1).

A key example of a mitigation approach used in the District is the integration of land use and urban form with transportation planning. Transportation emissions are a major contributor of GHGs. By encouraging use of public transportation, the District can reduce these emissions locally and contribute to global efforts to slow future climate change and limit its extent. The District has set a target, in the Official Community Plan, to reduce GHGs by 33% by 2030. Other mitigation initiatives include the Green Building Strategy, renewable energy initiatives, energy retrofit projects, waste diversion, and support for low-carbon vehicles.

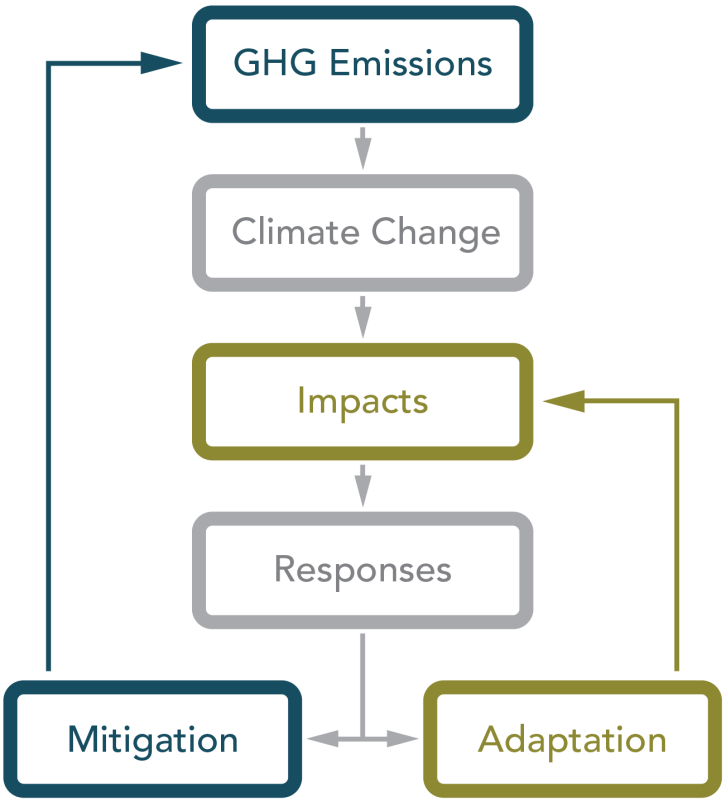


Figure 1 Mitigation actions focus on reducing greenhouse gases to prevent future climate change from happening. Simultaneously, adaptation actions focus on preparing for and responding to the impacts posed by climate change.

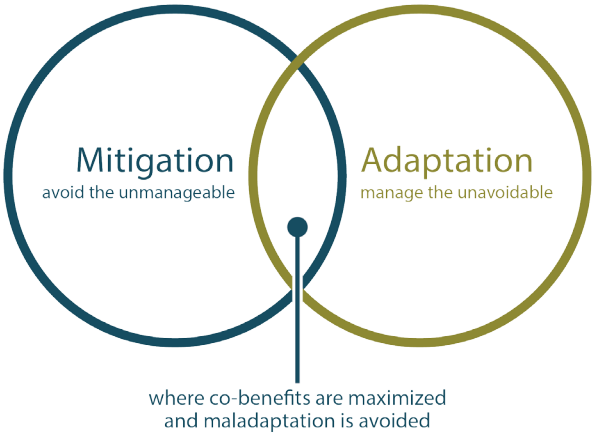


Figure 2 By integrating mitigation and adaptation approaches, co-benefits can be maximized and trade-offs minimized.

Both mitigation and adaptation approaches are needed to become resilient to climate change. On its own, adaptation will not be possible or effective enough to prepare for the global challenges posed by climate change, and mitigation alone will not be able to prevent all climate change from happening or prepare for the impacts that can no longer be avoided. Therefore, an integrated approach to mitigation and adaptation actions is required. Taken together, mitigation and adaptation will avoid the unmanageable and manage the unavoidable, while also reducing the probability of maladaptation and maximizing co-benefits (figure 2).

Some actions benefit both mitigation and adaptation objectives by providing co-benefits. Increasing the number of street trees, for example, helps to mitigate climate change because trees sequester carbon dioxide and also keep buildings cool, thereby reducing energy demand for cooling. Street trees also contribute to adaptation by intercepting and filtering stormwater runoff to prevent flooding and improve water quality.

Climate Change Benefits?

In addition to a wide range of negative impacts, climate change also has the potential to offer benefits. Part of proactive adaptation is recognizing and taking advantage of these potential benefits.

A few potential benefits were identified during the preparation of this strategy. However, the negative impacts of climate change far outweigh and largely counteract any potential benefits that the District could capitalize on. For example, although longer growing seasons could increase the potential for urban agriculture, this added benefit would likely be counteracted by less favourable agricultural conditions caused by extreme weather, such as seasonally waterlogged soils or decreased water availability. As well, though longer and drier summers could increase summer tourism, winter snowpack could decrease tourism in the winter, likely outweighing summertime tourism benefits.

Consequently, potential benefits were documented but these did not inform the adaptation actions described in this strategy.

2 Past and Future Climate Change in North Vancouver

Temperature and Precipitation

Average global air temperatures have increased by approximately 1°C since 1900.[5] In BC's South Coast region, temperatures have increased by approximately 1.2°C during this time, with winter temperatures increasing faster than summer temperatures (figures 3 and 4).[6]

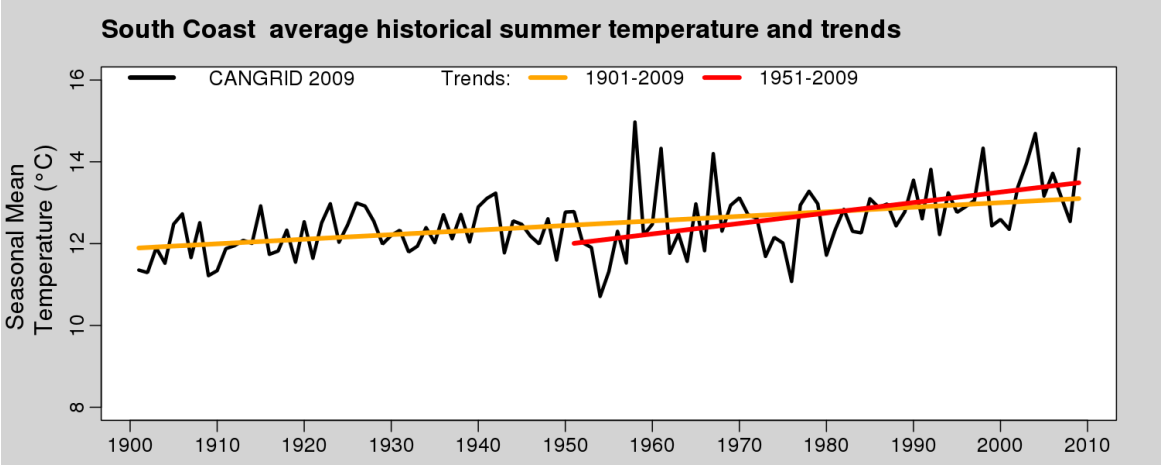


Figure 3 Historical summer temperature time series for the South Coast region of BC. Temperatures have been increasing at a more rapid rate since 1950. (Reprinted with permission from PCIC, 2013)

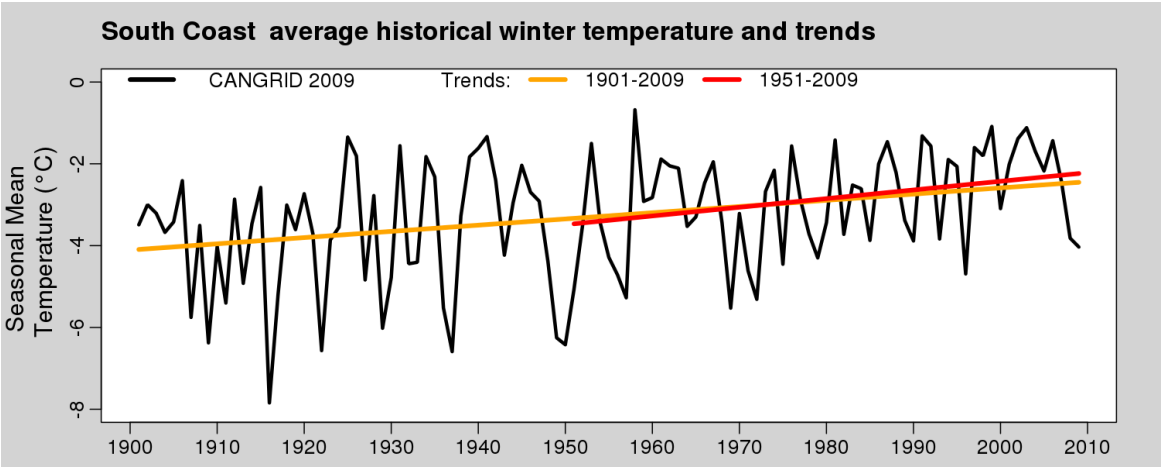


Figure 4 Historical winter temperature time series for the South Coast region of BC. Temperatures have been increasing at a more rapid rate since 1950 and rising faster than summer temperatures. (Reprinted with permission from PCIC, 2013)

5 NASA Goddard Institute for Space Studies (2017). Retrieved from: https://climate.nasa.gov/

6 PCIC (Pacific Climate Impacts Consortium) (2013). Climate Summary for: South Coast Region. Retrieved from: https://www.pacificclimate.org/sites/default/files/publications/Climate_Summary-South_Coast.pdf

Since 1900, precipitation has increased overall, but winter precipitation has decreased since 1950 (figures 5 and 6). Precipitation varies greatly by location and from year to year, much more so than temperature, so it is harder to discern clear trends with precipitation. Variation in both temperature and precipitation can be considerable throughout North Vancouver due to high levels of precipitation, proximity to the Pacific Ocean, and steep slopes.

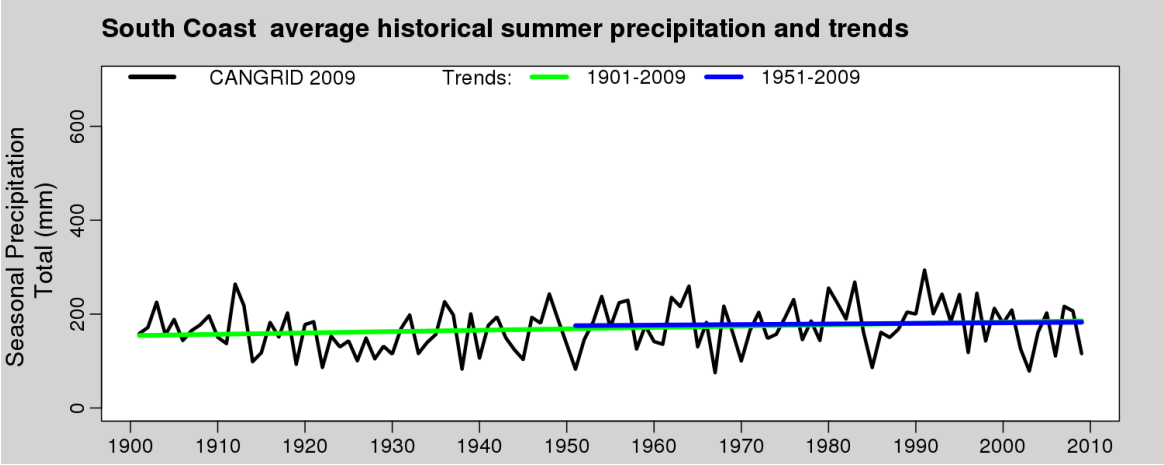


Figure 5 Historical summer precipitation time series for the South Coast region of BC. (Reprinted with permission from PCIC, 2013)

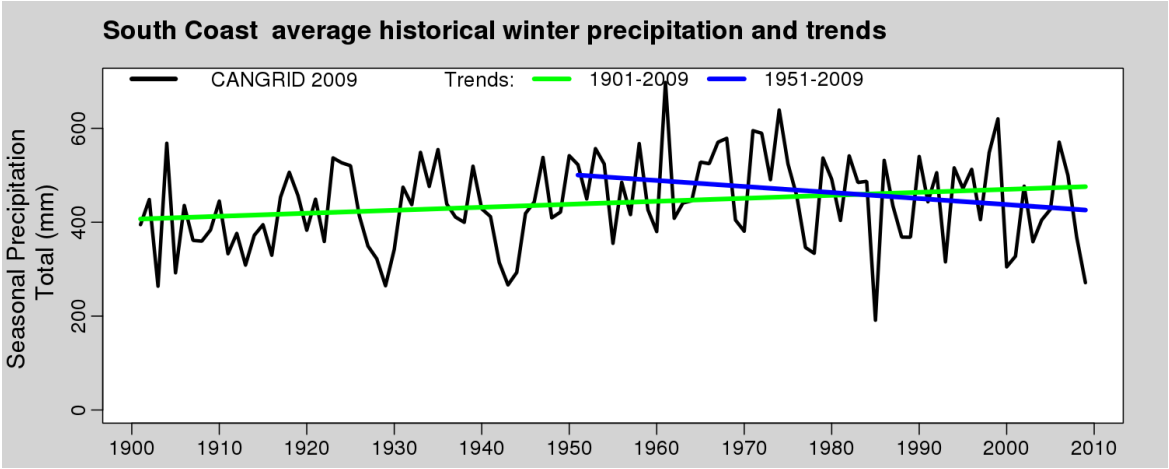


Figure 6 Historical winter precipitation time series for the South Coast region of BC. Precipitation has increased overall since 1900, but decreased from 1950-2011. (Reprinted with permission from PCIC, 2013)

Temperature and precipitation graphs illustrate that the District of North Vancouver is already experiencing climate change. In recent years, the District has endured many extreme and unusual climate-related events that have affected all District departments. These have resulted in high economic, environmental, and societal costs. For example, between 2014 and 2017, the District witnessed:

- record-setting summer temperatures, including multiple heat-wave warnings; these events increased the number of heat-related health issues among District residents, and required responses from health and district professionals
- extreme drought conditions that dropped reservoir levels to 60% capacity, requiring Level 3 water restrictions to drastically limit outdoor water use in order to conserve drinking water
- large regional wildfires, which resulted in prolonged air quality advisories
- intense rainfall events that caused flooding; in November 2014, flooding occurred as debris mobilized and creeks overflowed, damaging private and public property
- unusually low levels of snowfall, which reduced water reservoir levels and impacted winter recreation opportunities

While the historical weather observations reveal recent trends for how the climate has already changed in the District, climate models provide insight into how the climate may continue to change in the future. Climate modelling for the District, completed by the Pacific Climate Impacts Consortium, was undertaken to better understand how the District's climate is projected to change in the 2050s.

Modelling was focused on the 2050s because these are the climatic changes that will be largely unavoidable, regardless of the extent of global mitigation efforts. An ensemble of twelve global climate models (GCMs)[7] was used to assess four types of projected changes. For this ensemble, the highest-emission scenario was used, which assumes that fossil fuels continue to be burned for most energy needs. The major types of changes that were analyzed, and highlights of the results, are as follows.

1. Temperature change

- Average annual temperatures in the District are projected to increase by 1.6°C–4.2°C (with a median increase of 2.9°C) in the 2050s, relative to the 1980s baseline.[8]
- Temperature increases in North Vancouver are expected to be greatest in summer (+ ~3.6°C) and smallest in the winter (+ ~2.4°C).
- The average number of hot summer days (above 30°C) is expected to increase from twice per year (baseline) to 13 times per year in the 2050s.
- The temperature of extreme hot days, expected to happen once every 20 years (or have a 5% chance of occurring in any year), is projected to increase from 33°C to 38°C.
- Heating demand will decrease throughout the year due to warmer temperatures in the winter, but cooling demands will increase.
- There is a 68% projected decrease in the number of days with ice and a 63% decrease in the number of days with frost, which could lead to an increase in pests and invasive species.
- Agricultural opportunities may increase as a result of warmer temperatures and a longer growing season, but increases in extreme heat and decreases in soil moisture and water availability may hinder agriculture.

7 Temperature, precipitation, and indices of extremes were determined from an ensemble of 12 Global Climate Models as described at http://www.pacificclimate.org/data/statistically-downscaled-climate-scenarios (i.e., CMIP5 models following RCP 8.5 downscaled with BCCAQ)

8 A broader analysis of the larger South Coast region using 30 GCMs and multiple emissions scenarios by PCIC projected that the region's temperature will increase by 1.1°C to 2.5°C (with a median increase of 1.7°C) in the 2050s. PCIC (Pacific Climate Impacts Consortium) (2013). Climate Summary for: South Coast Region. Retrieved from: https://www.pacificclimate.org/sites/default/files/publications/Climate_Summary-South_Coast.pdf

2. Precipitation change

- Average annual precipitation in the District is projected to increase by approximately 5%.[9]
- The increase in precipitation is projected to fall in increasingly extreme events, with 33% more precipitation falling on very wet days (the wettest 5% of days) and 58% more precipitation falling on extremely wet days (the wettest 1% of days).
- Unusually high precipitation events are expected to increase by 19%. These are known as 1:20 year events, or events that have a 5% chance of happening each year.
- Precipitation is projected to increase in winter, spring, and fall, but to decrease by 18% in summer. Therefore, although overall precipitation is increasing, there may be more droughts.
- The maximum number of consecutive dry days per year is projected to increase from 19 to 23 days, on average.
- Snowpack is projected to decrease by 89% by the 2050s. Rates of decline will vary from nearly 100% near sea level to less than 30% at higher elevations, such as the tops of Grouse and Seymour mountains.

3. Extreme weather

- Changes in extremes in precipitation and temperature are projected (see above sections).
- In addition to precipitation and temperature, extremes in wind were also analyzed. Wind projections are highly uncertain, with some models indicating significant increases and others significant decreases.

4. Sea level rise

- Changes in sea level are difficult to predict. The Province of BC's sea level rise guidelines are to plan for a 1.0m increase in sea levels for 2100 and a 2.0m increase by 2200.[10]

9 A broader analysis of the larger South Coast region using 30 GCMs and multiple emissions scenarios projected that the region will be 2% to 11% wetter (with a median increase of 6%) in the 2050s. PCIC (Pacific Climate Impacts Consortium) (2013). Climate Summary for: South Coast Region. Retrieved from: https://www.pacificclimate.org/sites/default/files/publications/Climate_Summary-South_Coast.pdf

10 Sea level rise projections were determined from Ausenco Sandwell. (2011). Climate Change Adaption Guidelines for Sea Dikes and Coastal Flood Hazard Land Use. Report prepared for BC Ministry of Environment. Retrieved from: http://www.env.gov.bc.ca/wsd/public_safety/flood/pdfs_word/draft_policy_rev.pdf

Overall, these projected changes describe a future climate that is very different from what the District is used to. These climatic changes (figure 7) have the potential to threaten a wide range of District services and ecosystem health, and as a result can impact community livability and identity. See Appendix A: Summary of Detailed Climate Projections for the District for more information.

Figure 7 Common climate change impacts that can be expected as a result of four types of climatic change the District will experience.

Understanding Risk and Uncertainty

Historically, planners and engineers have looked at past conditions and used these to determine what standards to use when designing infrastructure and other systems. As the projections summarized above have illustrated, with climate change the past is no longer a good indicator of the future, and the District must be ready for conditions and events outside of the range previously experienced.

Modelling Climate

Climate models are inherently uncertain, and, although they will improve, they are likely to continue to project a range of plausible futures. Each climate model uses different parameters to model future change and these projections of change are based on different assumptions of future mitigation, or emission, scenarios (e.g., "business-as-usual" vs. "GHG-reductions" scenarios). Therefore, different climate models project different future scenarios—and thus the timing and extent of change is relatively uncertain. As well, other sources of uncertainty, such as future political priorities, population change, and economic growth, are difficult to predict, and will affect how the District must be planned, designed, operated, and maintained.

The different types of projections outlined in this section have different levels of uncertainty associated with them. Climate models are best at projecting long-term trends in average conditions over larger areas. Temperature projections have greater certainty than precipitation projections. Sea level rise projections have large associated uncertainties as they rely on temperature projections plus a number of factors related to glacier and ice sheet loss, and also location-specific factors.

The general public has a different definition of uncertainty than the scientific community. Typically, most people define uncertainty as "not knowing," while the scientific community defines it as a measure of how well something is known. The difference between the two interpretations of the word has led to significant confusion when trying to understand what is known about climate change. What is known with certainty is the cause and the direction of climate change. Therefore, while uncertainty is a challenge in adaptation planning, it is not a reason for inaction; it is a reason to prepare even more for the unknown extent and timing of changes that will be experienced.

The District must carefully consider the range of the projected changes—and not assume that future climate will land on the median or the average within any modelled scenario. This brings to light the importance of resiliency, or being able to prepare for and adjust to a range of possible futures. A resilient community can continue to function amid change.

3 The Opportunity to Proactively Adapt

Investing in Adaptation

Adapting to climate change is more than just preparing for unfamiliar weather and strange shifts in seasons. With deliberate and decisive planning, proactive action can achieve adaptation goals and simultaneously benefit multiple aspects of the community. Adaptation can even uncover the disproportionate climate impacts experienced by vulnerable populations, thereby highlighting issues such as inequality and poverty.

It is estimated that each dollar invested in adaptation now will yield from $9 to $38 of averted damages in the future (figure 8), depending on factors such as the extent of future climate change and rate of population growth.[11] As with many other preventative measures, investing in climate change adaptation may be costly at first, but over time it is usually the most cost-effective option.

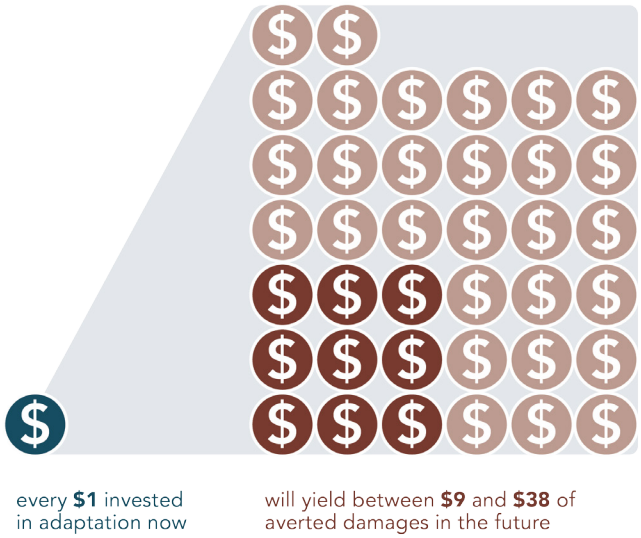


Figure 8 Investing in adaptation is cost-effective over time.

11 National Round Table on the Environment and Economy. (2011). Paying the Price: The economic impacts of climate change for Canada. Retrieved from: https://www.fcm.ca/Documents/reports/PCP/paying_the_price_EN.pdf

Infrastructure

Building infrastructure to a higher standard will require higher upfront costs but result in lower lifetime maintenance costs, longer operational lives, and reduced emergency response and public safety costs. Other economic benefits of adaptation include increased property and land values.

Planning and Management

Beyond traditional adaptation solutions like infrastructure, there are many planning and management options that help to reduce vulnerability to climate change. For example, a sea wall or a dyke is a large infrastructure solution to sea level rise, but ecosystem-based adaptation approaches are another option. Such approaches can focus on conservation, sustainable management, the restoration of green infrastructure (e.g., artificial wetland), and eco-assets (e.g., natural foreshore). In addition to helping people adapt to climate change, this adaptation approach may be less expensive and have many co-benefits for environmental health.

Ecosystem-based adaptation enhances biodiversity, which boosts ecosystem productivity and the ability of ecosystems to adapt to changing climatic conditions. This type of adaptation also increases the focus on and appreciation for ecosystem services, which will lead to increased effort to support natural and adaptable ecosystems.

Other strategies may include reorienting development away from areas that are at risk from flooding related to future sea level rise (and thus avoiding the need for flood risk mitigation measures), designing infrastructure that can accommodate flooding, or relocating (over time) existing infrastructure or neighbourhoods to other less vulnerable areas.

Adaptation in Context

Adapting to climate change has been recognized at all geographic scales, by all levels of government, as a necessary part of proactively responding to the threat of climate change.

International and Canadian Context

In 2015, along with 186 other countries, Canada endorsed the United Nations Sendai Framework for Disaster Risk Reduction (2015–2030) to reduce mortality, economic losses, and other impacts caused by natural disasters. According to the framework, "addressing climate change as one of the drivers of disaster risk … represents an opportunity to reduce disaster risk in a meaningful and coherent manner.…"[12]

The Agenda for Sustainable Development,[13] which includes a requirement for signatories to "take urgent action to combat climate change and its impacts," was agreed to by 193 countries, including Canada, in 2015.

The 2015 Paris Agreement further advanced climate change adaptation as a global priority. While the agreement's main goal was to limit global temperature rise to below 2°C, it also set out provisions for adaptation. The agreement "establishes a global goal of enhancing adaptive capacity, strengthening resilience, and reducing vulnerability to climate change with a view to contributing to sustainable development and ensuring an adequate adaptation response in the context of the temperature goal."

Provincial Context

British Columbia's 2010 Adaptation Strategy, Preparing for Climate Change,[14] sets out three strategies to "guide actions to help BC adapt to climate change." The first strategy is to "build a strong foundation of knowledge," the second is to "make adaptation part of government's business," and the third is to "assess the risks and implement priority adaptation actions in sectors."

BC's 2016 Climate Leadership Plan[15] identifies key areas where the Province can take climate action. Though the majority of the 21 actions in the plan are aimed at reducing greenhouse gases to mitigate climate change, the Province is committed to "mandating the creation of 10-year emissions reduction and adaptation plans for provincial public sector operations" to continue to support climate action leadership in the public sector.

12 United Nations Office for Disaster Risk Reduction. (2015). Sendai Framework for Disaster Risk Reduction 2015-2030. Retrieved from: http://www.preventionweb.net/files/43291_sendaiframeworkfordrren.pdf

13 United Nations. (2015). Transforming Our World: The 2030 Agenda for Sustainable Development. Retrieved from: https://sustainabledevelopment.un.org/post2015/transformingourworld/publication

14 British Columbia Ministry of Environment. (2010). Preparing for Climate Change: British Columbia's Adaptation Strategy. Retrieved from: http://www2.gov.bc.ca/assets/gov/environment/climate-change/policy-legislation-and-responses/adaptation/adaptation_strategy.pdf

15 Province of British Columbia. (2016). The Climate Leadership Plan. Retrieved from: www.gov.bc.ca/ClimateLeadership.

Regional Context

Metro Vancouver's Regional Growth Strategy[16] was adopted in 2011 and establishes five goals to "provide the basis for defining matters of regional significance … and guide the future growth of the region." Goal number three is to "protect the region's environment and respond to climate change impacts," with the 2040 vision that "Metro Vancouver and member municipalities meet their greenhouse gas emission targets, and prepare for, and mitigate risks from, climate change and natural hazards."

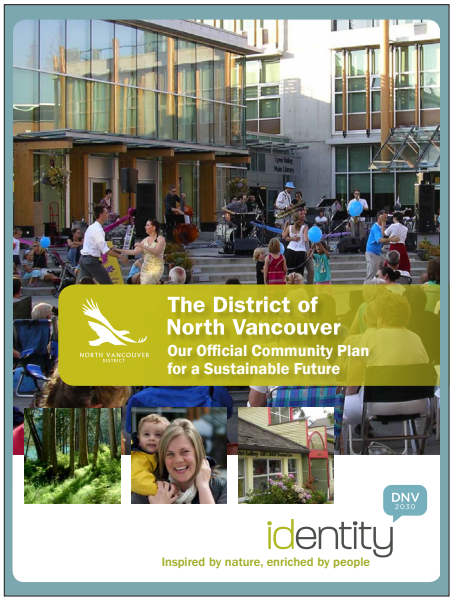
The District is an active member of the Fraser Basin Council's Joint Program Committee, working with other municipalities and the Province of BC to assess hazards, risk, and vulnerabilities, and then develop a mitigation plan for both coastal flooding due to sea level rise and riverine flooding from the Fraser River.

Adaptation in the District

The concept of adaptation is not new to the District of North Vancouver. The District has already been working on many initiatives that support climate change adaptation. This work is ongoing and includes, but is not limited to, the following list.

- risk assessments for natural hazards (e.g., landslides and debris flows, wildfires, earthquakes, and floods)
- hazard-specific management plans and implementation strategies (e.g., the Maplewood Flood Risk Management Strategy and the Community Wildfire Protection Plan)
- Hazard and Environment Development Permit Areas to ensure new development and major renovations consider hazards and environmental protection
- long-term (40 to 50 years) asset management framework
- Geotech-on-Demand program that provides one-on-one qualified professional consulting advice to property owners concerned about slope or creek hazards on their property
- progressive development standards for buildings, infrastructure, and utilities (e.g., flood construction levels to enhance flood protection, and new Intensity Duration Frequency curves based on climate change projections)
- emergency response and recovery training for staff

16 Metro Vancouver. (2011). Regional Growth Strategy: Metro Vancouver 2040 Shaping Our Future. Retrieved from: http://www.metrovancouver.org/services/regional-planning/PlanningPublications/RGSAdoptedbyGVRDBoard.pdf



Official Community Plan

The District's 2011 Official Community Plan (OCP)[17] places significant value on the environment. The OCP was developed as an Integrated Community Sustainability Plan, and it incorporates the environment it in its long-term vision: "Inspired by nature, enriched by people." Section 10.4 in the OCP identifies the need to "adapt proactively to climate change … which means integrating a climate change perspective into our infrastructure design and maintenance, ecosystem management and emergency preparedness." Several other sections within the OCP indirectly reference the consideration of climate change impacts. For example, Section 9.4 of the OCP aims to "reduce and mitigate the risk associated with natural hazards," and Schedule B guides the implementation of Development Permit Areas to protect development projects from natural hazards such as wildfire, slope, and creek hazards as well as ensure the protection of natural environment and streamside areas.

Corporate Plan

The District's 2015–2018 Corporate Plan[18] identifies 11 strategic priorities to "move the District closer to the shared vision of the community expressed in the Official Community Plan, and to fulfill the District organization's mission for service and leadership." Priority 10 includes a commitment to take action on climate change, with the goal of preparing "for the effects of climate change by reducing greenhouse gas emissions and developing and implementing a Climate Change Adaptation Strategy."

17 District of North Vancouver. (2011). Our Official Community Plan for a Sustainable Future. Retrieved from: https://www.dnv.org/sites/default/files/edocs/complete-official-community-plan.pdf

18 District of North Vancouver. (2016). 2015-2018 Corporate Plan. Retrieved from: https://www.dnv.org/sites/default/files/edocs/Corporate-plan-2015-2018.pdf

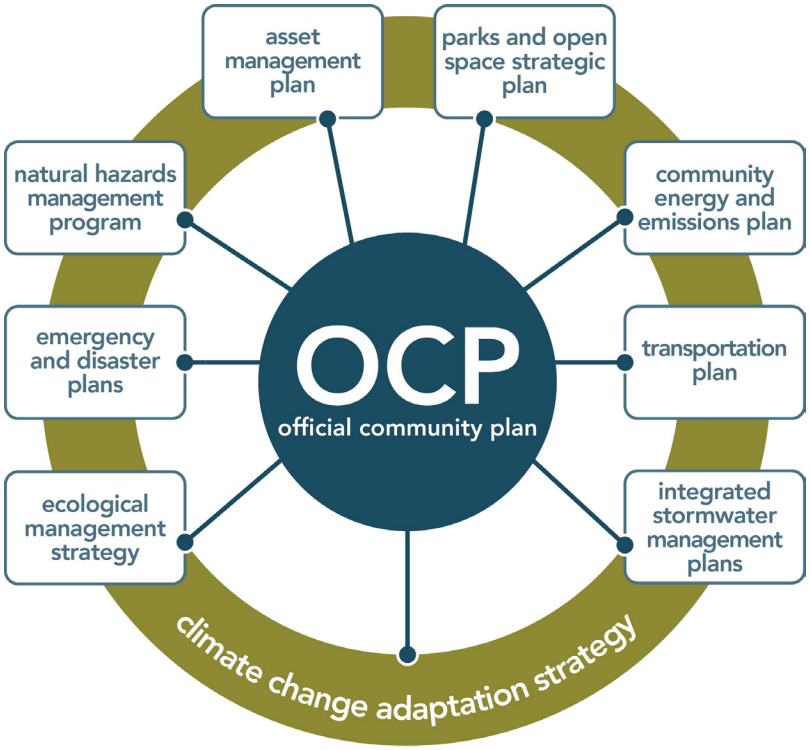


Figure 9 The Climate Change Adaptation Strategy will inform and support other programs and plans to incorporate adaptation considerations and longer-term thinking throughout all District activities.

United Nations Recognition

In 2011 the District received the United Nations Sasakawa Award for Excellence in Disaster Risk Reduction. The District is also recognized as a "Role Model City" as part of the UN's Resilient Cities Campaign; nearly 3,500 cities have joined the campaign.[19] This recognizes the District as a Canadian leader in disaster risk reduction, having made the commitment to continue to analyze and reduce local disaster risk and to inspire and support other cities to increase their own efforts in implementing disaster risk reduction measures.

Proactive adaptation, as set out in this strategy, will help to fulfill the District's commitments and help further its role as a leader in the disaster risk reduction and climate change adaptation fields.

Coordination and Leadership

The purpose of the Climate Change Adaptation Strategy is to coordinate and integrate District initiatives and to incorporate adaptation considerations and longer-term thinking throughout all District activities (figure 9). In doing so, this strategy will provide an opportunity to enhance the District's adaptive capacity and resiliency and reduce the long-term costs and impacts associated with climate change.

19 United Nations Office for Disaster Risk Reduction. (2011). Local Government Profile: North Vancouver – Canada. Retrieved from: -http://www.unisdr.org/campaign/resilientcities/home/cityprofile/City%20Profile%20Of%20North%20Vancouver/?id=2237

The Planning Process

The District of North Vancouver joined ICLEI Canada's Building Adaptive and Resilient Communities (BARC) program in January 2015 to develop the District's first Climate Change Adaptation Strategy. This followed approval by District Council in November 2013.[20]

The BARC program is an internationally recognized planning process that guides municipalities through developing, implementing, and monitoring a Climate Change Adaptation Strategy to proactively prepare for local climate-related challenges. The program provides a structured, five-milestone approach to adaptation planning where each milestone builds off the findings of the previous one (figure 9). The five milestones of the program are outlined in ICLEI's *Changing Climate, Changing Communities: Guide and Workbook for Municipal Climate Change Adaptation*.[21]

The BARC program is considered a best practice and has been widely adopted by government organizations in the Lower Mainland and across Canada. Throughout the planning process, the District took every opportunity to tailor each milestone of the BARC program to capture the District's unique situation and priorities.

20 Report to Committee Edoc No. 2221578

21 ICLEI. (2010). Changing Climate, Changing Communities: Guide and Workbook for Municipal Climate Change Adaptation. Retrieved from: http://www.icleicanada.org/resources/item/3-changing-climate-changing-communities

Milestone 1: Initiate

Climate change affects all areas of work, requiring the development of this strategy to use a collaborative, multidisciplinary approach. The District's Climate Change Adaptation Team comprised nine experienced Staff members from across the corporation, each bringing a unique perspective to the planning process. In-depth interviews were held with the four General Managers to gain understanding of expectations from senior management.

Milestone 2: Research

Climate modelling for the District was completed by the Pacific Climate Impacts Consortium (PCIC) to assist the District's understanding of how climate may change by the 2050s. Modelling was focused on the 2050s because these are the climatic changes that will be unavoidable, regardless of the extent of global mitigation efforts. An ensemble of twelve global climate models was used to assess projected changes in temperature, precipitation amounts, precipitation timing, changing precipitation patterns, extreme weather events of greater frequency and severity, and sea level rise.

Climate impacts were prioritized based on a comprehensive risk assessment. The risk posed by each climate change impact was assessed by determining the likelihood of the initiating climatic event and the likelihood of an impact caused by the occurrence of the event as well as the extent of potential consequences. The high-risk climate change impacts ranked highly in both likelihood and consequence, and thus became the priorities for action planning.

Milestone 3: Plan

Staff working groups used the results of assessment completed in Milestone 2 to consider hundreds of primary and supporting actions to proactively respond to high-risk climate change impacts. Many of the actions support and enhance ongoing work at the District and will focus efforts to further protect infrastructure, environment, and people. A structured decision-making framework was utilized to prioritize required actions (high benefit-to-cost ratio and should be implemented as soon as possible), opportunistic actions (medium benefit-to-cost ratio and should be implemented when opportunity arises), and possible actions (unknown benefit-to-cost ratio and may be implemented in the future).

Milestone 4: Implement

Most of the adaptation actions build on existing work that is well underway, such as leading-edge asset management and natural hazard management programs. The actions identified in this strategy can be integrated into existing programs and will assist in elevating, focusing, and coordinating work across multiple departments. A draft implementation plan has been created for each action and includes departmental leads, target completion dates, and references to relevant documents. The departmental leads identified for each priority action are responsible for implementing actions by incorporating them into departmental plans, asset management plans, and financial planning processes.

Milestone 5: Monitor/Review

To assist in the successful implementation of this strategy, a list of potential indicators for each priority action is included that will help monitor progress over time. The Climate Change Adaptation Team will carry out an annual review and evaluation of the strategy, which will involve documenting observed climatic changes or impacts in the District, successfully implemented actions, barriers to the implementation of actions, new sources of funding, and windows of opportunity for climate action. As the strategy is a living document and the climate is constantly changing, the Climate Change Adaptation Team will conduct a formal review and update process every five years to identify and implement new actions.

4 Taking Action

The following vision and guiding principles helped to direct the development of this Climate Change Adaptation Strategy to meet the challenges of climate change in the District. These were determined by the Climate Change Adaptation Team as part of Milestone 3 of the planning process.

Vision

We are proactive and resilient, adapting to a changing climate while balancing social, economic, and environmental priorities.

Guiding Principles

To achieve this vision, the strategy was guided by the following principles:

- Demonstrate proactive climate leadership
- Actively engage through meaningful collaboration and partnerships
- Foster shared responsibility for climate action
- Commit to ongoing learning and training to support forward thinking
- Consider current climate science, ways of knowing, and best management practices in all decision making
- Use a risk-based approach to manage uncertainty associated with climate change
- Integrate adaptation considerations throughout all District activities

From Climate Impacts to Action Objectives

This strategy focuses on four types of climatic change: temperature change, precipitation change, extreme weather (temperature, precipitation, wind), and sea level rise. With an understanding of these types of change and their associated uncertainties, interdepartmental working groups considered how the future climate will impact the District's infrastructure, environment, staff, residents, and responders.

Climate impacts were prioritized based on the results of a comprehensive risk assessment. The risk posed by each climate change impact was assessed by determining the likelihood of the initiating climatic event (e.g., drought) and the likelihood of an impact caused by the occurrence of the climatic event (e.g., reduced potable water) as well as the extent of potential consequences across five general dimensions: public health and safety, local economy and growth, community and lifestyle, environment and sustainability, and public administration and governance. High-risk climate change impacts were those that had a high combined likelihood score and high total consequence score; these were used to focus the District's efforts during action planning.

The following table provides a summary of the major impacts expected in the District of North Vancouver. For each impact, the underlying type of change and the effect of that change are also noted. Action objectives were created to describe the District's intent for how each climate impact should be addressed. These action objectives then guided the development of adaptation actions.

Summary of Impacts and Action Objectives

Cause + Effect	Priority Climate Impact	Action Objective
More staff responding to and recovering from more frequent and severe (and at times simultaneous) extreme weather events	Delayed delivery of important municipal services	1. Strengthen the District's capacity to respond to and recover from extreme weather events, and provide continuity of essential municipal services
Damaged and/or downed power lines and hydro poles due to more frequent and severe windstorms	More power outages	2. Ensure critical municipal functions are served by robust power systems and alternatives are provided where systems are vulnerable
More frequent and severe dry events (e.g., fires, droughts, windstorms) More frequent and severe wet events (e.g., urban/overland/ coastal floods, landslides, debris flows, and erosion)	Increased damage to public, private, and recreational property Increased damage to infrastructure, such as buildings, park facilities, water/ sewer systems	3. Increase the resiliency of municipal assets to more frequent and severe extreme weather and sea level rise 4. Support District residents in proactively managing privately owned property to adapt to more frequent and severe extreme weather and sea level rise
More frequent and severe wildfires due to warmer, drier weather	Loss of forest ecosystems and tree canopy and subsequent increased risk of landslide and debris flow	5. Support the long-term health of natural forest ecosystems and fire disturbance regimes
Spread of invasive organisms due to warmer, drier weather	Reduced native biodiversity, natural ecosystems less productive or resilient	6. Reduce the spread of invasive organisms 7. Restore and protect existing native biodiversity
Increased coastal floods, erosion, saltwater intrusion, and storm surges	Decreased quantity and quality of foreshore ecosystems	8. Preserve and enhance the viability of ecologically sensitive areas and critical habitat along the foreshore
More frequent and severe droughts due to reduced summer rain and winter snowpack	Reduced quantity and quality of potable water	9. Reduce potable water consumption 10. Provide alternative water sources for emergency response
More frequent and severe heat waves and wildfires due to warmer, drier weather	More heat-related and air quality–related health issues	11. Upgrade the District's preparedness and response to heat waves and poor air quality
All		12. Support the implementation of adaptation actions

Adaptation Actions

The District used a multi-criteria analysis to evaluate the robustness, ancillary benefits, and available funding sources for each adaptation action.

- Required action = high benefit-to-cost ratio and most resources for implementation are available. These should be implemented as soon as possible.
- Opportunistic action = medium benefit-to-cost ratio and resources for implementation are likely available. These should be should be implemented when the opportunity arises or the urgency of the climate impact increases.
- Possible action = unknown benefit-to-cost ratio and resources to support implementation have not been identified.

The following actions are categorized by District service area.

Municipal Services

The District's ability to maintain current day-to-day operations and services is being affected by climate change. Extreme weather events cause staff priorities to be redirected to emergency response and recovery, and other municipal services are delayed as a result.

The following actions focus the District's efforts on continuing to provide high-quality municipal services and demonstrating fiscal accountability while preparing and responding to climate change impacts.

Action Objective 1: Strengthen the capacity to respond to and recover from extreme weather events and provide continuity of essential municipal services

Required Action 1.1 *(completion target: 2020)*

- Complete Continuity of Operations plans to ensure delivery of priority services

A business impact analysis is needed for each department, to inform the development of Continuity of Operations plans. Continuity of Operations plans ensure delivery of priority services during emergency response and recovery phases.

To further ensure delivery of priority services, the District could improve its understanding about the capacity of local responders who live on the North Shore and develop a formal strategy to fill responder positions during an emergency. In addition, the District could facilitate more cross-training between departments so that resources can be shifted to any critical functions that may be overwhelmed during an emergency.

Required Action 1.2 *(completion target: 2018)*

- Develop and implement additional technological tools to assist in situational awareness and emergency response communication

The District relies on a number of resources to assist in situational awareness and emergency response communication during and after an emergency. For example, the District uses a supervisory control and data acquisition (SCADA) system for remote monitoring and control of pump stations, tracks municipal vehicle movement via GPS, and has access to the Rapid Notify emergency notification system to communicate efficiently with residents and businesses.

Additional technological tools may be needed to strengthen the District's capacity to respond to and recover from extreme weather events. Further research and option analysis is needed before making investments in technological tools, but the following are some potential options:

- purchase a computerized maintenance management system (CMMS) to report service requests
- contract drone operators to assist in rapid damage assessment
- complete the refinement of the damage assessment program
- develop a tri-municipal operating system or system of systems (geospatial and document sharing platform) to provide situational awareness across all three municipalities on the North Shore, thereby improving efficiency when the Emergency Operations Centre is activated

Required Action 1.3 *(completion target: 2017)*

- Provide targeted training for clerks to ensure emergency service requests and concerns are responded to in a timely manner

Clerks are often the first line of communication with the public. Providing targeted training for clerks on how to respond to public concerns during an emergency will ensure emergency service requests and concerns are responded to in a timely manner.

Opportunistic Actions

- Update intermunicipal response agreements to enhance resource sharing with City of North Vancouver and District of West Vancouver
- Consider standing agreements with local service providers to increase availability of equipment for response activities
- Include clearly defined emergency response roles in job descriptions and provide associated training programs
- Generate hazard-specific response strategies (for initial response, sustained response, and recovery phases) to enhance coordination and expedite response
- Engage in public awareness and education to encourage residents to be prepared for emergency situations

Possible Actions

- Develop an overtime protocol to identify emergency response positions in the union that qualify for overtime and under what situations such costs are recoverable
- Evolve the volunteer program to include volunteers from affiliated municipalities
- Plan for convergent volunteer management for people who want to help but have not previously been trained or screened
- Participate in (or initiate) regional response protocols and/or integrated systems that allow local governments in the Lower Mainland to efficiently and effectively share and allocate resources in the event of emergencies

Action Objective 2: Ensure critical municipal functions are served by robust power systems and alternatives are provided where systems are vulnerable

Required Action 2.1 *(completion target: ongoing)*

- Identify critical functions that are vulnerable to power outages and develop priority response and power restoration protocols

Energy needs for critical infrastructure and functions that are vulnerable to power outages must be identified and analyzed for interdependencies, co-location, and consequence of loss. Critical road intersections, sewage lift stations, water pump stations, the public works operations center, vulnerable population facilities (such as long-term care facilities, seniors' facilities, daycares), telephones, building and data security, and critical equipment are types of assets that could be vulnerable to power outages.

Once critical infrastructure and functions have been identified, priority response and power restoration protocols must be developed. These protocols could include regularly inspecting and maintaining emergency power sources and updating the priority power restoration list provided to BC Hydro to ensure that critical infrastructure is the top priority.

Required Action 2.2 *(completion target: ongoing)*

- Invest in backup power equipment for critical functions and develop a fueling strategy

Alternatives for power generation must be provided for vulnerable systems. Systems in municipal buildings that are currently served by backup generators must be analyzed and reprioritized.

Opportunistic Actions

- All power generator sets need to include a long-term fueling strategy

Possible Actions

- To contribute to climate mitigation efforts, the District could consider purchasing alternatively fueled (e.g., solar or natural gas) power generator sets

Infrastructure and Systems

The District is responsible for providing and maintaining approximately $2 billion worth of community infrastructure and systems (including transportation, sanitary, drainage, and water systems). These assets have long operational lifetimes and will be vulnerable to changing climatic conditions; some are already vulnerable due to changes that have occurred over the past 50 years. Much of the District's municipal infrastructure was constructed in the 1950s and 1960s and was designed to the standard of the day. Previous renewal and replacement programs were based on the condition of the asset; current programs now consider future demand and capacity.

Changing weather conditions and sea level rise are damaging grey infrastructure (e.g., buildings, park facilities, stormwater drainage), green infrastructure (e.g., green roofs and rain gardens), and eco-assets (e.g., forests and foreshore ecosystems).

The following actions focus the District's efforts to reduce the direct-damage losses to public and private assets caused by climate change.

Action Objective 3: Increase the resiliency of municipal assets to extreme weather events, changes in precipitation and temperature, and sea level rise

Required Action 3.1 *(completion target: ongoing)*

- Complete the Integrated Stormwater Management Plan and implement recommendations to maintain watershed health and reduce the impacts of extreme runoff

Stormwater has been managed by directing it to storm sewers and then into streams, creeks, and rivers. However, as the climate continues to change, the volume of stormwater is increasing. This can lead to greater erosion of stream, creek, and river banks, downstream flooding, ecological damage and habitat loss, and decreased water quality.

The District is currently developing an Integrated Stormwater Management Plan for each of its watersheds to guide stormwater management, with the goal of balancing land use and development planning with environmental concerns. For shared watersheds that cross municipal boundaries, the District is collaborating with the City of North Vancouver. Once these plans are complete, the District should implement recommendations and monitor and review each plan on an ongoing basis to maintain watershed health and reduce the impacts of extreme runoff.

Required Action 3.2 *(completion target: 2017/ongoing)*

- Update the Community Wildfire Protection Plan and implement recommendations to reduce wildfire risk and strengthen the capacity to respond

In 2007, the Community Wildfire Protection Plan assessed and made recommendations to reduce wildfire risk in the District. The District implemented most of the recommendations in the plan, including those regarding fuel treatments, development planning, public education, and wildfire suppression response.

Remaining recommendations should be implemented and the plan must be updated to account for an altered forest structure resulting from climate change and changes to the wildland urban interface areas through new development. Additionally, the plan requires the assessment and maintenance of areas that have been treated, identification of secondary areas that would benefit from treatment or ecosystem restoration to promote forest adaption, health, and resilience, and preparation of a post-fire rehabilitation plan. Once the Community Wildfire Protection Plan is updated, the administrative and reporting requirements within the Wildfire Hazard Development Permit Area should be amended.

Required Action 3.3 *(completion target: 2018/ongoing)*

- Identify eco-assets, conduct risk assessment under climate change conditions, and include these in the Asset Management Plan

The District has many eco-assets (e.g., foreshore and wetlands) that reduce the need for grey infrastructure (e.g., sea walls and stormwater drainage systems) and that may cost less to operate and maintain over the long term. The natural environment is also of prime importance to livability, and the District has begun to invest in the protection and enhancement of eco-assets by integrating them into the same asset management program as grey infrastructure. Work is needed to identify all eco-assets within the District, conduct a risk assessment under climate change conditions to better understand how eco-assets increase resiliency to climate change (and will be impacted by climate change), and further integrate these findings into the District's Asset Management Plan.

Required Action 3.4 *(completion target: 2018/ongoing)*

- Implement recommendations in the Debris Geohazard Risk and Risk Control Assessment for debris flood/flow creeks by integrating them into the Asset Management Plan

The Debris Geohazard Risk and Risk Control Assessment (2017) provided an assessment of debris geohazard risk and conceptual risk control options for creeks within the District. The study included 35 creeks prone to debris-related hazards. The majority of the study focused on the urban creeks drained by the District's stormwater management network, to support risk reduction planning for these areas. The risk control assessment summarized options to reduce economic and safety risks to tolerable levels and provided guidance in selecting options to provide the greatest reduction of risk for the lowest life-cycle cost. The assessment included risk-control design considerations applicable to all creeks and general guidance for sediment management and the design of culvert inlet debris barriers and trash racks. The next steps are to determine which of the study's recommendations should be implemented, inform and educate identified property owners about debris flood risks and options for risk reduction, and integrate recommendations into the District's Asset Management Plan.

Opportunistic Actions

- Develop and implement an Urban Forest Management Plan that focuses on growing resilient trees and maintains or improves canopy cover in urban areas (possibly considering tree species better suited for a warmer climate)
- Improve the current Inflow and Infiltration program to reduce inflow and infiltration of stormwater into the sanitary sewer system in order to reduce the risk of sewer overflows
- Increase the permeability of lands wherever possible, by minimizing asphalt and concrete, conserving land, and potentially considering permeable paving materials
- Consider climate change in the design of municipal infrastructure (e.g., consider passive house principles, building-envelope continuity, and green roofs)
- Invest in additional fire suppression equipment, training, and North Shore collaborations to strengthen the capacity to respond to wildland-urban interface fires

Possible Actions

- Review the Development Servicing Bylaw and street plant policy to require on-site and off-site landscaping to be resilient to both drought and flood
- Develop and implement a long-term coastal flooding risk management strategy and consider the Green Shores approach to sustainable shoreline development

Action Objective 4: Support residents in proactively managing privately owned property to adapt to temperature and precipitation changes, more frequent and severe extreme weather, and sea level rise

Required Action 4.1 *(completion target: 2018)*

- Review and strengthen building and development policies to require the consideration of climate change over the life cycle of a structure

A development projects built today must be able to withstand the climatic changes that it will experience over its entire life cycle. Currently, the District has a number of building and development policies, bylaws, guidelines, and regulations that guide development in the District. These should be reviewed and strengthened to require private projects to consider future climate change over the structure's life cycle. Additional research and analysis is needed to determine the best course of action, but the following are a few examples of building and development policies that could be amended:

- the Creek Hazard Development Permit Area could be updated to require appropriate drainage to accommodate future changes in precipitation
- the Development Servicing Bylaw could include alternative water storage systems
- a comprehensive set of residential guidelines for foreshore development could be created that would emphasize green infrastructure methods and adapt development to sea level rise
- the District could encourage or require passive power sources in private homes and new development to further mitigate climate change by reducing energy use and greenhouse gas emissions
- a "climate impacts checklist" (or similar assessment) could be required for new developments to identify current and potential vulnerabilities and proactive adaptation measures

Required Action 4.2 *(completion target: 2020)*

- Develop and implement an education and incentive program to encourage more resilient choices for the design, maintenance, and renewal of private development

The District has a limited number of educational and incentive initiatives to encourage more resilient choices for the design, maintenance, and renewal of private development. The District's Green Building Strategy includes an incentive program, which permits increases in the maximum floor space for single-family residential buildings when these meet the required building and energy performance baselines. The Geotech-on-Demand program provides one-on-one qualified professional consulting advice to property owners concerned about slope or creek hazards on their property.

Additional education and incentive programs are needed to encourage the public, developers, and architects to make more resilient development choices. For example:

- education programs could be developed to educate contractors, landscapers, and strata corporations about FireSmart siding, roofing, and landscaping choices to reduce the risk of fire damage
- incentive programs could be created to encourage homeowners to use green infrastructure, maintain perimeter drainage, upgrade older homes, or request wildfire risk assessments
- a process could be developed to administer incentives (e.g., waived permit fees, fast-tracked applications, a rebate program) for property owners, developers, and architects who are making resilient choices
- additional research could be completed about incentives provided by other local governments

Possible Actions

- Densify development in resilient areas and reduce development in vulnerable and greenfield areas (which will require ongoing resources for proactive adaptation and emergency response)

Parks and Environment

The District possesses a variety of invaluable and irreplaceable eco-assets, from saltwater marshes to alpine meadows, many of which are expected to be significantly altered by climate change.

The health of forested ecosystems is being disturbed by wildfire and insect outbreaks due to warmer and drier weather. More intense precipitation and wind storms are causing higher soil saturations that contribute to tree blowdowns, particularly those trees with shallow roots. Foreshore habitat is being affected by coastal flooding, erosion, and saltwater intrusion due to sea level rise and more frequent and intense storm surges. Over time a phenomenon called "coastal squeeze" is likely to occur, where intertidal ecosystems are lost because sea level rise has left little room between the ocean and coastal development for these ecosystems to adapt by migrating inland.

As temperature and precipitation regimes shift, critical habitats are no longer able to thrive and species are subsequently lost. Many species are unable to adapt fast enough to changing conditions while more robust invasive organisms gain a foothold in the ecosystem and out-compete or exclude native organisms. Additionally, changing climatic conditions are limiting the function and availability of ecosystem services such as water purification, flood mitigation, soil regeneration, and recreational opportunities.

The following actions focus the District's efforts on building ecological resilience to climate change by supporting natural and adaptable ecosystems.

Action Objective 5: Support the long-term health of natural forest ecosystems and fire disturbance regimes

Required Action 5.1 *(completion target: 2018)*

- Proactively manage all District-owned forested areas to increase forest resilience, health, and structure and reduce other natural hazards

The District is reducing the potential for fire to spread rapidly by removing excessive ladder fuels (small trees and brush that can help a fire spread from the ground to the tree canopy) and accumulations of organic materials that build up on the forest floor. The work is designed to be sensitive to streamside and forested ecosystems. Riparian and wetland areas are flagged before work starts and monitored to limit disturbances as much as possible. After work is completed, a mixture of native shrubs and trees suitable for site conditions are considered for replanting, to help restore the natural biodiversity of the area and replace non-native invasive plant and tree species that may colonize and prevent natural native regeneration from occurring. Additional proactive work is required on all District-owned forested sites, including areas beyond the wildland-urban interface, to increase forest resilience, health, and structure, and to simultaneously reduce other natural hazards (e.g., the increased risk of landslides following the wildfire season).

Opportunistic Actions

- Strengthen communication and education with the public about the economic, ecological, and social benefits of proactive management of the District's forested areas
- Partner with regional First Nations to explore approaches for understanding and managing forested areas

Possible Actions

- Invest in professional review of the District's forested areas and in post-treatment monitoring of proactively managed forested areas to assess the effectiveness of management approaches

Action Objective 6: Reduce the spread of invasive organisms

Required Action 6.1 *(completion target: 2025)*

- Implement the Invasive Plant Management Strategy to manage harmful invasive plants on public and private land

The District has been actively managing invasive plants on public land since 1998, and in 2015 developed an Invasive Plant Management Strategy to manage harmful invasive plants on public and private land. The strategy provides a framework and policy for strategic management of invasive plants in the District to meet the goals of awareness, prevention, detection, treatment, and restoration. The strategy provides a prioritized sequence of actions to accomplish its goals and objectives.

Opportunistic Actions

- Create new and align existing policies to support the Invasive Plant Management Strategy (e.g., update the Pesticide Use Control Bylaw to clearly include invasive organisms and standardize the bylaw application form; create a new policy on reporting requirements for priority-listed invasive organisms)
- Develop and implement additional management strategies for invasive organisms not identified in the Invasive Plant Management Strategy (e.g., European cordgrass, European fire ant, and American bullfrog)

Possible Actions

- Update the invasive species inventory and treatment area mapping in GIS annually
- Integrate response and enforcement options on all lands into GIS

Action Objective 7: Restore and protect existing native biodiversity

Required Action 7.1 *(completion target: 2020)*

- Within a Biodiversity Conservation Strategy, generate area-specific guidelines to acquire sensitive areas, restore existing lands with native species, and increase connectivity between biodiversity hubs

The District has existing initiatives aimed at restoring and protecting native biodiversity. For example, the District implements a wide range of native species replanting projects to restore native biodiversity, requires that the Natural Environment and Streamside Protection Development Permit Areas support native species growth, and provides fencing and signage for native species protection. Additionally, action 32 in the Invasive Plant Management Strategy calls for the development of a restoration protocol to ensure native species recover in treatment areas before invasive plants can recolonize.

A number of areas in the District will benefit from additional biodiversity projects. Area-specific guidelines within a Biodiversity Conservation Strategy are needed to identify these areas and recommend management options, such as acquiring sensitive areas, restoring existing lands with native species, or increasing connectivity between biodiversity hubs.

Opportunistic Actions

- Explore opportunities to preserve or salvage native plants currently being destroyed during development projects
- Partner with local nurseries and other sector stakeholders to promote an annual event where native and adaptable species are available for purchase

Possible Actions

- Perform a detailed assessment of past and future changes in soil moisture and the potential impacts of changes in soil moisture to ecosystems

Action Objective 8: Preserve and enhance the viability of ecologically sensitive areas and critical habitat along the foreshore

Required Action 8.1 *(completion target: 2018)*

- Create and implement a Coastal Hazard Development Permit Area to protect people, property, and foreshore ecosystems from coastal impacts

A Coastal Hazard Development Permit Area should be developed to protect people, assets, and critical marine and intertidal ecosystems from the impacts of "coastal squeeze," floods, erosion, saltwater intrusion, and storm surges resulting from rising sea level. Within this permit area, estuary preservation, protection, and restoration areas must be identified, designated, and promoted. Once the Coastal Hazard Development Permit Area is adopted, the Environmental Protection and Preservation Bylaw should be updated to remove the aquatic area permit.

Possible Actions

- Incentivize new development away from sensitive foreshore areas
- Over long time periods consider moving infrastructure away from sensitive foreshore areas and encourage different land uses (i.e., recreation) in these areas.

Health and Safety

A key component of the District's high quality of life is its mild climate. However, an increase in extreme events can negatively impact community livability and increase risk to human health and safety.

Hotter and drier weather is increasing the likelihood of more frequent and higher-severity wildfires and heat waves. Wildfires increase the concentration of fine particulate matter in the air, reducing air quality and causing asthma attacks, wheezing, and impaired lung function. Wildfires can also indirectly impact health and safety by damaging infrastructure and recreational areas. Extreme heat waves are increasing the instances of heat-related illnesses, such as heat stroke, sunburn, heat stress, dehydration, and cardiovascular-respiratory illness. Hotter and drier weather is also altering the geographic range of vectors (air, water, and food) and increasing the length of the transmission season, resulting in more incidences and wider spread of infectious disease and water- and food-borne illnesses.

Water supply is being impacted by lower winter snowpack and summer precipitation levels and water quality is being affected by increased turbidity in water reservoirs from more intense rainfall events and more frequent landslides at the source. Both result in elevated human health risks.

Vulnerable populations are particularly impacted by climate change because of inadequate shelter, lack of dry clothing and food, health issues, mobility challenges, and limited access to transportation. Emergency responders are uniquely impacted because of larger and simultaneous emergencies caused by climate change, leading to increased psychosocial effects.

The following actions focus the District's efforts on minimizing the impacts of climate change on human health and safety and thoughtfully considering the unique impacts to vulnerable populations.

Action Objective 9: Reduce potable water consumption

Required Action 9.1 *(completion target: 2020)*

- Develop and implement programs for rainwater and grey water collection and recycling

The District is employing proactive approaches to conserve water: a high-tech irrigation system to manage sprinkling in parks monitors current weather conditions and automatically shuts off when it rains, and a proactive leak detection program continually monitors water systems for leaks, allowing detected leaks to be repaired quickly. As well, the District works with local golf courses to create water use plans that reduce water consumption while maintaining high-quality greens. The District also collaborates with Metro Vancouver on water conservation strategies: during the dry summer months, water restrictions issued by Metro Vancouver are enforced by the District's water conservation officers. These proactive water conservation approaches will continue, and can be enhanced.

The District should further reduce potable water consumption by developing and implementing programs for rainwater and grey water collection and recycling. Rainwater can be collected in rain barrels or rainwater harvesting systems and can be reused to water gardens and other landscape features. Grey water includes wastewater from baths, sinks, washing machines, and other kitchen appliances, which can be captured and recycled for non-potable uses such as toilet flushing. Implementing water recirculation systems in water parks and public art features is another opportunity for water conservation. However, the use of reclaimed water is regulated by the BC Building Code and regulatory constraints must be overcome prior to implementing water collection and recycling programs.

Opportunistic Actions

- Apply Water Conservation Development Permit Area guidelines
- Increase the enforcement of water restrictions
- Enhance communication strategies and offer incentives to encourage indoor and outdoor water conservation
- Promote landscaping practices that conserve water and use drought-resistant plant species

Action Objective 10: Provide alternative water sources for emergency response

Required Action 10.1 *(completion target: 2017)*

- Plan for the distribution of alternative potable water supply during an emergency

The District is involved in the Regional Engineers Advisory Committee's Provision of Water working group. The District must plan for distribution to ensure that water is supplied to critical infrastructure and the public, especially vulnerable populations, during an emergency. Water treatment training for staff and the public could build community resiliency and relieve pressure on emergency responders to provide drinking water during an emergency.

Action Objective 11: Upgrade preparedness and response to heat waves and poor air quality

Required Action 11.1 *(completion target: 2020)*

- Create more opportunities for heat refuge areas

When an extreme heat wave advisory is issued by Environment Canada, the North Shore Extreme Heat Initial Response Guideline is implemented. The guide outlines initial steps for how local authorities can respond to extreme heat within the first four to six hours and includes the location of water fill stations, spray parks, and cooling centres across the North Shore. The District should upgrade its preparedness and response to heat waves and warmer summer temperatures by designing additional heat refuge areas that provide public access to shade and drinking water.

For example, the District could:

- review its park design guidelines to increase shade in parks
- provide more shade in urban areas (e.g., overhangs on buildings and above water fountains and rest areas)
- construct additional or expand public access to water parks and drinking water stations

Possible Actions

- Analyze where vulnerable populations are clustered in the District in order to concentrate heat refuge areas in these locations

Required Action 11.2 *(completion target: ongoing)*

- Seek opportunities for interagency coordination to minimize adverse health impacts to staff, responders, and the public during heat waves and air quality advisories

Though health care is formally the responsibility of the Province of BC and the Fraser Health Authority, the District contributes to the health and safety of its residents by providing civic services and long-term planning. To minimize adverse health impacts to staff, responders, and the public during heat waves and air quality advisories, the District will continue to support health and social-support organizations and other sector stakeholders with the distribution of regular public safety messaging using the District's communication channels. To further increase efforts, the District should seek opportunities for interagency coordination on a continual basis.

The District could consider working with other North Shore municipalities to acquire and use electronic, portable reader boards on bridges to distribute pre-scripted public safety messaging. Further, the District could consider including a public safety information kit as part of the existing community-building funding for block parties to help build neighborhood resiliency across the District.

Opportunistic Actions

- Update the North Shore Extreme Heat Initial Response Guideline to include specific strategies for vulnerable populations
- Update the District's general communication messaging guide, used by the Communications Department, to include heat wave and air quality advisories

Possible Actions

- Consider the addition of a disclaimer in District event permits that allows for the cancellation of outdoor events during times when temperatures are unusually high, water restrictions are in place, or other times when well-being is at risk

5 Moving Forward

This Climate Change Adaptation Strategy identifies required adaptation actions to proactively prepare for climate change and respond to high-risk impacts. To achieve the strategy's vision, the successful implementation, continuous monitoring, and regular review of adaptation actions and the strategy itself is essential.

Implementation

The District has many adaptation initiatives already underway, but such initiatives may not be labelled as working towards adaptation. The intent of this Climate Change Adaptation Strategy is to leverage existing work and identify new opportunities for enhanced adaptation.

Many of the adaptation actions presented in this strategy are interrelated. Many also work toward achieving additional goals identified in other District policies, plans, and strategies. Therefore, all adaptation actions, regardless of the lead department responsible for implementation, should be considered together during the implementation phase to enhance interdepartmental and collaborative implementation.

A draft implementation plan supports each required action by identifying resources to move adaptation into action. The lead department identified for each required action is responsible for implementing those actions by incorporating them into departmental plans, asset management plans, and financial planning processes (e.g., the long-term funding strategy).

Other details within the draft implementation plans, such as a completion target, a relative cost, and level of effort, are intended to provide departmental leads with the foundation to carry out each action.

However, because the details and prioritization of adaptation actions may change over time, each implementation plan is a living document. Implementation plans are expected to be revised through further collaborative work, facilitated by the lead department, to determine the best approach that will achieve each adaptation action objective.

Implementation Actions

The following actions focus the District's efforts on successful and timely implementation of adaptation actions identified in this strategy.

Action Objective 12: Support the implementation of adaptation actions

Required Action 12.1 *(completion target: 2017)*

- Assign specific indicators for each adaptation action to help monitor progress

While a potential list of indicators for each required action is included in this strategy (Appendix B: Potential Indicators for Required Actions), further refinement is needed to assign specific indicators. The majority of indicators are aligned with current District reporting efforts, but a number of new, potential indicators have also been identified.

Possible Actions

- Consider incorporating a rubric or scoring mechanism to monitor progress on each action and to require resources to be applied to actions that are not advancing

Required Action 12.2 *(completion target: 2018)*

- Integrate Required Actions into existing plans and decision-making processes to increase the likelihood of completion

Integrating related actions, targets, and indicators into existing plans such as the Official Community Plan, Asset Management Plan, Corporate Plan, and Long-Range Funding Strategy will increase the likelihood of the actions being completed. Alignment with existing decision-making processes, such as business case analyses and other programs, will ensure implementation efficiency and maximize co-benefits or synergies.

Opportunistic Actions

- Provide additional staff resources to work with each department on the implementation of adaptation actions
- Identify where equivalencies or options for some adaptation actions may be appropriate
- Provide new, stronger enforcement tools for adaptation actions
- Review all new and revised policies and plans to look for opportunities to address the climate change impacts identified in this strategy
- Ensure all employees are familiar with the Climate Change Adaptation Strategy

Monitor / Review

Indicators help to monitor progress over time. Baseline data should be collected and regularly analyzed for trends to gauge the effectiveness of adaptation actions and better understand drivers and barriers to implementation. Some examples of these drivers and barriers to be aware of include:

Drivers

- Grant funding available for climate change adaptation
- Need for efficient integrated work systems
- Long-range financial planning and asset management planning that requires the District to plan ahead
- Public awareness, public support, and public pressure

Barriers

- Insufficient resources (e.g., fiscal, technical, and staff capacity)
- Competing or short timelines
- Reduced availability of technology
- Legality and procedural feasibility, including provincial or territorial legislation
- Path dependency

- Lack of integration throughout the organization
- Lack of monitoring and enforcement
- Lack of high-quality data
- Uncertainty
- Behavioral obstacles
- Lack of public awareness or support

Global, regional, and local climate science is advancing rapidly, as are adaptation policies, technologies, and public values and expectations. As a result, the District's understanding of climate change, its impacts, and the opportunities for adaptation are continuously changing. A concerted effort is needed to ensure the District continues to use the best available climate science and management practices in all decision making. The District aims to review and evaluate this strategy on an annual basis and update it every five years.

Annual Evaluation

The Climate Change Adaptation Team will carry out the annual review and evaluation of this strategy. The team will develop a progress report to document observed climatic changes or impacts in the District, successfully implemented actions, barriers to the implementation of actions, new sources of funding, and windows of opportunity for climate action (e.g., leveraging new programs or initiatives). Using the information in the progress report, the team will make any necessary amendments to adaptation actions and their draft implementation plans to ensure successful implementation.

Five-Year Update

The Climate Change Adaptation Team will be responsible for updating this strategy every five years (from the date of initial adoption). Updating the strategy will include acquiring the most recent climate science, reviewing initial climate change impacts, and adding any new impacts to capture observed or recently projected changes. New adaptation actions, implementation plans, and indicators must be developed to address new impacts. All original adaptation actions must be reviewed to document those that have been completed, dropped, or amended to account for changes in risk or to leverage new opportunities.

6 Draft Implementation Plans for Required Actions

The following table outlines information about the District's 12 action objectives and the associated required actions.

Column Legend

- Action type: Governance and Management (G), Assets and Operations (A), and Education and Training (E)
- Funding type identifies if the action's implementation costs are Operational (Op) or Capital (Cap)
- Estimated-cost categories: <$ (< 100,000), $ (< 500,000), $$ (500,000 – 1,000,000), $$$ (> 1,000,000)
- Effort categories: Low (L), Medium (M), High (H)

Draft Implementation Plans

Required Actions	Action Type	Lead Department	Completion Target	Funding Type	Estimated Cost	Funding Sources	Effort	Implementation	Supporting Documents
Municipal Services									
Action Objective 1: Strengthen the capacity to respond to and recover from extreme weather events and provide continuity of essential municipal services									
RA 1.1 Complete Continuity of Operations plans to ensure delivery of priority services	G	Corporate Services, NSEM	2020	Op	<$	Required but not identified	M	Within local control	Continuity of Operations Planning (Edoc: 3308249)
RA 1.2 Develop and implement additional technological tools to assist in situational awareness and emergency response communication	A	NSEM	2018	Cap and Op	<$	Required and likely to be secured	L	Requires coordination with other jurisdictions	Common Operating Project (Edoc: 3306380)
RA 1.3 Provide targeted training for clerks to ensure emergency service requests and concerns are responded to in a timely manner	E	Planning	2017	Op	<$	Required and likely to be secured	L	Within local control	Emergency Response Quick Reference (Edoc: 3306060)
Action Objective 2: Ensure critical municipal functions are served by robust power systems and alternatives are provided where systems are vulnerable									
RA 2.1 Identify critical functions that are vulnerable to power outages and further develop priority response and power restoration protocols	G	Eng	2018/ ongoing	Cap	<$	Available*	L	Requires external approval	Priority Power Restoration (Edoc: 3078249)
RA 2.2 Invest in backup power equipment for critical functions and develop a fueling strategy	A	Eng	2019/ ongoing	Cap	$$	Available*	M	Within local control	NA

Required Actions	Action Type	Lead Department	Completion Target	Funding Type	Estimated Cost	Funding Sources	Effort	Implementation	Supporting Documents
Infrastructure and Systems									
Action Objective 3: Increase the resiliency of municipal assets to extreme weather, events, changes in precipitation and temperature, and sea level rise									
RA 3.1 Complete the Integrated Stormwater Management Plan and implement recommendations to maintain watershed health and reduce the impacts of extreme runoff	G	Eng, Environ	2017/ ongoing	Cap and Op	$$$	Required and likely to be secured	M	Within local control	ISMP Framework & Objectives (Edoc: 3205324)
RA 3.2 Update the Community Wildfire Protection Plan and implement recommendations to reduce wildfire risk and strengthen the capacity to respond	G	Environ, Parks	2017/ ongoing	Cap and Op	$$	Available*	L	Within local control	Community Wildfire Protection Plan (Edoc: 857903)
RA 3.3 Identify eco-assets, conduct risk assessment under climate change conditions, and include these in the Asset Management Plan	A	AMSC	2018/ ongoing	Op	<$	Required but not identified	M	Within local control	Asset Management Plan (Edoc: 2518550); Natural Capital & Green Infrastructure (Edoc: 3295858)
RA 3.4 Implement recommendations in the Debris Geohazard Risk and Risk Control Assessment for debris flood/flow creeks by integrating them into the Asset Management Plan	A	Eng	2018/ ongoing	Cap and Op	$$$	Required and likely to be secured	H	Within local control	Debris Geohazard Risk and Risk Control Assessment (Edoc: 3228443)

Required Actions	Action Type	Lead Department	Completion Target	Funding Type	Estimated Cost	Funding Sources	Effort	Implementation	Supporting Documents
Action Objective 4: Support residents in proactively managing privately owned property to adapt to temperature and precipitation changes, more frequent and severe extreme weather, and sea level rise									
RA 4.1 Review and strengthen building and development policies to require the consideration of climate change over the life cycle of a structure	G	Planning	2018	Op	$	Required and likely to be secured	M	Within local control	Hazard DPAs (Schedule B OCP); Development Servicing Bylaw 7388
RA 4.2 Develop and implement an education and incentive program to encourage more resilient choices for the design, maintenance, and renewal of private development	E	Planning, Eng	2020	Cap and Op	$$	Available*	M	Within local control	Green Building Policies (Corporate Policies) (Edoc: 3016715); Energy & Water Conservation DPA (Part 6 Schedule B OCP); ISMP Framework & Objectives (Edoc: 3205324)

Required Actions	Action Type	Lead Department	Completion Target	Funding Type	Estimated Cost	Funding Sources	Effort	Implementation	Supporting Documents
Parks and Environment									
Action Objective 5: Support the long-term health of natural forest ecosystems and fire disturbance regimes									
RA 5.1 Proactively manage all District-owned forested areas to increase forest resilience, health, and structure and reduce other natural hazards	A	Environ	2018	Op	$$	Available*	M	Requires external approval	Forest Ecosystem Mapping & Framework for Eco System Based Manage-ment (Edoc: 1272446); Urban Forest Climate Adaptation Framework for Metro Vancouver (Edoc: 3371713)
Action Objective 6: Reduce the spread of invasive organisms									
RA 6.1 Implement the Invasive Plant Management Strategy to manage harmful invasive plants on public and private land	A	Policy Planning, Parks	2025	Cap and Op	$$	Available*	H	Within local control	Invasive Plant Management Strategy (Edoc: 2576575)
Action Objective 7: Restore and protect existing native biodiversity									
RA 7.1 Within a Biodiversity Conservation Strategy, generate area-specific guidelines to acquire sensitive areas, restore existing lands with native species, and increase connectivity between biodiversity hubs	G	Environ, Parks	2020	Cap	$$$	Required but not identified	H	Within local control	Biodiver-CITIES (Edoc: 3306654)
Action Objective 8: Preserve and enhance the viability of ecologically sensitive areas and critical habitat along the foreshore									
RA 8.1 Create and implement a Coastal Hazard Development Permit Area to protect people, property, and foreshore ecosystems from coastal impacts	G	Policy Planning, Environ	2018	Cap	$$	Required and likely to be secured	H	Requires external approval	FCM application coastal hazards (Edoc: 3353918)

Required Actions	Action Type	Lead Department	Completion Target	Funding Type	Estimated Cost	Funding Sources	Effort	Implementation	Supporting Documents
Health and Safety									
Action Objective 9: Reduce potable water consumption									
RA 9.1 Develop and implement programs for rainwater and grey water collection and recycling	A	Eng, Parks	2020	Cap and Op	$$	Required and likely to be secured	M	Within local control	Development Servicing Bylaw 7388; ISMP Framework & Objectives (Edoc: 3205324); Energy & Water Conser-vation DPA (Part 6 Schedule B OCP)
Action Objective 10: Provide alternative water sources for emergency response									
RA 10.1 Plan for the distribution of alternative potable water supply during an emergency	A	Eng, NSEM	2017	Cap	<$	Required and likely to be secured	L	Within local control	Regional Temporary Provision of Water Plan (Edoc: 3306478)
Action Objective 11: Upgrade preparedness and response to heat waves and poor air quality									
RA 11.1 Create more opportunities for heat refuge areas	A	Planning, Parks, Rec Com	2020	Cap and Op	$$	Available*	M	Within local control	NA
RA 11.2 Seek opportunities for interagency coordination to minimize adverse health impacts to staff, responders, and the public during heat waves and air quality advisories	E	NESM	3 meetings per year	Op	<$	Available*	L	Requires coordin-ation with other jurisdictions	Emergency Response Quick Reference (Edoc: 3306060)

Required Actions	Action Type	Lead Department	Completion Target	Funding Type	Estimated Cost	Funding Sources	Effort	Implementation	Supporting Documents
Implementation									
Action Objective 12: Support the implementation of adaptation actions									
RA 12.1 Assign specific indicators for each adaptation action to help monitor progress	G	Planning	2017	Op	<$	Available*	L	Within local control	Appendix B in this Strategy
RA 12.2 Integrate Required Actions into existing plans and decision-making processes to increase the likelihood of completion	G	Planning	2018	Op	<$	Available*	M	With local control	NA

*Subject to approval of annual Financial Plan

Appendix A
Summary of Detailed Climate Projections for the District

Climate modelling was completed by the Pacific Climate Impacts Consortium (PCIC) to better understand how the District's climate may change by the 2050s. Modelling was focused on the 2050s because these are the climatic changes that will be unavoidable, regardless of the extent of global mitigation efforts. An ensemble of twelve global climate models[22] was used to assess projected changes in: temperature; precipitation amounts; precipitation timing; changing precipitation patterns; extreme weather events of greater frequency and severity; and sea level rise.[23]

Future projections for the 2050s represent an average of the modelled values over a 30-year period from 2041 to 2070. The 2050 projections are relative to a baseline of the 1980s (1971-2000) and are based on the "business as usual" greenhouse emissions scenario (RCP 8.5). Averages provided are the mean of the global climate model ensemble, calculated over the geographic extent of the District of North Vancouver, and ranges represent the tenth and ninetieth percentiles of the global climate model ensemble. Seasons are presented as winter (December, January, and February), spring (March, April, and May), summer (June, July, and August), and fall (September, October, and November).

While most of the projected climatic changes described in this summary are generally uniform in areas near sea level, certain climate indices may differ between lower and higher elevations as well as between regions adjacent to the ocean and those further from the shoreline. Maps that document this spatial variability have been provided for some of these climate indices. These maps were created using a regional downscaling approach (BCCAQ) with elevation corrections to achieve 800-metre resolution, and values at individual map cells may differ slightly from actual sites in the District.

Temperature Change (Increasing Temperatures)

Average annual temperature in the District is expected to increase by 2.9°C, with the greatest increase (3.6°C) occurring in the summer months (figure A1). By the 2050s, average daytime high temperatures in September will be hotter than temperatures occurring presently in July and August. In addition, the number of summer days above 25°C (SU) in the District will more than double by the 2050s, from 18 to 44 days per year, on average. In general, valleys and low-lying areas in the District will experience the most summer days above 25°C (50 to 80 days per year) and higher elevations (i.e., Grouse and Seymour mountains) will experience the fewest (<10 days per year) (figure A2). Summer maximum temperatures (TXX) are projected to increase by 3.9°C, while winter minimum temperatures (TNN) will warm by 5.1°C. Similarly, very hot days, expected to occur once every 20 years (RP20Tx), are projected to intensify, rising from 33°C to 38°C by the 2050s.

22 Temperature, precipitation, and indices of extremes were determined from an ensemble of 12 Global Climate Models as described at http://www.pacificclimate.org/data/statistically-downscaled-climate-scenarios (i.e., CMIP5 models following RCP 8.5 downscaled with BCCAQ)

23 Sea level rise projections were determined from Ausenco Sandwell. (2011). Climate Change Adaption Guidelines for Sea Dikes and Coastal Flood Hazard Land Use. Report prepared for BC Ministry of Environment. Retrieved from: http://www.env.gov.bc.ca/wsd/public_safety/flood/pdfs_word/draft_policy_rev.pdf

Appendix A Summary of Detailed Climate Projections for the District

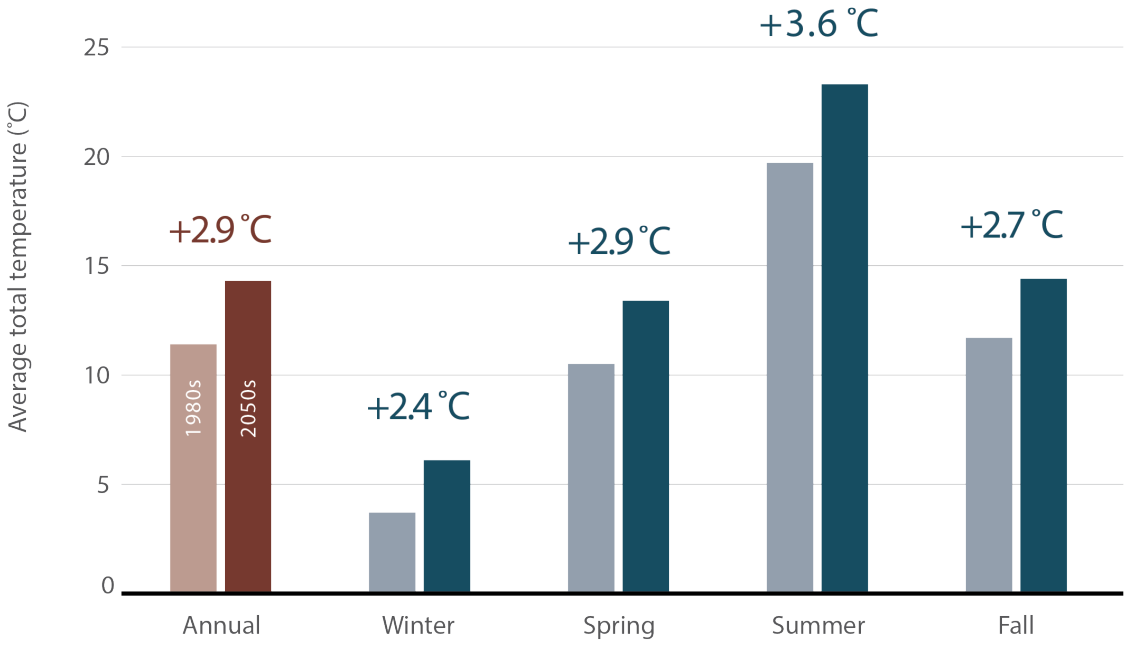


Figure A1 Average annual and seasonal daytime high temperatures in the District.

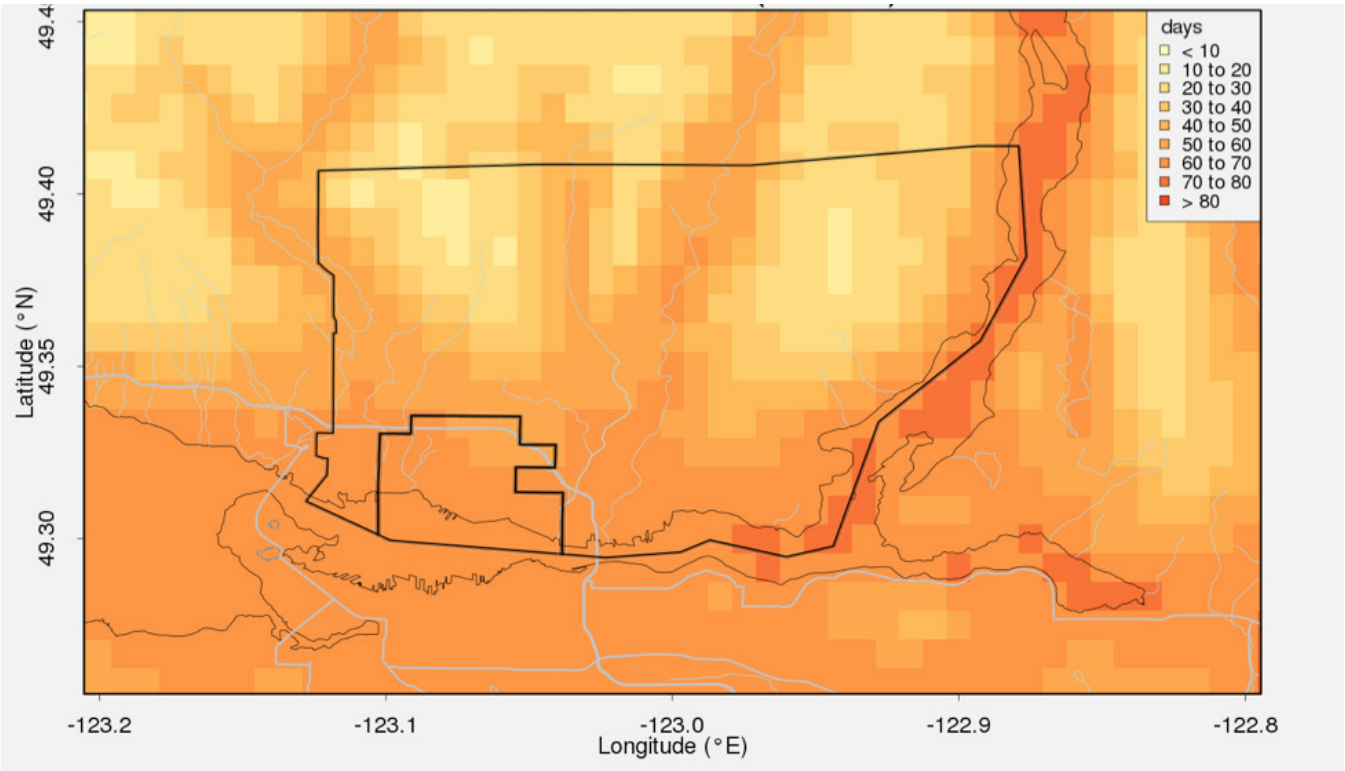


Figure A2 Spatial variability in the number of summer days above 25°C in the District by the 2050s. (Reprinted with permission from PCIC, 2013)

Heating and Cooling

By the 2050s, warmer winter, spring, and fall minimum temperatures will result in lower heating demand with 24% fewer heating degree days (HDD), from about 3800 to 2900 days per year. In contrast, warmer summer temperatures are expected to drive greater cooling requirements as cooling degree days (CDD) increase from about 40 to 180 degree days per year. Hot summer days (days above 30°C) (SU30) that occurred only twice per year on average in the past are projected to occur 13 times per year in the 2050s. In addition to these individual hot days, extended periods of hot temperatures associated with heat waves are also expected to occur more frequently.

Ecosystem Impacts

The projected warming, including a 68% reduction in the number of days with ice (ID) and a 63% reduction of days with frost (FD), has implications for ecosystems in the District. Fewer ice and frost days will likely increase the potential for pests and invasive organisms to thrive. In addition, the length of the growing season (GSL) and number of growing degree days (GDD) will increase by 29% and 52%, respectively. These changes could improve the growth and productivity of typical plants and crops in the region and allow for new species and varieties to grow; however, seasonally waterlogged soils, decreased water availability, and extreme heat may hinder any crop productivity.

Precipitation Change (Drier Summers and Wetter Winters)

A modest 5% increase in annual total precipitation is projected for the District by the 2050s (figure A3). However, this rain is expected to fall during increasingly extreme events, with 33% more precipitation on very wet days (R95p) and 58% more on extremely wet days (R99p). Events that are expected to occur once every 20 years (RP20p), and which are often associated with flooding, are projected to increase in intensity by 19%.

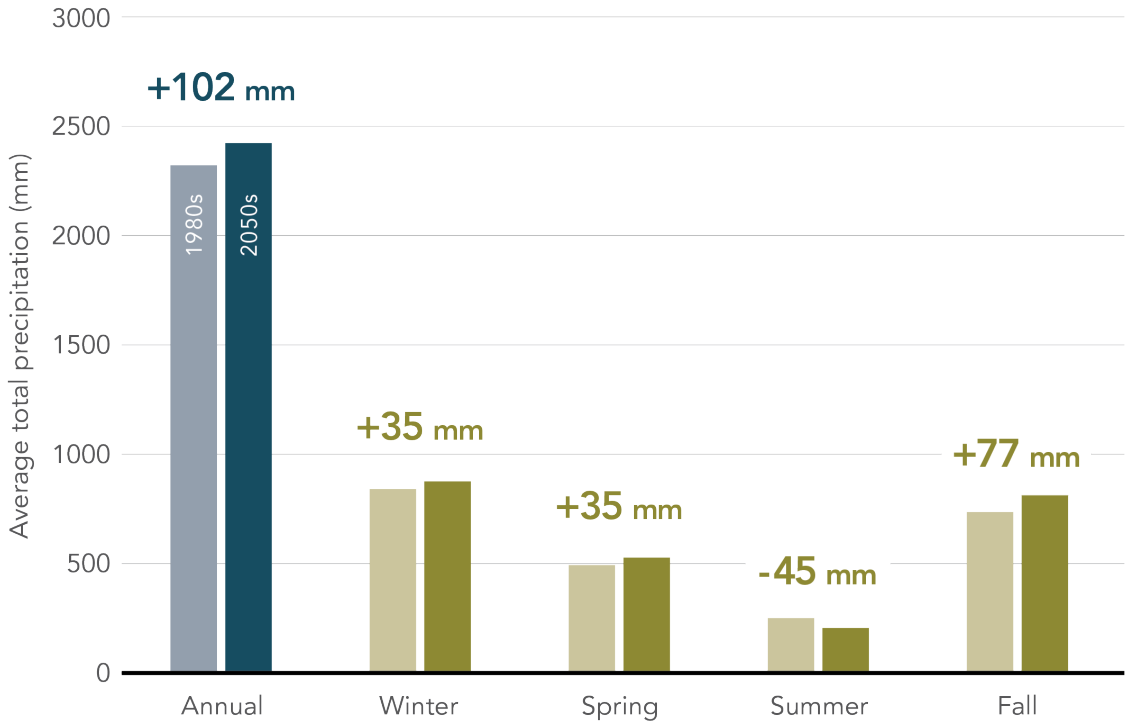


Figure A3 Average annual and seasonal total precipitation in the District.

Precipitation changes vary seasonally, exacerbating the existing differences between the wet and dry months of the year. Projections indicate that winter, spring, and fall in the District will see increases in rainfall totals between 4% and 11%. Despite the projected increased intensity of annual wet events (R95p and R99p), the amount of rain in the summer is expected to decrease by 18%, and the maximum length of dry spells (DS) in a year, which typically occur in the summer, is projected to increase by 19% from 19 to 23 consecutive dry days per year, on average.

Snowpack

Precipitation as snow and snowpack are projected to decrease significantly over time. In the District, snowpack is typically highest in the spring months, after snow has accumulated over the winter and early spring, with April 1st snow depth measuring 90 cm on average in the 1980s. Projections indicate that, on average, April 1st snowpack in the District will decrease by 89% by the 2050s. However, the projected changes will differ depending on elevation. At elevations near sea level, where snowpack was low in the past, declines of up to 100% are projected to occur (figure A4). At higher elevations, the projected changes are smaller, with declines of less than 30% on the upper portions of Grouse and Seymour mountains.

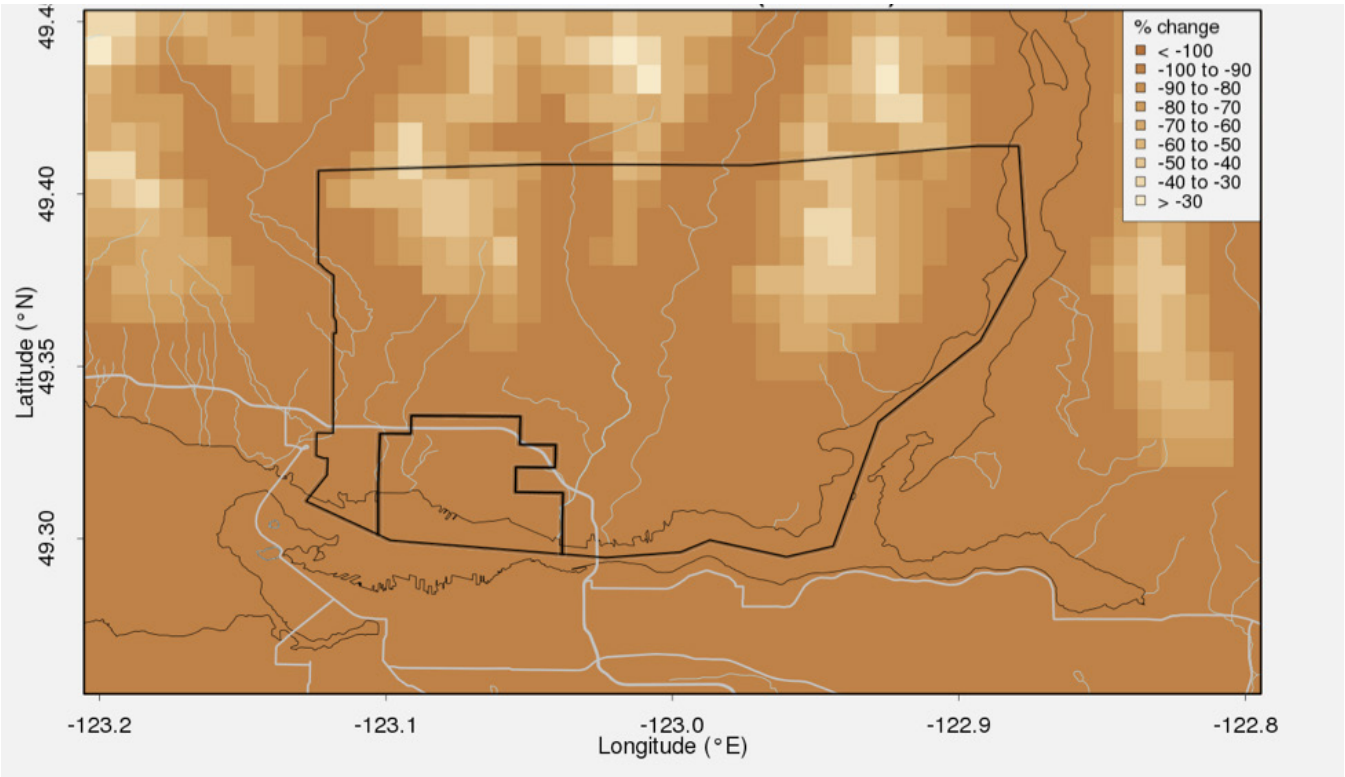


Figure A4 Spatial variability in the percent change in April 1st snowpack in the District by the 2050s. (Reprinted with permission from PCIC, 2013)

Extreme Weather (More Frequent and Severe Extremes)

The indices of extremes illustrate how climate conditions that are currently infrequent will change in frequency and/or intensity in the future. In addition to the temperature and precipitation extremes mentioned in the sections above, the District could experience an increase in the frequency and severity of windstorms.

Damaging windstorms in coastal BC are often associated with extratropical cyclones from the Pacific Ocean that occur primarily during the fall and winter months. The Intergovernmental Panel on Climate Change (IPCC) reports that climate model projections suggest a possible northward shift in the stormtracks of these events in the future, which could lead to increased frequency of extreme winds on the coast.[24] An analysis of climate change in the Georgia Basin[25] found that local projections of wind speeds were mixed, with both increases and decreases possible in the future. In this study, some climate models project extreme wind events to occur up to 2.6 times more often in the 2050s than in the past, while others project they will occur less than 0.1 times as often. Overall, these results imply that the future change in windstorms remains uncertain.

Sea Level Rise

Different climate models show different projections for future sea level rise. Given this model-based uncertainty and the rapid rise in ocean levels observed in past decades, the Province of BC released guidelines[26] in 2011 for evaluating long-term land use planning. In these guidelines, sea level in BC is expected to increase by 0.5 m by the 2050s, 1 m by 2100, and 2 m by the 2200s. Nonetheless, local factors—such as the vertical movement of land (i.e., subsidence or uplift), wind currents, and wave action—greatly influence the extent of sea level rise in a particular area and must be considered when examining local impacts.

24 IPCC. (2013). Chapter 14: Climate Phenomena and Their Relevance for Future Regional Climate Change. In Climate Change 2013: The Physical Sci¬ence Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Retrieved from: http://www.climatechange2013.org/images/report/WG1AR5_Chapter14_FINAL.pdf

25 Murdock et al. (2012). Georgia Basin: Projected Climate Change, Extremes, and Historical Analysis. Retrieved from: https://www.pacificclimate.org/sites/default/files/publications/GeorgiaBasinImpacts_Final.pdf

26 Ausenco Sandwell. (2011). Climate Change Adaption Guidelines for Sea Dikes and Coastal Flood Hazard Land Use. Report prepared for BC Ministry of Environment. Retrieved from: http://www.env.gov.bc.ca/wsd/public_safety/flood/pdfs_word/draft_policy_rev.pdf

Past Climate Indices and Projected Future Changes in the District

Index	Label	Past (1980s)	Future Change (2050s)	Percent Change (2050s)
Coldest Winter Days	TNN	-13.8 °C	+5.1 (3.4 to 6.9) °C	N/A
Cooling Degree Days	CDD	36 days	+141 (58 to 229) days	385 (212 to 595)%
Dry Spells	DS	19 days	+4 (0.5 to 7) days	19 (3 to 30)%
Extreme Precipitation (20 Year)	RP20p	121 mm	+23 (7 to 39) mm	19 (6 to 32)%
Extreme Temperature (20 Year)	RP20Tx	33 °C	+5 (3 to 6) °C	N/A
Extreme Wet Day Precipitation	R99p	154 mm	+86 (25 to 175) mm	58 (16 to 127)%
Frost Days	FD	92 days	-58 (-68 to -46) days	-63 (-76 to -50)%
Growing Degree Days	GDD	1467 days	+760 (411 to 1114) days	52 (27 to 78)%
Growing Season Length	GSL	217 days	+64 (43 to 82) days	29 (20 to 38)%
Heating Degree Days	HDD	3834 days	-927 (-1241 to -583) days	-24 (-33 to -16)%
Ice Days	ID	13 days	-9 (-11 to -5) days	-68 (-80 to -48)%
Summer Days	SU	18 days	+26 (16 to 36) days	144 (88 to 200)%
Hot Summer Days	SU30	2 days	+11 (5 to 16) days	550 (250 to 800)%
Hottest Summer Day	TXX	30 °C	+3.9 (2.5 to 4.8) °C	N/A
Wet Day Precipitation	R95p	498 mm	+158 (44 to 272) mm	33 (9 to 59)%

Definition of Climate Indices

Index	Label	Definition	Example of what the indices could indicate
Coldest Winter Days	TNN	Min temperature of the coldest day in winter	Potential for pests to thrive through the winter
Cooling Degree Days	CDD	Total of the number of degrees above 18°C that occur daily, summed over all days of the year	Energy demand for cooling
Dry Spells	DS	Number of consecutive days with precipitation less than 1 mm	Reduce reservoir levels and increased wildfire risk
Extreme Precipitation (20 Year)	RP20p	Maximum daily precipitation expected to occur once every 20 years	Potential for flooding after extreme one-day rain events that occur once every 20 years
Extreme Temperature (20 Year)	RP20Tx	Maximum daily temperature expected to occur once every 20 years	Potential for heat stress during extreme one-day heat events that occur once every 20 years
Extreme Wet Day Precipitation	R99p	Total precipitation that falls on the wettest days of the year (i.e., days when precipitation exceeds the 99th percentile of wet days in the past)	Intensity of extreme wet days during the year
Frost Days	FD	Annual count of days where minimum temperature is below 0°C, which may result in frost	Potential for invasives and pests to thrive
Growing Degree Days	GDD	Total of the number of degrees above 5°C that occur daily, summed over all days of the year	Improved plant growth and potential for invasives to thrive
Growing Season Length	GSL	Number of days between the first span of 6 days in spring with daily average temperatures above 5°C and the first span of 6 days in fall with daily average temperatures below 5°C	Improved productivity of typical plants/crops in the region and new species and varieties
Heating Degree Days	HDD	Total of the number of degrees below 18°C that occur daily, summed over all days of the year	Energy demand for heating

Appendix A Summary of Detailed Climate Projections for the District

Index	Label	Definition	Example of what the indices could indicate
Ice Days	ID	Annual count of days where maximum temperature is below 0°C, which may result in ice	Resource demand for snow and ice removal
Summer Days	SU	Annual count of days where maximum temperature is greater than 25°C	Typical "summer weather" in the District
Hot Summer Days	SU30	Annual count of days where maximum temperature is greater than 30°C	Potential for heat waves when persistent hot summer days occur
Hottest Summer Day	TXX	Max temperature of the warmest day in summer	Potential for heat stress
Wet Day Precipitation	R95p	Total precipitation that falls on the wettest days of the year (i.e., days when precipitation exceeds the 95th percentile of wet days in the past)	Intensity of wet days during the year

Appendix B
Potential Indicators for Required Actions

Potential Indicators

Required Actions	Action Type
Municipal Services	
Action Objective 1: Strengthen the capacity to respond to and recover from extreme weather events and provide continuity of essential municipal services	
RA 1.1 Complete Continuity of Operations plans to ensure delivery of priority services	• Development of critical service evaluation matrix • # of business continuity plans • Average time for the delivery of priority services during an emergency
RA 1.2 Develop and implement additional technological tools to assist in situational awareness and emergency response communication	• Option analysis of potential technological tools • # of staff trained on new technological tools • Average time to notify staff and residents to emergency situations
RA 1.3 Provide targeted training for clerks to ensure emergency service requests and concerns are responded to in a timely manner	• % of clerks who have completed training • Average wait time for emergency service requests and concerns • % of Request for Service cases closed in a timely manner
Action Objective 2: Ensure critical municipal functions are served by robust power systems and alternatives are provided where systems are vulnerable	
RA 2.1 Identify critical functions that are vulnerable to power outages and further develop priority response and power restoration protocols	• Analysis of energy needs for critical infrastructure and functions • Development of protocols for response and power restoration • % of critical infrastructure and functions that are impacted during a power outage
RA 2.2 Invest in backup power equipment for critical functions and develop a fueling strategy	• Analysis of current backup power equipment • Development of long-term fueling strategies • # of generators purchased • # of additional fuel systems installed • Frequency of service failure

Required Actions	Action Type
Infrastructure and Systems	
Action Objective 3: Increase the resiliency of municipal assets to extreme weather, events, changes in precipitation and temperature, and sea level rise	
RA 3.1 Complete the Integrated Stormwater Management Plan and implement recommendations to maintain watershed health and reduce the impacts of extreme runoff	• Development of management plans for each watershed • % of recommendations implemented • Proportion of permeable versus impermeable ground coverage • Total asset losses ($) from water and erosion damage
RA 3.2 Update the Community Wildfire Protection Plan and implement recommendations to reduce wildfire risk and strengthen the capacity to respond	• Updated Community Wildfire Protection Plan • % of recommendations implemented • % of high wildfire risk areas treated • Total asset losses ($) from fire damage
RA 3.3 Identify eco-assets, conduct risk assessment under climate change conditions, and include these in the Asset Management Plan	• Value ($) of eco-assets • Amended Asset Management Plan • Long-term operational and maintenance costs of grey infrastructure
RA 3.4 Implement recommendations in the Debris Geohazard Risk and Risk Control Assessment for debris flood/flow creeks by integrating them into the Asset Management Plan	• % of recommendations implemented • Amended Asset Management Plan • % of high debris flood/flow risk areas mitigated • # of property owners educated about debris flood risks and options for risk reduction • # of culvert blockages • Total asset losses ($) due to debris floods/flows
Action Objective 4: Increase the resiliency of municipal assets to extreme weather, events, changes in precipitation and temperature, and sea level rise	
RA 4.1 Review and strengthen building and development policies to require the consideration of climate change over the life cycle of a structure	• # of District policies that include climate change considerations • Total financial losses ($) incurred by the public related to climate change • # of new developments that explicitly consider climate risks proactively
RA 4.2 Develop and implement an education and incentive program to encourage more resilient choices for the design, maintenance, and renewal of private development	• # of residents, developers, architects, etc. educated about resilient development • # of incentives offered to the public to encourage more resilience choices • # of professional development activities (for engineers, planners, etc.)

Required Actions	Action Type
Parks and Environment	
Action Objective 5: Support the long-term health of natural forest ecosystems and fire disturbance regimes	
RA 5.1 Proactively manage all District-owned forested areas to increase forest resilience, health, and structure and reduce other natural hazards	• % of forested areas in the District that are proactively managed • Measurements of forest health (e.g., tree growth, mortality, regeneration, and crown condition; species composition; vegetation diversity and structure)
Action Objective 6: Reduce the spread of invasive organisms	
RA 6.1 Implement the Invasive Plant Management Strategy to manage harmful invasive plants on public and private land	• % of recommendations implemented • Proportion of native versus invasive plants on public and private lands
Action Objective 7: Restore and protect existing native biodiversity	
RA 7.1 Within a Biodiversity Conservation Strategy, generate area-specific guidelines to acquire sensitive areas, restore existing lands with native species, and increase connectivity between biodiversity hubs	• Analysis of areas that would benefit from biodiversity related projects • Development of a conservation strategy that includes area-specific guidelines • % of sensitive areas that are protected • % of existing lands that are restored with native species • Measures of connectivity between protected and conserved lands • Proportion of fragmented versus connected landscapes beneficial for biodiversity
Action Objective 8: Preserve and enhance the viability of ecologically sensitive areas and critical habitat along the foreshore	
RA 8.1 Create and implement a Coastal Hazard Development Permit Area to protect people, property, and foreshore ecosystems from coastal impacts	• Identification of sensitive estuary areas • Creation of Coastal Hazard Development Permit Area and guidelines • Total asset losses ($) due to coastal hazards • Measurements of foreshore health (e.g., species diversity; habitat quality; seafloor integrity; and marine food web abundance and diversity)

Required Actions	Action Type
Health and Safety	
Action Objective 9: Reduce potable water consumption	
RA 9.1 Develop and implement programs for rainwater and grey water collection and recycling	• # of new water collection and recycling initiatives • Water consumption per capita • District corporation water consumption
Action Objective 10: Provide alternative water sources for emergency response	
RA 10.1 Plan for the distribution of alternative potable water supply during an emergency	• Development of a water distribution strategy • # of people with access to potable water during an emergency
Action Objective 11: Upgrade preparedness and response to heat waves and poor air quality	
RA 11.1 Create more opportunities for heat refuge areas	• % shade coverage • # of drinking water stations • # of heat-related hospitalizations
RA 11.2 Seek opportunities for interagency coordination to minimize adverse health impacts to staff, responders, and the public during heat waves and air quality advisories	• # of new connections with health and social support organizations • # of heat-related hospitalizations • # of air quality–related health issues
Implementation	
Action Objective 12: Support the implementation of adaptation actions	
RA 12.1 Assign specific indicators for each adaptation action to help monitor progress	• # of adaptation actions with a refined list of indicators and baseline data • Regular review and updates based on indicator progress
RA 12.2 Integrate Required Actions into existing plans and decision-making processes to increase the likelihood of completion	• # of adaptation actions integrated into existing plans and processes

Appendix C Glossary

This glossary defines terms as they are intended to be interpreted in the context of climate change. Underlined words are terms that are defined elsewhere in the glossary.

adaptation: initiatives or actions in response to actual or projected changes in climate that reduce the effects of climate change on built, natural, and social systems and take advantage of potential opportunities.[27] Examples include: modifying building codes to account for future climatic conditions, providing heat refuges during heat waves, and planting drought- and flood-tolerant tree species.

adaptive capacity: the ability of built, natural, and/or social systems to adjust to climate change (including climate variability and extremes) by moderating potential damages, taking advantage of potential opportunities, or coping with consequences.[28]

climate: the average weather in a given region over a long period of time, typically 30 years or longer.

climate change: statistically significant variations in the climate that can be caused by natural Earth processes (e.g., volcanic eruptions and ocean currents), external factors (e.g., changes in solar intensity), or by human activity (e.g., greenhouse gas emissions and changes in land use).[29]

climate change impact: an issue resulting from a climate change outcome that has a positive or negative effect. Examples include: infrastructure damage, injury, and loss of native biodiversity.

climate change outcome: a hazard or event that is caused by climate change. Examples include: overland and urban floods, windstorms, and the spread of invasive organisms.

consequence: the known or estimated social, economic, and environmental concerns resulting from a climate change impact. Examples include: increased mental health issues in displaced residents, higher costs of emergency response, and loss of essential ecosystems services.

eco-assets: naturally built environments that provide ecosystem services. Examples include: forests, wetlands, and foreshores.

ecosystem services: the benefits people obtain from the natural environment. These include provisioning services such as food and water; regulating services such as flood and disease control; cultural services such as spiritual, recreational, and social benefits; and supporting services such as nutrient cycling that maintain favourable conditions for life on Earth.

27 ICLEI Canada. (2012). Changing Climate, Changing Communities: Guide and Workbook for Municipal Climate Change Adaptation. Retrieved from: www.icleicanada.org/resources/item/3-changingclimate-changing-communities

28 Ibid.

29 Intergovernmental Panel on Climate Change (IPCC). (2013). Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Retrieved from: www.climatechange2013.org

extreme weather event: a meteorological event that is rare for a particular time of year and/or place and is beyond the normal range of activity.[30] Examples include: windstorms, heat waves, and droughts.

green infrastructure: physically built natural environments that provide municipal services and ecosystem services. Examples include: green roofs, artificial wetlands, and rain gardens.

grey infrastructure: physically built environments that provide municipal services. Examples include: roads, sewers, and buildings.

likelihood: the probability of a particular climate change outcome or climate change impact occurring.

maladaptation: any changes in natural or human systems that do not succeed in reducing vulnerability to climate change but instead increase it.[31] For example, a sea wall can increase vulnerability if extensive development is built behind it.

mitigation: policy, regulatory, and project-based measures that help stabilize or reduce greenhouse gas emissions and/or enable natural systems to naturally sequester greenhouse gases (e.g., preventing forested areas from being developed into to urban cities). These actions prevent future climate change from happening.[32] Examples include: renewable energy programs, energy efficiency frameworks, and land-use policies.

municipal services: the benefits people obtain from the built environment. These include provisioning services such as water, sanitation and transportation; regulating services such as flood and disease control; cultural services such as spiritual, recreational, and social benefits; and supporting services such as conservation and restoration of values derived from eco-assets that provide ecosystem services.

resilience: the capacity of a system, community, or society exposed to hazards to adapt, by resisting or changing, in order to reach and maintain an acceptable level of functioning and structure.[33]

risk: a measure of the expected outcome of an uncertain event, which is estimated by combining an event's likelihood with the expected consequences. The concept of risk helps to grapple with uncertainty and allows for the comparison of potential impacts.[34]

30 ICLEI Canada. (2012). Changing Climate, Changing Communities: Guide and Workbook for Municipal Climate Change Adaptation. Retrieved from: www.icleicanada.org/resources/item/3-changingclimate-changing-communities

31 Intergovernmental Panel on Climate Change (IPCC). (2007a). Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Retrieved from: www.ipcc.ch/index.htm

32 Ibid.

33 Ibid.

34 CNV. (2013). City of North Vancouver Climate Change Adaptation Plan. Retrieved from: http://www.cnv.org/your-government/living-city/climate-action/climate-change-adaptation

uncertainty: a state of incomplete knowledge that can result from a lack of information or from disagreement about what is known or even knowable. It may have many types of sources, from imprecision in the data to ambiguously defined concepts or terminology or uncertain projections of human behaviour.[35]

vulnerability: the degree to which a system is susceptible to, or unable to cope with, the adverse effects of climate change. Vulnerability is a function of both the sensitivity and the adaptive capacity of a given system.[36]

vulnerable population: community members that experience greater impacts compared to the general population. This can result from the inability to move to avoid risks or to afford adaptation measures. Examples include: people who are homeless, those with low-incomes, youth, the elderly, and outdoor workers.

weather: the short-term (i.e., minutes to weeks), day-to-day variability in atmospheric conditions (e.g., temperature, precipitation, and wind) in a given region.[37]

35 Intergovernmental Panel on Climate Change (IPCC). (2013). Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Retrieved from: www.climatechange2013.org

36 ICLEI Canada. (2012). Changing Climate, Changing Communities: Guide and Workbook for Municipal Climate Change Adaptation. Retrieved from: www.icleicanada.org/resources/item/3-changingclimate-changing-communities

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