2020 Corporate Strategic Asset Management Plan

Appendix H
Climate Risk Assessment Framework

URBAN systems

OCTOBER 2018

Climate Risk Assessment

Cowichan Valley Regional District's Asset Systems

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ACKNOWLEDGEMENTS

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EXECUTIVE SUMMARY

Due to a changing climate, the Cowichan Valley Regional District (CVRD) expects to see changes to temperature, precipitation, and sea level rise that will result in hotter, drier summers; warmer, wetter winters; increased flooding and coastal inundation; greater wildfire risk and increasing intensity of storms[1]. These changes will likely have minor to significant impacts on assets and service delivery, such as:

- Increased levels of risk to delivering target levels of service
- Increased costs associated with managing risks and delivering target levels of service
- Decreased asset lifecycle associated with changes in loads and stresses

The purpose of this project was to systematically assess the vulnerability and risk of CVRD's asset systems to changing climate, to inform the planning and implementation of risk management actions (through the Asset Management Plan and other plans where relevant) and an update of the Asset Management Policy. This project was also designed to establish the process and a tool for the CVRD to use and adapt as further information and resources become available.

THE PROCESS

The scope of this project involved a high-level screening of 12 of the CVRD's major asset systems (recreation centres, community centres, community halls, administration, public safety, parks and trails, waste and recycling, water, sewer, ornamental lighting, transit, and drainage), and a more in-depth case study of two assets: Douglas Hill water system and Arbutus Park.

A custom process and tool were developed for CVRD to conduct the vulnerability and risk assessment, based on existing publicly available tools. Both the screening and the in-depth case studies use the same process and tool for assessing vulnerability and risk – the difference between the two is the level of detail and specificity of information about the asset being assessed.

The asset system vulnerability and risk assessment was conducted using a four-step process:

1. Identify Exposure
2. Vulnerability Assessment,
3. Risk Assessment
4. Risk Management.

This project focused on the first three steps. Although some potential actions for risk management have been identified, the final stage of risk management was outside the scope of this project because it requires considering and prioritizing all risks to asset systems, not just those related to climate change.

1 CVRD. (2017). Climate Projections for the Cowichan Valley Regional District

THE RESULTS

Of the 12 asset systems reviewed, the water and sewer systems will likely experience the highest level of risk.

Table ES 1. Highest Risks by Asset System

Asset System	Projected Climatic Change	Predicted Direct Impacts	Anticipated Outcome of Direct Impact
Recreation Centre	Warmer summers	Increase energy demands due to cooling needs.	Increase energy use and pressure on HVAC system.
Community Centres			
Community Halls			
Administration			
Parks and Trails	Longer and more intense storms	Increase damage to facilities due to storm surges and severe wind storms.	Loss or reduction of coastal recreation space. Damage to trees and infrastructure.
Water Systems	Drier summers	Reduced recharge of groundwater sources due to decrease in precipitation.	Reduced capacity to source aquifer and inability to meet water demands.
		Increase in watering and irrigation needs due to increased precipitation and drought.	Increased demand on water source, increased pumping and treatment requirements, and faster depletion of water storage.
	Warmer summers	Increased demand on services due to potential extension of summer, growing season, and tourism season.	Inability to meet demand and water conservation goals.
Sewer Systems	Wetter winters	Increased pressure on infrastructure due to more intense precipitation events.	Temporary flooding and increased inflow and infiltration. Temporary inability to meet local conveyance and treatment demands, surcharging and over flows.
	Sea Level Rise	Damage or loss to infrastructure due to higher king tides.	
	Longer and More Intense Storms	Damage to infrastructure due to increased frequency and severity of storms.	
Drainage Systems	Wetter Winters	Increased pressure on infrastructure due to more intense precipitation events.	System overflows and potential damage or washouts.

Common themes from the risk assessment demonstrated that the projected impacts of climatic changes will likely affect the CVRD's ability to meet level of service targets and sustainability goals.

The highest risk rating was allocated was to the sewer systems, associated with increased inflow and infiltration due to wetter winters. Total costs associated with future impacts will likely be dependent on the magnitude of the event and subsequent damage. It is also likely that cascading impacts may result from the damage of one asset system. For example, damage to sewer infrastructure may impact water systems and parks. In turn, creating public health and environmental concerns.

CASE STUDIES

Two individual asset systems were reviewed, the Douglas Hill water system and the Arbutus Park to test the application of the risk assessment process and tool on individual assets (i.e. increasing the level of detail from the screening level review). The Douglas Hill water system was selected to further explore the impacts of climate change on a water system with a groundwater source. The risk assessment revealed that potential stress on the source aquifer due to drier and longer summers posed the highest risk to this system. A significant conclusion was that CVRD does not have enough data on the capacity or recharge mechanisms of the aquifer, making it difficult to confidently assess the level of risk.

The Arbutus Park was selected to explore the impacts of climate change on a well visited waterfront park. Through review, it appeared that damage to trees and infrastructure due to longer and more intense storms posed the highest risk to this system. An outcome of the case study discussion demonstrated the need for future planning efforts and contingency funding to account for the unpredictable nature of such events.

The findings of the case studies illustrated that conducting a risk assessment can be an effective way of identifying and prioritizing important areas for data, planning and budgeting improvement.

CONSIDERATIONS FOR NEXT STEPS

Next steps were outlined to guide future strategic planning, operation and maintenance, and financial management systems decisions, to ensure the delivery of sustainable services to the Region's communities, and to direct customers. The following are next steps for consideration by the CVRD:

- Communicate results with appropriate audiences
- Consider going into "case study" level for selected asset systems
- Update Asset Management Policy
- Develop a corporate risk management framework
- Integrate results into asset management and operation plans

As with any new program or tool, success will be reinforced by using, reviewing, refining and updating the process and tool. It is likely that as CVRD staff gain familiarity with this tool and the risk assessment process, the response to climate change interactions will be strengthened.

1 BACKGROUND

From a global perspective, climate change affects global atmospheric and oceanic temperature rise, ocean acidification, loss of ice sheets and shelves, land mass rebound, glacial recession, reduced snow cover, wildfires, drought, flooding, and an increase in frequency of extreme events. Impacts of these events at a local perspective will be significant – including impacts to local government assets and service delivery such as:

- Increased levels of risk to delivering target levels of service
- Increased costs associated with managing risks and delivering target levels of service
- Decreased asset lifecycle associated with changes in loads and stresses

In the Cowichan Valley, year-round temperature increase is expected with higher temperatures in summer months, while valleys and low-lying areas will experience most of the warming. The majority of the Cowichan Valley Regional District (CVRD) population is concentrated in the Developed Area which is expected to experience the greatest increase in summer days (over 25 °C). In general, warmer winters are expected and temperatures below zero will be rare, except at the highest elevations[2].

The mean annual precipitation is expected to increase leading to wetter winter, spring, and fall while drier summer is likely. Precipitation events are expected to increase in frequency and intensity causing wetter areas to become wetter. The combination of warmer winters, the increase in frequency and intensity of rainfall, and dry spells will likely reduce ground water recharge and potentially impact water quality. In terms of freeze-thaw, fewer cycles in spring and fall are expected and the growing season is expected to start earlier and end later[3].

To adapt to the projected impacts, the CVRD has committed to a multi-phased project to act on climate change adaptation, aptly named New Normal Cowichan. In 2017, the outcome of Phase 1 was the Climate Projections for the Cowichan Valley Regional District report.

Additional programs and tools have been developed to support residents of the CVRD to mitigate and adapt to the climate changes which include DroughtSmart and FloodSmart, and SmartTools, respectively[4].

1.1 Purpose

To guide strategic planning, operations and maintenance, and financial management of systems and to ensure the delivery of sustainable services to CVRD communities and direct customers, the CVRD is preparing a detailed Asset Management Plan (AMP). To strengthen the CVRD's response to climate change impacts, climate change considerations are being integrated with the asset management program.

2 CVRD. (2017). Climate Projections for the Cowichan Valley Regional District.

3 CVRD. (2017). Climate Projections for the Cowichan Valley Regional District.

4 CVRD. (n.d.). CVRD New Normal Cowichan . Retrieved from http://cvrdnewnormalcowichan.ca/

The purpose of this project was to systematically assess the vulnerability and risk of CVRD's asset systems to changing climate, to inform the planning and implementation of risk management actions (through the Asset Management Plan and other plans where relevant) and an update of the Asset Management Policy. This project was also designed to establish the process and a tool for the CVRD to use and adapt as further information and resources become available.

Vulnerability and risk have been assessed for 12 asset systems:

- Recreation Centres
- Community Centres
- Community Halls
- Administration
- Public Safety
- Parks and Trails
- Waste and Recycling
- Water
- Sewer
- Ornamental Street Lights
- Transit
- Drainage

Additional details on individual systems and division stakeholders are available in **Appendix 1**.

The project objectives were:

1. Understand which asset systems could be impacted by climate change;
2. Identify the potential impact on the delivery of services and operations;
3. Quantify risks in a consistent manner, to support prioritization; and
4. Build knowledge within the CVRD to understand and manage these risks and vulnerabilities.

2 APPROACH

2.1 Developing An Assessment Framework

Three climate change risk assessment frameworks were reviewed for use: Public Infrastructure Engineering Vulnerability Committee (PIEVC), Changing Climate, Changing Communities – Guide and Workbook – ICLEI, and MRAT Insurance Bureau of Canada. A review of each of these frameworks relative to the objectives of this project is included in **Appendix 2**.

Each of the frameworks were assessed based on a set of criteria:

1. Suitable for both screening-level and in-depth vulnerability and risk assessment.
2. Provides a systematic and rigorous approach to identifying direct and indirect system vulnerabilities and risks.
3. Assesses risk to service delivery, in a way that will inform investments in systems.

The project team determined that although none of the frameworks exactly met all the project criteria, the ICLEI tools provided a good starting point for modification. These tools were used and adapted to develop a custom tool for CVRD that follows the process illustrated in **Figure 1.**

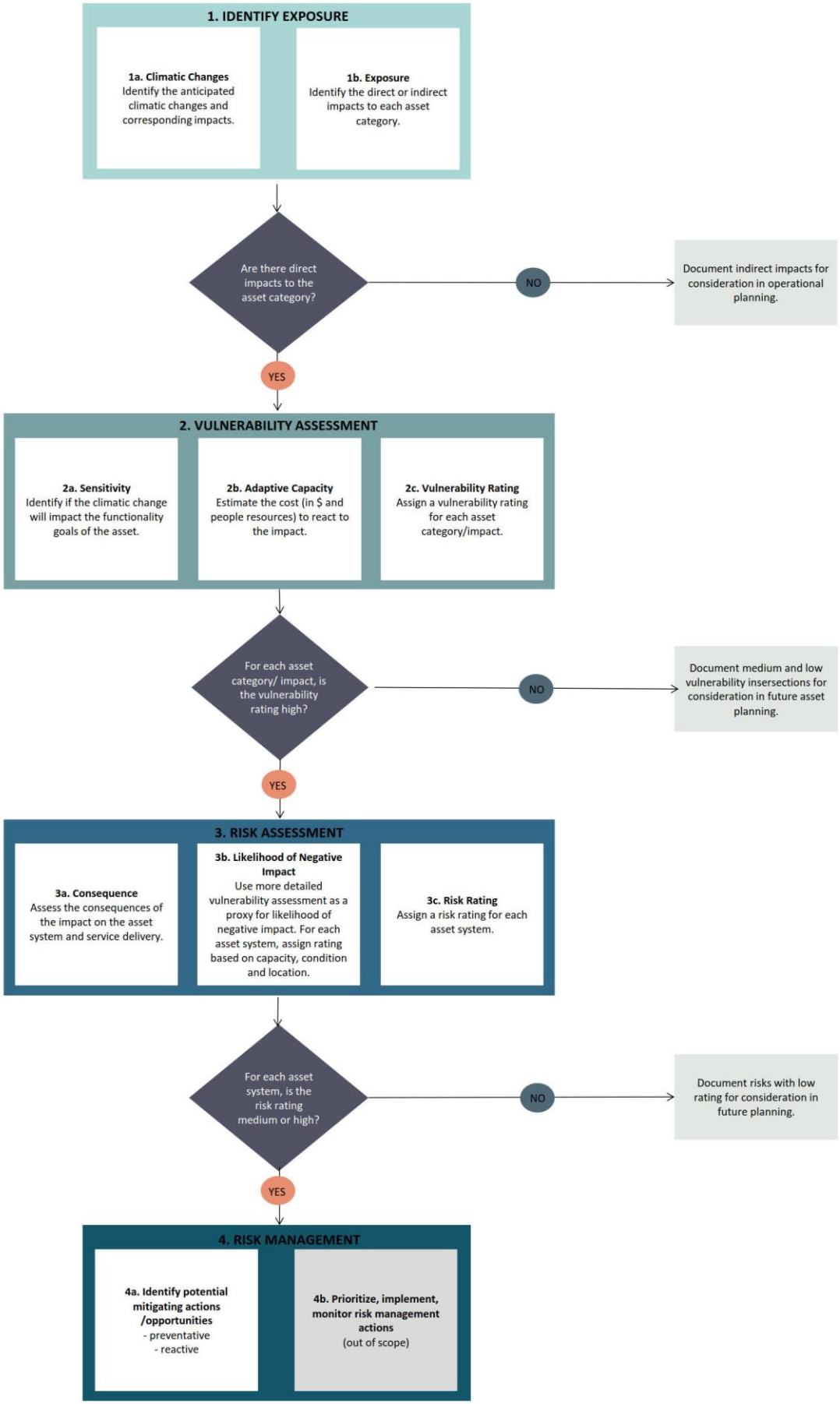

Figure 1. CVRD asset vulnerability and risk assessment process, adapted from the ICLEI Changing Climate, Chaning Communities Workbook

The framework developed was applied in two ways:

1. Screening level: each of the 12 asset systems was assessed as a full category. For example, water systems were assessed at the screening level as a category, rather than assessing each of the 19 water systems individually.
2. Case study level: two assets were selected for an in-depth assessment. The assessment could consider attributes that were unique to that asset such as geography, capacity, or physical condition.

Both levels of assessment used the same framework and tool – the difference between the approaches was the level of detail applied to the assessment.

2.2 Screening level assessment

STEP 1. IDENTIFY EXPOSURE

Recording Regional and Sub-Regional Climate Changes

CVRD Climate Projections for the Cowichan Valley Regional District[5] was used to identify the type and magnitude of climate changes that may impact asset systems. The changing climatic conditions were organized into three categories: warmer temperature, increased precipitation, and increase in sea level rise. Sub-regional variability by watershed was accounted for by including the three watersheds within the CVRD: Developed Area, Water Supply and West Coast. The screening level risk assessment used regional climate projections, and the case studies used the sub-regional projection that corresponded to the location of the asset.

Example climatic change
Wetter winter: Projected 11% increase in volume and intensity of precipitation during winter months (from 808 mm to 908 mm).

The range of uncertainty in projections between model and natural climate variability can be described by using the 10th and 90th percentile. For purposes of infrastructure planning (including this vulnerability and risk assessment), CVRD has selected to use the projection that allows for conservative planning (i.e. either the 90th or 10th percentile was used for each projection depending on which value would have the greatest impact on the asset system). The result is that the projected climatic changes were primarily recorded using the 90th percentile of the climate model. This provides allowance to plan to the extreme case. For example, number of sequential summer days, hottest day and 1-in-20 hottest days. There were a few instances that the 10th percentile was used. For example, coldest winter night, 1-in-20 coldest night and heating degree days. Applying the 10th percentile will enable the CVRD to plan for the coldest winter night, 1-in-20 coldest night and for cooling degree days, respectively.

To identify significant asset risks within a standard long-term capital planning time frame, 2050 was selected as the horizon for the asset risk screening purposes. The 2050 horizon was selected to identify risks that may arise within the remaining useful life of existing infrastructure. Note that the

[5] *Cowichan Valley Regional District. (2017). Climate Projections for the Cowichan Valley Regional District. 46 pgs.*

design of any new long-life infrastructure should consider climatic changes projected for the 2100 horizon.

Additional parameters that were applied to record the regional and sub-regional climate changes compared:

- Rate of change to past and current conditions for climatic change categories and sub-categories;
- Extent of variability conditions for climatic change categories; and
- Seasonal variability conditions for climatic change categories[3].

Exposure: *Will the climatic change impact the asset system?*

Based on the three climatic conditions (warmer temperature, increased precipitation, and increase in sea level rise), the potential exposure to asset systems was identified.

The potential for direct and indirect impacts between each climatic change and each asset system was assessed to identify exposures. Direct Impacts will impact the functionality of the asset while indirect Impacts will impact the service, but not the functionality of the assets. Direct impacts were noted where a direct impact was identified through GIS data for one or more asset systems within the asset category (intersection between the asset and flood extents or area of inundation, or proximity of the asset system to a steep slope), or where there may be an impact and further information about the assets was required[6].

Example direct impact
Increased inflow and infiltration in sewer systems due to increased winter precipitation.

STEP 2. VULNERABILITY ASSESSMENT

The vulnerability of an asset system was assessed as a product of the sensitivity and the adaptive capacity of the asset system to each of the direct impacts identified. Information for the vulnerability assessment was based on judgement and staff input, as well as asset condition information where available.

Sensitivity: *Will the climatic change impact the functionality goals of the asset system?*

A sensitivity rating was assigned to each direct impact on the asset system, based on the extent that the functionality goals of the asset system would be affected by the direct impact (**Figure 2**).

Sensitivity Rating					
If the impact occurs, will it impact the functionality goals of the asset system?					
	S1	**S2**	**S3**	**S4**	**S5**
	No - functionality will stay the same.	Possibly - functionality may get worse.	Yes - functionality will get worse on a temporary basis.	Yes - functionality will get worse permanently, or unmanageable temporarily.	Yes - functionality will become permanently unmanageable.

Figure 2. Sensitivity Rating Scale

6 CVRD. (2018). GIS Data. BC.

Adaptive capacity: *Can the asset system easily adjust to the impact?*

Adaptive capacity of the asset system reflects whether the asset system or service can adjust to the direct impact with minimal cost or disruption. The adaptive capacity rating was determined by estimating the cost and staff intervention required to react to the impact (**Figure 3**).

Adaptive Capacity Rating					
Can the asset system/ service adjust to the projected impact with minimal cost and disruption?					
	AC1	**AC2**	**AC3**	**AC4**	**AC5**
	No, will require substantial costs ($$$$$) and staff intervention.	No, will require substantial costs ($$$$) and staff intervention.	Maybe, will require some costs ($$$) and staff intervention.	Yes, but will require some costs ($$) and staff intervention.	Yes, will require minimal costs ($) and staff intervention.

Figure 3. Outlines the Adaptive Capacity Rating Scale

Vulnerability: *Is the impact of the climatic change a concern for the asset system?*

The product of the sensitivity rating and the adaptive capacity rating results in the vulnerability rating. (**Figure 4**).

Asset System Vulnerability Rating					
	S1	**S2**	**S3**	**S4**	**S5**
AC1	V1	V2	V4	V5	V5
AC2	V1	V2	V4	V5	V5
AC3	V1	V2	V4	V4	V4
AC4	V1	V2	V3	V3	V3
AC5	V1	V1	V3	V3	V3

V5	Risk assessment to prioritize implementation of actions.
V4	Risk assessment to prioritize implementation of actions.
V3	Actions to be implemented, prioritized based on S rating.
V2	Monitor changes in functionality or adaptive capacity.
V1	No action required at this time.

Figure 4. Vulnerability Rating Scale

Each direct impact that resulted in a high vulnerability rating was further reviewed under the risk assessment framework. Direct impacts with medium to low vulnerability rating for each asset system have been noted for consideration in future planning.

STEP 3. RISK ASSESSMENT

While a vulnerability assessment of asset systems can help to identify the potential problems, the number and scope of potential problems may be beyond what can be practically addressed with local government resources. Conducting a risk assessment can support the prioritization of actions to reduce risk.

Risk is the product of the consequence and likelihood of an event. For a climate change risk assessment, the event being considered is the impact of a specific climatic change on a specific asset system.

Risk = Consequence x Likelihood

Consequence is based on the overall severity of the impact on the CVRD's assets and the community. Consequence is assessed comprehensively by including many attributes, such as health and safety, levels of service, and financial impacts.

The role of the CVRD; stated vision, values and priorities in the Strategic Plan[7]; and input from staff were used to develop the categories and definitions in the consequence scale (Table 1).

For each climate/asset system interaction being assessed, a consequence was assigned for each of the seven consequence categories. These were added together for an overall consequence score. All categories were assumed to have equal weighting at this time, however staff discussed a desire to consider assigning a unique weighting to each of the consequence categories in the future.

7 CVRD. (2014). 2014-2018 CVRD Strategic Plan.

Table 1. Consequences Scale

Consequence Rating							
What will be the overall severity of the impact to the CVRD and the community?							
		C1	**C2**	**C3**	**C4**	**C5**	**Notes**
	Category	**Negligible**	**Minor**	**Moderate**	**Major**	**Catastrophic**	
1	**Health and Safety**	Appearance of threat but no harm	Serious near misses or minor injuries/health impacts that do not require medical consultation.	Small number of injuries that require medical consultation	Isolated instances of serious injuries, chronic health impacts, or fatality	Large numbers of serious injuries or loss of multiple lives	*Considers public and CVRD employees.*
2	**Environment and Environmental Sustainability**	Appearance of threat or short term irritants, but no harm. No impact to sustainability goals.	Minor instances of environmental damage that could be reversed. Minor impact to sustainability goals.	Isolated but significant instances of environmental damage that might be reversed with intensive efforts. Major impact to sustainability goals.	Severe loss of environmental amenity and a danger or continuing environmental damage	Major widespread loss of environmental amenity and progressive irrecoverable environmental damage.	*Refers to environmental damage as a result of impacts to infrastructure, not as a result of the climatic change.*
3	**Local Economy**	Minor shortfall relative to current forecasts	Individually significant but isolated areas of reduction in economic performance relative to current forecasts	Significant general reduction in economic performance relative to current forecasts	Regional stagnation such that businesses are unable to thrive and employment does not keep pace with population growth	Regional decline leading to widespread business failure, loss of employment and hardship	*Relates to the CVRD's function in local economic development.*
4	**Level of Service**	Isolated, short-term periods of not delivering target levels of service	Regular, short-term periods of interruptions to target levels of service	Noticeable impacts to quality of life due to occasional long-term periods of service interruption, OR noticeable permanent decline in level of service across the region	Substantial decline in quality of life across the region due to frequent long-term periods of service interruption, OR substantial permanent decline of level of service	Complete service interruption for an indefinite period, leading to major decline in quality of life across the region	*Will be assessed based on level of service framework for each asset system.*

5	**Administration and Operations**	One off adjustments required to operational or administrative processes	Isolated instances of operations or administration being under severe pressure	Prolonged and regular instances of operations or administration under severe pressure	Significant permanent challenges to operational or administrative functions	Completely unable to maintain or operate asset systems or provide critical administrative functions	*Relates to the ability of the CVRD to provide governance, administrative functions, and service operations.*
6	**Finances**	<$25k	>$25k - $100k	>$100k- $500k	>$500k - $1M	>$1M	*Reactive costs of addressing impact borne by the CVRD. Includes increased operational costs, capital costs, and any potential fines or damages that CVRD would be responsible for. May also include reduction in revenue or lost opportunity that is not accompanied by a reduction in costs.*
7	**Reputation**	One off localized negative publicity	Short term regionalized negative publicity	Short term provincial negative publicity, strain on relationships with neighbouring communities, small reduction in resident satisfaction	Prolonged regionalized negative publicity, damage to relationships with neighbouring communities, significant reduction in resident satisfaction	Prolonged major reputation damage, prolonged reports in national news, significant damage to relationships with neighbouring communities, major reduction in resident satisfaction	*Relates to the importance of relationships with neighbouring local governments and First Nations, as well as public confidence in the CVRD.*
Consequence rating table adapted for CVRD from Exhibit 8.2, Consequence Criteria - ICLEI Municipal Climate Adaptation Guide and Workbook							

The **likelihood** rating was determined by considering the likelihood of the direct impact, which includes consideration of the likelihood of the climatic event (e.g. drought or wildfire) and the capacity, condition and location for each asset system (Table 2).

Table 2. Likelihood Rating Scale

What is the likelihood of the impact occurring, given the magnitude of the predicted climatic change the location of the asset system, and the ability of the system to withstand the impact?

	L1	**L2**	**L3**	**L4**	**L5**	
	Rare	**Unlikely**	**Possible**	**Likely**	**Almost Certain**	**Notes**
Single Event	Probability very small, close to zero	Low probability but greater than zero	Probability less than 50%	As likely as not likely - 50/50 chance	More likely than not	*Considers likelihood of impacts due to climate event and specific location of individual asset systems.*
Recurring Event	Unlikely during next 30 years	May arise once during 30 years	May arise once in 10 year period	May arise once per year	Likely to occur more than once per year	

Vulnerability and Risk Assessment Reference Materials

Reference material used to confirm and refine the vulnerability and risk assessment included:

- CVRD climate projections
  - Regional for screening
  - Sub-regional for case studies
- Asset inventories
- GIS data
  - Flood, inundation, wildfire risk
  - Asset location where available
- Project team input (refining the process)
- Staff input and specific asset data (case studies)

STEP 4. RISK MANAGEMENT

Risk management is the ongoing process of identifying and assessing risks, implementing risk reduction actions, and monitoring risks over time.

The first part of this risk management process was implemented as part of this project. Risks to asset systems due to climate change were identified and assessed.

In cases where information was available, actions for reducing risk due to climate change have also been identified. Typical actions to reduce risk may include a capital project, changing an operational or maintenance program, or seeking additional information where the available information is insufficient for the nature of the decision it needs to inform.

The prioritization and implementation of risk reduction actions is outside the scope of this project. Risks related to climate change are only one type of asset or service risk. To most effectively prioritize the use of limited resources, risks related to other events should be identified and prioritized with the climate risks. The risk assessment framework developed as part of this project (specifically the consequence and likelihood ratings) are not specific to climate risks and can be applied to other types of risk.

2.3 Case Studies of Selected Asset Systems

The case studies were designed to act as a tool to support the CVRD with understanding the approach for conducting a more detailed risk assessment, and the benefits that can be gained. The CVRD selected two assets for detailed assessment: Douglas Hill water system and Arbutus Park.

To develop the case studies, the screening level assessment of the relevant asset system was used as a starting point. Then the following prompts were used to refine the vulnerability and risk rating:

- System specific vulnerabilities due to location, type of infrastructure, type of use.
- Consequence of climate impacts unique to that asset (e.g. financial impacts relative to the budget for the system).
- System attributes that would impact the likelihood of failure, such as existing system age and/or condition, existing system stresses, options for alternative service.

Information was gathered from a variety of information sources provided by the CVRD (refer to **Appendix 3** for a full list) and was refined using input from CVRD staff, gathered during a half day workshop.

3 RESULTS

3.1 Vulnerability and Risk Screening

The results of the vulnerability and risk screening are preliminary and are based primarily on a desktop review of available asset information. These results can be used to engage staff in discussions about the impacts of climate change on asset systems, and these discussions can be used to verify and refine the results. The tool that has been developed to support the vulnerability and risk assessment process provides a robust and systematic approach to assessing vulnerability and risk; one that can be modified and updated based on new and improved information. The results highlight the regional and sub-regional climate changes, potential direct and indirect climate change impacts and the vulnerability and risk assessment.

CLIMATIC CHANGES

Data about regional and sub-regional climatic changes was obtained from previous work to done by the CVRD to develop climate projections[8]. This data was organized by changing climatic condition: warmer temperatures, increased precipitation, and increased sea level rise. Some of the regional climate projections used include:

- Drier summers
  - Projected 8 day increase to average longest consecutive period without rain (from 22 days to 29.9 days). Total summer precipitation projected to reduce from 158mm to 93mm.
- Wetter winters
  - Projected 11% increase in total precipitation during winter months (from 808 mm to 908 mm). 99th percentile wettest days projected to increase 107% (from 134mm to 278mm).
- Sea Level Rise
  - Projected 1 m rise in sea level. (Recognizing the province is suggesting the use of a 2 m increase for strategic master planning and infrastructure purposes.)
- Longer and More Intense Storms
  - The duration and frequency of storms will increase, bringing high winds, storm surges, and intense rain.

For a further detail on regional and sub-regional climate projections used, refer to **Appendix 4**.

EXPOSURE: DIRECT AND INDIRECT IMPACTS

The potential direct and indirect climate impacts of asset systems and operations were identified. For example, increase energy demands due to increased cooling needs would directly impact the functionality of a recreation centre. Whereas, an increased demand on services due to potential extension of summer and tourism season would indirectly impact the service, but not the functionality of the recreation centre. For a full list of direct and indirect impacts, refer to **Appendix 5**.

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[8] *Cowichan Valley Regional District. (2017). Climate Projections for the Cowichan Valley Regional District. 46 pgs.*

VULNERABILITY AND RISK ASSESSMENT

The vulnerability assessment identified related services and operations that will likely be impacted by climate projections. The risk assessment identified where the asset system vulnerabilities would pose the greatest risk to the CVRD and community. Overall, the highest risk to CVRD asset systems was assessed to be the impact of inflow and infiltration on sewer systems.

Common themes from the risk assessment demonstrated that the projected impacts of climatic changes will likely affect the CVRD's ability to meet target levels of service and sustainability goals. The total costs associated with future impacts will likely be dependent on the magnitude of the event and subsequent damage.

The asset systems that experienced the highest level of risk and themes are summarized in Table 3. For the full, detailed vulnerability and risk assessments, refer to **Appendix 6**.

Table 3. Summary of Highest Risks by Asset System

Asset System	Projected Climatic Change	Predicted Direct Impacts	Anticipated Outcome of Direct Impact
Recreation Centre	Warmer summers	Increase energy demands due to cooling needs.	Increase energy use and pressure on HVAC system.
Community Centres			
Community Halls			
Aministration			
Parks and Trails	Longer and more intense storms	Increase damage to facilities due to storm surges and severe wind storms.	Loss or reduction of coastal recreation space. Loss or damage of trees and parks/trails infrastructure.
Water Systems	Drier summers	Reduced recharge of groundwater sources due to decrease in precipitation.	Reduced capacity to source aquifer and inability to meet water demands.
		Increase in watering and irrigation needs due to increased precipitation and drought.	Increased demand on water source, increased pumping and treatment requirements, and faster depletion of water storage.
	Warmer summers	Increased demand on services due to potential extension of summer, growing season, and tourism season.	Inability to meet demand and water conservation goals.
Sewer System	Wetter winters	Increased pressure on infrastructure due to more intense precipitation events.	Temporary flooding and increased inflow and infiltration. Temporary inability to meet local conveyance and treatment demands, surcharging and over flows.
	Sea Level Rise	Damage or loss to infrastructure due to higher king tides.	

Asset System	Projected Climatic Change	Predicted Direct Impacts	Anticipated Outcome of Direct Impact
	Longer and More Intense Storms	Damage to infrastructure due to increased frequency and severity of storms.	
Drainage Systems	Wetter Winters	Increased pressure on infrastructure due to more intense precipitation events.	System overflows and potential damage or washouts.

CASCADING IMPACTS

Impacts to one asset system may lead to impacts on other asset systems. This is called cascading impacts. For example, damage to a sewage disposal field due to increased inflow and infiltration may lead to localized surcharge and flooding, damaging other adjacent infrastructure such as a park.

Cascading impacts are related to specific interactions between asset systems, which is often related to the location and connection between specific assets. Cascading impacts have generally not been identified through the screening level assessment because this level of assessment lacks the detail of specific asset location. Cascading impacts can be identified through a detailed assessment for specific assets, using the level of detail that was applied for the case studies.

3.2 Case Study of Selected Asset Systems

3.2.1 CASE STUDY 1: DOUGLAS HILL WATER SYSTEM

The Douglas Hill water system services the Douglas Hill and Jim's Crescent subdivision from two groundwater wells. This asset was selected to further explore the impacts of climate change on a water system with a groundwater source.

The highest levels of climate risk to the Douglas Hill water system were related to drier and longer summers:

1. Potential reduced recharge of the groundwater aquifer due to decrease in precipitation, leading to potential stress on the groundwater source aquifer.
2. Increased watering due to decreased precipitation and longer summer/growing season, leading to potential stress on the groundwater source aquifer.

CVRD staff identified that likely the most effective way to manage these risks was to implement incentives or regulations that lead to changes in water use behaviour and increase conservation of water.

A significant conclusion of the case study discussion was that CVRD does not have sufficient data on the capacity or recharge mechanisms of the aquifer, making it difficult to confidently assess the level of risk. This conclusion illustrates that conducting a risk assessment can be an effective way of identifying and prioritizing important areas for data improvement.

Further details of the Douglas Hill case study can be found in **Appendix 7**.

3.2.2 CASE STUDY 2: ARBUTUS PARK

The Arbutus Park, located on Cowichan Lake in Youbou, was selected to explore the impacts of climate change on a well visited park in the CVRD.

The highest level of climate risk to the Arbutus Park was related to longer and more intense storms. This exposure will likely result in increased damage to facilities due to severe wind storms, leading to potential damage to trees and infrastructure due to windfall.

Future planning efforts by the CVRD staff should focus on identifying the most effective way to manage this risk. The unpredictable nature of such events impressed the importance of including the potential risk of climate change into future planning, operation and maintenance budgets.

Further details of the Arbutus Park case study can be found in **Appendix 8**.

4 BRIDGING THE GAP – CLIMATE CHANGE AND ASSET MANAGEMENT

4.1 Building Internal Capacity

To effectively understand and proactively manage the range of impacts that will likely affect the CVRD's infrastructure, the CVRD can use the vulnerability and risk assessment framework as a tool to build internal capacity. The existing tool serves as a foundation – it can (and should) be reviewed, modified, and updated to best reflect CVRD's context, the current state of assets, and to best support decision making.

Through practice, CVRD staff will gain a better understanding and working knowledge of the impacts of climate change on asset systems and services. This understanding will support data improvement programs, planning, capital, operation and maintenance, and financial management system decisions. The earlier potential risks are understood, the more opportunities will be available for acting to manage risk through other programs or actions (such as asset renewal or replacement).

4.2 Considerations for Asset Management Policy

Suggestions for amendments to the Asset Management Policy have made to support the integration of climate change and asset management. An effective asset management policy should reference the impacts of climate change on asset systems and commit the organization to understanding and managing these risks, as one of several types of risk to assets.

The suggested amendments are in **Appendix 9**

5 CONSIDERATIONS FOR NEXT STEPS

The following next steps have been identified for consideration by CVRD.

1. COMMUNICATE RESULTS WITH APPROPRIATE AUDIENCES

Results may be communicated with key stakeholders for varying purposes:

- CVRD staff (asset owners): support raising awareness of specifically how climate change will impact their operations. Provide an opportunity to review, verify, and update results to reflect their knowledge of the asset system.
- CVRD board: support raising awareness of tangible ways that climate change will impact the ability of CVRD to provide services and build support for updating the AM policy and taking actions that may be required to manage risk.
- Public: key results and messages may be selected to share with the public as part of existing communication efforts or as standalone initiatives when required to communicate a change to services.

2. CONSIDER GOING INTO "CASE STUDY" LEVEL FOR SELECT ASSETS

Given the number of assets owned by the CVRD, it is not practical to conduct a vulnerability and risk assessment on all assets at the case study level of detail. The following criteria should be considered to identify assets where detailed case studies may be helpful:

1. High levels of uncertainty and need to prioritize data improvements;
2. Those assets impacted by sea level rise; and
3. Those that are "typical" asset systems, which can support broader learning and action. For example, a recreation centre.

3. UPDATE ASSET MANAGEMENT POLICY

As outlined in Section 3.2, we have identified suggestions for modifying the CVRD's asset management policy to integrate climate change. It is recommended that these suggestions be reviewed and considered for inclusion in the policy.

4. DEVELOP A CORPORATE RISK MANAGEMENT FRAMEWORK

A corporate risk management framework outlines a consistent approach to risk identification, classification, prioritization, and management. The risk management framework should identify climate risks as one type of risk to be considered, as well as other types of risk. The risk management framework may leverage the consequence and likelihood definitions from the climate risk assessment tool. The corporate risk management framework will be a standalone document and include risks beyond asset risks, but it should be linked to the CVRD's Asset Management Strategy.

5. INTEGRATE RESULTS INTO ASSET MANAGEMENT PLAN

Rank climate change risks alongside other asset risks to support prioritization of risk management actions such as capital and operational improvements. Identify these actions and corresponding financial strategies in the asset management plan.

6. INTEGRATE RESULTS INTO OPERATIONS AND PLANNING

At the operation and planning level, the following steps should be considered:

1. Check existing plans for potential gaps (e.g. emergency response plans, etc.)
2. Update operation plans to reduce vulnerabilities where appropriate
3. Improve data confidence to refine risk ratings (e.g. groundwater information, monitoring operations and maintenance activities, incident reporting - including incidents related to climatic variables).

Ensuring operations and planning staff have the appropriate background context and time allowance to incorporate these steps will be key to successfully integrating the results.

7. USE, REVIEW, REFINE, AND UPDATE THE TOOL AS REQUIRED

The development of the risk assessment framework and tool is perhaps the most important result of this project. Using the tool together with staff will not only provide useful information about vulnerabilities and risks, but it will also build staff's understanding of the impacts of climate change on assets and services, and how to take a systematic approach to risk management. The inputs to the tool, and the tool itself, should be refined as improved information becomes available.

APPENDIX 1
Asset Systems in the CVRD

URBAN systems

Table 1A. Identifies 12 asset systems in the CVRD.

No.	Asset System/ Service Category	Individual Systems	Division Stakeholders
1	Recreation Centres	Island Savings Centre (Cowichan Performing Arts Centre), Kerry Park Recreation Centre, Cowichan Lake Sports Arena	Facilities/Arts and Culture/Cowichan Lake Recreation/Island Savings Centre/South Cowichan Recreation
2	Community Centres	Elsie Miles, Shawnigan Lake Community Centre	Facilities/South Cowichan Recreation
3	Community Halls	Honeymoon Bay, Youbou, Mesachie, Lake Cowichan, and Saltair	Facilities/Cowichan Lake Recreation/Parks and Trails
4	Administration	CVRD Head Office	Facilities
5	Public Safety	Honeymoon Bay Fire Hall, Mesachie Lake Fire Hall, Youbou Fire Hall, Sahtlam Fire Hall, Malahat Fire Hall, North Oyster Fire Hall, Communications Network	Public Safety
6	Parks and Trails	206 Community Parks, 6 regional parks and over 100 km of trails.	Parks and Trails
7	Recycling and Waste Management	Bings Creek Recycling Centre, Peerless Recycling Centre, Meade Creek Recycling Centre, and curbside pick-up	Recycling and Waste Management
8	Water Systems	19 systems	Water Management
9	Sewer Systems	16 systems	Water Management
10	Drainage Systems	8 systems	Water Management
11	Ornamental Street Lighting	5 systems	Water Management
12	Transit	27 Bus shelters	Facilities and Transit Management Division

APPENDIX 2
Risk Framework Review

URBAN systems

Framework	Overview	Information Inputs	Strengths (ability to meet objectives)	Weaknesses
PIEVC	Developed and owned by Engineers Canada. Five step evaluation process for screening risk to infrastructure systems. Includes optional TBL module. Requires a licensing agreement with EC, submission of the report, and destroying the tools after use.	Stakeholder knowledge of system design, capacity, operations, and current stresses. Calculations of current and future loads on infrastructure, as well as capacity. Professional judgement.	Provides systematic and organized approach to screening. Can incorporate quantitative data where available.	Local governments can struggle with data sufficiency to calculate loads, end up using professional judgement instead (spreadsheet tools not fully utilized and become cumbersome to work with). Worksheets would likely require adaptation to suit context. Licensing agreement may present challenges for building capacity and updating tools over time as new data is available (i.e. study would need to be started from the beginning each time).
Changing Climate, Changing Communities	Developed by ICLEI for local governments. Uses worksheets to:	Stakeholder knowledge of system design, capacity,	Provides systematic and organized	Vulnerability assessment is designed for

– Guide and Workbook - ICLEI	1. Refine impacts of climate change scenarios 2. Identify affected service areas 3. Assess the vulnerability of service areas (assessment of sensitivity, adaptive capacity, and then overall vulnerability) 4. Assess risk to services	operations, and current stresses. Professional judgement.	approach to screening. Considers direct and indirect impacts. Could be applied to all asset systems.	service area, not asset system. Worksheets would require adaptation to look specifically at asset systems and for local context.
MRAT Insurance Bureau of Canada	Developed by the Insurance Bureau of Canada, now owned by Tesera. Online tool used to develop risk maps and understand where the greatest sewer and stormwater vulnerabilities are.			Does not meet project objectives, focused on sewer and drainage systems.

APPENDIX 3
Case Study References

URBAN systems

Case Study References

CVRD. (2017). *WTP Treatment Plant Field Inspection.*

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APPENDIX 4
Climate Change

URBAN systems

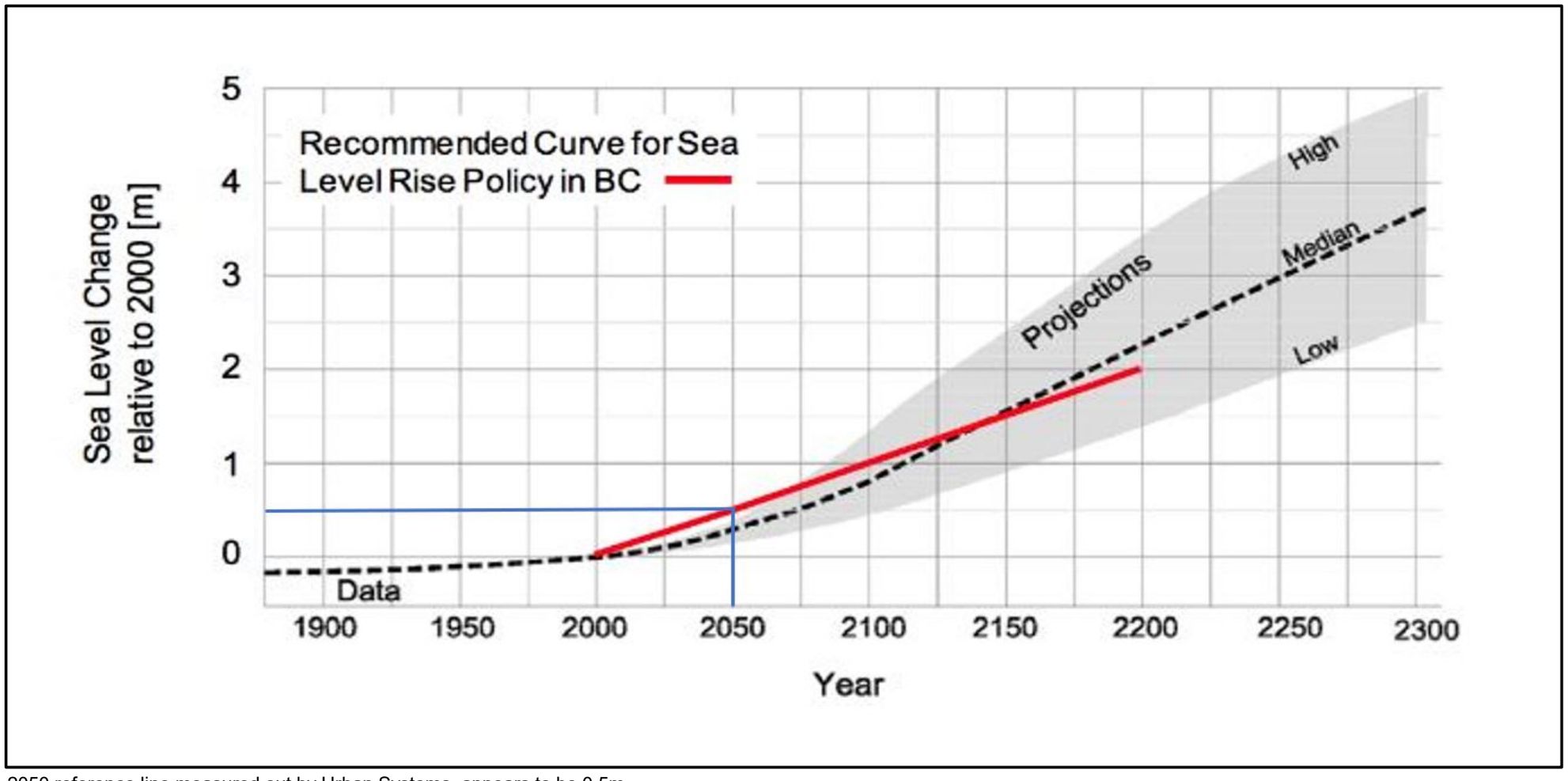
Cowichan Valley Regional District: Climate Risk Assessment - CVRD Asset Systems

Regional Climatic Changes (1)

Changing Climatic Condition	Sub-region Variability (2)	Regional Range of Expected Change By a Specific Date from 1971 - 2000 by 2050 (3, 4)	Comparing Rate of Change to Past and Current Conditions	Extent of variability by 2050	Seasonal Variability
Warmer Temperatures	Relatively uniform, with most warmer in valleys and low-lying areas.	4.0 °C increase annual in daytime high and 3.6 °C increase in nighttime low	**Past:** average annual daytime high temperature of 12.0 °C and average nighttime low temperature was below freezing -0.6°C. **Future:** annual daytime high will be 16.0 °C and the annual nighttime low is expected to rise to 7.6 °C. Meanwhile, only highest elevations will experience nighttime lows below freezing	In general, temperatures are expected to increase year round. Daytime high and nighttime low expected to increase by 4.0 °C and 3.6 °C , respectively.	**Daytime High: Summer:** will experience a 4.2 °C increase and equate to 24.2°C. **Fall:** will experience a 3.8°C increase and equate to 16.8°C. **Winter:** will experience a 3.3 °C increase and equate to 8.3°C . **Spring:** will experience a 4.6°C increase and equate to 15.6°C . **Nighttime low**: **Summer:** will experience a 4.0°C increase and equate to 13.0°C. **Fall:** will experience a 3.7 °C increase and equate to 8.7°C. **Winter:** will experience a 3.2 °C increase and equate to 2.2 °C . **Spring:** will experience a 3.6 °C increase and equate to 5.6°C .
Summer days	**Developed Area:** In the past an average number of days > 25 °C was 23 and by 2050 there will be 65 days. **Water Supply Watershed:** In the past an average number of days > 25 °C was 16 and by 2050 there will be 46 days. **West Coast Watersheds:** In the past an average number of days > 25 °C was 10 and by 2050 there will be 36 days.	32-day increase	**Past:** 16 summer days in a year was the norm. **Future:** expected to increase to 48 days.		
Hottest Day	**Developed Area:** In the past an average hottest daytime high (°C) was 31.0 and by 2050 it will be 35.4. **Water Supply Watershed:** In the past an average hottest daytime high (°C) was 30 and by 2050 it will be 34.0. **West Coast Watersheds:** In the past an average hottest daytime high (°C) was 29 and by 2050 it will be 32.6.	4.0 °C increase	**Past:** on average the hottest day temperature was 30.0°C. **Future:** expected to increase to 34.0 °C		
1-in-20 Hottest days	**Developed Area:** In the past the average 1-in-20 hottest day (°C) was 34.0 and by 2050 it will be 39.8. **Water Supply Watershed:** the average 1-in-20 hottest day (°C) was 33.0 and by 2050 it will be 38.3. **West Coast Watersheds:** the average 1-in-20 hottest day (°C) was 33.0 and by 2050 it will be 37.7.	5.2 °C increase	**Past:** on average the 1-in-20 hottest day temperature was 33.0°C. **Future:** expected to increase to 38.2°C		
Cooling Degree Days (CDD)	**Developed Area:** In the past, the number of degrees that a day's average temperature > 18°C was 47 and by 2050 there will be 289.1 cooling days.	575% increase	**Past:** on average there were 28 cooling days. **Future:** expected to rise to 189		
Growing Season Length	**Developed Area:** In the past the average growing season length was 262 days and by 2050 it will be 333. **Water Supply Watershed:** In the past the average growing season length was 218 days and by 2050 it will be 304. **West Coast Watersheds:** In the past the average growing season length was 232 days and by 2050 it will be 317.	80-day increase	**Past:** growing season length was an average of 237 days. **Future:** expected to increase to 317.		
Coldest Winter Night	**Developed Area:** In the past the average coldest winter night (°C) was -10.0 and by 2050 it will be -7.5. **Water Supply Watershed:** the average coldest winter night (°C) was -11.0 and by 2050 it will be -8.7. **West Coast Watersheds:** the average coldest winter night (°C) was -10.0 and by 2050 it will be -7.8.	2.3 °C increase	**Past:** coldest winter night was -10.0°C. **Future:** projected to increase to -7.3°C.		
1-in-20 Coldest Night	**Developed Area:** In the past the average 1-in-20 coldest night (°C) was -16.0 and by 2050 it will be -14.2. **Water Supply Watershed:** the average 1-in-20 coldest night (°C) was -18.0 and by 2050 it will be -16.2. **West Coast Watersheds:** the average 1-in-20 coldest night (°C) was -16.0 and by 2050 it will be -14.9.	1.8 °C increase	**Past:** 1-in-20 coldest night was -17.0°C.**Future:** projected to increase to -15.2 °C.		
Heating Degree Days (HDD)	Sub-regional trends align with regional trends with decreases of 23% to 26% by 2050	33% decrease	**Past:** HDD was 3659. **Future:** projected to decrease to 2451.5 HDD.		
Frost Days (FD)	**Developed Area:** In the past the average frost days was 66 and by 2050 it will be 31. **Water Supply Watershed:** the frost days was 101 and by 2050 it will be 55. **West Coast Watersheds:** frost days was 88 and by 2050 it will be 46.	41-day decrease	**Past:** on average the region experienced 86 frost days. **Future:** expected to decrease to 45 frost days.		
Increased Precipitation	The baselines for precipitation are different for regional and sub-regional. In general, similar changes throughout the region will be experienced.	10% increase	**Past:** average annual precipitation of 2028mm . **Future:** annual precipitation of 2230.8 mm is anticipated.	A modest 10% increase in total annual precipitation will occur. Majority of precipitation events will continue to occur during fall and winter months while summer months are expected to experience less precipitation.	**Summer:** will experience a 41% decline and equate to 93 mm. **Fall:** will experience a 25% increase and equate to 765 mm. **Winter:** will experience an 11% increase and equate to 908 mm. **Spring:** will experience a 13% increase and equate to 467 mm.
Longer Dry Spells	Sub-regional trends align with regional trends	8-day increase	**Past:** average longest consecutive period without rain was 22 days. **Future:** expected to increase to 29.9 days		
Single-day Maximum Precipitation	**Developed Area:** In the past an average rain fall of 61.0 mm and by 2050 a rainfall of up to 80.0 mm is predicted. **Water Supply Watershed:** In the past an average rain fall of 79.0 mm and by 2050 a rainfall of up to 103.0 mm is predicted. **West Coast Watersheds:** In the past an average rain fall of 87.0 mm and by 2050 a rainfall of up to 113.0 mm is predicted.	28% more rain	**Past:** single wettest day accumulated an average of 75.0 mm **Future:** single wettest day will accumulate 96.0 mm		
5-day Maximum Precipitation	**Developed Area:** In the past an average rain fall of 139.0 mm and by 2050 a rainfall of up to 168.0 mm is predicted. **Water Supply Watershed:** In the past an average rain fall of 186.0 mm and by 2050 a rainfall of up to 223.0 mm is predicted. **West Coast Watersheds:** In the past an average rain fall of 206.0 mm and by 2050 a rainfall of up to 244.0 mm is predicted.	20% more rain	**Past:** wettest 5-day period accumulated an average of 177.0 mm **Future:** wettest 5-day period will accumulate 212.4 mm		
95th-percentile Wettest Day	**Developed Area:** In the past an average rain fall of 329 mm and by 2050 a rainfall of up to 544.0 mm is predicted. **Water Supply Watershed:** In the past an average rain fall of 471.0 mm and by 2050 a rainfall of up to 734.0 mm is predicted. **West Coast Watersheds:** In the past an average rain fall of 536.0 mm and by 2050 a rainfall of up to 832.0 mm is predicted.	57% more rain	**Past:** wettest day that exceeds 95th-percentil threshold accumulated on average 448.0 mm **Future:** wettest day that exceeds 95th-percentile threshold will accumulate 703.4 mm		
99th-percentile Wettest Day	**Developed Area:** In the past an average rain fall of 100.0 mm and by 2050 a rainfall of up to 205.0 mm is predicted. **Water Supply Watershed:** In the past an average rain fall of 141.0 mm and by 2050 a rainfall of up to 285.0 mm is predicted. **West Coast Watersheds:** In the past an average rain fall of 158.0 mm and by 2050 a rainfall of up to 321.0 mm is predicted.	107% more rain	**Past:** wettest day that exceeds 99th-percentile threshold accumulated on average 134.0 mm **Future:** wettest day that exceeds 99th-percentile threshold will accumulate 277.4 mm		
1-in-20 (5%) Wettest Day	**Developed Area:** In the past an average rain fall of 95 mm and by 2050 a rainfall of up to 136.0 mm is predicted. **Water Supply Watershed:** In the past an average rain fall of 118.0 mm and by 2050 a rainfall of up to 177.0 mm is predicted. **West Coast Watersheds:** In the past an average rain fall of 128.0 mm and by 2050 a rainfall of up to 188.0 mm is predicted.	45% more intense	**Past:** 1-in-20 wettest day accumulated 112.0 mm. **Future:** projected to accumulate 162.4 mm		
Increase Sea Level Rise (5)	Coastal communities will likely experience sea level rise of 1 m by 2100	1 m rise		Based on projected sea level rise of 1 m (by 2100) coupled with storm surges and king tides, coastal communities will likely be vulnerable to flooding.	

Notes and Assumptions

1. Cowichan Valley Regional District. (2017). Climate Projections for the Cowichan Valley Regional District.
2. Sub-regional analysis has been conducted on three sub-regions by watershed: Developed Area Watersheds, Water Supply Watersheds, and West Coast Watersheds.
3. Projected climatic changes recorded in this table are the 90th percentile of the climate model ensemble. The 90th percentile value has been selected for risk screening purposes. Further detailed analysis of specific asset systems may consider risk sensitivity to the full estimated range of projected changes.
4. 2050 has been selected as the horizon for asset risk screening purposes in order to identify significant asset risks within a standard long-term capital planning time frame.



2050 reference line measured out by Urban Systems, appears to be 0.5m
Reference: https://cvrd.bc.ca/2953/Sea-Level-Rise

APPENDIX 5
Direct and Indirect Impacts

URBAN systems

Cowichan Valley Regional District: Climate Risk Assessment - CVRD Asset Systems

1b. IDENTIFY EXPOSURE

	A. Dryer Summers	Recreation Centres	Community Centres	Community Hall	CVRD Head Office	Public Safety (communication systems, fleet, and fire halls)	Parks and Trails (bridges and wooden structures, marine infrastructure, and facilities)	Recycling and Waste Management Centres	Water Systems	Sewer Systems	Ornamental Street Lights	Transit (bus shelters)	Drainage Systems
1	Less groundwater recharge due to decrease in precipitation								X				
2	Increased stress on vegetation due to increase drought	X					X						X
3	Increase in watering and irrigation needs due to decreased precipitation and drought						X		X				
4	Decrease in air quality due to increase in wildfires	X					O						
5	Increase in erosion and/or decrease in slope stability due to insect disease and loss of vegetation [2]					X	X		X	X		X	X
6	Damage of infrastructure and interruption of services due to increase in risk of wildfire [3]	X	X	X	X	X	X	X	X	X	X	X	
7	Population displacement due to wildfires	O	O	O	O			X	X	X			
8	Increase demand on fire services due to dryer conditions [4]					X			X				

X Direct impact
O Indirect impact

Cowichan Valley Regional District: Climate Risk Assessment - CVRD Asset Systems

1b. IDENTIFY EXPOSURE

	B. Wetter Winters	Recreation Centres	Community Centres	Community Hall	CVRD Head Office	Public Safety (communication systems, fleet, and fire halls)	Parks and Trails (bridges and wooden structures, marine infrastructure, and facilities)	Recycling and Waste Management Centres	Water Systems	Sewer Systems	Ornamental Street Lights	Transit (bus shelters)	Drainage Systems
1	Damage to infrastructure due to stream/river flooding						X		X	X		O	X
2	Damage to infrastructure due to local drainage system flooding	X	X	X	X	X	X	X	X	X		O	X
3	Increased pressure on infrastructure due to more intense precipitation events	X	X	X	X		X	X	X	X			X
4	Damage to infrastructure due to excess debris and flow in watercourses and drainage systems						X		X	X			X
5	Damage to infrastructure due to embankment failure [2]					O	X	O					X
6	Reduced access to CVRD services associated with flooding	O	O	O	O	O	O	O				O	
7	Increase in enteric diseases due to increase in agricultural run-off								X				

X Direct impact
O Indirect impact

Cowichan Valley Regional District: Climate Risk Assessment - CVRD Asset Systems

1b. IDENTIFY EXPOSURE

	C. Rising Sea Levels	Recreation Centres	Community Centres	Community Hall	CVRD Head Office	Public Safety (communication systems, fleet, and fire halls)	Parks and Trails (bridges and wooden structures, marine infrastructure, and facilities)	Recycling and Waste Management Centres	Water Systems	Sewer Systems	Ornamental Street Lights	Transit (bus shelters)	Drainage Systems
1	Loss of freshwater source due to sea water intrusion to groundwater aquafers								X				
2	Damage/loss of infrastructure due to coastal inundation	O	O	O		X	O		X	X		X	X
3	Damage to infrastructure due to higher king tides and storm surges	O	O	O		X	O		X	X		O	X

X Direct impact
O Indirect impact

Cowichan Valley Regional District: Climate Risk Assessment - CVRD Asset Systems

1b. IDENTIFY EXPOSURE

	D. Increased Temperatures	Recreation Centres	Community Centres	Community Hall	CVRD Head Office	Public Safety (communication systems, fleet, and fire halls)	Parks and Trails (bridges and wooden structures, marine infrastructure, and facilities)	Recycling and Waste Management Centres	Water Systems	Sewer Systems	Ornamental Street Lights	Transit (bus shelters)	Drainage Systems
1	Increase energy demands due to increased cooling needs	X	X	X	X	X							
2	Increased demand on services due to potential extension of summer and tourism season.	O	O			O	O	X	X	X			
3	Increased demand on public safety services due to increase in heat waves					X							
4	Increase in nuisance odour emitted from waste facilities							X		X			

X Direct impact
O Indirect impact

Cowichan Valley Regional District: Climate Risk Assessment - CVRD Asset Systems

1b. IDENTIFY EXPOSURE

	E. Milder Winter Temperatures	Recreation Centres	Community Centres	Community Hall	CVRD Head Office	Public Safety (communication systems, fleet, and fire halls)	Parks and Trails (bridges and wooden structures, marine infrastructure, and facilities)	Recycling and Waste Management Centres	Water Systems	Sewer Systems	Ornamental Street Lights	Transit (bus shelters)	Drainage Systems
1	Increase local drainage system flooding due to rain on snow events	X	X	X	X	X	X	X	O	O		O	X
2	Increase of insects and pests due to warmer winters						X	X					

X Direct impact
O Indirect impact

Cowichan Valley Regional District: Climate Risk Assessment - CVRD Asset Systems

1b. IDENTIFY EXPOSURE

	F. Longer and More Intense Storms	Recreation Centres	Community Centres	Community Hall	CVRD Head Office	Public Safety (communication systems, fleet, and fire halls)	Parks and Trails (bridges and wooden structures, marine infrastructure, and facilities)	Recycling and Waste Management Centres	Water Systems	Sewer Systems	Ornamental Street Lights	Transit (bus shelters)	Drainage Systems
1	Increase damage to infrastructure due to increased frequency and severity of storm surges						O		X	X			
2	Increase damage to energy transmission networks due to severe wind storms	O	O	O	O	X			X	X	O		
3	Loss of shoreline due to erosion from increase wave action and storm surges						X						
4	Increase damage to facilities due to storm surges and severe wind storms	X	X	X	X	X	X	X	X	X	X	X	
5	Cascading infrastructure failure due intense storms [5]				O	X		O					
6	Population displacement as a result of extreme weather events	O	O	O	O			X	X	X			

X Direct impact
O Indirect impact

Cowichan Valley Regional District: Asset Systems - Climate Risk Assessment
1b. IDENTIFY EXPOSURE

Definitions:

Direct impacts	Will impact the functionality of the asset
Indirect impact	Will impact the service, but not the functionality of the assets
Inundation	Permanent submersed area
Flooding	Temporary submersed area

Note: direct impacts have been marked where a direct impact has been identified through GIS data for one or more asset systems within the asset category, or where there may be an impact and further information about the assets is required.

Assumptions:

Impacts are related to specific infrastructure and service functionality impacts. General operation impacts i.e. organizational health and safety, construction timelines, etc. not considered

Slope stability buffer zone is assumed to be 30 metres [1]
Drainage systems include natural attenuation holding ponds and constructed wetlands
Water supply for fire protection considered in water system
Cascading infrastructure failure may include transport networks due to embankment failure, energy and communication network

Reference:

CVRD (2005). Area I and Area D Bylaw. https://www.cvrd.bc.ca/DocumentCenter/View/571/Area-I-Bylaw-
https://www.cvrd.bc.ca/DocumentCenter/View/9799/Area-D-Bylaw-3605?bidId=

APPENDIX 6
Vulnerability and Risk Assessment

URBAN systems

CVRD - Asset Climate Risk

3. RISK ASSESSMENT

Consequence Rating							
What will be the overall severity of the impact to the CVRD and the community?							
		C1	**C2**	**C3**	**C4**	**C5**	**Notes**
	Category	**Negligible**	**Minor**	**Moderate**	**Major**	**Catastrophic**	
1	**Health and Safety**	Appearance of threat but no harm	Serious near misses or minor injuries/health impacts that do not require medical consultation	Small number of injuries that require medical consultation	Isolated instances of serious injuries, chronic health impacts, or fatality	Large numbers of serious injuries or loss of multiple lives	*Considers public and CVRD employees.*
2	**Environment and Environmental Sustainability**	Appearance of threat or short term irritants, but no harm. No impact to sustainability goals.	Minor instances of environmental damage that could be reversed. Minor impact to sustainability goals.	Isolated but significant instances of environmental damage that might be reversed with intensive efforts. Major impact to sustainability goals.	Severe loss of environmental amenity and a danger or continuing environmental damage	Major widespread loss of environmental amenity and progressive irrecoverable environmental damage.	*Refers to environmental damage as a result of impacts to infrastructure, not as a result of the climatic change.*
3	**Local Economy**	Minor shortfall relative to current forecasts	Individually significant but isolated areas of reduction in economic performance relative to current forecasts	Significant general reduction in economic performance relative to current forecasts	Regional stagnation such that businesses are unable to thrive and employment does not keep pace with population growth	Regional decline leading to widespread business failure, loss of employment and hardship	*Relates to the CVRD's function in local economic development.*
4	**Level of Service**	Isolated, short-term periods of not delivering target levels of service	Regular, short-term periods of interruptions to target levels of service	Noticable impacts to quality of life due to occaisonal long-term periods of service interruption, OR noticable permanent decline in level of service across the region	Substantial decline in quality of life across the region due to frequent long-term periods of service interruption, OR substantial permanent decline of level of service	Complete service interruption for an indefinite period, leading to major decline in quality of life across the region	*Will be assessed based on level of service framework for each asset system.*
5	**Adminstration and Operations**	One off adjustments required to operational or administrative processes	Isolated instances of operations or administration being under severe pressure	Prolonged and regular instances of operations or administration under severe pressure	Signifcant permanent challenges to operational or administrative functions	Completely unable to maintain or operate asset systems or provide critical administrative functions	*Relates to the ability of the CVRD to provide governance, administrative functions, and service operations.*
6	**Finances**	<$25k	>$25k - $100k	>$100k- $500k	>$500k - $1M	>$1M	*Reactive costs of addressing impact borne by the CVRD. Includes increased operational costs, capital costs, and any potential fines or damages that CVRD would be responsible for. May also include reduction in revenue or lost opportunity that is not accompanied by a reduction in costs.*
7	**Reputation**	One off localized negative publicity	Short term regionalized negative publicity	Short term provincial negative publicity, strain on relationships with neighbouring communities, small reduction in resident satisfaction	Prolonged regionalized negative publicity, damage to relationships with neighbouring communities, significant reduction in resident satisfaction	Prolonged major reputation damage, prolonged reports in national news, signficant damage to relationships with neighbouring communities, major reduction in resident satisfaction	*Relates to the importance of relationships with neighbouring local governments and First Nations, as well as public confidence in the CVRD.*
Consequence rating table adapted for CVRD from Exhibit 8.2, Consequence Criteria - ICLEI Municipal Climate Adaptation Guide and Workbook							
Likelihood Rating							
What is the likelihood of the impact occuring, given the magnitude of the predicted climatic change the location of the asset system, and the ability of the system to withstand the impact?							
		L1	**L2**	**L3**	**L4**	**L5**	
		Rare	**Unlikely**	**Possible**	**Likely**	**Almost Certain**	**Notes**
1	Single Event	Probability very small, close to zero	Low probability but greater than zero	Probability less than 50%	As likely as not likely - 50/50 chance	More likely than not	*Considers likelihood of impacts due to climate event and specific location of individual asset systems.*
	Recurring Event	Unlikely during next 30 years	May arise once during 30 years	May arise once in 10 year period	May arise once per year	Likely to occur more than once per year	

General Notes

For each hazard being evaluated, a consequence score will be assigned for each of the seven consequence categories. These will be added together for an overall consequence score.

Categories and definitions in this consequence scale are based on the role of CVRD; stated vision, values, and priorities in the Strategic Plan; and financial standing reported in the 2017 audited financial statements.

CVRD may wish to assign a weighting to each consequence category which would impact overall risk scores.

For each hazard being evaluated, a likelihood score will be assigned for each of the two likelihood categories. These will be added together for an overall likelihood score.

Final risk score will be calculated as consequence x likelihood.

CVRD - Asset Climate Risk
2. RISK ASSESSMENT
Timeline

ASSET SYSTEM	**Recreation Centres**							
Asset System Description	Three centres: Island Savings Centre (Cowichan Performing Arts Centre) and Kerry Park Recreation Centre, both located in the Developed Area Watersheds, and Cowichan Lake Sports Arena, located in the Water Supply Watersheds.							
Asset System Functionality Goals	Provide a functional space for recreation services and programming Meet corporate sustainability goals (energy, water use, etc.)							
Available Asset Information	Condition assessment report dated November 2017 (to be used for risk assessment only, not vulnerability assessment) GIS locations of facilities							
SENSITIVITY								
Climatic Change	**Dryer summers**			**Wetter Winters**		**Warmer Summers**	**Warmer Winters**	**Longer and More Intense Storms**
	Projected 8 day increase to average longest consecutive period without rain (from 22 days to 29.9 days).			Projected 11% increase in volume of precipitation during winter months (from 808 mm to 908 mm). 99th percentile wettest days projected to increase 107% (from 134mm to 278mm).		Daytime high and nighttime low will increase by 4.2 °C to 24.2 °C and 4.0 °C to 13.0 °C, respectively. Increase of Cooling Degree Days (28 to 189).	Daytime high and nighttime low will increase by 3.3 °C to 8.3 °C and 3.2 °C to 2.2°C, respectively.	The duration and frequency of storms will increase, bringing high winds, storm surges, and intense rain.
Identified Direct Impact	Increased stress on vegetation due to increased drought	Decrease in air quality due to increase in wildfires	Damage of infrastructure and interuption of services due to increase in risk of wildfire	Damage to infrastructure due to local drainage system flooding	Increased pressure on infrastructure due to more intense precipitation events	Increase energy demands due to increased cooling needs	Increase local drainage system flooding due to rain on snow events	Increased damage to facilities due to storms and wind fall
What are the anticipated impacts to assets?	Green/landscaped areas surrounding the recreation centres will be under increased stress	Increased stress on ventilation/air filtration systems.	Damage to centres due to fire, smoke, or water from fire suppression.	Flooded parking lots and playfields, potential building flooding.	Leaks through roof or windows and potential damage to the building.	Increase stress on HVAC units and increase energy use negatively impacts corporate sustainability targets	Flooded parking lots and playfields.	Damage to centres due to wind fall, precipitation, and flash floods.
What are the potential anticipated impacts to the functionality goals of the asset category?	Negative impacts to visual appearance of facility, reduced functionality of outdoor space for programming.	Reduced functionality of the space if system can't keep up.	Temporary closure of centres	Temporary closure of playfields used for programming, and restricted access to facility	Reduced functionality due to restricted use of areas experiencing leaks	Reduced functionality of the space if system can't keep up.	Reduced functionality if system can't keep up.	Temporary closure of centres or restricted access
Within the asset category, will there be greater impact on specific asset systems?	No	No	No	Yes	Yes	No	No	No
Specific assets/ systems referenced	N/A	N/A	All	Cowichan Lake Sports Arena due to greater increase in annual precipitation and intensity. OR facilities with local drainage system constraints	Cowichan Lake Sports Arena due to increase in annual precipitation.	All	N/A	All
Asset System Sensitivity Rating	**S2**	**S2**	**S4**	**S2**	**S2**	**S3**	**S2**	**S2**
ADAPTIVE CAPACITY								
What types of actions would be required to adjust the asset category to the anticipated impact, after it has happened? *(Actions may be O&M or capital responses.)*	Increase irrigation to areas, transition landscaping to drought resistant or xeriscaping.	Change air filters, repair filtration system.	Minor - major repairs. Prevent with Fire Smart practices.	Temporary pumping and diversion solutions. Rehabilitate any damaged infrastructure. Maintenance resources to support flooding issues.	Contain and repair areas damaged by leaks, inspect and repair leaks in building envelope, regularly inspect and maintain building envelope to prevent future leaks	Energy conservation and efficiency plans and HVAC system retrofits.	Temporary pumping and diversion solutions. Maintenance resources to support flooding issues.	Minor - major repairs
Can the asset system adjust to the projected impact with minimal cost and disruption?	Maybe	Yes	No	Yes	Maybe	Maybe	Yes	No
Explain response	Increased irrigation may be undesirable during periods of drought. Transitioning landcaping may result in additional capital costs.	Actions identified do not require signficant efforts or changes to normal O&M procedures.	If the centre sustains this damage, will require major repairs	Actions identified do not require signficant efforts or changes to normal O&M procedures.	Will depend on extent of leaks and damage	Depends on capacity and efficiency of current HVAC system and energy conservation practices	Actions identified do not require signficant efforts or changes to normal O&M procedures.	If the centre sustains this damage, may require major repairs
Referenced Sources	Anecdotal	Anecdotal	Extent of fire risk, anecdotal	Anecdotal	Anecdotal	Anecdotal	Anecdotal	Anecdotal
Adaptive Capacity Rating	AC3	AC5	AC1	AC4	AC4	AC3	AC4	AC3
VULNERABILITY								
Vulnerability Rating	**V2**	**V1**	**V5**	**V2**	**V2**	**V4**	**V2**	**V2**
NEXT STEPS								
Conduct risk assessment?	NO	NO	YES	NO	NO	YES	NO	NO
Considerations to be noted in risk assessment						Review capacity of current HVAC systems and energy conservation practices		
Other considerations to be noted	Identify opportunities for gradual transition to drought resistant/xeriscaping.			Review capacity of local drainage systems and procedures for flood diversion/protection. Note that condition	Follow component replacement schedule as identified in condition assessment report to maintain integrity of the building	Identify opportunities to improve energy efficiency of facilities	Review operational practices for clearing drains of ice/snow.	Review procedures for tree maintenance near facilities
RISK ASSESSMENT								
CONSEQUENCE								
Health and Safety			1			1		1
Environment			1			3		1
Local Economy			1			1		1
Level of Service			1			2		2
Adminstration and Operations			2			1		2
Finances			3			2		2
Reputation			2			1		1
Total Consequence Score	**0.00**	**0.00**	**1.57**	**0.00**	**0.00**	**1.57**	**0.00**	**1.43**
LIKELIHOOD								
Single or Recurring Event?			single			recurring		recurring
Location/Magnitude			2			5		3
Total Likelihood Score	**0**	**0**	**2**	**0**	**0**	**5**	**0**	**3**
Risk Rating	**0.000**	**0.000**	**3.143**	**0.000**	**0.000**	**7.857**	**0.000**	**4.286**
Identified Mitigating Actions								
Preventative								
Reactive								

CVRD - Asset Climate Risk

2. RISK ASSESSMENT

Timeline: 2050

ASSET SYSTEM	**Community Centres**					
Asset System Description	One community centre: Shawnigan Lake Community Centre, located in Water Supply Watershed					
Asset System Functionality Goals	Provides a functional and flexible space for community members to gather, socialize and recreate. Sites are staffed by CVRD employees. Meet corporate sustainability goals (energy, water use, etc.)					
Available Asset Information	Condition assessments and GIS locational data.					
SENSITIVITY						
Climatic Change	**Dryer summers**	**Wetter Winters**		**Warmer Summers**	**Warmer Winters**	**Longer and More Intense Storms**
	Projected 8 day increase to average longest consecutive period without rain (from 22 days to 29.9 days).	Projected 11% increase in volume of precipitation during winter months (from 808 mm to 908 mm). 99th percentile wettest days projected to increase 107% (from 134mm to 278mm).		Daytime high and nighttime low will increase by 4.2 °C to 24.2 °C and 4.0 °C to 13.0 °C, respectively. Increase of Cooling Degree Days (28 to 189).	Daytime high and nighttime low will increase by 3.3 °C to 8.3 °C and 3.2	The duration and frequency of storms will increase, bringing high winds, storm surges, and intense rain.
Identified Direct Impact	Damage of infrastructure and interruption of services due to increase in risk of wildfire.	Damage to infrastructure due to local drainage system flooding	Increased pressure on infrastructure due to more intense precipitation events	Increased energy demands due to increased cooling needs.	Increased local drainage system flooding	Increased damage to facilities due to storms and wind fall
What are the anticipated impacts to assets?	Damage to centre due to fire, smoke, or water from fire suppression.	Parking lot and playground space may experience flooding. Potential building flooding.	Leaks through roof or windows and potential damage to the building	Increase stress on HVAC units and increase energy use negatively impacts corporate sustainability targets.	Parking lot and playgroun d space may	Damage to centre due to wind fall and hail.
What are the potential anticipated impacts to the functionality goals of the asset category?	Temporary closure of centre.	Temporary closure or restricted access of parking lot, playground, or facility.	Reduced functionality of areas impacted by leaks.	Reduced functionality of the space if system can't keep up.	Temporar y closure or restricted access of	Restricted access or temporary closure of centre.
Within the asset category, will there be greater impact on specific asset systems?	No	No	No	No	No	No
If yes, which locations or specific asset systems will be impacted?	N/A	N/A	N/A	N/A	N/A	N/A
Asset System Sensitivity Rating	**S4**	**S2**	**S2**	**S3**	**S2**	**S3**
ADAPTIVE CAPACITY						
What types of actions would be required to adjust the asset category to the anticipated impact, after it has happened? *(Actions may be O&M or capital responses.)*	Minor - major repairs. Prevent with Fire Smart practices.	Temporary pumping and diversion solutions. Maintenance resources to support flooding issues.	Contain and repair areas damaged by leaks, inspect and repair leaks in building envelope, regularly inspect and maintain building envelope to prevent future leaks	Energy conservation and efficiency plans and HVAC system retrofits.	Temporar y pumping and diversion solutions. Maintenan ce resources to support flooding issues.	Minor - major repairs.
Can the asset system adjust to the projected impact with minimal cost and disruption?	No	Yes	Maybe	Maybe	Yes	No
Explain response	If the centre sustains this damage, will require major repairs	Actions identified do not require significant efforts or changes to normal O&M procedures.	Will depend on extent of leaks and damage	Depends on capacity and efficiency of current HVAC system and energy conservation practices.	Actions identified do not require significant	If the centre sustains extensive damage, may require major repairs.
Referenced Sources	Extent of fire risk, anecdotal	Anecdotal	Anecdotal	Anecdotal	Anecdotal	Anecdotal
Adaptive Capacity Rating	**AC1**	AC4	AC4	AC3	AC4	AC3
VULNERABILITY						
Vulnerability Rating	**V5**	**V2**	**V2**	**V4**	**V2**	**V4**
NEXT STEPS						
Conduct risk assessment?	YES	NO	NO	YES	NO	YES
Considerations to be noted in risk assessment				Review capacity of current HVAC systems and energy conservation practices, review notes from condition assessment reports.		
Other considerations to be noted			Follow component replacement schedule as identified in condition assessment report to maintain integrity of the building envelope.	Identify opportunities to improve energy efficiency of facilities during normal component replacement schedule.	Review operationa l practices for clearing	Review procedures for tree maintenance near facilities
RISK ASSESSMENT						
CONSEQUENCE						
Health and Safety						
score	1			1		1
Environment						
score	1			3		1
Local Economy						
score	1			1		1
Level of Service						
score	1			2		2
Administration and Operations						
score	2			1		2
Finances						
score	3			2		2
Reputation						
score	2			1		1
Total Consequence Score	**1.57**	**1.57**	**1.57**	**1.57**	**0.00**	**1.43**
LIKELIHOOD						
Single or Recurring Event?	single			recurring		recurring
Location/Magnitude	2			5		3
Total Likelihood Score	**2**	**0**	**0**	**5**	**0**	**3**
Risk Rating	**3.143**	**0.000**	**0.000**	7.857	0.000	4.286
Identified Mitigating Actions						
Preventative						
Reactive						

CVRD - Asset Climate Risk
2. RISK ASSESSMENT
Timeline: 2050

ASSET SYSTEM	**Community Halls**					
Asset System Description	Four community halls: Honeymoon Bay Community Hall, Centennial Hall, Mesachie Lake Community Hall, and Youbou Community Hall, located in Water Supply Watershed					
Asset System Functionality Goals	Provides a space for community members to gather, socialize and recreate. Sites are not staffed by CVRD employees. Meet corporate sustainability goals (energy, water use, etc.)					
Available Asset Information	Condition assessments and GIS locational data.					
SENSITIVITY						
Climatic Change	**Dryer summers**	**Wetter Winters**		**Warmer Summers**	**Warmer Winters**	**Longer and More Intense Storms**
	Projected 8 day increase to average longest consecutive period without rain (from 22 days to 29.9 days).	Projected 11% increase in volume of precipitation during winter months (from 808 mm to 908 mm). 99th percentile wettest days in Water Supply Watershed projected to increase from 141mm to 285mm.		Daytime high and nighttime low will increase by 4.2 °C to 24.2 °C and 4.0 °C to 13.0 °C, respectively. Increase of Cooling Degree Days (28 to 189).	Daytime high and nighttime low will increase by 3.3 °C to 8.3 °C and 3.2 °C to 2.2°C, respectively.	The duration and frequency of storms will increase, bringing high winds, storm surges, and intense rain.
Identified Direct Impact	Damage of infrastructure and interruption of services due to increase in risk of wildfire	Damage to infrastructure due to local drainage system flooding	Increased pressure on infrastructure due to more intense precipitation events	Increase energy demands due to increased cooling needs	Increase local drainage system flooding due to rain on snow events	Increase damage to facilities due to storms and wind fall
What are the anticipated impacts to assets?	Damage to halls due to fire, smoke, or water from fire suppression.	Parking lots may experience flooding. Potential facility flooding.	Leaks through roof or windows and potential damage to the building.	Increase stress on HVAC units and increase energy use negatively impacts corporate sustainability targets.	Parking lot, park space and ball field may experience flooding.	Damage to centre due to wind fall and hail.
What are the potential anticipated impacts to the functionality goals of the asset category?	Temporary closure of halls	Temporary closure of parking lot. Restricted access/closure of facility.	Reduced functionality of areas impacted by leaks.	Reduced functionality of the space if system can't keep up.	Temporary closure of parking lot. Restricted access/closure of facility.	Restricted access or temporary closure of centre.
Within the asset category, will there be greater impact on specific asset systems?	No	Yes	No	No	No	No
If yes, which locations or specific asset systems will be impacted?	N/A	Facilities with local drainage system constraints.	N/A	N/A	N/A	N/A
Asset System Sensitivity Rating	**S4**	**S2**	**S2**	**S3**	**S2**	**S3**
ADAPTIVE CAPACITY						
What types of actions would be required to adjust the asset category to the anticipated impact, after it has happened? *(Actions may be O&M or capital responses.)*	Minor - major repairs	Temporary pumping and diversion solutions. Maintenance resources to support flooding issues.	Contain and repair areas damaged by leaks, inspect and repair leaks in building envelope, regularly inspect and maintain building envelope to prevent future leaks.	Energy conservation and efficiency plans and HVAC system retrofits.	Temporary pumping and diversion solutions. Maintenance resources to support flooding issues.	Minor - major repairs
Can the asset system adjust to the projected impact with minimal cost and disruption?	No	Yes	Maybe	Maybe	Yes	No
Explain response	If the halls sustain this damage, will require major repairs.	Actions identified do not require significant efforts or changes to	Will depend on extent of leaks and damage.	Depends on capacity and efficiency of current HVAC	Actions identified do not require significant efforts or changes to	If the halls sustains this damage, may require major repairs
Referenced Sources	Extent of fire risk, anecdotal	Anecdotal	Anecdotal	Anecdotal	Anecdotal	Anecdotal
Adaptive Capacity Rating	**AC1**	AC4	AC4	AC3	AC4	AC3
VULNERABILITY						
Vulnerability Rating	**V5**	**V2**	**V2**	**V4**	**V2**	**V4**
NEXT STEPS						
Conduct risk assessment?	YES	NO	NO	YES	NO	YES
Considerations to be noted in risk assessment				Review capacity of current HVAC systems and energy conservation practices		
Other considerations to be noted			Follow component replacement schedule as identified in condition assessment report to maintain integrity of the building envelope.	Identify opportunities to improve energy efficiency of facilities during normal component replacement schedule.	Review operational practices for clearing drains of ice/snow.	Review procedures for tree maintenance near facilities
RISK ASSESSMENT						
CONSEQUENCE						
Health and Safety						
score	1			1		1
Environment						
score	1			3		1
Local Economy						
score	1			1		1
Level of Service						
score	1			2		2
Administration and Operations						
score	2			1		2
Finances						
score	3			2		2
Reputation						
score	2			1		1
Total Consequence Score	**1.57**	**0.00**	**0.00**	**1.57**	**0.00**	**1.43**
LIKELIHOOD						
Single or Recurring Event?	single			recurring		recurring
Location/Magnitude	2			5		3
Total Likelihood Score	**2**	**0**	**0**	**5**	**0**	**3**
Risk Rating	**3.143**	**0.000**	**0.000**	**7.857**	**0.000**	**4.286**
Identified Mitigating Actions						
Preventative						
Reactive						

CVRD - Asset Climate Risk

2. RISK ASSESSMENT

Timeline: 2050

ASSET SYSTEM	**Administration**					
Asset System Description	CVRD Administration is located in the Developed Area Watershed					
Asset System Functionality Goals	Provides a space for employees of CVRD to carryout services for the patrons of CVRD. Meet corporate sustainability goals (energy, water use, etc.)					
Available Asset Information	Condition assessment and GIS locational data.					
SENSITIVITY						
Climatic Change	**Dryer summers**	**Wetter Winters**		**Warmer Summers**	**Warmer Winters**	**Longer and More Intense Storms**
	Projected 8 day increase to average longest consecutive period without rain (from 22 days to 29.9 days).	Projected 11% increase in volume and intensity of precipitation during winter months (from 808 mm to 908 mm). 99th percentile wettest days in the Developed Area Watershed projected to increase from 100mm to 205mm.		Daytime high and nighttime low will increase by 4.2 °C to 24.2 °C and 4.0 °C to 13.0 °C, respectively. Increase of Cooling Degree Days in Developed Area Watershed from 47 to 242.	Daytime high and nighttime low will increase by 3.3 °C to 8.3 °C and 3.2 °C to 2.2°C, respectively.	The duration and frequency of storms will increase, bringing high winds, storm surges, and intense rain.
Identified Direct Impact	Damage of infrastructure and interruption of services due to increase in risk of wildfire [3].	Damage to infrastructure due to local drainage system flooding	Increased pressure on infrastructure due to more intense precipitation events	Increase energy demands due to increased cooling needs.	Increase local drainage system flooding due to rain on snow events.	Increase damage to facilities due to storms and wind fall
What are the anticipated impacts to assets?	Damage to head office due to fire, smoke, or water from fire suppression.	Parking lots may experience flooding. Potential facility flooding.	Leaks through roof or windows and potential damage to the building.	Increase stress on HVAC units and increase energy use negatively impacts corporate sustainability targets. Potential overheating in server space.	Parking lots may experienc e flooding. Potential facility flooding.	Damage to centre due to wind fall and hail.
What are the potential anticipated impacts to the functionality goals of the asset category?	Temporary closure of head office.	Temporary closure of parking lot. Restricted access/closure of facility.	Reduced functionality of areas impacted by leaks.	Reduced functionality of the space if system can't keep up.	Temporar y closure of parking lot. Restricted access/clo sure of facility.	Restricted access or temporary closure of centre.
Within the asset category, will there be greater impact on specific asset systems?	No	No	No	No	No	No
If yes, which locations or specific asset systems will be impacted?	N/A	N/A	N/A	N/A	N/A	N/A
Asset System Sensitivity Rating	**S4**	**S2**	**S3**	**S3**	**S2**	**S3**
ADAPTIVE CAPACITY						
What types of actions would be required to adjust the asset category to the anticipated impact, after it has happened? *(Actions may be O&M or capital responses.)*	Minor - major repairs.	Temporary pumping and diversion solutions. Maintenance resources to support flooding issues.	Contain and repair areas damaged by leaks, inspect and repair leaks in building envelope, regularly inspect and maintain building envelope to prevent future leaks.	Energy conservation and efficiency plans and HVAC system retrofits.	Temporar y pumping and diversion solutions. Maintenan ce resources to support flooding issues.	Minor - major repairs
Can the asset system adjust to the projected impact with minimal cost and disruption?	No	Yes	Maybe	Maybe	Yes	No
Explain response	If the head office sustains this damage, will require major repairs.	Actions identified do not require significant	Will depend on extent of leaks and damage.	Depends on capacity and efficiency of current HVAC	Actions identified	If the head office sustains this damage, may require major repairs
Referenced Sources	Extent of fire risk, anecdotal	Anecdotal	Anecdotal	Anecdotal	Anecdotal	Anecdotal
Adaptive Capacity Rating	**AC1**	**AC4**	**AC4**	**AC3**	**AC4**	**AC3**
VULNERABILITY						
Vulnerability Rating	**V5**	**V2**	**V2**	**V4**	**V2**	**V4**
NEXT STEPS						
Conduct risk assessment?	YES	NO	NO	YES	NO	YES
Considerations to be noted in risk assessment				Review capacity of current HVAC systems and energy conservation practices		Review capacity of current HVAC systems and energy conservation practices
Other considerations to be noted			Follow component replacement schedule as identified in condition	Identify opportunities to improve energy efficiency of facility during normal component replacement schedule.	operation al practices for	Review procedures for tree maintenance near facilities
RISK ASSESSMENT						
CONSEQUENCE						
Health and Safety						
score	1			1		1
Environment						
score	1			3		1
Local Economy						
score	1			1		1
Level of Service						
score	1			2		2
Administration and Operations						
score	2			1		2
Finances						
score	3			2		2
Reputation						
score	2			1		1
Total Consequence Score	**1.57**	**0.00**	**0.00**	**1.57**	**0.00**	**1.43**
LIKELIHOOD						
Single or Recurring Event?	single			recurring		recurring
Location/Magnitude	1			5		3
Total Likelihood Score	**1**	**0**	**0**	**5**	**0**	**3**
Risk Rating	**1.571**	**0.000**	**0.000**	**7.857**	**0.000**	**4.286**
Identified Mitigating Actions						
Preventative						
Reactive						

CVRD - Asset Climate Risk

2. RISK ASSESSMENT

Timeline: 2050

ASSET SYSTEM	**Public Safety**											
Asset System Description	Public safety assets encompass communication systems, fleet, fire halls and emergency centres Fleet inventory includes: Fire Department and Search and Rescue Vehicles Fire halls include: three located in the Water Supply Watershed and two located in the Developed Watershed: Honeymoon Bay Fire Hall, Mesachie Lake Fire Hall and Youbou, and Malahat Fire Hall and Sahtlam, respectively.											
Asset System Functionality Goals	Fire prvention, fire suppression, emergency response operations, emergency prevention and recovery. Corporate sustainability goals (water, energy, etc.)											
Available Asset Information	Asset inventories, condition assessments and GIS information on emergency service locations.											
SENSITIVITY												
Climatic Change	**Dryer Summers** Projected 8 day increase to average longest consecutive period without rain (from 22 days to 29.9 days).			**Wetter Winters** Projected 11% increase in volume and intensity of precipitation during winter months (from 808 mm to 908 mm). 99th percentile wettest days projected to increase 107% (from 134mm to 278mm).	**Sea Level Rise** Predicted 1 m rise in sea level.		**Warmer Summers** Daytime high and nighttime low will increase by 4.2 °C to 24.2 °C and 4.0 °C to 13.0 °C, respectively. Increase of Cooling Degree Days (28 to 189).		**Warmer Winters** Daytime high and nighttime low will increase by 3.3 °C to 8.3 °C and 3.2 °C to 2.2°C, respectively.	**Longer and More Intense Storms** The duration and frequency of storms will increase, bringing high winds, storm surges, and intense rain.		
Identified Direct Impact	Increase in erosion and/or decrease in slope stability	Damage of infrastructure and interruption of services due to increase in risk of wildfire	Increase demand on fire services due to dryer conditions	Damage to infrastructure due to local drainage system flooding	Damage/loss of infrastructure due to coastal inundation	Damage to infrastructure due to higher king tides and storm surges	Increase energy demands due to increased cooling needs	Increased demand on public safety services due to increase in heat waves	Increased local drainage system flooding due to rain on snow events	Increased damage to energy transmission networks due to severe wind storms	Increased damage to facilities due to storm surges and severe wind storms	Cascading infrastructure failure due intense storms
What are the anticipated impacts to assets?	Damage to facilities from slope slides. Access to facilities	Damage to facilities due to fire, smoke, or water from fire suppression.	Increased demand on fire services, inability to meet demands.	Potential roadway flooding causing damage to fleet vehicles or increase in accidents due to poor driving conditions. Potential roadway flooding restricting access to	Loss of facilities due to inundation.	Damage to buildings or communication infrastructure due to flooding	Increase demand on HVAC systems and fleet AC systems	Increased demand on fleet vehicles and emergency centres due to increase response to public health calls. Increased risk to communication infrastructure due to high	Facilities may experience flooding. Fleet subjected to risk of accident due to poor driving conditions.	Power outages	Increased damage to fleet, facilities and communication systems due to storms and wind fall.	Embankment failure may restrict access to fire halls, emergency fleet or emergency centres; power outages may reduce capacity of water system and availability of water for fire suppression.
What are the potential anticipated impacts to the functionality goals of the asset category?	Restricted access or temporary closure of facilities.	Restricted access or temporary closure of facilities.	Inability to meet full demands.	Loss of public safety resource for areas impacted by flooding. Stress on other emergency centres to accommodate loss of resource	Loss of public safety resource for areas impacted by inundation. Stress on other emergency centres to accommodate loss of resource	Reduced ability to provide services when required.	Negatively impact corporate sustainability targets due to increase energy and emission use for AC	Inability to meet additional demands. Communication system outages.	Reduced ability to meet service demands.	Reduced ability to provide communication and emergency response services.	Reduced ability to provide communication and emergency response services.	Reduced ability to provide communication and emergency response services.
Within the asset category, will there be greater impact on specific asset systems?	Yes	No	No	No	Yes	Yes	No	No	No	Yes	Yes	No
If yes, which locations or specific asset systems will be impacted?	Facilities near steep slopes, facilities that have only one road in/out.	N/A	N/A	N/A	Two emergency centres impacted by inundation: Maple Bay Rowing Club and Stzuminus First Nation	Assets within the coastal flood zone.	N/A	N/A	N/A	Communication systems and facilities that do not have access to backup power supplies.	Damage for communication systems may be more serious.	N/A
Asset System Sensitivity Rating	**S3**	**S4**	**S4**	**S2**	**S5**	**S4**	**S3**	**S2**	**S2**	**S4**	**S4**	**S4**
ADAPTIVE CAPACITY												
What types of actions would be required to adjust the asset category to the anticipated impact, after it has happened? *(Actions may be O&M or capital responses.)*	Clean up slide debris to open roads. Repair or replace damaged	Establish temporary emergency operations centres. Minor - major repairs.	Coordinate with other jurisdictions to provide additional fire protection services when needed. Increase capacity of fire services.	Relocate fleet to prevent flood damage. Sandbagging and pumping to prevent facility flooding. Clear drains and culverts. Prevent flooding of roads with culvert	Identify adaptation actions to address inundation issues.	Sandbagging and pumping to reduce flood risk. Identify adaptation actions to reduce likelihood of flooding of critical infrastructure.	Energy conservation plans. Energy retrofits. Energy conservation education practices. Increase O&M on HVAC and AC units.	Energy conservation plans. Energy retrofits. Energy conservation education practices. Increase O&M to meet increase demand.	Temporary pumping and diversion solutions. Maintenance resources to support flooding issues. Coordinate with appropriate jurisdictions to improve snow and ice control on roads.	Provide temporary backup power. Prevent future outages by installing permanent backup power.	Minor - major repairs	Provide emergency services from alternate facilities. Use alternate water sources to provide fire suppression needs where possible.
Can the asset system adjust to the projected impact with minimal cost and disruption?	Maybe	No	Maybe	Maybe	No	Maybe	Maybe	Maybe	Yes	No	No	Yes
Explain response	Depends on severity of damage.	If facilities sustained this damage, repair would be costly.	Depends on availability of fire services in neighbouring jurisdictions.	Actions may not require significant resources, but during time of emergency there are limited resources available to address issues.	Appropriate adaptation actions likely costly.	Actions may not require significant resources, but during time of emergency there are limited resources available to address issues.	Depends on opportunities for improved energy efficiency.	Depends on current energy conservation efforts and contingency plans.	Actions identified do not require significant efforts or changes to normal O&M procedures.	Depends on current availability of backup power sources.	If the assets sustain damage, may require major repairs	Availability of alternative systems may provide some system redundancy.
Referenced Sources	Anecdotal	Anecdotal	Anecdotal	Anecdotal	Anecdotal and GIS	Anecdotal	Anecdotal	Anecdotal	Anecdotal	Anecdotal	Anecdotal	Anecdotal
Adaptive Capacity Rating	**AC4**	**AC2**	**AC4**	**AC3**	**AC2**	**AC3**	**AC3**	**AC3**	**AC4**	**AC3**	**AC3**	**AC4**
VULNERABILITY												
Vulnerability Rating	**V3**	**V5**	**V3**	**V2**	**V5**	**V4**	**V4**	**V2**	**V2**	**V4**	**V4**	**V3**
NEXT STEPS												
Conduct risk assessment?	NO	YES	NO	NO	YES	YES	YES	NO	NO	YES	YES	NO
Considerations to be noted in risk assessment						Location of infrastructure within flood zones.				Review availability of temporary and permanent backup power sources.	Review susceptibility of communication infrastructure to wind storms.	
Other considerations to be noted	Note that slopes may fail during		Increased demand due to drought compounded due to increase in summer temperatures.	Review coordination plans with appropriate jurisdictions to maintain critical roads during				Review susceptibility of communication infrastructure to high temperatures.				Review mutual aid agreements with neighbouring jurisdictions.
RISK ASSESSMENT												
CONSEQUENCE												
Health and Safety		Requirement for use of public safety facilities during emergency leads to greater likelihood of near miss.			Assume alternate location has not yet been identified and innundated facilities are needed during an emergency	Assume alternate location has not yet been identified and innundated facilities are needed during an emergency				If backup power is not available, may lead to near-misses	If backup communication systems are not available, may lead to near misses or minor injuries	
score		2			3	3	1			2	2	
Environment												
score		1			1	1	2			1	1	
Local Economy												
score		1			2	2	1			1	1	
Level of Service		decline in LOS across the region										
score		3			3	3	1			2	2	
Administration and Operations												
score		2			2	2	1			2	2	
Finances					negligible costs of identifying another facility	negligible costs of identifying another facility	cumulative costs of increased energy use			costs of installing additional backup power sources	cost of restoring communication systems and/or installing new communication systems	
score		3			1	1	1			2	2	
Reputation												
score		2			2	2	1			1	1	
Total Consequence Score	**0.00**	**2.00**	**0.00**	**0.00**	**2.00**	**2.00**	**1.14**	**0.00**	**0.00**	**1.57**	**1.57**	
LIKELIHOOD												
Single or Recurring Event?		single			single	recurring	recurring			recurring	recurring	
Location/Magnitude		2			1	3	4			3	3	
Total Likelihood Score	**0**	**2**	**0**	**0**	**1**	**3**	**4**	**0**	**0**	**3**	**3**	
Risk Rating	**0.000**	**4.000**	**0.000**	**0.000**	**2.000**	**6.000**	**4.571**	**0.000**	**0.000**	**4.714**	**4.714**	
Identified Mitigating Actions												
Preventative												
Reactive												

CVRD - Asset Climate Risk

2. RISK ASSESSMENT

Timeline: 2050

ASSET SYSTEM	**Parks and Trails**															
Asset System Description	206 Community Parks, 6 regional parks and over 100 km of trails. Additional assets include: bridges and wooden structures, and marine infrastructure.															
Asset System Functionality Goals	Provide spaces, facilities, and amenities for community recreation. Meet needs of individuals and organized sports groups. Meet corporate sustainability goals (water use, energy)															
Available Asset Information	Parks and trails inventory and GIS location data.															
SENSITIVITY																
Climatic Change	**Dryer summers**				**Wetter Winters**					**Sea Level Rise**		**Warmer Winters**		**Longer and More Intense Storms**		
	Projected 8 day increase to average longest consecutive period without rain (from 22 days to 29.9 days).				Projected 11% increase in volume and intensity of precipitation during winter months (from 808 mm to 908 mm). 99th percentile wettest days projected to increase 107% (from 134mm to 278mm).					Predicted 1 m rise in sea level.		Daytime high and nighttime low will increase by 3.3 °C to 8.3 °C and 3.2 °C to 2.2°C, respectively.		The frequency, intensity, and duration of storm will increase		
Identified Direct Impact	Increased stress on vegetation and trees due to increased drought	Increase in watering and irrigation needs due to decreased precipitation and drought.	Increase in erosion and/or decrease in slope stability due to insect disease and loss of vegetation.	Damage of infrastructure and interruption of services due to increase in risk of wildfire	Damage to infrastructure due to stream/river flooding.	Damage to infrastructure due to local drainage system flooding	Increased pressure on infrastructure due to more intense precipitation events	Damage to infrastructure due to flooding or excess debris and flow in watercourses and drainage systems	Damage to infrastructure due to embankment failure	Damage/loss of infrastructure due to coastal inundation	Damage to infrastructure due to higher king tides and storm surges	Increased local drainage system flooding due to rain on snow events.	Increase of insects and pests due to warmer winters	Loss of shoreline due to erosion from increase wave action and storm surges	Increase damage to facilities due to storm surges and severe wind storms	
What are the anticipated impacts to assets?	Green/landscaped areas will be under increased stress. Tree stress and death.	Increased demand on irrigation systems	Parkland and trail erosion, loss of vegetation, embankment failure impacting parks or trails.	Damage to park and trail facilities, due to fire, smoke, or water/retardant from fire suppression.	Temporary loss of access to parks and trails. Damage to wooden bridges and other park features nearby. Flooding of parkland and parks facilities. Erosion/washout of parkland or trail.	Flooded parking lots, parkland, parks facilities and trails.	Leaks through roof or windows and potential damage to the building	Potential damage or washout of wooden bridges and marine infrastructure, damage to utilities infrastructure (especially septic fields)	Damage to trails and structural integrity of wooden bridges and other trail features along embankments.	Permanent loss of park land and trails in inundation zone.	Temporary loss of a park and a trail due to coastal flooding. Damage to marine infrastructure.	Parking lot and playground space may experience flooding. Potential facility flooding.	Potential damage to facilities and vegetated or turfed areas due to insect infestation or vermin nests. Loss of vegetation from parasitic species.	Loss of parkland and trails.	Damage of marine infrastructure. Damage to infrastructure due to wind fall.	
What are the potential anticipated impacts to the functionality goals of the asset category?	Negative impacts to visual appearance and comfort in parks, reduced functionality of outdoor space for programming.	Increased demand on irrigation systems, however would not irrigate during drought conditions.	Reduced access to parks or trails, potential temporary trail closures.	Temporary closure of parks or park facilities and trails, restricted use of parks or trails.	Temporary closure or restricted access of parks, parks facilities, and trails.	Temporary closure or restricted access to parking lots and playfields and facilities. Temporary closure or restricted access to parkland trails.	Reduced functionality of areas impacted by leaks.	Temporary closure or restricted access to areas impacted by debris.	Temporary closure or restricted access to areas impacted by embankment failure.	Permanent loss of ability to to recreate in areas impacted by inundation.	Temporary closure or restricted access to areas impacted by coastal flooding.	Temporary closure or restricted access of parking lot, playground, or facility.	Reduced aesthetic appearance or functionality.	Loss/reduction of coastal recreation space.	Loss/reduction of coastal recreation space.	
Within the asset category, will there be greater impact on specific asset systems?	Yes	No	Yes	No	Yes	No	No	Yes	Yes	Yes	Yes	No	No	Yes	Yes	
If yes, which locations or specific asset systems will be impacted?	Park green space, parks with playfield turf, parks with young trees.	N/A	Parks and trails within slide area of steep embankments.	N/A	Parks, trails, and facilities located within flood zone.	N/A	N/A	Trails with wooden / bridge structures	Trails with bridges or retaining structures.	Parks and trails impacted by inundation.	One park and one trail impacted by coastal flooding. Marine infrastructure.	N/A	N/A	One park and one trail impacted by coastal flooding.	One park and one trail impacted by coastal flooding.	
Asset System Sensitivity Rating	**S3**	**S2**	**S3**	**S4**	**S3**	**S2**	**S2**	**S4**	**S3**	**S5**	**S4**	**S2**	**S2**	**S4**	**S3**	
ADAPTIVE CAPACITY																
What types of actions would be required to adjust the asset category to the anticipated impact, after it has happened? *(Actions may be O&M or capital responses.)*	Increase irrigation to trees, transition to drought resistant landscaping, replace grass turf with artificial turf.	Turn off irrigation, let the lawn go into dormant stage. Fall fertilize, spring lawn maintenance. Overseeding if needed. Implement use of rain water or grey water irrigation systems.	Temporary closure of areas of park and trail impacted. Slope restoration.	Minor - major repairs, environmental and habitat restoration. Prevent with Fire Smart practices.	Sandbagging and pumping to avoid or reduce flooding of facilities. Implement natural drainage features to mitigate future occurrence.	Temporary pumping and diversion solutions. Maintenance resources to support flooding issues.	Contain and repair areas damaged by leaks, inspect and repair leaks in building envelope, regularly inspect and maintain building envelope to prevent future leaks	Close structures when waters are high or structure is flooded to manage safety concerns. Remediate damaged infrastructure.	Closure of structure. Park and trail restoration. Remediation of damaged infrastructure.	Move infrastructure out of inundated areas. Development of new parks and trails to meet demand.	Sandbagging and pumping to reduce flood risk. Identify adaptation actions to reduce likelihood of flooding of facilities. Install breakwaters to prevent damage to marine infrastructure.	Temporary pumping and diversion solutions. Maintenance resources to support flooding issues.	Integrated pest management plan and action. Park or facility restoration. Additional maintenance resources to respond to issues.	Close coastal areas to the public when at risk of storm surge. Shoreline restoration. Build storm surge adaptation infrastructure.	Minor to major repairs. Shoreline restoration. Wind fall cleanup. Additional maintenance resources. Build storm surge adaptation infrastructure.	
Can the asset system adjust to the projected impact with minimal cost and disruption?	Maybe	Yes	Maybe	No	Yes	Yes	Maybe	Maybe	Maybe	No	Maybe	Yes	Yes	Yes	Maybe	
Explain response	Increased irrigation may be undesirable during periods of drought. Transitioning landscaping and replacing grass turf with artificial turf will result in additional capital costs.	Programs currently in place are likely sufficient to handle changes.	Depends on extent of erosions and slope failure.	If facilities sustain this damage, repairs will be costly.	Minimal to moderate costs of remediating parks, trails, and park facilities.	Actions identified do not require significant efforts or changes to normal O&M procedures.	Will depend on extent of leaks and damage	If structures are washed out, replacement may be costly.	Depends on extend of damage. Loss of full retaining wall or bridge may be costly to replace.	Parks and trails impacted by inundation will be permanently lost.	If damage to marine infrastructure is serious, will be more costly to repair.	Actions identified do not require significant efforts or changes to normal O&M procedures.	Adjustments to operational procedures could likely manage most of the impacts.	Parklands and trails can be an effective storm/flood buffer.	Depends on extent of damage to marine infrastructure. Parklands and trails can be an effective storm/flood buffer.	
Referenced Sources	Anecdotal	Anecdotal	Anecdotal and GIS	Extent of fire risk, anecdotal	Anecdotal	Anecdotal	Anecdotal	Anecdotal	Anecdotal	GIS	Anecdotal	Anecdotal	Anecdotal	GIS	Anecdotal	
Adaptive Capacity Rating	**AC3**	**AC5**	**AC3**	**AC2**	**AC4**	**AC4**	**AC4**	**AC3**	**AC3**	**AC1**	**AC3**	**AC4**	**AC4**	**AC4**	**AC3**	
VULNERABILITY																
Vulnerability Rating	**V4**	**V1**	**V4**	**V5**	**V3**	**V2**	**V2**	**V4**	**V4**	**V5**	**V4**	**V2**	**V2**	**V3**	**V4**	
NEXT STEPS																
Conduct risk assessment?	YES	NO	YES	YES	NO	NO	NO	YES	YES	YES	YES	NO	NO	NO	YES	
Considerations to be noted in risk assessment	Review type of turf and user requirements.	Identify current use of irrigation in parks and current irrigation requirements.						Review condition of wooden structures, location of septic fields and susceptibility to flooding	Review condition of wooden structures and retaining walls.	Identify parks structures within inundation zone.	Identify types of marine infrastructure and condition (if available).					
Other considerations to be noted		Identify opportunities to use rainwater or grey water irrigation. Requirements for irrigation during drought may be compounded by increase in summer temperatures.			Identify if any significant assets are within flood zone. Review flood operational response plan. Review ability of parks to act as flood buffer/flood protection to adjacent property or infrastructure systems.		Follow component replacement schedule as identified in condition assessment report to maintain integrity of the building envelope.							Identify if there is parks infrastructure within coastal flood zone.		
RISK ASSESSMENT																
CONSEQUENCE																
Health and Safety	tree debris falling due to dead limbs		if people are in the park during a slide, may result in near-miss	people would be evacuated, not in park				people likely not in park during flood/high water conditions	people moving on trails, not as likely to be injured by imbankment failure						windstorms unpredictable for timing	
score	2		2	2				1	2	1	1				2	
Environment	loss of vegetation, changes biodiversity in park.		loss of embankments, increased sedimentation in watercourses	Loss of vegetation				Inundation of septic disposal fields	potential release of debris into watercourses	depends on the type of infrastructure that is submerged	depends on the type of infrastructure that is submerged					
score	2		3	3				3	3	2	2				2	
Local Economy										Closure or reduced use of coastal parks near businesses leading to decrease in business	Closure or reduced use of coastal parks near businesses leading to decrease in business					
score	1		1	2				1	1	2	2				1	
Level of Service			partial park closure if slide occurred	significant impact to quality of life for regular park users												
score	2		2	3				1	1	4	4				3	
Administration and Operations				clean up, replanting, rebuilding												
score	2		2	3				2	2	2	2				3	
Finances			depends if bank re-stabilization is required	loss of trees and facilities											loss of trees	
score	2		2	5				3	3	5	5				5	
Reputation										reduction in resident satisfaction	reduction in resident satisfaction					
score	1		2	1				1	1	4	4				1	
Total Consequence Score	**1.71**	**0.00**	**2.00**	**2.71**	**0.00**	**0.00**	**0.00**	**1.71**	**1.86**	**2.86**	**2.86**	**0.00**	**0.00**	**0.00**	**2.43**	
LIKELIHOOD																
Single or Recurring Event?																
Location/Magnitude	4		1	2				3	3	1	3				3	
Total Likelihood Score	**4**	**0**	**1**	**2**	**0**	**0**	**0**	**3**	**3**	**1**	**3**	**0**	**0**	**0**	**3**	
Risk Rating	**6.857**	**0.000**	**2.000**	**5.429**	**0.000**	**0.000**	**0.000**	**5.143**	**5.571**	**2.857**	**8.571**	**0.000**	**0.000**	**0.000**	**7.286**	
Identified Mitigating Actions																
Preventative									identify trails along embankments and monitor drainage and slope stability							
Reactive																

CVRD - Asset Climate Risk
2. RISK ASSESSMENT
Timeline: 2050

ASSET SYSTEM	**Water Systems**															
Asset System Description	19 water systems in CVRD. Assets include groundwater wells, water mains, reservoirs, pump stations, and treatment facilities.															
Asset System Functionality Goals	Supply water to Canadian Water Quality Guidelines and Standards. Meet system user demands and corporate sustainability goals (energy, water use, etc.)															
Available Asset Information	Condition assessments and GIS location information.															
SENSITIVITY																
Climatic Change	**Dryer summers**					**Wetter Winters**						**Sea Level Rise**			**Warmer Summers**		**Longer and More Intense Storms**
	Projected 8 day increase to average longest consecutive period without rain (from 22 days to 29.9 days). Total summer precipitation projected to reduce from 158mm to 93mm.					Projected 11% increase in total precipitation during winter months (from 808 mm to 908 mm). 99th percentile wettest days projected to increase 107% (from 134mm to 278mm).						Predicted 1 m rise in sea level.			Daytime high and nighttime low will increase by 4.2 °C to 24.2 °C and 4.0 °C to 13.0 °C, respectively.		The duration and frequency of storms will increase, bringing high winds, storm surges, and intense rain.
Identified Direct Impact	Reduced recharge of groundwater sources due to decrease in precipitation	Increase in watering and irrigation needs due to decreased precipitation and drought	Increase in erosion and/or decrease in slope stability due to insect disease and loss of vegetation	Damage of infrastructure and interruption of services due to wildfire	Population displacement due to wildfires	Damage to infrastructure due to streamriver flooding	Damage to infrastructure due to local drainage system flooding	Increased pressure on infrastructure due to more intense precipitation events	Damage to infrastructure due to excess debris and flow in watercourses and drainage systems	Increase in enteric diseases due to increase in agricultural run-off	Loss of freshwater source due to sea water intrusion to groundwater aquifers	Damage/loss of infrastructure due to coastal inundation	Damage to infrastructure due to higher king tides and concurrent storm surges	Increased demand on services due to potential extension of summer, growing season, and tourism season.	Changes to lake ecosystems, including change in temperature, chemical composition, habitat/species, and increase in algal blooms.	Damage to infrastructure due to increased frequency and severity of storm surges
What are the anticipated impacts to assets?	Reduced capacity of source aquifer	Increased demand on water source, increased pumping and treatment requirements, faster depletion of water storage.	Increased sediment in surface water sources leading to increased stress on water treatment facilities.	Fire damage to water system facilities, forest fire ash and debris contaminate surface water sources	Increased demand on water systems (particularly treatment plant and reservoir capacity) in areas where residents are temporarily relocated	Infrastructure damage from increase in debris and sediment, potential damage to facilities due to flooding	Potential damage to facilities due to flooding, potentially leading to interrupted operations.	Increased stress on building envelope and eaves/downspouts, leading to potential leakage/internal flooding.	Potential damage to surface water intake systems, increased demand on filtration systems, potentially ineffective disinfection systems.	Increased stress on treatment facilities	Loss of freshwater aquifer and corrosion of infrastructure. Increased demand on CVRD systems due to loss of private groundwater sources.	Significant damage or loss of system/system components.	Significant damage or loss of system/ system components.	Increased demand on water supply leads to increased demand on water sources as well as pumping and treatment infrastructure.	Change/ increased demands on surface water treatment systems. Potential blockages of surface water intakes.	Significant damage or loss of system/ system components.
What are the potential anticipated impacts to the functionality goals of the asset category?	Inability to meet water demands	May deplete water supply for other system uses	Inability to meet water demands and quality standards	Inability to meet water demands and quality standards	Temporary inability to meet water demands	Inability to meet water demands and quality standards	Inability to meet water demand or quality standards	Temporary inability to meet water demand or quality standards if equipment is damaged.	Inability to meet water demands or quality standards	Inability to meet quality standards	Inability to meet quality standards and demands	Inability to meet demand and quality standards	Inability to meet demand and quality standards	Inability to meet demand and water conservation goals	Inability to meet water quality standards.	Inability to meet demand and quality standards
Within the asset category, will there be greater impact on specific asset systems?	Yes	Yes	Yes	Yes	Depends	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes
If yes, which locations or specific asset systems will be impacted?	Systems with groundwater sources	Systems with water sources currently under stress, systems with higher irrigation rates.	Water systems with surface water sources (Youbou, Saltair, and Shawnigan Lake)	Water systems with surface water sources (Youbou, Saltair, and Shawnigan Lake) and water systems with above ground reservoirs that are not concrete. All water systems are in areas of high-extreme fire risk	Are some areas designated for emergency management relocation?	Water systems with surface water sources. Water systems with facilities in flood zones.	Systems with above ground structures or facilities.	Systems with treatment facilities or pump stations.	Systems with surface water source.	Systems with surface water sources, systems with groundwater sources that may be vulnerable to contamination.	Water systems with groundwater sources near the coast/ near inundation zones.	Systems with components in innundation zones.	Systems with components located in king tide and storm surge flood zones.	N/A	Systems with lake surface water source.	Systems with components located in storm surge flood zones.
Asset System Sensitivity Rating	**S4**	**S3**	**S3**	**S4**	**S2**	**S3**	**S3**	**S2**	**S3**	**S4**	**S4**	**S5**	**S4**	**S3**	**S4**	**S4**
ADAPTIVE CAPACITY																
What types of actions would be required to adjust the asset category to the anticipated impact, after it has happened? *(Actions may be O&M or capital responses.)*	Follow phase 3 DroughtSmart restrictions, remove water restriction exemptions for local businesses, water conservation incentives, adjust rate structure. Increase water storage capacity on a regional and individual level, including rain barrel collection systems. Identify and connect to additional water sources. Provide temporary trucked water to meet supply.	Implement water and irrigation restrictions. Create incentives for xeriscaping and sustainable storage practices. Identify and connect to additional water sources. Provide temporary trucked water to meet supply.	Issue boil water advisory, install filtration equipment	Suppress fires to minimize damage. Implement boil water advisories. Implement water restrictions to reduce demand. Repair damaged facilities. Provide temporary water source or temporary water pumps.	Provide temporary water supply to supplement local supply. Implement water restrictions. Identify and connect to additional water sources.	Implement boil water advisory and water restrictions. Remediate damaged facilities. Build flood protection systems around at-risk facilities. Provide temporary water supply.	Implement boil water advisory and water restrictions. Deploy operations crews to address drainage system issues and pump water. Remediate damaged facilities. Improve drainage and grading around facilities. Provide temporary water supply.	Implement boil water advisory and water restrictions. Deploy operations crews to address leaks. Remediate damaged facilities.	Implement boil water advisory and water restrictions. Remediate damaged facilities. Increase frequency of filter cleaning. Provide temporary water supply.	Implement boil water advisory and water restrictions. Remediate vulnerable facilities. Provide temporary water supply.	Provide temporary potable water supply. Identify and connect to other water sources. Remediate degraded infrastructure if still required.	Provide temporary potable water supply if water quality is compromised. Identify and connect to other water sources or build adaptation measures for infrastructure. Remediate degraded infrastructure if still required.	Implement temporary flood protection (e.g. sandbags and pumping). Provide temporary potable water supply if water quality is compromised. Identify and connect to other water sources or build adaptation measures to protect or re-locate infrastructure. Remediate degraded infrastructure if still required.	Water conservation practices. Adjust water rates. Increase water storage capacity on a regional and individual level, including rain barrel collection systems. Identify and connect to additional water sources. Provide temporary trucked water supply to stressed systems.	Implement boil water advisory. Adjust O&M procedures and plant operations to meet demands. Implement water treatment system upgrades where necessary. Clear blockages from surface water intake structures and increase frequency of cleaning.	Implement temporary flood protection (e.g. sandbags and pumping). Provide temporary potable water supply if water quality is compromised. Identify and connect to other water sources or build adaptation measures to protect or re-locate infrastructure. Remediate degraded infrastructure if still required.
Can the asset system adjust to the projected impact with minimal cost and disruption?	Maybe	Yes	Maybe	No	Yes	Yes	Yes	Yes	Yes	Yes	No	No	No	Maybe	Maybe	No
Explain response	Depends on additional water savings that could be realized through operational and planning programs	Implement irrigation restrictions for an additional 8 day during periods of drought	Depends on the current turbidity levels of the water sources and their sensitivity to increased turbidity.	If facilities sustain fire damages, will require costly repair.	Depends on Emergency management plans and practices.	Depends on flood risk management plan, emergency management plan and operation protocol	Temporary operational fix required.	Temporary operational fix required.	Temporary operational fix required.	Fix required will not likely require significant resources.	Connecting to alternate source would likely be costly in terms of financial resources and staff time.	Adaptation measures will likley be costly.	Adaptation measures may be costly.	Depends on current levels of stress on water sources.	Depends on adaptive capacity of treatment plants and extent of changes to O&M procedures or captial upgrades.	Adaptation measures may be costly.
Referenced Sources	Anecdotal	Anecdotal			Anecdotal	Anecdotal	Anecdotal	Anecdotal								
Adaptive Capacity Rating	**AC3**	**AC3**	**AC3**	**AC2**	**AC4**	**AC4**	**AC4**	**AC4**	**AC4**	**AC4**	**AC2**	**AC1**	**AC2**	**AC3**	**AC3**	**AC2**
VULNERABILITY																
Vulnerability Rating	**V4**	**V4**	**V4**	**V5**	**V2**	**V3**	**V3**	**V2**	**V3**	**V3**	**V5**	**V5**	**V5**	**V4**	**V4**	**V5**
NEXT STEPS																
Conduct risk assessment?	YES	YES	YES	YES	NO	NO	NO	NO	NO	NO	YES	YES	YES	YES	YES	YES
Considerations to be noted in risk assessment	Current levels of stress on groundwater aquifers.	Consider compounding effects of drought and prolonged hot temperatures.			Review condition assessments							Develop adaptation plan for inundated areas, including inundated assets.	Review procedures in flood response plan for critical water system assets.	Identify anticipated water savings from various stages of water restrictions.		Adaptive capacity of water treatment plants.	
Other considerations to be noted	Review existing water conservation policies and programs. Review drought response plans.	Review existing water conservation policies and programs. Review drought response plans.		Review existing fuel and emergency management plans.		Review flood and emergency plans and operating protocols for impacted facilities.	If there are any existing drainage issues, identify opportunities to improve drainage and grading. Update operations plans to include checking site drainage during periods of heavy rain. Ensure eaves and downspouts on buildings are functioning properly.	Ensure eaves and downspouts on buildings are functioning properly. Check condition of facilities.		Review agriculture run-off zones and protection of groundwater wells.						
RISK ASSESSMENT																
CONSEQUENCE																
Health and Safety	appearance of threat but no harm.			may be issues with chlorinating water if reservoir is damaged. If reservoir is concrete, can chlorinate at the reservoir							Concerns with water reliability for people with individual medical requirements.	Concerns with water reliability for people with individual medical requirements. If water mains are submerged, may not detect contamination.	Concerns with water reliability for people with individual medical requirements. If water mains are submerged (even temporarily), may not detect contamination.			Concerns with water reliability for people with individual medical requirements. If water mains are submerged (even temporarily), may not detect contamination.
score	1	1	1	2							2	3	3	2	1	3
Environment	some impacts, related to interplay between surface and groundwater										continued use of groundwater aquifer can expedite the saltwater intrusion.					
score	2	1	2	1							4	1	1	1	1	1
Local Economy	Shut down water supply to local business			Depending on the extent of the damage to full system.												
score	2	2	2	2							2	2	1	1	2	1
Level of Service	impact to quality of life if water is shut off										long term interruption until new water source is established					
score	3	3	2	2							3	3	1	3	2	1
Administration and Operations	isolated instances										pressure while establishing new supply					
score	2	2	2	2							2	2	1	3	2	1
Finances															cumulative cost of operational adjustments over time	
score	2	2	1	3							3	3	1	3	2	1
Reputation											May impact relationships with neighbouring jurisdictions, depending on options for alternate source.					
score	2	2	2	1							3	2	1	2	2	1
Total Consequence Score	**2.00**	**1.86**	**1.71**	**1.86**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**2.71**	**2.29**	**1.29**	**2.14**	**1.71**	**1.29**
LIKELIHOOD																
Single or Recurring Event?	recurring event	recurring	recurring	single							single	recurring	recurring	recurring	recurring	recurring
Location/Magnitude	4	4	3	1							2	1	3	4	3	3
Total Likelihood Score	**4**	**4**	**3**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**2**	**1**	**3**	**4**	**3**	**3**
Risk Rating	**8.000**	**7.429**	**5.143**	**1.857**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**5.429**	**2.286**	**3.857**	**8.571**	**5.143**	**3.857**
Identified Mitigating Actions																
Preventative		Emphasis on communication tools, behavior incentives, rate structure. Development services to provide a role in new development - cross functional strategies. Set appropriate expectations for new builds.		Fire Smart plan							Identify specific wells at risk and evaluate options for alternate sources.	Identify specific infrastructure at risk, evaluate options for protecting or relocating infrastructure.	Identify specific infrastructure at risk, evaluate options for protecting or relocating infrastructure.			
Reactive																

General notes and observations
1. Information about groundwater aquifers and connectivity to surface water is limited, leading to undertainty of some of the vulnerability and risk ratings.
2. Spatial information about extents of king tides and storm surges was not available.

CVRD - Asset Climate Risk
2. RISK ASSESSMENT
Timeline: 2050

ASSET SYSTEM	**Sewer Systems**																	
Asset System Description	16 Sewer Systems include: sewer main lines, sewer structures, pumps, lift stations, treatment plants, drainage fields, lagoons, etc.																	
Asset System Functionality Goals	Protect environmental quality and public health. Meet corporate sustainability goals (energy, water use, etc.)																	
Available Asset Information	Condition assessments and GIS location information.																	
SENSITIVITY																		
Climatic Change	**Dryer summers**			**Wetter Winters**				**Sea Level Rise**		**Warmer Summers**		**Longer and More Intense Storms**					
	Projected 8 day increase to average longest consecutive period without rain (from 22 days to 29.9 days).			Projected 11% increase in volume and intensity of precipitation during winter months (from 808 mm to 908 mm). 99th percentile wettest days projected to increase 107% (from 134mm to 278mm).				Predicted 1 m rise in sea level.		Daytime high and nighttime low will increase by 4.2 °C to 24.2 °C and 4.0 °C to 13.0 °C, respectively.		The duration and frequency of storms will increase, bringing high winds, storm surges, and intense rain.					
Identified Direct Impact	Increase in erosion, flooding and/or decrease in slope.	Damage of infrastructure and interruption of services due to increase in risk of wildfire	Population displacement due to wildfires	Damage to infrastructure due to stream/river flooding	Damage to infrastructure due to local drainage system flooding	Increased pressure on infrastructure due to more intense precipitation events	Damage to infrastructure due to excess debris and flow in watercourses and drainage systems	Damage/loss of infrastructure due to coastal inundation	Damage to infrastructure due to higher king tides	Increased demand on services due to potential extension of summer and tourism season.	Increase in nuisance odour emitted from waste facilities	Damage to infrastructure due to increased frequency and severity of storm surges	Damage to energy transmission networks due to severe	Damage to facilities due to severe winds	Population displacement as a result of extreme weather events		
What are the anticipated impacts to assets?	Reduced access to sewer main lines and sewer structures infrastructure.	Fire damage to sewer system facilities, forest fire ash and debris contaminate lagoons.	Increased demand on sewer systems in areas where residents are temporarily relocated	Potential damage to facilities, damage or washout of infrastructure due to flooding. High inflow and infiltration.	Above ground sewer structures may experience some flooding. Potential for restricted access to facilities if roads are flooded. Potential increased inflow and infiltration.	Increased stress on building envelope and eaves/downspouts, leading to potential leakage/internal flooding. Increased inflow and infiltration.	Damage of surface water outfall structures.	Loss of sewer main lines and structures in identified inundation zone. Increased inflow and infiltration as sea level rises.	Restricted access to facilities, temporary flooding of facilities, increased inflow and infiltration.	Increase in volume of wastewater, increased demand on systems.	Increase demand on odour control mechanisms.	Restricted access to facilities, temporary flooding of facilities, increased inflow and infiltration.	Loss of power to treatment systems and pump stations, triggering backup	Damage of treatment facilities or lift stations due to fallen	Increase demand on areas hosting re-located people.		
What are the potential anticipated impacts to the functionality goals of the asset category?	Potential inability to properly operate the system.	Inability to meet environmental and public health requirements.	Temporary inability to meet sewer conveyance and tratement demands	Inability to meet conveyance and treatment demands, temporary surcharging or overflows.	Minimal impact to functionality goals	Inabilty to meet conveyance and treatment demands, temporary surcharging or overflows.	Improper system discharge, potential outfall blockage.	Permanent inability to meet local conveyance and treatment demands, surcharging or overflows.	Temporary inability to meet local conveyance and treatment demands, surcharging or overflows.	Likley very low impact. System will likely be able to accommodate increased demands during dry weather periods. (This assumes that systems are upgraded to accommodate regional population growth).	Negatively impact reputation and public opinion	Temporary inability to meet local conveyance and treatment demands, surcharging or overflows.	Temporary inability to meet local conveyance and treatment demands, surcharging or overflows.	Reduced ability to meet conveyance or treatment demand.	Reduced ability to meet conveyance or treatment demand.		
Within the asset category, will there be greater impact on specific asset systems?	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes			
If yes, which locations or specific asset systems will be impacted?	Systems with facilities on or near steep slopes.	Systems with above ground structures or facilities.	N/A	Systems with infrastructure in the flood zone.	Systems with above ground structures or facilities.	Systems with lagoons, systems currently near capacity, systems experiencing high levels of I/I.	Systems with surface water outfall structures.	Systems with assets in the inundation zone.	Systems with assets in the coastal flood zone.	N/A	Systems with above ground lift stations or treatment facilities.	Systems with assets in the coastal flood zone.	Systems with lift stations or treatment processes that rely on power.	Systems with above-ground facilities in heavily treed areas.	Systems that are currently at or near capacity.			
Asset System Sensitivity Rating	**S3**	**S4**	**S2**	**S4**	**S2**	**S3**	**S3**	**S5**	**S4**	**S1**	**S2**	**S4**	**S4**	**S2**	**S2**			
ADAPTIVE CAPACITY																		
What types of actions would be required to adjust the asset category to the anticipated impact, after it has happened? *(Actions may be O&M or capital responses.)*	Remove debris, rehabilitate damaged infrastructure.	Minor - major repairs of structures.	Provide temporary facilities for displaced populations. Pump waste to systems with additional capacity.	Remediate environmental discharge where required. Minor major repairs of structures. Pump waste to systems with additional capacity.	Deploy operations crews to address drainage system issues and pump water. Increase ventilation to reduce moisture buildup and mould growth. Remediate damaged facilities. Improve drainage and grading around facilities.	Deploy operations crews to address building leaks. Remediate damaged facilities. Discharge untreated effluent when system over capacity. Implement I/I management solutions (e.g. increased buffer storage, lining mains and manholes, replacing mains, increase lagoon size, etc.)	Clear potential blockages. Minor repairs of structures.	Idenifty sea level rise adaptation strategies for sewer infrastructure (relocation, asset protection, etc.)	Implement inflow and infiltration management strategies. Identify sea level rise adaptation strategies for sewer infrastructure.	Implement water conservation measures, with additional incentives for tourism industry.	Operational and capital improvements to reduce odours.	Implement inflow and infiltration management strategies. Identify sea level rise adaptation strategies for sewer infrastructure.	Switch to backup power supply. Implement water restrictions.	Implement water restrictions to reduce demand. Repair damaged facilities. Prevent tree/debri	Provide temporary facilities for displaced populations. Pump waste to systems with additional capacity.			
Can the asset system adjust to the projected impact with minimal cost and disruption?	Maybe	No	Yes	Maybe	Yes	No	Yes	No	No	Yes	Maybe	No	Yes	Yes	Yes			
Explain response	Depends c	If the facilities sustain this damage, will require major	Multiple systems provide system redundancy if sewage can be	Depends on severity of damage.	Actions identified require minimal cost.	Implementation of I/I management solutions can be	Actions identified require minimal cost.	Inundation leads to permanent submersion of assets; adaptation	I/I management strategies and adaptation actions can be costly.	Actions outline require minimal cost.	Depends on whether there are ongoing odour issues and if	I/I management strategies and adaptation actions can be costly.	Temporar y	Damage likely	Multiple systems provide system redundancy if sewage can be hauled to another system on a temporary basis.			
Referenced Sources	Anecdotal	Extent of fire risk, anecdotal	Extent of fire risk, anecdotal	Anecdotal	Anecdotal	Anecdotal	Anecdotal	Anecdotal and GIS	Anecdotal and GIS	Anecdotal	Anecdotal	Anecdotal	Anecdotal	Anecdotal	Anecdotal			
Adaptive Capacity Rating	**AC4**	**AC2**	**AC4**	**AC3**	**AC4**	**AC2**	**AC4**	**AC1**	**AC2**	**AC5**	**AC3**	**AC2**	**AC4**	**AC5**	**AC4**			
VULNERABILITY																		
Vulnerability Rating	**V3**	**V5**	**V2**	**V4**	**V2**	**V4**	**V3**	**V5**	**V5**	**V1**	**V2**	**V5**	**V3**	**V1**	**V2**			
NEXT STEPS																		
Conduct risk assessment?	NO	YES	NO	YES	NO	YES	NO	YES	YES	NO	NO	YES	NO	NO	NO			
Considerations to be noted in risk assessment				Condition of sewer mains and levels of I/I in current system.		Review condition assessments, system capacity, and current levels of I/I in systems.												
Other considerations to be noted	Note that slopes may fail during				Identify any current issues with site drainage. Ensure operations plans include checks and maintenance of drainage		Identify risk of damage to specific outfall structures based on condition, location, and consequence of potential	Opportunity to time replacement/relocation with asset renewal strategies.			Current odour issues at locations may worsen with climate change. Identify opportunities to address issues through asset		maintenan ce procedure s for	operation al procedure s for	Review strategies for providing sanitary sewer services to relocated populations during emergency situations.			
RISK ASSESSMENT																		
CONSEQUENCE																		
Health and Safety		May be health impacts associated with the discharge of untreated effluent		May be health impacts associated with the discharge of untreated effluent		May be health impacts associated with the discharge of untreated effluent		May be health impacts associated with the discharge of untreated effluent	May be health impacts associated with the discharge of untreated effluent			May be health impacts associated with the discharge of untreated effluent						
score		3		3		3		3	3			3						
Environment		discharge of untreated effluent		discharge of untreated effluent		discharge of untreated effluent		discharge of untreated effluent	discharge of untreated effluent			discharge of untreated effluent						
score		3		3		3		3	3			3						
Local Economy		Depending on the extent of the damage to full system.		Depending on the extent of the damage to full system.		Potential economic impacts to coastal businesses with regular, prolonged discharges?		Potential economic impacts to coastal businesses with regular, prolonged discharges?										
score		2		2		2		2	1			1						
Level of Service																		
score		3		3		3		3	3			3						
Administration and Operations																		
score		2		2		3		3	3			3						
Finances						total cost will depend on the extent of I&I		total cost will depend on the extent of I&I	total cost will depend on the extent of I&I			total cost will depend on the extent of I&I						
score		3		3		4		4	4			4						
Reputation																		
score		1		2		3		3	3			3						
Total Consequence Score	**0.00**	**2.43**	**0.00**	**2.57**	**0.00**	**3.00**	**0.00**	**3.00**	**2.86**	**0.00**	**0.00**	**2.86**						
LIKELIHOOD																		
Single or Recurring Event?																		
Location/Magnitude		1		2		5		1	3			3						
Total Likelihood Score	**0**	**1**	**0**	**2**	**0**	**5**	**0**	**1**	**3**	**0**	**0**	**3**						
Risk Rating	**0.000**	**2.429**	**0.000**	**5.143**	**0.000**	**15.000**	**0.000**	**3.000**	**8.571**	**0.000**	**0.000**	**8.571**						
Identified Mitigating Actions																		
Preventative																		
Reactive																		

CVRD - Asset Climate Risk

2. RISK ASSESSMENT

Timeline: 2050

ASSET SYSTEM	Transit (bus shelters)
Asset System Description	27 Transit bus shelters.
Asset System Functionality Goals	Provide a shelter from external elements for public transportation riders.
Available Asset Information	Bus Shelter Inventory and GIS location of shelters.
SENSITIVITY	
Climatic Change	**Sea Level Rise**
	Predicted 1 m rise in sea level.
Identified Direct Impact	Damage/loss of infrastructure due to coastal inundation
What are the anticipated impacts to assets?	Permanent loss of bus shelters
What are the potential anticipated impacts to the functionality goals of the asset category?	Inability to provide shelter from external elements.
Within the asset category, will there be greater impact on specific asset systems?	No
If yes, which locations or specific asset systems will be impacted?	GIS analysis indicates that 11 bus shelters will be impacted
Asset System Sensitivity Rating	**S4**
ADAPTIVE CAPACITY	
What types of actions would be required to adjust the asset category to the anticipated impact, after it has happened? *(Actions may be O&M or capital responses.)*	Redesign bus routes to adjust to inundated area. Relocate or replace bus shelters.
Can the asset system adjust to the projected impact with minimal cost and disruption?	No
Explain response	Relocation of bus shelters will require additional planning and coordination effort.
Referenced Sources	Anecdotal and GIS
Adaptive Capacity Rating	**AC3**
VULNERABILITY	
Vulnerability Rating	**V4**
NEXT STEPS	
Conduct risk assessment?	YES
Considerations to be noted in risk assessment	
Other considerations to be noted	
RISK ASSESSMENT	
CONSEQUENCE	
Health and Safety	
score	1
Environment	
score	1
Local Economy	
score	1
Level of Service	
score	3
Administration and Operations	
score	1
Finances	
score	2
Reputation	
score	2
Total Consequence Score	**1.57**
LIKELIHOOD	
Single or Recurring Event?	
Location/Magnitude	1
Total Likelihood Score	**1**
Risk Rating	**1.571**
Identified Mitigating Actions	
Preventative	
Reactive	

CVRD - Asset Climate Risk
2. RISK ASSESSMENT
Timeline: 2050

ASSET SYSTEM	**Drainage Systems**					
Asset System Description	Drainage systems include inlet structures, detention pond, detention tank, catch basin, booms, control flow manhole, headwalls, cleanouts, and strata system.					
Asset System Functionality Goals	Protection of infrastructure and private property from flooding. Attenuate and treat stormwater flows to protect the health of natural drainage systems.					
Available Asset Information	CVRD asset inventory.					
SENSITIVITY						
Climatic Change	**Wetter Winters**				**Sea Level Rise**	
	Projected 11% increase in volume and intensity of precipitation during winter months (from 808 mm to 908 mm). 99th percentile wettest days projected to increase 107% (from 134mm to 278mm).				Predicted 1 m rise in sea level.	
Identified Direct Impact	Damage to infrastructure due to stream/river flooding	Increased pressure on infrastructure due to more intense precipitation events	Damage to infrastructure due to excess debris and flow in watercourses and drainage systems	Damage to infrastructure due to embankment failure	Damage/loss of infrastructure due to coastal inundation	Damage to infrastructure due to higher king tides and storm surges
What are the anticipated impacts to assets?	Detention ponds, pipes and catch basins will be subject to overflow and may experience washout or damage.	System overflows and potential damage or washout.	Sediment and debris may create blockages in drainage systems, leading to overflows and potential washout.	Sediment and debris may create blockages in drainage systems, leading to overflows and potential washout. Failure of embankments that support drainage infrastructure.	Gradual loss of drainage system	Unable to accommodate flows
What are the potential anticipated impacts to the functionality goals of the asset category?	damage or washout of infrastructure	More frequent inundation of the system, flooding of property, damage of infrastructure	Flooding of property, damage of infrastructure	Flooding of property, damage of infrastructure	Failure of system due to inundation.	Temporary failure of system.
Within the asset category, will there be greater impact on specific asset systems?	Yes	No	No	Yes	Yes	Yes
If yes, which locations or specific asset systems will be impacted?	Systems that are within flood zones.	N/A	N/A	Systems near steep slopes, systems with above ground structures.	Drainage systems within inundation zone	Drainage systems within king tide and storm surge zones
Asset System Sensitivity Rating	**S4**	**S4**	**S4**	**S4**	**S5**	**S4**
ADAPTIVE CAPACITY						
What types of actions would be required to adjust the asset category to the anticipated impact, after it has happened? *(Actions may be O&M or capital responses.)*	Temporary pumping and diversion measures, repair or replace damaged infrastructure.	Temporary pumping and diversion measures, repair or replace damaged infrastructure.	Clear system blockage, repair or replace damaged infrastructure.	Clear system blockage, repair or replace damaged infrastructure.	Idenitfy sea level rise adaptation strategies for drainage infrastructure (relocation, asset protection, etc.)	Idenitfy sea level rise adaptation strategies for drainage infrastructure (relocation, asset protection, etc.)
Can the asset system adjust to the projected impact with minimal cost and disruption?	Maybe	Maybe	Maybe	Maybe	No	No
Explain response	Depends on extent of flooding and damage to system.	Depends on system capacity and local drainage conditions.	Depends on system capacity and local drainage conditions.	Depends on local conditions and extent of embankment failure.	Adaptation measures are likely costly to implement.	Adaptation measures are likely costly to implement.
Referenced Sources	Anecdotal	Anecdotal	Anecdotal	Anecdotal	Anecdotal	Anecdotal
Adaptive Capacity Rating	**AC3**	**AC3**	**AC3**	**AC3**	**AC2**	**AC2**
VULNERABILITY						
Vulnerability Rating	**V4**	**V4**	**V4**	**V4**	**V5**	**V5**
NEXT STEPS						
Conduct risk assessment?	YES	YES	YES	YES	YES	YES
Considerations to be noted in risk assessment		Review existing system capacity and condition information	Review existing system capacity and condition information	Proximity of systems to steep slopes.	Presence of drainage system infrastructure in inundation zones.	Presence of drainage system infrastructure in coastal flood zones.
Other considerations to be noted		This impact may also result in damage to other asset systems (as noted elsewhere in this vulnerability assessment).	This impact may also result in damage to other asset systems (as noted elsewhere in this vulnerability assessment).			
RISK ASSESSMENT						
CONSEQUENCE						
Health and Safety						
score	1	1	1	1	1	1
Environment		washout of infrastructure may lead to excess debris entering watercourses				
score	1	3	1	1	1	1
Local Economy		depends on the extent and frequency of property flooding				
score	1	3	1	1	2	2
Level of Service		depends on the extent and frequency of property flooding				
score	2	4	2	2	3	3
Administration and Operations						
score	2	3	2	2	2	2
Finances	depends on extent of damage to system		depends on extent of damage to system	depends on extent of damage to system	depends on extent of inundation and options for relocation of infrastructure	depends on extent of inundation and options for relocation of infrastructure
score	3	5	3	3	3	3
Reputation						
score	2	4	2	2	3	3
Total Consequence Score	**1.71**	**3.29**	**1.71**	**1.71**	**2.14**	**2.14**
LIKELIHOOD						
Single or Recurring Event?						
Location/Magnitude	2	3	1	2	1	2
Total Likelihood Score	**2**	**3**	**1**	**2**	**1**	**2**
Risk Rating	**3.429**	**9.857**	**1.714**	**3.429**	**2.143**	**4.286**
Identified Mitigating Actions						
Preventative						
Reactive						

General Notes

1. Do not have GIS information to identify whether drainage assets are in flood or inundation zones.

APPENDIX 7
Douglas Hill Water System Case Study

URBAN systems

CVRD - Asset Climate Risk
4. CASE STUDY - DOUGLAS HILL WATER

ASSET SYSTEM	**Water Systems**
Asset System Description	The Douglas Hill and Jim's Crescent subdivision are serviced by the Douglas Hill Water System. The water is sourced from two groundwater wells. The 454m3 reservoir receives chlorine disinfection. The customers' demand dictates water pumping and distribution. A 24-hour monitoring and alarm system are in place to monitor critical equipment. Detailed asset list as follows: Water treatment building, Duty pump, 20 HP, 600V/3Ph/60Hz (17.1 L/s at 61.5 m TDH), Duty pump, 3HP, 600V/3Ph/60Hz (1.75 L/s at 61.5 m TDH), 75mm Siemens F M Magflo electromagnetic flowmeter w/ Mag5100W sensor & Mag5000 transmitter (4-20mA), Chlorination system c/w analyzer, dosing pump, tank, Communications (WTP), Process piping c/w valves, pipes, tees, Generator (WTP) c/w building (assumed 20 kW), Well 1 and Well 1 pump (assumed 5 hp), Well 2 and Well 2 pump Well 1 and Well 1 pump, Concrete reservoir, 454 m3, 100mm Gate valve, 150mm Gate valve, Fire hydrant c/w 150 HxF gate valve (N/O), 150 FxFxF Tee, 25mm, 50mm, 100mm and 150 mm Watermain pipe, Drywell, Watermain pipe, fire hydrant assembly, touch transmission water meters, air control valve, flush out valve, hydrant valve and system valve. All properties have water meters. Water treatment building is attached to reservoir.
Asset System Levels of Service	Stakeholder groups include service users (utility users/customers, rate payers), service providers (CVRD Utility Maintenance Staff and Contractors), Compliance, Standard and Regulators (Provincials Regulations/Regulators, i.e. building code, fire code and environmental regulations), WorkSafe BC BC i.e. health and safety and CVRD internal standards), and Wider CVRD community (Strata organization). Customer performance measures vary for each stakeholder group and can include but not limited to: satisfaction surveys, number of complaints - failure or interruption of service, number of issues identified by staff, appropriate staff space and equipment, non-conformance or violation notices or findings, and time to respond to Strata on related projects.
Available Asset Information	Draft LOS, Asset Inventory, Capital Plan, Replacement Schedule, 10-year Capital Plan, Infrastructure Condition Assessment, Mapping, Record Drawings and Site Inspection Forms, unique demands, annual and weekly sample schedule.

VULNERABILITY ASSESSMENT																			
SENSITIVITY																			
Climatic Change	**Dryer summers**				**Wetter Winters**						**Sea Level Rise**			**Warmer Summers**			**Longer and More Intense Storms**		
	Projected 8 day increase to average longest consecutive period without rain (from 22 days to 29.9 days). Total summer precipitation projected to reduce from 158mm to 93mm.				Projected 11% increase in total precipitation during winter months (from 808 mm to 908 mm). 99th percentile wettest days projected to increase rainfall from 100mm to 205mm.						Predicted 1 m rise in sea level.			Daytime high and nighttime low will increase by 4.2 °C to 24.2 °C and 4.0 °C to 13.0 °C, respectively.			The duration and frequency of storms will increase, bringing high winds and intense rain. Storms will be more intense in the fall with the change of the polar vortex and in the summer with hot conditions.		
Identified Direct Impact	Reduced recharge of groundwater sources due to decrease in precipitation	Increase in watering and irrigation needs due to decreased precipitation and drought.	Increase in erosion and/or decrease in slope stability due to insect disease and loss of vegetation	Damage of infrastructure and interruption of services due to wildfire	Damage to infrastructure due to stream/river flooding	Damage to infrastructure and aquifer due to local drainage system flooding	Increased pressure on infrastructure due to more intense precipitation events	Damage to infrastructure due to excess debris and flow in watercourses and drainage systems	Increase in enteric diseases due to increase in agricultural run-off	Loss of freshwater source due to sea water intrusion to groundwater aquifers	Damage/loss of infrastructure due to coastal inundation	Damage to infrastructure due to higher king tides and concurrent storm surges	Increased rolling brown outs	Increased demand on services due to potential extension of summer and tourism season and growing season. Will impact Douglas Hill but don't know full capacity of reservoir.	Changes to lake ecosystems, including change in temperature, chemical composition, habitat/species, and increase in algal blooms.	Damage to infrastructure due to increased frequency and severity of storm surges	Damage to energy transmission networks or communication systems due to severe wind storms	Damage to facilities due to severe winds
What are the anticipated impacts to assets?	Reduced capacity of source aquifer	Increased demand on water source, increased pumping and treatment requirements, faster depletion of water storage.	Increased sediment in surface water sources leading to increased stress on water treatment facilities.	Fire damage to water system facilities. Woodframe building for treatment facility. Reservoir would not be impacted.	Infrastructure damage from increase in debris and sediment, potential damage to facilities due to flooding	Potential damage to facilities due to flooding, potentially leading to interrupted operations. Facility is on a hill, site drainage is not an issue. If there are low lying areas and erosion that could lead to pipe failure, could impact aquifer (if there are not protections in place) or underground infrastructure. Likelihood depends on interaction between aquifer and surface water.	Increased stress on building envelope and eaves/downspouts, leading to potential leakage/internal flooding.	Potential damage to surface water intake systems, increased demand on filtration systems, potentially ineffective disinfection systems.	Increased stress on treatment facilities	Loss of freshwater aquifer and corrosion of infrastructure. Increased demand on CVRD systems due to loss of private groundwater sources.	Significant damage or loss of system/system components.	Significant damage or loss of system/ system components.	Increased demand on generators. Douglas Hill generator is old but in reasonable condition. Increased manhours for refuelling and maintenance.	Increased demand on water supply leads to increased demand on water sources (greater concern) as well as pumping and treatment infrastructure (minor impacts). Similar to concerns about increased irrigation.	Change/ increased demands on surface water treatment systems. Potential blockages of surface water intakes.	Significant damage or loss of system/ system components.	Loss of power to treatment systems and pump stations, triggering backup generators where available. Loss of communication systems, difficult to recognize if there is an issue. Douglas Hill uses phone line.	Damage of treatment facilities or pump stations due to fallen trees or debris
What are the potential anticipated impacts to the functionality goals of the asset category?	Inability to meet water demands	May deplete water supply for other system uses	Inability to meet water demands and quality standards	Inability to meet water demands and quality standards.	Inability to meet water demands and quality standards	Inability to meet water demand or quality standards	Temporary inability to meet water demand or quality standards if equipment is damaged.	Inability to meet water demands or quality standards	Inability to meet quality standards	Inability to meet quality standards and demands	Inability to meet demand and quality standards	Inability to meet demand and quality standards	Temporary inability to meet water demands.	Inability to meet demand and water conservation goals. Customers are unhappy with significant restrictions. Could reduce fire fighting ability.	Inability to meet water quality standards.	Inability to meet demand and quality standards	Inability to meet demand and water quality standards.	Inability to meet demand and water quality standards.
Asset System Sensitivity Rating	**S4**	**S4**	**S3**	**S3**	**S3**	**S2**	**S1**	**S2**	**S3**	**S4**	**S5**	**S6**	**S3**	**S4**	**S4**	**S4**	**S3**	**S2**
ADAPTIVE CAPACITY																		
What types of actions would be required to adjust the asset category to the anticipated impact, after it has happened? *(Actions may be O&M or capital responses.)*	Follow phase 3 DroughtSmart restrictions, remove water restriction exemptions for local businesses, water conservation incentives, adjust rate structure. Increase water storage capacity on a regional and decentralized level, including rain barrel collection systems. Identify and connect to additional water sources. Provide temporary trucked water supply to stressed systems. No significant leaks that could be addressed and make up shortfall. Don't have backup aquifer. Long term potential for amalgamation of systems? Issue of pricing and compensation for trucking water from one system to another system - existing policy gap. Provide incentives to customers to reduce water use. Rate structure could be adjusted.	Implement water and irrigation restrictions. Create incentives for xeriscaping and sustainable storage practices. Identify and connect to additional water sources. Provide temporary trucked water to meet supply. Changes to rate structure, define how service is provided in the bylaw - allow people to adjust to level of service provided by CVRD. Provide incentives for cisterns, etc.	Issue boil water advisory, install filtration equipment	Suppress fires to minimize damage. Implement water restrictions to reduce demand. Repair damaged facilities. Prevent fire damage by implementing emergency management plan, forest fuel management plan, fuel suppression management plan. Provide temporary water source or temporary water pumps. Can provide chlorination at reservoir if needed. Could provide service within 24 hours, but would not be able to provide fire services for months. Rebuild asset to fire proofing standards.	Implement boil water advisory and water restrictions. Remediate damaged facilities. Build flood protection systems around at-risk facilities. Provide temporary water supply.	Remediate pipe failure.	Deploy operations crews to address leaks. Remediate damaged facilities.	Implement boil water advisory and water restrictions. Remediate damaged facilities. Increase frequency of filter cleaning. Provide temporary water supply.	Implement boil water advisory and water restrictions. Remediate vulnerable facilities. Provide temporary water supply.	Provide temporary potable water supply. Identify and connect to other water sources. Remediate degraded infrastructure if still required.	Provide temporary potable water supply if water quality is compromised. Identify and connect to other water sources or build adaptation measures to protect or re-locate infrastructure. Remediate degraded infrastructure if still required.	Implement temporary flood protection (e.g. sandbags and pumping). Provide temporary potable water supply if water quality is compromised. Identify and connect to other water sources or build adaptation measures to protect or re-locate infrastructure. Remediate degraded infrastructure if still required.	Run generator, provide additional maintenance and fuelling.	Water conservation practices. Adjust water rates. Increase water storage capacity on a regional and individual level, including rain barrel collection systems. Identify and connect to additional water sources. Provide temporary trucked water supply to stressed systems. MATCH WITH INCREASED IRRIGATION	Implement boil water advisory. Adjust O&M procedures and plant operations to meet demands. Implement water treatment system upgrades where necessary. Clear blockages from surface water intake structures and increase frequency of cleaning.	Implement temporary flood protection (e.g. sandbags and pumping). Provide temporary potable water supply if water quality is compromised. Identify and connect to other water sources or build adaptation measures to protect or re-locate infrastructure. Remediate degraded infrastructure if still required.	Switch to backup power supply. Implement water restrictions. Operators on site to check facilities during major storms.	Repair damaged facilities. Prevent tree/debris damage by pruning trees and removing dead trees near facilities.
Can the asset system adjust to the projected impact with minimal cost and disruption?	No	Yes	Maybe	No	Yes	Yes	Yes	Yes	Yes	No	No	No	Yes	Maybe	Maybe	No	Yes	Yes
Explain response	Public communication, change in perception needed around water use. Difficult to change. Capital and operational impacts are also significant.	Demonstrated in other service areas that people can understand need for restriction and will adapt. Transparency and communication will be necessary.	Depends on the current turbidity levels of the water sources and their sensitivity to increased turbidity.	If facilities sustain fire damages, will require costly repair. Within the scope of the financial resources for Douglas Hill, would be significant costs.	Depends on flood risk management plan, emergency management plan and operation protocol	Temporary operational fix required.	Temporary operational fix required.	Temporary operational fix required.	Fix required will not likely require significant resources.	Connecting to alternate source would likely be costly.	Adaptation measures will likely be costly.	Adaptation measures may be costly.		Currently, undetected leaks an issue. This may add stress to the water supply.	Depends on adaptive capacity of treatment plants and extent of changes to O&M procedures or capital upgrades.	Adaptation measures may be costly.	Temporary operational fix (assuming backup power supplies are available).	Damage likely limited and easy to remediate.
Referenced Sources	Anecdotal - workshop	Anecdotal			Anecdotal	Anecdotal	Anecdotal											
Adaptive Capacity Rating	**AC2**	**AC3**	**AC3**	**AC2**	**AC4**	**AC5**	**AC5**	**AC6**	**AC7**	**AC8**	**AC9**	**AC10**	**AC5**	**AC3**	**AC3**	**AC2**	**AC5**	**AC2**
VULNERABILITY																		
Vulnerability Rating	**V5**	**V4**	**V4**	**V5**	**V3**	**V1**	**V1**	**V3**	**V3**	**V5**	**V5**	**V5**	**V3**	**V4**	**V4**	**V5**	**V3**	**V2**
NEXT STEPS																		
Conduct risk assessment?	YES	YES	YES	YES	NO	NO	NO	NO	NO	YES	YES	YES	NO	YES	YES	YES	NO	NO
Considerations to be noted in risk assessment	Current levels of stress on groundwater aquifers. Undetected leaks	Consider compounding effects of drought and prolonged hot temperatures.													Adaptive capacity of water treatment plants.			
Other considerations to be noted	Review existing water conservation policies and programs. Review drought response plans.	Review existing water conservation policies and programs. Review drought response plans.		Review existing fuel and emergency management plans.	Review flood and emergency plans and operating protocols for impacted facilities.	If there are any existing drainage issues, identify opportunities to improve drainage and grading. Update operations plans to include checking site drainage during periods of heavy rain. Ensure eaves and downspouts on buildings are functioning properly.	Ensure eaves and downspouts on buildings are functioning properly. Check condition of facilities.		Review agriculture run-off zones and protection of groundwater wells.		Develop adaptation plan for inundated areas, including inundated assets.	Review procedures in flood response plan for critical water system assets.		Identify anticipated water savings from various stages of water restrictions.			Review maintenance procedures for backup power supplies. Develop a plan for an alternate backup supply if main backup fails.	Review operational procedures for maintaining trees near facilities to reduce risk of damage.
RISK ASSESSMENT																		
CONSEQUENCE																		
Health and Safety	Only a H&S issue if there is no water. Some individual specific requirements.			Would still chlorinate at the reservoir														
score	2	2		1										2				
Environment																		
score	1	1		1										1				
Local Economy	No businesses in service area.																	
score	1	1		1										1				
Level of Service																		
score	3	3		1										3				
Administration and Operations																		
score	3	3		2										3				
Finances																		
score	3	3		2										3				
Reputation	Customers already somewhat unhappy																	
score	4	4		1										4				
Total Consequence Score	**2.429**	**2.429**	**0**	**1.286**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**2.429**	**0**	**0**	**0**	**0**
LIKELIHOOD																		
Single or Recurring Event?	recurring event													recurring				
Location/Magnitude	4	4		1										4				
Total Likelihood Score	**4**	**4**	**0**	**1**				**0**	**0**	**0**	**0**	**0**	**0**	**4**	**0**	**0**	**0**	**0**
Risk Rating	**9.714**	**9.714**	**0**	**1.286**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**9.714**	**0**	**0**	**0**	**0**
Identified Management Actions																		
Preventative	Amount of water they're allowed to use at Douglas Hill is higher than other service areas. Shift to standard water capacity allowance. Improve understanding of the water balance model and relative stress to aquifer. Education programs. Adjust the inclined block structure. Evaluate possibility of monthly billing (rather than quarterly). Realtime metering. Agreements with neighbouring water systems.	Emphasis on communication tools, behavior incentives, rate structure. Development services to provide a role in new development - cross functional strategies. Building expectations.		Fire Smart plan, have fire alarm and suppression services from fire hall. Don't manage trees, not on CVRD property.														
Reactive	Trucking water. Evaluating potential sources, amalgamation.																	
DATA CONFIDENCE	low understanding of aquifer behavior and interaction with surface water																	

APPENDIX 8
Arbutus Park Case Study

URBAN systems

4. CASE STUDY - ARBUTUS PARK

ASSET SYSTEM	**Parks and Trails**																
Asset System Description	Arbutus Park water main lines, concrete pads, picnic shelter, picnic tables, playground, change houses and washrooms, garbage receptacles, irrigation, gravel parking lot, first aid building, dock, swimming lines/buoys, flag pole, bridge over Arbutus Creek, and park benches.																
Asset System Levels of Service (LOS)	Stakeholder groups include service users (rate payers and residents), service providers (developers, and maintenance contractors), CVRD staff, groups, schools and organizations), compliance standards and regulators (varying levels of government and sporting associations) and the wider CVRD community (Park Commission, community interest groups, and First Nations) and neighbouring communities (municipalities within CVRD, BC parks and tourists). Customer performance measures vary for each stakeholder group and can include but not limited to: tax allocation, parking capacity, number of complaints, return of value, quality of service vs expectation, satisfaction survey, availability during requested times, compliance with requirements, response volume and timeliness, and availability of information on parks.																
Available Asset Information	Draft LOS, 2014 - 2018 Strategic Pan, CVRD Inventory Summary, Annual Park Visitation, Operational Expenses, 2018 Budget, 2019 Proposed Budget, Park and Maintenance Services Contract for Area I Parks, Topographic Survey Base Plan, Photos and Google Maps.																
SENSITIVITY																	
Climatic Change	**Dryer summers**			**Warmer Summers**	**Wetter Winters**					**Sea Level Rise**		**Warmer Winters**			**Longer and More Intense Storms**		
	Projected 8 day increase to average longest consecutive period without rain (from 22 days to 29.9 days). Total summer precipitation projected to reduce from 158mm to 93mm.			Daytime high and nighttime low will increase by 4.2 °C to 24.2 °C and 4.0 °C to 13.0 °C, respectively.	Projected 11% increase in volume and intensity of precipitation during winter months (from 808 mm to 908 mm). 99th percentile wettest days projected to increase from 141.0 mm to 285.0 mm.					Predicted 1 m rise in sea level.		Daytime high and nighttime low will increase by 3.3 °C to 8.3 °C and 3.2 °C to 2.2°C, respectively.			The frequency, intensity, and duration of storm will increase		
Identified Direct Impact	Increased stress on vegetation and trees due to increase drought	Increase in watering and irrigation needs due to decreased precipitation and drought.	Damage of infrastructure and interruption of services due to increase in risk of wildfire	Increase in park use leading to increase in risky behaviours (health and safety), fire, wear and tear on infrastructure. Environmental impacts of increased use - water quality, vegetation, habitat.	Damage to infrastructure due to lake flooding.	Damage to infrastructure due to local drainage system flooding	Increased pressure on infrastructure due to more intense precipitation events	Damage to infrastructure due to excess debris and flow in watercourses and drainage systems	Damage to infrastructure due to embankment failure	Damage/loss of infrastructure due to coastal inundation	Damage to infrastructure due to higher king tides and storm surges	Increased local drainage system flooding due to rain on snow events.	Increased year round use of parks	Increase of insects and pests due to warmer winters	Loss of shoreline due to erosion from increase wave action and storm surges	Increase damage to facilities due severe wind storms. Winds coming from different directions
What are the anticipated impacts to assets?	Green/landscaped areas will be under increased stress. Tree stress and death. Douglas Fir and Cedar. Fir beetles attacking Douglas Fir, also losing Maples. Increased migration of invasive plants.	Increased demand on irrigation systems, however would not irrigate during drought conditions.	Damage to park and trail facilities, due to fire, smoke, or water/retardant from fire suppression.	Reduced lifespan of assets, pressure to upgrade capacity of assets.	Temporary loss of access to park and trails. Damage to dock and swim floats. Flooding of parkland and parks facilities. Erosion/washout of parkland or trail. Loss of beach front. Damage to retaining wall. Septic system that is close to the lake, docks.	Perimeter drains all go into a single pit drain. If that flooded, would have overland sheet flooding. May have some erosion. Stream beside the park. Flooding from this creek would impact the park.	Leaks through roof or windows and potential damage to the first aid room/lifeguard station, change houses/washrooms. Parking lot is at high end of park.	Potential damage or washout of wooden bridges and marine infrastructure. Foreshore infrastructure could be damaged. Arbutus Creek is well contained.	Damage to trails and structural integrity of wooden bridges and other trail features along embankments.	Permanent loss of park land and trails in inundation zone.	Temporary loss of a park and a trail due to coastal flooding. Damage to marine infrastructure.	Currently get snow in large alpine areas near park, could impact stormwater flow in the park and lead to inundation of the stormwater system. Potenial lake levels rising, impacts to foreshore.	increased demand on assets during traditional winter months	Loss of vegetation(trees) from parasitic species.	Loss of parkland and trails.	Damage to trees due to different wind directions and infrastructure due to windfall.
What are the potential anticipated impacts to the functionality goals of the asset category?	Negative impacts to visual appearance of park, reduced functionality of outdoor space for use or programming.	Inability to meet Strategic Plan sustainability goals related to Protection of Water Resources.	Temporary closure of park or park facilities and trails, restricted use of park or trails. Temporary restriction of access to park (one road in and out).	Decrease in park experience for users.	Temporary closure or restricted access of beach, park, park facilities, and trails.	Temporary closure or restricted access to parking lots, playfields facilities and beach. Temporary closure or restricted access to parkland trails.	Reduced functionality of areas impacted by leaks. Decreased park use during winter.	Temporary closure or restricted access to areas impacted by debris.	Temporary closure or restricted access to areas impacted by embankment failure.	Permanent loss of ability to recreate in areas impacted by inundation.	Temporary closure or restricted access to areas impacted by coastal flooding.	Temporary closure or restricted access of park	Decreased park use experience (overflowing garbage, unclean facilities, etc)	Reduced aesthetic appearance or functionality and loss of Native plant species. Trees become a risk, becomes an emergency call.	Loss/reduction of coastal recreation space.	Loss/reduction of vegetation/trees. Temporary closure or restricted access to areas impacted.
Asset System Sensitivity Rating	**S3**	**S2**	**S4**	**S3**	**S4**	**S2**	**S2**	**S4**	**S3**	**S5**	**S4**	**S2**	**S3**	**S3**	**S4**	**S3**
ADAPTIVE CAPACITY																	
What types of actions would be required to adjust the asset category to the anticipated impact, after it has happened? *(Actions may be O&M or capital responses.)*	Would not irrigate during drought conditions. Trees well established in Arbutus Park. Could transition lawn into more natural meadow, reduce the size of lawn.	Turn off irrigation, let the lawn go into dormant stage. Fall fertilize, spring lawn maintenance. Overseeding if needed.	Close park, minor - major repairs, environmental and habitat restoration over time to spread out the costs. Would not be able to bring park back to current service levels. Prevent with Fire Smart practices.	Increase operations and maintenance	Remove retaining wall, transition away from sandy beach. Repair or replace dock and swim floats, close washroom facilities if septic system repaired.	Temporary closure of impacted structures. Maintenance resources to support flooding issues. Could increase the depth of drainage pit or adapt drainage system.	Contain and repair areas damaged by leaks, inspect and repair leaks in building envelope, regularly inspect and maintain building envelope to prevent future leaks	Close full park, can't manage safety concern until cleanup is complete. Clean up. Remediate damaged infrastructure.	Closure of structure. Park and trail restoration. Remediation of damaged infrastructure.	Move infrastructure out of inundated areas. Development of new parks and trails to meet demand.	Sandbagging and pumping to reduce flood risk. Identify adaptation actions to reduce likelihood of flooding of facilities. Install breakwaters to prevent damage to marine infrastructure.	Wait for lake to recede and remediate damaged infrastructure. If lake levels were sustained for a long time, could adapt and reopen.	Increase operations to meet demand	Additional maintenance resources to respond to issues. Hazard tree assessments are done to identify trees that are at risk of falling.	Close coastal areas to the public when at risk of storm surge. Shoreline restoration. Build storm surge adaptation infrastructure.	Minor to major repairs. Wind fall cleanup. Additional maintenance resources.
Can the asset system adjust to the projected impact with minimal cost and disruption?	Maybe	Yes	No	Yes	Yes	Yes	Maybe	Maybe	Maybe	No	Maybe	Yes	Yes	Yes	Yes	No	
Explain response	Cost of transitioning lawn. Would need to remove existing irrigation system, plumbing.	Programs currently in place are likely sufficient to handle changes.	If facilities sustain this damage, repairs will be costly.	Will be a cost, but not significant	Minimal to moderate costs of remediating parks, trails, and park facilities.	Actions identified do not require significant efforts or changes to normal O&M procedures.	Will depend on extent of leaks and damage	If structure is washed out, replacement may be costly.	Depends on extend of damage. Loss of full retaining wall or bridge may be costly to replace.	Parks and trails impacted by inundation will be permanently lost.	If damage to marine infrastructure is serious, will be more costly to repair.	Actions identified do not require significant efforts or changes to normal O&M procedures. Some costs may be incurred with adapting to higher lake levels.		Adjustments to operational procedures could likely manage most of the impacts.	Parklands and trails can be an effective storm/flood buffer.	Depends on extent of damage to trees and infrastructure. Can be costly to replace, and will not be able to replace the trees.
Referenced Sources	Anecdotal	Anecdotal	Extent of fire risk, anecdotal		Anecdotal	Anecdotal	Anecdotal	Anecdotal	Anecdotal	GIS	Anecdotal	Anecdotal		CVRD Inventory Summary	GIS	Anecdotal	
Adaptive Capacity Rating	**AC3**	**AC5**	**AC1**	**AC4**	**AC3**	**AC4**	**AC5**	**AC3**	**AC3**	**AC1**	**AC3**	**AC4**	**AC4**	**AC4**	**AC4**	**AC2**	
VULNERABILITY																	
Vulnerability Rating	**V4**	**V1**	**V5**	**V3**	**V4**	**V2**	**V2**	**V4**	**V4**	**V5**	**V4**	**V2**	**V3**	**V3**	**V3**	**V4**	
NEXT STEPS																	
Conduct risk assessment?	YES	NO	YES	NO	YES	NO	NO	YES	YES	YES	YES	NO	NO	NO	NO	YES	
Considerations to be noted in risk assessment		Irrigation in park is transitioning from lake withdraw to irrigation. Need to confirm source of water (Groundwater or surface water).						Review condition of wooden structures.	Review condition of wooden structures and retaining walls.	Identify parks structures within inundation zone.	Identify types of marine infrastructure and condition (if available).			Will need to monitor impact of efforts.			
Other considerations to be noted		Identify opportunities to use rainwater or grey water irrigation. Requirements for irrigation during drought may be compounded by increase in summer temperatures.			Identify if any significant assets are within flood zone. Review flood operational response plan. Review ability of parks to act as flood buffer/flood protection to adjacent property or infrastructure systems.	Busiest visitation months are June, July and August.	Follow component replacement schedule as identified in condition assessment report to maintain integrity of the building envelope.								Identify if there is parks infrastructure within coastal flood zone.	
RISK ASSESSMENT																	
CONSEQUENCE																	
Health and Safety	tree debris falling due to dead limbs		people would be evacuated, not in park		lake flooding slow over time			unlikely that people will be in the lake during winter months								windstorms unpredictable for timing	
score	2		2		1			1								2	
Environment	loss of vegetation, changes biodiversity in park.		Loss of vegetation		Inundation of septic disposal fields												
score	2		3		3			1								2	
Local Economy																	
score	1		2		1			1								1	
Level of Service			significant impact to quality of life for regular park users														
score	2		3		1			1								3	
Administration and Operations			clean up, replanting, rebuilding														
score	2		3		2			1								3	
Finances					septic system, retaining wall, dock, foreshore												
score	2		5		3			2								5	
Reputation																	
score	1		1		1			1								1	
Total Consequence Score	**1.714**	**0**	**2.714**	**0**	**1.714**	**0**	**0**	**1.143**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**2.429**	
LIKELIHOOD																	
Single or Recurring Event?	recurring		single event		recurring			recurring								recurring	
Location/Magnitude	4		2		3			2								3	
Total Likelihood Score	**4**	**0**	**2**		**3**	**0**	**0**	**2**	**0**	**0**	**0**	**0**		**0**	**0**	**3**	
Risk Rating	**6.857**	**0**	**5.429**		**5.143**	**0**	**0**	**2.286**	**0**	**0**	**0**	**0**		**0**	**0**	**7.286**	
Identified Mitigating Actions																	
Preventative																	
Reactive																	

Not high confidence in likelihood rating

APPENDIX 9
Asset Management Policy

URBAN systems

CVRD ASSET MANAGEMENT POLICY

Applicability: All CVRD

Effective Date: April 13, 2016

PURPOSE:

The purpose of this policy is to set out the overall objectives and direction of the CVRD Asset Management Strategy and the application of continuous improvement in the management of its assets in order to:

1. Complete and maintain a structured asset management inventory of current fixed assets including condition and replacement costs;
2. Identify the appropriate level of service to meet the community's current and future needs;
3. Review asset risk and tolerance to a range of hazards; including climate change
4. Develop structured financial policies to support ongoing asset management and end of life replacement;
5. Ensure that the policy and supporting strategy are adopted across the whole of the organization in an integrated fashion;
6. Manage the necessary data as a part of ongoing operational activities; and
7. Ensure that assets are managed in a way that supports regional priorities.

This will:

1. Improve decision-making accountability and transparency;
2. Demonstrate the long term consequences consideration of short-term decisions;
3. Reduce life cycle costs while maintaining appropriate acceptable levels of service;
4. Link infrastructure investment decisions to service outcomes; and
5. Improve customer service.

DEFINITION:

Asset management

An integral business approach involving all components of the organization (e.g., planning, finance, engineering, maintenance and operations) towards effectively managing existing and new infrastructure to maximize benefits, reduce risk, and provide appropriate levels of service to community users. This is accomplished in a socially, culturally, environmentally, and economically conscious manner.

In some situations, it can include additional infrastructure such as parks and the natural environment where the key components provide some form of community service such as clean air, water and waste management, or social benefits such as recreation. The CVRD will explore the potential inclusion of natural or green assets as a community asset class in the provision of services.

POLICY:

Policy Statement

The Cowichan Valley Regional District (CVRD) shall adopt and apply recognized holistic Asset Management practices in its strategic planning, operations, and financial management systems to deliver sustainable services to its communities and direct customers.

Guiding Principles

The detailed Asset Management objectives will be achieved through the application of the following guiding principles:

1. Customer Focused
    a. The CVRD will have clearly defined appropriate levels of service and applying asset management practices to maintain the confidence of customers in how CVRD assets are managed.
2. Forward Looking
    a. The CVRD will make the appropriate decisions to ensure assets will meet future challenges, including changing demographics and population, customer expectations, legislative requirements, technological, and environmental factors.
3. Service Focused

include "climate change" in Principle #2

    a. The CVRD will consider all the assets in a service context and take into account their interrelationships as opposed to optimizing individual assets in isolation.
4. Risk-Based
    a. The CVRD will manage the asset risk associated with attaining the agreed levels of service by focusing resources, expenditures, and priorities based upon risk assessments and the corresponding cost-benefit analysis, recognizing that the public safety is the priority.
5. Value-Based / Affordable
    a. The CVRD will choose practices, interventions, and operations that aim at reducing the life cycle cost of asset ownership, while satisfying agreed levels of service. Decisions are based on balancing service levels, risks, and cost.
6. Holistic
    a. The CVRD will take a comprehensive approach that looks at the big picture and consider the combined impact of managing all aspects of the asset life cycle.
7. Systematic
    a. The CVRD will adopt a formal, consistent, repeatable approach to the management of its assets that will ensure services are provided in the most effective manner.
8. Innovative

a. The CVRD will continually improve its asset management approach by driving innovation in the development of tools, practices, and solutions.

Scope

The policy currently applies to all physical assets of the CVRD, such as water treatment plants and distribution systems, sewage treatment plants and collection systems, stormwater systems, flood management structures (dikes and early warning systems), water storage systems (dams, impoundment areas, and reservoirs), monitoring networks, (groundwater, surface water, and emergency warning), recreation centres, community halls, parks and trails improvements, emergency management (fire halls and equipment, communications towers), transit shelters, street lighting, etc.

The policy does not apply to fleet, IT assets, and mobile equipment.

Asset Management Program

The Asset Management Program encompasses all aspects of the management of each asset through its life cycle in a way that it:

1. Integrates with CVRD's Strategic Plan framework to complement the strategic objectives of the CVRD, other key business systems, legislation, and regulations;
2. Creates a framework that establishes the mechanism for a clear line of sight between the asset and corporate objectives and strategies; and
3. Commits to providing appropriate levels of service for present and future customers and communities in the most effective way, through the planning, design, construction, acquisition, operation and maintenance, renewal, and disposal of assets.

Asset Management relies on three key organizational components integrated to achieve the desired service outcomes:

suggest that point #1 is modified to reference an understanding of asset vulnerabilities, and #2 is modified to also reference management of risks.

1. Up to date information regarding the inv
2. Well-planned and integrated strategies, ongoing maintenance to meet service le
3. Adequate staff resources with the appropriate training and capacity (Integrated business processes).

These components, supported by appropriate technologies and tools, will provide a robust foundation for the necessary management and maintenance of assets required for appropriate service delivery.

The basis for our asset related decisions are:

1. Anchored on the four pillars of sustainability – economic, environmental, social and cultural;
2. Based on applying the right intervention, on the right asset, at the right time recognizing risk and the CVRD's fiscal constraints; and
3. Founded on a sustainable economic approach to ensure that increases or enhancements to the asset base consider the ability of the CVRD to fund future maintenance and rehabilitation.

Policy Direction

To meet the goals and objectives of this policy, senior management will:

1. Create and maintain a Detailed Asset Management Plan to lead the development of Asset Management tools and practices and ensuring their application across the organization.
2. Adopt an Asset Management Strategy to:
    a. Establish, document and continually adhere to industry recognized asset management protocols;
    b. Define levels of service that balance customer expectations with risk, affordability and timing constraints;
    c. Adopt risk-based decision making processes that consider the likelihood of asset failure and the consequence of a failure wit of service;
    d. Develop asset management knowledge an competency frameworks and adequate sta
    e. Entrench lifecycle costing when evaluati across CVRD assets; and
    f. Monitor the performance of the assets and track deficiencies of Asset Management practices with a view to continuous improvement.
3. Where practical, strive to go beyond minimum legislative solutions to make CVRD assets more resilient to changing social, environmental, and economic conditions.
4. Seek funding and service delivery opportunities to address infrastructure investment pressures.
5. Provide regular updates to the Board on the state of the CVRD's assets and forecasted trends (typically aligned with tabling of the five-year financial plans.

Suggest adding a new bullet that speaks to integrating climate change response (mitigation and adaptation) with asset decision-making processes. There are different ways to approach this, to be discussed.

Key Strategic Comprehensive Asset Management Documents

The following key strategic Detailed Asset Management documents, in addition to the five-year financial plans, form part of the CVRD's overall approach to asset management:

1. Asset Management Policy
    a. Establishes the Board's expectations around the management of the CVRD's physical assets. It is to be approved by the Board and reviewed on a five-year rolling basis.
2. Asset Management Strategy
    a. Defines the organization's commitment and approach to achieving the Board's approved policy.
3. Customer Levels of Service

a. Defines the levels to which assets are to be maintained to achieve defined levels of service. These are to be approved by the Board.

4. Asset Management Plans

a. Documents how assets are being managed through their lifecycle in support of the delivery of services. These are to be approved at the departmental level for all service areas.

5. State of the Assets Report

a. Provides information on the state of the CVRD's physical assets which can be referenced when making infrastructure asset investment decisions as part of the annual budget and long range financial planning processes. This is to be submitted to the Board for information.