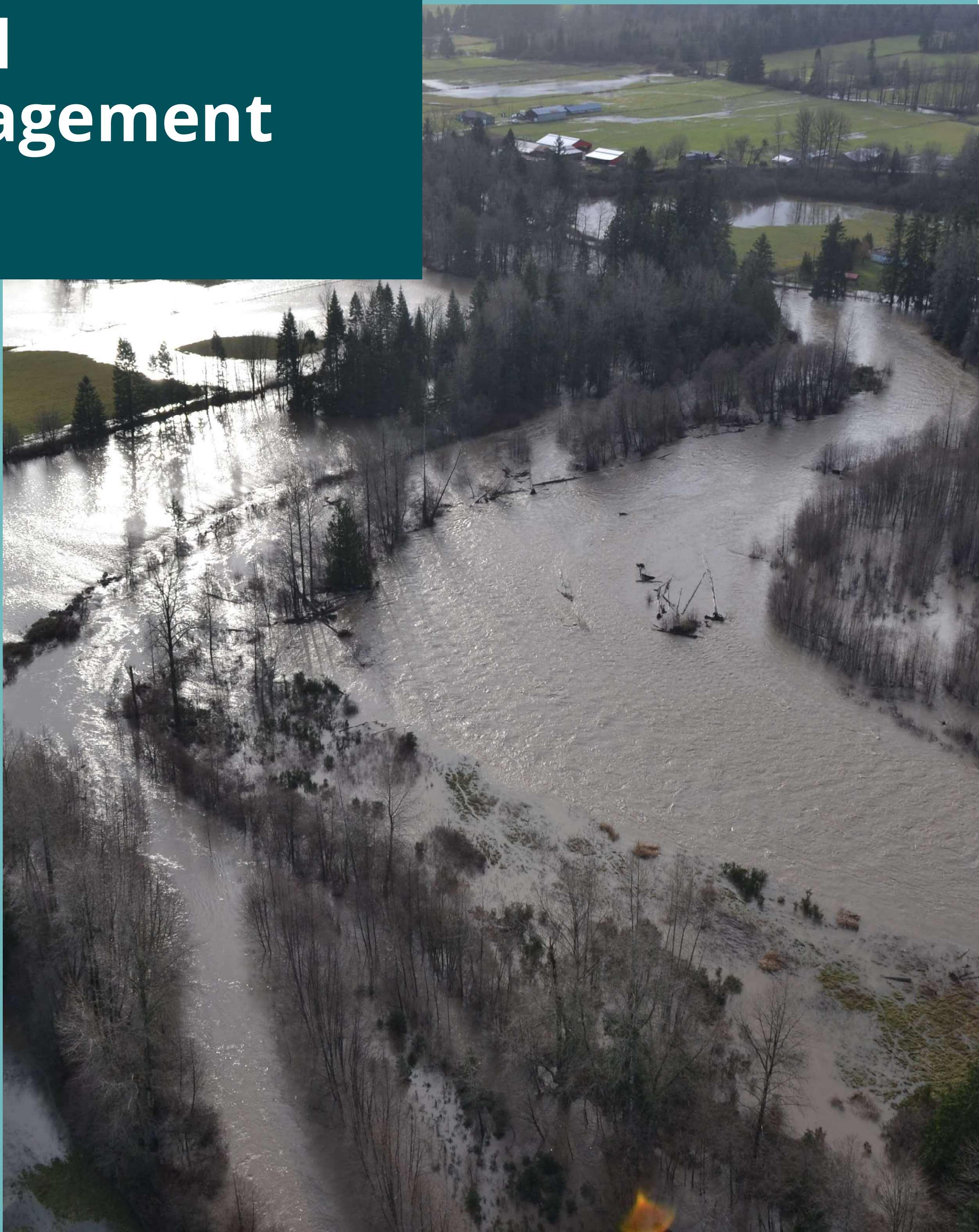
City of Courtenay

Flood Management Plan



Cover Photo: Tsolum River, City of Courtenay, during the 2014 Flood.

Report date: 22 August 2024

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EGBC Permit 100929

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Revision History

Revision No.	Date	Author of Record	Description	Remarks
1	1 December 2023	Silja Hund	Draft Report	Shared with client for comments
2	May 2024	Silja Hund	Final Draft	Shared revised Chapters 6,7,8 with client for comments
3	22 August 2024	Silja Hund	Final Report	Final report to client.

Territorial Acknowledgement

We respectfully acknowledge that the project area and the land that we gathered on for the in-person workshop is on the Unceded Traditional Territory of the K'ómoks First Nation, the traditional keepers of this land.

We would also like to acknowledge that this report was written at the Ebbwater Consulting Inc. office, which is located on the unceded traditional territories of the *xʷməθkʷəy̓əm* (Musqueam Indian Band), *Sḵwx̱wú7mesh* (Squamish Nation), and *səlilwətaɬ* (Tsleil-Waututh Nation), as well as at the SHIFT Collaborative office located on unceded *Kwakwaka'wakw* Territory of the *'Namgis*, *Mamalilikala*, and *Kwakuitl* Nations. We are grateful to be guests of these Nations.

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This project was conducted by a multi-disciplinary team as follows:

- Silja Hund, Ph.D. (Ebbwater) was the project manager, and led the technical work and report writing.
- Tamsin Lyle, M.Eng., MRM, P.Eng. (Principal of Ebbwater) was the senior technical lead and provided senior review of the report.
- Erica Crawford, MA (SHIFT Collaborative) led the development, coordination, and delivery of the public and partner engagement. She wrote summaries of partner and public engagement in this report, as well as provided Appendices D and E.
- Nikoletta Stamatatou, M.Sc., P.Eng. (Ebbwater) led the flood risk assessment and calculation of performance measures for the options analysis, and wrote parts of Appendices A and B (Chapters 2 and 4).
- Yinlue Wang, M.Sc. (Ebbwater) contributed to the flood risk assessment and wrote a part of Appendix B (Chapter 3).
- Tira Okamoto, MRM (SHIFT Collaborative) supported on the public engagement surveys and materials.
- Tamsin Mills, M.Sc., RPP (Adapt Collaborative) led the development of the draft floodplain bylaw and provided insight on planning related recommendations. She wrote sections on planning tools for the flood management strategies for this report, as well as the overview of flood-related policies.
- James Ogilivie, P.Eng., Water Street Engineering, wrote Appendix F and provided drawings and insights on structural options.
- Spencer Pakulak, EIT, Water Street Engineering, provided support for Appendix F.
- Allan Bronsro, M.Sc., P.Eng., and David Marshall, P.Eng. Water Street Engineering, provided senior review and revisions for Appendix F.

- Robert Larson, M.Sc., P.Ag. (Ebbwater) supported with the in-person workshop, and reviewed sections of the report.
- Reza Rezvani, M.Sc. (Ebbwater) provided the climograph, as well as further figures throughout the report.
- Mia Hansen provided design for the communications materials and the executive summary.

City of Courtenay

City of Courtenay Flood Management Plan

Executive Summary

August 2024

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1. Project Background

In the City of Courtenay, flood risk is present along the coast and the rivers. With expected changes in water levels due to climate change, we are taking proactive steps to reduce impacts from future flood events. The City of Courtenay worked with a team of consultants on the development of a Flood Management Plan. This project aimed to understand the risk of flooding to our community and develop risk reduction and resilience strategies that reflect community priorities.

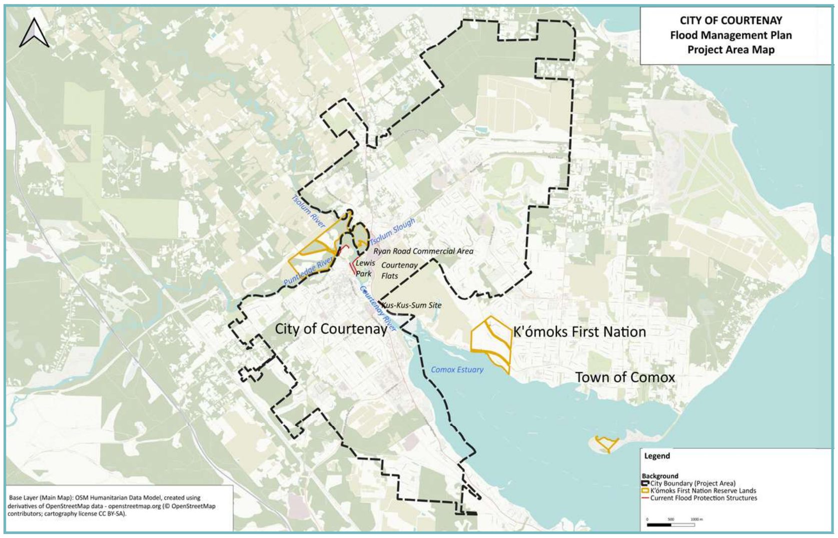
1.1 Project Objectives

1. **To outline a long-term approach for flood management (what needs to be done, by when).**
2. **To recommend specific actions for the next 5 years.**
3. **To align our approach with the BC Flood Strategy, the new Emergency and Disaster Management Act (EDMA), and international best practices, including the United Nations Sendai Framework for Disaster Risk Reduction.**

1.2 Project Area

The project area covers the City of Courtenay (City) on Vancouver Island (see map below). Within the boundaries of the City are a number of rivers and creek systems, the major ones being the Puntledge and Tsolum Rivers, which join together to form the Courtenay River and estuary before flowing out to the Salish Sea. Along the estuary, the City also has a coastal shoreline.

Water knows no boundaries, and with this in mind, previous flood hazard modelling and mapping was done at the regional scale for the entire Comox Valley Regional District (CVRD). For the Flood Management Plan, the development of risk reduction and resilience strategies was limited to the City of Courtenay's jurisdictional boundary, and opportunities to work with regional partners were identified. These regional partners include the CVRD, the Town of Comox, and importantly the K'ómoks First Nation on whose Territory these modern jurisdictions lie and who has present-day First Nation reserves adjacent to the City of Courtenay.



1.3 What is Risk and Resilience?

Risk is the "potential loss of life, injury, or destroyed or damaged assets and values which could occur to a system, society, or a community, determined as a function of hazard, exposure and vulnerability" (United Nations Office for Disaster Risk Reduction). As shown in the figure to the right, risk is defined by the total area of a triangle, whose sides are hazard (in this case flood), exposure (the things people care about that are located within the floodplain), and the vulnerability or susceptibility of these things to being damaged by floodwaters. When planning for flooding, it is also important to consider where and how communities can build resilience and adapt to flooding. Resilience is the "ability of a system, community or society exposed to hazards to resist, absorb, accommodate, adapt to, transform and recover from the effects of a hazard in a timely and efficient manner" (United Nations Office for Disaster Risk Reduction).

1.4 What Types of Flooding Do We Experience in Courtenay?

With climate change, communities are more likely to experience flooding than in the past. This is especially the case when sea level rise combines with high tides and coastal storms (e.g., storm surge, and wind and wave effects) or when extreme rain storms (e.g., atmospheric rivers) and/or snowmelt drive river water levels to rise.

1.4.1 Types of Flooding

Coastal flooding is flooding that occurs along the shoreline and estuaries due to higher than typical water levels in the ocean. There are two main drivers of coastal flooding that this project is studying – **sea level rise** and **storm surge**. While sea level rise is a slower, climate change-driven process, storm surge occurs more suddenly when pressure changes from a storm cause water levels in the ocean to rise.

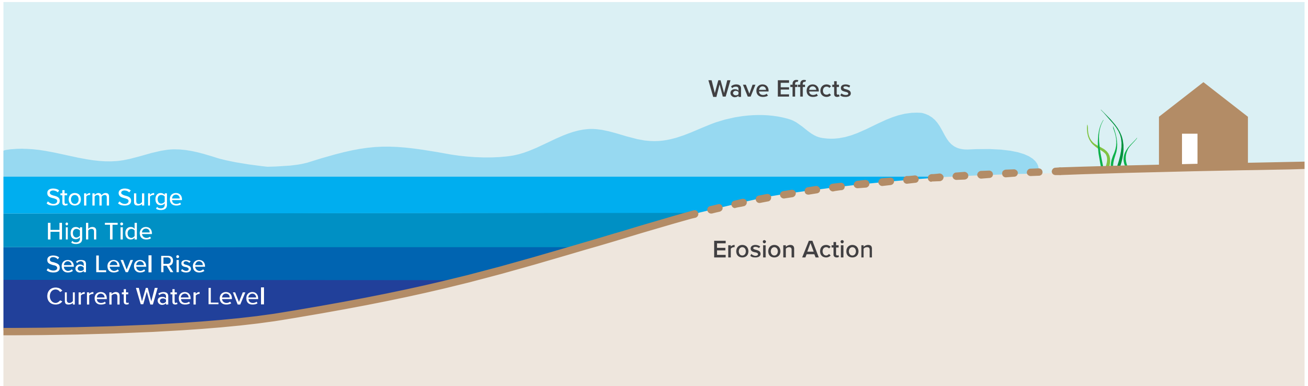
DID YOU KNOW?
As global temperatures increase due to climate change, seawater is expanding as it warms, and polar ice caps and glaciers are melting, resulting in sea level rise around the world.

Riverine flooding occurs when extreme rain or snowmelt causes water levels in a river to overflow its banks onto adjacent land. This type of flooding can also cause damage to dikes increasing the area of flooded land.

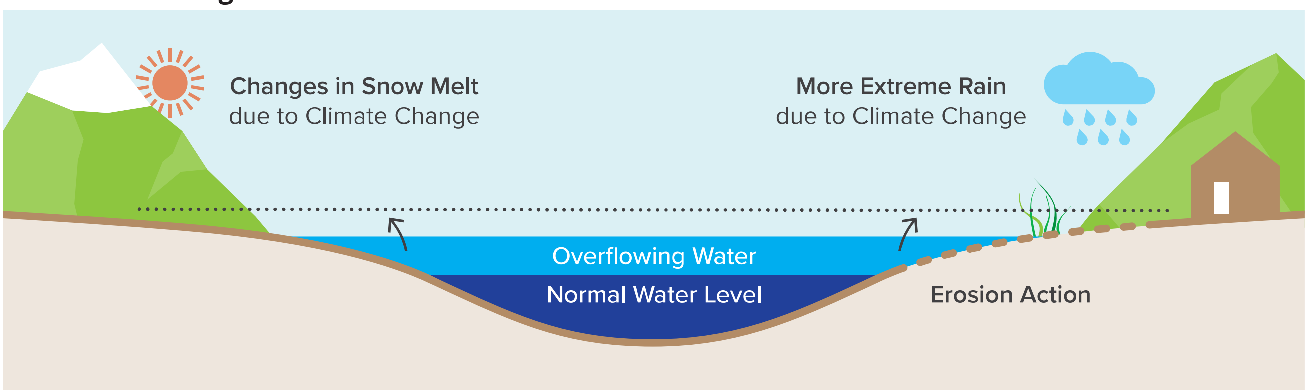
DID YOU KNOW?
Atmospheric rivers (ARs) are like long, narrow rivers in the sky. When they flow over land, strong ARs can bring extreme precipitation in a short amount of time, often resulting in riverine and pluvial flooding.

Pluvial flooding (flash floods; surface water flooding) happens when extreme rain cannot be accommodated by drainage systems. This type of flooding can happen anywhere, even in places without a nearby river or estuary.

Coastal Flooding



Riverine Flooding

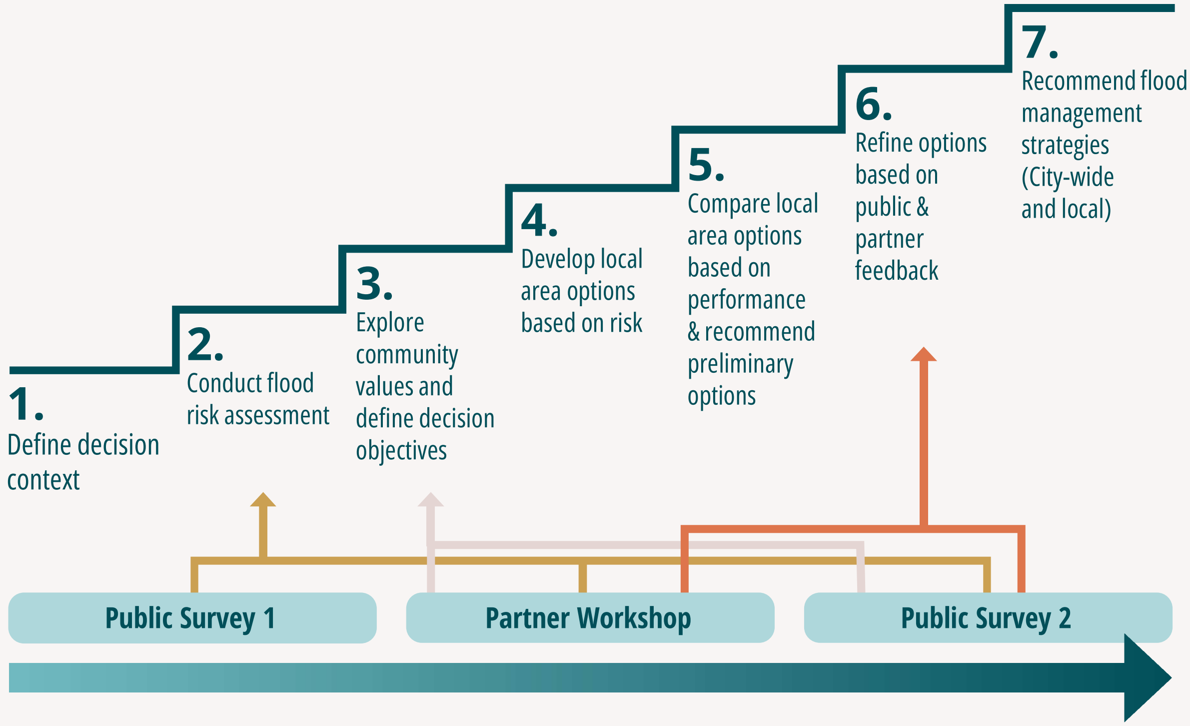


Larger floods occur less frequently and typically have a greater impact. However, the cumulative impacts of small, more frequent floods should not be underestimated. Frequent, smaller floods can damage assets along the shoreline or riverbank over time.

2. How Was the Flood Management Plan for Courtenay Developed?

A Flood Management Plan (FMP) is a tool to support actions to reduce flood risk. It provides a strategic plan that outlines a toolbox of recommendations to reduce flood risk and increase resilience, which will allow adaptation and flexibility into the future, whilst considering environmental, societal, and economic opportunities.

The FMP for the City was developed over a couple of years and included a number of technical and engagement subtasks to further explore and understand the nature of the flood risk in Courtenay, and then to systematically work through risk reduction options and next steps. For this, an adapted structured decision-making approach was used to explore trade-offs between various flood risk reduction and resilience options and recommend a set of preferred strategies (see figure on following page). The steps are explained below the figure.

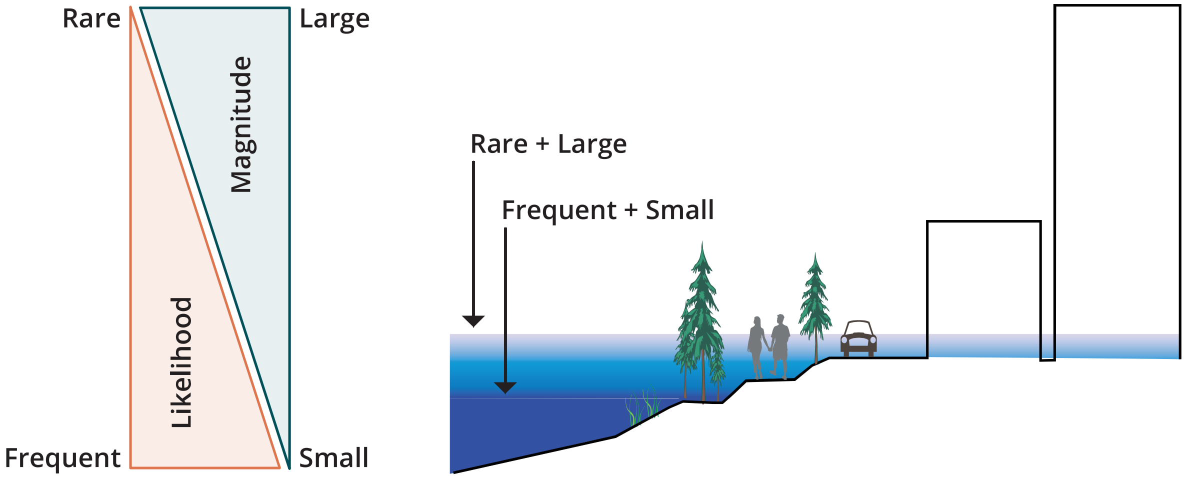


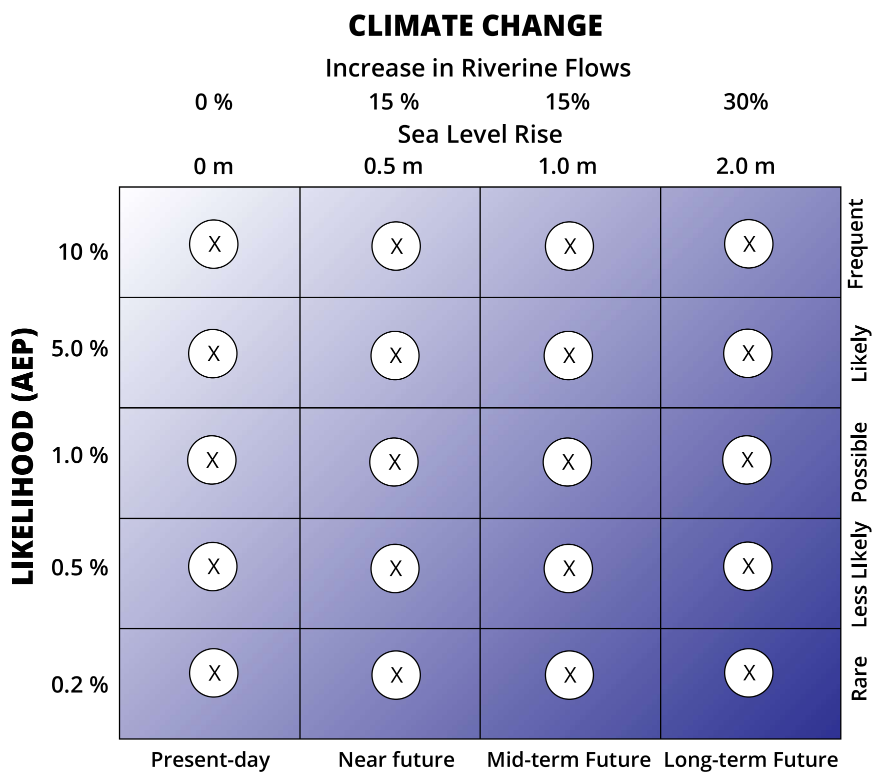
1. Decision Context:

- The project was focused on coastal and riverine flood hazards in the City of Courtenay boundary.
- The project considered present-day risks as well as future risks.

2. Flood Risk Assessment

- A detailed quantitative and holistic flood risk assessment identified assets and areas most at risk.
- **Flood Hazard Input:** A diversity of flood hazards was considered, from small and frequent to large and rare. In total, 20 different scenarios were included, based on the CVRD Flood Hazard Mapping (2021). The annual exceedance probability (AEP) is the probability of an event of a given size occurring or being exceeded in any year, described as a percentage. Five AEPs (or likelihoods) were considered for four different time periods, considering climate change (see figure on following page).





• **Consequence Input:** A range of things that matter to the community were included in the quantitative risk assessment. These were based on national and international best practice, including the Sendai Framework for Disaster Risk Reduction:

People	People are affected in a range of ways by flood. This may include people who are injured or suffer other health effects (e.g., trauma or stress), are evacuated or displaced, or suffer due to compromised livelihoods (e.g., their uninsured house is damaged or they lose their job).
Economy	Flooding can cause potential economic losses through property and equipment damage and other far-reaching consequences. This includes repairs to public and private infrastructure, and losses due to reduced revenues following a flood.
Environment	Flooding is an important component of many ecosystems and is a naturally occurring process. Green spaces can provide positive benefits by absorbing flood waters. On the other hand, floods may lead to the overflow or discharge of contamination sources into the environment, or cause damage to environmentally sensitive areas. Contamination may include sewage and fuel spills from flooded septic systems and storage buildings.
Culture	The cultural life of a community may experience various impacts due to a flood. This includes both Indigenous and non-Indigenous cultural sites, historic uses, beach access points as well as recreational spaces, trails, and sacred areas. It can also include community centres, schools, and other important gathering places.
Critical Infrastructure	Flood can impact many types of infrastructure that are regarded as necessary for communities to function. This can include transportation infrastructure such as docks and highways, as well as health services, emergency response (police, fire, ambulance), and government facilities. Utilities, such as power systems, water and wastewater, and telecommunications, are also critical.

- **Flood Risk:** Flood consequences were calculated for these categories for all 20 hazard scenarios. In addition, a set of consequence maps showing the impact of flood on people, economy, environment, culture, and critical infrastructure were developed for two scenarios - a present-day likely event, and a mid-term future less likely event. Flood risk curves were also developed for each scenario, and the average annual loss (i.e., the long-term expected loss on an annualized basis, averaged overtime) was calculated.
- **Qualitative Information:** In addition to the quantitative analysis, qualitative information gathering during the public and partner engagement as well as provided by City staff informed the risk assessment.

3.-6. Options Analysis

- The development of options was guided by community values, identified within the Official Community Plan (OCP) and project-specific public and partner engagement. Based on these values, decision objectives were defined. Decision objectives are simple values-based statements of the things that matter to people when considering flooding. Importantly, these decision objectives do not only consider the effect of an option during a flood (i.e., the risk reduction), but also the effect this option may have year-round on a community. For instance, a structural option will be in place 365 days of the year, affecting community life and the environment. Based on the decision objectives, quantitative and qualitative performance measures then provide a means of assessing the suitability of different alternative options.

- The City was divided into six local areas based on characteristics of flood water and land use. For each local area, a range of local area options for risk reduction were developed. Each of these local area options was assessed according to performance measures, and preliminary proposed options were identified. Options that are better implemented at a City-wide scale were also identified and evaluated.
- The proposed options were then refined based on feedback from public and partner engagement as well as feedback by various City departments.

7. Recommendations

- The set of refined options forms the recommendations of the Flood Management Plan, and includes both City-wide and local area specific recommendations.

Engage the Public and Partners Throughout

- Public and partner engagement throughout the project was key. Two public surveys were conducted, along with a public information session, and public communications, including: project updates on the City website, backgrounders, social media, and information pamphlets for residents in the floodplain. A workshop with City staff and community partners was held for in depth discussion of the options. Further technical review and discussion was held with City staff, and Provincial regulatory authorities.

3. What Flood Risk Does Courtenay Face?

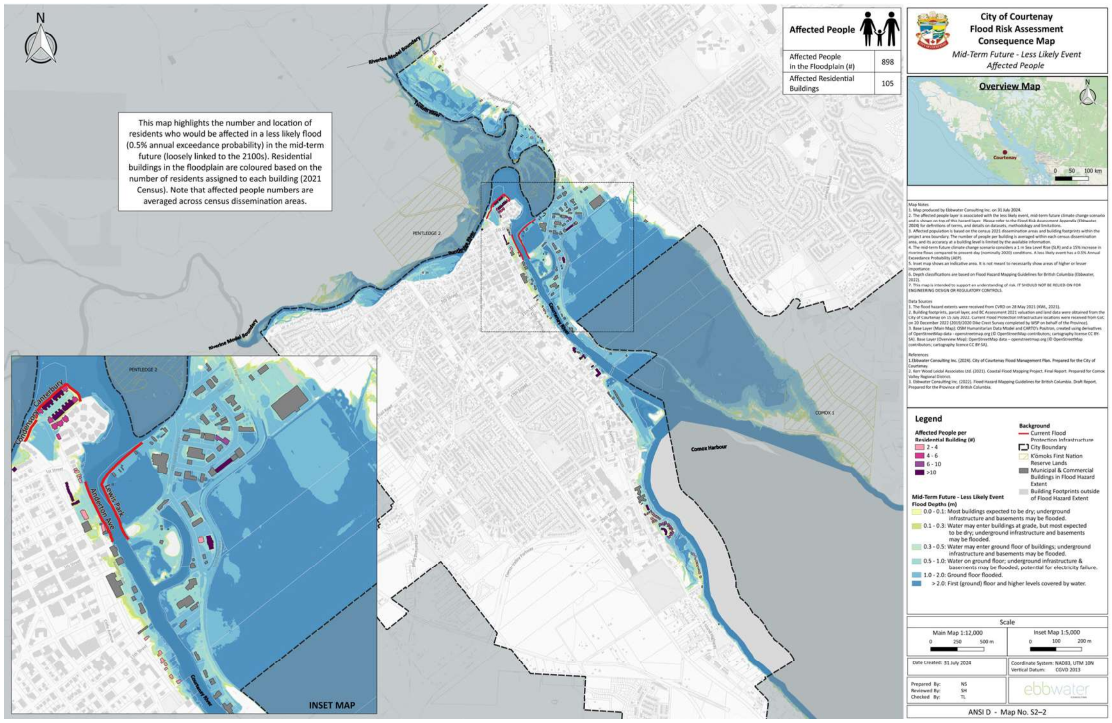
The project highlighted what is likely to be impacted by flooding in the present-day, and what will be impacted in the future, if no risk reduction and resilience actions are taken. It was found that even the less severe but more frequent floods in the future will have more devastating consequences than rare and extreme floods today (see table below). This is particularly concerning when considering the cumulative impacts of multiple flood events over time.

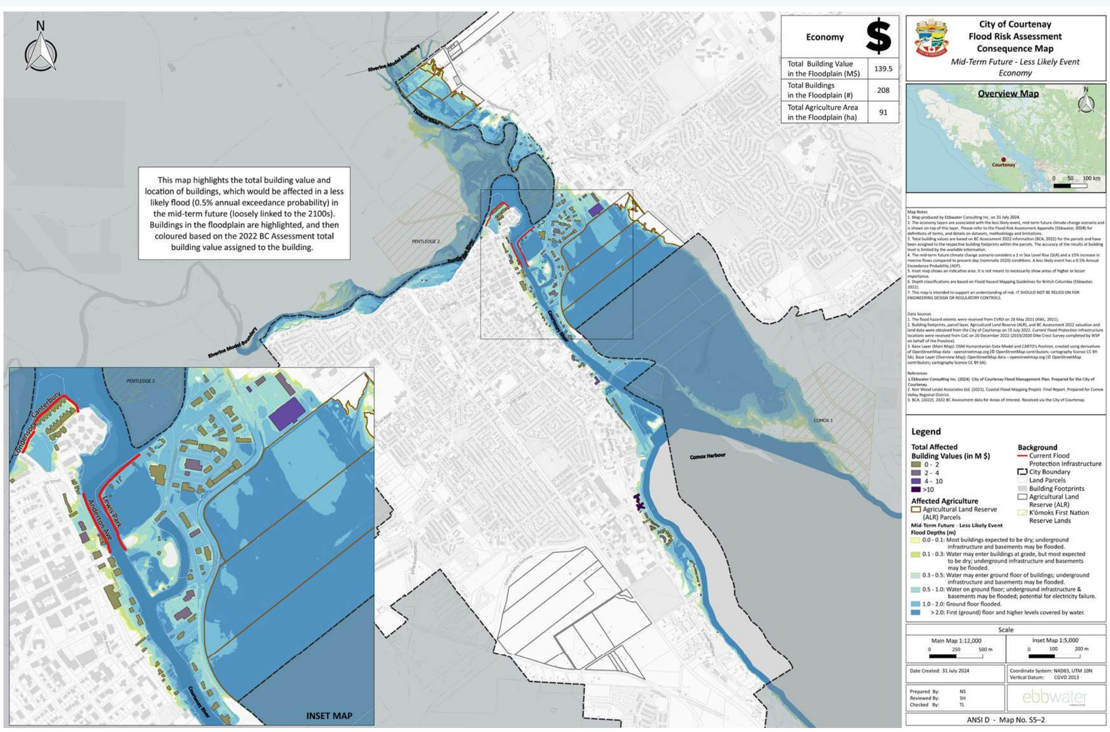
Impacts of floods on people, the economy, the environment, culture and critical infrastructure (CI) are summarized for two present-day flood scenarios, and two future flood scenarios (assuming no action is taken) in the table below.

It was noted that many residents live in the floodplain, and would be directly affected by flooding. Similarly, many buildings and much agricultural land are in the floodplain. Critical infrastructure impacts and disruption will have cascading consequences on the wider society. Many potential contamination sources are also within the floodplain, which may cause detrimental consequences for downstream sensitive ecosystems. Cultural sites, including Indigenous archaeological sites, are also located within the floodplain.

	PEOPLE	ECONOMY			ENVIRONMENT			CULTURE		CI & DISRUPTION	
Scenario description/details	**Affected People (#)**	**Buildings (#)**	**Total Building Value (M$)**	**Total Agricultural Land (ha)**	**Contamination Sources (#)**	**Species/ Ecosystems at Risk & Conservation Lands (ha)**	**Greenspace, Parks (ha)**	**Total Cultural Sites (#)**	**Community Buildings (#)**	**CI Facilities (#)**	**Total Road lengths (km)**
Present-day Likely (No SLR/increase in riverine flows; 5% AEP)	290	96	42	57	26	9	41	30	14	3	3.1
Present-day Less Likely (No SLR/increase in riverine flows; 0.5% AEP)	320	128	69	58	31	10	45	33	15	5	5.5
Mid-term Future Likely (1 m SLR; 15% increase in riverine flows; 5% AEP)	660	166	116	58	30	11	47	33	15	6	5.7
Mid-term Future Less Likely (1 m SLR; 15% increase in riverine flows; 0.5% AEP)	900	208	140	59	32	12	48	37	19	6	6.5

A set of maps, showing the consequences associated with each flood scenario were developed. For example, maps showing the affected people and economic consequences for a future flood scenario are provided below. The full map book can be found on the City of Courtenay website.





Risk curves were developed to analyse how the impacts from a flood event will change, as the pressures of climate change intensify. It was found that frequent events of the future will have a greater impact than rare events that occur today.

4. Flood Management Recommendations for the City

4.1 Overarching Framing

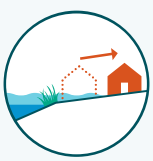
Flood management actions may be grouped into general strategies, such as: *Protect*, *Accommodate*, *Retreat*, *Avoid* and *Resilience-building*. To reduce flood risk and increase resilience in the City, a combination of flood management actions from different strategies should be selected to work together. A brief overview of these general strategies is provided below; they are not listed in order of importance.

PROTECT

Reduce the hazard by reducing its presence or power. Building "green" or artificial barriers or land forms to reduce water hazard of existing developed areas. Protect options are best applied to medium risk areas. Protect options are vulnerable to catastrophic failure as these options generally will not protect against very high hazard events.

ACCOMMODATE

Reduce the vulnerability of the built environment and society to flooding by accommodating the presence and movement of water ('living with the water'). Adapt buildings, infrastructure and land uses to allow areas in the floodplain or along the estuary to flood over time without causing negative impacts. It is best applied for low to medium risk scenarios but it may not be sufficient for extreme events.



RETREAT (also called managed retreat or relocation)

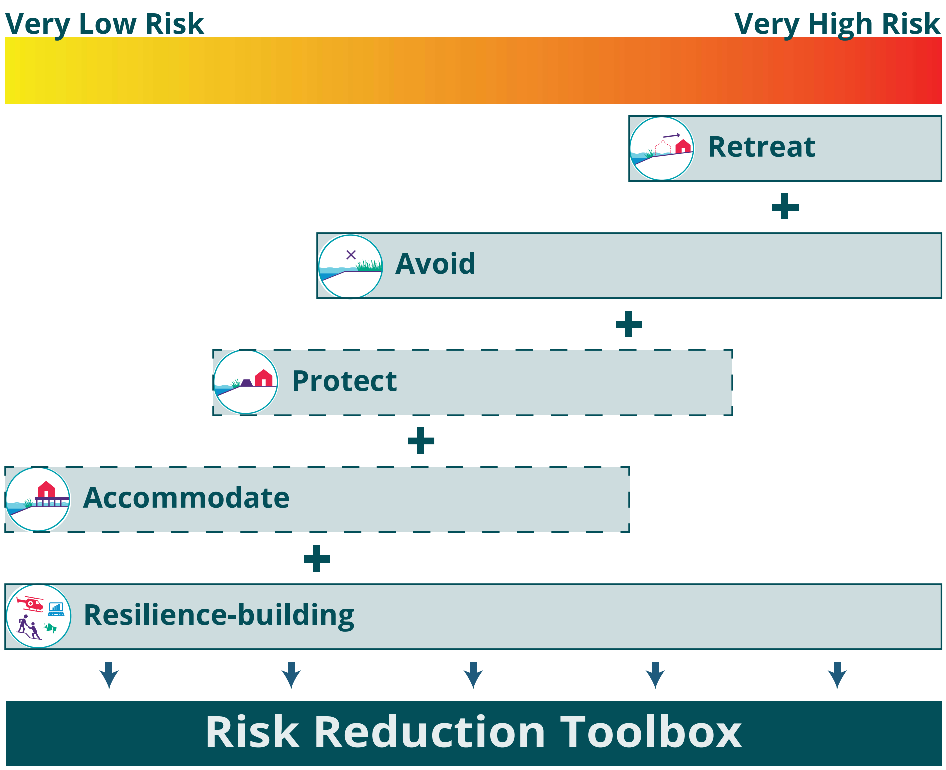
Reduce exposure by moving existing structures out of floodplain. Explore alternative locations to relocate homes and infrastructure back from affected areas and restore natural ecosystems. It is recommended for areas with existing high risk (e.g., residential housing in high hazard areas).

AVOID

Prevent new building, infrastructure or some land uses from happening in areas at risk of future flooding and related impacts, by limiting development within the floodplain. This strategy is particularly important for medium to high risk, whereas in lower risk, *Accommodate* and *Resilience-building* strategies may be sufficient.

RESILIENCE-BUILDING

Invest in awareness, preparedness and emergency response as a community, so that we can work together well to respond to challenges and bounce back from negative impacts. This strategy focuses on setting communities up to prepare, cope with, and bounce back from flood events. It can address low to high risk, and should always complement other strategies.



The strategy of *Retreat* is most effective for all levels of hazards but is best reserved for high to very high risk hazards due to its high economic and social costs. Similarly, *Avoid* strategies can be applied across the board, and should be considered for areas of risk. *Protect* strategies often address moderate to high risk areas, however they also have a high economic, social, and environmental cost, and are vulnerable to catastrophic failure, so they may not be necessary if the risk can be addressed by other means. *Accommodate* strategies are suitable for low to moderate risk areas. *Resilience-building* is effective for all levels of flood risk, helping communities prepare for the next flood event. The five strategies are meant to work together as a combined 'toolbox' to jointly reduce risk.

4.2 Recommendations Overview

A set of flood management recommendations was developed for the City. The recommendations were based on community values, as identified in the OCP and in public engagement for this project (see box to the right), as well as the risk profile of the City. Overall, the recommendations align with the direction provided in the OCP. These include directing growth away from the floodplain while developing a long-term strategy for managed retreat from vulnerable areas. OCP policies also promote a priority on environmental protection, soft edges and restoration along shorelines and riverbanks.

The figure below provides an overview of the recommendations, which are grouped by strategy. Out of the 86 recommendations that were identified in the Flood Management Plan, 81 apply to the short-term (5-Year Capital Plan), and the remaining five apply to the medium- to very long-term.

Community Values That Guided Recommendations

- Biodiversity
- Recreation and Natural Assets
- Community & Culture
- Social Equity
- Economic Success
- Low carbon
- Public Safety

City of Courtenay - Flood Management Plan Recommendations Overview

City-wide Recommendations

Avoid

- Develop flood risk-based zoning bylaw.
- Avoid new residential development in the floodway.
- Recommended floodway land uses include: agricultural, recreational, and parks.
- New development in the flood fringe must accommodate flood waters.
- Over the long term, opportunistically acquire land in the floodway .

Retreat

- Develop a managed retreat strategy to convert residential land uses in the floodway to land uses that are compatible with the flood risk.

Protect

- Clarify Provincial expectations for vegetation management on dikes that only offer erosion protection.
- Manage vegetation along all dikes in accordance with Provincial expectations.
- Complete annual inspections for all dikes, as required by the Dike Maintenance Act.

Resilience-Building

- Develop a comprehensive Communications Campaign to educate the public, residents of the floodplain, and property owners in high risk areas about flood risk, and actions to reduce the risk.
- Update monitoring and warning procedures.
- Update emergency response plan.
- Develop flood recovery and post-disaster plans.
- Work with insurance companies to address residual risk.
- Collaborate regionally on emergency preparedness and response.

Accommodate

- Update floodplain bylaw (new flood construction levels & erosion setbacks).
- Consider Development Area Permit for flood and erosion hazards.
- Encourage property-level flood barriers to reduce damages to properties in the floodplain.
- Use temporary flood barriers as an emergency response measure.
- Floodproof City-owned facilities and infrastructure (including lift stations).
- Develop tools to track all flood related covenants registered on property titles. Inform property owners of the covenant requirements and seek enforcement.
- Work with residents, business owners, the Airpark, agricultural producers, and City Operations to minimize contamination sources (septic systems, hazardous material storage).
- Consider regulation of hazardous material storage in floodplain.
- Improve the resiliency of park infrastructure to flooding (through Park Master Plans).
- Work together with K'ómoks First Nation to identify solutions for Indigenous sites at risk that are supported by their community.

Local Area Recommendations

Condensory & Canterbury:

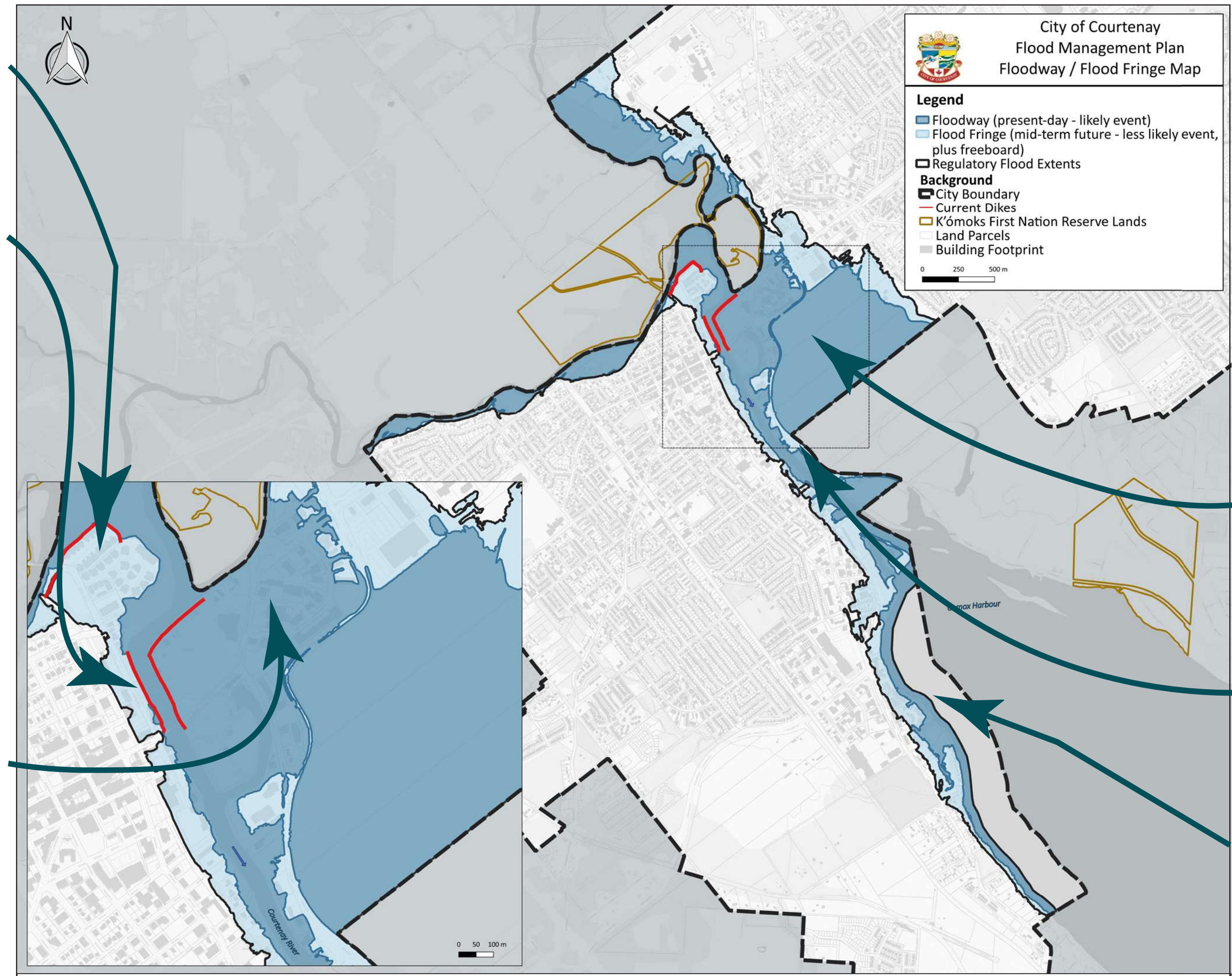
- Resolve the ownership dispute associated with Canterbury Dike by working with the Province and the strata.
- Ensure inspections of Canterbury Dike are conducted, and any required repairs are made.

Anderton Avenue:

- Conduct additional inspections and monitoring needed to ensure public safety.
- Develop plans to remediate Anderton Dike, including removal of the wall and naturalization of the shore.

Puntledge Road Commercial Area:

- Ensure City-owned buildings and infrastructure, including the Lewis Recreation Centre, LINC Youth Centre, Memorial Outdoor Pool, and outbuildings are floodproof and resilient to flood damages.
- Complete repairs of Lewis Park Dike, and consider naturalizing the shore over the long-term.
- Floodproof Puntledge Road lift station.
- Develop a detailed evacuation plan for the area, with a focus on traffic management, signage, and public education.
- Maintain TideFlex valves in the area, and consider the installation of additional TideFlex valves.
- Update, repair, and maintain culverts along the Rye Road Flood corridor, and in Lewis Park.
- Remove tall wall, and replace with a traffic barrier, if required.
- Change Tiger Dam from seasonal deployment in current location to targeted critical infrastructure protection on an event-basis.
- Work with the Ministry of Transportation and Infrastructure on Highway 19A upgrades.



Floodway: The river channel and shoreline and adjacent areas, where water depths, veolocities and wave action are greatest and most hazardous.

Flood Fringe: The remaining areas of the floodplain that are outside the floodway. Floods less likely with less depth and velocity/wave action.

Agricultural Area:

- Communicate flood risk and resources to reduce risk to local agricultural producers as part of communi-cations campaign. Align with the CVRD Comox Valley Agricultural Plan information.
- Encourage minimizing agricultural contamination sources.

Kus-kus-sum Site:

- Continue restoration and naturalization at Kus-kus-sum site.

Coastal Area:

- Restrict new development in coastal erosion setback.
- Continue working with Airpark to avoid potential contamination sources.
- Over the long-term, consider increasing erosion protection given sea level rise and associated coastal erosion, with a Green Shores approach.

16 August 2024

The City will implement recommendations within municipal boundaries and will collaborate with individuals and partners in the region wherever needed.

The table below summarizes the total number of actionable recommendations associated with each strategy.

STRATEGY	NUMBER OF RECOMMENDATIONS
Protect	**26**
Accommodate	**39**
Retreat	**3**
Avoid	**3**
Resilience-building	**15**
Total Flood Management Plan	**86**

5. Next Steps Forward

This Flood Management Plan outlines the steps required to reduce flood risk in the City of Courtenay and build resilience. Implementation of this plan over the short and long term will limit impacts of future flood events, and ensure Courtenay is equipped for the climate of the future.

City of Courtenay, August 2024. The Flood Management Plan was developed with support from Ebbwater Consulting Inc. and its team (SHIFT Collaborative, Water Street Engineering, and Adapt Collaborative).

Contents

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Figures

Tables

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List of Acronyms and Abbreviations

Acronym/Abbreviation	Description
AAFC	Agriculture and Agri-Foods Canada
AAL	Average Annual Loss
ACI	Annual Crop Inventory
AEP	Annual Exceedance Probability
AIDR	Australian Institute for Disaster Resilience
ALC	Agricultural Land Commission
ALR	Agricultural Land Reserve
BC	British Columbia
BCA	British Columba Assessment
CHIP	Cultural Heritage Investigation Permit
CI	Critical Infrastructure
CGVD2013	Canadian Geodetic Vertical Datum of 2013
CGVD28	Canadian Geodetic Vertical Datum of 1928
CMIP	Coupled Model Intercomparison Project
CVEG	Comox Valley Exhibition Ground
CVRD	Comox Valley Regional District
DEM	Digital Elevation Model
DFAA	Disaster Financial Assistance Arrangements
DMA	Dike Maintenance Act
DPA	Development Permit Area
DRIPA	Declaration on the Rights of Indigenous People Act
DRR	Disaster Risk Reduction
EAD	Expected Annual Damage
EDMA	Emergency and Disaster Management Act
EGBC	Engineers and Geoscientists BC
EMBC	Ministry of Emergency Management British Columbia (now EMCR)
EMCR	Ministry of Emergency Management and Climate Readiness
EV	Electric Vehicle
FCL	Flood Construction Level
FMP	Flood Management Plan
FRA	Flood Risk Assessment
ICI	Integrated Cadastral Information (Society)
KFN	K'ómoks First Nation
KWL	Kerr Wood Leidal Associates Ltd.
LG	Local Government
LiDAR	Light Detection and Ranging (remote sensing method)
MoTI	Ministry of Transportation and Infrastructure
NRCan	Natural Resources Canada
OCP	Official Community Plan

Acronym/Abbreviation	Description
PARAR	Protect, Accommodate, Retreat, Avoid, and Resilience Building
PSC	Public Safety Canada
RSLR	Relative Sea Level Rise
RV	Recreational Vehicle
SDM	Structured Decision-Making
SLR	Sea Level Rise
SVI	Social Vulnerability Index
UNDRIP	United Nations Declaration on the Rights of Indigenous People
WSC	Water Survey Canada

Glossary

Flood and Risk Terminology

Term	Description
Annual Exceedance Probability (AEP)	Probability of an event of a given size occurring or being exceeded in any year, described as a percentage. For example, a 0.5% AEP event has a 0.5% chance of occurring or being exceeded in any given year.
Capacity	Combination of all the strengths, attributes and resources available within an organization, community or society to manage and reduce disaster risks and strengthen resilience. (UN, 2016; UNDRR, 2017a)
Consequence	The physical/environmental, social, economic, and political impact or adverse effects that may occur as the result of a hazardous event (EMBC, 2020).
Coastal Flooding	Occurs when water levels in coastal areas are higher than normal because of high tides and/or storm processes (storm surge, wind, and waves) (Ebbwater Consulting Inc, 2022).
Dam failure	Anthropogenic failure occurs when infrastructure fails, and releases impounded or otherwise controlled water in an uncontrolled manner (Ebbwater Consulting Inc, 2022). Failure of a dam or spillway structure releases water/debris downstream. This can be a 'sunny-day' failure (i.e., a failure occurring outside a storm event as a result of a seismic event or engineering failure) or a 'rainy-day' failure as a result of high-water levels and inflows.
Design (Designated) Flood	A hypothetical flood representing a specific likelihood of occurrence, which is used to develop the regulatory/designated floodplain (BC Ministry of the Environment, 2018). It typically includes consideration of a freeboard to account for uncertainties.
Design Flood Level	The observed or calculated elevation for the Designated Flood and is used in the calculation of the Flood Construction Level.
Exposure	Situation of people, infrastructure, housing, production capacities and other tangible human assets located in hazard-prone areas. Measures of exposure can include the number of people or types of assets in an area. (UN, 2016; UNDRR, 2017a; EMBC, 2020)
Hazard	A source of potential harm, or a situation with a potential for causing harm, in terms of human injury; damage to health, property, the environment, and other things of value; or some combination of these (EMBC, 2020).
Flooding	The temporary inundation by water of normally dry land (NRCan, 2023).
Floodplain	Areas adjacent to the river channel, lake shoreline, or coastline that are subject to flooding (NRCan, 2023).
Floodway	The river channel and adjacent areas where water depths and velocities are greatest and most hazardous (NRCan 2023). Conveys most of the riverine flow, but also is the part of the channel that has the highest damage potential and potential for secondary hazards.

Term	Description
Flood Fringe	The remaining areas of the floodplain that are outside of the floodway (NRCan, 2023).This area may still flood, but likely with less depth and velocity than within the floodway.
Flood Construction Level (FCL)	The Designated Flood Level plus the allowance for freeboard and is used to establish the elevation of the underside of a wooden floor system or top of concrete slab for habitable buildings. It also establishes the minimum crest level of a Standard Dike (BC Ministry of the Environment, 2018). It is provided as an elevation.
Freeboard	A vertical distance added to the actual calculated flood level to accommodate for uncertainties (hydraulic and hydrologic variables) (EGBC, 2017, 2018)
Hydrometric	Relating to the monitoring and recording of water levels, velocities, and flows (NRCan, 2023).
Likelihood	Chance of an event or an incident happening (EMBC, 2020).
Pluvial Flooding	Occurs when heavy precipitation cannot be absorbed into natural or infrastructure systems, creating localized ponding (Ebbwater Consulting Inc, 2022).
Qualified Professional	A professional engineer or professional geoscientist with appropriate education, training and experience to conduct flood assessments (EGBC, 2018).
Regulatory (or designated) Floodplain	The floodplain extent that is designated/regulated in a floodplain bylaw. This refers to the extents of the design flood scenario.
Resilience	Ability of a system, community, or society exposed to hazards to resist, absorb, accommodate, adapt to, transform, and recover from the effects of a hazard in a timely and efficient manner, including through the preservation and restoration of its essential basic structures and functions through risk management (UN, 2016; EMBC, 2020).
Riverine/Fluvial Flooding	The temporary inundation of normally dry land by water that escapes the river channel and flows onto the adjacent floodplain and which may be caused by rainfall, snowmelt, stream blockages including ice jams, failure of engineering works, or other factors (NRCan, 2023).
Risk	A concept that takes into consideration the likelihood that a hazard will occur, as well as the severity of possible impacts to health, property, the environment, or other things of value (EMBC, 2020). Thus, risk is a function of the likelihood of an event occurring and the consequences of that event.
Risk Tolerance (risk threshold)	A risk threshold divides acceptable risk (i.e., what risk a community is willing to tolerate) from unacceptable risk (Ausenco-Sandwell, 2011).
Storm Surge	A change in water level caused by the action of wind and atmospheric pressure variation on the sea surface.
Streamflow	The volume of water passing by a specific point in a stream at a defined interval. Often referred to as discharge (e.g., in cubic metres per second—m3/s). “streamflow”, “flow”, and “discharge” are often used interchangeably (NRCan, 2023).
Vulnerability	Conditions determined by physical, social, economic and environmental factors or processes which increase the susceptibility of an individual, a

Term	Description
	community, assets or systems to the impacts of hazards (EMBC, 2020; UN, 2016; UNDRR, 2017; EMBC, 2020).
Wave Set-up	An increase in mean water surface close to the shoreline caused by wave action; important during storm events as it results in a further increase in water level above the tide and surge levels, landward of the location where waves start to break (Ausenco-Sandwell, 2011).
Wind Set-up	A rise of the water surface above the water level on the open coast due to the local action of wind stress on the water surface (Ausenco-Sandwell, 2011).

Option Analysis Terminology

Term	Description
Value	Aspect of importance to the local community (conceptual).
Decision Objective	Value-based statements of the things that matter to a community when considering flooding.
Performance Measure	Provides a (quantitative or qualitative) means of assessing the performance of different flood management options across objectives.
Scale	A description of the scoring system for the measure (constructed scale, or quantitative)
Strategy	Overarching flood risk reduction or resilience-building approach based on the *Protect*, *Accommodate*, *Retreat*, *Avoid*, and *Resilience-Building* (PARAR) framework.
Option	Place-based detailed flood risk reduction activity that can be compared to alternative options.
Recommendation	Specific actions within the Flood Management Plan that are recommended based on the options analysis.

1 Introduction

Floods matter. People whose homes are inundated or damaged will remember for the rest of their lives; landscapes are changed forever; regional and national economies suffer; and ecosystems are impacted. Flooding and other natural hazards continue to pose a risk to Canada's economic vitality, infrastructure, environment, and citizens. The City of Courtenay (City, Courtenay) is no stranger to flood damages having experienced both river and coastal flooding in recent years (e.g., in 2009, 2010, and 2014). With climate change, flood hazards are anticipated to worsen. In coastal areas, sea levels are anticipated to rise, and there is potential for more frequent storms over the ocean. Similarly, more frequent and intense rainstorms over the upstream watersheds may occur, leading to higher peak river flows. This will create an increased toll as floods occur more often and become more damaging.

The City of Courtenay has recognized the need to adapt to the present-day and future flood risk. They retained a team led by Ebbwater Consulting Inc. (Ebbwater) to develop a Flood Management Plan. This project builds on previous work including a 2013 flood management plan, regional flood mapping (2021), a regional high-level coastal flood adaptation strategy (2021), and a flood operations manual (2022), dike inspection and maintenance activities, as well as numerous related planning initiatives at the City (e.g., Official Community Plan (OCP) development and associated public engagement, in which general directions for floodplain management were developed).

1.1 Project Goal and Objectives

A Flood Management Plan (FMP) is a tool to support actions to reduce flood risk. It is a strategic planning document that should outline a 'portfolio of responses to manage flood risks', that allow adaption and flexibility into the future, promote 'environmental, societal and economic opportunities, and also recognizes that some residual risk will remain (Sayers *et al.*, 2014). This project aims to increase understanding of present-day and future flood risks, and to provide recommendations to mitigate risk through the development of an FMP. Specifically, for this project, the objectives were to:

1. Conduct a detailed holistic flood risk assessment to inform the FMP.
2. Develop an FMP that is aligned with best practice (i.e., strategic, risk-based, holistic, flexible and adaptive) and aligned with the British Columbia Flood Strategy[1].

[1] The British Columbia Flood Strategy provides policy direction on flood management in the province. An intentions paper outlining the direction of the strategy was made public at the mid-point of this project (late fall 2022); the final strategy was released in March 2024 after the FMP was mostly complete.

3. Provide a strategic plan and provide tangible steps for implementation, with a focus on the next 5 years.
4. Develop a draft floodplain bylaw.

Note that objectives one to three are addressed in this report. For the floodplain bylaw, a draft was provided to the City, which is currently in review. A summary of the floodplain bylaw recommendations is provided in Section 7.3.1.

Also note that the Flood Management Plan focuses on riverine and coastal flooding; it was out of scope for this project to consider dam failure, nor recommend dam operations management. Refer to the BC Hydro Emergency Planning Guide for the Comox and Puntledge System (BC Hydro, 2022) for details on current risks and emergency plans.

1.2 Project Area

The project area encompasses the City of Courtenay (City, Courtenay) on Vancouver Island (Figure 1-1). Within the boundaries of the City are a number of rivers and creek systems, the major ones being the Puntledge and Tsolum Rivers, which join together to form the Courtenay River before flowing out to the Salish Sea. The City also has a coastal shoreline and related coastal flood hazard from the Salish Sea.

The project and the City are constrained to its jurisdictional boundaries. However, water knows no boundaries, and it is important to consider the neighbouring jurisdictions of the Town of Comox and the Comox Valley Regional District (CVRD) and importantly, the K'ómoks First Nation on whose Territory these modern jurisdictions lie and who's present-day First Nation reserves are adjacent to the City of Courtenay. Although the focus of this work is the provision of a strategic plan and actions for the City (that fall within its jurisdiction), the plan references actions that can and should be taken regionally, as well as actions that will require input from the Province.

Additional details on the project area are provided in Chapter 2.

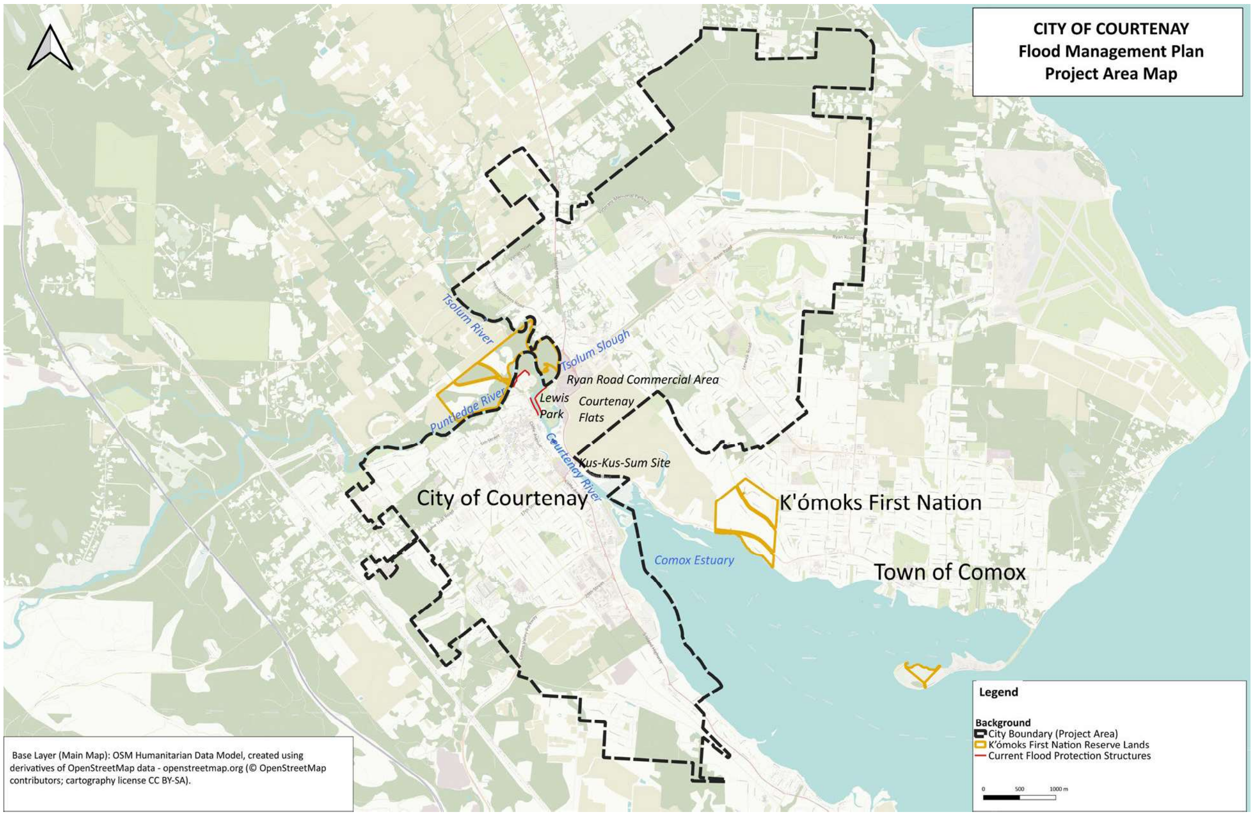

Figure 1-1: Project area – City of Courtenay, Vancouver Island.

1.3 Project Report Structure

Following this introductory chapter, Chapter 2 provides background information to support the framing of the FMP, and Chapter 3 provides project area background. This is followed by an overview of the flood management approach (for the technical work as well as planning efforts) (Chapter 4). Chapter 5 provides city-wide results of the flood risk assessment. Chapter 6 describes the option development for local areas (including local area characteristics, local area risk, as well as recommended options, and for transparency, the alternative options which are not recommended). Chapter 6 also includes feedback on community support from public surveys. In Chapter 7, the recommended flood management strategies are presented. In Chapter 8, the implementation plan summarizes the short-term (Five-Year Capital Plan) and long-term strategies. This is followed by the conclusion (Chapter 9) and the references (Chapter 10).

Six appendices complete the report:

- Appendix A – Historic Flood Events.

- Appendix B – Methodology Details (Quantitative Risk Assessment; BC Assessment and Parcel Data Processing; Options Analysis).
    - Attachment 1 - Risk Assessment Results: tabulated results of the risk assessment, including Average Annual Losses (AALs) of the baseline ('do nothing') option (spreadsheet).
    - Attachment 2 – Spatial data package, including hazard and consequence datasets for the present-day - likely and mid-term future – less likely scenarios.
- Appendix C – Hazard & Consequence Map Atlas.
- Appendix D – Public Communications Material (Backgrounders).
- Appendix E – Public Surveys Results (SHIFT Collaborative).
- Appendix F – Flood Protection Structures Review and Dike Master Plan (Water Street Engineering).

2 Risk and Resilience Background

Risk exists not because hazards (i.e., floods) exist, but because these hazards may harm people, buildings, assets, and other things we value. These negative interactions can be reduced through intentional decisions that decrease risk and increase the resilience of the system. The following sections provide some context on the terminology used in the field of flood risk reduction and reflects the risk-based approach taken in the development of the FMP. Understanding the nuances of the terminology is key to understanding the process of risk assessments as well as risk reduction actions.

2.1 Risk

Risk is a function of both the *likelihood* of an event (i.e., what is the chance of an event occurring?) and the *consequences* (or impacts) if that event occurs. C*onsequence* is defined as a function of the *hazard* (where and how severe is the event?) and *vulnerability*. *Vulnerability* can be further described as a function of *exposure* (what is in the way?) and the susceptibility (or inversely the capacity) of the exposed elements to the hazard (UN, 2016). Figure 2-1 provides a conceptual model for risk, and terminology definitions follow the figure.

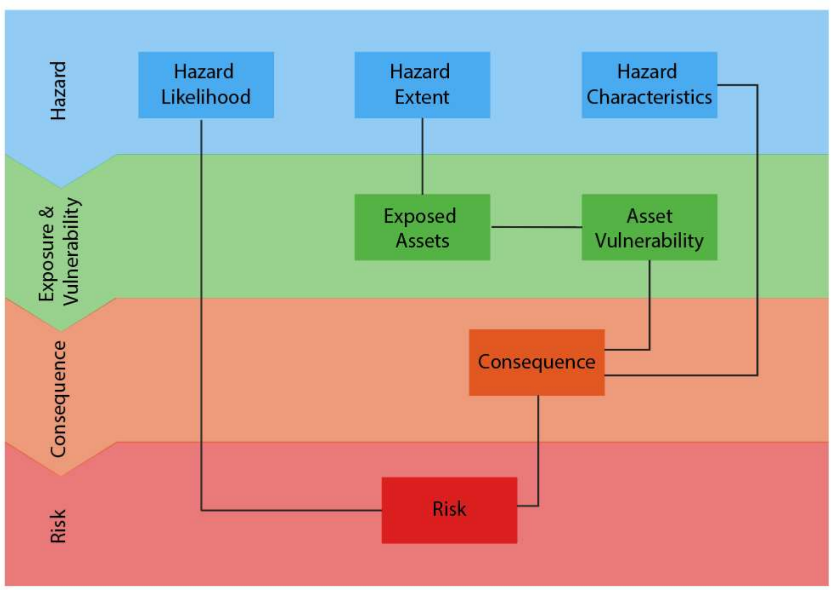

Figure 2-1: Risk as a function of consequence and likelihood.

Hazard is "a source of potential harm, or a situation with a potential for causing harm, in terms of human injury; damage to health, property, the environment, and other things of value; or some combination of these" (EMBC, 2020).

Vulnerability describes the "conditions determined by physical, social, economic and environmental factors or processes which increase the susceptibility of an individual, a community, assets or systems to the impacts of hazards" (EMBC, 2020; UN, 2016; UNDRR, 2017; EMBC, 2020).

Exposure is the "situation of people, infrastructure, housing, production capacities and other tangible human assets located in hazard-prone areas. Measures of exposure can include the number of people or types of assets in an area." (UN, 2016; UNDRR, 2017a; EMBC, 2020)

Consequence is "the physical/environmental, social, economic, and political impact or adverse effects that may occur as the result of a hazardous event" (EMBC, 2020).

Capacity is the "combination of all the strengths, attributes and resources available within an organization, community or society to manage and reduce disaster risks and strengthen resilience." (UN, 2016; UNDRR, 2017a)

Likelihood is the "chance of an event or an incident happening" (EMBC, 2020).

Risk is a "concept that takes into consideration the likelihood that a hazard will occur, as well as the severity of possible impacts to health, property, the environment, or other things of value" (EMBC, 2020). Thus, risk is a function of the likelihood of an event occurring and the consequences of that event.

2.1.1 Flood Hazard

Flood hazards are not equal. Floods, the spilling of water into areas that are normally dry, can arise from a number of different sources (e.g., rivers, coastal waters, rainfall, tsunami, and infrastructure failure). For this project, the focus is on riverine and coastal flooding. Additionally, flood characteristics, such as likelihood and magnitude, depth, and duration affect the potential consequences of flooding and therefore, the flood risk. This section provides a brief overview of relevant flood characteristics, as well as descriptions of riverine and coastal flooding.

2.1.1.1 Flood Characteristics

Flood Hazard Likelihood and Magnitude: Likelihood (the probability that a flood of a certain size will occur) and magnitude (the size of a flood) are two defining characteristics of flood. These are inversely proportional to each other; large events occur rarely, and small events more frequently (Figure 2-2). Frequent but small floods present very different risks than rare and large floods. Flood magnitude describes the size of an event. It is either measured as a flow (in cubic metres per second) for riverine events, or as an elevation or depth (in metres) for coastal and lake events. Likelihood is generally defined or presented as an Annual Exceedance Probability (AEP), which is the probability of an event of a given size occurring or being exceeded in any year, described as a percentage. For example, a 0.5% AEP event has a 0.5% chance of occurring or being exceeded in any given year. This is sometimes referred to as a 1:200 or 200-year event. However, this is misleading, as it infers that once an event of this size has occurred, it will not occur again for 200 years, which is not the case.

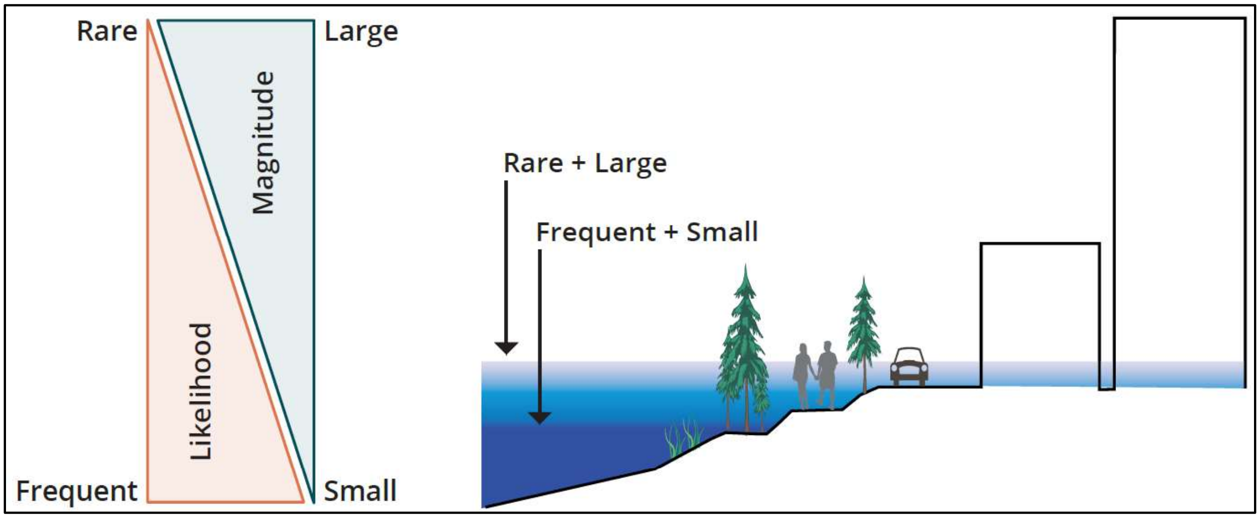

Figure 2-2: Simplified relationship between flood hazard likelihood and magnitude.

Another way to think about flood likelihood is with encounter probabilities[2], where it is possible to calculate the likelihood of encountering an event of a given size over a defined time period - for example, the length of an average mortgage (25 years) or the average lifespan of a human (75 years). For instance, for a 0.5% AEP event, there is a 12% chance that an event of this size or greater will occur over a 25-year period (Table 2-1). Understanding the likelihood and encounter probability of an event can support decisions related to flood management.

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[2] The encounter probability is calculated as $Pe = 1 – (1-1/T)^n$, where Pe is the encounter probability, T is the return period in years, and n the length of the encounter period in years. E.g., to calculate the encounter probability for a 0.5% AEP event (return period T = 200) over 25 years, one calculates it as $Pe = 1 – (1-1/200)^{25} = 12\%$.

Table 2-1: Encounter probabilities for various flood likelihoods.

AEP	Indicative Return Period	Encounter Probability of Occurrence…			
		in 25 years	in 50 years	in 75 years	in 100 years
100%	Annual	100%	100%	100%	100%
10%	1:10 years	93%	99%	100%	100%
5%	1:20 years	72%	92%	98%	99%
1%	1:100 years	22%	39%	53%	63%
0.5%	1:200 years	12%	22%	31%	39%
0.2%	1:500 years	5%	10%	14%	18%

Flood Hazard Depth and Power: In addition to the total volume or flow associated with a flood event, how the water spreads and moves over the floodplain is an important consideration. Flood depth is a big determinant of how much damage is caused. Nuisance flooding in a basement, for example, is very different from moderate (>30 cm) or severe (>2m) flooding, which can cause substantial to sometimes unrecoverable damage to a structure. Depth generally, but not always, decreases with distance from the water source. Water velocity as it moves down a channel or across a floodplain also affects its damage potential. Faster moving water, especially if it has entrained materials (this could be rocks and logs from natural slopes, or garden furniture or cars that are picked off the urban floodplain) can be more damaging than slow, stagnant water. Higher velocity systems have more power, and can cause erosion or avulsion of natural systems, as well as knocking over people, cars, and even some structures. Similarly, powerful waves on the shoreline of lakes have additional energy that can cause erosion and other damage to assets within the wave zone.

Flood Onset and Duration: Also, the characteristic of temporal scale (how quickly it happens, when, and how long it lasts) is an important consideration. The onset time is directly related to the efficacy of many temporary flood mitigation actions, as these are only effective if they are put in place in time. Further, it is important to consider how long an event will last, and therefore how long water will be in contact with assets on the floodplain. For example, in general, the damage associated with flood is less for shorter events, whereas if a building is wet for days or weeks the structural damage will be severe and may require that the building be destroyed.

Other Considerations: Depth and sometimes velocity are the dominant characteristics that affect flood damages. But it is important to consider the local context, as other factors may be equally or more important. For example, the quality of water can have a big impact on flood damages and risk. Sediment laden flood waters can drop substantial volumes of material on land as the water recedes that may require removal, and flood waters often carry and disperse contaminants (e.g., fertilizers from agricultural areas, heavy metals and other persistent contaminants from roadways and industry, invasive species, etc.).

2.1.1.2 Riverine Flooding

Riverine floods occur under a variety of conditions that cause a river to exceed its capacity and overflow onto its banks and into the floodplain (Figure 2-3). The main driver is usually high runoff from heavy rain and/or snowmelt. However, other mechanisms related to channel blockages can be important factors (e.g., debris or ice jams). The blockages cause flooding by creating backwatering conditions upstream; conversely, when the blockage is released, an outburst flood occurs downstream. With climate change and continued warming (see Section 3.4), less precipitation is expected to fall as snow, leading to smaller snowpacks. More extreme precipitation (falling as rain) is projected, increasing peak flows in rivers. All of the above will affect rivers in various ways; peak flows will change in terms of magnitude, but also flow timing and volume might present differences. In terms of flood management, concerns are the fast-rising water levels in the river, leading to overflow onto the floodplain, i.e., the extent and depth of flooding need to be managed.

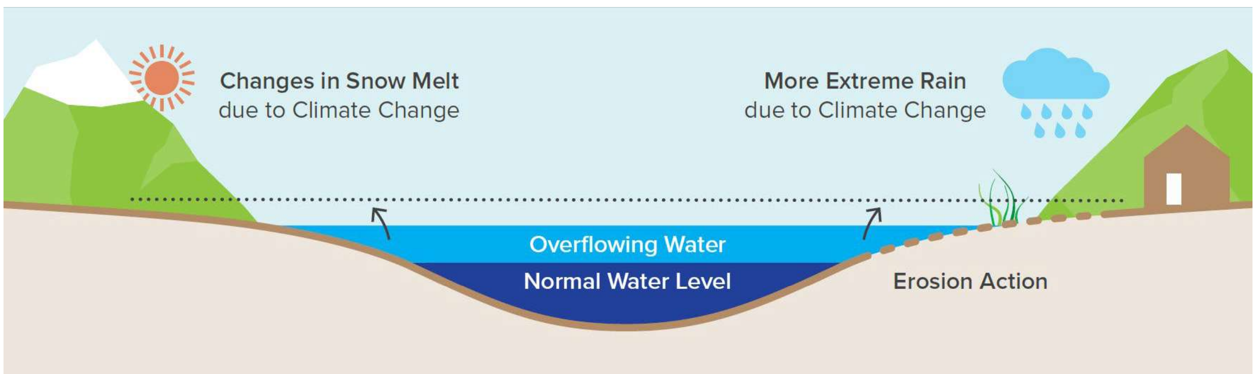


Figure 2-3: Conceptual riverine flood processes, and potential changes due to climate change.

2.1.1.3 Coastal Flooding

Weather-driven coastal flood hazards arise when water levels are higher than normal in the Pacific Ocean because of storm activities. Water levels in the ocean off the coast are a function of many components. Some of these components are predictable (deterministic), such as tides. Other components are less predictable (probabilistic); these are factors that increase water elevations as a result of storm events and include storm surge, wind and wave set-up, and waves (Figure 2-4). These processes have varying likelihoods of occurrence and require detailed analyses of specific events to quantify the resultant combined effect on total water levels. In terms of flood management, considerations for micro-local conditions (coastal slope and aspect, which affect water level and energy) need to be also considered, along with the extent and depth of flooding, and the potential force and energy of waves.

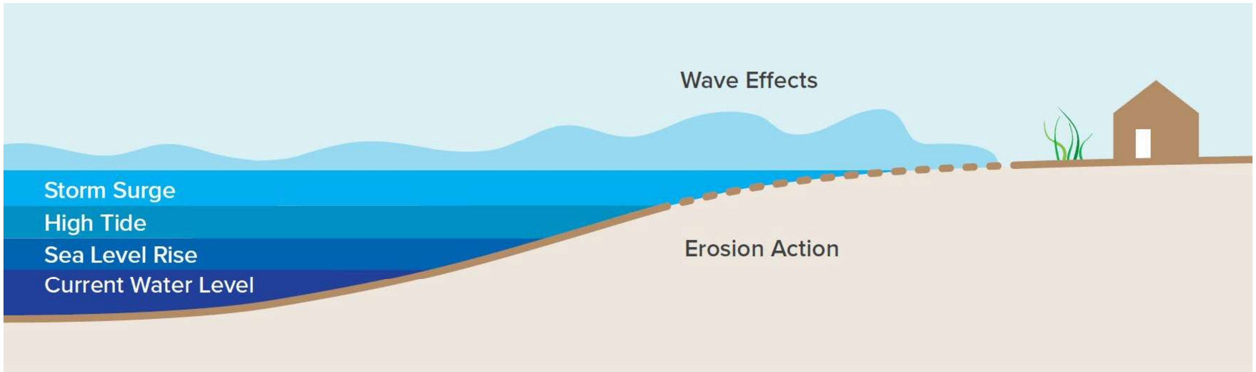


Figure 2-4: Coastal Flooding - Components of total water level (composed of tide, storm surge, wind set-up, wave set-up and wave runup and sea level rise).

Around the world, sea levels are rising because of the melting of ice caps and glaciers, and the expansion of ocean water caused by global warming. Variations in local sea level rise occur due to differences in topography, gravitational forces, and ocean currents; the west coast of North America generally experiences lower than average global SLR rates. The rise in the base sea elevation only tells one side of the story. The change in sea level can also result from vertical changes triggered from geological processes (land subsidence or uplift over time). This is called relative sea level rise (RSLR) and is a function of the rise in sea level compared to aforementioned vertical changes. Sea level rise (SLR) is a quasi-deterministic process (i.e., the upward trend is known, but the rate of change is unknown) and the uncertainty in projections is large.

2.1.1.4 Secondary Hazards – Erosion

Importantly, secondary hazards such as erosion can also occur during floods. Saturated soils and high energy environments (fast riverine flows, high waves) can result in erosion of riverbanks and coastal shoreline. Erosion has a different risk profile to flood, because of the suddenness and permanence of the hazard. Specifically, coastal erosion describes the loss of land due to the net removal of sediment or bedrock (UNISDR, 2017), and is in particular a concern with rising sea levels. It can occur as a result of the forces associated with waves and currents, and therefore substantial coastal erosion is generally associated with extreme weather events and other coastal hazards. During extreme weather, waves are generally more intense, but also reach further inland to landforms that are otherwise not exposed. Waves are often also accompanied by intense precipitation, which can saturate and weaken the coastal landforms.

2.1.1.5 Dam Failure

Dam failure occurs when infrastructure fails, and releases impounded or otherwise controlled water in an uncontrolled manner. Failure of a dam or spillway structure releases water and/or debris downstream. This can be a 'sunny-day' failure (i.e., a failure occurring outside a storm event as a result of a seismic event or engineering failure) or a 'rainy-day' failure as a result of high-water levels and inflows. Note that it was out of scope for this project to address dam failure.

2.1.2 Consequence

2.1.2.1 Consequence Types

Flood hazards may lead to direct and indirect consequences or impacts. Direct consequences describe all harm that is caused by the direct physical contact of water with people, infrastructure, or the environment (AIDR, 2020). Indirect consequences are those that are outside the direct spatial and temporal extent of the consequence. They are typically consequences that are caused by the disruption of the physical and economic links in the region, as well as the costs associated with the emergency response to a hazard.

The effects of a flood hazard event on the environment, community health, human health, or loss of life are difficult to quantify in terms of financial values and are therefore considered to be *intangible* impacts. On the other hand, the *tangible* dollar losses from a damaged building or ruined infrastructure are more easily calculated. This does not mean that tangible losses are more important than the intangibles, just that they are easier to quantify and assess. Figure 2-5 provides examples of direct versus indirect and tangible versus intangible consequences. The inclusion of intangible impacts is desirable for the development of a robust risk assessment (Messner *et al.*, 2006; Murphy *et al.*, 2020).

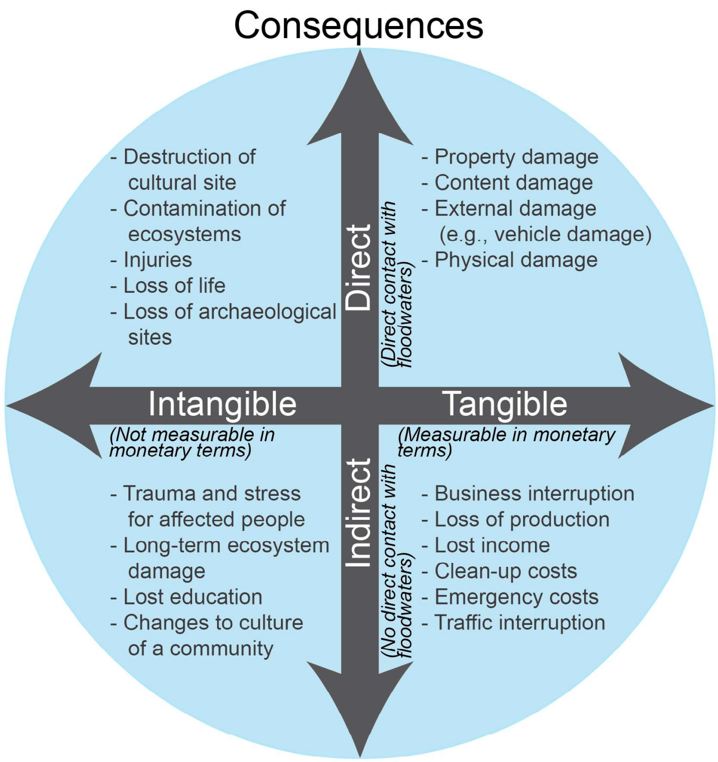


Figure 2-5: Types of consequences from flooding (Figure from Murphy et al. 2020).

2.1.2.2 Receptors

As discussed above, floods have varied and diverse impacts. To support flood risk assessments, it is helpful to categorize and organize these impacts. There are a number of taxonomies (schemes of classification) that are used in the field of Disaster Risk Reduction (DRR) (e.g., UN Indicators and Terminology relating to DRR, Societal impacts within the Sendai Framework (UNDRR, 2015), consequence types within Canada's National Risk Profile (Public Safety Canada, 2023) as well as other national and international resources (UNDRR 2015, 2016, 2017; BC MECCS 2019; AIDR, 2020). Based on these documents, the following six receptors can guide risk assessments, and are aimed at providing a holistic view of potential consequences (Table 2-2). Note that these are not listed in order of importance.

Table 2-2: Description of receptors.

	People are affected in a range of ways by floods. This may include people who are injured or suffer other health effects (e.g., trauma or stress), are evacuated or displaced, or suffer due to compromised livelihoods (e.g., their uninsured house is damaged, or they lose their job).
	This receptor describes the estimated number of deaths and missing persons due to a flood.
	Flood can impact many types of infrastructure that are regarded as necessary for communities to function. This can include transportation infrastructure such as ferry docks and highways, as well as health services, emergency response (police, fire, ambulance), and government facilities. Utilities, such as power systems, water and wastewater, and telecommunications, are also critical.
	Flooding can cause potential economic losses through property and equipment damage and other far-reaching consequences. This includes repairs to public and private infrastructure, and losses due to reduced revenues following a flood.
	The cultural life of a community may experience various impacts due to a flood. This includes both Indigenous and non-Indigenous cultural sites, historic uses, as well as recreational spaces, trails, and sacred areas. It can also include community centres, schools, and other important gathering places.
	Flooding is an important component of many ecosystems and is a naturally occurring process. Green spaces can provide positive benefits by absorbing flood waters. On the other hand, floods may lead to the overflow or discharge of contamination sources into the environment, or cause damage to environmentally sensitive areas. Contamination may include sewage and fuel spills from flooded septic systems and storage buildings.

2.1.2.3 Social Vulnerability (Intersectional Disadvantage)

An important consideration is the intersectional disadvantage (or social vulnerability) of people, which will affect how well they can respond to a flood, and what the impacts may be.

Intersectional disadvantage: The intersection of social categorizations of persons or classes of persons, including Indigenous identity, race, economic status, sex, sexual orientation, gender identity and expression, age and ability, in ways that may result in overlapping systems of discrimination or disadvantage or disproportionate adverse effects (Province of BC, 2023).

Research for social vulnerability explores how some individuals are more susceptible than others to exposures (differential susceptibilities) and capacities of populations affected by disasters (Tate and Emrich, 2021). However, the research is complex, has limitations, and is still evolving. Importantly, addressing vulnerability means addressing a wider range of issues related to equity, diversity, and inclusion. These terms are defined below according to UBC's Equity & Inclusion Glossary of Terms.

Equity: Refers to fairness and justice in policies, processes, and outcomes for historically and/or currently underrepresented and/or marginalized people and groups. It considers power, access, opportunities, treatment, impacts and outcomes.

Diversity: Refers to the presence of differences. These differences can relate to the different dimensions of the following: race, ethnicity, colour, ancestry, place of origin, political belief, religion, marital status, family status, physical disability, mental disability, sex, gender identity or expression, sexual orientation, age, class and/or socio-economic situations.

Inclusion: Refers to feeling welcome, belonging, with the capacity to engage and succeed in any given environment. It also relates to recognizing, reducing, and removing barriers to belonging and true participation. It is an active, intentional, and continuous process to address inequities in power and privilege and build a respectful and diverse community that ensures welcoming spaces and opportunities to flourish for all.

2.1.3 Considerations for Assessment

Risk and flood risk describe a range of ways of looking at combinations of hazards and consequences. Measuring and presenting risk through a risk assessment requires consideration of how to bound and scope risk, including the time frame for which risk will be considered.

Figure 2-6 shows risk is a function of hazard likelihood and consequence. Risk increases radially across the diagram. A virtually certain but insignificant event can have the same risk as a catastrophic but unlikely event. This becomes particularly important as we look across time-horizons. For example, a nuisance flood, which occurs annually over several decades and accumulates losses, may in fact be more impactful over time than a catastrophic flood that occurs once.

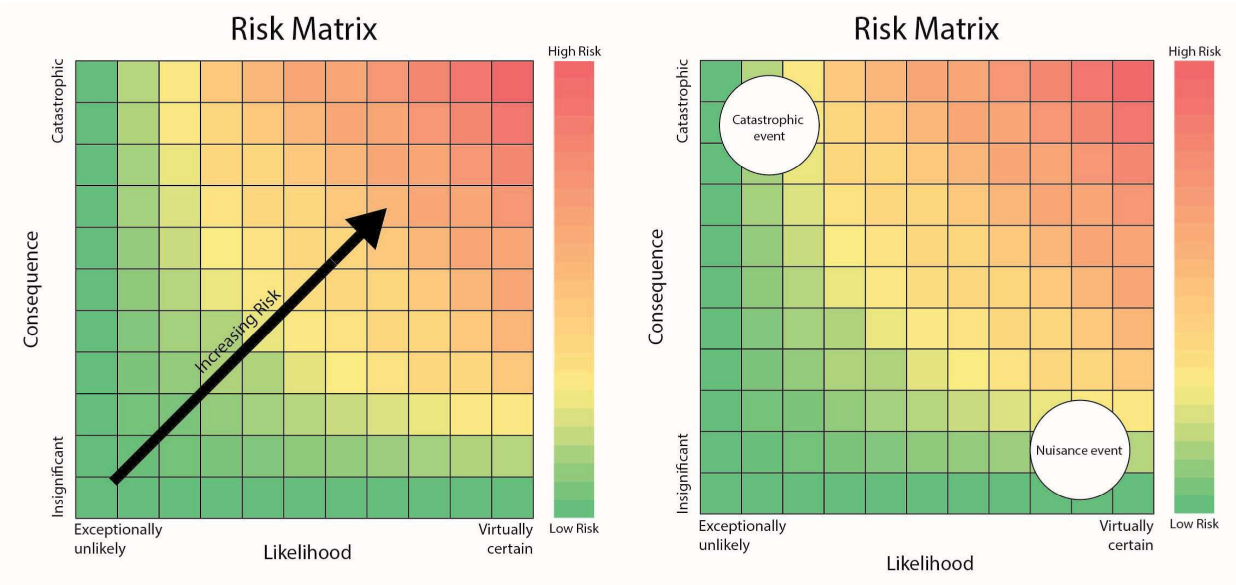


Figure 2-6: Risk as a function of hazard likelihood and consequence, showing risk for both catastrophic and nuisance events.

2.1.3.1 Dynamic Risk

Further, risk is dynamic and changes over time (GFDRR, 2016). The variables that form risk are prone to change, driven by natural and human influences. These changes are a result of both global-scale issues, such as climate change that can impact local hazard profiles, and local issues such as land-use decisions. For instance, if increased development is directed to a hazard extent, consequences and therefore risk will increase. In contrast, if land use within a hazard extent is adapted with resilience in mind, risk may decrease.

For many natural hazards it is expected that climate change will increase the likelihood of occurrence (it may also increase the severity and therefore the consequences), which shifts risk from the left to the right of the diagram, resulting in increased risk (Figure 2-7). Alternatively, risk can be changed by increasing the consequences of the hazard occurring, for example by allowing increased development in hazard areas. In this case, the risk shifts from the bottom to the top of the graphic, resulting in increased risk. It should also be noted that these issues can be compounded, and increased likelihood combined with increased consequences will result in dramatically increased risk (as illustrated by the top right of the graphic). Even with increasing hazard likelihood, it is possible to maintain or decrease risk. This can be achieved by reducing the consequences of the hazard either by changing the exposure or vulnerability of assets, and overall, making the system more resilient to the natural hazard.

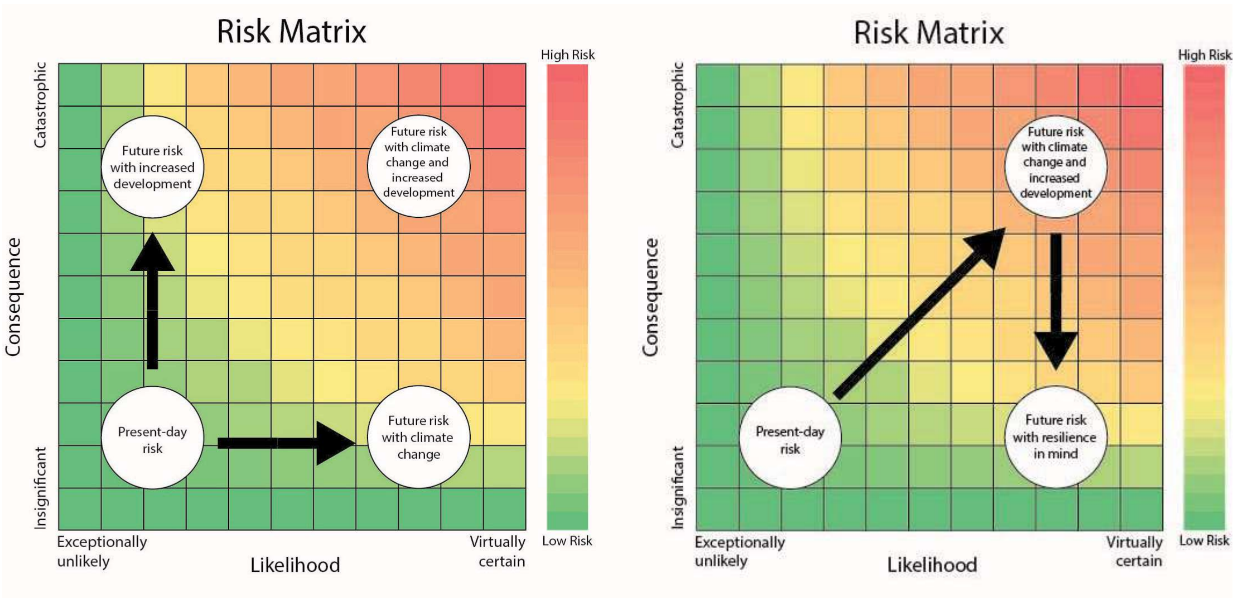


Figure 2-7: Dynamic risk and resilience.

2.1.3.2 Flood Risk Assessments

Flood risk assessments are structured risk-based methods that seek to understand flooding, and its resulting consequences to support risk-based decision-making. They are ordered and methodological processes that work through the components of risk described in the previous section. Given the complexity of flood risk, approaches to FRAs vary. They can be very simple and only consider some components of risk, or they can be more detailed and complicated in an effort to better reflect the full complexity of flood risks. The approach taken for the FMP was driven by the project goal and objectives, and is further described in Section 5.1 and Appendix B.

2.2 Resilience

Whereas risk describes the negative impacts associated with the shock of an event, resilience describes the positive responses to both the shock and recovery periods.

Resilience is the "ability of a system, community, or society exposed to hazards to resist, absorb, accommodate, adapt to, transform, and recover from the effects of a hazard in a timely and efficient manner, including through the preservation and restoration of its essential basic structures and functions through risk management" (UN, 2016; EMBC, 2020).

Resilience can be framed around the ability to withstand and bounce back from both shocks such as floods, earthquakes, hurricanes, wildfires, chemical spills, or power outages, as well as chronic stresses such as sea level rise or socio-economic issues such as homelessness and unemployment.

Given that the world is faced with increasing risks, the field of disaster risk reduction is moving toward promoting solutions that allow for quicker recovery (i.e., resiliency) rather than focusing solely on hazard or risk reduction. Conventionally, focus has been mostly on hazard management – for example, by defining a hazard standard that should be met such as designing for a 0.5% AEP flood event. However, there is increasing evidence that this approach is failing, and that as a next step, a risk-based approach is needed that considers the hazard and consequences of multiple events as the basis of mitigation. A risk-based approach is a great improvement but is still focused on the shock itself, and not on how a community will respond. Consideration of how a community will recover (and potentially thrive) is a resiliency-based approach, this is an evolution in approach requiring understanding the risk and the capacity of the community to respond and recover.

2.3 Decision-Making and Strategies for Flood Management

Flood is a wicked problem with infinite potential impacts where individual flood risk reduction activities have the potential to increase risk or disbenefits elsewhere, and therefore decision-making to support flood risk reduction requires consideration of the many trade-offs associated with flood. These include considerations to risk reduction (e.g., the potential number of structures that would or would not be damaged, potential for mortality, etc.) as well as commonly used criteria for government decisions (e.g., cost, public and/or political will, etc.).

In addition, most flood management options involve the expenditure of resources and alteration of current land uses or environments to create new situations that, except during future potential flood events themselves, are otherwise less-desirable than they were before: a scenic beach becomes spoiled by a berm; a community centre near a shoreline has its view of the water obscured by a raised dike. However, not all changes are negative. With an understanding of values and creativity, mitigation features can become integrated into the landscape. Nevertheless, where there is a need to take an existing location and intervene to incorporate features that are only necessary in rare flood events, controversy is to be expected. This will occur no matter which option is selected.

The principles of structured decision-making (SDM) (Gregory et al., 2012) can support this process through a set of generic planning steps. The steps start with clarifying the decision context, and bringing stakeholders, partners, and decision-makers through to implementation. The SDM steps applied for this project are detailed in Chapter 4.

2.3.1 PARAR Strategies Overview

To guide the decision-making process, options can be developed, based on five commonly used risk reduction and resilience strategies: *Protect*, *Accommodate*, *Retreat*, *Avoid*, and *Resilience-Building* (i.e., PARAR). Within each strategy, there are a range of options that could be implemented. An overall flood management plan would typically include a combination of options from many, or all, of these PARAR categories. The PARAR strategies are described below.

PROTECT

This strategy of mitigation options reduces the hazard by restoring previous, enhancing existing, or constructing new features to reduce the presence or power of the hazard. These can be green measures that are considered “soft” and low impact (e.g. coastal erosion protection via Green Shores (natural foreshore) approaches), and also include grey, or “hard” engineered, structures, such as flood protection structures (also referred to as dikes in this report). Some of these options will work at a neighbourhood (local area) scale, like a dike, whereas others focus on protecting specific individual assets. All these approaches can occur in combination.

ACCOMMODATE

This strategy considers a range of options that assume flooding will occur with minimal damage or consequence. It is sometimes described as a “living with water” strategy, in the sense that humans adjust their behaviours and built environment to accommodate the presence and movement of water. Typical actions range through educational, planning, and building options, and they include the following:

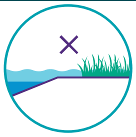
- Using Flood Construction Levels (FCLs) to raise the height of the damageable components of new structures.
- Retrofitting (flood-proofing) infrastructure, buildings, and communities over the natural building cycle.
- Property-level flood barriers.

RETREAT

Also called *Managed Retreat* or *Relocation*, this strategy reduces exposure by moving existing structures out of flood risk areas. It is increasingly considered as governments spend taxpayer funds on costly rebuilding efforts. Typical actions are policy-based:

- Opportunistic buyouts as homes and businesses come up for sale over time, with more aggressive buyouts as hazards become greater with climate change.
- Opportunistic removal of roads, other infrastructure, and contaminants as land is vacated.

AVOID



This strategy prevents or limits development within the floodplain. These options reduce risk by not putting things we care about in the way of flood. Natural shorelines also act as erosion protection. Typical options are based on planning and regulation and include:

- Developing tools such as flood or zoning bylaws so that rules and practices are consistent across the region.
- Integrating future flood hazard area considerations within guidance documents such as regional growth strategies and official community plans.

RESILIENCE-BUILDING

In contrast to the previous four conceptual adaptation categories, *Resilience-building* is less about reducing risk and more about helping communities bounce back from flood events. It covers all aspects of work with the community to enhance its ability to cope with and recover from flood events, and the cumulative effects of change. Typical options range from education to policy-based approaches and include:

- Engaging broadly in city and community planning to build understanding and capacity of the community to address risk and build resilience (individual and collective).
- Grow social connectedness (with emphasis on care for vulnerable populations).
- Developing robust emergency preparedness and response plans (e.g., flood monitoring and warning systems) to limit damages during a flood event.

2.4 Guidance and Frameworks for Flood Risk Reduction

The following provides overviews of the key guidance and frameworks that informed the FMP.

2.4.1 Sendai Framework

The Sendai Framework for Disaster Risk Reduction 2015-2030 (Sendai Framework) (UNDRR, 2015) outlines the international best practice and actions to protect development gains from the risk of disaster.

Sendai is the global blueprint for reducing disaster risk and increasing community resilience. The goal of Sendai is to "prevent new and reduce existing disaster risk through the implementation of integrated and inclusive economic, structural, legal, social, health, cultural, educational, environmental, technological, political and institutional measures… to strengthen resilience". The framework is thus multi-disciplinary and follows four priorities (Figure 2-8). The Sendai Framework recognizes that humans are at the centre of disasters; i.e., not only are humans responsible for increasing hazards, hazards themselves are not problematic unless they interact with humans. The framework therefore places human decisions at the centre of disaster risk reduction, and advocates for a risk-based approach to managing multiple hazards (i.e., all-hazards approach). The Federal Government is a signatory to the Sendai Framework, with Public Safety Canada as the lead agency[3]. The BC Government was the first jurisdiction in Canada to have formally adopted the Sendai Framework. It forms a cornerstone of BC's modernization of the *Emergency and Disaster Management Act* (*EDMA*).

Figure 2-8: Four priorities of the Sendai Framework for Disaster Risk Reduction.

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[3] Public Safety Canada. Sendai Framework for Disaster Risk Reduction 2015-2030. Weblink: https://www.publicsafety.gc.ca/cnt/mrgnc-mngmnt/dsstr-prvntn-mtgtn/pltfrm-dsstr-rsk-rdctn/snd-frmwrk-en.aspx. Accessed 4 July 2019.

2.4.2 Consideration for Indigenous People

The Sendai Framework encourages whole-of-society engagement and holistic actions such as, "to empower local authorities, as appropriate, through regulatory and financial means to work and coordinate with civil society, communities and Indigenous Peoples and migrants in disaster risk management at the local level." (UNDRR, 2015). In this sense, the Sendai Framework is supported by the United Nations Declaration on the Rights of Indigenous Peoples (UNDRIP). UNDRIP establishes a universal framework for minimum standards for the survival, dignity, and well-being of the Indigenous Peoples of the world and it elaborates on existing human rights standards and fundamental freedoms. BC was the first Canadian province to enact a version of UNDRIP; the *Declaration of the Rights of Indigenous Peoples Act (DRIPA)* [2019], in November 2019. At the federal level, Bill C-15, *United Nations Declaration on the Rights of Indigenous Peoples Act* [2020] received Royal Assent in June 2021.

2.4.3 *Emergency and Disaster Management Act* (*EDMA*)

BC (Ministry of Emergency Management and Climate Readiness, EMCR) modernized its emergency legislation in November 2023, replacing the previous *Emergency Program Act* [1995]. The new *Emergency and Disaster Management Act* (*EDMA*). The goal of the new *EDMA* is a proactive approach that includes mitigation, preparedness, response, and recovery[4]. Its guiding principles establish a framework for collaboration between different levels of government, reflect the United Nations Sendai Framework for Disaster Risk Reduction, and acknowledge the relation between climate change and emergency management. Importantly, *EDMA* is in alignment with *the Declaration on the Rights of Indigenous Peoples Act* (*DRIPA*), and recognizes the inherent right of self-government of Indigenous peoples, and requires co-management and shared decision-making and consultation and cooperation with Indigenous governing bodies. It also includes and protects Indigenous knowledge, and addresses the disproportionate impacts of emergencies and aims to promote cultural safety. Currently, the Province is updating and developing new regulations to support the legislation. More requirements for critical infrastructure owners (e.g. risk assessments, emergency management plans, etc.) may also be required in the future.

[4] *EDMA* is summarized below based on Province of BC (2024) https://www2.gov.bc.ca/gov/content/safety/emergency-management/emergency-management/legislation-and-regulations/modernizing-epa. Accessed 16 July 2024.

2.4.4 BC Flood Strategy

The Province of BC recently published their new Flood Strategy (From Flood Risk to Resilience: a BC Flood Strategy to 2035; Province of British Columbia, 2024). The BC Flood Strategy is aligned with the Sendai Framework, *DRIPA* and *EDMA*. The principles for strategic flood resilience in the province are visualized in Figure 2-9. Below, it is described how these principles are addressed in the City of Courtenay FMP.

Figure 2-9: Principles for strategic flood resilience in the BC Flood Strategy. Figure from the Province of British Columbia (2024).

- **Holistic:** a holistic, interdisciplinary approach to the flood risk assessment and to the FMP was taken, considering a range of receptors of risk (e.g., people, environment, etc.).
- **Pro-active:** The FMP provides many recommendations to build flood resilience before a flood may occur.
- **Place-based:** The FMP was developed with detailed look at local areas within the City and using City and regional values to guide the decisions.
- **Accountable:** The City is taken action by supporting the development of the FMP, and planning to implement the recommended actions.
- **Collaborative:** The FMP involved substantial public and partner engagement, and recommendations include collaboration and engagement with many actors.
- **Transparent:** The development of the recommended strategies is described in detail in this report and its appendices, including decisions on removal or selection of strategies.
- **Fair:** Equity is an important consideration in the flood risk assessment and the flood management recommendations.
- **Risk-informed:** A detailed holistic flood risk assessment informs the recommended strategies for flood risk reduction and resilience in the FMP.

Based on these principles, four pathways (and 25 actions) define the BC Flood Strategy (Figure 2-10). Specific to this project, there is emphasis on first understanding risk (this project includes a detailed flood risk assessment), to address flood preparedness/response and recover (this project includes recommendations for these actions), and importantly, to incorporate non-structural approaches such as flood avoidance, flood accommodation and retreat (which this project does).

Figure 2-10: Pathways for shifting from flood risk to resilience between now and 2035 in the BC Flood Strategy. Figure from the Province of British Columbia (2024).

3 Project Background

The City of Courtenay lies on the east coast of Vancouver Island (Figure 3-1) within British Columbia (BC), and it is the biggest community in the Comox Valley Regional District (CVRD). The City area is 26.68 km² in size and has a population of approximately 28,420 (Statistics Canada, 2021).

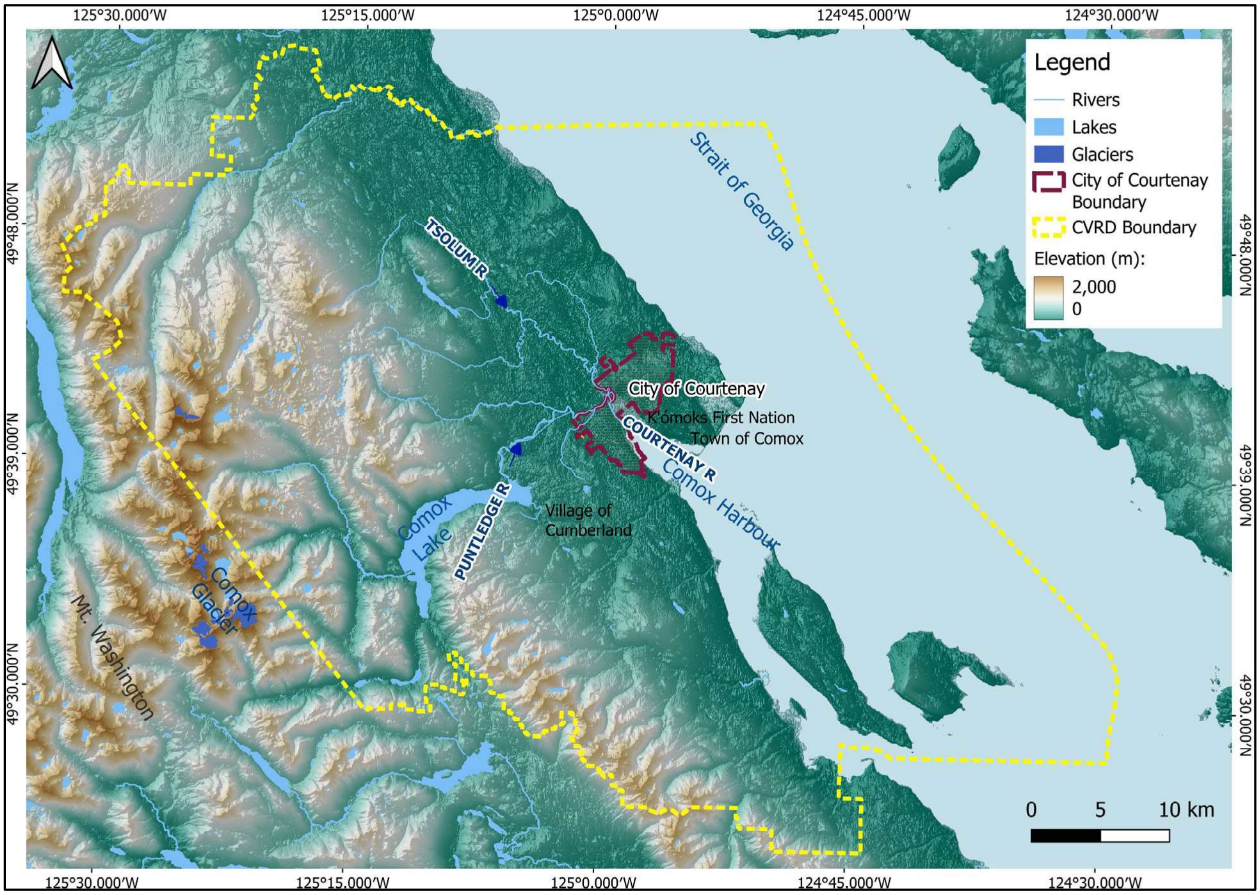

Figure 3-1: City of Courtenay within the Comox Valley Regional District (CVRD), including Comox Lake, Mt. Washington, and Puntledge, Tsolum, and Courtenay Rivers. Data obtained from the Canadian Digital Elevation Model, City of Courtenay, and BC Data Catalogue.

3.1 Population

For thousands of years, Indigenous people occupied the shoreline of eastern Vancouver Island. This is the traditional territory of the people called K'ómoks today; they have called this the 'land of plenty' since time immemorial[5]. Following European settlement, conflict, and colonial policies and practices, the K'ómoks families endured hardship through loss of land, resources, and cultural connection. Today, the City has a government-to-government relationship with the K'ómoks First Nation. They work together under a shared understanding for living on, and caring for, the lands and waters of Courtenay.

The City, along with Town of Comox, the Village of Cumberland, and Electoral areas A, B, and C form the Comox Valley Regional District (CVRD). The K'ómoks Indian Reserve No. 1 and the Puntledge Indian Reserve No. 2 are located near the City and are outside CVRD's jurisdiction. From 2016 to 2021, the population of Courtenay grew by more than 2,800 people. Population growth is projected to continue, reaching almost 30,100 people by 2031 and 32,500 people by 2051 (City of Courtenay, 2022). However, it is acknowledged by the City[6] that these population estimates are low, and the City is growing much faster than anticipated. The City Official Community Plan (OCP) (City of Courtenay, 2022) states that residents care about reconciliation, climate action, community wellbeing, and equity.

3.2 Physiography and Watersheds

The City is located within the Courtenay River watershed. This watershed has a diverse topography, consisting of unregulated and regulated river systems, many streams, and lakes (Figure 3-2). The three main rivers that cross the City are the Courtenay, Puntledge, and Tsolum. The Puntledge River is the natural boundary of the north-western part of the City, whereas the Tsolum River flows from the north and meets the Puntledge River within the City. The Courtenay River is formed at the confluence of the two rivers and flows downstream for 3.1 km through the City to the mouth at Comox Harbour and into the Salish Sea. The Browns River is a tributary to the Puntledge River, with the confluence just upstream of the City.

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[5] K'ómoks First Nation. Weblink: https://komoks.ca/. Accessed 21 November 2022.

[6] Personal communication with Development Services, City of Courtenay, 18 February 2024.

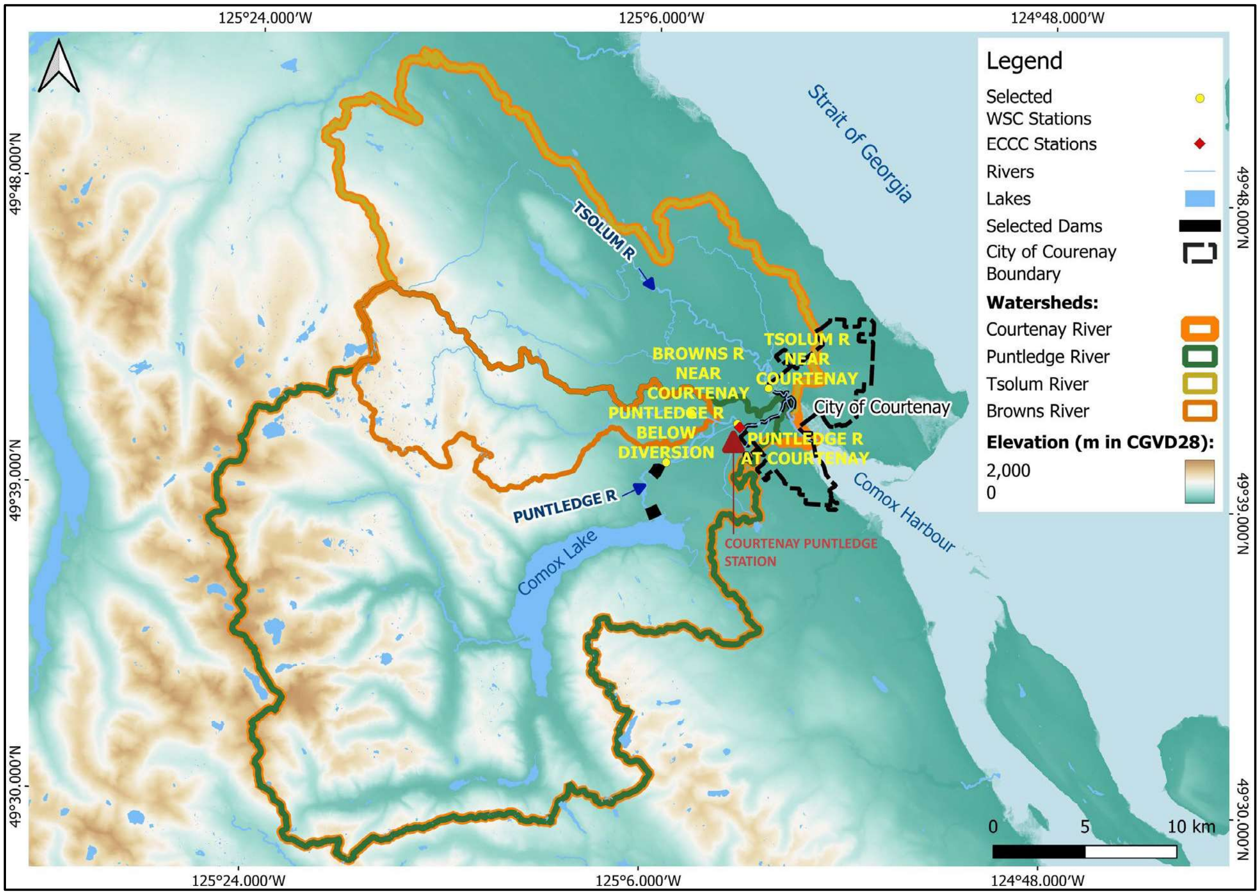

Figure 3-2: Courtenay, Puntledge, and Tsolum watersheds, and City of Courtenay. Data obtained from the Canadian Digital Elevation Model, City of Courtenay, and BC Data Catalogue.

The Puntledge River is a controlled system (see Section 3.2.1 below). The Puntledge River sub-watershed drains from its mountainous headwaters (including Comox Glacier) through Comox Lake, which is the largest lake in the region (lake surface area is approximately 16.2 km^2) (Table 3-1; Figure 3-2). The watershed has a relatively high elevation, ranging up to 2,000 m (Canadian Geodetic Vertical Datum of 1928, CGVD28).

The Tsolum River sub-watershed drains naturally from Mount Washington eastward towards the confluence with the Puntledge River (Table 3-1; Figure 3-2). Most of the watershed is relatively low-lying, apart from the higher elevation around Mount Washington.

Both sub-watersheds, along with a small, additional area, form the Courtenay River watershed, with a total watershed area of 868 km^2 (Table 3-1; Figure 3-2).

Table 3-1: Watersheds and characteristics (Kerr Wood Leidal Associates Ltd., 2021; McElhanney Consulting Services Ltd., 2013).

Catchment	Drainage Area (km^2)	Tributary Streams	Elevation
Puntledge River (sub-catchment of Courtenay River)	598	Cruickshank River, Browns River, Perseverance Creek, Morrison Creek.	Relatively high elevations. Most parts of the catchment are located above 200 metres (CGVD28), ranging up to over 2,000 m (CGVD28).
Tsolum River (sub-catchment of Courtenay River)	266	Murex Creek, Headquarters Creek, Dove Creek, and Portuguese Creek.	Relatively low-lying topography. Half of the watershed area is below an elevation of 300 m (CGVD28). However, some parts of the headwaters are higher (up to almost 1,600 m (CGVD28) at Mount Washington.
Courtenay River	868	Puntledge River and Tsolum River.	See above for Puntledge River and Tsolum River sub-watershed elevations, in combination with a very low-lying area near the estuary of the Courtenay River.

3.2.1 BC Hydro Control on Puntledge River

The flows in the Puntledge River are controlled by BC Hydro. There are two dams in the Puntledge River system, the Comox Lake Storage Dam (located at the outlet of Comox Lake Reservoir) and the Puntledge Diversion Dam (4 km downstream of Comox Lake along the Puntledge River, from which water is carried to a powerhouse) (see Figure 3-2 in previous section). The Puntledge Diversion Dam is located about 3 km west of the City. Note that it was out of scope for this project to consider dam failure, nor recommend dam operations management for flood management as part of this FMP. Refer to the BC Hydro Emergency Planning Guide for the Comox and Puntledge System (BC Hydro, 2022) for details on current risks and emergency plans.

BC Hydro tends to control the flows in the Puntledge River to reduce flooding as much as possible, with a reduction in outflows from Comox Lake Reservoir during highest tides and release during lower tides (McElhanney, 2022). During BC Hydro releases, flow velocities in the downstream Puntledge River and Courtenay River increase and the river is typically closed for recreational activities[7]. While dam management tries to reduce flooding, during high rainfall events, such as during the flood in

[7] City communications, 2024.

December 2014, the outflows overtopped the spillway and flowed uncontrolled. Other concerns may be dam failure due to anthropogenic error or major earthquakes.

3.3 Hydroclimate

Courtenay's climate is like much of Vancouver Island. The City experiences low levels of precipitation in the summer months, cool and wet falls and springs, and mild winters with high precipitation and temperatures that occasionally drop below freezing levels (Figure 3-3). The higher elevations of the Courtenay River Watershed can receive a substantial snowpack in winter months, while snowfall in the lower elevations is relatively limited (see Figure 3-3 for a lower elevation example).

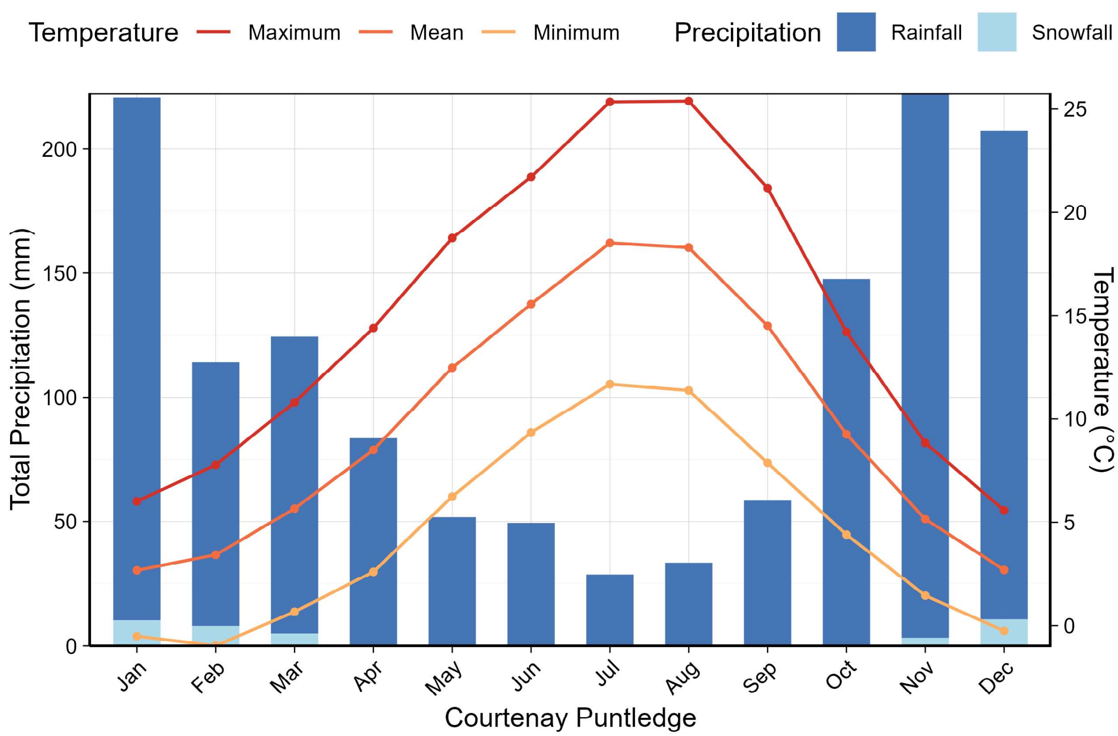

Figure 3-3: Climograph (precipitation in millimetres (mm) and air temperature in degree Celsius (ºC) for the Courtenay Puntledge meteorological station (Environment Canada Station #1021989; location at 125.0325 W, 49.68639 N, Elevation at 40 m above sea level; data availability from 1984-12-01 to 2024-06-30, however, some days and months are missing in the time series). See Figure 3-2 for station location. Note that this meteorological station is in the lower parts of the watershed, while the higher elevation areas may receive more snow.

Figure 3-4 shows how average monthly air temperatures varies from colder winters to warm summers, and indicates the variability across the years [8].

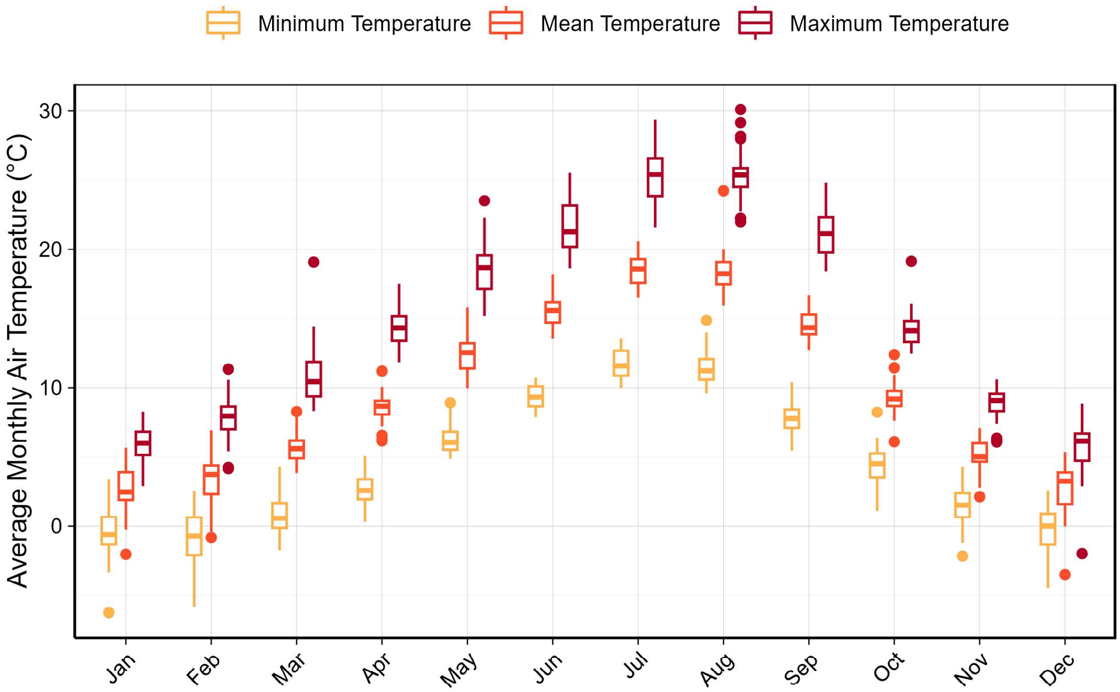

Figure 3-4: The average monthly air temperature in degree Celsius (ºC) for the Courtenay Puntledge meteorological station. See Figure 3-3 for station details.

Similarly, Figure 3-5 shows the high variability in monthly rainfall and snowfall across the years. It highlights how extreme rainfall events occur in particular November to January, with some heavy rains also in October and February.

[8] Boxplots indicate median or the 50th percentile (line in box), the 25th and 75th percentile (lower and upper end of box), the 10th and 90th percentile (lines), as well as any more extremes (dot).

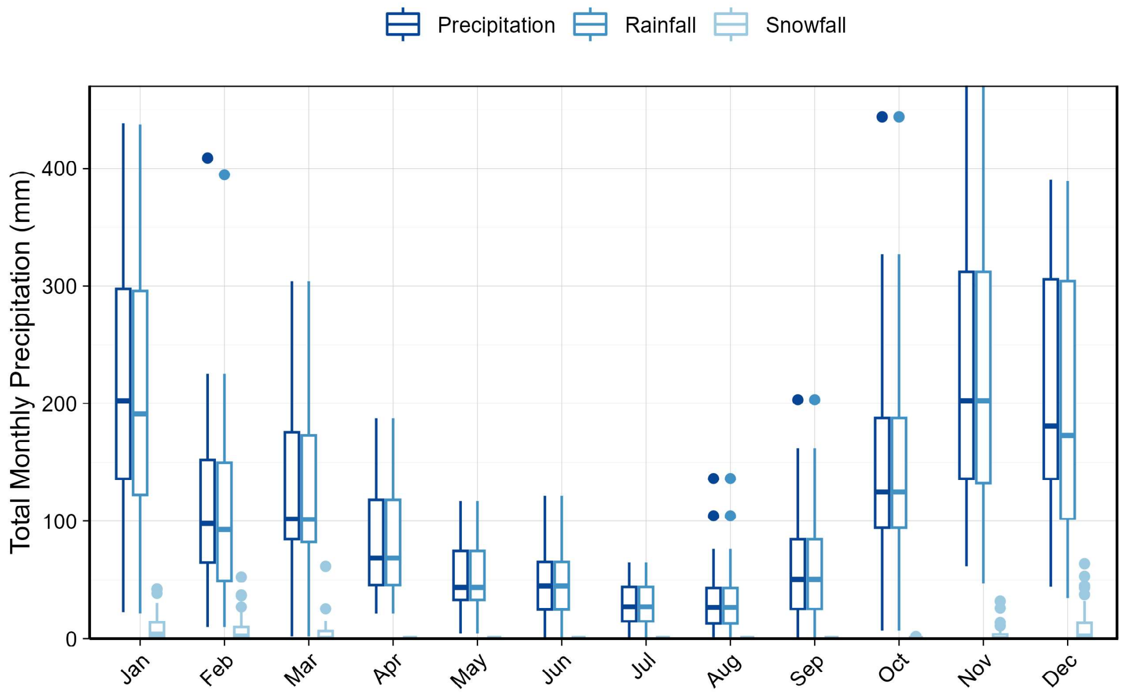

Figure 3-5: Total monthly precipitation in millimetre (mm) for the Courtenay Puntledge meteorological station. See Figure 3-3 for station details.

Figure 3-6 highlights the seasonal changes of flows for the Puntledge, Browns, and Tsolum Rivers. The highest flows occur from October to February, typically triggered by heavy precipitation (see Figure 3-5 above for precipitation). For the Puntledge River given its higher elevation watershed, some lower flow peaks can be seen around May/June during freshet (spring snowmelt). Often, the October to February peaks occur during large frontal storms from the Pacific Ocean that can also lead to coastal storm surges and wave set-ups in the mouth of Courtenay River (McElhanney Consulting Services Ltd., 2013). This combination of coastal and riverine events exposes Courtenay to higher water levels during that time of year, which is generally known as the 'flood season' in the City.

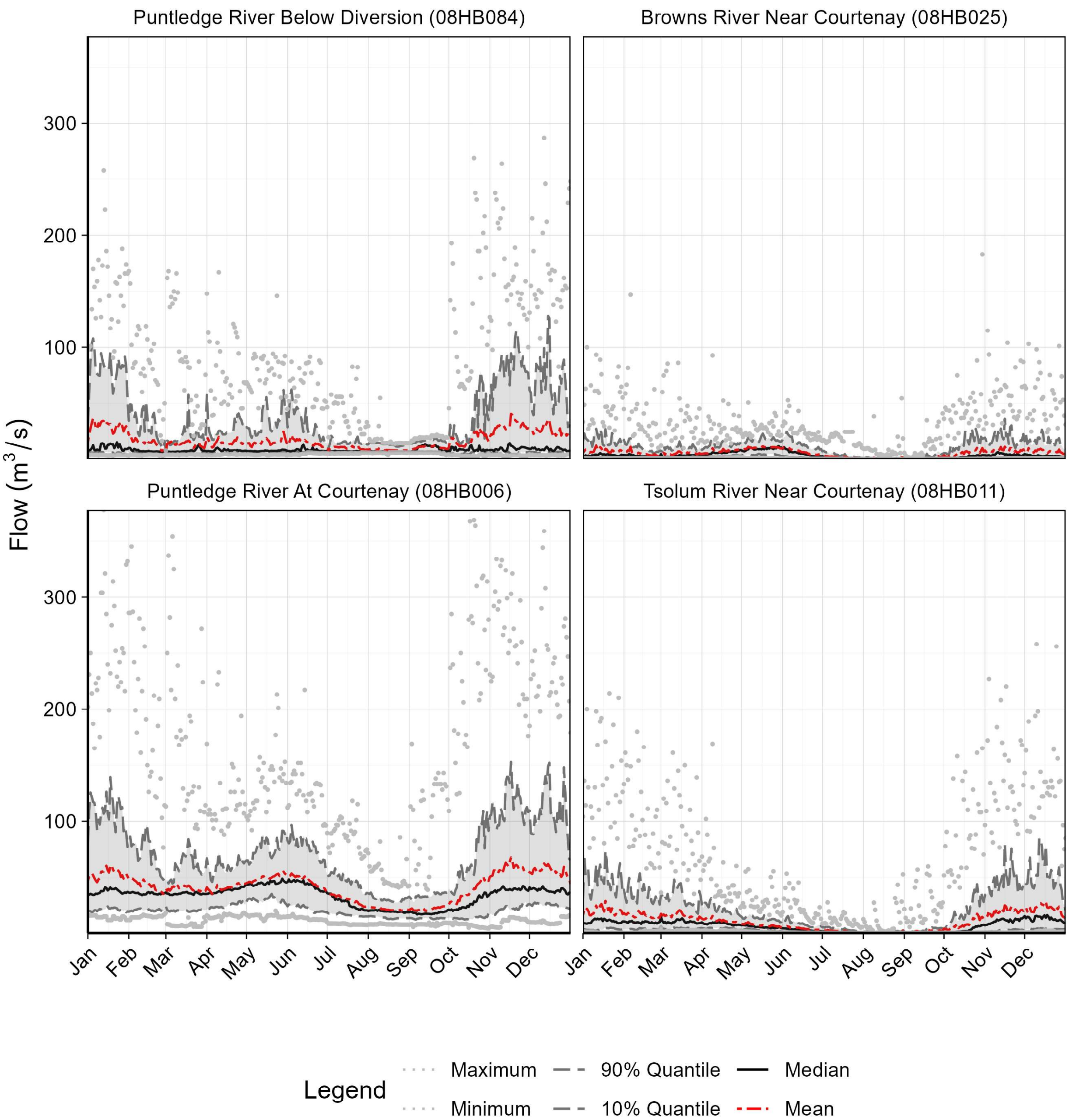

Figure 3-6: River regime plots for four Water Survey of Canada (WSC) gauging stations on the Puntledge River below Diversion (WSC #08HB084), Browns River near Courtenay (Browns River is a tributary to the Puntledge River) (WSC #08HB025), the Puntledge River at Courtenay (WSC #08HB006), and the Tsolum River near Courtenay (WSC #08HB011) (see Figure 3-2 for

gauge locations). Figures highlight the seasonal changes of daily discharge in cubic metres per second (m^3/s). Data availabilities are provided in footnote[9]. Data was downloaded from Hydat database in July 2024.

3.4 Climate Change

Climate change will impact Courtenay and its surrounding watersheds and coastline. According to recent Coupled Model Intercomparison Project (CMIP) six projections for a high emission scenario[10] (PCIC, Ouranos, PCC, ECC, CRIM, 2023), the annual average temperature will increase from 9.6°C (baseline period from 1971-2000) to 11.4°C for the 2021-2050, 12.8°C for the 2051-2080 and 14.3°C for the 2071-2100 periods. Average annual precipitation for the baseline period was 1,335 mm, which is projected to increase by 9% for the 2051-2080 period, and by 11% for the end of the century. Rainfall intensities will also increase substantially towards the end of the century (PCIC, Ouranos, PCC, ECC, CRIM, 2023).

Sea levels are also projected to continue to increase (James *et al.*, 2021). For the project area, the median projection for the year 2050 is an increase of 1 cm in relative sea level rise (RSLR) for the high emission scenario, and 23 cm for 2100. However, projections for an "enhanced" high emission scenario, which considers an enhanced meltwater source from West Antarctica increases the projection to 96 cm for the year 2100. The increases are relative to the 1986 to 2005 period (James, Robin, Henton, and M. Craymer, 2021)[11]. The Professional Practice Guidelines for Flood Mapping in BC (EGBC, 2017) propose the use of 1 m of SLR by 2100.

[9] Data availabilities (note that indicated year ranges may still include some days of missing data):
Puntledge River below Diversion (WSC #08HB084): 1993-2023.
Browns River near Courtenay (WSC #08HB025): 1960-1971; 1985-2023.
Puntledge River at Courtenay (WSC #08HB006): 1914-1917; 1955-1957; 1964-2022.
Tsolum River near Courtenay (WSC #08HB011): 1914-1917; 1955-1957; 1964-2022.

[10] Relative concentration pathway 8.5 (the planet's radiative forcing will have increased by 8.5 W/m2 by the year 2100, relative to 1750).

[11] The refined data from James et al. (2021) was obtained from Climate Data for a Resilient Canada. Weblink: https://climatedata.ca/explore/variable/slr/?coords=49.79855248452189,-124.31373596191408,10&geo-select=&rcp=rcp85-p95&decade=2100&rightrcp=disabled. Accessed 08 December 2022.

3.5 Historic Flood Hazards

Given the location of Courtenay within an estuary, it is subject to distinct flood hazards from rivers (riverine) as well as from the ocean (coastal). It is also subject to mixed (or joint) hazards when high ocean water levels combine with high riverine flows. The City has experienced many floods (detailed list in Appendix A; summary in Table 3-2). In many of these historic flood events, the main triggers were heavy rains, but in some cases, the heavy rainfalls and high riverine flows also coincided with storm surges and/or high tides (i.e. were joint events). Most of the historic floods occurred between October and February, when winter storms bring precipitation and low pressure with winds that create high ocean levels.

One of the most outstanding recent floods occurred in December 2014, when heavy rainfall coincided with high tides, and flows of the Courtenay River were estimated to be approximately a 2%[12] Annual Exceedance Probability (AEP)[13] (1:50 year return period). Wide-spread damages occurred throughout the City. Smaller, but still substantial floods also occurred in November 2016 and November 2020. Note that impacts during the 2021 atmospheric hazard event were not as substantial for the City, as for other parts of the Province.

Table 3-2: Overview of historic flood events recorded in the City of Courtenay, with daily peak flows of the Puntledge and Tsolum Rivers provided in cubic metres per second (m^3/s), based on Septer (2006) Kerr Wood Leidal Associates Ltd. (2021) and newspaper articles. See Appendix A with full details on flood events and references. N/A = not available (or not known).

Date	Punt-ledge (m^3/s)	Tsolum (m^3/s)	Primary Mechanism	Description
October 1905	N/A	N/A	N/A	9 m of dike failed near floodgates on Comox Road.
February 1935	N/A	N/A	Riverine	Moderate flood on the Puntledge River.
November 1939	N/A	N/A	Joint riverine & coastal	Heavy rain and high tide and high winds.
December 1939	N/A	N/A	N/	Courtenay River flooding.

[12] Note that there are many uncertainties associating an observed flood event with a likelihood, especially in a complex combined riverine (regulated/unregulated) and coastal system such as in Courtenay. Therefore, the conditions leading to the 2014 floods and observed flood extents are not directly comparable to the modelled scenario assumptions and extents used for this project.

[13] An AEP describes the likelihood of a flood event of a given size occurring or being exceeded. It is a statistical representation that is used in flood planning. Higher AEP events are less severe and occur more frequently, whereas lower AEP events are more rare but more severe (i.e., larger).

Date	Punt-ledge (m^3/s)	Tsolum (m^3/s)	Primary Mechanism	Description
November 1941	N/A	N/A	Riverine	Courtenay River.
November 1953	N/A	N/A	Riverine	Heavy rain and high winds.
November 1975	263	170	Riverine	Floodwaters caused considerable damage.
December 1980	281	136	Riverine	Record temperatures and heavy rain.
October 1982	319	105	Riverine	High inflow to Comox Lake.
February 1983	246	180	Riverine	Warm temperature, high winds, and heavy rains. Tides were low during riverine peaks.
March 1987	354	136	N/A	N/A
November 1990	324	73	N/A	N/A
January 1992	345	154	N/A	N/A
October 1997	285	158	N/A	N/A
December 2005	236	140	N/A	N/A
November 2009	303	220	Riverine	Heavy rain.
January 2010	378	155	Riverine	High flow levels in the Browns, Tsolum, and Puntledge Rivers.
December 2010	157	256	Joint riverine & coastal	Heavy rain, rising freezing levels and melting snow, and high tides.
December 2014	359	258	Joint riverine & coastal	Heavy rain, combined with high tides. Major flooding in the City.
November 2016	333	227	Riverine	Heavy rain.
November 2020	78	58	Coastal	Powerful winds and high tides. Storm surge.
October 2021	220	161	Riverine	Atmospheric River event; heavy rain.

3.6 Previous Flood Studies

The City has conducted, or has been included, in the following related studies:

- **2013 Courtenay Integrated Flood Management Study** (McElhanney Consulting Services Ltd., 2013): This included the development of a hydrodynamic model for the Courtenay River, stakeholder engagement, and the presentation of three mitigation options for flood management.
- **2021 Dike Replacement and Flood Management Strategy** (Urban Systems, 2021). This project explored and evaluated a range of flood management options, focusing on structural work.
- **2021 Phase 1 CVRD Coastal Flood Mapping** (Kerr Wood Leidal Associates Ltd., 2021): The study included the development of a coastal model and incorporation of modelling scenarios from riverine models for the Courtenay River. The results included a set of 21 riverine flood scenarios for the Courtenay River system (including one dike alternative scenario) and 20 coastal flood scenarios (see Section 4.3.1 for more details).
- **2022 Phase 2 CVRD Coastal Flood Adaptation Strategy** (Ebbwater Consulting Inc. and SHIFT Collaborative, 2022): This study focussed on determining adaptation pathways for the larger CVRD coastline from Oyster River in the north to Union Bay in the south, and included a high-level risk assessment, stakeholder engagement, and a community-led decision process. The City participated in the project as a stakeholder, however the focus areas of this CVRD project were all outside the City boundaries.
- **2022 City of Courtenay Flood Operations Manual** (McElhanney, 2022): The Flood Operations Manual provides a set of emergency management protocols and operational procedures to follow base don predicted or observer water levels of the Courtenay River, including information on typical flood entry points and evacuation areas. See also Section 6.6.2.1 for more details.
- On-going work about the **Anderton Dike Option Analysis** (McElhanney, 2023).

3.7 Current Flood Protection Structures

There are four flood protection structures in the City (Figure 3-7): Condensory and Canterbury Lane Dikes along the Puntledge River, Anderton Ave Dike along the Courtenay River, and Lewis Park Dike along the Courtenay River. Along Tsolum Slough, in extension of Lewis Park Dike, there is also a seasonally deployed Tiger Dam (previously, AquaDam), as well as a jersey barrier (called 'Tall Wall'). These flood protection structures are described in more detail in Chapter 6, as part of the local area descriptions.

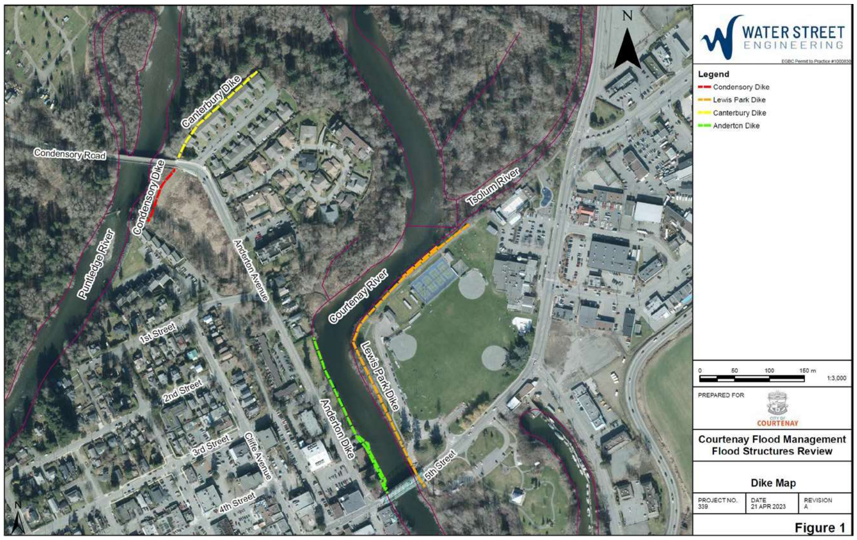

Figure 3-7: Locations of flood protection structures in Courtenay (Credit: Water Street Engineering, 2024).

3.8 Flood-Related Policies in the City of Courtenay

The City of Courtenay has existing policies and regulation directing land use around the shoreline and in the floodplain. Bylaw No. 1743 from the 1990s is a floodplain bylaw with flood construction levels and setbacks. The City has traditionally put restrictive covenants in favour of the municipality on title for buildings within the floodplain [14] (see also Section 7.3.1.1 with more details on restrictive covenants). Development Permit Area (DPA) Guidelines exist for aquatic environmentally sensitive areas including lands within 30 m of the natural boundary of freshwater and the water and lands adjacent to the Comox Estuary and Courtenay River to the Condensory Bridge. The objectives of the guidelines are to protect, enhance, and restore biodiversity, ecosystems and their connectivity, and water quality. Guidelines outline site planning, fencing, restoration, and other items with additional guidelines specific to developing near the estuary and marine shoreline.

Adopted in July 2022, the Official Community Plan (OCP) (City of Courtenay, 2022) includes a range of flood-related policies that include directing growth away from the floodplain while developing a long-term strategy for managed retreat from vulnerable areas. This approach stipulates that the appropriate land uses for the floodplain areas are agriculture, parks and recreation, as well as commercial use, but no residential use. The OCP also directs development of a zoning bylaw section to formalize shoreline uses and setbacks with a priority on environmental protection and passive

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[14] Personal communication from City Planning, building, and development staff.

recreation and the prevention of hard shorelines while encouraging Green Shores[15] approaches. However, the zoning bylaw has not been updated since the new OCP was adopted in 2022[16], which created a regulatory loophole, where development applications may not comply with the OCP.

Taken together, the existing guidelines and OCP policies promote limited, lower risk land uses in the floodplain and a priority on environmental protection, soft edges, and restoration along shorelines and riverbanks.

The OCP also directs the development of several planning mechanisms related to the floodplain. An update of the floodplain bylaw and application of Flood Construction Levels (FCLs[17]) to redevelopment is mentioned as is the development of a local area plan for the Courtenay River Floodplain that accounts for adaptive land uses. Additionally, a DPA for protection of development from flood/erosion hazard is called for alongside the Shoreline zoning addition mentioned above. While these mechanisms and tools all have varying objectives and applications, they should integrate to provide a strong policy framework for flood and erosion hazard management, as low as practicable community risk and environmental protection and restoration. These regulatory tools, their integration, and associated recommendations are discussed in more detail in Section 7.3.1.

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[15] Green Shores describes an approach to coastal shoreline management that minimizes the environmental impacts of projects. In BC, the Green Shores approach is advocated for and support is provided by the Stewardship Centre for British Columbia.

[16] Zoning updates are currently in process given changes from the Province (new *Provincial Bill 44 Housing Statutes* (Residential Development) Amendment Act, 2023), which requires higher density residential zoning. However, there is also an option to exclude hazardous areas from higher density residential zoning in Bill 44; for more details on zoning updates and recommendations, see Section 7.5.1.

[17] FCLs are flood level elevations that are used in regulation to limit development that might be damaged below the expected flood level. The City currently uses a floodplain bylaw and FCLs, but the FCLs are out-of-date, as the 2021 CVRD Coastal Flood Mapping (Kerr Wood Leidal Associates Ltd., 2021) provides updated FCLs.

4 Flood Management Plan Approach

The FMP project included a number of technical and engagement subtasks to explore and understand the nature of the flood risk in Courtenay and to then systematically work through options and next steps. This chapter presents an overview of the methods. Method details are given for the Risk Assessment and Option Analysis in Appendix B. Public Communications Material and Public Surveys Results are provided in Appendices D and E, respectively. Lastly, details on the development of the structural recommendations, conducted by Water Street Engineering, are provided in Appendix F.

We used an adapted structured decision-making (SDM) approach to explore trade-offs between various flood risk reduction and resilience options and to recommend a set of preferred strategies (Figure 4-1). This adapted SDM process provided the scaffolding for the overall project process (Figure 4-1), with terminology (Table 4-1) and a brief description of the key steps below.

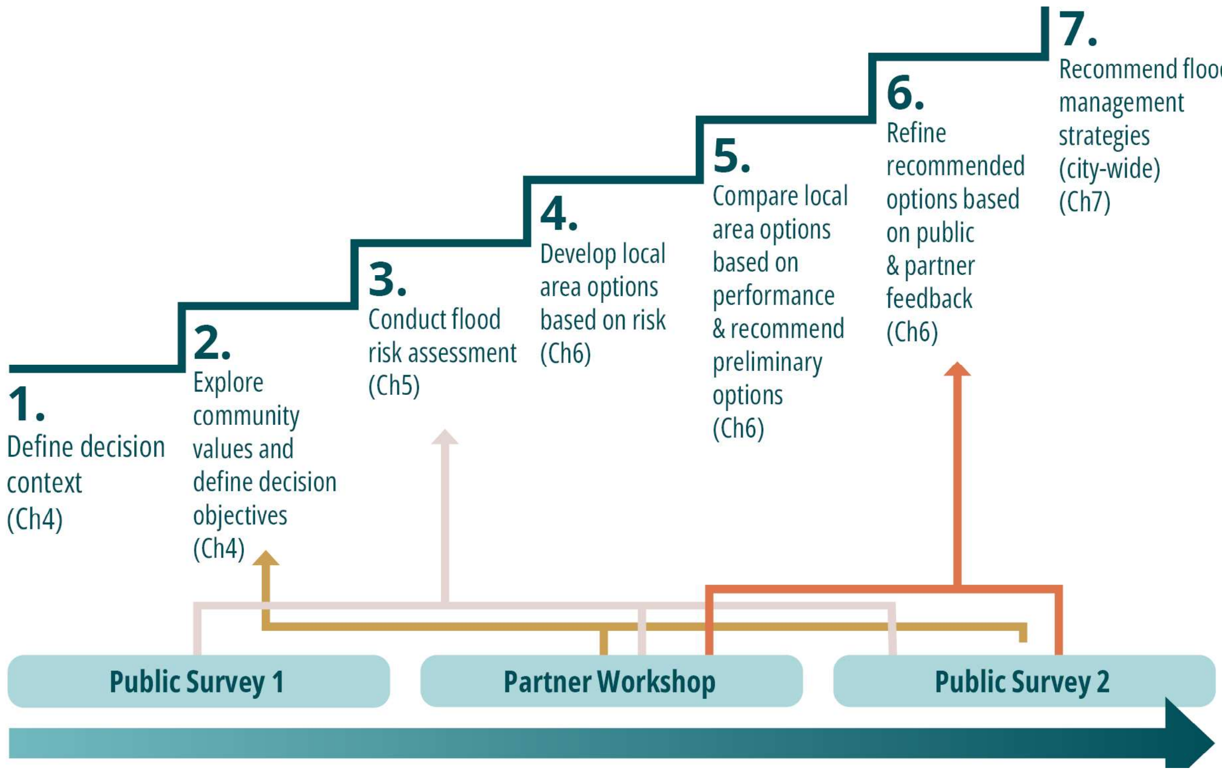


Figure 4-1: Project flow – risk-based structured decision-making for the City of Courtenay FMP.

Table 4-1: Terminology descriptions for adapted structured decision-making process.

Term	Description
Value	Aspect of importance to the community (conceptual).
Decision Objective	Value-based statements of the things that matter to a community when considering flooding.
Performance Measure	Provides a (quantitative or qualitative) means of assessing the performance of different flood risk reduction and resilience options across objectives.
Scale	A description of the scoring system for the performance measure (constructed scale, or quantitative)
Strategy	Overarching flood risk reduction or resilience-building approach based on the *Protect*, *Accommodate*, *Retreat*, *Avoid*, and *Resilience-Building* (PARAR) framework.
Option	Place-based detailed flood risk reduction activity (for a local area, or city-wide) that can be compared to alternative options.
Recommended Action	Specific actions within the FMP that are recommended based on the options analysis (these are found in Chapter 7).

The principles of SDM (Gregory, et al., 2012) supported the process of identifying preferred strategies through a set of planning steps that guide working through decisions. The steps of SDM were adjusted for the purposes of this project and are described below. An important component is to bring the public, partners, and decision-makers through to implementation.

- **Step 1: Define the decision context.** This involved defining the geographic scope of the study, as well as the hazard assumptions.
- **Step 2: Explore community values and define decision objectives & performance measures.** First, community values were explored and aggregated to ensure decisions are based on these. Values are aspects of importance to the local community. These values should be informed by public and partner engagement. Based on these values, decision objectives were developed. Objectives are simple values-based statements of the things that matter to people when considering flooding. They aim to capture many of the aspects that are important to local government staff, decision makers, partners, and the public. Quantitative and qualitative performance measures then provide a means of assessing the suitability of different alternative options across objectives. Various methods may be used to estimate the value of the performance measures.
- **Step 3: Conduct flood risk assessment:** To ensure that options address local risk, a detailed flood risk assessment was conducted, looking at a range of flood likelihoods and time periods from the present-day to the future with increasing climate change. A holistic set of receptors (people, economy, culture, environment, and critical infrastructure) that reflected community values as much as possible were considered.

- **Step 4: Develop alternative local area and city-wide options based on risk.** The City was divided into local areas based on hydraulic/hydrodynamic and land use characteristics, and for each area, a range of alternative options for risk reduction and increasing resilience was developed. Further, options that should be considered city-wide were also developed.
- **Step 5: Compare local area options based on performance and recommend preliminary options.** This step involved estimating the performance of each alternative option across the decision objectives using the selected performance measures. Performance was measured using empirical data, models, or judgement. Strengths and weaknesses tables were used to facilitate comparison of the performance measures. The performance of each alternative can then be compared against one another, facilitating the identification of key trade-offs for decision-making. Preliminary option recommendations for discussion in a partner workshop and public survey were then provided.
- **Step 6: Refine options based on public and partner feedback.** Based on feedback received from the public, stakeholders and First Nation[18] (partners), and City staff, the options were refined. It was also an opportunity to iteratively improve alternative options and develop new hybrid alternatives designed to take the best aspects of existing alternatives to improve performance.
- **Step 7: Recommend flood management strategies (city-wide) based on feedback.** The refined local area options were aggregated into a set of recommended city-wide flood management strategies that provide a holistic approach to flood risk reduction and increasing resilience. These were combined with previously identified city-wide options that were vetted by the public and project partners.

4.1 Step 1: Define Decision Context

The focus of this project was the City of Courtenay (Figure 1-1 in Section 1.2). However, some flood management options may affect other jurisdictions (e.g., CVRD, K'ómoks First Nation, Town of Comox), and moving forward, the City should continue to collaborate with neighbouring jurisdictions to coordinate flood management.

For option development, local areas were defined based on distinct hydraulic/hydrodynamic characteristics (flood hazard) and distinct land use characteristics (exposure).

[18] Note that due to capacity issues, feedback from the K'ómoks First Nation was limited to participation in workshop.

The focus was on riverine, coastal, and joint riverine-coastal flooding in the estuary, along the Tsolum, Puntledge and Courtenay Rivers and Comox Estuary within the City of Courtenay boundary. Other types of flood hazards (e.g., pluvial, stormwater system failure, etc.) were not included, and it was out of scope to consider flow regulation by BC Hydro or the potential inundation from the failure of the Puntledge River control structures (as well as other actions under control of others). Flood hazards were considered as mapped in the 2021 CVRD Coastal Flood Mapping (Kerr Wood Leidal Associates Ltd., 2021).

4.2 Step 2: Explore Community Values and Develop Decision Objectives

Previous projects in the region already explored values (i.e., what is important to the community). This included engagement as part of the CVRD Coastal Flood Adaptation Strategy (Ebbwater Consulting Inc. and SHIFT Collaborative, 2022) (Figure 4-2 and the City of Courtenay OCP (City of Courtenay, 2022) (Figure 4-3).

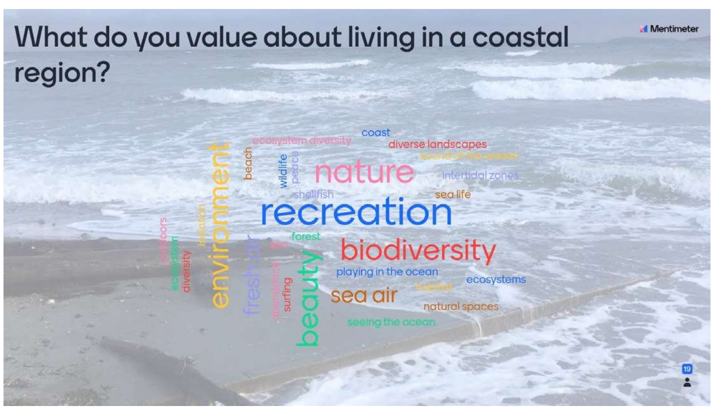


Figure 4-2: Values discussed during the (CVRD) Coastal Flood Adaptation Strategy (Ebbwater Consulting Inc. and SHIFT Collaborative, 2022).

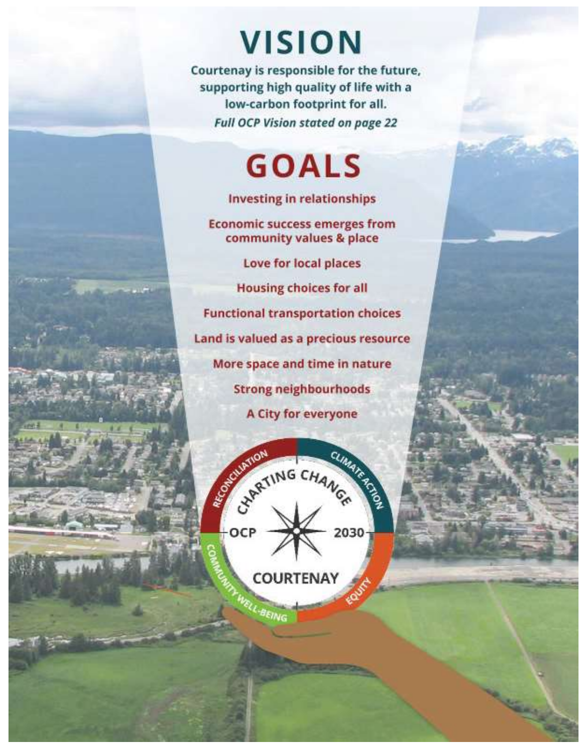


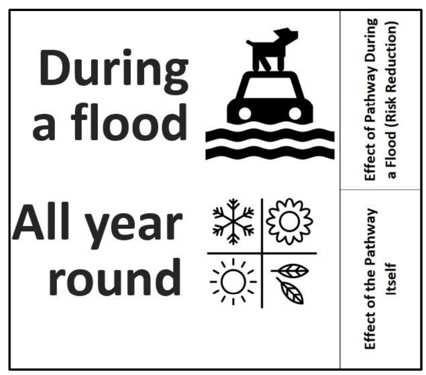
Figure 4-3: Vision and Goals, based on local values, developed for the OCP (City of Courtenay, 2022).

Based on the above resources, as well as further input from the public survey and the workshop (see Section 4.5 on Engagement), the following community values were aggregated to guide the evaluation of risk mitigation options:

City of Courtenay - Community Values:

- **Biodiversity** (habitat, stewardship, caring for lands and waters)
- **Recreation and Natural Assets** (access to nature, beauty)
- **Community & Culture** (strong neighbourhoods, community involvement; art, heritage; Indigenous culture)
- **Reconciliation** (recognition of past and present harms, respectful relationship building with K'ómoks First Nation and other Indigenous peoples who live on these unceded lands)
- **Social Equity** (housing choices for all, consider equity in planning and design, diversity)
- **Economic Success** (viewed holistically through environmental, social, and economic systems)
- **Low carbon** (net zero emissions by 2050)
- **Public and Community Safety**

Drawing on these community values and supplemented by standard receptors used in disaster risk reduction (e.g., life safety), we then developed decision objectives. Importantly, these decision objectives do not only consider the effect of an option during a flood (i.e., the risk reduction), but also the effect this option may have year-round on a community. For instance, a structural option will be in place 365 days of the year, affecting community life and the environment. These decision objectives, which are very important to the evaluation process and the recommendations within the FMP, were vetted by City staff as well as project partners.



Based on the decision objectives, we then developed quantitative and qualitative performance measures, i.e., measures that allow the comparison of different options. These are summarized in Table 4-2. For the risk reduction measures, where possible, the performance measures drew upon the risk assessment and compared the risk reduction, i.e., the percentage change from the baseline risk (see Section 4.3 and Appendix B on risk assessment methods and dataset details, and on calculation of performance measures). For each option, different assumptions on effectiveness of the options needed to be taken (e.g., a structural option that would protect against up to a specific flood scenario). These assumptions are provided in Appendix B.

For each option, we then calculated or estimated the performance measure, and presented these in strengths and weaknesses tables. These tables are provided in Chapter 6, along with description of the different options considered.

Table 4-2: Decision objectives and performance measures, including both the effect of an option during the flood, as well as year-round.

	Category	Objectives	Performance Measure
Effect of Option During a Flood (Risk Reduction)	People (General)	Reduce risks to health and safety of people	# of all residents in flood extents based on Census 2021 data (Average Annual Loss (AAL[19]) for the mid-term future). % change compared to baseline ('Do nothing').
	People (Socially Vulnerable)	Reduce impacts to socially vulnerable people	Qualitative. Based on NRCan Social Vulnerability data. % change compared to baseline.
	Environment	No risk of contaminant release	# of contamination sources in flood extents (AAL for the mid-term future). % change compared to baseline.
	Culture	Minimize damage of cultural and community sites	# of cultural sites (incl. Indigenous archaeological sites) (AAL for the mid-term future). % change compared to baseline.
	Critical Infrastructure	Minimize failure of critical infrastructure facilities	# of Critical Infrastructure facilities in flood extents (AAL for the mid-term future). % change compared to baseline.
	Disruption	Minimize disruption of transportation and mobility	Length of major roads in flood extents. % change compared to baseline.
	Economy	Minimize damage to structures/buildings	Total building values ($) exposed in flood extents, based on BCA 2022 (AAL for the mid-term future). % change compared to baseline.
Effect of the Option Itself	Community	Encourage community relationships & connectedness	Qualitative (-2 to +2)
	Social Equity	Reduce impacts to socially vulnerable people & improve equity	Qualitative (-2 to +2)
	Environment	Improve habitat health	Qualitative (-2 to +2)
	Recreation & Nature Access	Improve recreation and access to nature	Qualitative (-2 to +2)
	Implemen-tation Cost	Implementation cost	Protect Options (Class D cost estimates); other Options: Estimates
	Maintenance Cost	Maintenance cost	Protect Options (Class D cost estimates); other Options: Estimates

[19] The Average Annual Loss is an estimate of annual impacts averaged over a very long time. See Section 4.3 for more details.

	Category	Objectives	Performance Measure
	Implemen-tability	Regulatory Obstacles	1. Not possible, 2. Possible with regulatory/legislative changes., 3. Easily implementable under existing regulations/legislation

The following scales were used for visualization of the Strengths and Weaknesses of options. Note that in this colour coding, grey to dark green are favourable ratings, while light to dark orange are unfavourable.

Risk & Resilience Scale

Very ineffective	Ineffective	Moderately effective	Effective	Very effective
No risk reduction compared to baseline	0-25% risk reduction compared to baseline (e.g., 0-25% less people affected)	25-50% risk reduction compared to baseline	50-75% risk reduction compared to baseline	75-100% risk reduction compared to baseline

Externalities Scale

Very negative	Negative	Neutral	Positive	Very positive
-2	-1	0	1	2

Cost Scale

	$$$$$	$$$$	$$$	$$	$
Implementation Costs	> $50 M	< $50 M	< $20 M	< $10 M	< $0.1 M
Maintenance Costs (per year)	$50,000-$100,000	$25,000-$50,000	$15,000-$30,000	$5,000-$15,000	<$5,000

Implementability Scale

Very challenging (not possible)	Moderately challenging (possible with regulatory/ legislative changes)	Relatively easy
1	2	3

4.3 Step 3: Conduct Flood Risk Assessment

Based on the principles outlined in Chapter 2, we conducted a holistic risk assessment. the methods and input data for hazard, consequence, and risk steps are provided below.

4.3.1 Flood Hazard Data

4.3.1.1 Flood Hazard Data Overview

As outlined in Chapter 2, consideration of a diversity of flood hazards is important to the development of a robust flood risk assessment. In this case, a total of 20 scenarios were considered, based on the CVRD Flood Hazard Mapping (Kerr Wood Leidal Associates Ltd., 2021). These are summarized, along with naming conventions for this report, in Table 4-3 and Figure 4-4. While timelines are not explicitly associated with the scenarios, generally the planning range can be loosely linked to the present-day, and the 2050s (near future), 2100s (mid-term future), and 2200s (long-term future). Note however that these time period estimates are approximate and based on sea level rise considerations as recommended in the EGBC Professional Practice Guidelines for Flood Mapping (EGBC, 2017), as well as estimates of riverine flow increases. Actual future changes in SLR and riverine flows and their associated timing will depend on how the rate of warming due to climate change, and its related consequences of SLR and change in riverine flows, develops.

The flood hazard scenarios take both coastal and riverine conditions into account. The scenarios consider the joint occurrence of a riverine and coastal event of the same likelihood at the same time (e.g., the likely (5% AEP) scenario considers a 5% AEP riverine peak flow, combined with a 5% AEP coastal storm surge)[20]. This is a relatively conservative estimate, but there could also be the case that a more extreme (lower probability) event of one flood hazard (e.g., riverine) would occur in combination with a lower probability event of the other (e.g., coastal).

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[20] I.e., a joint-probability approach, where a range of different coastal storm surge and riverine peak flow probabilities are combined, was not taken for the flood hazard mapping.

Table 4-3: Flood hazard layer scenarios and naming conventions for the risk assessment (coastal and riverine flooding).

AEP for River Flow and Extreme Ocean Level (Indicative Return Period)	Likelihood Qualifier	Sea Level Rise[21]	River Flow (% Increase with Climate Change)	Climate Scenarios
10% (1:10 years)	Frequent	0 m 0.5 m 1 m 2 m	0% 15% 15% 30%	Present-day Near Future Mid-term Future Long-term Future
5% (1:20 years)	Likely	0 m 0.5 m 1 m 2 m	0% 15% 15% 30%	Present-day Near Future Mid-term Future Long-term Future
1% (1:100 years)	Possible	0 m 0.5 m 1 m 2 m	0% 15% 15% 30%	Present-day Near Future Mid-term Future Long-term Future
0.5% (1:200 years)	Less Likely	0 m 0.5 m 1 m 2 m	0% 15% 15% 30%	Present-day Near Future Mid-term Future Long-term Future
0.2% (1:500 years)	Rare	0 m 0.5 m 1 m 2 m	0% 15% 15% 30%	Present-day Near Future Mid-term Future Long-term Future

[21] Note that coastal depths include an allowance for regional land uplift, or subsidence as appropriate minus the ground surface elevation at any point.

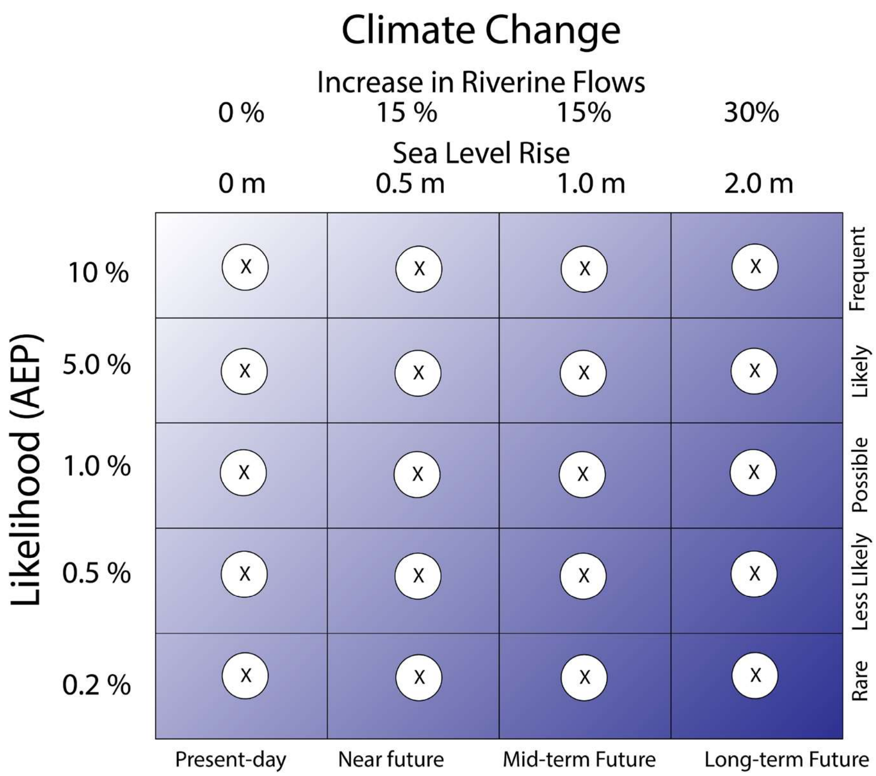

Figure 4-4: Visualization of the hazard scenario range included in risk assessment.

4.3.1.2 Flood Hazard Data Limitations

While the flood hazard data used for this project draws upon the most recently available study for the region (Kerr Wood Leidal Associates Ltd., 2021), which applied standard modelling approaches, there are some limitations to be aware of. The flood hazard datasets were produced for a regional study (coastline of the entire CVRD), and the results were generated separately for coastal and riverine hazards, and later combined in one spatial layer per scenario, instead of in a combined coastal-riverine model that would allow to account for more dynamic feedback between coastal and riverine processes.

Further, due to the large study region, relatively large coastal reaches (sections) were used for the one-dimensional coastal flood model. Within one reach (of hundreds of metres), the same shoreline characteristics (e.g., slope and aspect) are assumed to estimate wave-run up in a one-dimensional model. This of course introduces uncertainty at the local scale, as there may be much variability in shoreline characteristics within one section.

A simplified approach for riverine modelling was also followed based on a 2013 hydraulic model. The model was based on relatively old LiDAR[22] information (2012, adjusted locally to update the elevations along the Canterbury floodwall), in which flood protection structures were included in the model Digital Elevation Model (DEM) based on LiDAR data only (not surveyed or modelled as structures). For the riverine modelling, design flows for input into the riverine model were based on a 2013 regional flood frequency analysis (i.e., more recent hydrological data was not included) and climate change was considered with percent increases (i.e., not based on a detailed climate change study). More details about datasets, methods, and limitations of the flood hazard data can be found in Kerr Wood Leidal Associates Ltd. (2021).

Based on standardized hazard confidence ratings (see Appendix B), a hazard confidence rating of *high* was assigned for the hazard data, drawing on a 5-scale categorical rating (very low, low, moderate, high, very high).

Despite these limitations, the flood hazard data is the most recent flood hazard mapping available for the City of Courtenay, and provides flood hazard depths and extents at high-spatial resolution and for a range of likelihoods and climate change scenarios. It was out of scope for this project to conduct additional flood hazard modelling.

4.3.1.3 Floodway/Flood Fringe and Further Concepts

Impacts vary strongly depending on depth and velocity of a flood (see Section 2.1.1.1). Most of the flow in river systems is carried in the deepest part of the channel. It is common across Canada as well as elsewhere in the world to divide the floodplain into two zones, a floodway, and the remainder of the area, called a flood fringe. This allows to distinguish distinct parts of the floodplain for different flood adaptation options.

The floodway refers to the river channel and shoreline and adjacent areas where water depths, velocities and wave action are greatest and most hazardous. The flood fringe are the remaining areas of the floodplain that are outside the floodway. This area may also flood, but likely less often and with less depth, velocity and wave action than within the floodway.

For this project, we use a simple approach of using modelled scenarios, where the present-day - likely scenario represents the "floodway" and the remainder of the area up to the extents of regulatory

[22] LiDAR (Light Detection and Ranging): remote sensing method that uses light pulses to measure distances (range) from e.g. a surveying airplane to the Earth, from which high spatial scale elevation data can be developed.

floodplain (i.e., the mid-term future - less likely scenario plus freeboard) is considered the "flood fringe" (Table 4-4).

The regulatory floodplain is the floodplain extent designated for policy regulations, for instance via a floodplain bylaw. It is developed based on a specific flood scenario, i.e., the design flood (for the City, this is the mid-term future - less likely scenario plus freeboard). Flood construction levels (FCLs) are the water surface levels associated with the design flood scenario (including freeboard) and are used to establish the elevation of the underside of a wooden floor system or top of concrete slab for habitable buildings in a floodplain bylaw.

Table 4-4: Relevant flood extent terminology.

Type	Description	FMP Reference Scenario (Name)	FMP Reference Scenario (Details)
Floodway	Conveys most of the riverine flow, but also is the part of the channel that has the highest damage potential and potential for secondary hazards.	Present-day likely	5% AEP; 0 m SLR & 0% increase in riverine flows, compared to present-day (nominally 2020)
Flood Fringe	Remainder of the area from floodway to the extents of the mid-term future - less likely scenario plus freeboard (regulatory floodplain). This area may still flood, but likely with less depth and velocity than within the floodway.	Difference between the present-day - likely event and the mid-term future - less likely event plus freeboard	0.5% AEP; 1 m SLR & 15% increase in riverine flows + 0.6 m freeboard
Regulatory/ Designated Floodplain	The floodplain extent that are designated/regulated in a floodplain bylaw. This refers to the extents of the design flood scenario.	Mid-term Future – Less Likely Event plus freeboard	0.5% AEP; 1 m SLR & 15% increase in riverine flows + 0.6 m freeboard
Design Flood	Flood scenario used to develop the regulatory/designated floodplain.	Mid-term Future – Less Likely Event plus freeboard	0.5% AEP; 1 m SLR & 15% increase in riverine flows + 0.6 m freeboard
Flood Construction Level (FCL)	This is used to establish the elevation of the underside of a wooden floor system or top of concrete slab for habitable buildings, provided as an elevation in CVGD2013.	Mid-term Future – Less Likely Event plus freeboard	0.5% AEP; 1 m SLR & 15% increase in riverine flows + 0.6 m freeboard

4.3.2 Flood Consequences

Consequences to floods can vary widely – from direct/tangible consequences to indirect/intangible consequences (see Section 2.1.2.1). They can also affect different assets valued by society. Based on national and international guidance, six receptors were selected to capture these different assets (see Section 2.1.2.2 for descriptions). In a risk assessment, where direct measures are not possible to characterize a receptor, proxies can be used. A proxy is a measurable quantity (e.g., number of affected people, or buildings in a floodplain) that is a reasonable representation of a receptor, based on a set of assumptions. The datasets used to measure each of the receptors, as well as related assumptions and limitations are summarized in Table 4-5; details are provided in Appendix B. Note that for all future scenarios, current exposure input data was assumed (i.e., not considering changes to population and land use, as these are also explored as part of the risk mitigation/option analysis).

Table 4-5: For each receptor, proxies, datasets, assumptions, and limitations are provided. For further descriptions and detail, refer to Appendix B.

Receptor/Proxy	Dataset	Assumption	Limitations
Affected People			
Number of people in flood hazard extent	Building footprints from the City; number of people assigned to each residential building (adjusted for unit numbers), based on the 2021 census (Statistics Canada, 2021) and (BCA, 2022).	People are most affected where they live, and not in their work environment or recreation.	Assumption of an even distribution of people per unit. Census data dissemination areas size. Uncertainty associated with the available BCA information and related parcel fabric. Does not include indirect impacts on people outside the hazard extent.
Mortality			
Associated fraction of number of affected people	Mortality fraction of approx. 0.01% (Public Safety Canada, 2022)	Fatalities can be estimated based on observed events (flooding due to structure failure).	Does not consider individual site and event characteristics, which differ widely, nor warning time, evacuation, etc. High-level estimate only. Depends on affected people estimate, i.e., same limitations.
Economy			
Building value in flood hazard extent	2022 BC Assessment Authority (BCA) data (BCA, 2022) Building footprints (City, 2022)	Damage occurs to the whole building (total building value).	Does not consider other potential direct and indirect economic losses. Uncertainty associated with building footprints, BCA data, and parcel fabric.

Receptor/Proxy	Dataset	Assumption	Limitations
Agricultural Area in flood hazard extent	Annual Crop Inventory (ACI) 2021 (Agriculture and Agri-Foods Canada (AAFC), 2021) For consequence mapping: Agricultural Land Reserve (ALR); (Province of British Columbia, 2022)	Damage to agricultural land.	No economic data/crop data attributed. Canada-wide layer obtained from remote sensing – there are uncertainties at the local scale.
Environment			
Location of contamination sources in flood hazard extent	Contaminated sites (City 2022 data package)	Damage leads to contamination of flood waters, with negative consequences for sensitive ecosystems.	Not all local contamination sources were captured in the datasets (e.g., no septic systems). No differentiation between different contamination source types.
Area of Sensitive Ecosystems in hazard extent	BC Data Catalogue (Province of British Columbia, 2022): Species and ecosystems at risk, conservation lands, groundwater wells, greenspaces; City (2022) data	Flooding has negative effects on ecosystems due to contamination of floodwaters.	Not all sensitive ecosystems are captured in provincial database, especially species at risk distribution might be wider than indicated in spatial dataset.
Culture			
Cultural sites in hazard extent	BC Data Catalogue (Province of British Columbia, 2022): Civic facilities, childcare, education (schools K12, post-secondary) Archaeological and Heritage Sites (MFLNRORD, 2022): Heritage Sites, Indigenous archaeological/ traditional use sites City (2022) data:	Cultural sites can indicate consequences to the culture of a community.	Proxies for cultural consequences cannot capture intangible consequences of cultural impacts. Not all local cultural sites may be captured, and data uncertainties/inconsistencies exist. Building locations (point files) in the datasets were associated with the nearest building footprints, an assumption which might not always be accurate, depending on data quality. Archaeological dataset may not be complete.

Receptor/Proxy	Dataset	Assumption	Limitations
	Trails, greenways, City buildings, cultural buildings		
Critical Infrastructure			
Location of critical facilities in flood hazard extent	BC Data Catalogue (Province of British Columbia, 2022): First responders, local government offices, hospitals, airparks, food banks ICI Society Data (ICI, 2022): BC Hydro Substations City (2022) data: Critical Facilities List	Flood damage to critical facilities.	Some local critical facilities might not be captured. Building locations (point files) in the datasets were associated with the nearest building footprints, an assumption which might not always be accurate, depending on data quality.
Location of line/point features of basic services in flood hazard extent	ICI Society Data (ICI, 2022) BC Hydro and Fortis distribution poles; BC Hydro and Fortis transmission structures; Telus and Shaw telecommunication facilities (pedestals) City (2022) data: Roads	Damage or interruption of roads and railways. Damage to overhead electrical poles (underground features assumed to not be affected).	Damage to overhead electrical poles might be limited due to flooding but is included for a conservative approach.

Based on standardized consequence confidence ratings (see Appendix B), the following confidence ratings were assigned for the consequence data, drawing on a 5-scale categorical rating (very low, low, moderate, high, very high) (Table 4-6).

Table 4-6: Assigned consequence confidence ratings for each receptor and rationale for this project.

Receptor	Confidence Rating	Rationale
1. Affected People	*Moderate*	Dissemination area (i.e., local data) is available, which can capture primary consequences, but some uncertainties/ inconsistencies exist in the data.
2. Mortality	*Low*	Only a very uncertain method exists to estimate mortality.

Receptor	Confidence Rating	Rationale
3. Economy	*High*	A detailed local and up-to-date (BCA 2022) dataset exists, which captures the primary economic consequences, albeit not all direct and indirect consequences.
4. Environment	*Low*	While available contamination sources data is relatively reliable, not all contamination sources are included. Further, many more tangible and intangible consequences may exist.
5. Culture	*Low*	While provincial and local cultural sites datasets exist, some uncertainties/ inconsistencies exist in the data, e.g., not all Indigenous archaeological sites may be captured. Further, this proxy can only capture a small part of the tangible/intangible consequences to the cultural of a community.
6. Critical Infrastructure	*Moderate*	Relatively reliable data exists, which can indicate the primary critical infrastructure consequences. However, the cascading consequences may not be captured.

Flood consequences were assessed by identifying the assets located within the flood hazard extents of the 20 scenarios. For two scenarios (present-day - likely and mid-term future - less likely), flood consequence maps were developed (Appendix C). Note that no consequence map was developed for mortality, as the spatial distribution is exactly the same as for the Affected People map (mortality is estimated as a percentage of affected people numbers), and the total mortality estimates are so small, that showing a spatial distribution would not be meaningful.

Note that the mid-term future - less likely scenario plus freeboard defines the regulatory floodplain (and the flood fringe is the difference between the extent of the regulatory floodplain and the floodway; see Section 4.3.1.3). However, in the context of the consequence and risk assessment, the flood extent of the scenario is considered without the freeboard for consistency with all the other modelled flood scenarios that were included in the risk assessment. It is a complex process to develop flood extent maps that include freeboard (i.e., an additional 0.6 m elevation is added to flood water surface elevations and the respective larger flood extent is developed). Therefore, the flood hazard data provided for this project only included the freeboard for selected scenarios (0.5% AEP for four time periods), not the whole range of 20 scenarios that was considered in the risk assessment.

In addition to the Affected People estimates, intersectional disadvantages (social vulnerability) were mapped. The Canada Social Vulnerability Model from Natural Resources Canada (NRCan), based on the 2016 census data, was adopted. The regional Social Vulnerability Index (SVI) assessment system utilizes four thematic categories, each represented by a specific set of indicators (Journeay et al., 2022), including Social Capital, Individual Autonomy, Housing Conditions, and Financial Agency. These are then consolidated into a composite SVI.

For details on the dataset and processing, see Appendix B.

4.3.3 Flood Risk

While consequence maps provide key spatial information for selected scenarios, they do not capture the full range of potential flood events nor factor in the likelihood of those events. As a result, while they can give a useful snapshot of potential risk in specific scenarios, they may not provide a comprehensive understanding of the full range of risk. We therefore also developed exceedance probability curves ('risk curves'), which relate the hazard likelihood (i.e., AEP) with an associated consequence, such as the number of affected people (Figure 4-5). We developed risk curves for each receptor for each of the four time periods, by linearly interpolating between the five likelihoods for each time period. Next, we calculated the average annual loss (AAL) (sometimes referred also as expected annual damage (EAD)), which is the "long-term expected loss on an annualized basis, averaged over time" (UNDRR, 2017a). The AAL describes the average expected loss over a long period, which takes into account frequent events with potentially little loss, as well as infrequent events with potentially larger losses. In other words, AALs are an estimate of annual impacts averaged over a very long time. In terms of dollar values, the AAL could represent the "amounts of funds that need to be put aside annually in order to cumulatively cover the average disaster loss over time" (UNDRR, 2017a). The AAL refers to the total risk (or full statistical risk), as a product of likelihood and consequence for each possible likelihood and is calculated as the total area under the risk curves.

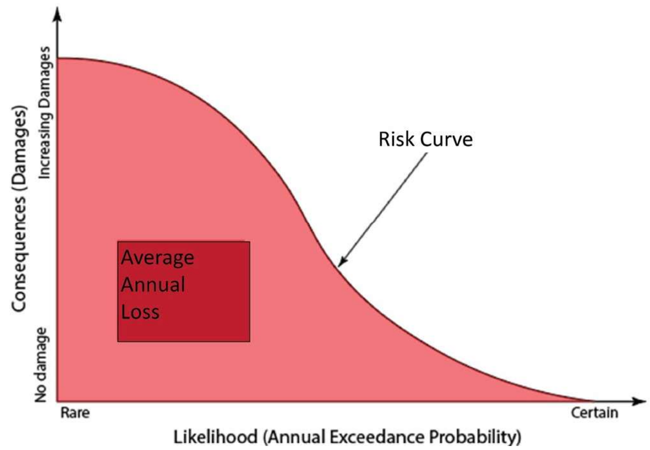

Figure 4-5: Example of a risk curve (exceedance probability curve), and AAL (average annual loss) calculated as area under the curve.

4.4 Steps 4-7: Develop, Compare, and Refine Local Area Options and Recommend Flood Management Strategies

Given the diversity of hydraulic and hydrodynamic as well as land use characteristics in the City, we divided the City into six local areas. A range of options was then developed for each local area, based on the PARAR framework, which includes *Protect*, *Accommodate*, *Retreat*, *Avoid*, and *Resilience-Building* Strategies (see Section 2.3.1 for descriptions). These options were associated with performance measures, as discussed in Section 4.2, as well as in Appendix B. Note that quantitative AAL calculations applied mostly to *Protect* options and *Retreat* options. For *Accommodate* options, generally a moderate effectiveness was assumed, given that these options can reduce some risk, but not all. Note that *Avoid* and *Resilience-building* options were not evaluated as part of the strengths and weaknesses tables for local areas, as they are generally recommended city-wide.

Based on the performance measures, local options were compared and preliminary options presented in the public survey and partner workshop (see next Section 4.5). Following these engagement activities, recommendations were refined with input from various City staff departments as well as regulatory authorities.

4.5 Engage the Public and Partners Throughout

Public and partner engagement throughout the project was key. Early on in the project, a detailed communications and engagement strategy was developed with the City. The City defined in particular the following objectives for engagement:

- Ensure flood information is publicly accessible and understandable.
- Facilitate the feedback required to complete the flood management plan.
- Get public feedback on the proposed flood management options and collect data that is needed to inform the recommendations.
- Identify the preferred approach to reduce flood risk, and the associated actions required for implementation.
- Build knowledge to enable property owners to take action to reduce the flood risk at their property.
- Build public, staff, and council support for the actions required for the City to reduce flood risk.

4.5.1 Engagement & Communications Strategy

Based on the objectives, the Engagement and Communications Strategy consisted of three phases:

Phase 1: Raise Awareness

Raise profile of the project, introducing residents, community members and partners to the project and coastal and riverine flood adaptation concepts and best practices.

Phase 2: Assess, Review & Refine

Gather input to risk assessment and feedback on a proposed range of flood risk reduction and resilience options. Identify the preferred approaches and associated actions for the City to take.

Phase 3: Report Out

Provide information to the public and decision-makers about the chosen approach for the City and what can be done by individual property owners.

Table 4-7 summarizes key activities in each phase. Note that substantial efforts were expended by the consultant team and the City staff team to reach out to K'ómoks First Nation, but due to capacity issues, they were not able to engage Chief and Council throughout the project (one staff member attended the workshop however).

Appendix D provides the backgrounders produced, and Appendix E provides the public survey results.

Table 4-7: Overview of engagement activities.

Activity	Target Audience; Details
Phase 1: Raising Awareness	
Council Lunch 'n' Learn	City of Courtenay Mayor and Council; online discussion.
Reach out to K'ómoks First Nation	K'ómoks First Nation Chief and Council
Dedicated webpage on City website: **www.courtenay.ca/floodready**	Public
Backgrounders: Flood Risk & Resilience Ways to Take Action	Public
Informational pamphlet (mail out)	Residents, commercial businesses and property owners in the floodplain. Distributed to 181 commercial addresses and 1,178 residential addresses in June 2023 by the City. Note: In multi-family buildings, information was sent to each unit.

Activity	Target Audience; Details
Public communications campaign	Public Social media (15-20 posts on Facebook, Twitter and Instagram) Media release (1) Newspaper ads (2, advertising opportunities for public participation) E-newsletters and distribution list (2)
Internal meeting with City staff to provide input to draft proposed flood management options	Staff. Online discussion
Part 2: Assess, Review, Refine	
Survey 1: Flood impacts survey	Staff and Community Partners Public
Options & Trade-offs Workshop, in person	Staff and Community Partners City staff
Information Session, online Survey 2: Proposed Flood Management Options Survey	Public
Phase 3: Reporting Out	
Council Meeting	City Council & Mayor
Overview of Flood Management Plan (including recommendations) as public communications document for website etc.	Public

4.5.2 Details for Key Engagement Components

4.5.2.1 Public Survey 1: Flood Impacts

Survey 1 aimed to raise awareness of the project while gathering background information relating to flood impacts and values from a wide range of participants. The survey was available online or in print version from May 1st – 24th 2023, and was promoted through the public communications campaign, including direct emails and social media. 112 responses were received for survey 1, with 64 of those participating to the end of the survey and 48 exiting the survey prior to the end. The maximum number of individuals responding to a given question was 85.

4.5.2.2 Public Survey 2: Proposed Flood Management Options

Survey 2 was administered in June and July 2023. The survey was available online or in print version from June 20 to July 17, and was promoted through print and online media, including 2 newspaper advertisements. The social media posts advertising the survey were "boosted" (a paid service) to ensure greater reach. This was a longer survey that shared proposed flood management options that were "city-wide" as well as those that were specific to each local area in flood hazard areas. Participation in Survey 2 was supported by an online information session (live on Zoom, and as a recording that was posted on the webpage). 217 responses were received for survey 2, with 67 of those participating to the end of the survey and 150 exiting the survey prior to the end. For questions providing feedback on proposed options, between 48 and 79 people responded, with participation rates dropping as the survey progressed.

4.5.2.3 Staff and Community Partners Workshop

An in-person workshop was held on 15 June 2023 at the Courtenay Fire Hall. City of Courtenay staff and other community partners were invited to attend the workshop, and 25 attended. Participants included local government (City of Courtenay, Comox Valley Regional District, Town of Comox), K'ómoks First Nation (staff), local environmental groups (Project Watershed, river stewardship and restoration societies), local engineering firms, and others relating to transportation infrastructure (Ministry of Transportation and Infrastructure, Mainroad Group) and emergency management (Comox Valley Emergency Program, Comox Valley Search & Rescue). Participants were arranged in small groups and reviewed information providing background and detailed information on the suites of proposed flood management options for each of the six local areas. Participants provided additional detail regarding the conditions or context in each local area, as well as thoughts on strengths and weaknesses of the proposed options.

4.6 Project Limitations

The approach and analysis for this project included a range of limitations:

- **Indigenous Engagement:** A major limitation to this project is that only limited engagement with the K'ómoks First Nation was possible, due to capacity limitations from the Nation.
- **Hazard Data:** Limited focus on riverine, coastal, and combined riverine-coastal flooding, along the Tsolum, Puntledge and Courtenay Rivers and Comox Estuary within the City of Courtenay boundary, while other types of flood hazards were not included. Uncertainties are also associated with the original hazard data, in particular for coastal data (see Section 4.3.1.2 and Appendix B).
- **Risk Assessment:** Limitations associated to consequence data uncertainties, see Section 4.3.2 and Appendix B, as well as the hazard data uncertainties referenced above. There were also specific limitations to processing of parcel and BC Assessment data, leading to uncertainties for affected people and economy estimates in particular (see Appendix B for details).
- **Options Analysis:** Limitations associated to performance measure estimates and calculations (in some cases, only high-level estimates were possible), see Appendix B. These include

limitations to AAL estimates, uncertainties related to input data (see above), and that scoring of quantitative measures was performed comparatively to baseline, i.e., results are sensitive to result numbers. Lastly, qualitative performance measures relied on expert knowledge and other guidance. Further, not all possible options may have been considered.

5 Flood Risk in the City of Courtenay

A key step for identifying flood management strategies is to first look at risk, i.e., who/what may be impacted by flooding now and in the future, and how likely is this to occur? This chapter provides a detailed quantitative flood risk assessment with a focus on city-wide risk (noting that local risk details are discussed in Chapter 6) combined with qualitative impact information received from the public survey. The chapter closes with a summary of the quantitative and qualitative information.

5.1 Quantitative Risk Assessment

This section includes a brief description of flood hazard maps for the City, and then summarizes the results from the quantitative risk assessment for the six risk receptors: Affected People, Mortality, Critical Infrastructure and Disruption, Economy, Environment, and Culture. Note that the analysis assumes present-day exposure into the future, and does not consider population growth, land use changes, or risk mitigation measures that may be taken in the future. This is to capture baseline risk, upon which then flood risk reduction measures are recommended to hopefully avoid such risk into the future (see Chapters 6 and 7).

5.1.1 Flood Hazard Overview

As discussed in Section 4.3.1, the CVRD Flood Hazard Mapping (Kerr Wood Leidal Associates Ltd., 2021) was used as input information for the risk assessment. Flood depth classification represents different thresholds for impacts to buildings (Figure 5-1), based on Ebbwater (2022). Figure 5-2 and Figure 5-3 visualize flood depth for two scenarios (present-day - likely and mid-term future - less likely).

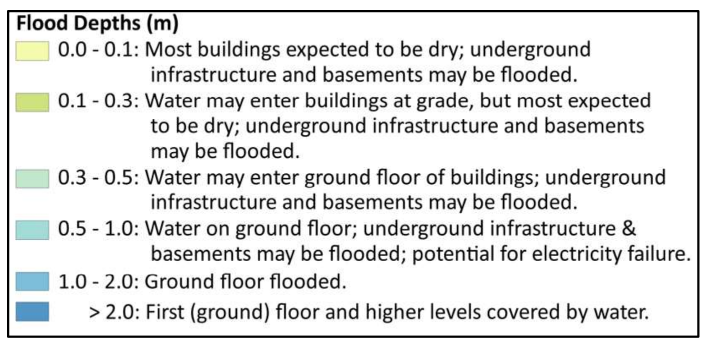

Figure 5-1: Flood depth classification, based on Ebbwater (2022).

Even for the present-day - likely scenario, flooding can be expected for the City, in particular along the Tsolum River, in parks along the Puntledge River, in the Lewis Park/Ryan Road Commercial Area, and in the Courtenay Flats agricultural area (Figure 5-2). Flood depth is dominantly below 0.5 m, but does reach between 0.5-1.0 m for some areas in the Ryan Road Commercial Area, as well as even higher depth along the Tsolum River and parts of the Courtenay Flats.

For the mid-term future - less likely scenario, flood extents are larger, including now also areas behind the Canterbury Lane Dike, and more area along the coast (Figure 5-3). Flood depth is also substantially increased, and in many areas between 1.0-2.0m, or even above 2.0 m.

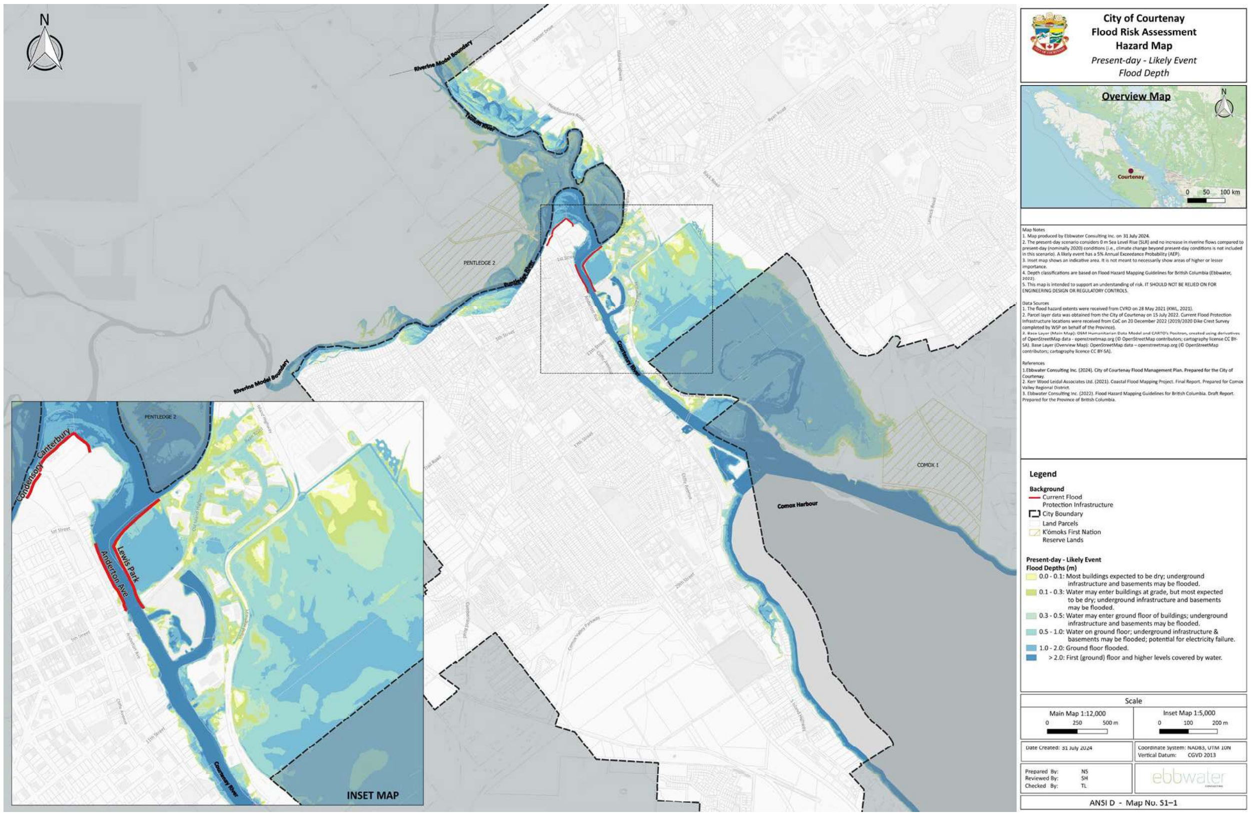

Figure 5-2: Present-day likely (5% AEP) scenario, indicating flood depth for the City of Courtenay, based on (Kerr Wood Leidal Associates Ltd., 2021). Refer to map book in Appendix C for full-sized (ANSI D) maps.

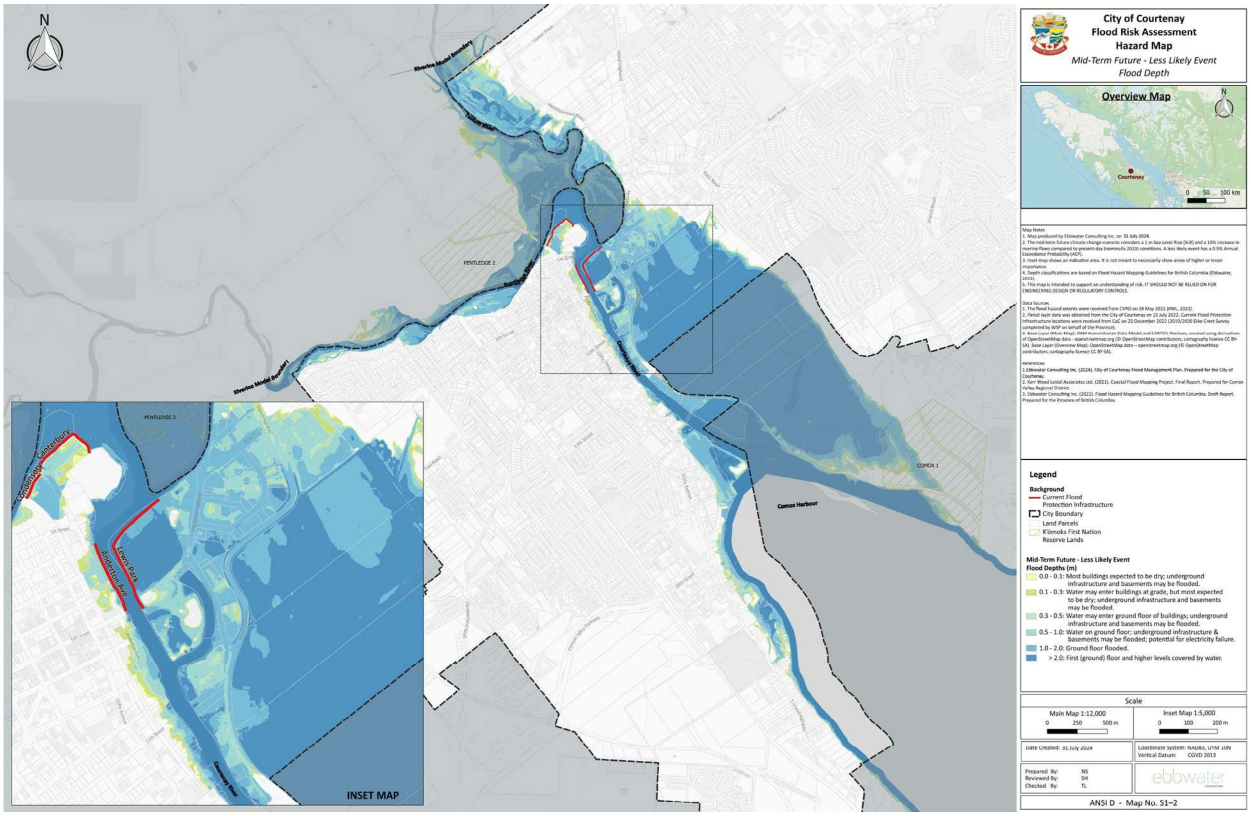

Figure 5-3: Mid-term future - less likely scenario (considering 1 m SLR and 15% increase in riverine flows for the 0.5% AEP), based on (Kerr Wood Leidal Associates Ltd., 2021). Refer to map book in Appendix C for full-sized (ANSI D) maps.

5.1.2 Consequence and Risk to Affected People

This receptor portrays the number of people who are directly affected by a flood. This may include people who are injured or suffer other health effects, are evacuated or displaced, or suffer direct damages to their livelihoods (e.g., their house is damaged). We also include a very high-level estimate for mortality, which is generally very low for riverine and coastal flooding in Canada (see also Appendix B for methods). Note that the numbers provided here focus on directly affected people, whose primary residence (as per Census 2021 data) was within a flood hazard extent. Floods can also have wide-reaching indirect impacts on people, for instance, when critical infrastructure failure leads to cascading consequences throughout the society, or transportation becomes disrupted due to flooded roads (potential critical infrastructure consequences are discussed in the next Section 5.1.3).

Flooding will impact many people across the City, as indicated in Figure 5-4 for the mid-term future - less likely scenario. In this scenario, those most impacted are located behind Canterbury Dike, along the Puntledge River, downstream of the Tsolum River, and along the Cliffe Avenue Corridor. The number of impacted people increases from a likely to a less likely scenario, but in particular with climate change (rising sea levels and increasing river flows) into the future (Table 5-1). These are estimates and are inherently uncertain. Note that these numbers are based on Census data and do for instance not include people living in Mobile Home Parks (see also Section 6.3). The analysis also does not take population growth into account, i.e., if no risk reduction measures are implemented and population growth in the floodplain continues, the number of affected people in the future may even be higher.

Table 5-1 also indicates mortality estimates for each scenario. These are calculated as a percentage of affected people, and the spatial distribution throughout the City is therefore the same for this simplified approach as for the affected people consequence map shown in Figure 5-4. Given this, as well as the very low mortality estimates, no separate mortality consequence map was developed. Note that mortality estimates do not consider individual site and event characteristics, which differ widely, nor warning time and evacuation procedures and are a high-level estimate only. However, generally in Canada, mortality rates due to flooding remain statistically low[23].

[23] Here, a mortality fraction of approx. 0.01% (Public Safety Canada, 2022) was assumed, see also Section 4.3.2.

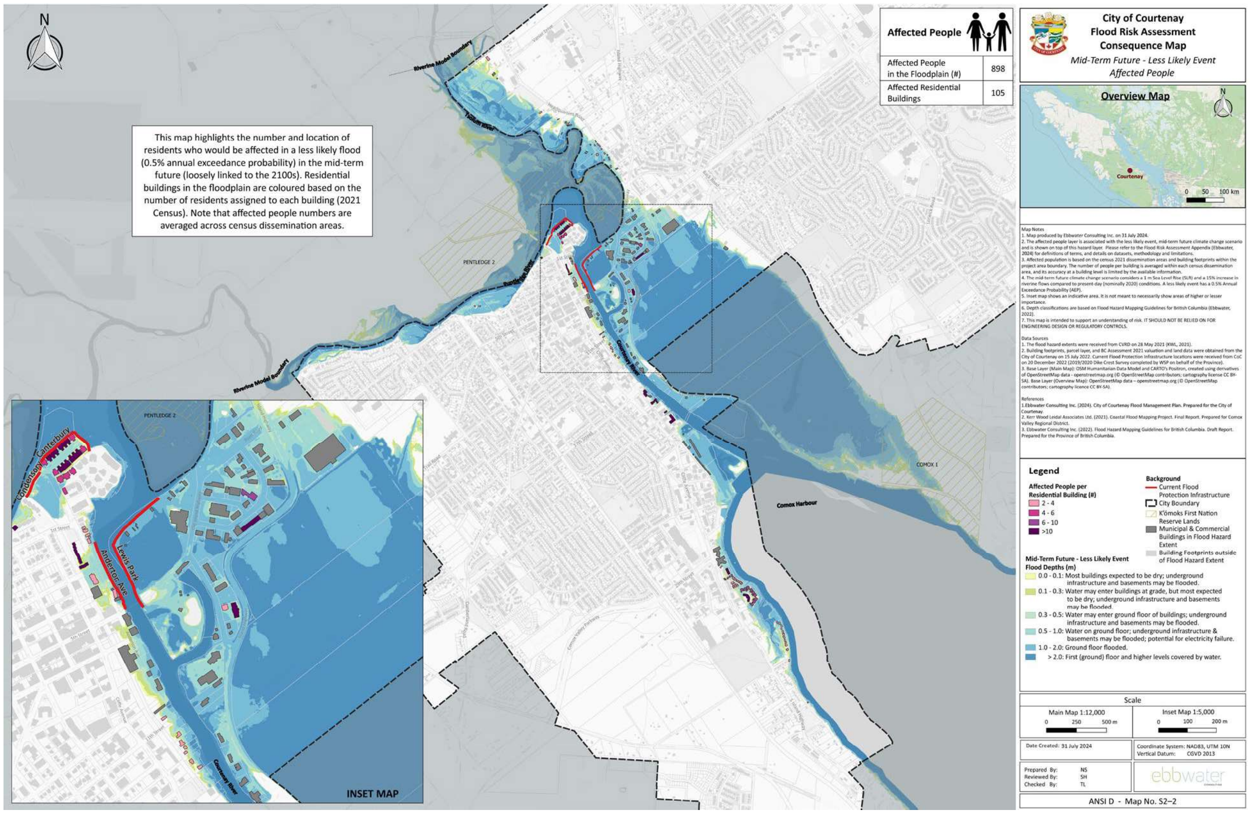

Figure 5-4: Consequence map for Affected People for the mid-term future - less likely scenario (0.5 % AEP, 1 m SLR/15% increase in riverine flows). Refer to map book in Appendix C for full-sized (ANSI D) maps.

Table 5-1: Number of people affected (rounded) as well as a mortality estimate for four scenarios. Note that mortality is very low, and all estimates are below 1 (loss of life may still occur).

Scenario	Affected People (#)	Mortality estimate (#)
Present-day - Likely	290	0.13
Present-day - Less Likely	320	0.14
Mid-term Future - Likely	660	0.29
Mid-term Future - Less Likely	900	0.40

Risk is the combination of flood consequences and the likelihood for a flood hazard to occur. We portrayed full statistical risk (i.e., risk for many likelihoods) by developing exceedance probability curves (risk curves) for the four time periods, indicating the number of affected people for different likelihood scenarios from a more frequent but smaller flood (10% AEP) to a rare but large flood (0.2% AEP) (Figure 5-5). Through interpolation between data points, the risk curves also provide estimates of affected people for each AEP of interest by reading the figure from the x-axis (AEP) to the y-axis value (affected people) for each of the 4 curves. Or, the curves can inform the other way around (i.e., reading from y-axis to x-axis), on how likely it would be that a specific number of people would be affected by a flood event.

A more frequent (e.g., 5% or 10% AEP) flood is typically associated with a smaller magnitude (smaller flood extents, lower flood depths) than a rare flood (e.g., 0.5% AEP). This is also visualized in the risk curves, as the number of affected people is higher for smaller AEP values (less likely to rare) than for higher AEPs.

The curves in Figure 5-5 visualize how even a frequent (10% AEP) event in the future may impact more people than a rare (0.2% AEP) event today. The figure also highlights tipping points (i.e., substantial increases in risk) for more consequences, where sudden changes occur along the line. For instance, for any floods that may occur less frequently than a likely (5% AEP) flood in the near-future, the number of affected people suddenly increases. The number of affected people also increases dramatically in the long-term future.

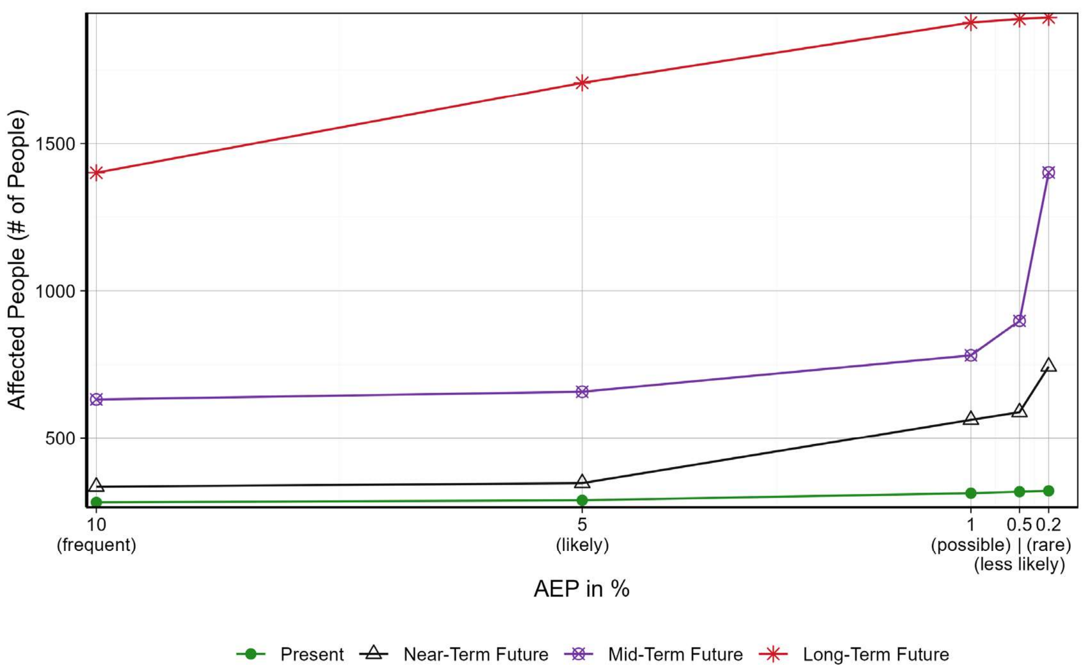

Figure 5-5: Risk curves for affected people for four time periods. The figure indicates how many people may be affected for different AEPs and time periods.

These curves can also be used to calculate total risk as the product of likelihood and consequence (calculated as the area under the curve, as all possible likelihoods are considered). This risk value is presented as an average annual loss (AAL), and in this case, describes the approximate long-term average of directly affected people on an annualized basis. For the present-day scenario, on average over a long time period, 60 people would be affected every year (Table 5-2.). Of course, this does not mean that every year, exactly 60 people are affected, but that potentially one year, many people are affected due to a catastrophic rare scenario, while the next year maybe none or only minor flooding occurs (resulting in a lower average over many years). As it is with statistics, it might also happen that two (seemingly) rare events occur in subsequent years. This possibility serves to remind us that just because a rare flood event has occurred in the near past, it does not mean that it will not happen again in the near future. In summary, these risk values have a mostly statistical meaning. But they do show that overall risk will increase dramatically with sea level rise, doubling from the present-day to the mid-term future, and increasing to almost six-fold from present-day to the long-term future (Table 5-2).

Table 5-2: Average Annual Loss (AAL) (risk) for four time periods, indicating how many people, on average over a long time, may be affected each year by flooding (rounded).

Receptor	Average Annual Loss (AAL)			
	Present-day	Short-term Future	Mid-term Future	Long-term Future
Affected People (#)	60	80	140	340

5.1.2.1 Intersectional Disadvantage (Social Vulnerability) Considerations

An important consideration when looking at people is the intersectional disadvantage (or social vulnerability) of some people, which will affect how well they can respond to a flood, and what the impacts may be. Certain individuals or societal groups are more prone to harm from exposure to hazards, directly affecting their ability to prepare for, respond to, and recover from disasters and crises. It encompasses a variety of factors including socio-economic status, demographic characteristics, health, and ability status, as well as many other social factors. Someone living in a modern home and with financial resources to cope with and recover from a flood will likely experience fewer impacts compared to someone who does not have these material conditions. Furthermore, an individual with more financial resources and freedom is more likely to have more agency to make choices that will reduce their exposure to natural hazards such as choosing where to live. Other factors such as age and ability may also make individuals more vulnerable to the impacts of a flood (see also Section 2.1.2.3). Taking into account social vulnerability when dealing with hazards is important as it can lead to less human distress and a decrease in the financial costs associated with post-disaster public assistance and social services (Flanagan et al., 2011).

Social vulnerability is visualized for the City of Courtenay in Figure 5-6, based on data from the Canada Social Vulnerability Model by NRCan (Journeay *et al.*, 2022), showing a composite index (SVI) that includes several physical and social characteristics, focused on vulnerability to natural hazards (see Section 2.1.2.3). While it is based on the 2016 Census data alone, and does not capture all aspects of social vulnerability, it provides a first spatial glance at social vulnerability.

Figure 5-6 shows social vulnerability within the flood extents of the long-term future rare (0.2% AEP) scenario (hatched light-blue area) and within the rest of the City to provide context, as the SVI is scaled relatively to the community. In the floodplain, social vulnerability ranges from moderate (light green) along the Courtenay River below 17th Street and South Courtenay, to considerable (light orange) within the Canterbury, Anderton, and Lewis Park Commercial Areas, as well as along the Tsolum River. A small section near the Old Island Highway/Headquarters Road intersection is also considered to have high social vulnerability (dark orange) (Figure 5-6). These more vulnerable populations must be considered in flood management actions, whether it is ensuring appropriate evacuation and recovery plans (e.g., providing transportation and planning for longer term shelter) or considering how some city-wide actions may not be easily implemented for equity-seeking populations.

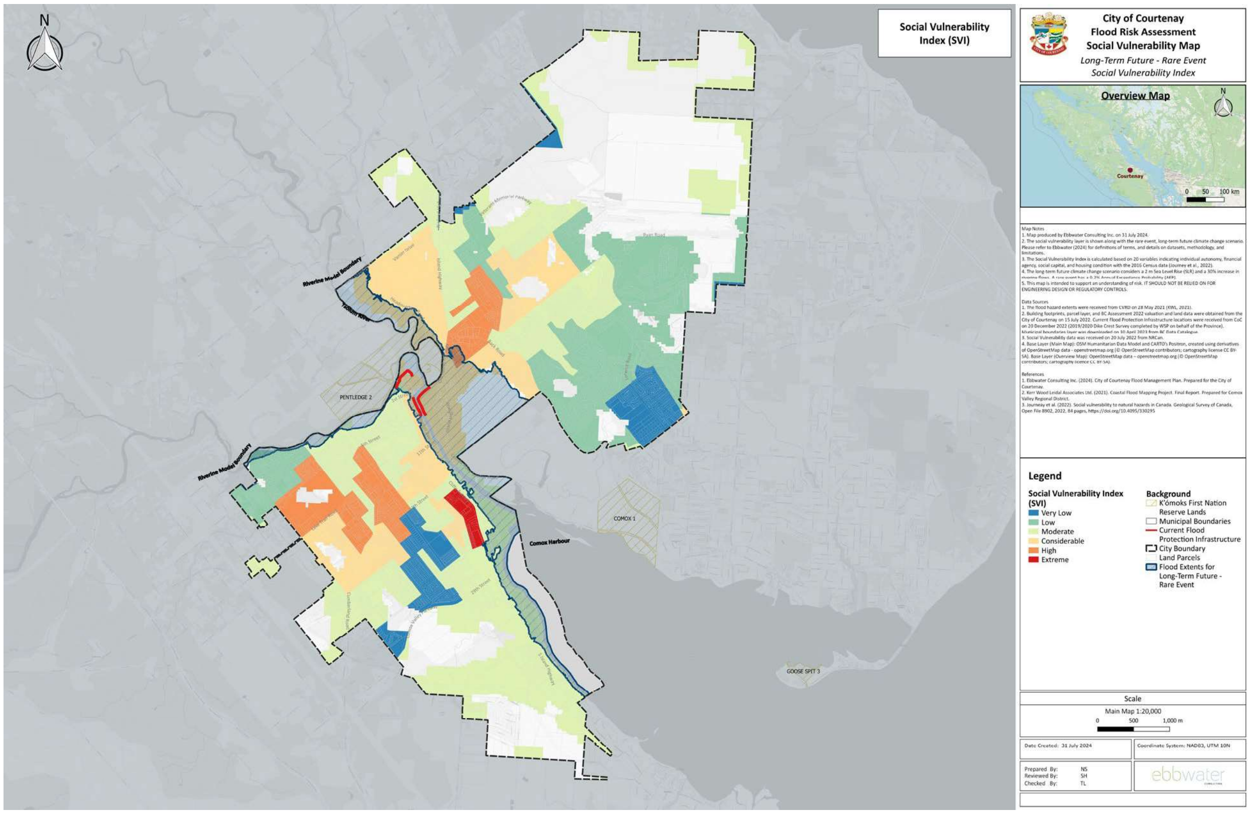

Figure 5-6: Social Vulnerability for the City of Courtenay, based on the Canada Social Vulnerability Model from NRCan (Journeay et al., 2022). The mapped Social Vulnerability Index (SVI) is the sum of four indicator categories, and flood extents of the long-term future rare (0.2% AEP) scenario are shown.

5.1.3 Consequence and Risk of Critical Infrastructure Failure and Disruption

This receptor describes consequences that can potentially have widespread cascading effects on society, such as damage to critical infrastructure (CI) and disruption of basic services. This can include damages to health facilities, emergency response facilities, government services, transportation infrastructure, roads, electrical systems, and more. Details on specific infrastructure facilities are provided in the Local Area sections in Chapter 6, but Figure 5-7 (next page) provides an overview of potential impacts to critical infrastructure and disruption for the mid-term future - less likely flood scenario city-wide. CI facilities in the floodplain include the airpark, sanitary sewer lift stations, a water distribution system, and others. The number of CI facilities increases from three in the present-day - likely scenario to eight in the mid-term future - less likely scenario (Table 5-3). Flooding may also impact electricity distribution poles, as well as two electrical transmission structures in the floodplain, along with telecommunication facilities (Table 5-3). Total road lengths in the flood extents ranges from ~3 km in the present-day - likely scenario to more than 6 km in the mid-term future - less likely scenario, including important connection and evacuation routes such as the Island Highway (Highway #19A) between 17th Street Bridge and Ryan Road.

Table 5-3: Critical infrastructure (CI) and disruption for four scenarios. Road length is provided in kilometres (km).

Scenario	CI Facilities (#)	Distribution Poles (#)	Trans-mission Structures (#)	Telecom facilities (pedestals) (#)	Total Road lengths (km)
Present-day - Likely	3	89	2	7	3.1
Present-day - Less Likely	5	126	2	9	5.5
Mid-term Future - Likely	6	133	2	10	5.7
Mid-term Future - Less Likely	6	165	2	10	6.5

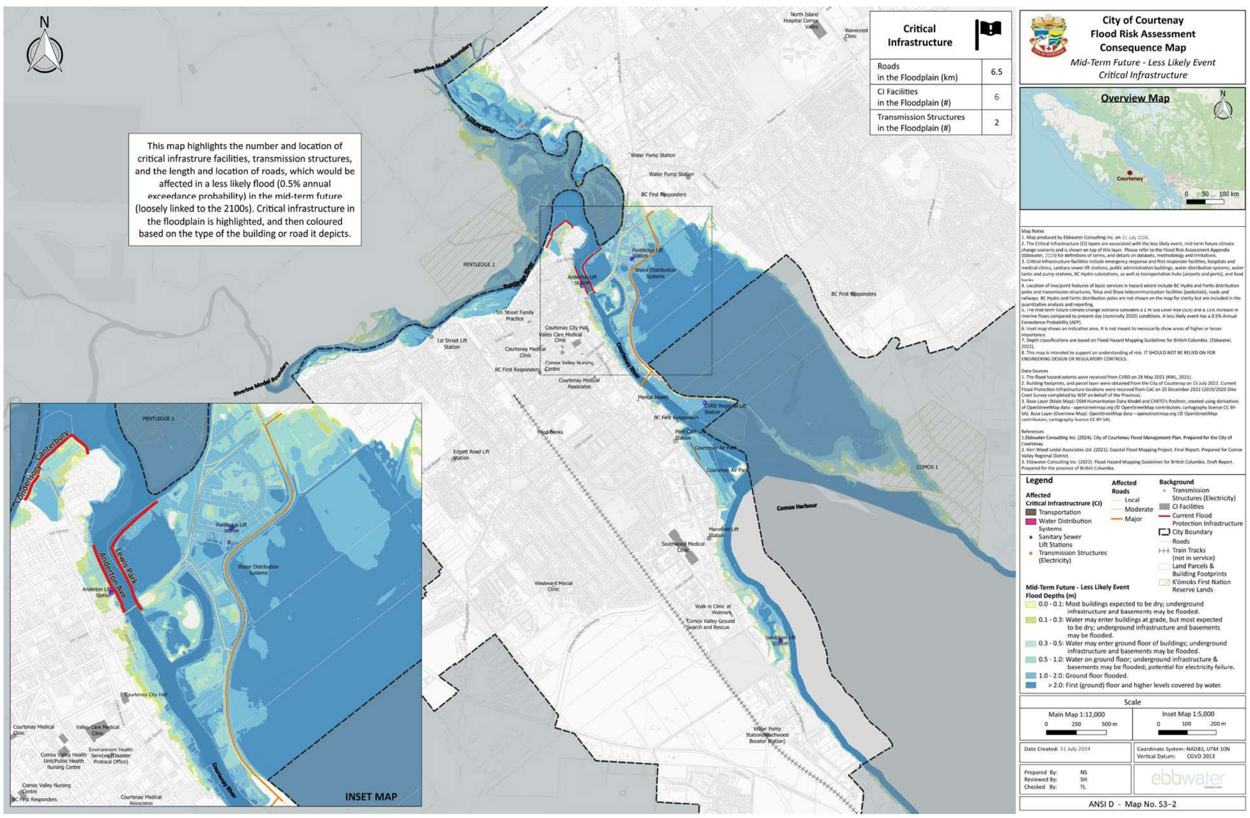

Figure 5-7: Consequence map for Critical Infrastructure for the mid-term future – less likely scenario (0.5 % AEP, 1 m SLR/15% increase in riverine flows). Refer to map book in Appendix C for full-sized (ANSI D) maps.

The risk curves show clearly that most CI facilities are already within the flood extent for a frequent event in the near future (Figure 5-8). And even during the present-day, starting at the possible likelihood scenario (1% AEP), many CI facilities are within the flood extent. Essentially, there are a number of CI structures that will be wet under rare conditions today, but that will be frequently wet in the near future and beyond.

Critical infrastructure does not necessarily fail (temporarily or permanently) when wet, the specific fragility (or vulnerability) of the CI structure will play a role in failure alongside the depth and duration of flooding. Flood depth and other characteristics for CI are discussed in more detail in the Local Area sections (Chapter 6). Lastly, Table 5-4 indicates that the AAL for CI increases from 0.7 to 1.6 in the mid-term future.

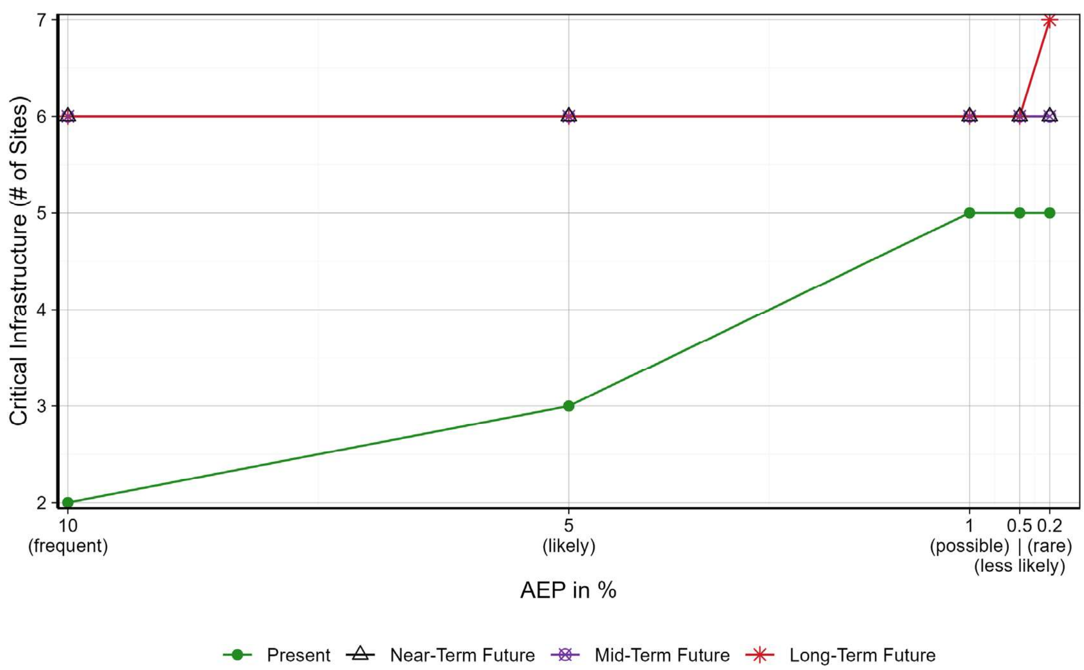

Figure 5-8: Risk curves for critical infrastructure facilities for four time periods.

Table 5-4: Average Annual Loss (AAL) for four time periods, indicating how many critical infrastructure (CI) facilities, on average over a long time, may be affected each year by flooding.

Receptor	Average Annual Loss (AAL)			
	Present-day	Short-term Future	Mid-term Future	Long-term Future
CI Facilities (#)	0.7	1.2	1.2	1.2

5.1.4 Consequence and Risk to Economy

This receptor describes potential economic (financial) loss resulting from a flood disaster. This can include direct damage and reconstruction costs for private and public buildings. As a proxy for direct economic consequences, we assessed the total building value exposed in the flood hazard area. This provided a conservative estimate for potential economic costs, as buildings may not be fully damaged by flood. This proxy is widely used as a receptor for economic loss across BC. Flooding may also impact agricultural businesses, and we provide the total agricultural area in the flood hazard area. Indirect economic consequences may also occur in a flood, such as emergency response costs and economic losses due to disruption of business operations. These were not assessed quantitatively but are discussed throughout this report.

Figure 5-9 shows that while economic consequences are spread-out throughout the City, there will be many buildings impacted in the Puntledge Road Commercial Area. This is because many businesses are located in this area, which is currently zoned for commercial uses and may either be impacted directly by damage to their property, or indirectly due to closure of roads and access, or critical infrastructure failure. From the present-day - likely flood scenario to the mid-term future - less likely scenario, the number of affected buildings more than doubles and total affected building value increases by threefold (Table 5-5). Much of the agricultural land within the City boundary is already located within the present-day - likely flood extents, but depth of flooding in agricultural areas increases substantially in the future (Figure 5-9; and Appendix C for present-day - likely flood map).

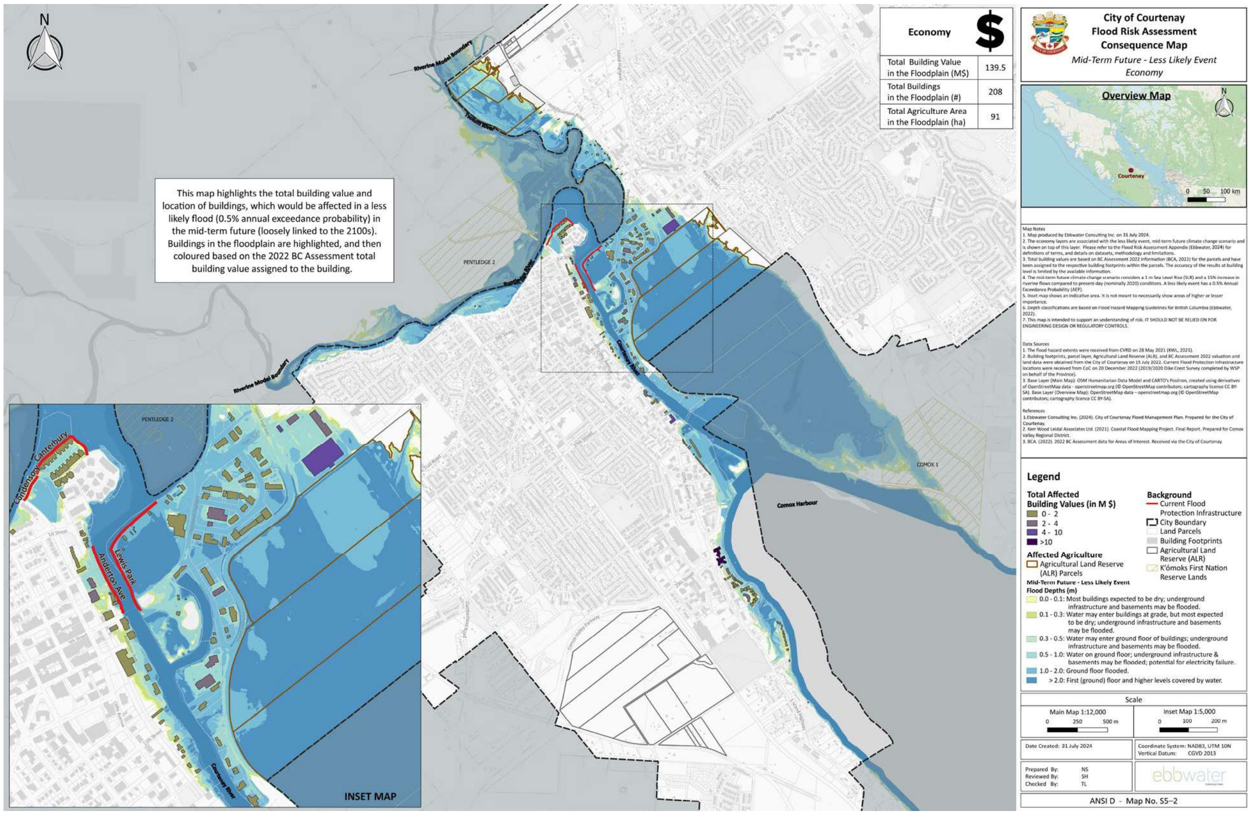

Figure 5-9: Consequence map for Economy for the mid-term future – less likely scenario, indicating the total building value exposed in flood extents, as well as agricultural area based on the Agricultural Land Reserve (ALR). Reported agricultural area in floodplain in hectares (ha) in map table is also based on ALR extents. Refer to map book in Appendix C for full-sized (ANSI D) maps.

Table 5-5: Estimates of potential economic consequences for four scenarios. Building values are shown in million Canadian dollars (M$) and agricultural land in hectares (ha). Note that for the analysis as represented in this table, agricultural land in flood extents is shown based on the Annual Crop Inventory (ACI) based on satellite imagery classification of crops (see Section 4.3.2), in contrast to ALR extents which are given in the map for easier public communication. ALR extents are larger, as not all ALR land may currently be cultivated with crops.

Scenario	Buildings (#)	Total Building Value (M$)	Total Land Value (M$)	Total Property Value (M$)	Total Agricultural Land - ACI (ha)
Present-day - Likely	96	42.3	44.2	86.5	57.0
Present-day - Less Likely	128	69.4	72.4	141.8	57.9
Mid-term Future - Likely	166	116	138.5	254.5	58.2
Mid-term Future - Less Likely	208	139.5	175.9	315.4	59.0

Risk curves for Economy indicate how consequences increase substantially into the future, where even the mid-term future likely events may have higher consequences than the present-day rare events (Figure 5-10). Similarly, the AAL increases by more than double from the present-day to the mid-term future, and by almost fivefold from present-day to the long-term future (Table 5-6). The high dollar numbers, that may be on average, exposed annually, sets any risk reduction and resilience measures discussed later on in this report into perspective, in particular, when thinking about the long-term (i.e., expensive flood risk reduction actions should be compared to potentially avoided financial costs of implementing them).

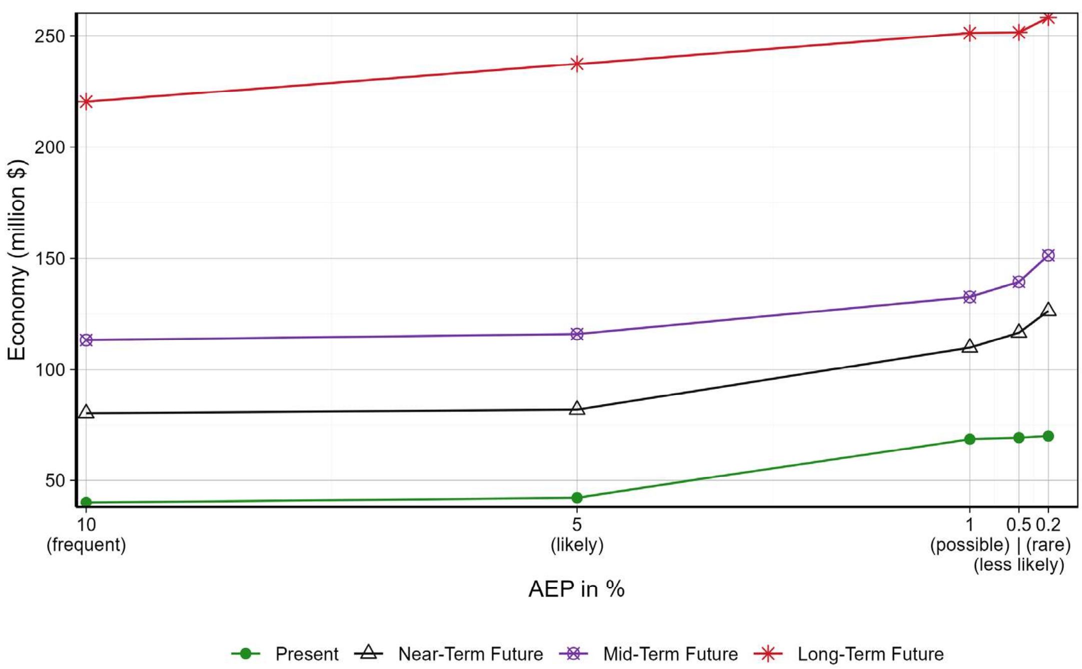

Figure 5-10: Risk curves for Economy for four time periods. The figure indicates how much total building value in million dollars ($) may be affected for different AEPs and time periods.

Table 5-6: Average Annual Loss (AAL) for four time periods, indicating how much total building value in million dollars ($) on average over a long time may be affected each year by flooding.

Receptor	**Average Annual Loss (AAL)**			
	Present-day	Short-term Future	Mid-term Future	Long-term Future
Economy (million $)	9.8	17.9	23.9	47.0

5.1.5 Consequence and Risk to the Environment

This receptor includes the overflow or discharge of contamination sources into the receiving environment, and the exposed environmentally sensitive areas that could be negatively affected by flood waters. While flooding is an important component of many ecosystems and is a naturally occurring process, the contamination of flood waters by anthropogenic sources as well as natural processes (e.g., erosion) can be detrimental to sensitive ecosystems. Figure 5-11 shows the spatial distribution of environmentally sensitive areas, as well as potential contamination sources in the City. Of concern are the many potential contamination sources within the Puntledge Commercial Area, in particular, as these are also upstream of the sensitive ecosystems of the Comox Estuary. These sources include auto dealers/repair shops, gasoline/diesel bulk plants and outlets, and other former/current industrial or commercial sites. Further contamination sources may also include fuel storage at private buildings, as well as septic systems (for which no quantitative data was available to include on maps and calculations). The number of contamination sources increases from the present-day to the mid-term future, along with the exposure of parks/greenspaces and sensitive environmental ecosystems (Table 5-7). It should be highlighted here that flooding of parks can be an effective risk mitigation strategy (see more in Chapters 6 and 7) and that flooding is a natural process for many ecosystems. However, the main concern here is contamination of flood waters, which can lead to detrimental consequences for ecosystems and human health (Ross *et al.*, 2021). There are also two groundwater wells within the mid-term future - less likely flood extents, which may be impacted, if contaminated flood water enters into the well and contaminates groundwater[24].

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[24] Groundwater wells were assessed based on the Provincial Groundwater Wells Registry (https://apps.nrs.gov.bc.ca/gwells/?map_centre=49.690357,-124.988785&map_zoom=12). Out of this database, only two groundwater wells were found to be within the largest flood extents assessed for this project (0.2% AEP, 2 m SLR/+30% increase in riverine flows). All other registered groundwater wells within the City boundary are not within the floodplain. Further information on the two wells located in the floodplain are provided in Chapter 6, specifically for Local Areas 3 and 4.

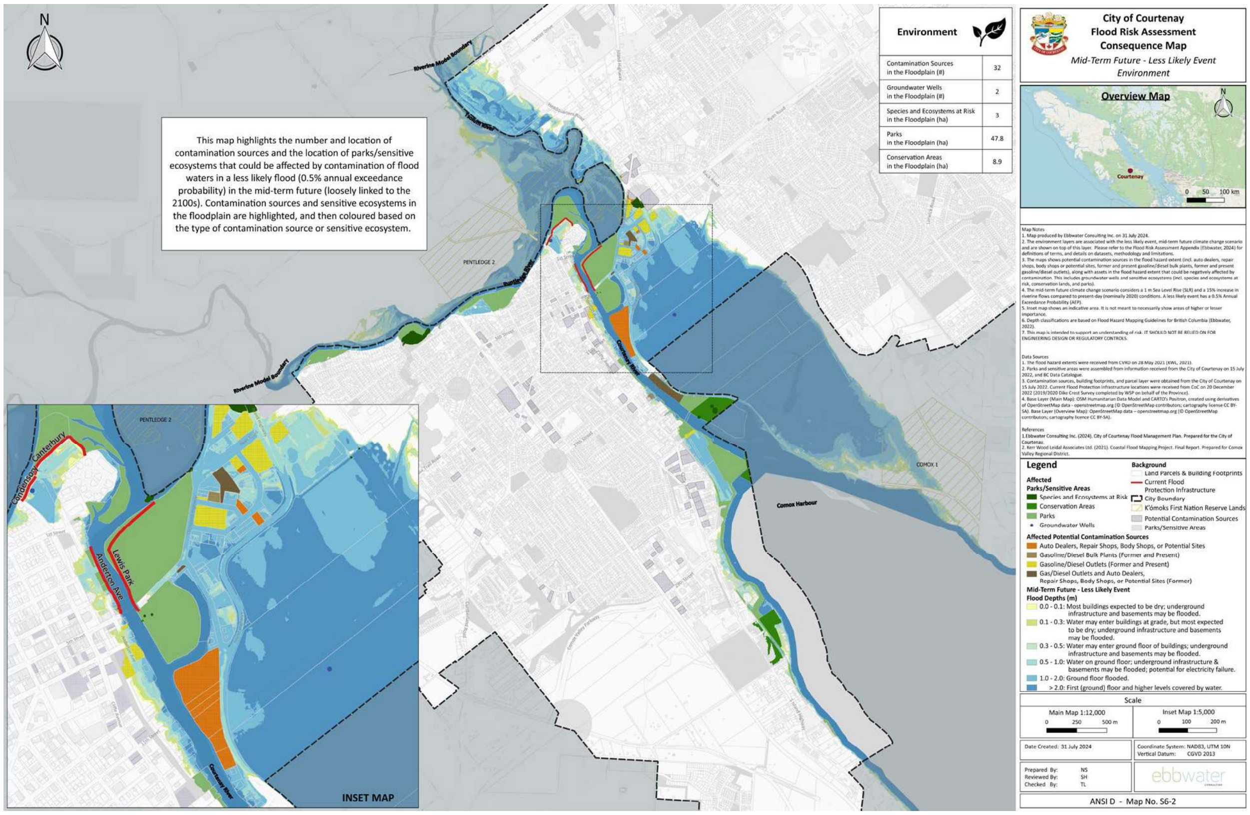

Figure 5-11: Consequence map for Environment for the mid-term future – less likely scenario (0.5 % AEP, 1 m SLR/15% increase in riverine flows). Refer to map book in Appendix C for full-sized (ANSI D) maps.

Table 5-7: The number of potential contamination sources and affected parks/environmentally-sensitive areas in hectares (ha) for four scenarios. Areas are provided in hectares (ha).

Scenario	Contamination Sources (#)	Species & Ecosystems at Risk Distribution (ha)	Greenspace & Parks (ha)	Conservation Lands (ha)	Groundwater Wells (#)
Present-day - Likely	26	2.1	40.7	6.8	1
Present-day - Less Likely	31	2.6	44.7	7.3	1
Mid-term Future - Likely	30	2.3	46.8	8.5	1
Mid-term Future - Less Likely	32	3	47.8	8.9	2

Risk curves highlight how even in the present-day, many contamination sources exist, and their numbers increase substantially between the likely and the less likely flood, i.e., one of the tipping points occurs for scenarios more extreme than the present-day - likely scenario (Figure 5-12). With climate change, these numbers become even higher, especially for the long-term future. A high number of contamination sources may be, on average over along time, impacted by flooding each year (Table 5-8). This is particularly concerning given the many sensitive ecosystems in the area. Note that the AAL shown in (Table 5-8) does not refer to annual flooding (i.e., small but frequent floods), but includes both extreme rare floods and small frequent floods in the calculation of a long-term annual average.

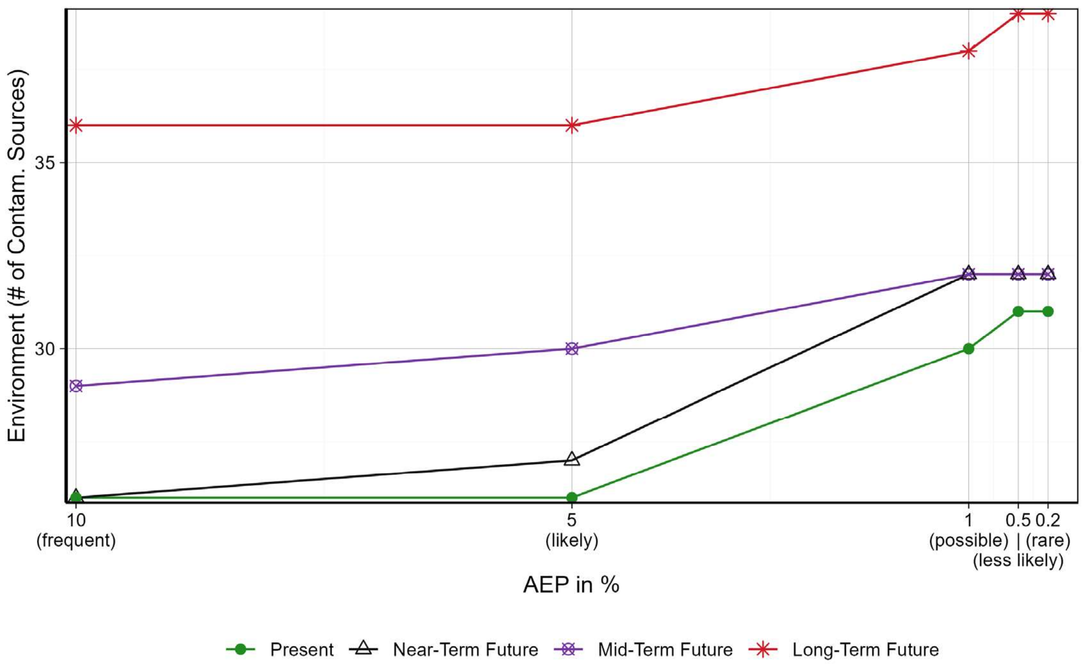

Figure 5-12: Risk curves for Environment for four time periods. The figure indicates how many potential contamination sources may be affected for different AEPs and time periods.

Table 5-8: Average Annual Loss (AAL) for four time periods, indicating how many potential contamination sources, on average over a long time, may be affected each year by flooding.

Receptor	Average Annual Loss (AAL)			
	Present-day	Short-term Future	Mid-term Future	Long-term Future
Environment (# of contamination sources)	5.4	5.6	6.0	7.3

5.1.6 Consequence and Risk to Culture

This receptor describes potential negative consequences of flooding to the cultural identity of a community. As proxies for the quantitative risk assessment, we assessed the number of publicly recorded cultural sites in the flood hazard area. These cultural sites can obviously only capture part of what forms the culture of a community, but they can provide an indication of potential cultural consequences of flooding. The cultural sites include educational facilities, municipal buildings, recreational facilities, heritage sites, as well as archaeological and heritage sites (including publicly documented Indigenous archaeological and traditional use sites) (Figure 5-13). Note that Indigenous archaeological sites are not shown on the map, as it is sensitive information that cannot be distributed publicly; they are however included in the aggregated risk calculations.

The majority of the indoor recreational assets of the City (the Lewis Recreation Centre, the Florence Filberg Centre, and the LINC Youth Centre) are located within the floodplain, along with the outdoor pool (Memorial Outdoor Pool at the Lewis Centre), as well as other outdoor assets. While many of the outdoor assets can be replicated elsewhere or other locations used, there are no alternatives to indoor recreational assets such as the Lewis Recreation Centre and LINC Youth Centre.

Table 5-9 shows that already in the present-day - likely scenario, 14 community buildings, as well as 11 Indigenous archaeological sites, along with four heritage sites and one post-contact site may be impacted. These numbers further increase for the mid-term future - less likely scenario. There are also many kilometres of trails and greenways potentially impacted by flooding. These results are of particular concern, as many cultural sites exposed to flooding are Indigenous archaeological sites from before the arrival of European settlers, and therefore, constitute very valuable and irreplaceable cultural heritage. Some of these sites are indicated as located in the subsurface, but flooding and erosion could nevertheless lead to the potential damage of these sites.

The City staff reviewed the related consequence maps, to support in the identification of most, if not all, local cultural sites within the floodplain. However, note that a major limitation to this project is that only limited engagement with the K'ómoks First Nation was possible, due to capacity limitations, and many more sites of cultural importance to the Nation may exist.

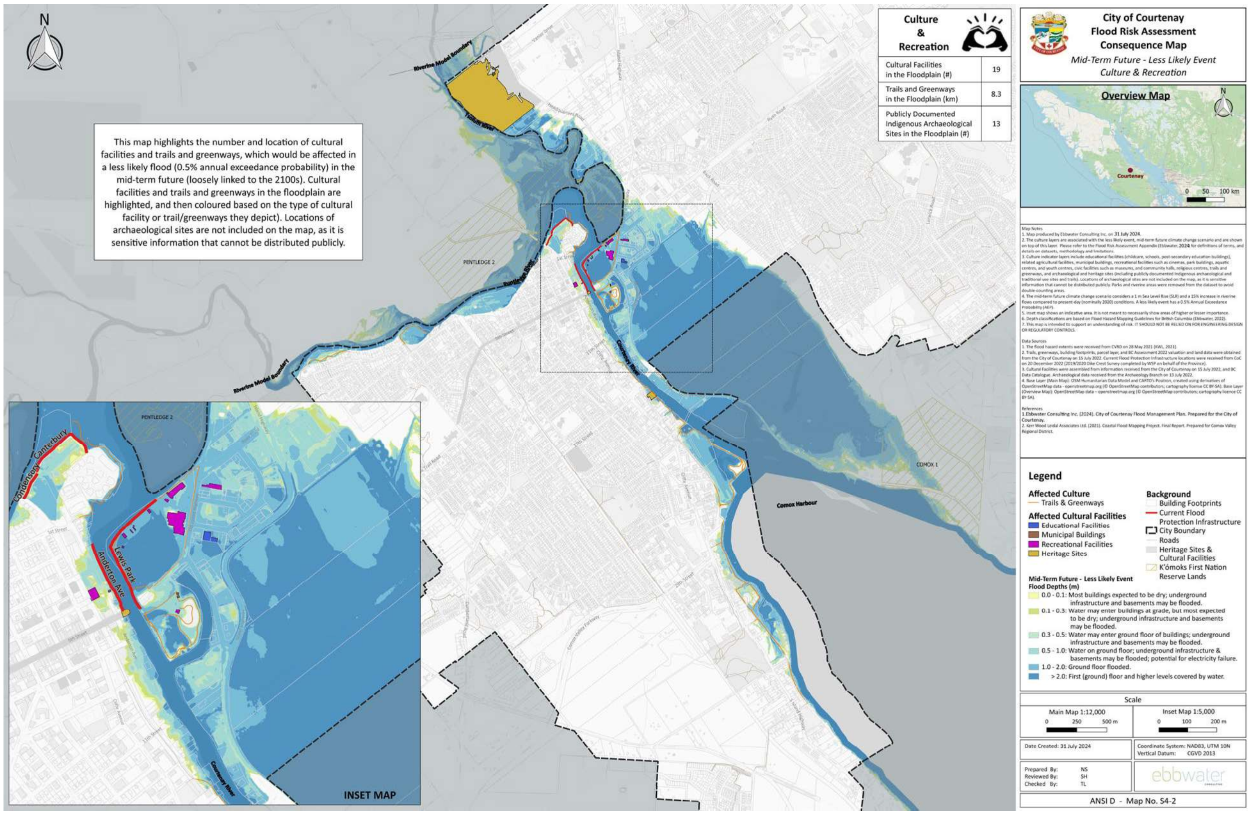

Figure 5-13: Consequence map for Culture for the mid-term future – less likely scenario (0.5 % AEP, 1 m SLR/15% increase in riverine flows). Refer to map book in Appendix C for full-sized (ANSI D) maps.

Table 5-9: Numbers of cultural sites (including archaeological sites) as well as length of trails and greenways in kilometres (km) in flood extents for four scenarios. Trails and greenways are provided in kilometres (km).

Scenario	Community Buildings (#)	Heritage Sites (#)	Indigenous Pre-Contact Arch. Sites (#)	Post Contact Arch. Sites (#)	Total Cultural Sites (#)	Trails & Greenways (km)
Present-day - Likely	14	4	11	1	30	4.6
Present-day - Less Likely	15	4	13	1	33	6.3
Mid-term Future - Likely	15	4	13	1	33	7.9
Mid-term Future - Less Likely	19	4	13	1	37	8.3

The risk curves and AALs highlight the large impact that floods may have on culture and community, with sharp increases for less likely events, as well as the mid-term future (Figure 5-14, Table 5-10). Further, an AAL of six (i.e., that on average over a long time, six cultural sites are impacted each year) in the present-day is concerning.

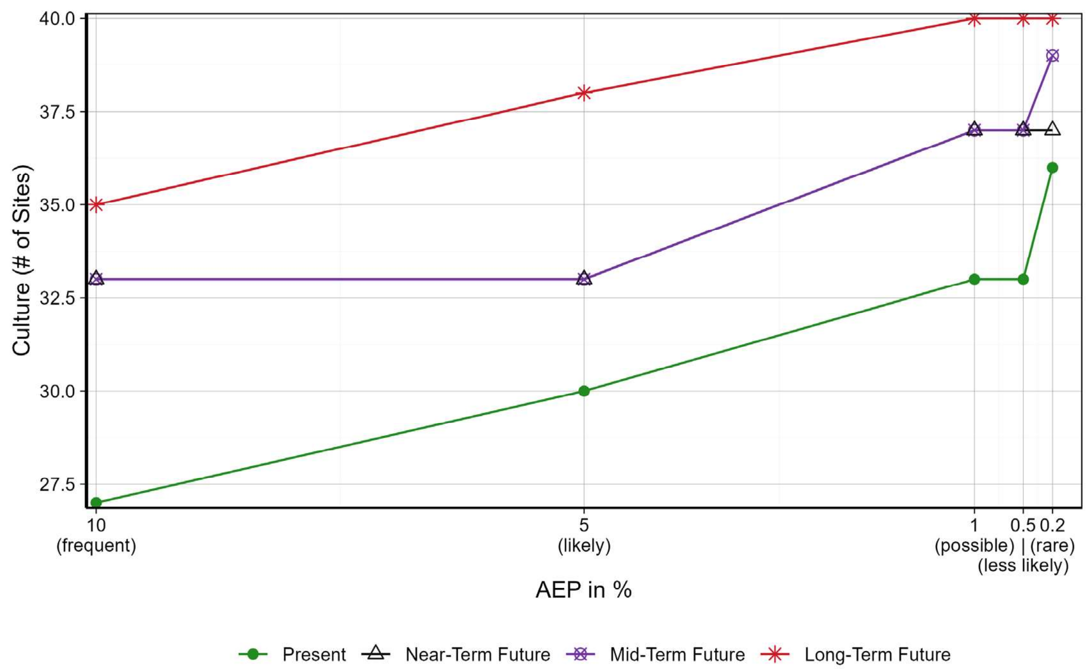

Figure 5-14: Risk curves for Culture for four time periods. The figure indicates how many cultural sites may be affected for different AEPs and time periods.

Table 5-10: Average Annual Loss (AAL) for four time periods, indicating how many cultural sites, on average over a long time, may be affected each year by flooding.

Receptor	Average Annual Loss (AAL)			
	Present-day	Short-term Future	Mid-term Future	Long-term Future
Culture (# of sites)	6.0	6.8	6.8	7.5

5.2 Qualitative Risk - Impacts and Experiences

As described in the earlier chapters, many flood impacts are intangible (not directly measurable). This does not mean that they are any less important than the quantified risks. To explicitly address these qualitative risks, the project team conducted a number of engagement activities to understand community impacts.

This section summarizes some of the city-wide survey results related to flood impacts; details for local areas are discussed in Chapter 6 (Local Areas). Note that Chapter 6 also includes further insights that we heard from the community in other engagement events (such as the workshop and the second survey), as well as in discussions with City staff.

In the public survey, most people indicated that they have not experienced flooding in their current place of residence (90%) nor another place of residence in Courtenay (91%) (see Section 4.5.2.1 on survey details, such as participant numbers). Among those, who have experienced flooding in Courtenay, impacts included:

- Interruptions to transportation routes / accessibility
- Damages to land / property
- Interruptions to power or communications
- Evacuation

Most participants have witnessed flooding happen for others or elsewhere in the City of Courtenay (73%). Impacts included (participants could check all that applied):

- Infrastructure: impacts to roads, power, communications, and other essential infrastructure (41 selections)
- Homes and properties: impacts to houses, buildings, personal / household possessions (37 selections)
- Environment: impacts to species, habitats and ecological health, including from pollution (35 selections)
- Economy: impacts to economic activities, industry, agriculture, and business (34 selections)

Further, we asked survey participants what they are most concerned about in relation to flood risk, in the present-day (Figure 5-15) and for the future (Figure 5-16). For the present-day, the top concerns were 1) Homes & Properties, 2) Infrastructure and 3) Environment. In the future, the relative priority was different with Infrastructure being the first priority, followed by 2) Environment and then 3) Homes & Properties.

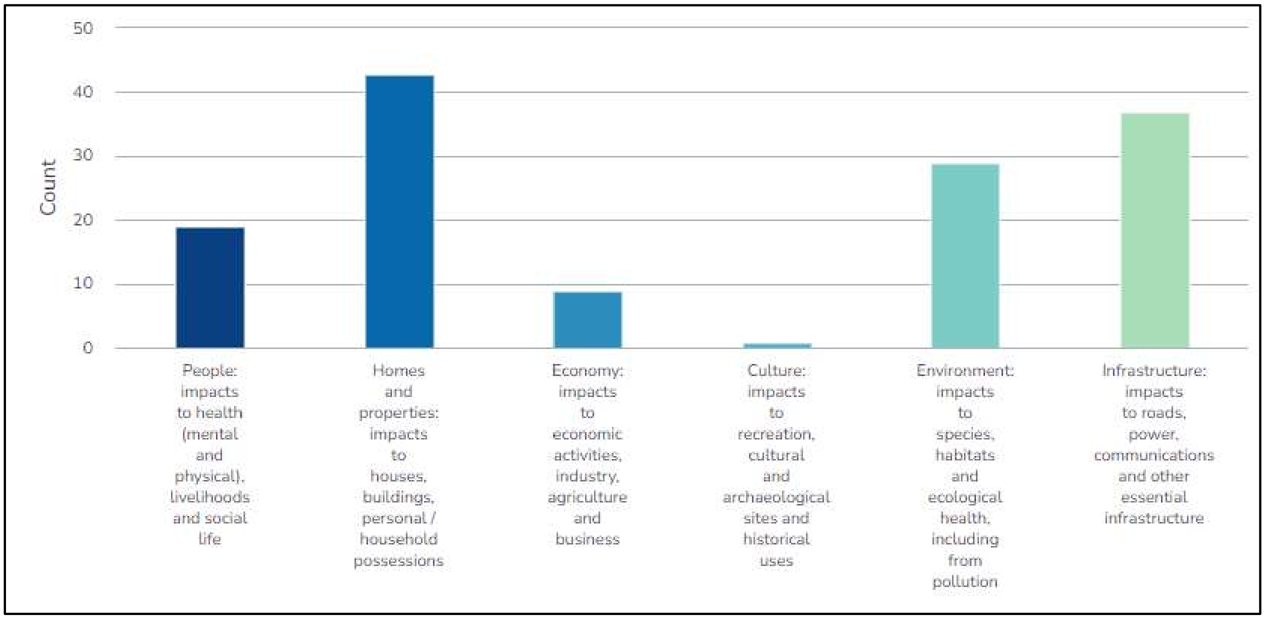

Figure 5-15: Present-day: Flood impacts that public survey 1 participants are most concerned about today (N=71).

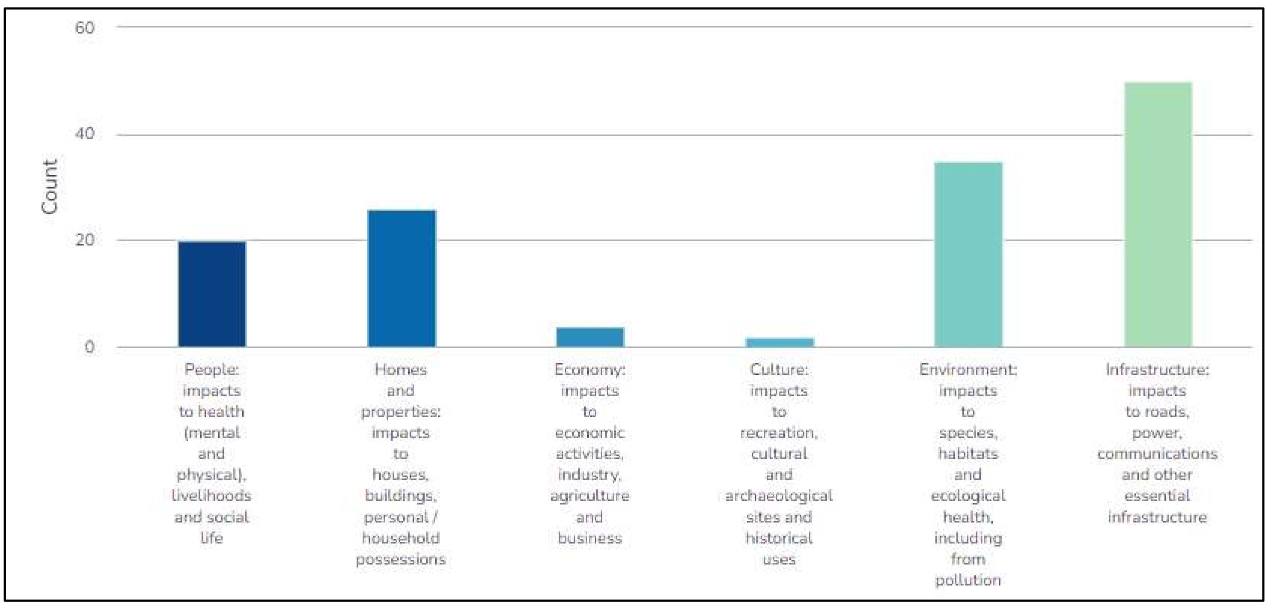

Figure 5-16: In the future: Flood impacts that public survey 1 participants are most concerned about in the future (N = 69).

Similarly, when asked what we must preserve, restore, or improve for the benefit of future generations, the majority of comments related to environmental values, followed by critical infrastructure and assets (e.g., transportation, utilities, food, drinking water), public access to the waterfront, K'ómoks First Nation culture, and the capacity to work together and adapt.

5.3 Risk Summary

Risk results in this chapter highlight how much is already at risk of flooding in the present-day, and how even more will be affected in the future with climate change, if no risk reduction and resilience actions are taken. For most receptors, frequent flood events in the future will have more devastating consequences than rare and extreme floods today. This is particularly concerning when thinking about the cumulative impacts of many floods happening in shorter time periods.

Further, several tipping points (i.e., substantial increases in risk) were identified with climate change. Of concern are the many people that may be directly affected by flooding in the present-day, but in particular, in the future with climate change. Critical infrastructure and disruption will have cascading consequences on the wider society, impacting people and the economy. Many potential contamination sources have also been identified in the floodplain, which will lead to detrimental consequences for downstream sensitive ecosystems. There are also many cultural sites, including Indigenous archaeological sites, within the flood hazard areas. Similar to the quantitative risk assessment, the public survey highlighted that key concerns of the community are around critical infrastructure and interruptions, home and properties, as well as the environment.

6 Option Analysis and Local Area Risk

This chapter provides information on flood mitigation options considered within the City. First, city-wide options are described at high-level (these are detailed more in Chapter 7). This is followed by a place-based options analysis for local areas. As outlined in earlier sections, there is much diversity across the City of Courtenay, and as a result, individual flood risk reduction strategies will be more or less effective in different parts of the City. This section describes six different distinct areas within the City, explores their unique flood hazard and risk profiles, and then describes, at a high-level, flood strategies and associated options for each area, including both recommended options and the alternative options which were eventually removed. Detailed recommended flood management strategies and actions, based on the preferred options in each area, as well as actions that are applicable city-wide, are described in Chapters 7 and 8.

Reminder:

Strategy: Overarching flood risk reduction or resilience approach, based on *Protect*, *Accommodate*, *Retreat*, *Avoid*, and *Resilience-Building* (PARAR) framework.

Option: Place-based detailed flood risk reduction activity (for a local area, or across the City) that can be compared to alternative options.

Recommendation: Specific actions within the FMP that are recommended based on the options analysis.

6.1 City-wide Options

Many of the *Accommodate*, *Retreat*, *Avoid*, and *Resilience-building* options can be implemented City-wide, whereas typically, *Protect* strategies are more targeted towards a specific local area.

Table 6-1 highlights some of the recommended city-wide options. These are detailed in Chapter 7 to avoid duplication between the chapters. Note that the city-wide options of *Avoid* and *Resilience-building* were not explored quantitatively in local area options.

Table 6-1: Overview of city-wide options.

PARAR Strategy	City-wide Option
Accommodate	Floodplain bylaw update (update to new Flood Construction Levels (FCLs) (Section 7.3.1.1).
	Development Permit Area for flood and erosion hazard (Section 7.3.1.2).
	Regulate hazardous material storage (Section 7.3.1.3).
	Encourage permanent floodproofing of buildings-at-large (Section 7.3.2.1), City-owned buildings (Section 7.3.2.2), the sanitary system (Section 7.3.2.3), and groundwater wells (Section 7.3.2.4).
	Encourage temporary property-level flood barriers (Section 7.3.3).

PARAR Strategy	City-wide Option
	Minimize potential industrial/commercial/residential (Section 7.3.4.2), as well as agricultural contamination sources (Section 7.3.4.3).
	Encourage ongoing adaptation on agricultural lands (Section 7.3.5).
	Develop resiliency for parks and trails (Section 7.3.6).
	Redesign major transportation routes (Section 7.3.7).
	Work with K'ómoks First Nation to minimize impacts to Indigenous sites (Section 7.3.8).
Avoid	Develop flood-risk based zoning bylaw (Section 7.5.1).
Resilience-building	Build flood awareness and education via targeted and public communication campaigns (Section 7.6.1). Contribute to neighbourhood resilience building (Section 7.6.5).
	Update monitoring and warning procedures (Section 7.6.2), the emergency response plan (Section 7.6.3), and develop flood recovery and post-disaster plans (Section 7.6.4).
	Work with insurance companies to address residual risk (Section 7.6.6).
	Collaborate regionally on emergency preparedness and response (Section 7.6.7).

6.2 Local Area Options Analysis Overview

To address flood risk in the City and develop adequate local risk reduction and resilience strategies, one needs to consider local hydraulics and hydrodynamics (the hazard) as well as land use characteristics (the exposure and vulnerability) of an area. These vary widely in the City and range from unregulated and regulated riverine hazards and coastal hazards, as well as from agricultural land use to urban areas. While it is important to develop city-wide strategies (see Section 6.1 above) and ensure all recommended local actions work well together, it is necessary to also explore issues at the local area scale to identify the local risk, develop a range of relevant options, evaluate these, and recommend a toolbox of options adequate for managing risk and increasing resilience. Therefore, the City was divided into local areas (see Section 6.2.1).

This chapter focuses on the local areas, with description of their characteristics and their local flood risk, including description of current flood protection structures. It further describes the decision-making process and outcomes for each local area, i.e., it presents a suite of recommended options, along with alternative options that were considered but ultimately rejected. This chapter also includes feedback from the workshop and public surveys, integrated into local area sections where relevant. A summary of the results of the public survey (with feedback on specific options) is further provided in Section 6.9.

Note that the recommended options are only described briefly in this chapter, but then detailed more in Chapter 7 to avoid duplication between local areas. This chapter provides background on why options are recommended and what considerations and trade-offs need to be taken into account. In contrast, the following Chapter 7 focuses on the recommended actions, organized by the overarching PARAR strategies, and includes both city-wide recommendations as well as more detail for local area recommendations.

6.2.1 Determination of Local Areas

To support development of local risk reduction and resilience options, the City was divided into six local areas based on hydraulic/hydrodynamic and land use characteristics. Table 6-2 provides an overview of the local areas, and Figure 6-1 indicates their location in the City.

Table 6-2: Local area names, flood hazard characteristics, and land use characteristics.

#	Local Area Name	Boundary	Flood Hazard Characteristics	Land Use Characteristics
1	Tsolum River – Headquarters Road	Tsolum River from City boundary to Tsolum Slough at Dingwall Rd.	Riverine (unregulated).	Agricultural, sub-urban residential.
2	Puntledge River	Puntledge River from City boundary to ridge upstream of Condensory Dike.	Riverine (regulated).	Dominantly residential (urban residential to multi-residential), parks and recreation.
3	Condensory Bridge & Anderton Ave	Puntledge River from ridge upstream of Condensory Dike to 5th Street Bridge (east side of Courtenay River)	Riverine, with tidal influence, but limited wave effects.	Multi-residential, parks and recreation, some commercial.
4	Lewis Park & Puntledge Road Commercial Area	From Tsolum Slough at Dingwall Rd to Courtenay River (east side) at 21st Street. Includes Lewis Park, commercial area, and west side of Courtenay River.	Riverine, with tidal influence, but limited wave effects.	Commercial, multi-residential, parks and recreation, mixed use, agricultural, industrial.
5	Courtenay River – Cliffe Avenue Corridor	Courtenay River (east side) downstream of 5th Street Bridge to 21st Street.	Riverine, with tidal influence, but limited wave effects.	Commercial, urban residential, parks, mixed use.
6	Airpark & South Courtenay	From Courtenay River east and west downstream of 21st Street to City boundary at coastal shoreline along estuary.	Coastal-riverine conditions (Courtenay River below 21st Street) & coastal (estuary).	Multi-Residential & park (mainly), mixed use, some commercial, suburban residential.

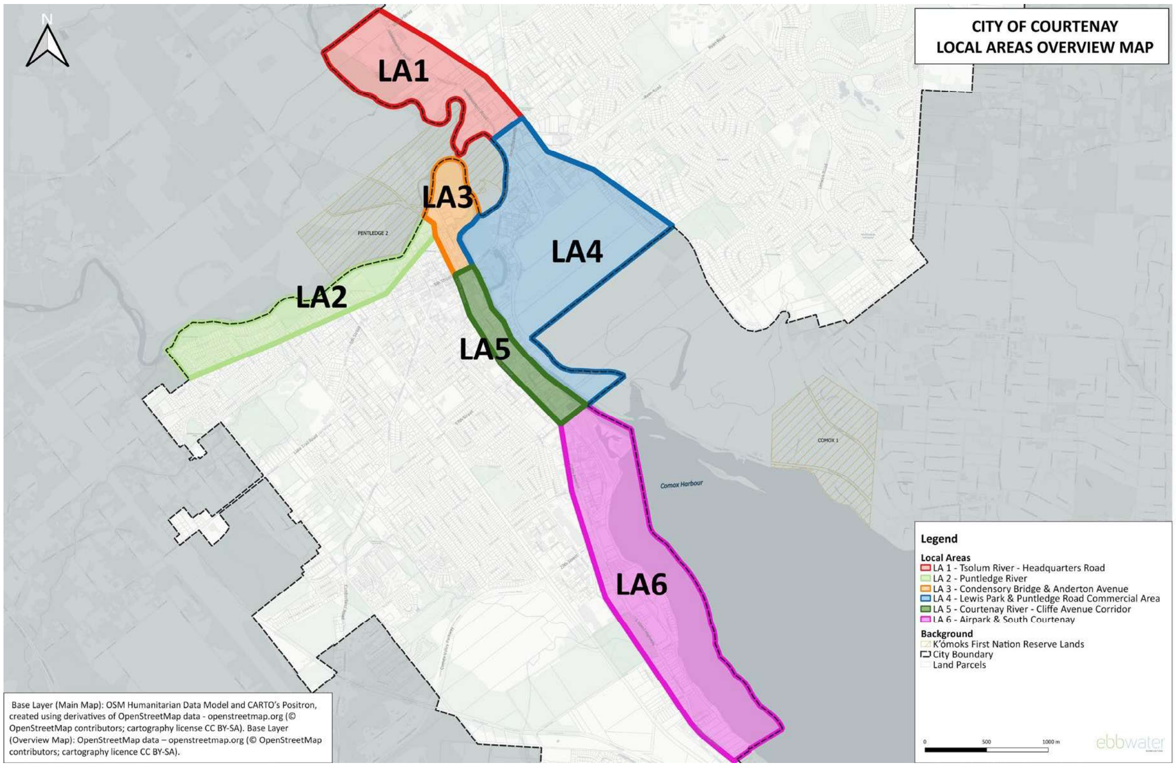

Figure 6-1: Local areas for option development, City of Courtenay.

6.2.2 Options Timing

As described earlier in the report, the flood hazard and risk profiles of the region are changing with climate and land use. The options that were considered for this FMP take this into account. In some cases, where the flood hazard is expected to change substantially over time, especially where it is anticipated to be deeper in the future, two sets of options are presented. One for the present-day and near future, when for example some small property-level flood barriers might be appropriate to reduce damage, and a second option for the far future, where these same barriers would not function as they would be overtopped.

6.2.3 Screening Requirements

As a first step towards recommended options for the Local Areas, we identified screening requirements that an option needed to satisfy to be developed in further detail and be included in the options analysis:

- Within authority of the City:
    - Does the City have actual authority to enact mitigation measures? For instance, if a proposed flood protection structure serves a single private property, it is responsibility of the property owner (not the City) to construct and maintain the structure.
- Complies with regulations:
    - If a proposed option does not meet current City, provincial or federal regulations, and if there is no foreseeable change in regulations to potentially allow such a mitigation measure.
- Effectiveness:
    - If a proposed measure has unrealistic practical or financial implications. For instance, a proposed flood protection structure that would cover many kilometres of river, without there being high exposure in that area.

6.2.4 Option Comparison

As discussed in more detail in Chapter 4 (Flood Management Plan Approach), options are compared and selected options are then recommended. In this chapter, for each local area, we first describe the suite of options that are recommended. Strengths and weaknesses of each option are visualized in tables; robust calculations and assumptions underly the tables. Figure 6-2 provides a guide to read the strengths and weaknesses tables. Following the recommended options, for transparency, all alternative options that were dismissed are also provided, including strengths and weaknesses tables and discussion on why the options were not recommended.

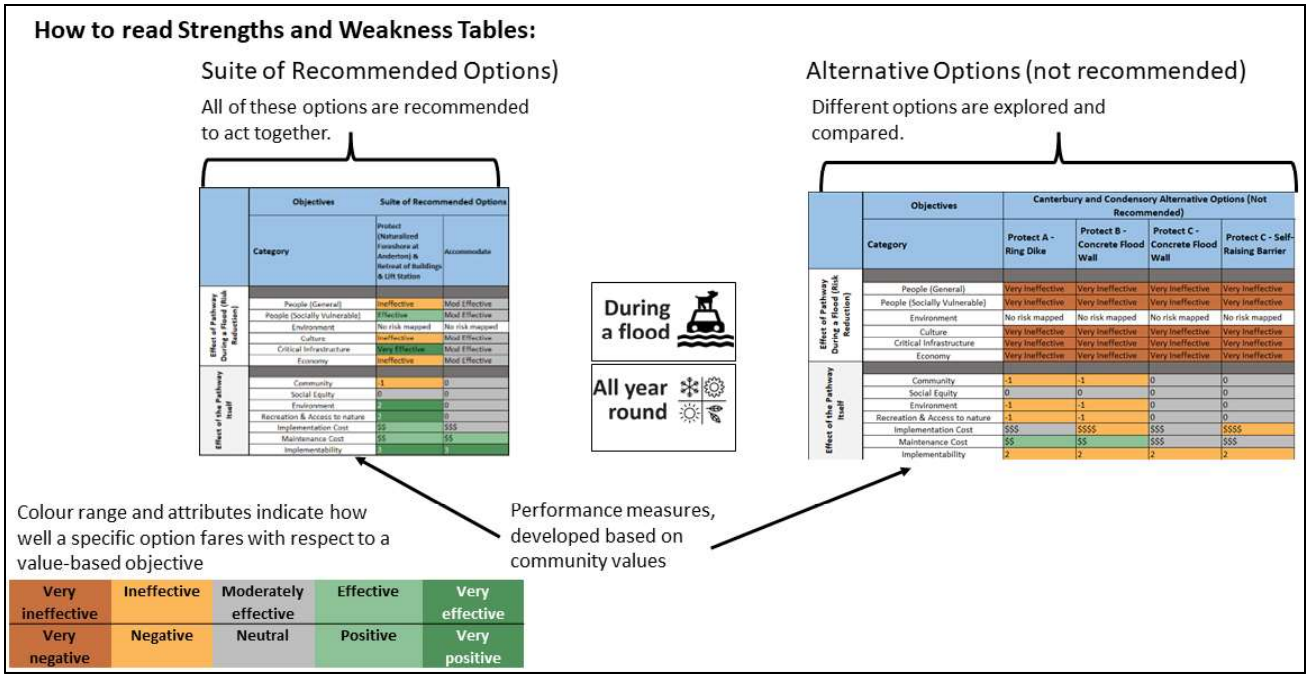

Figure 6-2: Overview of how to read Strengths and Weaknesses Tables for different options. For details, refer to Chapter 4 (Methods) and Appendix B.

6.3 Local Area 1: Tsolum River – Headquarters Road

6.3.1 Local Area Characteristics

Flood Hazard	Riverine (unregulated)
Land Use	Agricultural, sub-urban residential.

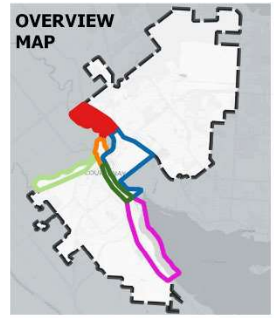

Figure 6-3: Location of Local Area 1 indicated in red.

This local area is located along the Tsolum River, upstream of the confluence with the Puntledge River (Figure 6-3; Figure 6-4; Figure 6-5). It is characterized by flood hazards of the Tsolum River (unregulated, riverine hazard), where peak flows are driven by intense precipitation events from October to February (see Section 3.3, Figure 3-6). Land use is characterized by mostly agricultural and sub-urban residential land use, as well as public/institutional use at the Comox Valley Exhibition Grounds (CVEG) (Figure 6-5). The development generally includes either suburban residential buildings older than 1965, or newer buildings (post 2005) (Figure 6-5). Building age is an important consideration for strategic planning as it provides an indication of the likely timeline for any turnover of building structures and building occupation. It also provides an indication, for properties within the floodplain, what FCL would have been applied during construction.

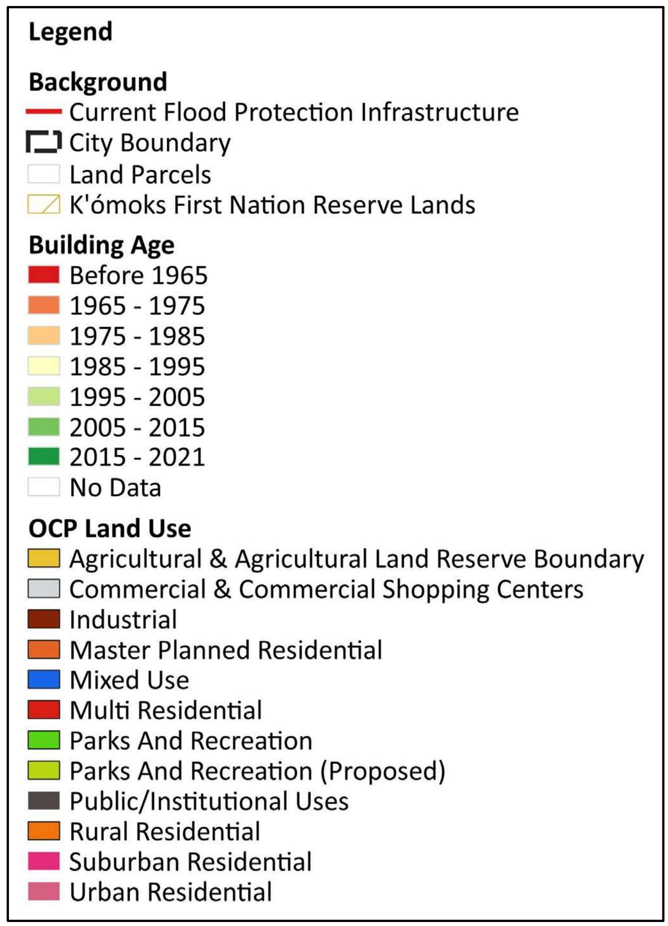

Figure 6-4: Legend for local area characteristics map.

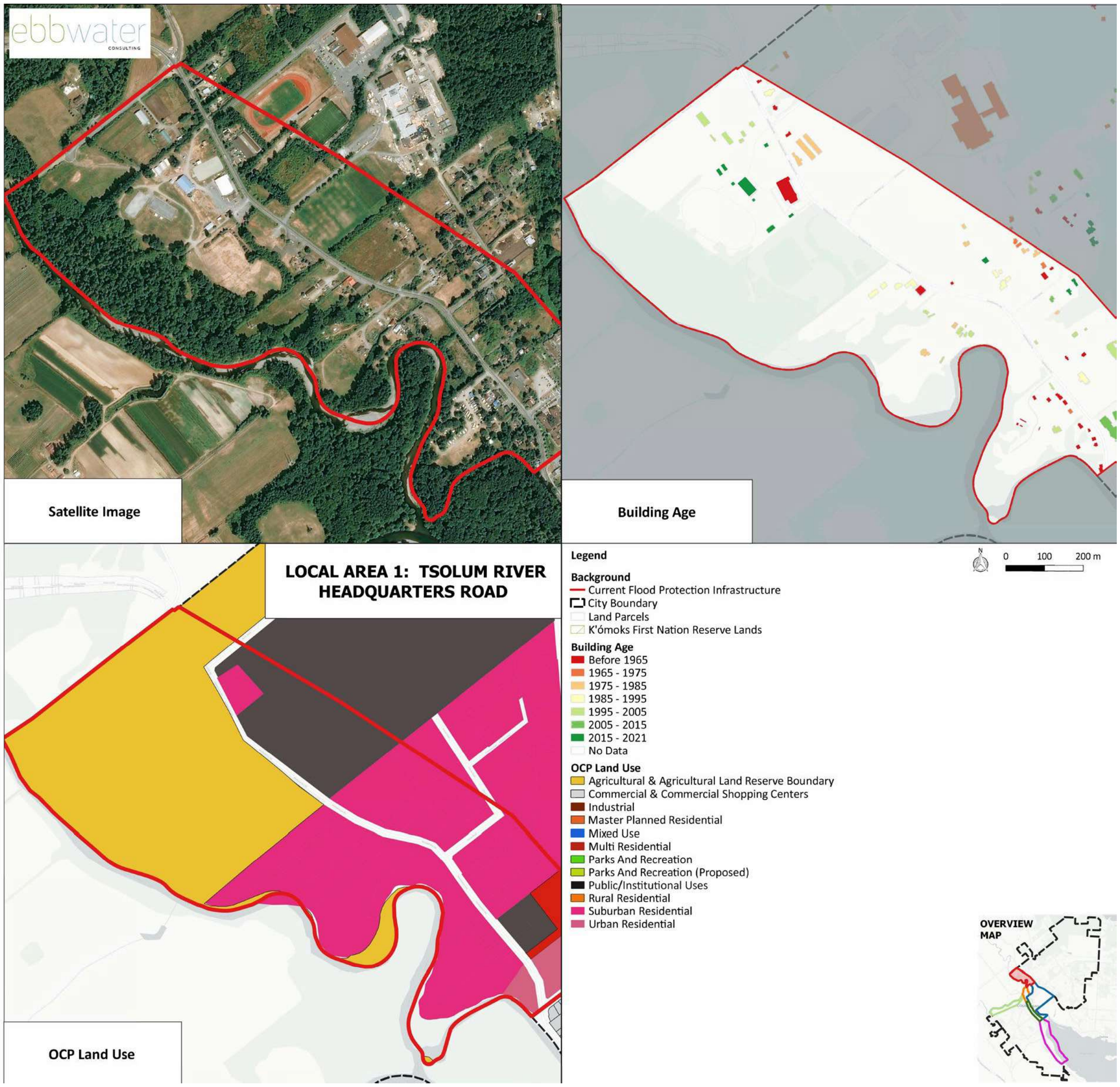

Figure 6-5: Local Area 1 (Tsolum River – Headquarters Road): Satellite imagery, building age based on BC Assessment 2022 data, as well as OCP land use (OCP land use layer as received from the City on 15 July 2022).

6.3.2 Baseline Risk ('Do Nothing')

This section describes the current and future risk, if no risk reduction actions are taken, based on both the quantitative flood risk assessment, as well as local information and experience (from the two surveys, the workshop, staff input, as well as reports and news articles). Figure 6-6 shows the extents of the floodway and mid-term future – less likely flood event[25] in the local area.

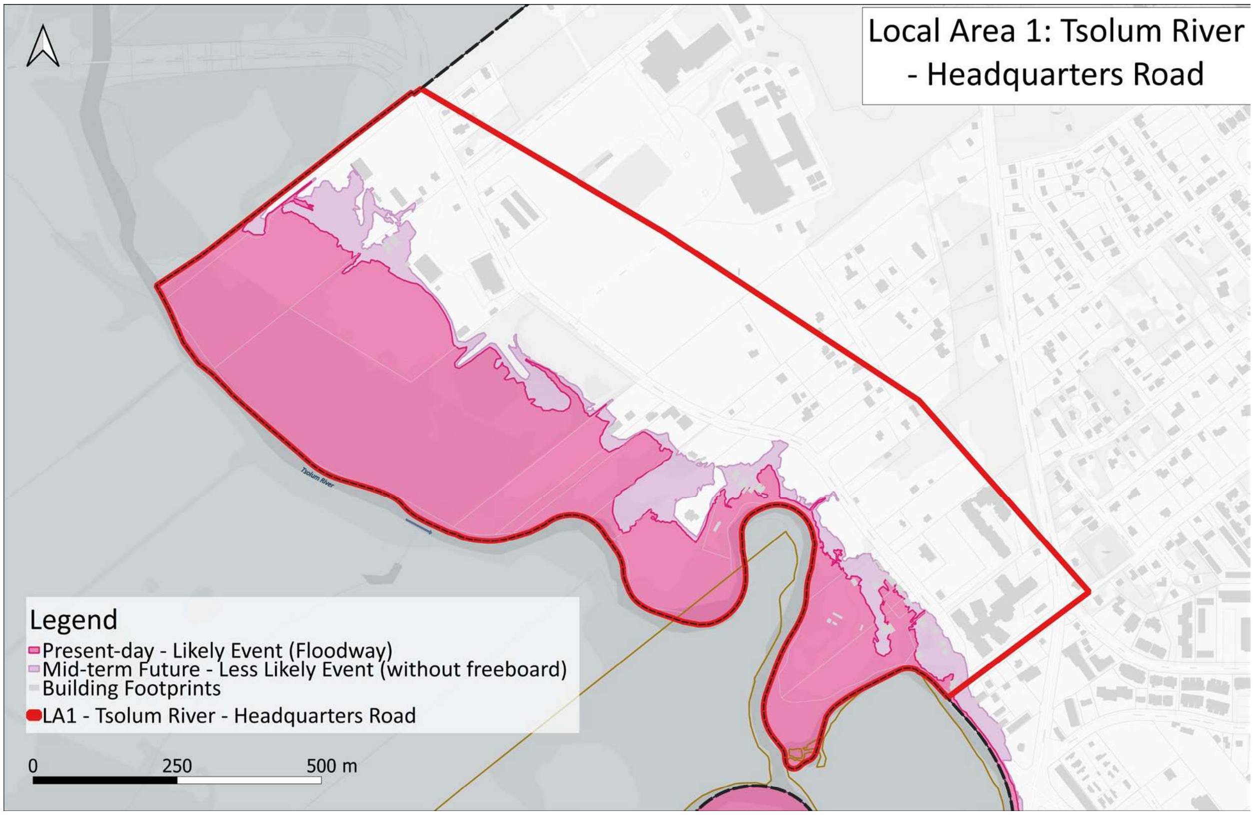

Figure 6-6: Floodway (present-day – likely event) and the mid-term future – less likely event) for Local Area 1: Tsolum River and Headquarters Road.

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[25] Note that the mid-term future - less likely scenario plus freeboard defines the regulatory floodplain and flood fringe. However, in the context of the risk assessment presented in here, the flood extent of the mid-term future - less likely scenario is considered without the freeboard, for consistency with all the other modelled flood scenarios that were included in the risk assessment (see also Section 4.3.2. The floodway (present-day – likely event) does not include the freeboard, and we therefore refer as such in these maps. Note that in the following Chapter 7, when we discuss recommendations that are specific to floodway/flood fringe concepts (such as zoning), we use the flood fringe terminology and by doing that, always refer to the extents of the regulatory floodplain (i.e., including the freeboard).

As Local Area 1 is mostly rural, the number of affected people is relatively low compared to other local areas. People are mostly exposed in the southern part of the area, along Headquarters Road. About 60 people[26] are estimated to reside within the floodplain[27] and are likely to be affected by floods. Residential homes are mostly not located within the floodway; however, some buildings are within the floodway and therefore of concern. Importantly, most residents at Maple Pool RV Park are within the floodway, which is a major concern as many of the residents may be socially vulnerable and more likely to be negatively affected by flood events. Maple Pool RV Park provides important housing for low-income residents and the WeCan Shelter Society is also actively adding new shipping container homes for people in need at that location to provide better housing[28]. Some residents also face housing insecurity and a risk of homelessness. Any risk reduction measures must consider these different risks, and vulnerabilities that residents face.

To reduce risks in the area, the City sought to address the flood risk by imposing a covenant in 2015 where permanent residences are only allowed at higher elevations, away from the river.

"A few years ago when there was extreme flooding, we were told to evacuate: Maple Pool RV campsite. I did not due to being disabled. Water surrounded me. I had heat and electricity." Public survey response

"Consider impacts to people with disabilities, seniors, and K'ómoks First Nation, especially in emergency response." Public survey response

In addition to the direct impacts to people are indirect impacts and impacts to non-human lives. For example, horses are boarded at CVEG.

Two electrical power transmission structures are within the floodway, which, depending on their structural components and flood depth and velocities, could be damaged.

[26] Note that the estimated number of affected people does not include Maple Pool RV Park residents, as the estimate is based on census data and building footprints from which RVs and mobile homes are excluded, and therefore, likely many more people will be affected by flooding in this local area.

[27] With reference to the mid-term future - less likely flood.

[28] Comox Valley Record. https://www.comoxvalleyrecord.com/community/wecan-shelter-society-unveils-seventh-and-eighth-sea-can-homes-at-maple-pool-1636049. Published 20 September 2022. Accessed 1 Nov 2023.

About 30 residential properties are located within flood extents (~3 $M total building value)[29]. Apart from dollar damages associated with potential flooding of buildings, there is also substantial agricultural land (~39 ha[29]), which might be impacted during a flood. Some of the CVEG buildings are also located within the extents of the mid-term future – less likely flood. Currently, there is planning underway for the future of the CVEG, with respect to infrastructure and uses, which will need to consider the extent of the floodplain.

As mentioned above, part of the CVEG is within the floodplain. The CVEG has an important cultural and community function, with many events being situated there (e.g., the annual agricultural fair, music festivals, farmers markets, and more). Furthermore, there is a larger Indigenous archaeological site located in the floodway, with pre-settler contact cultural items in the sub-surface. In the public survey, many people referenced flooding along Headquarters Road and how walking trails near the Tsolum River were impacted.

> "In 2014, our favourite walking area - Rotary Bowl & trails near the Tsolum River was flooded really badly" Public survey response

While no environmental contamination sources were identified in the floodplain during the quantitative risk assessment, there are likely further contamination sources, such as septic systems, fuel storage, and agricultural contamination sources (manure piles etc.). There were also concerns mentioned in the public survey on how the City's sewer system will respond to flooding. Further, while no sensitive ecosystems were mapped based on the available spatial data, important natural assets such as sensitive riparian areas, fish species, and wetlands have been highlighted by community partners. It was also noted that substantial investments have been made in the past to restore the Tsolum River, and that is important to make room for the river to flow and de-channelize.

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[29] With reference to the mid-term future - less likely flood.

Figure 6-7: Flooding in 2014, at Maple Pool RV Park (left) and along the Tsolum River and agricultural fields (right). (Photo credit: City of Courtenay).

6.3.3 Recommended Options, Alternatives, and Trade-offs

A range of risk mitigation options was considered for Local Area 1, based on the PARAR framework. Many of these options can be implemented as a suite and are not mutually exclusive. First, recommended options along with trade-offs to be considered are presented, followed by alternative options, which were screened or otherwise discounted.

6.3.3.1 Suite of Recommended Options and Considerations

Table 6-3 provides an overview of the recommended options, with context on short-term and longer-term recommendations. This is followed by details on how these recommendations were developed.

Table 6-3: Overview of recommended options for Local Area 1.

Short-term:	Focus on *Accommodate* strategies by encouraging temporary property-level flood barriers. *Avoid* new residential and commercial development (via zoning) and build *Resilience* for residents and agriculture. Work with property owners at RV Park to ensure compliance with the 2015 covenant. Collaborate with current residents in the floodway to ensure they are prepared for the next flood event, and ask for their input on the development of a long-term *Retreat* strategy of residential dwellings in the floodway, including RV parks and mobile homes. The plan should contemplate future land uses of the floodway, and an approach to relocate vulnerable residents in an equitable way.
Longer-term:	Consider buy-out or relocation of residential properties in the floodway (*Retreat)*, as they become available, or opportunistically after a flood event.

The full suite of options for this area are listed in Table 6-4, along with discussion of concerns and potential improvements, drawing on the feedback from the workshop and public survey (note that public survey support is summarized at the end of this chapter). Also note that some options are discussed in more detail in Chapter 7 as part of city-wide strategies to avoid duplication for each local area. Strengths and weaknesses of recommended options are visualized for Local Area 1 in Table 6-5 and discussed below.

Table 6-4: Suite of options recommended for Local Area 1.

Accommodate				
Implement updated FCLs	**Flood-proof buildings & critical infrastructure**	**Share resources on flooding with agricultural operators**	**Work with K'ómoks First Nation to minimize impacts to Indigenous sites**	**Encourage Property-level Flood Barriers**
Discussion: *Accommodate* can provide means to continue using an area in the floodplain. However, *Accommodate* actions also rely on the capacity of property owners, and there is a lot of private property in this area. It is also difficult to flood-proof septic systems, but there are some ways to decrease the risk of contamination. *Accommodate* also includes working with property owners at RV Park to ensure compliance with the 2015 covenant. While property-level flood barriers can provide some protection, there are also several concerns associated with them. They can vary in effectiveness due to different designs and standards, only work up to a specific flood depth/velocity and need time to set up. Further, this option would rely on property owners for finances and motivation. See also Chapter 7 for more details.				
Retreat				
Longer term: Retreat residential buildings (including RVs and mobile homes) in floodway *(e.g., opportunistic buy-outs, as they become available (~10 permanent buildings in the floodway) and convert to natural systems)*				
Discussion: *Relocation* of people would face challenges due to lack of space, zoning bylaws, and potential loss of social services. *Retreat* should prioritize and involve the most vulnerable, with an emphasis on psychosocial resilience.				
Avoid				
***Avoid* new residential and commercial development via planning tools (e.g., zoning bylaw that builds on current statements within the OCP)** Discussion: *Avoid* strategies would allow for re-imagining land use with fewer people and amenities in the floodplain. Further, it provides opportunities for (sustainable) agriculture and ecological restoration.				

Resilience-building	
Flood-resilient agriculture	**Residential awareness-building and preparedness**
Discussion: This should focus on residents and agriculture (including consideration of the CVRD Comox Valley Agricultural Plan, which is currently being updated, alongside aspects of emergency planning for agriculture).	

Table 6-5: Local Area 1: Strengths and weaknesses of suite of recommended options, with respect to performance measures.

	Objectives	**Suite of Recommended Options**	
	Category	**Accommodate**	**Retreat - residential**
Effect of Pathway During a Flood (Risk Reduction)	People (General)	Mod Effective	Effective
	People (Socially Vulnerable)	Mod Effective	Effective
	Environment	No risk mapped	No risk mapped
	Culture	Mod Effective	Very Ineffective
	Critical Infrastructure	No risk mapped	No risk mapped
	Economy	Mod Effective	Mod Effective
Effect of the Pathway Itself	Community	0	-2
	Social Equity	0	-1
	Environment	0	2
	Recreation & Access to nature	0	1
	Implementation Cost	$$$	$$$
	Maintenance Cost	$$	$
	Implementability	3	2

Note that *Avoid* and *Resilience*-building Options have not been scored, as they are recommended for implementation city-wide. Further note that for Local Area 1, no environmental contamination sources nor critical infrastructure facilities were mapped, and therefore, not included in the quantitative risk reduction assessment. Of course, there might be further, unknown contamination sources, or other aspects to the environment to be considered.
Lastly note that Retreat – residential includes all residents as captured by census data at permanent residential buildings.

The recommended suite of options for this area includes a variety of diverse flood management tools. This is by design, as each unique option has trade-offs. It will perform well on one objective, but poorly on another. But as a whole, all the options together provide risk reduction, maximize co-benefits, and minimize negative externalities (i.e., minimize negative consequences of the flood management action).

For Local Area 1, to achieve flood risk reduction benefits, especially robust and long-term benefits, *Retreat* (residential buildings) should be considered. However, this does not manage the short-term risks and this gap needs to be filled through the consideration of property-level flood barriers and improved emergency response plans. These same barriers will not work in the far future when flood waters are deeper and so they will need to be replaced by more robust options like *Retreat*.

In addition to choosing a suite of options that create an overall risk reduction over time, it is important to look at the potential consequences of these actions on community values generally. In this instance, it is important to consider the financial costs of actions as well as the very important social costs. Although *Retreat* and *Relocation* bring strong risk reduction benefits and will reduce financial and social costs when it floods, they will create hardship to those who are moved.

6.3.3.2 Alternative Options (Not Recommended)

For Local Area 1, specifically, the alternative option (Table 6-6) for permanent protection did not meet screening requirements and was therefore not further developed in detail in the options analysis (i.e., no drawings and strength and tradeoff tables were created). These dike structures would either protect a single property only or be very large and protect an area in the floodway, which is not currently zoned as residential and where, as in other parts of the City, further development in the floodplain should be discouraged. Flood protection structures do not offer a complete protection, as they may overtop or breach, and therefore, avoiding new residential development in the floodplain (especially in the floodway) is strongly recommended in this FMP.

Table 6-6: Local Area 1: Alternative options considered (not recommended).

Alternative Options Considered (Not Recommended)	Reasons for Removal
Permanent Dike Structures *(Structure at Maple Pool RV Park and residential buildings. Ring structure to protect CVEG buildings).*	Option did not pass the screening requirements, due to not meeting authority and effectiveness requirements, and therefore was not further developed. Incentivizing development in a hazardous area (via building structural protections) is to be avoided. Dikes can also only protect up to a certain water level, and may be overtopped or breached. Structural protection for these areas would mean an extraordinary expense to serve a relatively small area. The risk can be more effectively managed using different methods that are cheaper.

6.4 Local Area 2: Puntledge River

6.4.1 Local Area Characteristics

Flood Hazard	Riverine (regulated)
Land Use	Mostly residential (urban residential to multi-residential), parks and recreation.

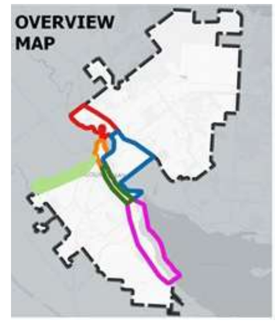

Figure 6-8: Location of Local Area 2 indicted in light green.

This local area is located along the Puntledge River, upstream of the confluence with the Tsolum River (and upstream of Condensory Dike) (Figure 6-8; Figure 6-9). It is characterized by riverine (regulated) flood hazards from the Puntledge River (see also Section 3.2.1 on BC Hydro flood control). Similar to the Tsolum River, high peak flows in the Puntledge River are driven by intense precipitation events from October to February, though given the larger, more mountainous watershed area, peak flows also occur during the snowmelt in spring (May-June), see Section 3.3, Figure 3-6. Further concerns here are the steep riverbanks, which limit flooding extents because the channel is confined, but may erode or become unstable during high flows[30].

Land use is mostly characterized by urban residential, parks and recreation, as well as some multi-residential parcels upstream of Condensory Dike (Figure 6-9). Most single-family houses were built before 1965, while the multi-residential buildings are from 1975-1985, and there are newer residential neighbourhoods on the western (upstream) boundary of the Local Area. Given the many older residences part of this Local Area is designated as a Heritage Neighbourhood (Old Orchard Neighbourhood Local Planning Area) in the OCP, with goals to preserve the heritage style of buildings and mature trees, and avoid densification.

[30] See also the City of Courtenay DPA 5 – Hazardous Conditions – Steep Slopes (2022), which is applied to all properties containing a slope of equal to or great than 20% measured over a minimum horizontal distance of 10 metres.

Figure 6-9: Local Area 2 (Puntledge River): Satellite imagery, building age based on BC Assessment 2022 data, as well as OCP land use (OCP land use layer as received from the City on 15 July 2022).

6.4.2 Baseline Flood Risk ('Do Nothing')

This section describes the current and future risk, if no risk mitigation actions are taken, based on both the quantitative flood risk assessment and local information and experience. Figure 6-10 shows the extent of the floodway and mid-term future – less likely flood event in the local area.

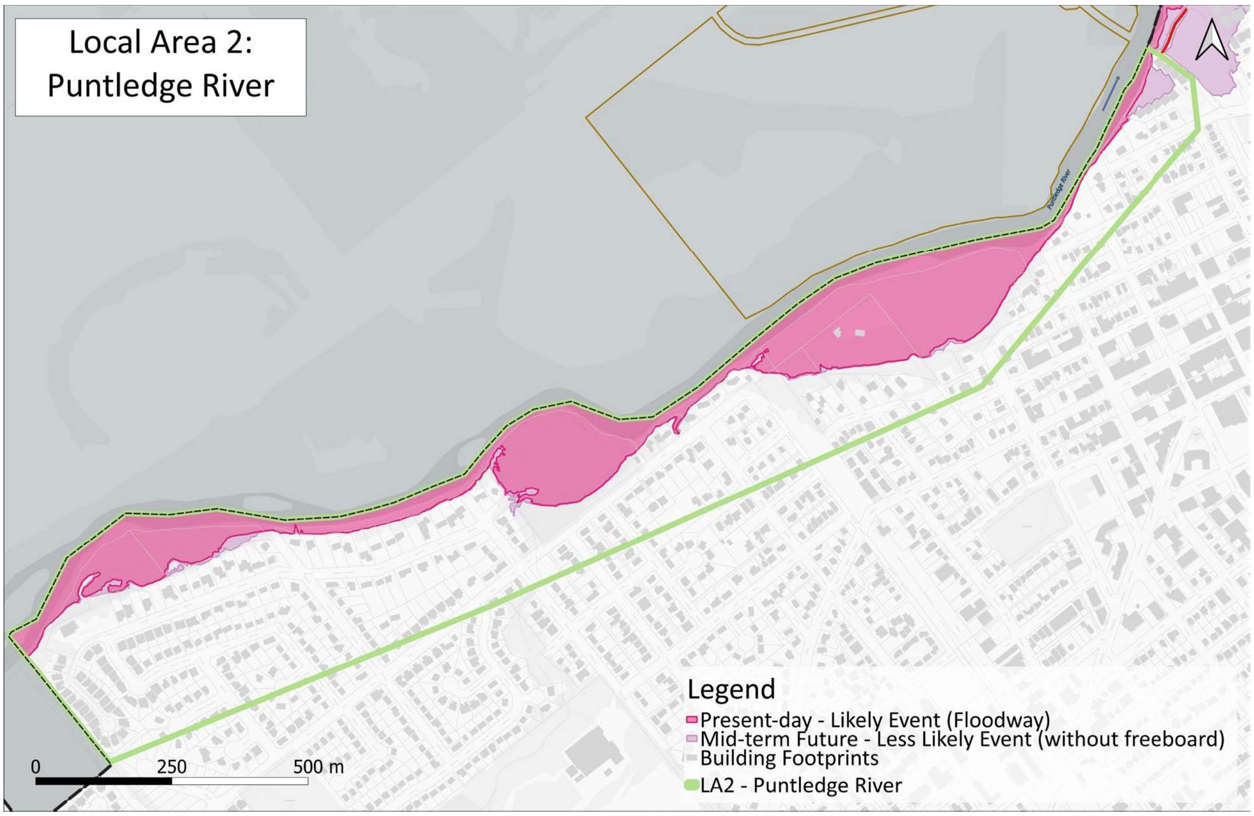

Figure 6-10: Floodway and mid-term future – less likely flood extents for Local Area 2: Puntledge River.

In Local Area 2, not many residential homes are exposed, in particular not within the floodway. About 20 people are estimated to be within the flood extents[31]. Most of the multi-residential housing near Condensory (Puntledge Terraces complex) is only within the flood hazard extent of the more extreme long-term future rare scenario (nine buildings[32]), while one building is within the extent of the mid-term future – less likely event. There

[31] With reference to the mid-term future - less likely flood.

[32] Long-term future rare flood is the scenario for 0.2% AEP with 2 m SLR and 30% increase in riverine flows.

are however concerns with respect to vulnerable people and unhoused people that may be living in parks and exposed to flooding.

There is no critical infrastructure within even the most extreme the flood hazard extent. First Street Lift Station is however located nearby.

There are also relatively minimal economic damages associated with flooding for this Local Area, with two buildings in floodway, and 1 building in the remainder of the mid-term future – less likely flood extents, with ~1.2 $M estimated total building damage[31].

A number of local trails are within the flood hazard extents. Further, while Puntledge Elementary School is not within the floodplain itself, indirect impacts of flooding to schools and families were raised as concerns during the public survey.

Several parks (Bear James, Puntledge, McPhee Meadows) may be impacted by flooding in this Local Area. Further concerns are the slope stability of the steep banks and risk of erosion during peak flows.

Figure 6-11: Dam Spillover during the 2014 flood at the Puntledge Diversion Dam (Photo credit: City of Courtenay).

6.4.3 Recommended Options, Alternatives, and Trade-offs

6.4.3.1 Suite of Recommended Options and Considerations

Table 6-7 provides an overview of the recommended options, with context on short-term and longer-term recommendations. This is followed by details on how these recommendations were developed.

Table 6-7: Overview of recommended options for Local Area 2.

Short-term:	Focus on *Accommodate*. *Avoid* new developments in flood hazard area (including on or near steep slopes) and build *Resilience* for residents. Redesign parks/trails to accommodate occasional flooding.
Longer-term:	Consider buy-out of the couple of residential properties in the floodway (*Retreat*), as they become available, and convert to public space/parks.

Options for this area are listed in Table 6-8, along with discussion on concerns and potential improvements, drawing on the feedback gained in workshop and public survey (note that public survey support is summarized at the end of this chapter). Also note that some options are discussed in more detail in Chapter 7 as part of city-wide strategies to avoid duplication for each local area. Strengths and weaknesses of recommended options are visualized for Local Area 2 in Table 6-9 and discussed below.

Table 6-8: Suite of options recommended for Local Area 2.

Protect	
Discussion: There is limited development in the floodplain in this local area, i.e., limited need for *Protect* actions.	"Protection strategies mean fighting water at all costs, which is a losing battle, and that you can't make everybody happy" Workshop participant
Accommodate	
FCLs; Flood-proof buildings; Redesign parks and trails Discussion: Many workshop participants felt that flooding parks, parking lots, and trails could be good *Accommodate* options in this area that can be adjusted to over time (while ensuring that unhoused people in parks are not impacted). Further, the need to restore and maintain sensitive natural areas and control bank erosion was noted.	

Retreat
***Retreat* residential buildings in floodway** *(Buy-out buildings, as they become available over the longer-term (~2 buildings located in the floodway) and convert to natural systems.* Discussion: *Retreat* was considered a good option for this area, as there are not many residents to move and properties could be converted to parks. The adjacent land use is parkland, and so the maintenance of this area as park suits the neighbourhood. If converting to parks, it was recommended to consider traditional ecological management approaches for managing the park.
Avoid
***Avoid* new residential and commercial development in floodplain** Discussion: There is limited expected future development in this area, as it is mostly zoned as a heritage neighbourhood with low density. It is recommended to continue to avoid densification and residential development. Restricting of new development should include development on or near slopes (see also steep slopes DPA[33]).
Resilience-building
Residential awareness-building and preparedness; Parks Recovery Planning Discussion: Workshop participants noted that existing spawning channels build *Resilience*, and that education is the best interest of a property buyer.

[33] DPA 5 – Hazardous Conditions – Steep Slopes. https://www.courtenay.ca/assets/Departments/Development~Services/OCP~Update/OCP-DPAs-Zoning~July~2022/DPA-SteepSlope.pdf

Table 6-9: Local Area 2: Strengths and weaknesses of suite of recommended options, with respect to performance measures.

	Objectives	Suite of Recommended Options	
	Category	Accommodate	Retreat - residential
Effect of Pathway During a Flood (Risk Reduction)	People (General)	Mod Effective	Effective
	People (Socially Vulnerable)	Mod Effective	Mod Effective
	Environment	No risk mapped	No risk mapped
	Culture	Mod Effective	Very Ineffective
	Critical Infrastructure	No risk mapped	No risk mapped
	Economy	Mod Effective	Very Effective
Effect of the Pathway Itself	Community	0	-2
	Social Equity	0	-1
	Environment	0	2
	Recreation & Access to nature	0	1
	Implementation Cost	$$$	$$$
	Maintenance Cost	$$	$
	Implementability	3	2

Note that *Avoid* and *Resilience-building* Options have not been scored, as they are recommended for implementation city-wide. Further note that for Local Area 2, no environmental contamination sources nor critical infrastructure facilities were mapped, and thus, these categories were not included in the quantitative risk reduction assessment. Of course, there might be further, unknown contamination sources, or other aspects to the environment to be considered.

For Local Area 2, *Accommodate*, *Avoid,* and *Resilience-Building* actions should prevail, as current risk is relatively low, meaning the focus should be on avoiding future increases in risk. *Retreat* of the few buildings in floodway should be considered opportunistically. These properties could be joined to the park, increasing overall community values. Over the very long term, more residential buildings at the Puntledge Terrace complex become increasingly at risk and should be targeted for *Resilience-Building* and flood-proofing activities.

6.4.3.2 Alternative Options (Not Recommended)

For Local Area 2, there was only one alternative option (Table 6-10), which did not meet screening requirements and was therefore not further developed in detail in the options analysis (i.e., no drawings and strength and weaknesses tables were created).

Table 6-10: Local Area 2: Alternative options considered (not recommended).

Alternative Options Considered (Not Recommended)	Reasons for Removal
Protect McPhee Meadows buildings & Puntledge Terrace: Small dike structure to protect two buildings near McPhee Meadows (in floodway) (note, the buildings are not City-owned), and dike structure to extend from Condensory Dike to protect Puntledge Terraces complex (nine buildings in rare	Option did not pass the screening requirements, due to not meeting authority and effectiveness requirements, and therefore was not further developed. At McPhee Meadows, only one parcel is exposed to flooding, i.e., it is not within the City's authority.

Alternative Options Considered (Not Recommended)	Reasons for Removal
long-term future flood extents (0.2% AEP and 2 m SLR/30% increase in riverine flows (~2200s); only one building of these is located in mid-term future – less likely flood extents.	For Puntledge Terrace, only the most extreme far-future flood extents include this area, therefore it does not meet effectiveness requirements.

6.5 Local Area 3: Condensory Bridge & Anderton Avenue

6.5.1 Local Area Characteristics

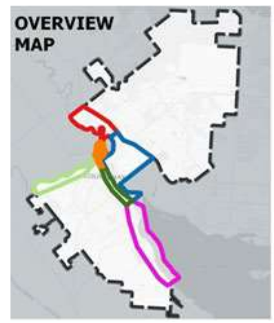

Figure 6-12: Location of Local Area 3 indicted in orange.

Flood Hazard Riverine (regulated and unregulated), with tidal influence, but limited wave effects.

Land Use Multi-residential, parks and recreation, some commercial.

Local Area 3 extends from upstream of Condensory Dike (along the Puntledge River to 5th Street Bridge on the east-side of the Courtenay River (i.e., below the confluence of the Puntledge and Tsolum Rivers) (Figure 6-12; Figure 6-13). Flood hazards include both regulated and unregulated riverine conditions (from the Puntledge and Tsolum Rivers, respectively, that merge to form the Courtenay River) in combination with tidal influence coming up the Courtenay River (with limited wave effects).

Land use is characterized by parks and recreation, multi-residential, and some commercial zoning. Building age ranges from pre-1965 along Anderton Ave, to buildings from the 1980s and 1990s at Canterbury. This local area is mostly within the Old Orchard Heritage Neighbourhood, as designated in the OCP, which has goals related to preserving the heritage style of buildings and mature trees, maintaining the residential neighbourhood, and no densification. 3rd and 5th Streets are also part of the Downtown Town Centre Land Use Designation in the OCP, with goals to establish character districts such as riverfront along the Courtenay River, protect views, and ensure public gathering spaces, while also protecting retail character of 4th and 5th Streets.

Further consideration for this local area is that across the Condensory Bridge (outside of City boundary) is the Puntledge Lands IR#2 reserve lands of the K'ómoks First Nation, with Puntledge RV Campground, which is connected to City-services (water, sewer) via Condensory Bridge.

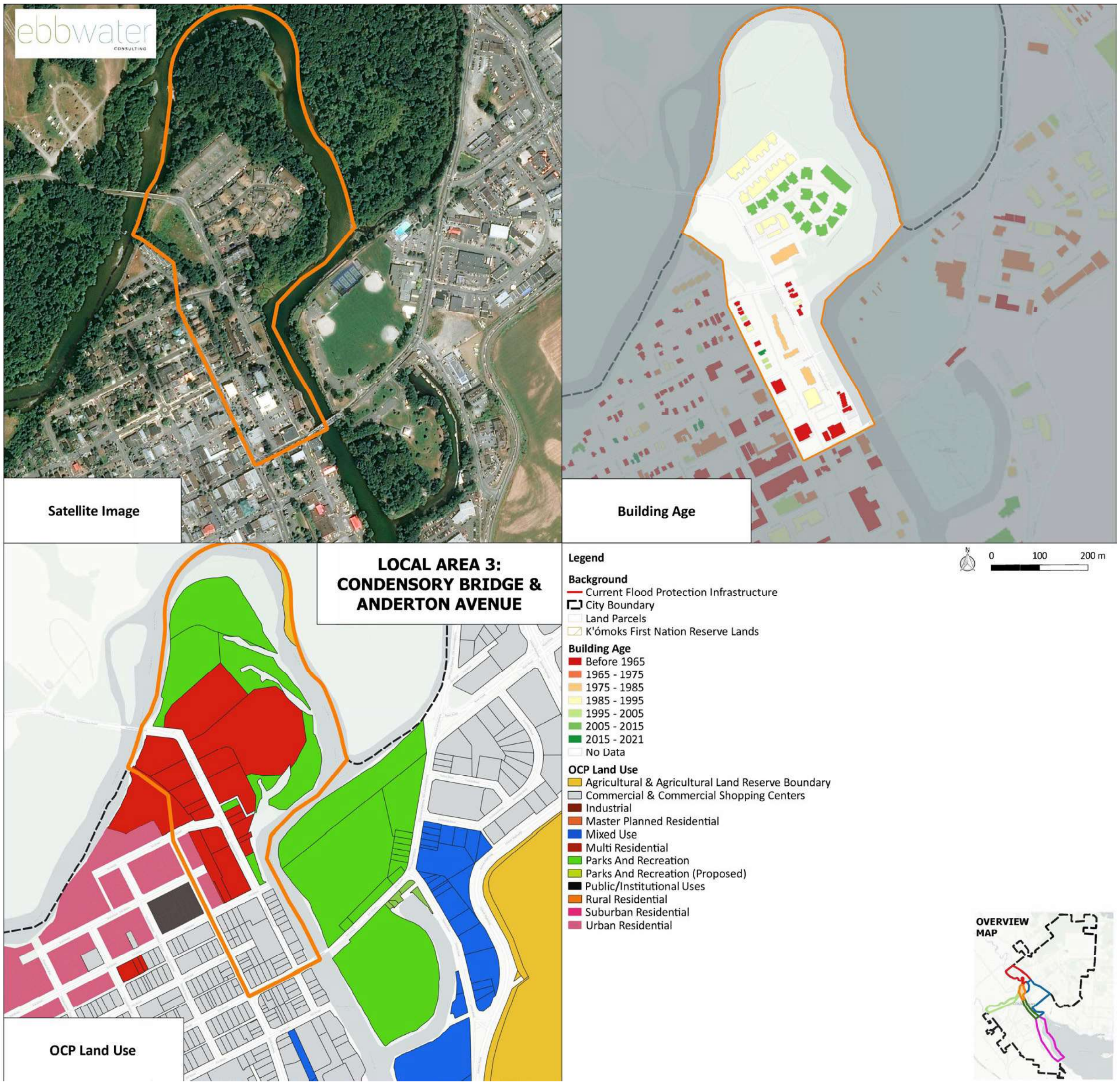

Figure 6-13: Local Area 3 (Condensory Bridge & Anderton Ave): Satellite imagery, building age based on BC Assessment 2022 data, as well as OCP land use (OCP land use layer as received from the City on 15 July 2022).

6.5.2 Baseline Risk ('Do Nothing')

Figure 6-14 shows the extent of the floodway and mid-term future – less likely flood event in the local area. This section describes current flood protection structures in the area, followed by the local risk.

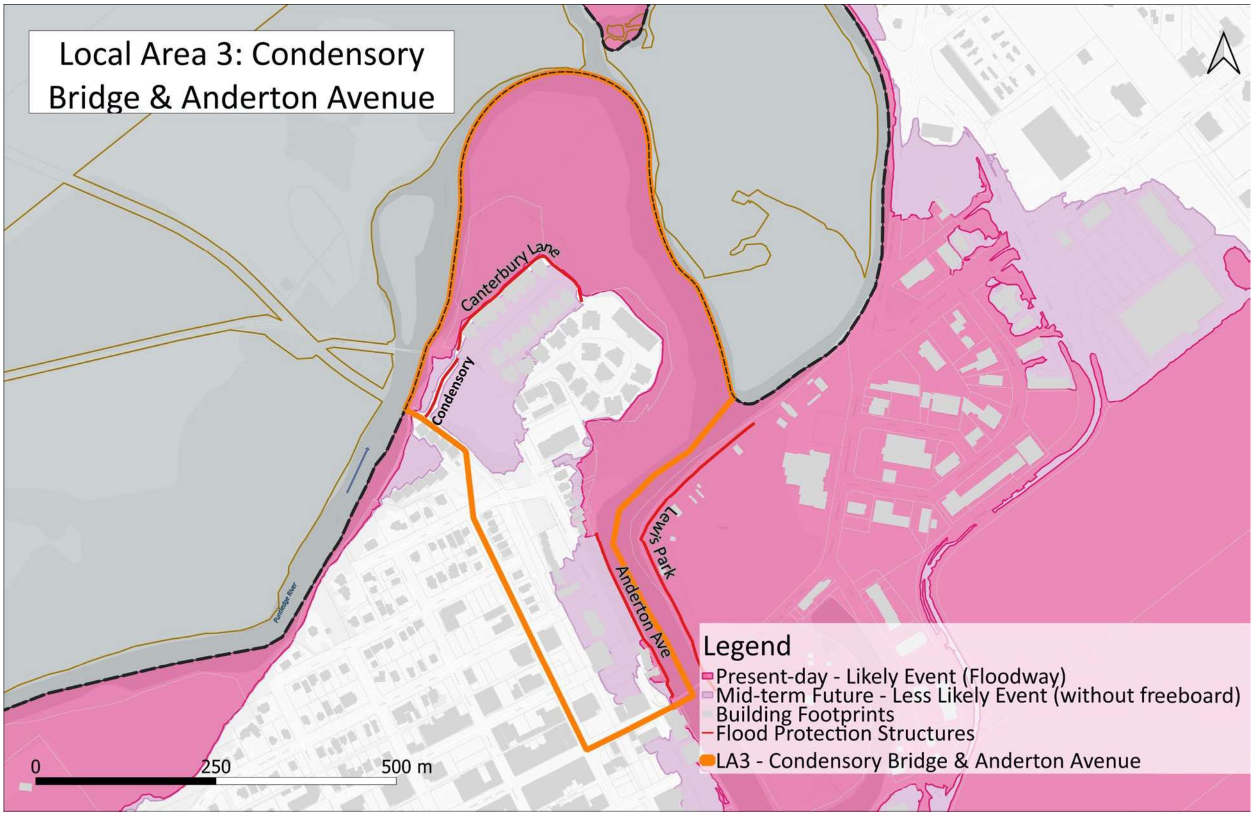

Figure 6-14: Floodway and mid-term future – less likely flood extents for Local Area 3: Condensory Bridge & Anderton Avenue.

6.5.2.1 Current Flood Protection Structures

There are three flood protection structures within this local area: Condensory Dike, Canterbury Lane Dike, and Anderton Avenue Dike (Figure 6-15). None of the structures, however, provide adequate protection for the design flood[34]. Their primary function is to act as erosion mitigation structures. Brief descriptions are provided below based on the Dike Master Plan (Appendix F).

[34] The design flood refers to the mid-term future – less likely event plus freeboard (i.e., 0.5% AEP; 1 m SLR & 15% increase in riverine flows + 0.6 m freeboard).

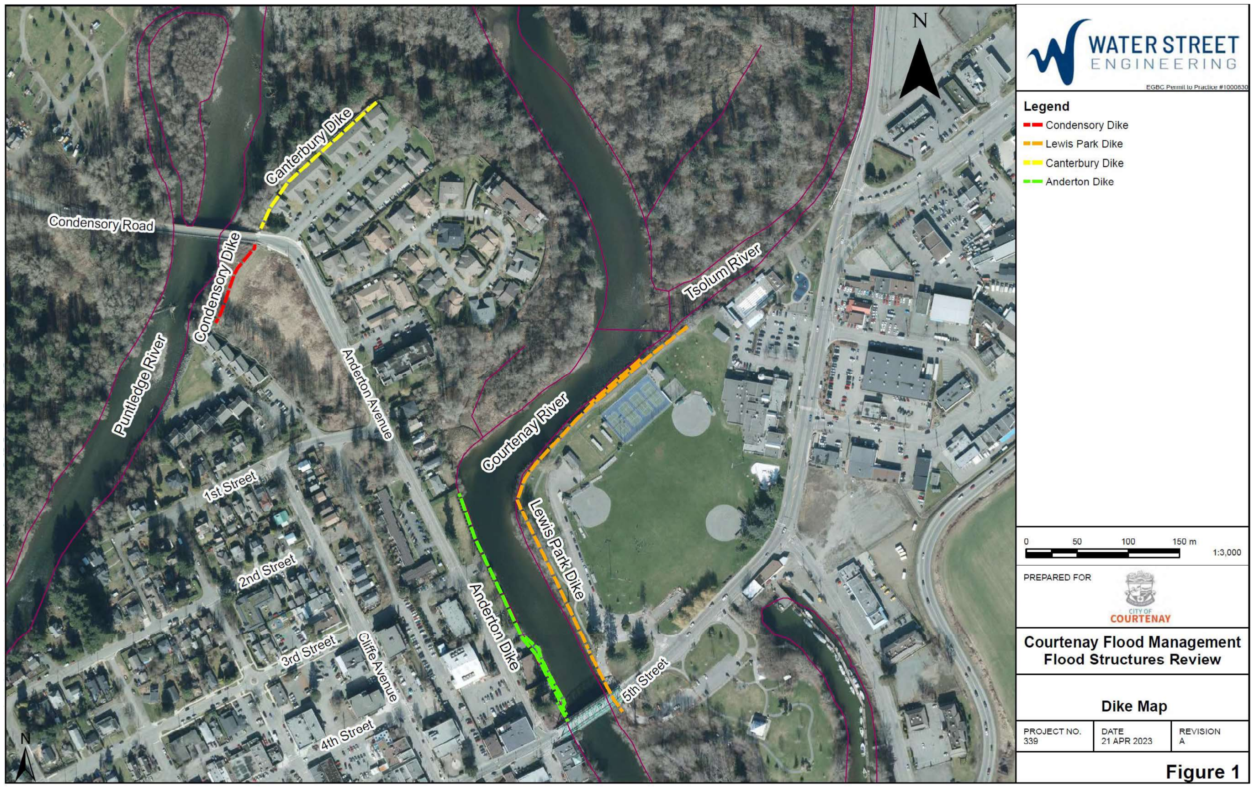

Figure 6-15: Dike Map (Credit: Water Street Engineering).

Condensory Dike consists of an earthen berm with a low permeability core (Figure 6-16). It was constructed in 2005 and provides erosion protection to an undeveloped area of land along the south bank of the Puntledge River. It is approximately 95 m long with a 4 m wide crest. Riprap[35] placed on its outside banks provides erosion protection, but the structure does not provide flood protection as the existing soils surrounding the dike are permeable and floodwater infiltrates through the structure. Further, its crest elevation of 6.7 m is below the FCL (7.2 m) for the area. Given that it is a relatively 'new' structure, it is in good condition with no substantial concerns noted. However, it was not constructed to function as a flood protection structure, but to provide erosion protection

Figure 6-16: Condensory Dike, looking upstream with Puntledge River on the right. (Credit: Ebbwater, 27 Feb 2023).

[35] Riprap describes engineered rock slopes that are designed to mitigate bank erosion.

against high flows in the Puntledge River. It is registered as flood protection works No. 363 in the Provincial Inventory. The responsible authority is the City who must ensure compliance with the *Dike Maintenance Act*.

Figure 6-17: Canterbury Lane Dike, with setback concrete wall, riprap toe protection and fencing, with residential complex immediately behind structure. (Credit: Water Street Eng., 27 Feb 2023)

Canterbury Lane Dike is a vertical concrete floodwall that runs along the south bank of the Puntledge River (Figure 6-17). Residential development is located immediately behind the concrete wall, with backyards and gardens on the landside of the retaining wall behind the fencing. Canterbury Lane Dike is approximately 260 m long and was constructed in 1989 as part of the multi-family development adjacent to the river. The embankment in front of the concrete floodwall is armoured with riprap. There is a walking trail through the forested area between the floodwall and the Puntledge River, with heavy vegetation. The height of the concrete wall above ground varies from 0.5 m to 3.2 m, with wooden fencing on top. The concrete wall has a typical elevation of ~6.0 m, which is below the FCL of 6.9 m in this area. The finished ground behind the wall (in the backyards of the residential properties) is higher than the land on the river side of the structure. High-level observations from the field review identified limited deterioration or damage to the dike crest and wall, as well as no major cracking or movement. However, a thorough inspection was not possible, as no access was available to the backside of the structure (via residents' backyards) and vegetation also obscured the view. Consistent with a previous inspection report from 2021, there were no signs of issues related to seepage, erosion, or deterioration of the structure. No signs of riprap movement or slope instability were noted, and the structure appears to be functioning well. Vegetation was noted to be encroaching on the riprap which reduced visibility of the toe. Ownership of the structure has been disputed, as it was built by the residential development to protect patios, prior to the *Dike Maintenance Act*. After the *Dike Maintenance Act* became law in 1996, the Province sought to make the City responsible for the structure. The City does not have a Statutory Right of Way (SRW) to access the structure. Due to the ownership dispute and missing SRW, the City has not been maintaining the structure or taken ownership of it. In fall 2023, the Province clarified that their policies do not support designating stratas as diking authorities. The structure is currently registered as Dike No. 373 with the Province of BC. This ownership dispute results in significant risk for the property owners and the City.


Figure 6-18: Anderton Avenue Dike, view from 5th Street Bridge. (Credit: Ebbwater, 27 Feb 2023).

Anderton Avenue Dike extends along the west bank of the Courtenay River, extending upstream from the 5th Street Bridge (Figure 6-18). The Anderton Avenue Dike is approximately 300 m long, with 250 m of precast concrete sections and 50 m of steel sheet piling with a concrete cap. The precast concrete sections and steel sheet piling were constructed from 1978 to 1980 to replace a log and lagging wooden wall that was built in the 1950s. Remnants of the former log wall remain at the toe of the current structure, which appears to contribute to the anchoring and support of the structure in some places. The crest elevation of the dike is between 4-4.5 m, below the FCL of 6.0 m in this area. A number of geotechnical and structural deficiencies have been noted in assessments, since 1998. Following geotechnical and structural inspections in 2016, an emergency repair was required, to stabilize the structure. The section of sheet pile wall was temporarily stabilized through the addition of a riprap buttress along the toe of the flood protection structure. Since completing the repair, monitoring of the sheet pile section of the wall has been conducted quarterly since 2016. The structure has many concerns, including riverbank scour and erosion, gradually moving of the wall towards the river, cracks in concrete cap, as well as substantial vegetation and root intrusion issues. The structure is reaching the end of its service life, and the City currently is working to identify the best path forward to address the risk. As of 31 July 2024, the City has purchased the property directly behind the failing dike structure, and gave notice to tenants to move out by the end of the year due to the high public safety risk, providing monetary compensation and support from housing society to support tenants in their search for new housing[36].

Anderton Avenue Dike is registered as Dike No. 28 with the Province of BC and regulated under the *Dike Maintenance Act*. The diking authority is the City.

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[36] City of Courtenay (2024). City Acquires Anderton Arms to Address Safety Risk. https://www.courtenay.ca/EN/meta/news/news-archives/2024-archives/city-acquires-anderton-arms-to-address-safety-risk.html (published on 31 July 2024; accessed on 16 August 2024).

Comox Valley Record (2024): Courtenay's Anderton Arms apartment to be demolished. https://www.comoxvalleyrecord.com/local-news/courtenays-anderton-arms-apartment-to-be-demolished-7465142 (Published on 31 July 2024). Accessed on 16 August 2024.

6.5.2.2 Local Risk

This section describes the current and future risk, if no risk mitigation actions are taken, based on both the quantitative flood risk assessment and local information and experience.

Affected People

Approximately 170 people are estimated to reside within the floodplain extent[37], and thus potentially affected by flooding. This includes the multi-residential homes (strata) at Canterbury, as well as residences at Anderton Ave. At Canterbury, the first two rows of houses behind the Canterbury Lane Dike are within the mid-term future – less likely flood extents, the rest of the residences are only in the more extreme, long-term future flood extents. Given the concerns with the Anderton Ave Dike, residents behind this structure are at a particularly high risk. In contrast, residents at Canterbury are not within the floodway, and at lower risk. There is also a concern for the safety of unhoused people, who may be camping in the parks along the river and be at risk during flood events.

Critical Infrastructure

The Anderton sanitary lift station (Figure 6-19) is particularly at risk considering its location near Anderton Avenue Dike (Figure 5-7). Flood waters may flood the structure at present-day frequent[38] (with 0.3 m depth) and less likely[39] (0.5 m depth) events (Figure 6-20). Note that this assessment is based on available flood modelling data. During the 2014 flood, Anderton Avenue and lift station stayed dry, with no recorded issues at the lift station[40]. The electrical panel of Anderton lift station is ~40 cm above ground, and a vent that would allow water access to the building is ~30cm above ground (facing away from river). The Anderton lift station services ~460 people[41] in the City, with the catchment including both the Canterbury residences, as well as extending over the 5th Street Bridge to the Lewis Park amenities. The sanitary service lines also extend over the Condensory Bridge to

Figure 6-19: Anderton lift station, with the outside vent visible.

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[37] With reference to the mid-term future - less likely flood.

[38] Frequent event = 10% AEP.

[39] Less likely = 0.5% AEP.

[40] The 2014 flood has been described as a 2% AEP flood, but there are many uncertainties associating a flood event with a likelihood, especially in a complex combined riverine (regulated/unregulated) and coastal system such as this. Therefore, the conditions leading to the 2014 floods and observed flood extents are not directly comparable to the modelled scenario assumptions and extents. See Section 3.5 for more details.

[41] Number of people serviced by the Anderton lift station was estimated based number of residential dwellings (219) within the catchment of the lift station, multiplied with the average number of people per dwelling (2.1) for this dissemination area, based on the 2021 Census.

IR#2 reserve lands of the K'ómoks First Nation; however, it is assumed that there are no year-round residents.

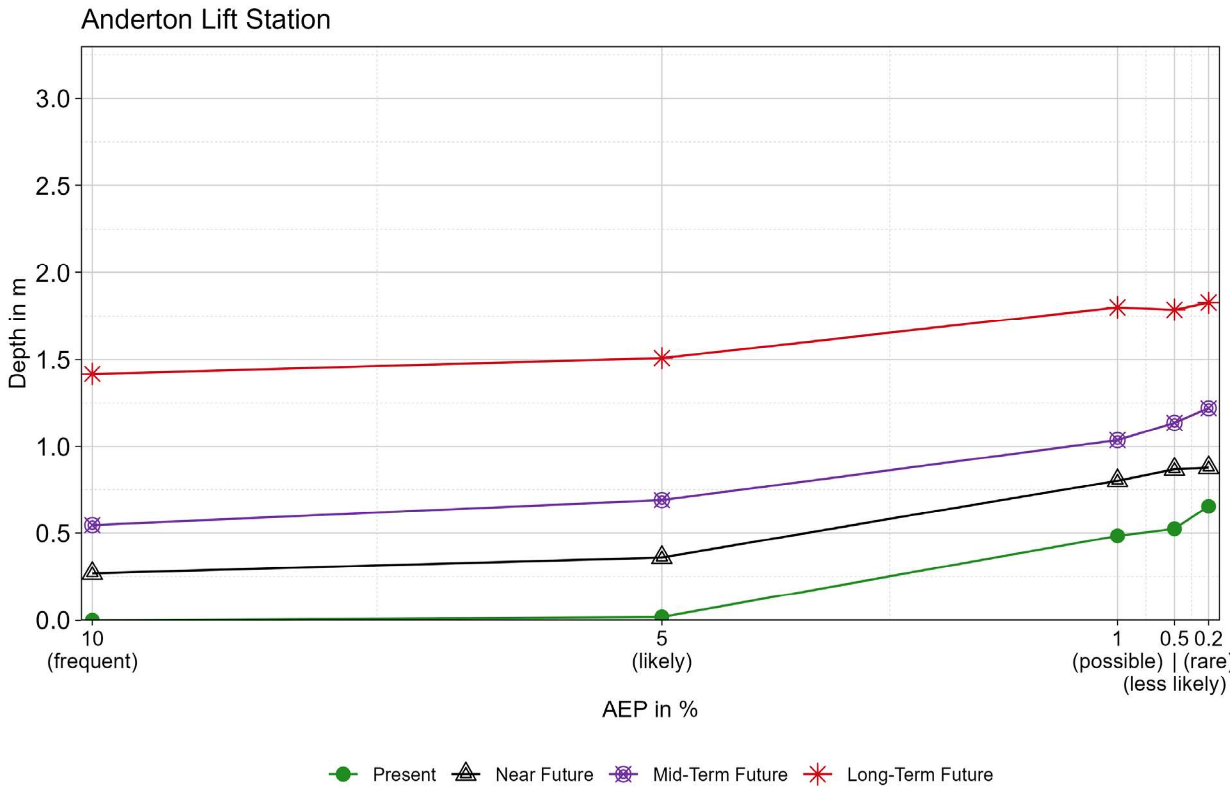


Figure 6-20: Modelled maximum depth of flood water in metres (m) for the Anderton Lift Station, for five AEP scenarios, as well as four time periods.

> "I got stuck downtown because both bridges were closed due to flooding. Ended up having to take a really scary dirt road home. S Farnham Road was the only bridge passable. I was SO lucky to have lots of gas & water with me." Public survey response

This local area also includes access to two important bridges, Condensory Bridge and 5th Street Bridge, that are essential transportation routes. Condensory Bridge is operated by Ministry of Transportation and Infrastructure (MoTI), with water and sewer lines (located at bridge deck level) to the Puntledge IR#2 reserve lands. The access point to Condensory Bridge is also below FCL, and may be flooded during peak flows, limiting transportation routes, for instance, to and from Campbell River and to Mount Washington. The City operates 5th Street Bridge, with water and gas lines going over the bridge. Access points to 5th Street Bridge are at higher elevation but impacts to bridge access may still occur during floods (e.g., due to scouring).

Many residential as well as some municipal buildings are located within the floodplain (~25 buildings), with a total building value of ~18$M[42]. Indirect economic damages may occur in case of sanitary lift station failure (and related closures of businesses serviced by the Anderton Ave Lift Station) and transportation issues due to bridge closures.

The Florence Filberg Centre, a municipal multi-use facility with space for special events, is located within the flood extent starting at a possible event in the mid-term future, when it may experience flooding between 0.5-1.0 m depth (Figure 6-21). Further, an Indigenous archaeological site is in the floodway (a pre-contact, cultural material in subsurface). Trails in the parks and a popular river swimming spot also provide important recreational value.

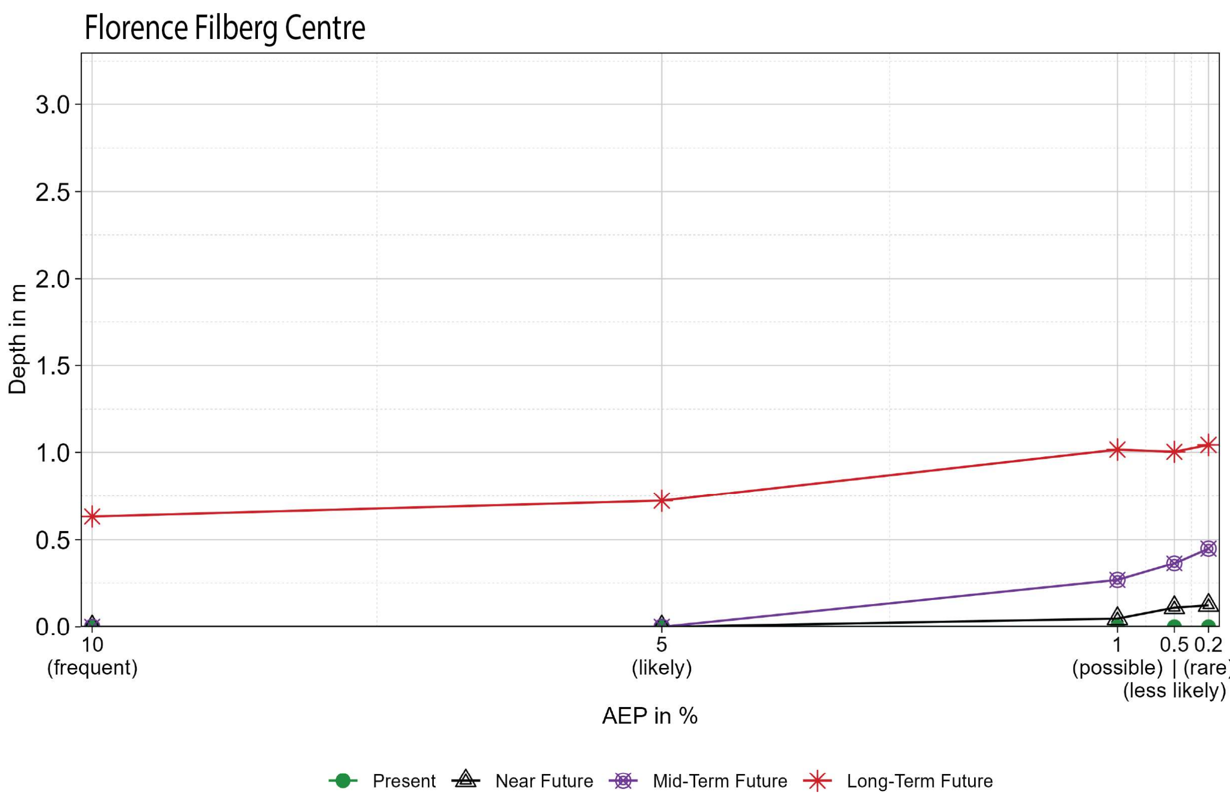


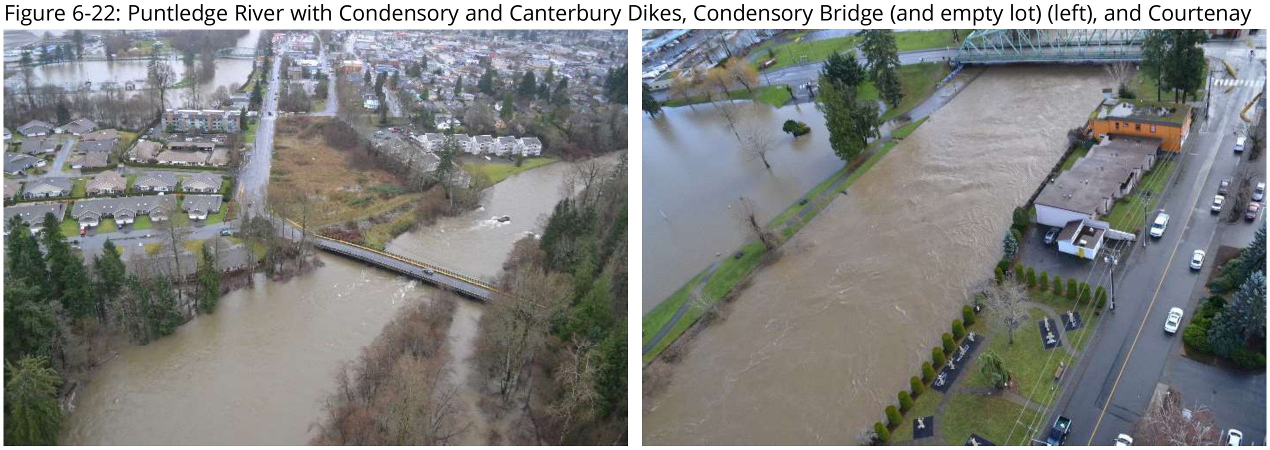
Figure 6-21: Modelled maximum depth of flood water in metres (m) for the Florence Filberg Centre, for five AEP scenarios, as well as four time periods.

[42] With reference to the mid-term future - less likely flood.

A groundwater well is located behind Condensory Dike, which may be of risk of contamination during a flood[43]. The well was set up as a test well in 2004. It is not clear if the well is still being actively used, however, no information on it being decommissioned is provided in the Provincial Well Registry. Therefore, in case of flooding, there is still a risk that contaminated floodwaters may enter through cracks in the well into the groundwater.

Further, several parks are within the flood hazard extent, including Condensory Park and Riverside Park. Further, it was noted in the workshop that trees and other debris pile up, creating dams in the river, which can exacerbate flooding.

Figure 6-22: Puntledge River with Condensory and Canterbury Dikes, Condensory Bridge (and empty lot) (left), and Courtenay



River at Anderton Ave (right) during the 2014 flood (Photo credit: City of Courtenay).

[43] Well tag number: 85130 (Provincial Groundwater Well Registry; https://apps.nrs.gov.bc.ca/gwells/well/85130#well_activity_fieldset).

6.5.3 Recommended Options, Alternatives, and Trade-offs

6.5.3.1 Suite of Recommended Options and Considerations

Table 6-11 provides an overview of the recommended options, with context on short-term and longer-term recommendations. This is followed by details on how these recommendations were developed.

Table 6-11: Overview of recommended options for Local Area 3.

Short-term:	Focus on *Accommodate*. *Avoid* new residential and commercial developments in floodplain and build *Resilience* for residents. Consider Naturalized Foreshore (replacement of current Anderton Dike) and *Retreat* of buildings in floodway for Anderton Ave. Address the ownership dispute with the Canterbury Strata. Complete a detailed assessment of the structure and ensure expectations of the provincial DMA are fulfilled. Encourage property-level flood barriers at Canterbury Strata. Continue with annual inspections and maintenance at Condensory Dike and Canterbury Dike.
Longer-term:	Consider buy-out of residential buildings directly behind Canterbury Lane structure over the longer-term, as they become available, or after a flood event (*Retreat*).

Options for this area are listed in Table 6-12, along with discussion on concerns and potential improvements, drawing on the feedback gained in workshop and public survey (note that public survey support is summarized at the end of this chapter). Also note that some options are discussed in more detail in Chapter 7 as part of city-wide strategies to avoid duplication for each local area. Strengths and weaknesses of recommended options are visualized for Local Area 3 in Table 6-13 and discussed below.

Table 6-12: Suite of options recommended for Local Area 3.

Protect	
 **Vegetation Management and Repairs and Condensory and Canterbury Dikes** *(For Canterbury Lane Dike: Address the ownership dispute with the Canterbury Strata. Complete a detailed assessment of the structure, and ensure expectations of the provincial DMA are fulfilled.)*	**Naturalized Foreshore at Anderton Ave Dike.** *(The existing structure would be removed, and a naturalized foreshore be constructed for erosion protection. See Section 7.2.3 for more details).*
Discussion: In the workshop, participants asked if the undeveloped area behind Condensory Dike could be used for flood retention. A review of this deemed this idea challenging given the local topography and the substantial infrastructure that would be required along with the relatively small storage capacity. The importance of the *Protect* options to maintain or improve recreation options was also highlighted in workshop. For the replacement of Anderton Dike with a naturalized foreshore for erosion control, the public survey showed high support (see the end of the chapter for more information on Community Support).	

Accommodate

FCLs **Flood-proof buildings** **Property-level Flood Barriers at Canterbury** (*Encourage property owners/residents to protect single/multiple buildings with temporary flood barriers (typically paid for/organized by property owner).*	**Develop park resiliency**	**Flood-proof or decommission groundwater well**	**Work with K'ómoks First Nation to minimize impacts to Indigenous sites**

Discussion: Importantly, *Accommodate* options for residences will need to come with socio-economic considerations for low-income housing. *Accommodate* options will require guidance from the City (see Chapter 7). Given the importance of nature recreation to the community, ensuring that parks and trails are resilient to occasional flood will also be needed.

While property-level flood barriers can provide some protection, there are also several concerns associated with them. They can vary in effectiveness due to different designs and standards, only work up to a specific flood depth/velocity and need time to set up. Further, this option would rely on property owners for finances and motivation. See also Chapter 7 for more details.

Retreat

Retreat buildings in floodway at Anderton Ave	**Longer-term: *Retreat* residential buildings** *(Buy-out buildings in row directly behind Canterbury Dike, followed by second row in mid-term future – less likely flood extents, as they become available over the longer-term and convert to park)*

Discussion: Social considerations of *Retreat* will be important to consider.

> "This area will be flooded anyway, and the cost will be lower to rebuild once vs. many times. Education of residents is important, as well as considering vulnerable populations when deciding on a process for moving them." Workshop participant

Avoid

***Avoid* new vulnerable residential and commercial development**

Discussion: The area behind Condensory Dike (west of Condensory Bridge) was discussed in the workshop, as it is a large piece of undeveloped land, currently zoned as residential, but it is not within the floodway, and any proposed future land uses will need to be informed by the current and future flood risk, and be designed to reduce the impact of a flood on the community.

Resilience-building

Residential awareness-building and preparedness; Parks Recovery Planning

Discussion: At the workshop, the importance of investing in reception and recreation centres that are flood-proof and equipped for hosting people during flood events was noted. They also suggested using an emergency management lens and aligning with local evacuation route planning.

Table 6-13: Local Area 3: Strengths and weaknesses of suite of recommended options, with respect to performance measures.

	Objectives	Suite of Recommended Options	
	Category	Protect (Naturalized Foreshore at Anderton) & Retreat of Buildings & Lift Station	Accommodate
Effect of Pathway During a Flood (Risk Reduction)			
	People (General)	Ineffective	Mod Effective
	People (Socially Vulnerable)	Effective	Mod Effective
	Environment	No risk mapped	No risk mapped
	Culture	Ineffective	Mod Effective
	Critical Infrastructure	Very Effective	Mod Effective
	Economy	Ineffective	Mod Effective
Effect of the Pathway Itself			
	Community	-1	0
	Social Equity	0	0
	Environment	2	0
	Recreation & Access to nature	2	0
	Implementation Cost	$$	$$$
	Maintenance Cost	$$	$$
	Implementability	3	3

Note that *Avoid* and *Resilience-building* Options have not been scored, as they are recommended for implementation city-wide. Further note that for Local Area 3, no environmental contamination sources were mapped, and therefore, these categories were not included in the quantitative risk reduction assessment. Of course, there might be further, unknown contamination sources, or other aspects to the environment to be considered.

The recommended suite of options for this area includes a variety of diverse flood management tools. This is by design, as each unique option has trade-offs. It will perform well on one objective, but poorly on another. But as a whole, all the options together provide risk reduction, maximize co-benefits, and minimize negative externalities (i.e., minimize negative consequences of the flood management action).

For Local Area 3, the recommended option for Anderton Ave, including *Retreat*, is essential to reduce immediate risk, but the social costs of that actions will need to be recognized and as much as possible minimized or compensated (e.g., by finding alternate suitable housing, providing appropriate financial compensation for the loss of property, etc.).

For Condensory and Canterbury Dikes, the alternative *Protect* options were not viable, and therefore, the focus is here in the short-term on *Accommodate* and *Resilience-building*, and ideally avoiding increasing further exposure by new development. However, these approaches will not work in the far future when flood waters are deeper and so they will need to be replaced by more robust options like *Retreat* and *Relocation*.

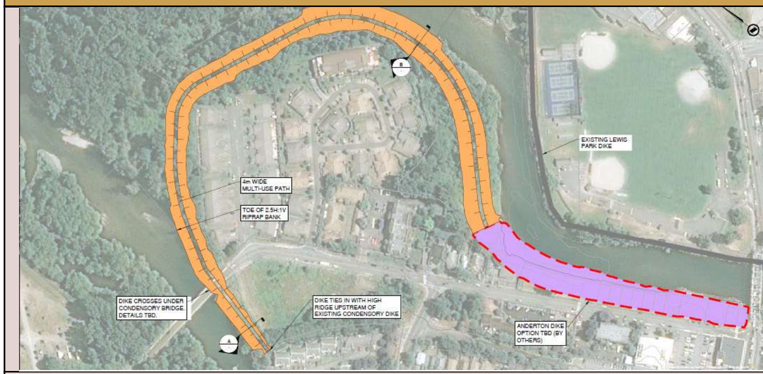
6.5.3.2 Alternative Options (Not Recommended)

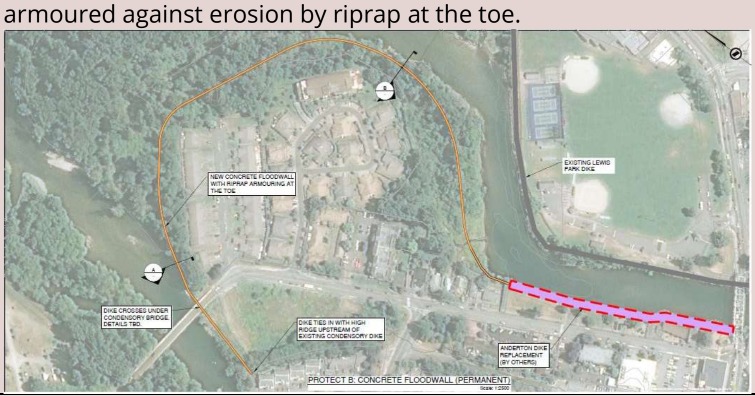
For Local Area 3, several alternative options were explored for Canterbury and Condensory Dikes, but eventually not recommended (Table 6-14). The main constraint in this area is Condensory Bridge, which has an elevation lower (~6 m CGVD2013) than the FCL (~7 m CGVD2013) required for flood protection. Therefore, during a flood event, it is likely that water would enter at the bridge, and flow behind flood protection structures. Therefore, even if the structures themselves are raised to the FCL, floodwaters would still enter at Condensory Bridge, therefore not providing any risk reduction benefits compared to the baseline scenario (as indicated in Table 6-14). To avoid flood waters entering at Condensory Bridge, an option would be to raise the bridge. However, the bridge is owned by MoTi, and the City does not have the authority to raise the bridge crossing. This may be a future option, however the City must manage the risk associated with the existing height of the bridge. Raising the bridge would also be a major undertaking, as it also has many service lines underneath. Blocking the bridge with temporary flood protection is also not an option, as the bridge is needed for evacuation out of the hazard zone. A downstream tie-in into Anderton Dike would also be required for any new structures. Also, flood protection structures are unlikely to be permitted by the Province, if they transfer risk upstream or downstream. Further dikes in this area would likely transfer risk to adjacent parcels.

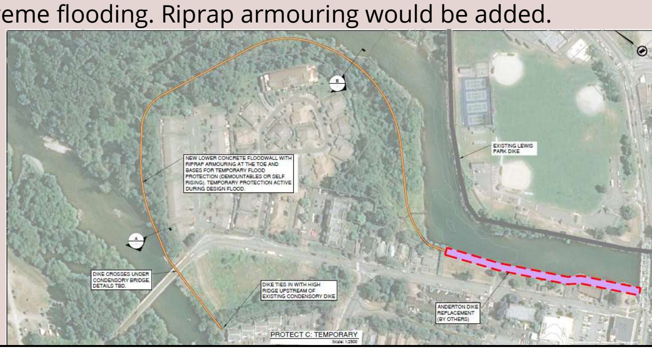
In addition to providing limited risk reduction (given the Condensory Bridge water entry), as can be seen in Table 6-15, these structures themselves would also have negative impacts on the environment, recreational access and community year-round. These options are also described in more detail in Appendix F.

Table 6-14: Local Area 3: Alternative options considered for Canterbury and Condensory Dikes (not recommended).

Alternative Options Considered (Not Recommended)	Reasons for Removal
Protect A: Ring Dike (Permanent): Dike around Canterbury and Condensory, with crest elevation up to FCL and riprap armouring on riverside to protect against erosion. Dike with a sloped foreshore (i.e., provides more ecosystem value, but also needs more space), with multi-use pathway. Existing Condensory Dike removed, Canterbury retaining wall kept in place. Dike crosses under Condensory Bridge and ties in with high elevation ridge upstream of Condensory Dike.	The ring dike would be ineffective, due to flood waters entering at Condensory Bridge, a discussed above. Further concerns with this option are related to ecosystem impacts and recreation opportunities (e.g., swimming), given the large size of the structure (width of dike varies between 20-35 m), as well as costs. There are also concerns with soft sediment soils that may make this structure unfeasible. Further, a downstream tie-in with Anderton Dike would also be required. A large dike structure would also block views.

<table>
<tr><th>Alternative Options Considered (Not Recommended)</th><th>Reasons for Removal</th></tr>
<tr><td>


</td><td>Maintenance concerns, as well as potential risk transfers to KFN and other jurisdictions are further concerns. Lastly, such a dike would have very high capital costs, and it is not aligned with Provincial expectations for flood management (see e.g. BC Flood Strategy overview in Section 2.4.4).</td></tr>
<tr><td>Protect B: Concrete Floodwall (Permanent):
Same alignment as Protect A but working with concrete wall to have a smaller footprint, up to FCL. Riverside of floodwall is armoured against erosion by riprap at the toe.


</td><td>Similar concerns as Protect A, in particular the tie-in with Condensory Bridge, where flood waters may still get behind the structure, rendering it ineffective, and challenging tie-in with Anderton Dike. The concrete wall would also be up to 4 m above ground, blocking views.</td></tr>
<tr><td>Protect C: Semi-Permanent Demountable or Self-Rising Barrier:
Same alignment as Protect B but using a demountable or self-rising (hydrostatic) barriers up to FCL. A lower concrete floodwall would serve as a base for the semi-permanent barrier, and also protect against minor flooding. The demountable/self-rising barrier would be placed on top of the lower floodwall to prevent extreme flooding. Riprap armouring would be added.


</td><td>Similar concerns as Protect A, in particular the tie-in with Condensory Bridge, where flood waters may still get behind the structure, rendering it ineffective. Further concerns included high costs, potential implementation challenges with soft soils and high sediment content of water, maintenance, as well as challenging tie-in downstream to Anderton Dike, as well as risk transfer to other jurisdictions (e.g., Puntledge IR#2 reserve land) and local areas. Note that this option was proposed in workshop and survey, but was met with many concerns.</td></tr>
</table>

Table 6-15: Strengths and weaknesses of alternative options (not recommended) for Canterbury and Condensory (Local Area 3)[44].

	Objectives	Canterbury and Condensory Alternative Options (Not Recommended)			
	Category	Protect A - Ring Dike	Protect B - Concrete Flood Wall	Protect C - Concrete Flood Wall	Protect C - Self-Raising Barrier
Effect of Pathway During a Flood (Risk Reduction)					
	People (General)	Very Ineffective	Very Ineffective	Very Ineffective	Very Ineffective
	People (Socially Vulnerable)	Very Ineffective	Very Ineffective	Very Ineffective	Very Ineffective
	Environment	No risk mapped	No risk mapped	No risk mapped	No risk mapped
	Culture	Very Ineffective	Very Ineffective	Very Ineffective	Very Ineffective
	Critical Infrastructure	Very Ineffective	Very Ineffective	Very Ineffective	Very Ineffective
	Economy	Very Ineffective	Very Ineffective	Very Ineffective	Very Ineffective
Effect of the Pathway Itself					
	Community	-1	-1	0	0
	Social Equity	0	0	0	0
	Environment	-1	-1	0	0
	Recreation & Access to nature	-1	-1	0	0
	Implementation Cost	$$$	$$$$	$$$	$$$$
	Maintenance Cost	$$	$$	$$$	$$$
	Implementability	2	2	2	2

The table above highlights that the discounted options are not effective at preventing risk. Due to the low elevation of Condensory Bridge, it would not be possible to prevent water from going behind the structures without blocking the bridge (which is needed for evacuation out of the hazard zone). The discounted options also come with many other negative aspects, such as high cost, community separation, environmental degradation, and more.

Note that alternative options (not recommended) for Anderton Dike Ave are detailed and discussed along with their reasons for removal in McElhanney (2023). An overview is also provided in Appendix F.

[44] Note that for Local Area 3, while the protection structures (permanent and semi-permanent) are assumed to be up to FCL, there are concerns on the tie-ins at Condensory Bridge, as discussed above, and would let flood waters enter behind the structure. Therefore, the structures would not provide protection up to FCL, and no risk reduction as compared to the baseline was assumed for these structures (in this case, no additional AAL calculations were carried through, due to the specificity of the situation). See Appendix B for details.

6.6 Local Area 4: Lewis Park & Puntledge Road Commercial Area

6.6.1 Local Area Characteristics

Flood Hazard	Riverine, with tidal influence, but limited wave effects.
Land Use	Commercial, multi-residential, parks and recreation, mixed use, agricultural, industrial.

Figure 6-23: Location of Local Area 4 indicted in blue.

This local area is located along Tsolum Slough and the east side of the Courtenay River, and includes Lewis Park, the Puntledge Commercial Area, the agricultural lands of the Courtenay Flats, and the east shore of the Courtenay River to the City boundary (Figure 6-23; Figure 6-24). Flood hazards include unregulated riverine conditions from Tsolum Slough and the regulated/unregulated riverine conditions of the Courtenay River in combination with tidal influence coming up the Courtenay River (but limited wave effects).

Land use in Local Area 4 is dominated by commercial and mixed use, agricultural land, as well as parks and recreation (Figure 6-24). On a former industrial site (of the Field Sawmill) along the Courtenay River in the southern part of the local area, the Kus-kus-sum restoration project is returning the site to a natural ecosystem (see Section 6.6.2.2). The OCP highlights the area around Ryan Road as a 'Town Centre', a primary focus area of commercial and residential densities outside of downtown and is intended to support a mix of land uses, including commercial and multi-residential housing.

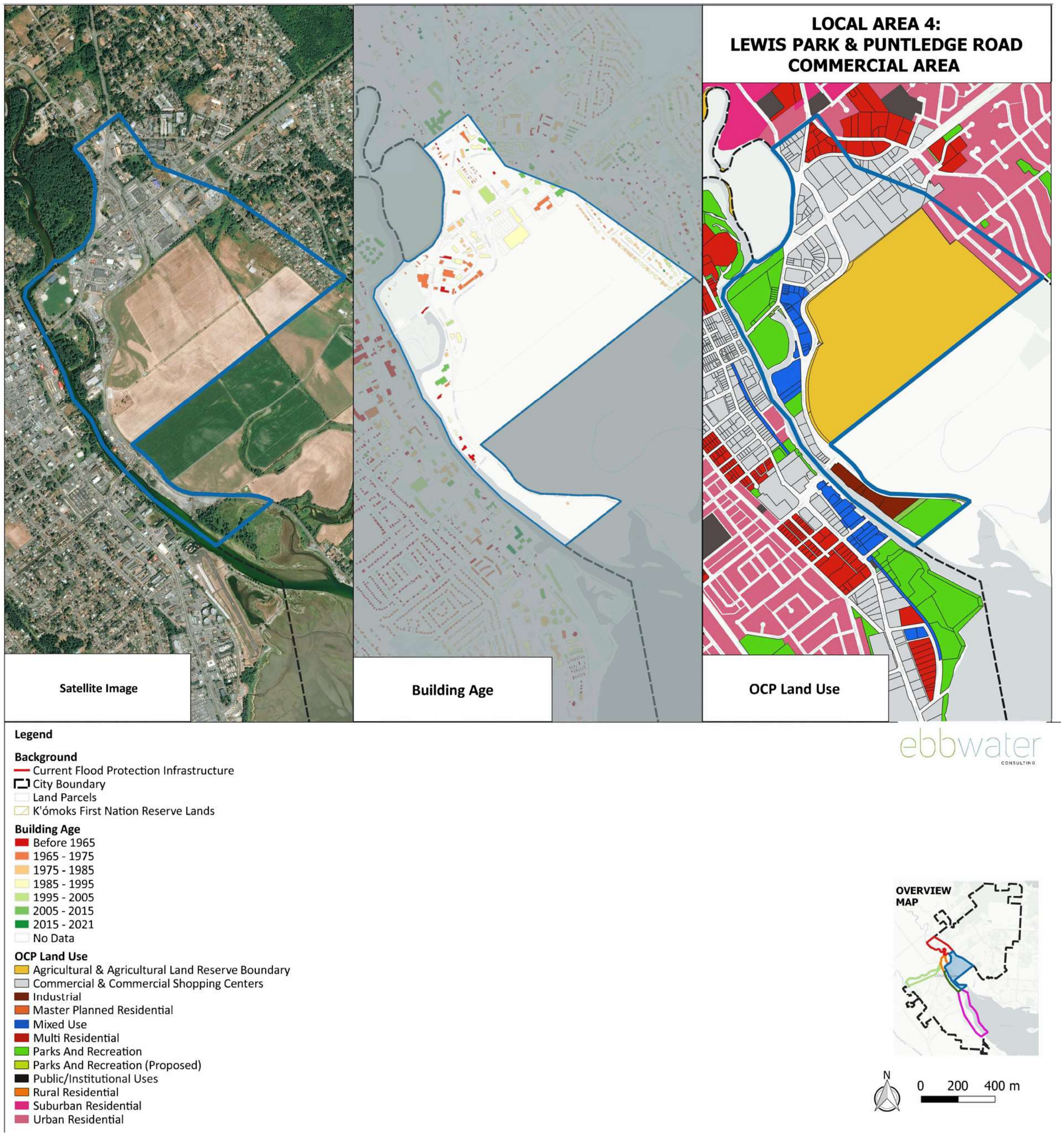


Figure 6-24: Local Area 4: Satellite imagery, building age based on BC Assessment 2022 data, as well as OCP land use (OCP land use layer as received from the City on 15 July 2022).

6.6.2 Baseline Flood Risk ('Do Nothing')

This section describes current flood protection measures, emergency flood operations, as well as the Kus-Kus-Sum restoration project. This is followed by discussion of current and future risk. Figure 6-25 shows the extent of the floodway and mid-term future – less likely flood event in the local area. The majority of this local area is located within the floodway, i.e., will flood at smaller, present-day events, as has been seen in the past (for instance in 2014) and will see deeper, faster and generally more damaging flood waters.

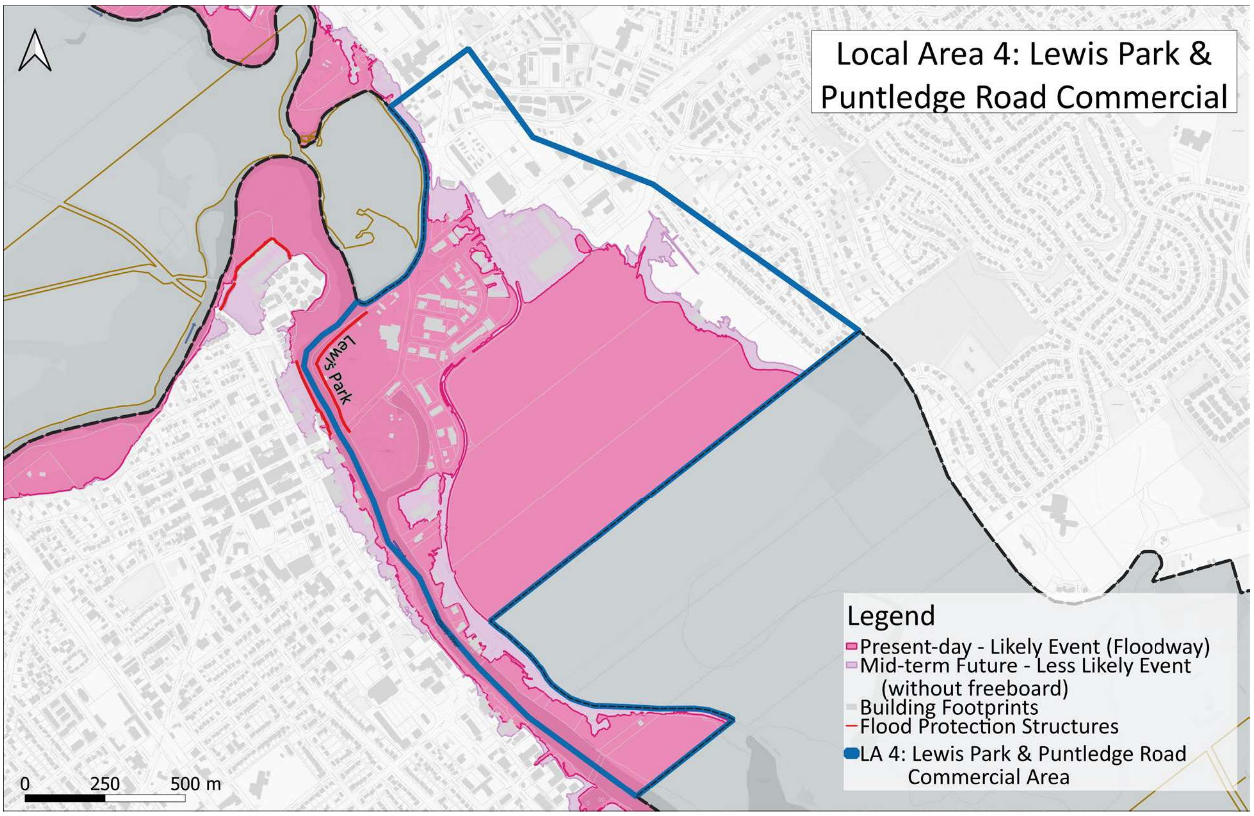


Figure 6-25: Floodway and mid-term future – less likely flood extents for Local Area 4. Note that some buildings appear to not be in the floodway, when they may be in fact in the floodway. This is due to the data used to develop the maps, which includes buildings in the topography, and therefore the building footprints appear to be in the mid-term future – less likely flood extents, when the ground is in the floodway. Note that the building footprint layer (grey polygons) overlies the flood layers.

6.6.2.1 Current Flood Protection and Emergency Response Measures

In Local Area 4, flood protection measures include the Lewis Park Dike, the temporary Tiger Dam (AquaDam in previous years), as well as the so-called 'Tall Wall'.

Figure 6-26: Lewis Park Dike, viewed from the west shore of the Courtenay River (Anderton Ave area). (Credit: Ebbwater, 27 Feb 2023).

Lewis Park Dike follows the south bank and east bank of the Courtenay River as it flows around Lewis Park (see map in Local Area 3, Figure 6-15) (Figure 6-26). It is approximately 450 m long and was constructed from precast concrete sections with riprap placed along the toe of the structure. Over time, vegetation has established along the toe and banks of the dike. And ongoing deposition of gravels has occurred along the toe, particularly at the inside of the bend in the Courtenay River. Crest elevation of the dike is between 3 to 4 m (CGVD2013), below the area FCL of 6 m, i.e., the dike does not provide adequate flood protection for the design flood. During field inspection (see Appendix F, Flood Protection Structures Review and Dike Master Plan), several areas of localized erosion and undermining were observed, and it was also noted that vegetation and root intrusions are a substantial issue for Lewis Park Dike. There also seem to be cracks in concrete wall. The Lewis Park Dike is a flood protection structure registered as Dike No. 29 with the Province of BC and regulated under the *Dike Maintenance Act*. The City is the diking authority.

Tiger Dam: The City also maintains temporary seasonal flood protection through the use of an Tiger Dam upstream of Lewis Park along Tsolum Slough (Figure 6-27), typically installed between October and February each year.

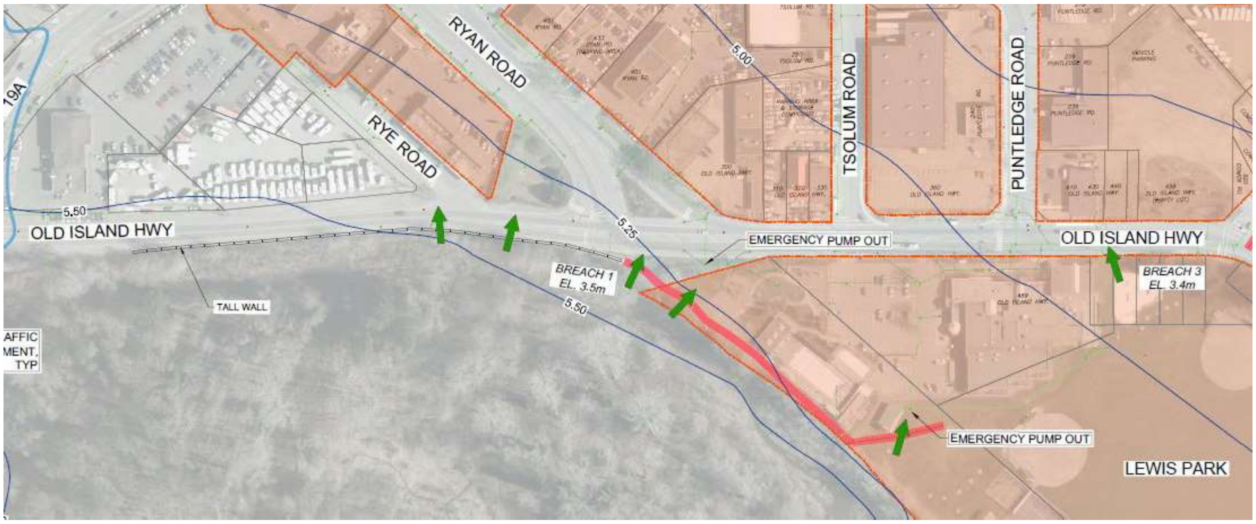


Figure 6-27: Location of AquaDam (thick red line) and Tall Wall (grey bars) near Lewis Park and along Old Island Highway (see Figure 6-37 for complete map) (Credit: McElhanney, 2022).

The Tiger Dam[45] (in the single Tiger Dam configuration used by the City) is a tube of approximately 60 cm height, which gets filled with water and secured (Figure 6-28). Typically, 11 lengths of 50' (approx. 168 m) are installed at the north end of Lewis Park, adjacent to the Tsolum River, which is usually the first area to flood during a high flow event. The Tiger Dam has replaced the AquaDam that was used until spring 2023.

Figure 6-28: Tiger Dam. Credit: U.S. Flood Control.

[45] Tiger Dam: https://usfloodcontrol.com/24-fm-approved-tiger-dam/

The AquaDam was also a waterfilled bladder (with two inner tubes) used as a flood barrier[46] (Figure 6-29, Figure 6-30). Similarly to the Tiger Dam, it could provide protection up to ~60 cm depth of flood waters. The AquaDam was first installed after the 2014 floods, but had not been tested by a similar or higher flood event; there is no proof that it would work as intended. The AquaDam also experienced many issues with vandalism and deflation (Figure 6-30), and environmental concerns due to water withdrawals from and back into the Tsolum River to fill the tubes. Operation costs for setup and maintenance throughout the winter averaged $19,000 annually from 2015-2022. Further, the Tiger Dam/AquaDam are not designed to stay up an entire season.

Figure 6-29: Aquadam near Lewis Park (Credit: Ebbwater, 27 Feb 2023).

Figure 6-30: Deflated Aquadam (Credit: Ebbwater, 27 Feb 2023).

With the height of ~60 cm, if the Tiger Dam holds and does not leak, it is expected to hold a likely (5% AEP) present-day event, but a less likely (0.5% AEP) present-day event may overtop it (~70cm flood depth in this location). In the mid-term future, even the likely event would be expected to overtop the height of the Tiger Dam.

Further concerns with the Tiger Dam/AquaDam are that water may go around the ends (in particular, given the issues discussed with the adjoining Tall Wall below). Typically, these measures are designed and used on an events-basis to protect a specific piece of infrastructure, not for a long length of riverbank.

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[46] AquaDam: https://www.aquadam.net/

Figure 6-31: Tall Wall along Headquarters Road (Credit: Ebbwater, 27 Feb 2023).

Tall Wall: Connecting to the Tiger Dam along Headquarters Road along Tsolum Slough (Figure 6-27) is the so-called 'Tall Wall', which are jersey barriers with an approximate height of 110 cm above ground (Figure 6-31). The idea of the Tall Wall is that it would protect the road from flooding, but again, this has not been tested since installation. Jersey barriers are not engineered to provide flood protection and do not meet the Provincial guidelines for Dike Design and Construction (BC Ministry of Water, 2003). There are major concerns that the wall cannot withstand water pressure. If water were to back up behind it, it is likely that the wall would fall over and become a safety hazard for traffic on Old Island Highway. Further, similar to the Tiger Dam, it may be overtopped with more extreme events in the present-day.

Lewis Park Culverts: Lewis Park also contains three big culverts that are open to Courtenay Slough near Simms Millenium Park to the south (Figure 6-32; Figure 6-33). These were installed to allow flood waters to exit Lewis Park, but they also allow flood waters to enter into Lewis Park from the Courtenay Slough during times of high water levels. In this way, Lewis Park stores water and buffers the effects of flood.

Figure 6-32: Lewis Park Culverts, connecting Lewis Park to Courtenay Slough. (Credit: Google Earth Imagery, 17 May 2023).

Figure 6-33: View of Lewis Park culverts from the South from Courtenay Slough. (Credit: Ebbwater, 27 Feb 2023).

Rye Road Flood Corridor: Old Island Highway at Rye Road and Ryan Road is one of the first breach points in the City during high riverine water levels (see Figure 6-37 below, under Flood Operations Manual). When water levels crest Tsolum Slough, flood water collects and runs along Rye Road (overland flow) (Figure 6-34). To manage this overflow at the end of Rye Road water enters an open ditch, which leads to twin 1200 mm diameter stormwater mains crossing Island Highway 19A and Ryan Road diagonally, and then enters a 1650 mm diameter stormwater main along Island Highway to the south (Figure 6-35). This discharges behind the Superstore into a pond and ditch system operated by Ducks Unlimited. The pond and ditch system are adjacent to the agricultural land and part of the agricultural irrigation network. Further overflow water could potentially spill onto agricultural land. There is also concern of flood water being backed-up and overflowing onto adjacent lands if the pond and ditch system are already saturated with high water.

In 2023, BC Hydro installed infrastructure (connected to new Electrical Vehicle (EV) charging stations in the nearby parking lot) part-way within the open ditch. Along with the infrastructure, a berm was installed within the ditch. To continue to allow overland flow of flood waters to flow through the ditch, four culverts (450 mm) were then installed across the berm (Figure 6-34). The berm and the flow capacity of the four culverts may limit the amount of floodwaters that can runoff via the ditch to the twin culverts. However, given that the surrounding parking lots are at slightly higher elevation (~50 cm), water would likely still pool within the ditch, even if overtopping the berm, and eventually run off towards the twin culverts at Highway 19A[47].

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[47] No drainage modelling was conducted as part of the FMP. This would have to be confirmed through modelling.

The twin culverts under Highway 19A are slanted, to avoid backwatering. However, according to the City's Public Works, they are in a bad condition[48] and should be cleaned, but there are concerns of them collapsing when doing so. These twin culverts may also limit the flow that can be conveyed to the agricultural fields. Lastly, the Ducks Unlimited ditch at the end of the culverts is also overgrown with vegetation according to the City, and some cleaning may be necessary to allow for more capacity.

Overall, the Rye Road flood corridor alleviates some pressure during high rainfall events based on discussions with City operations staff. However, it is not expected to support drainage for larger floods.

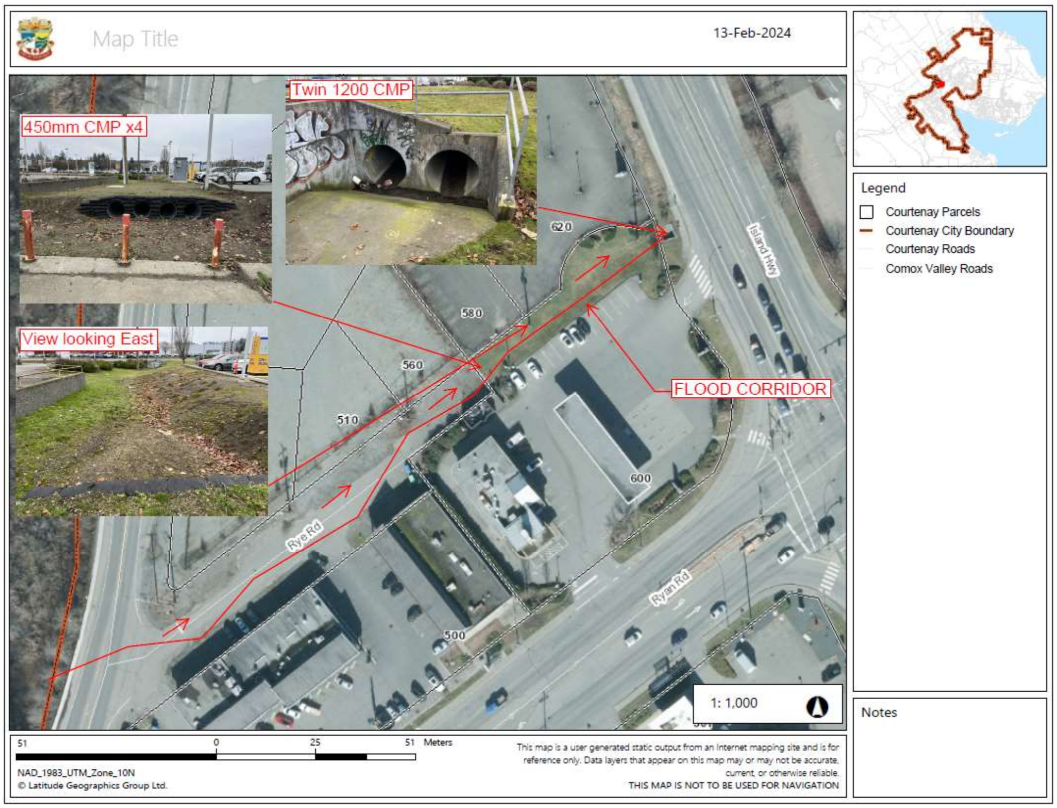


Figure 6-34: Indication of overflow channel via stormwater system below Rye Road. Credit: City of Courtenay.

48 Note that this site has not been reviewed by consulting engineers during the field visit.

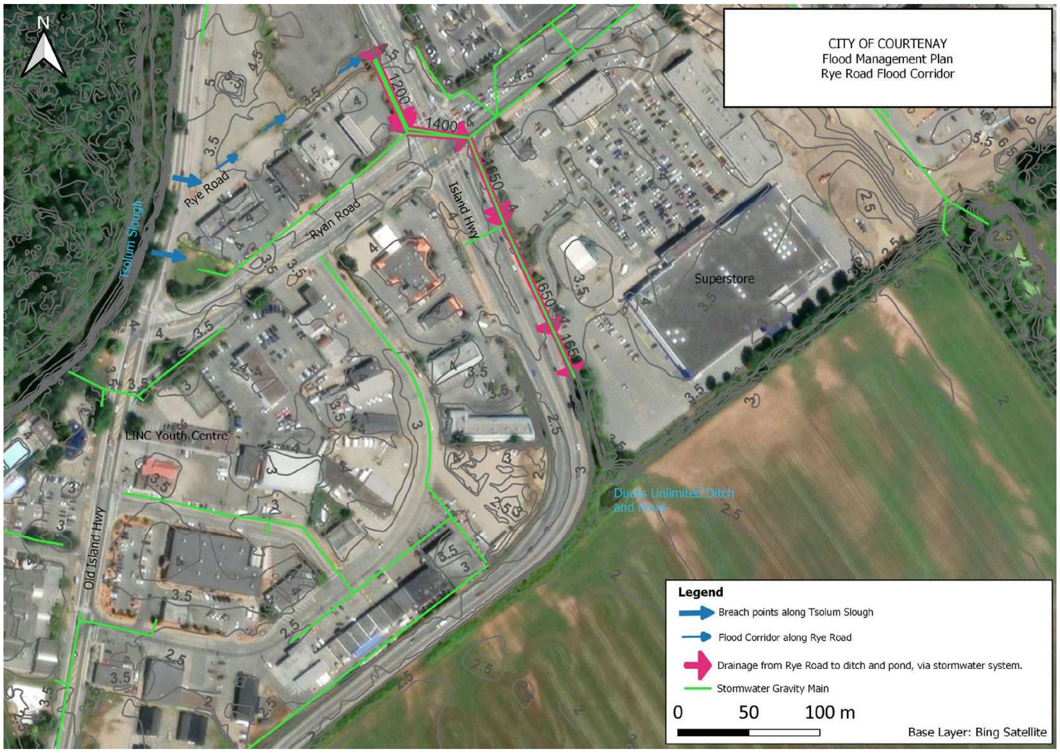


Figure 6-35: Rye Road flow path.

TideFlex Valves: The City also installed TideFlex Checkmate Valves[49] in 2016 in select locations in the floodplain to prevent stormwater from backing up during high tide and flooding the Puntledge Road area (Figure 6-36).

[49] TideFlex Valves: https://www.redvalve.com/tideflex

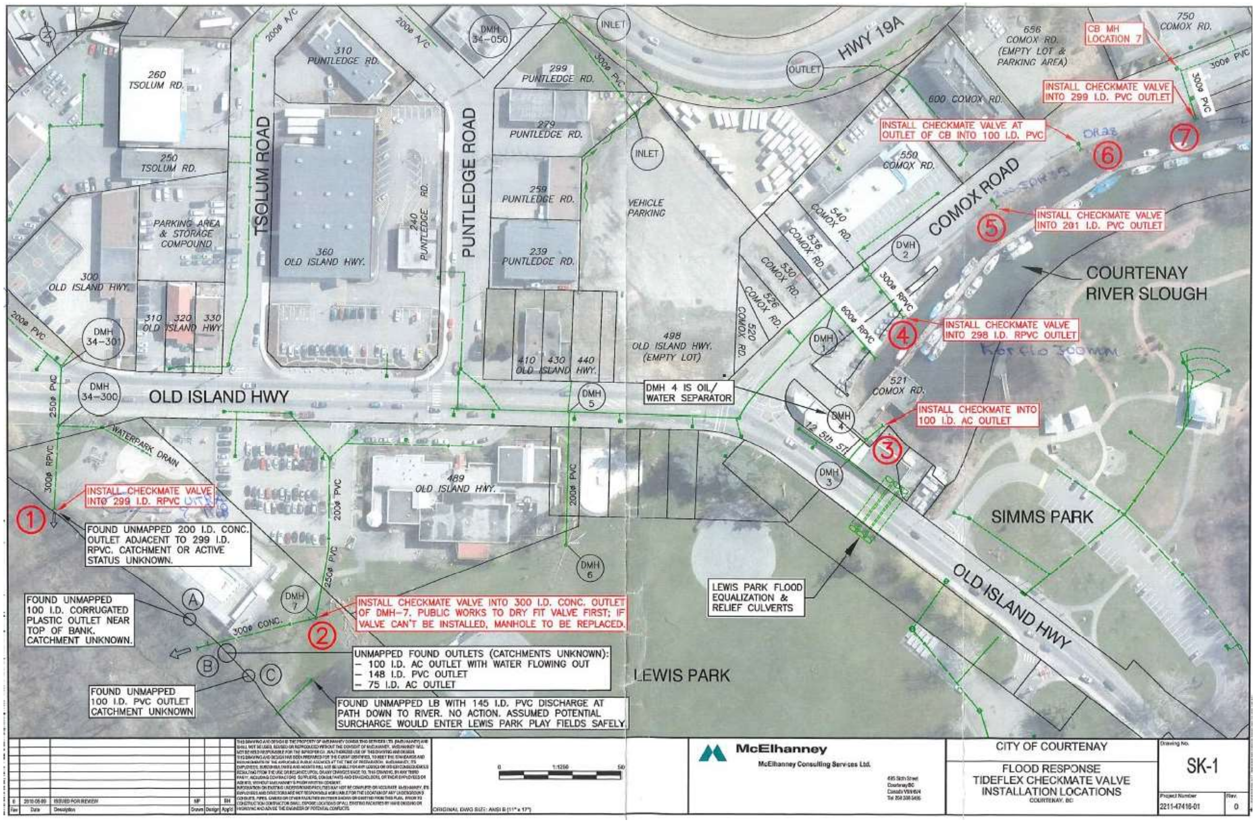


Figure 6-36: TideFlex Checkmate Valve locations marked in red. (Credit: McElhanney, 2016)

An **Integrated Stormwater Management Plan** is currently under development and should address some of the issues discussed above.

Flood Operations Manual: The City also has developed a comprehensive Flood Operations Manual (McElhanney, 2022), with focus on the Lewis Park Commercial Area, which provides operational procedures to mitigate flooding. The plan indicates typical flood entry points (potential breach areas) (Figure 6-37), and highlights a set of protocols to follow based on predicted or observed water levels of the Courtenay River at 5th Street Bridge (Figure 6-38). Flood warnings may be issued by the River Forecast Centre or BC Hydro. Based on McElhanney (2022), typical breach areas include (Figure 6-37):

1. Breach 1: Low points on Old Island Highway near the Rye Road and Ryan Road intersection breach first, if water levels in the Tsolum Slough (Old Tsolum River Channel) are above the crest elevation.

2. Breach 2: Comox Road from Old Island Highway South also has a low area that can breach when river levels are high in the Courtenay River Slough. This area can breach at the same time as Breach 1, or independently, depending on river discharges and tide and storm surge levels, as this area is strongly influenced by tide levels.
3. Breach 3: Old Island Highway near the south corner of the Lewis Centre is at lower elevation and may be breached in an event, slightly larger for instance than the 2014 floods.

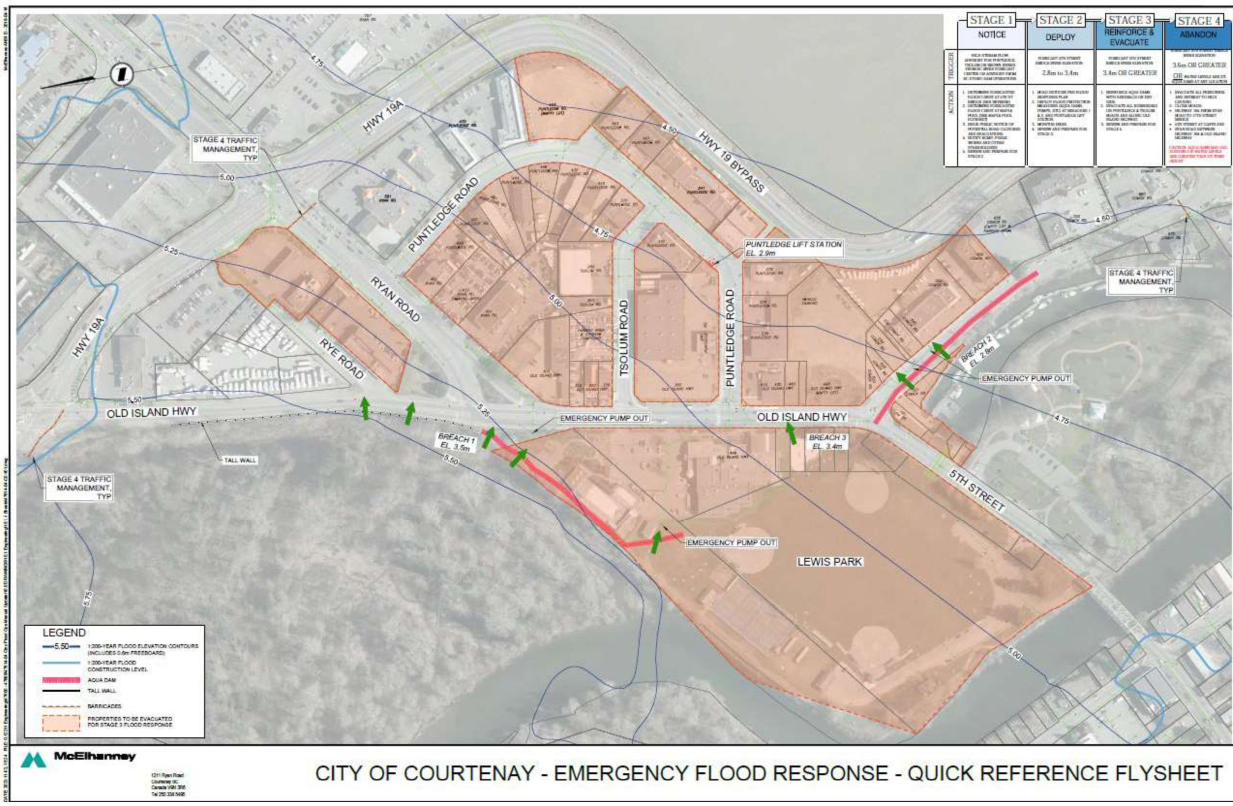


Figure 6-37: Emergency flood response reference sheet for the Lewis Park area, with indication of typical flood entry points; Flood Operations Manual (Credit: McElhanney, 2022).

	STAGE 1 NOTICE	STAGE 2 DEPLOY	STAGE 3 REINFORCE & EVACUATE	STAGE 4 ABANDON
TRIGGER	HIGH STREAM FLOW ADVISORY FOR PUNTLEDGE, TSOLUM OR BROWN RIVERS FROM BC RIVER FORECAST CENTRE OR ADVISORY FROM BC HYDRO DAM OPERATIONS	FORECAST 5TH STREET BRIDGE RIVER ELEVATION: 2.8m to 3.4m	FORECAST 5TH STREET BRIDGE RIVER ELEVATION: 3.4m OR GREATER	FORECAST 5TH STREET BRIDGE RIVER ELEVATION 3.6m OR GREATER OR WATER LEVELS ARE 2/3 AQUA DAMS AT ANY LOCATION
ACTION	1. DETERMINE FORECASTED FLOOD CREST AT 5TH ST BRIDGE (SEE REVERSE) 2. DETERMINE FORECASTED FLOOD CREST AT MAPLE POOL (SEE MAPLE POOL FLYSHEET) 3. ISSUE PUBLIC NOTICE OF POTENTIAL ROAD CLOSURES AND EVACUATIONS. 4. NOTIFY RCMP, PUBLIC WORKS AND OTHER STAKEHOLDERS 5. REVIEW AND PREPARE FOR STAGE 2.	1. ROAD DETOURS PER FLOOD RESPONSE PLAN 2. DEPLOY FLOOD PROTECTION MEASURES (AQUA DAMS, PUMPS, ETC) AT BREACHES 1 & 2, AND PUNTLEDGE LIFT STATION. 3. MONITOR DIKES. 4. REVIEW AND PREPARE FOR STAGE 3.	1. REINFORCE AQUA DAMS WITH SANDBAGS ON DRY SIDE. 2. EVACUATE ALL BUSINESSES ON PUNTLEDGE & TSOLUM ROADS AND ALONG OLD ISLAND HIGHWAY. 3. REVIEW AND PREPARE FOR STAGE 4.	1. EVACUATE ALL PERSONNEL AND RETREAT TO HIGH GROUND. 2. CLOSE ROADS: • HIGHWAY 19A FROM RYAN ROAD TO 17TH STREET BRIDGE • 5TH STREET AT CLIFFE AVE • RYAN ROAD BETWEEN HIGHWAY 19A & OLD ISLAND HIGHWAY CAUTION: AQUA DAMS MAY FAIL SUDDENLY IF WATER LEVELS ARE GREATER THAN 2/3 THEIR HEIGHT.

Figure 6-38: Triggers and actions for flood emergency response; Flood Operations Manual (Credit: McElhanney, 2022).

6.6.2.2 Kus-kus-sum Restoration Project

At the location of the former industrial site of the Field Sawmill along the west shore of the Courtenay River, the Kus-kus-sum restoration project aims to re-naturalize the site to bring back a thriving foreshore and inter-tidal habitat. The efforts are led by Project Watershed, in partnership with the K'ómoks First Nation and City of Courtenay. The site was bought in from Interfor in 2020, and restoration started in 2021.

Concrete at the location has been removed and planting of native plants started in the Spring of 2023. Once the sheet pile currently still facing the Courtenay River side is removed (in the next couple years), the Kus-kus-sum site will also provide room for high flood waters, although the benefits are mainly on site given the location of the wetland in the lower estuary. This is a showcase of returning a former industrial site within the floodplain back to a natural ecosystem.

6.6.2.3 Local Risk

This section describes current and future baseline risk for Local Area 4, i.e., if no risk mitigation actions are taken, based on both the quantitative flood risk assessment and local information and experience.

> "Areas that have flooded in the past include: Comox Rd, 19A by the farm, Superstore parking lot, Ryan Road & 19A through the drain hole." Public survey response

While the local area is primarily commercial/agricultural, there are still some residential homes, all of them located within the floodway with an estimated ~50 residents potentially directly. Similarly to other parks, it is important to consider the risk to unhoused people in case of flooding. Further, there may be many more impacts to people using this local area, either as a corridor to other parts of town (for instance, parents dropping their kids off at daycare or school), or conducting errands at the commercial centres.

"I think it was 2016 when the whole of the Superstore, Lewis Park area was majorly flooded. That was the worse I saw, thankfully the Lewis Park area is a great catchment for storing flood waters." Public survey response

In this local area, much critical infrastructure is exposed to flooding (Figure 6-39). The Puntledge Lift Station, the CVRD Regional Lift Station, as well as the Water Distribution System are within the floodway. The Island Highway (Hwy 19A) is within the mid-term future – less likely flood extents for almost its entire length from 17th Street Bridge to Ryan Road, and even partially in the floodway. The highway is regionally important for connectivity and is a transportation route to the hospital and fire station.

"Flooding has blocked all roadways to cross the river before." Public survey response

"Critical infrastructure can be damaged (bridges, CVRD pump station, water, gas, telecom, sewer)." Workshop discussion

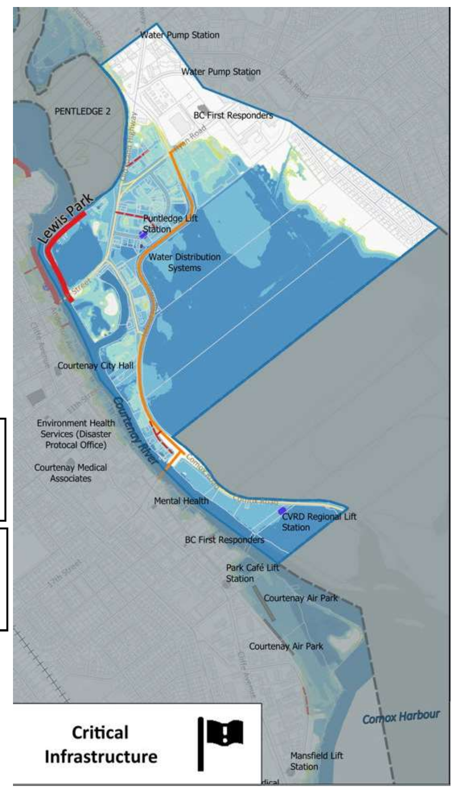


Figure 6-39: Excerpt of consequence map (see Figure 5-7 in Section 5, Risk) for Local Area 4 for the mid-term future - less likely event.

The elevation of the 5th Street bridge is above the expected depth of flood waters in a long-term future event. However, damage due to debris striking the bridge may occur.

The **Puntledge Lift Station** is newer than the Anderton Lift Station and has been replaced in the same location with upgraded pumps. It was estimated by City staff that about ~0.6 m of flood depth would not affect the station, as the water would flood into the wet well. The City Operations team have previously put sandbags around the station, but there is no permanent berm around it. The electrical panel is at ~1.80 m above ground. Modelled flood depth for the Puntledge Lift Station shows that likely events in the present-day may lead to flood depth of ~0.70 m, and the height of the electrical panel may be reached with a 1% AEP flood in the mid-term future (Figure 6-40). This highlights that this newer station remains vulnerable to flood damage. As discussed below under potential impacts to the environment, there is also concern that the pump station would need to be shut down during high stormwater inflows, due to the cross-connection of stormwater and sanitary system at the parking lot of the LINC Youth Centre nearby the Puntledge Lift Station, leading to potential sewer back-ups.

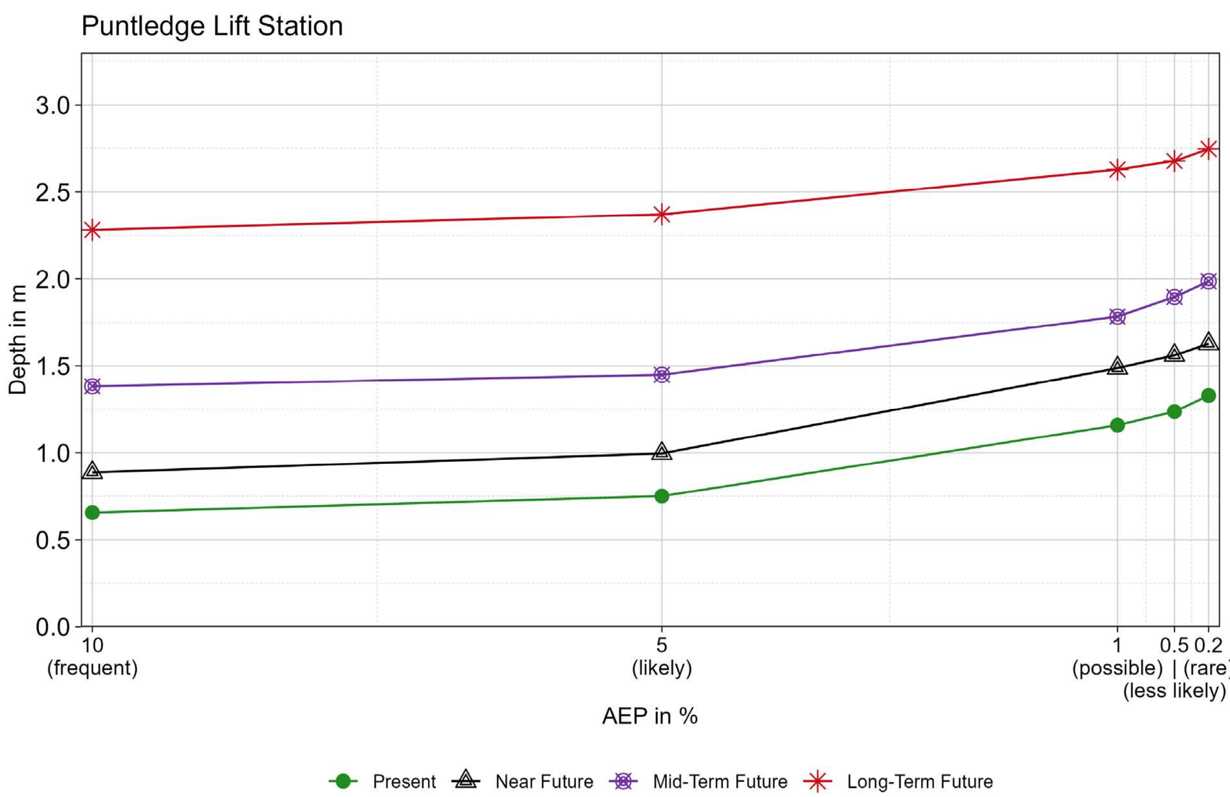


Figure 6-40: Modelled maximum depth of flood water in metres (m) for the Puntledge Lift Station, for five AEP scenarios, as well as four time periods.

The **CVRD Regional Lift Station** is operated by the CVRD, not the City. It plays an important role, as all sewer lines from the City's lift stations connect to it. Flood waters will reach the lift station during present-day and near-future events, albeit with not much depth (< 10 cm and <30 cm, respectively) (Figure 6-41). Flood depth increases to ~0.5-0.8 m for less likely events in the mid-term future, and especially increases in the far future, where flood depth can reach more than 1.5 m. The threshold depths for this station are not presented here as this station is not owned by the City.

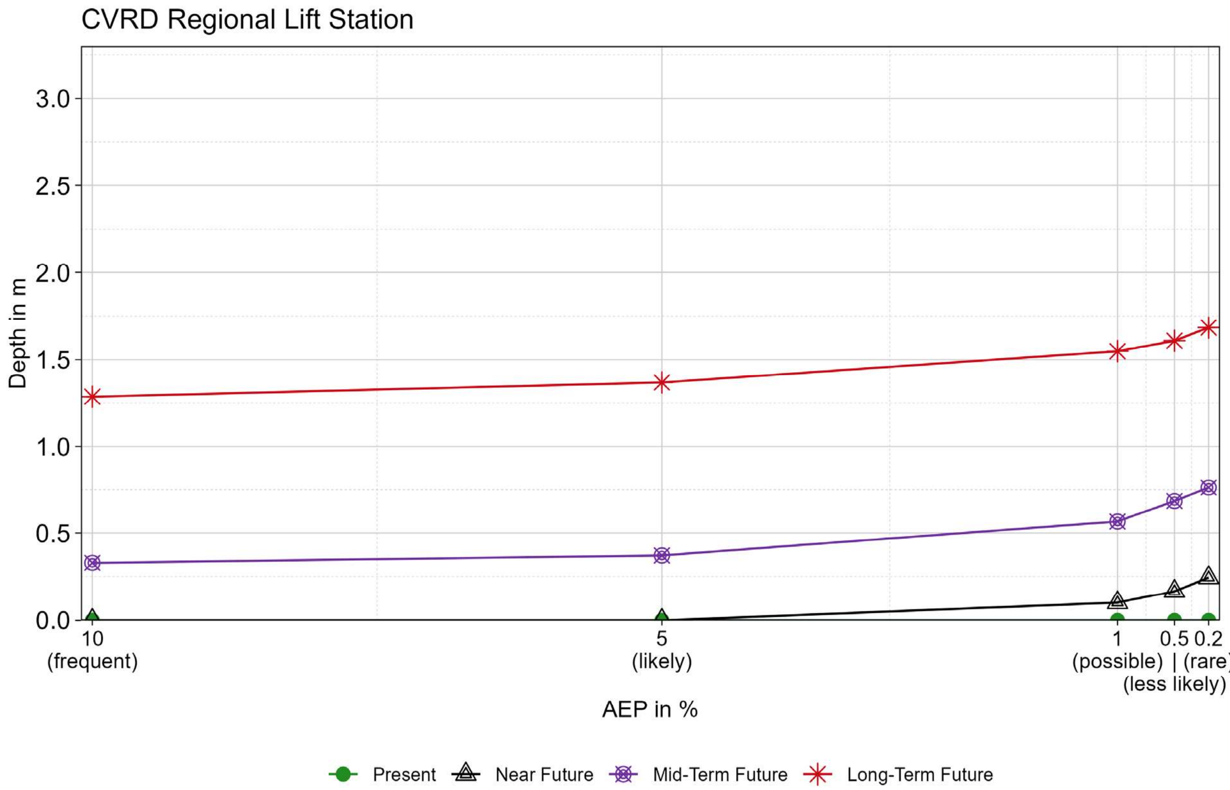


Figure 6-41: Modelled maximum depth of flood water in metres (m) for the CVRD Regional Lift Station, for five AEP scenarios, as well as four time periods.

Many commercial buildings are located within the floodplain, along with some residential buildings (~80 buildings and a ~57$M total building value[50]). There are further concerns on indirect economic damages, when businesses have to close due to flooding, or become otherwise damaged. Further, ~130 hectares of agricultural land are also within the flood extents[50].

[50] With reference to the mid-term future - less likely flood.

Culture

This local area has many community amenities, with the Lewis Recreation Centre, Memorial Outdoor Pool, LINC Youth Centre, a daycare, as well as trails and recreational use of parks. With the Lewis Recreation Centre and the LINC Youth Centre, two of the main indoor recreational assets of the City are in the floodplain, and there are no alternatives to these indoor recreation assets. Furthermore, there are six Indigenous archaeological sites in this local area.

> "Recreational and cultural values here." Workshop discussion

The **Lewis Recreation Centre,** located near the river, is at substantial risk. In the present-day - likely flood events (i.e. 5% AEP) will mean more than 1 m of water at the site (Figure 6-42). Worse flooding is expected in more extreme and future events. For buildings in general, 0.3 m of flood depth is an important damage threshold, as this level of flooding often affects electrical systems (e.g., electrical outlets). This threshold will be exceeded in most floods. Memorial Outdoor Pool is also located next to the Lewis Recreation Centre and within the flood extents.

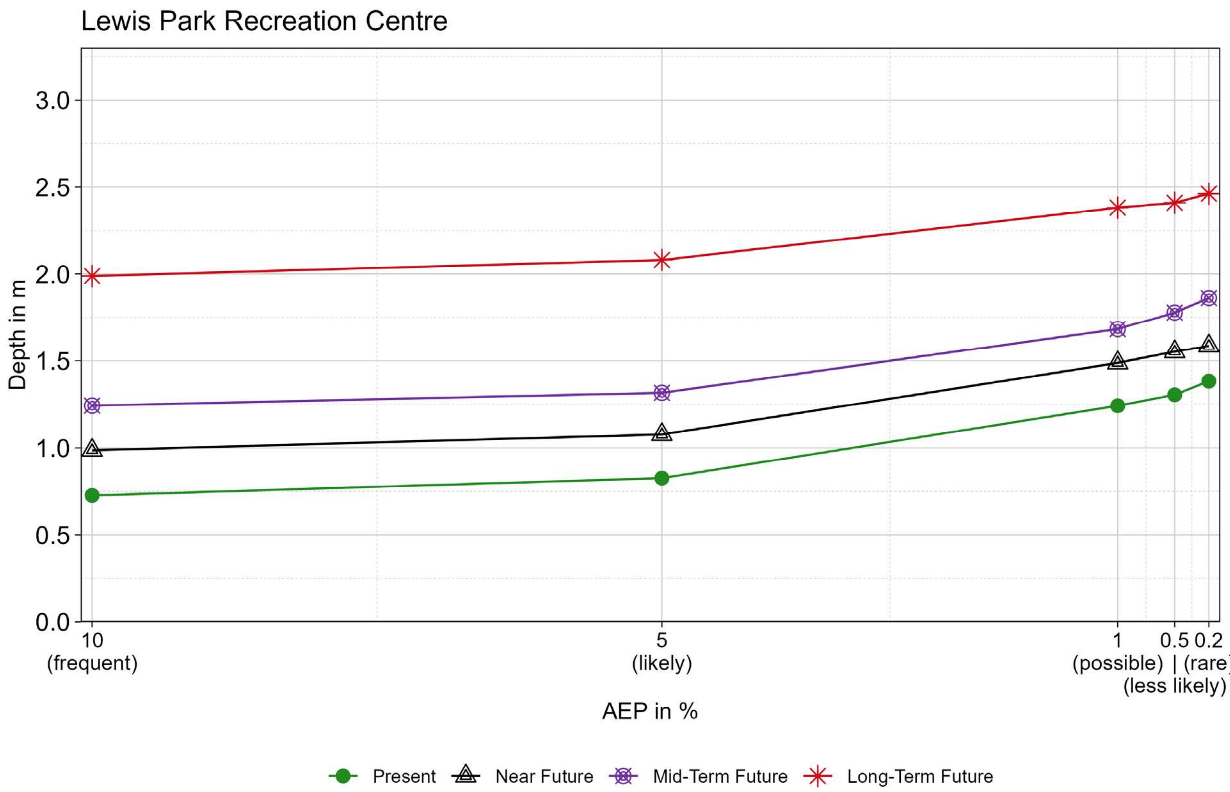


Figure 6-42: Modelled maximum depth of flood water in metres (m) for the Anderton Lift Station, for five AEP scenarios, as well as four time periods.

The **LINC Youth Centre** is another City-owned building providing important community value. It is also at risk of flooding already at likely present-day events, with flood depth increasing substantially for more extreme events and in the future (Figure 6-43). Like the Lewis Recreation Centre, the 0.3 m threshold is exceeded for most floods. The potential damage is expected to be less at the LINC Youth Centre than the Recreation Centre.

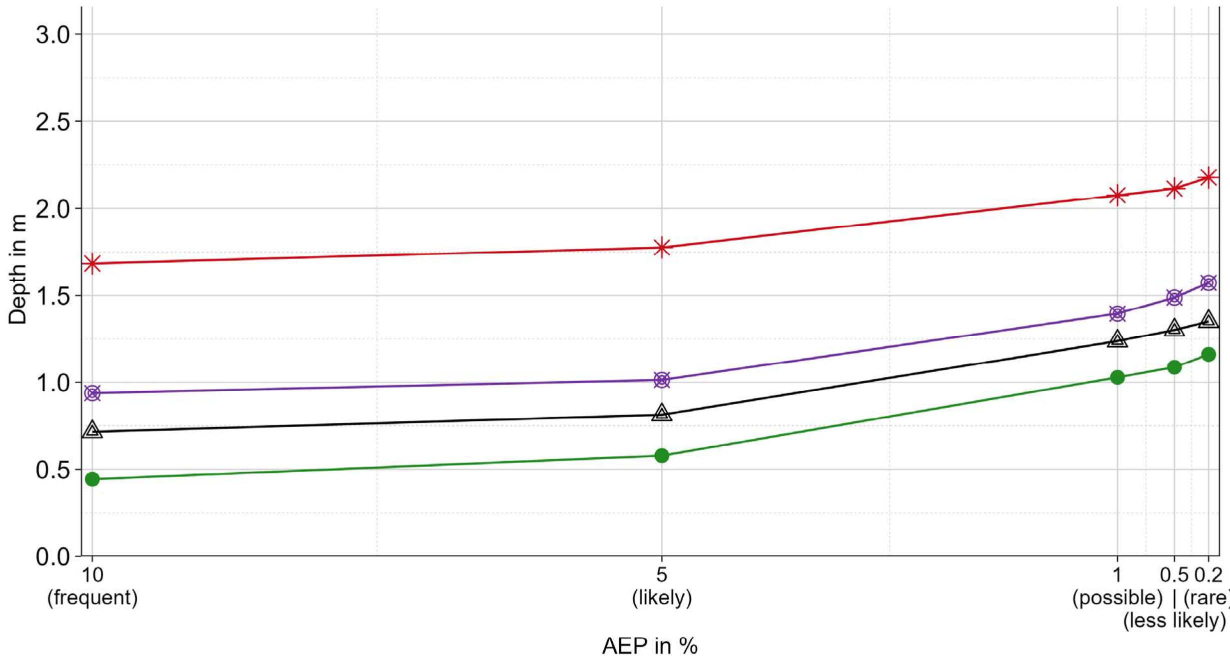


Figure 6-43: Modelled maximum depth of flood water in metres (m) for the LINC Youth Centre, for five AEP scenarios, as well as four time periods.

The City has a separated stormwater and sanitary sewer system, and therefore, concerns of floodwaters entering the sewer system, leading to backups into homes and businesses, and potential contamination of floodwaters are relatively limited. There are however a few locations where cross-connections exist between the stormwater and sanitary system. One of these locations within the floodplain is at the LINC Youth Centre, located near Old Island Highway and Ryan Road (see Section 6.6.2.3, Figure 6-35 for location on map). Here, the stormwater catchbasins in the LINC Youth Centre parking lot drain into the sanitary system, because it is a low spot, and the grade of the sanitary system allows for gravity drainage; the sanitary system is located below the stormwater system. There is a risk that the stormwater could overwhelm the sanitary system, backing up sewage and leading to contamination of surface water (stormwater/floodwater). The catchbasins are only an issue when they are overwhelmed by floodwaters. They have so far not caused back-ups since being put in in December 2002, but the large volume of entering water is a problem. The City typically covers the catchbasins with rubber matting and sandbags, to reduce the amount of inflow towards the Puntledge Lift Station during storm events. The City also tends to shut down the nearby Puntledge pump station during storm events, to avoid pumping flood waters.

> "Lewis park regularly flooded, tends to fill from culverts from Simms Park, before dike overtops." Workshop discussion

Environment

Several parks are within the flood extents, including Lewis Park and Simms Millenium Park, as well as mapped species and ecosystems at risk (e.g., in the southern part of the local area). Furthermore, of particular concern in this local area are the many potential contamination sources that have been identified. These include auto dealers, repair shops, body shops, former and present gasoline/diesel bulk plants and outlets, which could contribute to contamination of flood waters, and thus lead to detrimental consequences for ecosystems.

There is also one groundwater well[51] located within the floodplain of Local Area 4, where there is a risk that contaminated floodwaters may leak through well sealing into the groundwater.

A further concern is the Memorial Outdoor Pool located within the floodplain at Lewis Centre near Tsolum Slough, where chlorine and other hazardous materials are stored, and may contribute to contamination of floodwaters.

[51] Well tag number: 12545 (Provincial Groundwater Well Registry; https://apps.nrs.gov.bc.ca/gwells/well/12545). The groundwater well was established in 1950 and is used for irrigation, according to the registry.

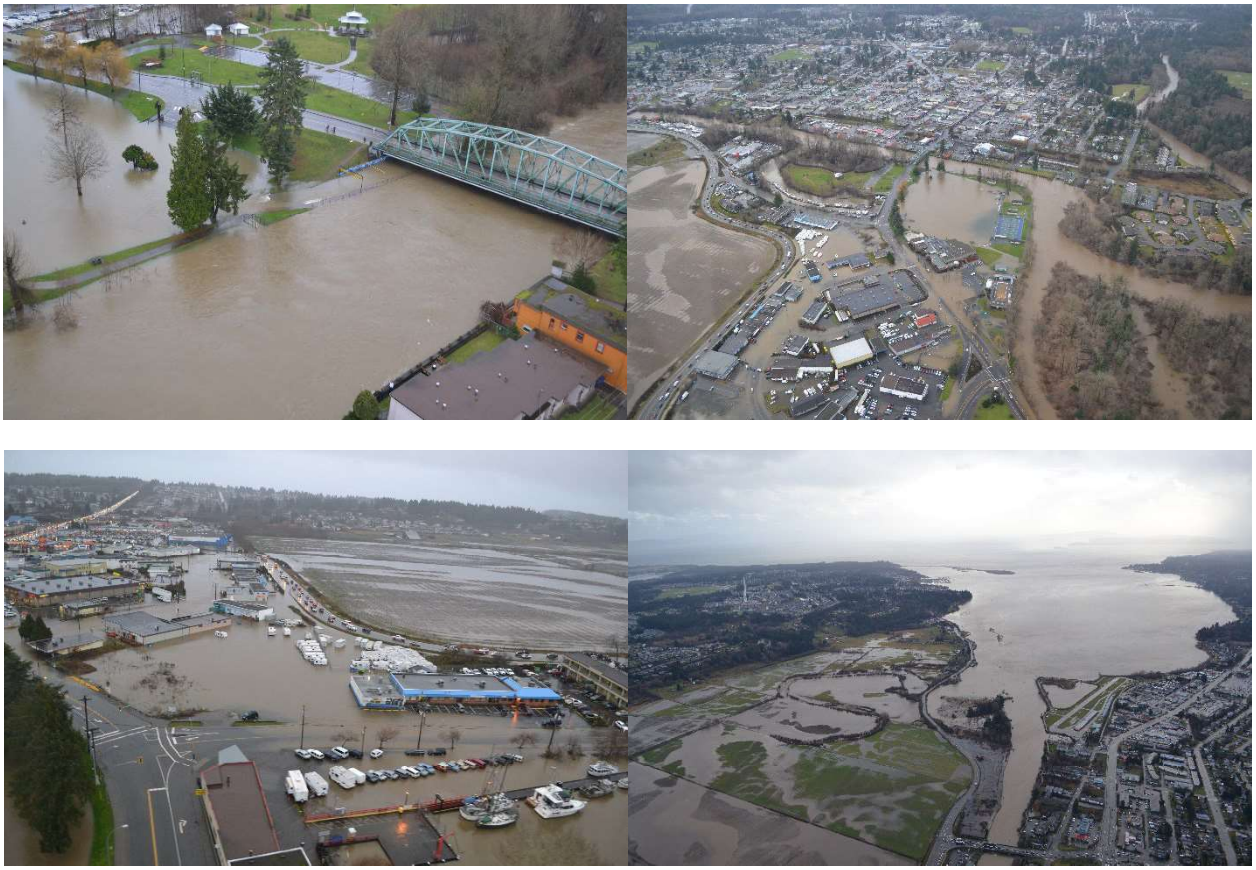


Figure 6-44: Flooding in 2014, with Courtenay River and Lewis Park (top left), the commercial area and Lewis Park (top right), the highway and commercial area as well as the agricultural land (bottom left), and view of the flooded agricultural land and downstream along Courtenay River and the Estuary (bottom right). (Photo Credit: City of Courtenay).

6.6.3 Recommended Options, Alternatives, and Trade-offs

6.6.3.1 Suite of Recommended Options and Considerations

Table 6-16 provides an overview of the recommended options, with context on short-term and longer-term recommendations. This is followed by details on how these recommendations were developed.

Table 6-16: Overview of recommended options for Local Area 4.

Short-term:	Focus on *Accommodate,* including encouraging property-level flood barriers and limiting potential contamination sources), as well as *Resilience-building* for residents and business owners. *Avoid* new residential developments. Remove Tall Wall and change Tiger Dam use from seasonal deployment to events-based deployment around critical infrastructure. Focus on evacuation strategies, traffic management (road closures), and education. Work with MoTI

	to consider options for Highway 19A (critical transportation). Develop long-term plans for the Lewis Recreation Centre, Lewis Park, the LINC, and Memorial Outdoor Pool that are informed by the flood risk. Work with farmers to accommodate occasional flooding of agricultural lands. Continue restoration and naturalizing of the Kus-kus-sum site.
Longer-term:	Consider buy-out of residential properties in the floodway, as they become available. Consider relocating the pool or flood-proofing it. Over the long-term, consider re-naturalization of Lewis Park Dike (with erosion protection).

Options for this area are listed in Table 6-17, along with discussion on concerns and potential improvements, drawing on the feedback gained in workshop and public survey (note that public survey support is summarized at the end of this chapter). Strengths and weaknesses of recommended options are visualized for Local Area 4 in Table 6-18. Detail for Local Area 4 specific *Protect* actions are provided after the strength and weaknesses tables, and also described in more detail in Appendix F. Also note that other options are discussed in more detail in Chapter 7 as part of city-wide strategies to avoid duplication for each local area.

Table 6-17: Suite of options recommended for Local Area 4.

Protect				
	**Conduct Vegetation Management and Repairs at Lewis Park Dike**	**Remove Tall Wall**	**Employ Tiger Dam on events-basis for critical infrastructure**	**Ensure Rye Road flow path is operational**
Discussion: The effectiveness of the Tall Wall and the Tiger Dam in their current deployment are questionable, and the Tall Wall may actually present a safety concern if it falls over due to flood water pressure (the need of a traffic barrier will need to be assessed however). The Tiger Dam is not made for seasonal deployment and should be redirected for targeted protection of critical infrastructure using an events-based approach. The Tall Wall and Tiger Dam cannot ensure public safety. To ensure the safety of the public, evacuation plans and road closures will be required during times of high water. Therefore, it is recommended to focus efforts on traffic management and evacuation measures instead, along with encouraging property-level flood barriers to make individual buildings more resilient to flooding, and apply the Tiger Dam for targeted critical infrastructure protection around the City as needed.			"Need more considerations for people with disabilities and seniors." Public survey response	

Accommodate					
	**FCLs & Flood-proof buildings & Encourage property-level flood barriers**	**Minimize contamination sources**	**Flood-proof ground-water well**	**Develop park resiliency**	**Communicate occasional park flooding**

Flood-proof recreational amenities	**Flood-proof Puntledge lift station & Reduce risk due to stormwater-sanitary system connection at LINC Youth Centre**	**Support CVRD in their ongoing efforts to flood-proof regional lift station**	**Share resources on flooding with agricultural operators**	**Work with MoTI and regional partners on redesigning major routes**	**Work with K'ómoks First Nation to minimize impacts to Indigenous sites**

Discussion: This area has parks and fields that could be used and/or built for flooding while protecting some of the history of the city. Drawbacks include the costs of raising the road, potential loss of central location/access, and potential destruction of farmland due to flooding and while widening/raising the road. Considerations should include evacuation routes, keeping at least one bridge open (currently undersized for the population), and the capacity of Lewis Park and ability to accommodate people.

"Farmer education is important" Public survey response

[Regarding raising of highway] "Engage with families using roadway to drop off children" Public survey response

Retreat

Retreat residential buildings in floodway. *Buy-out ~4 residential properties, as they become available.*

Relocate or redesign pool. *Consider relocation of pool in current options analysis for pool. Alternatively, floodproof it.*

Discussion: It was noted in workshop that the area as a whole is challenging to retreat, and the importance of considering environmental, social, recreational, economic, and service impacts of retreating was discussed. Multiple tables in workshop noted the need for further information and for connecting with regional agriculture and recreation plans.

The outdoor pool is located within the floodway, and costs for repair may accummulate over time, given repeated (and increasingly frequent) flooding. Further, there are concerns for contamination of floodwaters due to chlorine and other chemicals.

"Expensive option [to move the Lewis Centre], live with the facility in the flood zone and protect it"
"Rec centre at Lewis Park is part of Courtenay's legacy"
Public survey responses

Avoid

***Avoid* new residential developments.** *Consider allowing commercial developments that are built above FCL and designed with flood-proofing.*

Discussion: There was not much discussion in either the workshop or public survey regarding the suggested *Avoid* options in the area.		"Build upon and expand the work of Kus-kus-sum in this area." Public survey response
Resilience-building		
Residential awareness-building and preparedness	**Commercial awareness-building and preparedness**	**Community centre and pool preparedness and recovery**
Parks Recovery Planning and Communications	**Resilient transportation planning**	**Flood-resilient agriculture**
Discussion: It was noted at the workshop that investing in reliable bridges is critical, as well as building response/resilience facilities on both sides of the river. It was also suggested talking to chamber and businesses in the area, and wondered if commercial operations get Disaster Financial Assistance Arrangements (DFAA).		

Table 6-18: Local Area 4: Strengths and weaknesses of suite of recommended options, with respect to performance measures.

	Objectives	Suite of Recommended Options	
	Category	**Accommodate**	**Retreat residential**
Effect of Pathway During a Flood (Risk Reduction)	People (General)	Mod Effective	Very Effective
	People (Socially Vulnerable)	Mod Effective	Effective
	Environment	Mod Effective	Very Ineffective
	Culture	Mod Effective	Very Ineffective
	Critical Infrastructure	Mod Effective	Very Ineffective
	Economy	Mod Effective	Ineffective
Effect of the Pathway Itself	Community	0	-2
	Social Equity	0	-1
	Environment	0	2
	Recreation & Access to nature	0	1
	Implementation Cost	$$$$	$$$
	Maintenance Cost	$$	$
	Implementability	2	2

Note that *Avoid* and *Resilience-building* Options have not been scored, as they are recommended for implementation city-wide.

Also note that recommended *Protect* options are not included in the table, as they are focused on erosion protection and other measures, but would not lead directly to risk reduction. Structural *Protect* options were assessed as part of the options analysis, but ultimately not recommended (see next Section 6.6.3.2).

The recommended suite of options for this area includes a variety of diverse flood management tools. This is by design, as each unique option has trade-offs. It will perform well on one objective, but poorly on another. But as a whole, all the options together provide risk reduction, maximize co-benefits, and minimize negative externalities (i.e., minimize negative consequences of the flood management action).

The table above shows that to enable robust flood risk reduction multiple options must be enacted together. And further, the table shows that retreating the residential structures is very effective in terms of reducing direct risks to people, but does not benefit other important assets and values on the floodplain.

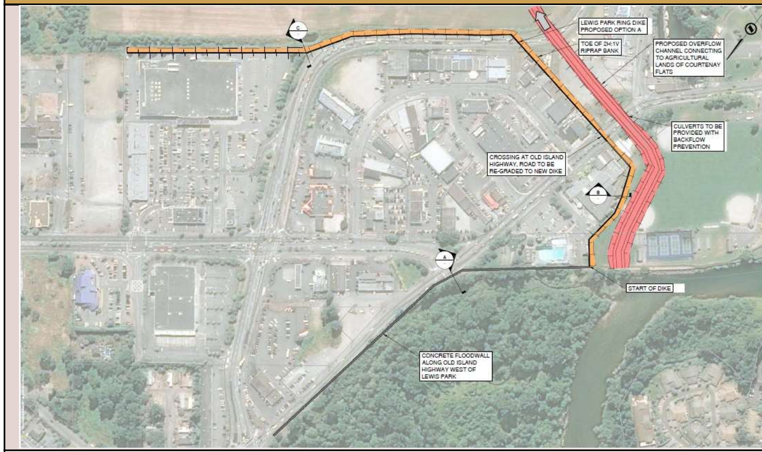
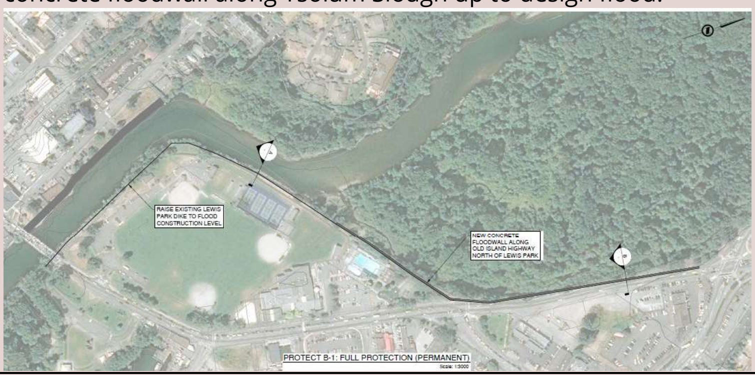
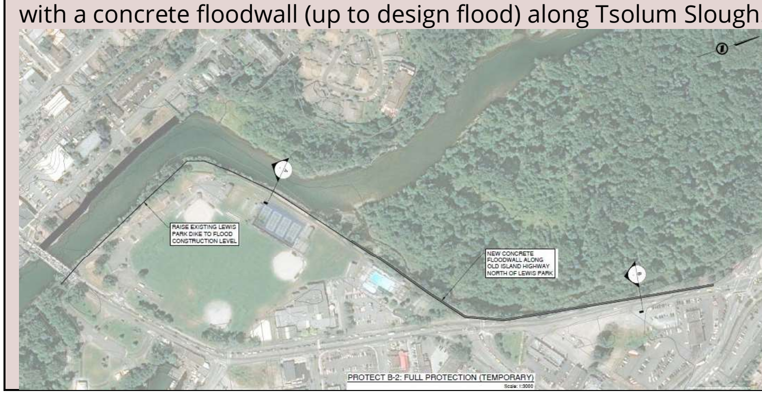
6.6.3.2 Alternative Options (Not Recommended)

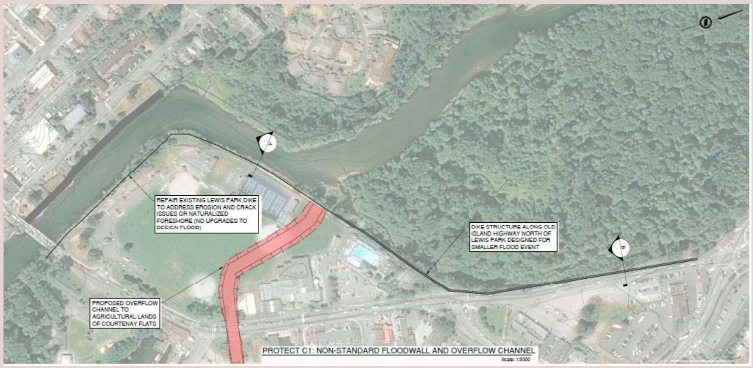
For Local Area 4, several alternative options were explored, but eventually not recommended (Table 6-19). Further details on these alternative options are provided in Appendix F. As can be seen in Table 6-20, benefits of the alternative options are solely associated with risk reduction, but the structures themselves would have substantial negative consequences on ecosystems and the community year-round (i.e., most of the time, when there is no flood occurring).

For all these options, the built-up dikes and walls have the chance of making flooding worse, if water approaches from two directions (e.g., from the river and from the coastal area in the southeast) and a wall may slow drainage, thereby making flood waters potentially higher than they would have been. The walls/dikes may also transfer risk upstream and downstream. Lastly, the City prepared designs and applied for Provincial funding to develop walls in 2015, and this proposal was rejected [52].

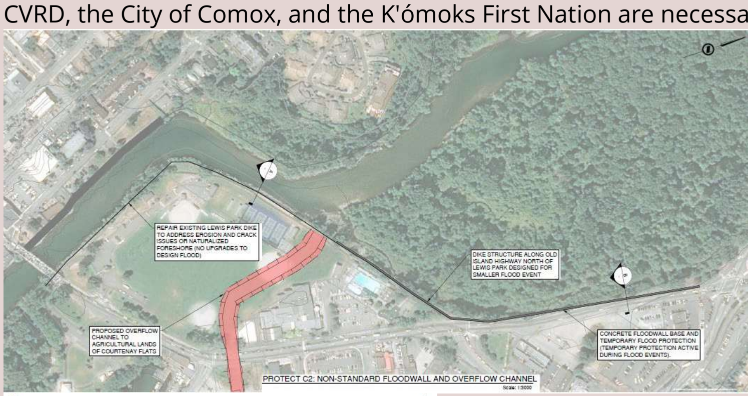
Alternative Options Considered (Not Recommended)	Reasons for Removal
Protect A: Ring Dike and Overflow Channel: Partial ring dike around the commercial area, which would start at Lewis Park (but not include the park) (orange line in drawing). This would be combined with an overflow channel (red feature in drawing) leading to agricultural lands of the Courtenay Flats, and a concrete floodwall (vertical) along Tsolum Slough (along Old Island Highway west of Lewis Park) (grey line in drawing), armoured with riprap. Lewis Park Dike would be maintained for erosion protection only (i.e., Lewis Park would flood occasionally).	Concerns about very high costs, impacts to ecosystems and community. It would be a massive, very high structure (dike crest ~2.0-2.5 m above ground), which would also require the Old Island Highway and Highway 19A to be re-graded to new dike. The tall concrete wall along Tsolum Slough (~3m) would also block river views and create a potentially unsafe space between river and wall.

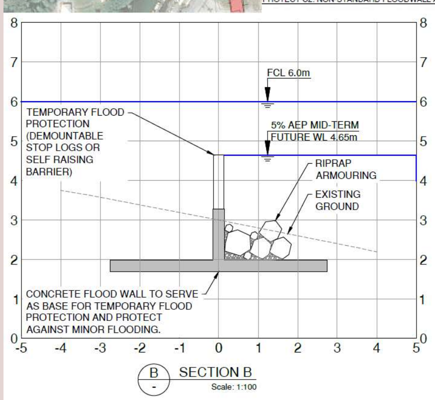
[52] According to communication from the City.

Alternative Options Considered (Not Recommended)	Reasons for Removal
	
Protect B-1: Full Protection (permanent): Raise existing Lewis Park to design flood, combined with a new concrete floodwall along Tsolum Slough up to design flood. 	Concerns about high costs and impacts to ecosystems. It would also negatively impact recreation and access to nature, with a tall concrete wall along Tsolum Slough and a high Lewis Park Dike that would block river views. As discussed above, the tall concrete wall along Tsolum Slough (~3m) would also create a potentially unsafe space between river and wall.
Protect B-2: Full Protection (Semi-permanent): Upgrade Lewis Park with a temporary (demountable or self-rising) barrier on top of existing dike crest up to design flood, in combination with a concrete floodwall (up to design flood) along Tsolum Slough. 	Concerns about high costs and impacts to ecosystems. It may also negatively impact recreation and access to nature with the high concrete floodwall along Tsolum Slough, blocking river views and creating a potentially unsafe space behind. The temporary wall along Lewis Park Dike would decrease some of the concerns around views and safe spaces.

<table>
<tr><th>Alternative Options Considered (Not Recommended)</th><th>Reasons for Removal</th></tr>
<tr><td>Protect C-1: Non-standard Flood wall and Overflow Channel:
Concrete floodwall along Tsolum Slough, which is not as high as for the design flood, but up to a likely (5% AEP, mid-term future event), combined with an overflow channel (red in drawing) to agricultural lands. Repairs to existing Lewis Park Dike, but not raised to design flood.

</td><td>Concerns about high costs and impacts to ecosystems, combined with only moderately effectiveness for risk reduction.</td></tr>
<tr><td>Protect C-2: Semi-permanent (non-standard) Flood Protection and Overflow Channel:
Adjustable semi-permanent flood protection (using demountable log barriers or a self-rising barrier) and overflow channel along Tsolum Slough to replace the AquaDam and Tall Wall. This would include the building of a low concrete floodwall base along Tsolum Slough (along old Island Highway north of Lewis Park) to serve as base for adjustable flood protection, and as protection for minor flooding. On top of the base, adjustable flood protection could be added (e.g., demountable barriers or a self-rising barrier). Temporary protection would become active for flood events (up to a non-standard likely mid-term future event - this could also be extended to reach the design flood as well). Adjustable structures offer benefits in contrast to normal flood walls or dikes, which would be very high.
The semi-permanent flood protection would be paired with an overflow channel from the Tsolum River to the agricultural lands of the Courtenay Flats to manage more extreme events. Detailed analysis (dynamic hydraulic modelling) would be needed to assess if this channel can support flood hazard reduction (and is cost-effective given the trade-offs), and to further determine if this channel just needs to lead to the beginning of the agricultural lands, or further along and into Comox Estuary. It might also be possible to add another smaller channel from the southern end of the Courtenay Flats to the estuary to ensure draining of the agricultural land. This channel would need to be developed with a landscape architect to ensure an aesthetically pleasing feature that is well integrated into</td><td>This option was discussed in detail throughout the partner workshop and following discussions with the City's different departments. Many challenges were mentioned, which ultimately led to removal of this option.
One of the main concerns for removal was that the City does not want to provide a 'false sense of security' from flooding by implementing a structure, which ultimately may still fail, and thereby encourage further development in the floodplain. This area is primarily commercial, where the risk to personal safety and health is lower than in a residential neighbourhood, and the City plans to work with commercial property holders to increase their resilience (e.g., via property-level flood barriers) and implement other risk reduction and resilience measures, as discussed above in Section 6.6.3.1, on recommended options.</td></tr>
</table>

Alternative Options Considered (Not Recommended)	Reasons for Removal
the park landscape and would provide recreational and ecosystem benefits when not in use. The overflow channel would only be used for extreme floods. Discussions with the agricultural operators at Courtenay Flats would also be needed around the very rare operation of the overflow channel, and potential compensation payments considered. Potential impacts to habitat, farmland, recreation areas, and Indigenous culture/harvesting would also need to be carefully investigated, and engagement with the K'ómoks First Nation and guardians is necessary in the planning process. Furthermore, given the regional impacts outside of the City boundary (including Comox Road and CVRD land), discussions with regional partners including the CVRD, the City of Comox, and the K'ómoks First Nation are necessary.	Another major concern was on the feasibility of risk reduction, and if floodwaters may also enter the area from the southwest (which could only be determined by detailed hydraulic modelling), especially during high coastal water levels. Further, in 2013, a similar non-standard flood wall was proposed, but not approved by the Province. Another concern was potential risk transfer downstream, given higher water levels in the Courtenay River, as well as potential risk transfer upstream towards the Maple Pool area (higher levels in Tsolum Slough). Lastly, concerns were also related to the overflow channel. These concerns include its substantial impacts on recreation at Lewis Park (e.g., loss of fields, courts, and lights), on biodiversity, for agricultural operators (loss of agricultural land, as well as impacts for farmers due to higher flood waters), as well as obtaining the right-of-way for building the structure. Substantial costs are also associated with this option, which would be higher than acquiring the land. Lastly, Lewis Park already acts as a storage basin during high water levels and implementing an overflow channel through Lewis Park would limit that storage capacity. From Workshop Discussion: In the workshop, there were concerns expressed that protection methods could impact evacuation routes out of the area, as well as safety concerns for the use of the overflow channel. One table raised concerns





Alternative Options Considered (Not Recommended)	Reasons for Removal
	around impacts to habitat, farmland, recreation areas, and Indigenous culture/harvesting – and suggested engaging with guardians in the planning process.
Protect D: Raising the Sidewalk along Tsolum Slough: This would include raising the sidewalk and walkway along Tsolum Slough, at the location of the current Tall Wall and AquaDam. To be effective, the sidewalk would need to be raised by at least 0.6 m to avoid being topped by a likely present-day flood event, but ideally even higher to account of uncertainties (freeboard) and topping by a less likely present-day event (> ~1m).	This option was not formally evaluated as part of the decision-making process (e.g., in Table 6-20), but has come up several times in discussion with the City and is therefore included here. Raising the sidewalk, especially for as much as 1 m, would essentially require building a small dike. This would require a larger width than the current sidewalk to stabilize, for which there is limited space at the location between Old Island Highway and Tsolum Slough. Such a high sidewalk might also pose a hazard to pedestrians if not properly designed. Further, a (small) dike would come with all the other negative impacts discussed above for other structural options (false sense of security, high costs, risk transfer downstream, ...).

Table 6-20: Strengths and weaknesses of alternative options (not recommended) for Local Area 4.

	Objectives	Alternative Options (Not Recommended)						
	Category	Protect A: Ring Dike & Overflow Channel	Protect B-1: Full Protection (permanent)	Protect B-2: Full Protection (Semi-Permanent - Demountables)	Protect B2 - Full Protection (Semi-Permanent -Self-Raising Barrier)	Protect C-1: Non-standard Floodwall & Overflow Channel	Protect C-2: Semi-permanent (Non-standard) Demountables & Overflow Channel	Protect C-2: Semi-permanent (Non-standard) Self-raising Barrier) & Overflow Channel
Effect of Pathway During a Flood (Risk Reduction)	People (General)	Effective	Effective	Effective	Effective	Mod Effective	Mod Effective	Mod Effective
	People (Socially Vulnerable)	Effective	Effective	Effective	Effective	Mod Effective	Mod Effective	Mod Effective
	Environment	Effective	Effective	Effective	Effective	Mod Effective	Mod Effective	Mod Effective
	Culture	Mod Effective	Effective	Effective	Effective	Mod Effective	Mod Effective	Mod Effective
	Critical Infrastructure	Effective	Effective	Effective	Effective	Mod Effective	Mod Effective	Mod Effective
	Economy	Effective	Effective	Effective	Effective	Effective	Effective	Effective
Effect of the Pathway Itself	Community	-1	-1	0	0	0	0	0
	Social Equity	0	0	0	0	0	0	0
	Environment	-1	-1	0	0	0	0	0
	Recreation & Access to nature	-1	-2	0	0	-1	0	0
	Implementation Cost	$$$$$	$$$	$$$	$$$$	$$$$	$$$$	$$$$
	Maintenance Cost	$$	$$	$$$	$$$	$$$	$$$	$$$
	Implementability	2	2	2	2	2	2	2

The table above shows that although many of the Protect options result in reduced flood risk during a flood event (green and grey in top of table), but the long-term externalities associated with these options (browns, yellow in the bottom of the table) do not make them viable.

6.7 Local Area 5: Courtenay River – Cliffe Avenue Corridor

6.7.1 Local Area Characteristics

Flood Hazard Riverine, with tidal influence, but limited wave effects.

Land Use Commercial, mixed use, some residential and parks/recreation.

Figure 6-45: Location of Local Area 5 indicated in dark green.

This local area is located along the east side of the Courtenay River between the 5th Street Bridge and 21st Street (Figure 6-45; Figure 6-46). Flood hazards include the riverine hazard of the Courtenay River, combined with coastal hazard in the form of tidal influences. Land use is dominantly commercial and mixed use, with some urban residential and parks (Figure 6-46).

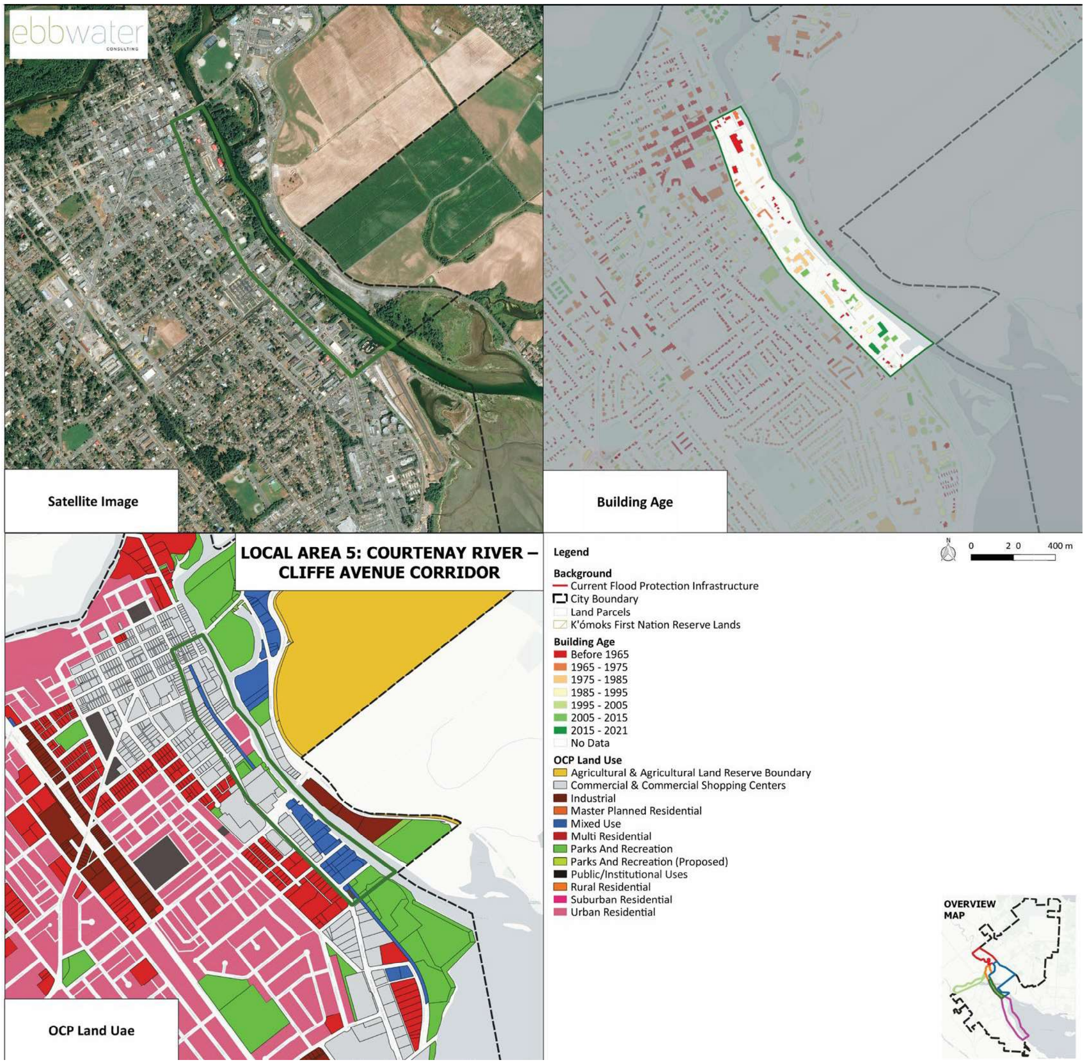


Figure 6-46: Local Area 5: Satellite imagery, building age based on BC Assessment 2022 data, as well as OCP land use (OCP land use layer as received from the City on 15 July 2022).

6.7.2 Baseline Flood Risk ('Do Nothing')

This section describes the current and future risk, if no risk mitigation actions are taken, based on both the quantitative flood risk assessment and local information and experience. Figure 6-47 shows the extent of the floodway and mid-term future – less likely flood event in the local area.

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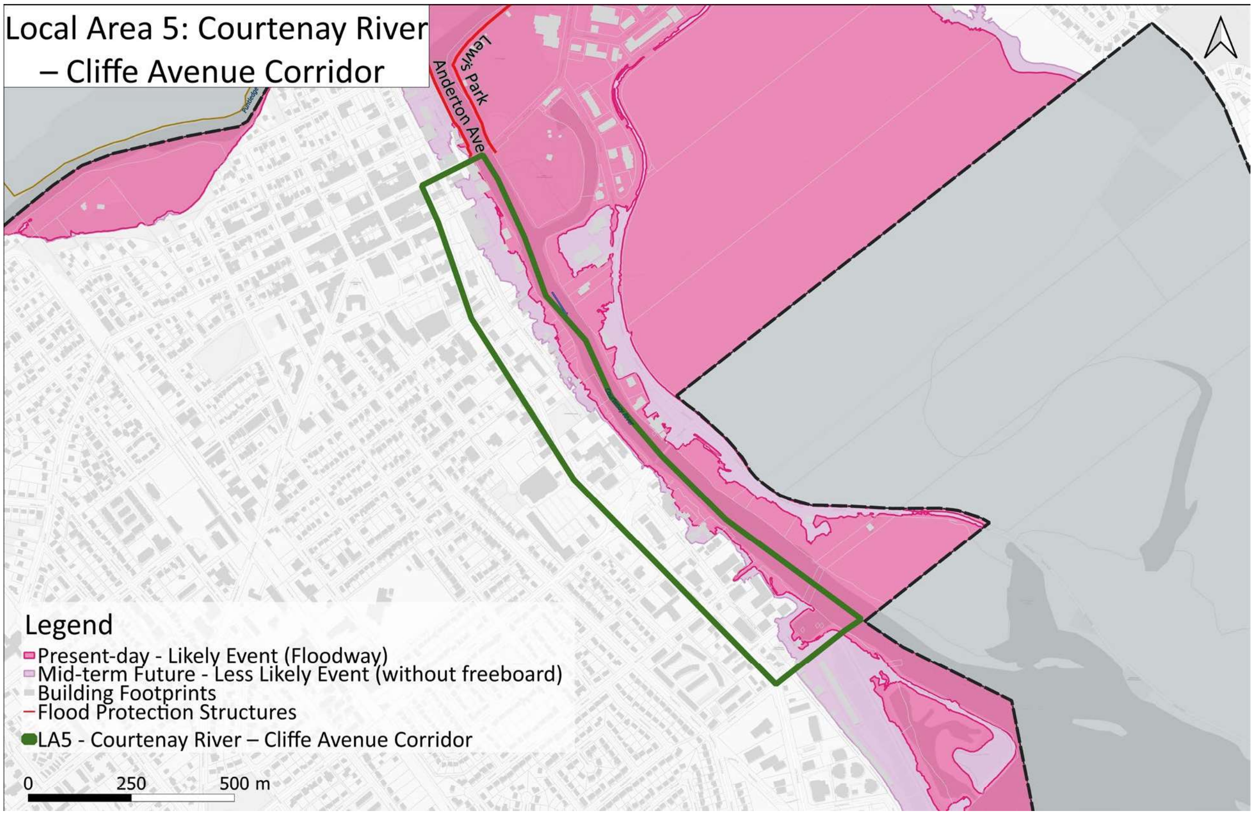

Figure 6-47: Floodway and mid-term future – less likely flood extents for Local Area 5.

> "New housing and businesses are being built between Cliffe Ave and Courtenay River. Why is this happening with the flood risk?" Public survey response

There are some single and multi-residential homes within the flood extents (with a total of ~380 people[53]). While there are not many residential buildings in this local area, there are two multi-residential properties, where parts of the buildings are within the floodway, with another two within the remainder of the mid-term future – less likely flood extents.

> "Parents drive their kids all over the region to go to school" Public survey response

Concern for this local area is the access to 17th Street Bridge, which based on available information, is high enough to

[53] With reference to the mid-term future - less likely flood.

City of Courtenay

avoid substantial flooding in most scenarios.

There are about ~20 residential/commercial buildings within the flood extents, with a total building value of ~19$M[54].

There are two Indigenous archaeological sites as well as trails that may be impacted.

There is parkland, as well as four potential contamination sources (commercial site).

"Having a "straight" channelized river doesn't allow for the river to 'breathe'." Public survey response

6.7.3 Recommended Options, Alternatives, and Trade-offs

6.7.3.1 Suite of Recommended Options and Considerations

Table 6-21 provides an overview of the recommended options, with context on short-term and longer-term recommendations. This is followed by details on how these recommendations were developed.

Table 6-21: Overview of recommended options for Local Area 5.

Short-term:	Focus on *Accommodate*. *Avoid* new residential and commercial development in the floodway. Ensure development in the remainder of the floodplain is designed to accommodate the flood risk. Build *Resilience* for residents and business owners. Develop park and trails resiliency to accommodate occasional flooding.
Longer-term:	Consider buy-out of the residential and commercial properties in floodway, as they become available.

These options are listed in Table 6-22, along with discussion on concerns and potential improvements, drawing on the feedback gained in workshop and public survey (note that public survey support is summarized at the end of this chapter). Also note that some options are discussed in more detail in Chapter 7 as part of city-wide strategies to avoid duplication for each local area. Strengths and

54 With reference to the mid-term future - less likely flood.

weaknesses of recommended options are visualized for Local Area 5 in Table 6-23 and discussed below.

Table 6-22: Suite of options recommended for Local Area 5.

Accommodate

Flood construction levels (FCLs)	**Flood-proof buildings**	**Redesign parks and trails**

Discussion: In contrast to some sentiment noted in the workshop, most *Accommodate* measures are assumed to be at the cost of the individual, and not a cost to taxpayers. It was also noted in workshop there may be challenges with older homes, including oil tanks, asbestos, and lead paint. Workshop participants also noted the importance of assessing traffic flow across the river to better understand the potential disruption.

> "Need for emergency response disaster route to be implemented to help emergency vehicles get to and from hospital and across bridges" Public survey response

Retreat

Retreat residential and commercial buildings in floodway

Discussion: It was noted in the workshop that *Retreat* is a very long-term proposition in this area, as there are many types of industries and landscapes which make *Retreat* complicated. But it was also noted that recovery and response costs may be more than financial *Retreat* costs, highlighting a potential long-term benefit of *Retreat*.

> "Purchase the old night club that is currently rotting on the riverbanks, along with the hostel just upstream of the 5th Street bridge. Demolish these buildings and slope back the riverbanks to create healthy riparian and aquatic vegetated areas. Work with Home Hardware to find a way to get them off the riverbanks as well, and reclaim the land similar to Kus-kus-sum." Public survey response

Avoid

***Avoid* new residential and commercial developments**

Discussion: There was not much discussion on *Avoid* (and *Protect)* options during workshop and survey for this Local Area specifically.

> "Need for more setbacks from the river for multi-family residential buildings" Public survey response

Resilience-building
Residential and commercial awareness-building and preparedness; Parks Recovery Planning Discussion: There was not much discussion on *Resilience-building* options during workshop and survey for this Local Area specifically.

Table 6-23: Local Area 5: Strengths and weaknesses of suite of recommended options, with respect to performance measures.

	Objectives	Suite of Recommended Options	
	Category	**Accommodate**	**Retreat Residential & Commercial**
Effect of Pathway During a Flood (Risk Reduction)	People (General)	Mod Effective	Effective
	People (Socially Vulnerable)	Mod Effective	Effective
	Environment	Very ineffective	Very Ineffective
	Culture	Mod Effective	Very Ineffective
	Critical Infrastructure	No risk mapped	No risk mapped
	Economy	Mod Effective	Mod Effective
Effect of the Pathway Itself	Community	0	-1
	Social Equity	0	-1
	Environment	0	1
	Recreation & Access to nature	0	1
	Implementation Cost	$$	$$$
	Maintenance Cost	$$	$
	Implementability	3	2

Note that *Avoid* and *Resilience-building* Options have not been scored, as they are recommended for implementation city-wide. Note that for Local Area 5, no critical infrastructure facilities were mapped.

The recommended suite of options for this area includes a variety of diverse flood management tools. This is by design, as each unique option has trade-offs. It will perform well on one objective, but poorly on another. But as a whole, all the options together provide risk reduction, maximize co-benefits, and minimize negative externalities (i.e., minimize negative consequences of the flood management action).

Key for Local Area 5 is the need to combine several non-structural approaches to achieve optimal risk reduction and resilience. The analysis above shows that a mix of *Retreat* and *Accommodate* is needed to reduce risk in the event of a flood. It also shows that there is a mix of neutral, negative, and positive externalities associated with these options. For example, the retreat of residences means that people will have to be relocated, impacting community values, but that this also creates an opportunity for improved ecological and environmental function.

6.7.3.2 Alternative Options (Not Recommended)

For Local Area 4, several alternative options were explored (see Appendix F for details), but not recommended (Table 6-24). As can be seen in Table 6-25, benefits of the alternative options are solely associated with risk reduction, but the structures themselves would mean substantial challenges year-round.

Table 6-24: Local Area 5: Alternative options considered (not recommended).

<table>
<tr><th>Alternative Options Considered (Not Recommended)</th><th>Reasons for Removal</th></tr>
<tr><td>Protect: Vertical Flood Wall
Concrete vertical floodwall, ~4m above ground, from 5th Street Bridge to Courtenay Marina Park), with riprap armouring at toe.

</td><td>While this option would reduce risk during a flood, there are substantial concerns for its impacts year-round. A ~4m high wall would obstruct any view, and have very negative impacts to the environment, the community, and access to recreation. Given its length, it would also be very expensive and challenging to implement overall.</td></tr>
</table>

Table 6-25: Strengths and weaknesses of alternative options (not recommended) for Local Area 5.

	Objectives	Alternative Options (Not Recommended)
	Category	**Protect - Vertical Flood Wall**
Effect of Pathway During a Flood (Risk Reduction)	People (General)	Very Effective
	People (Socially Vulnerable)	Effective
	Environment	Very Effective
	Culture	Very Effective
	Critical Infrastructure	No risk mapped
	Economy	Very Effective
Effect of the Pathway Itself	Community	-1
	Social Equity	0
	Environment	-2
	Recreation & Access to nature	-2
	Implementation Cost	$$$$$
	Maintenance Cost	$$
	Implementability	1

6.8 Local Area 6: Airpark & South Courtenay

6.8.1 Local Area Characteristics

Flood Hazard	Coastal-riverine conditions (Courtenay River below 21st Street), coastal (estuary).
Land Use	Multi-Residential & park (mainly), mixed use, some commercial, suburban residential.

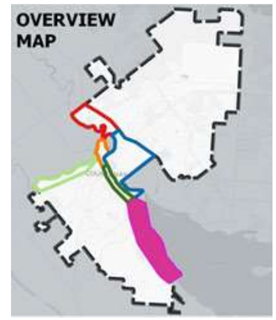

Figure 6-48: Location of Local Area 6 indicated in pink.

This local area is located at the mouth of the Courtenay River (below 21st Street) and coastal area along the estuary (Figure 6-48, Figure 6-49). In contrast to the other local areas where riverine hazards are dominant, here, coastal conditions dominate. A major concern in this coastal area along with flooding is coastal erosion, especially with rising sea levels due to climate change. Land use includes mainly multi-residential and parks, as well as mixed use and some commercial (Figure 6-49).

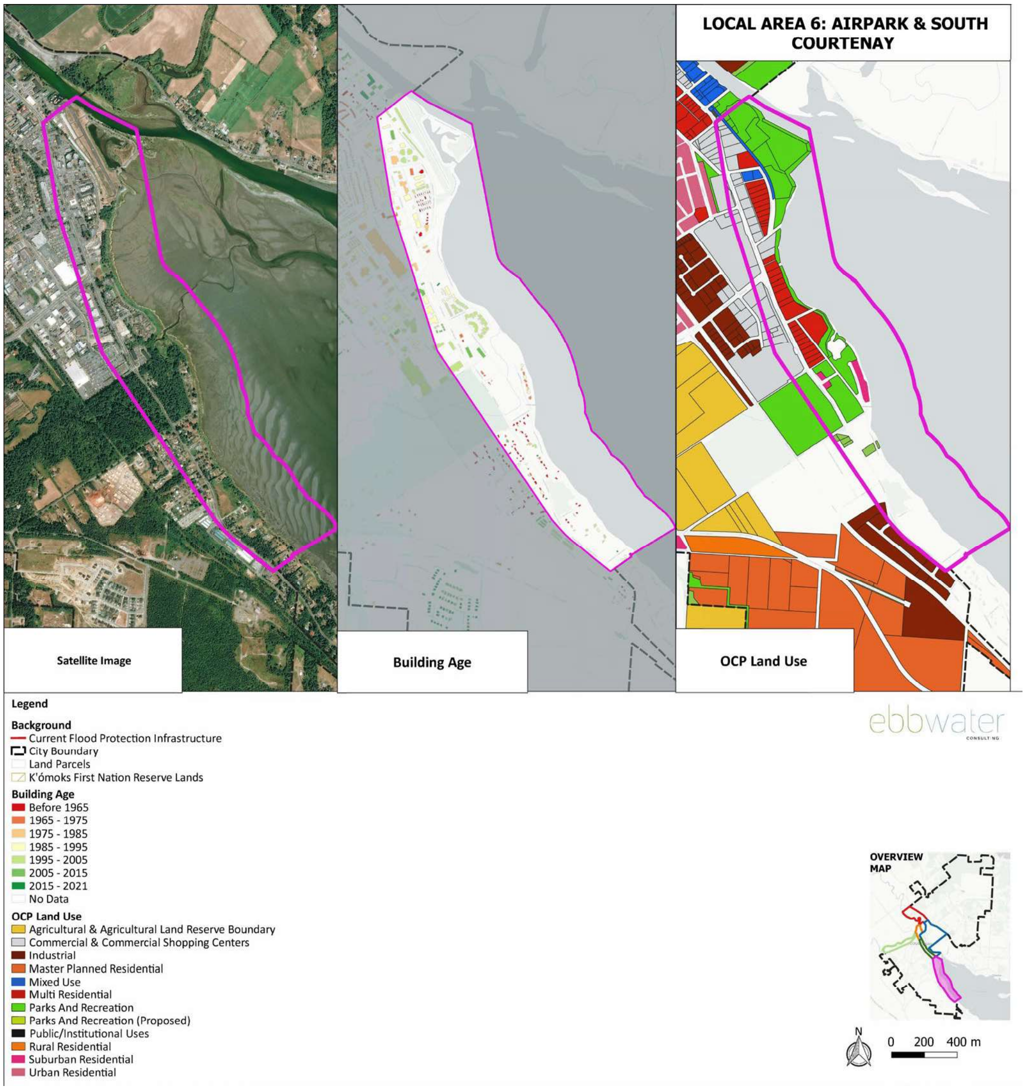

Figure 6-49: Local Area 6: Satellite imagery, building age based on BC Assessment 2022 data, as well as OCP land use (OCP land use layer as received from the City on 15 July 2022).

6.8.2 Baseline Risk ('Do Nothing')

This section describes the current and future risk, if no risk mitigation actions are taken, based on both the quantitative flood risk assessment and local information and experience. Figure 6-50 shows the extent of the floodway and mid-term future – less likely flood event in the local area. A secondary hazard to flooding in this local area is coastal erosion, which will become more and more of a concern with sea level rise. The extents of the coastal erosion setback are shown in Figure 6-51.

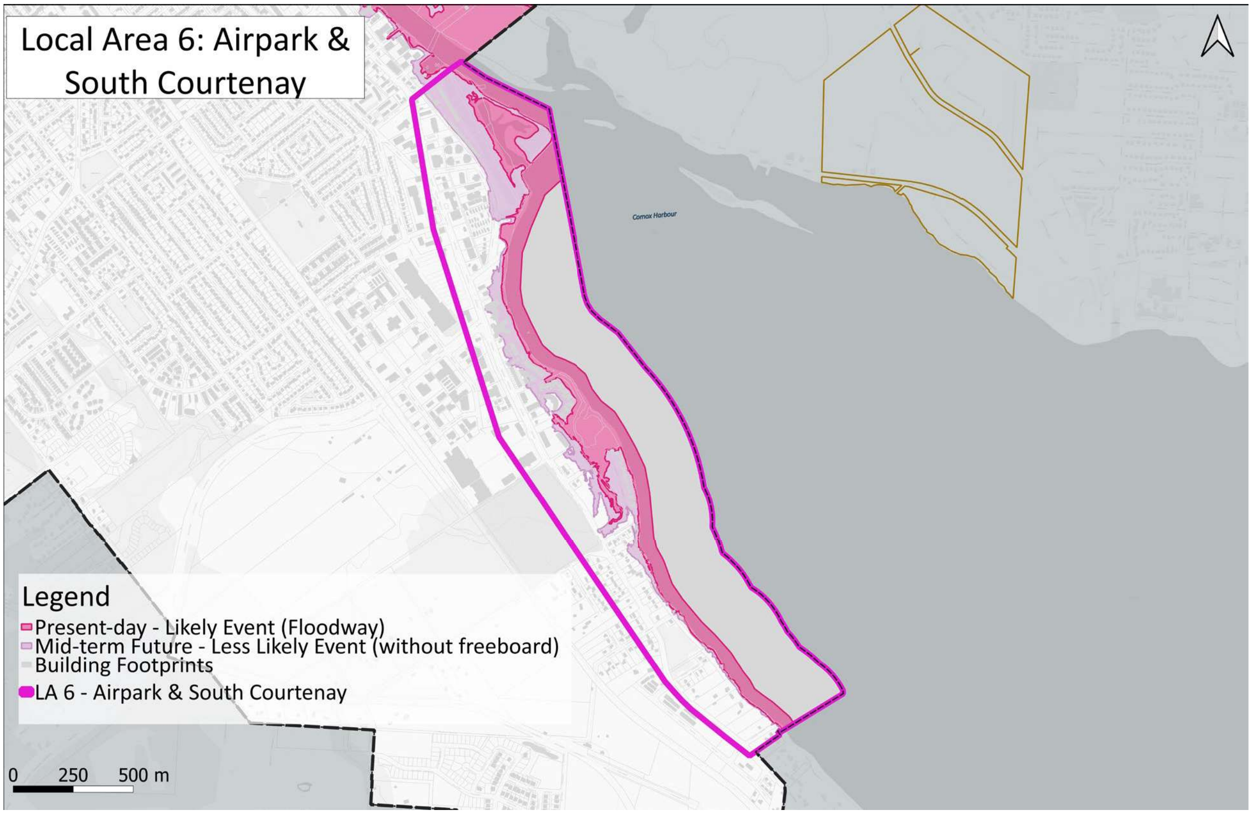

Figure 6-50: Flood extents for the present-day - likely and mid-term future - less likely event for Local Area 6.

Figure 6-51: Coastal erosion setback for the coastal zone (Local Area 6).

There are many residential buildings in the flood extents, with ~230 people potentially affected[55]. Apart from three residential buildings, most of these are not within the extents of the present-day - likely event and are a future rather than an immediate concern.

Potential impacts to critical infrastructure include primarily the Sandpiper Sanitary Lift Station, as well as the Mansfield Lift Station, and the Courtenay Airpark. The Mansfield Lift Station will experience only between 10 cm to 30 cm flood depth for 0.5% and 0.2% AEP for long-term future scenario (Figure 6-52), while the Sand Piper Lift station may already be impacted in the near-term future with up to 0.6 m depth of flooding, and above 1 m of water depths in the mid-term future (Figure 6-53).

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[55] With reference to the mid-term future - less likely flood.

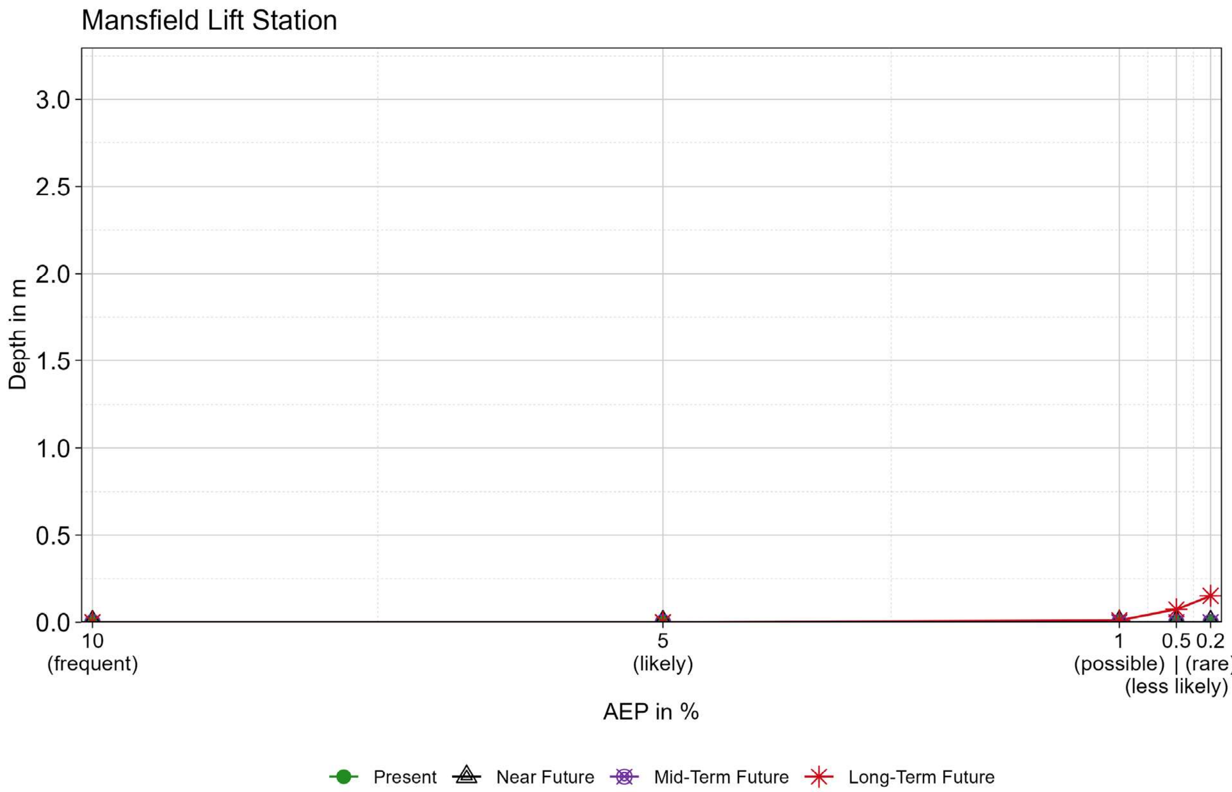


Figure 6-52: Modelled maximum depth of flood water in metres (m) for the Mansfield Lift Station, for five AEP scenarios, as well as four time periods.

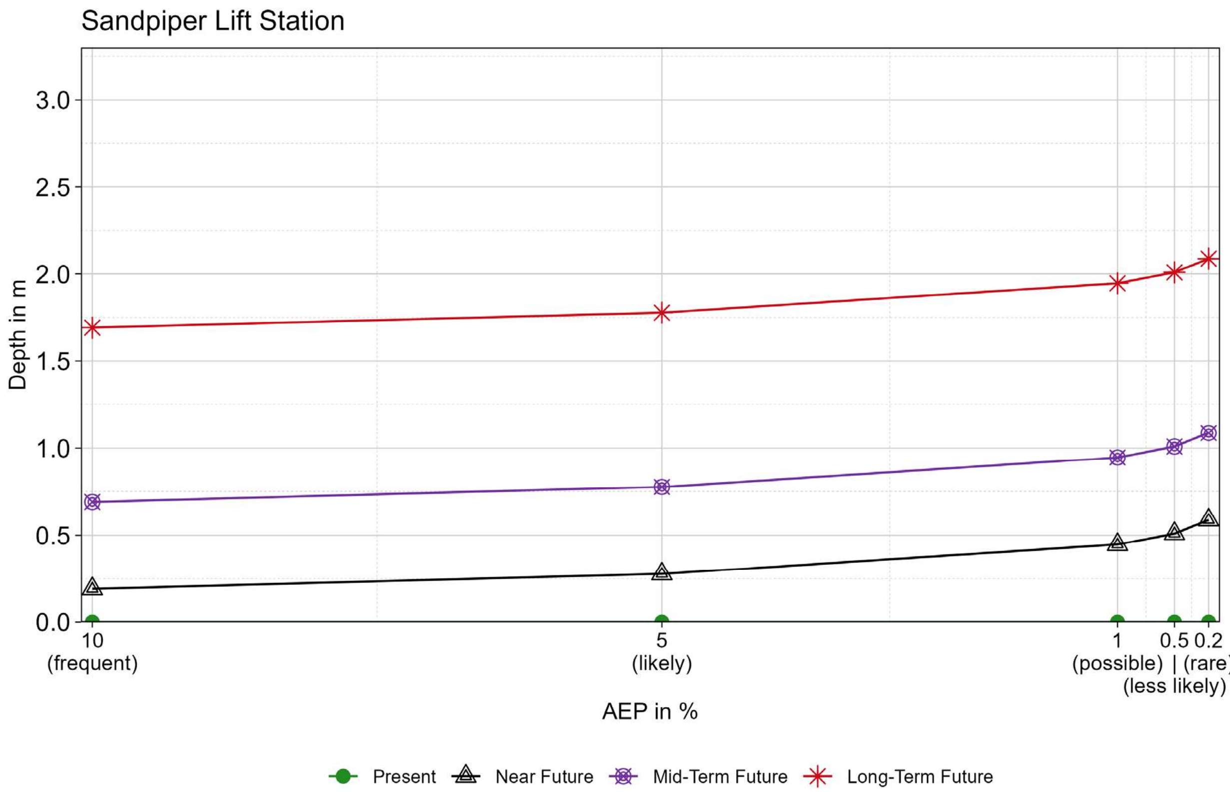


Figure 6-53: Modelled maximum depth of flood water in metres (m) for the Sandpiper Lift Station, for five AEP scenarios, as well as four time periods.

Economics

There are around 50 residential and commercial buildings (~43$M total building value) within the flood extents[56].

"Past flood events – upstream of airpark only. 2010 king tide and storm surge – up to edge of property" Workshop discussion

Culture

There are also five Indigenous archaeological sites potentially exposed to flooding, as well as recreational trails.

56 With reference to the mid-term future - less likely flood.

> "Estuary is now really shallow, tree debris now gets deposited in estuary, soil is building up."
> "Fish can get trapped when water goes somewhere it was not meant to go."
> Workshop discussion

Environment

Multiple parks (Rotary Skypark, Courtenay Riverway), as well as a Conservation Area (Comox Estuary) are within the flood extents, as well as potential contamination sources. Concerns are contamination sources in particular at the Airpark. Note that the City works with the Airpark Association regarding an environmental assessment of fuel storage tanks, and that an investigation into potential leaks is required every four years (or if evidence of a leak).

6.8.3 Recommended Options, Alternatives, and Trade-offs

6.8.3.1 Suite of Recommended Options and Considerations

Table 6-26 provides an overview of the recommended options, with context on short-term and longer-term recommendations. This is followed by details on how these recommendations were developed.

Table 6-26: Overview of recommended options for Local Area 6.

Short-term:	Focus on *Accommodate*. *Avoid* new residential and commercial development in regulatory floodplain and within coastal erosion setback and build *Resilience* for residents and business owners. Redesign parks and trails to accommodate occasional flooding. Limit potential contamination sources and continue working with the Airpark to ensure fuel storage tanks do not become a source of contamination during flood events.
Longer-term:	Consider increasing erosion protection, given sea level rise and associated coastal erosion, using a natural foreshore (Green Shores) approach (e.g., vegetated slope with buried erosion protection and armouring on upper foreshore), expanding on existent measures (current mix of rip rap, flood walls, natural shores) where needed. Consider buy-out of residential properties in the floodway, as they become available. Consider *Retreat* from the coastal erosion setback over the very long-term.

These options are listed in Table 6-27, along with discussion on concerns and potential improvements, drawing on the feedback gained in workshop and public survey (note that public survey support is summarized at the end of this chapter). Also note that recommended options are discussed in more detail in Chapter 7 as part of city-wide strategies to avoid duplication for each local area. Further details for the naturalized foreshore option are also provided in Chapter 7. Strengths and weaknesses of recommended options are visualized for Local Area 6 in Table 6-28 and discussed below.

Table 6-27: Suite of options recommended for Local Area 6.

Protect

Protect B: Naturalized Foreshore (Green Shores) over the long-term.

Discussion: There was support in the workshop and survey for the long-term Green Shores erosion mitigation and restoration of the coastal shoreline. Challenges include working with multiple property owners, erosion of parks and archeological sites if not addressed, and potential impacts on Indigenous culture and salmon. There is also a need to involve and consult KFN and utilize a *DRIPA* lens, as well as ensure construction prevents salmon stranding. Note that erosion protection is not providing additional flood protection.

> "Will be complex and require coordination"
> "People use this area for birdwatching and nature experiences. Shoreline restoration would enhance this"
> Public survey responses

Accommodate

Flood construction levels (FCLs)	**Flood-proof buildings**	**Work with K'ómoks First Nation to minimize impacts to Indigenous sites**
Minimizing potential contamination sources	**Flood-proof Sandpiper Lift Station**	**Redesign parks and trails**

Discussion: There were discussions in the workshop that flood-proofing lift stations may only help with immediate critical infrastructure concerns, but not over the long-term. The City is working with the Airpark association regarding environmental assessment of fuel storage tanks, with new tanks installed in 2005. Helicopter fuel access restrictions were also discussed to minimize potential contamination of floodwaters and the estuary.

> "[Flood-proofing sanitary lift stations] will prevent pollution in estuary" Public survey

Retreat

Retreat properties in high flood hazard areas	**Retreat properties in coastal erosion setback over the very long-term**

Discussion: It was mentioned in the workshop that retreating could have long-term benefits for the environment. It was also discussed if flood-proofing could be enough in this area, and *Retreat* may not be needed.

Avoid

Avoid **new residential and commercial developments in floodplain and in coastal erosion setback**

Discussion: Any expansion of the sewer system should consider location of lift stations and avoid the floodplain and coastal erosion setback.

> "More lift stations should be included with the south sewer expansion" Public survey response

Resilience-building

Residential and commercial awareness-building and preparedness

Parks Recovery Planning

Discussion: Consider the multiple uses of Courteney Airpark aerodrome with an emergency management lens, including emergency services, patient transfer, and emergency resupply if bridge access is unavailable.

Table 6-28: Local Area 6: Strengths and weaknesses of suite of recommended options, with respect to performance measures. Note that Avoid and Resilience-building Options have not been scored, as they are recommended for implementation city-wide.

	Objectives	Suite of Recommended Options			
	Category	Protect B - Green Shores (Erosion Protection) (long-term)	Accommodate	Retreat - Buildings in Floodway	Retreat - all Buildings in Coastal Erosion Setback (long-term)
Effect of Pathway During a Flood (Risk Reduction)	People (General)	Very ineffective	Mod Effective	Ineffective	Very effective
	People (Socially Vulnerable)	Very ineffective	Mod Effective	Ineffective	Very effective
	Environment	Very ineffective	Mod Effective	Very ineffective	Very effective
	Culture	Very ineffective	Mod Effective	Very ineffective	Very ineffective
	Critical Infrastructure	Very ineffective	Mod Effective	Very ineffective	Very Ineffective
	Economy	Very ineffective	Mod Effective	Ineffective	Very effective
Effect of the Pathway Itself	Community	0	0	-1	-1
	Social Equity	0	0	0	0
	Environment	2	0	1	1
	Recreation & Access to nature	2	0	1	1
	Implementation Cost	$$$$	$$	$$$	$$$
	Maintenance Cost	$$$$$	$$	$	$
	Implementability	3	3	2	2

The recommended suite of options for this area includes a variety of diverse flood management tools. This is by design, as each unique option has trade-offs. It will perform well on one objective, but poorly on another. But as a whole, all the options together provide risk reduction, maximize co-benefits, and minimize negative externalities (i.e., minimize negative consequences of the flood management action).

The analysis conducted for this report shows that the *Accommodate* options will be moderately effective in the short term (grey in top of table above), but that better risk reduction can be achieved through *Retreat* (green in table above). These two options can work together over time. The analysis also shows that although erosion protection is ineffective at stopping flood waters (brown in top of table above), it brings other benefits, namely the protection of land loss (not directly considered in the decision matrix), as well as significant environmental and recreational benefits (green in bottom of table). All the options analysed for this work show neutral or positive co-benefits, although costs and the practical implementation of the option may be challenging.

6.8.3.2 Alternative Options (Not Recommended)

For Local Area 6, several alternative options were explored, but ultimately not recommended (Table 6-29). More details on these alternative options are also provided in Appendix F. As can be seen in Table 6-30, benefits of the alternative options are solely associated with risk reduction, but the structures themselves would mean substantial challenges year-round.

Table 6-29: Local Area 6: Alternative options considered (not recommended).

Alternative Options Considered (Not Recommended)	Reasons for Removal
Protect A: Floodwall. This would include a new concrete floodwall along Comox Bay (approx. 5 m in height above ground).  	Concerns about the environmental and community impacts of such a high, long wall, combined with high costs. Most residential properties are also not located within the floodway.
Protect C: Dike with Riprap Banks. This would include constructing a new dike with riprap banks along Comox Bay. The dike crest would be approximately 3.5-4 m above ground, and the horizontal footprint would be 19-22 m	Concerns about the environmental and community impacts of such a high, long, and wide dike, combined with high costs. Most residential properties are also not located within the coastal high flood hazard area.

wide.

Table 6-30: Strengths and weaknesses of alternative options (not recommended) for Local Area 6.

	Objectives	Alternative Options (Not Recommended)	
	Category	Protect A: Flood Wall	Protect C: Dike with Riprap
Effect of Pathway During a Flood (Risk Reduction)	People (General)	Very Effective	Very Effective
	People (Socially Vulnerable)	Very Effective	Very Effective
	Environment	Very Effective	Very Effective
	Culture	Very Effective	Very Effective
	Critical Infrastructure	Very Effective	Very Effective
	Economy	Very Effective	Very Effective
Effect of the Pathway Itself	Community	-1	0
	Social Equity	0	0
	Environment	-1	-1
	Recreation & Access to nature	-1	-1
	Implementation Cost	$$$$$	$$$$
	Maintenance Cost	$$$$	$$$$
	Implementability	1	1

Analysis of the table above shows that although the protect options do offer flood risk reduction benefits (green on the top of the table), the long-term and full-time costs of these are high (yellow on the bottom of the table).

6.9 Summary of Community Support for Proposed Strategies (Public Survey)

The second public survey asked participants to provide feedback on the proposed flood management options. A summary of the results is provided in this chapter, with details in Appendix E.

Of the 148 participants who fully or partially completed Survey #2 (Flood Management Options), 68% were Courtenay residents, and 30% were from other areas in the region (see Section 4.5.2.2 on survey participant numbers). Of the Courtenay residents, 21% indicated that they reside in the floodplain, 68% indicated they did not, and an additional 11% did not know if they were in a floodplain or not.

Participants were also asked to indicate their existing knowledge of the Courtenay Flood Management Plan (Figure 6-54). Most (72%) had visited the project website, and some (37%) had previously participated in other flood management processes in the region. A number of others had engaged with materials in earlier stages of this project.

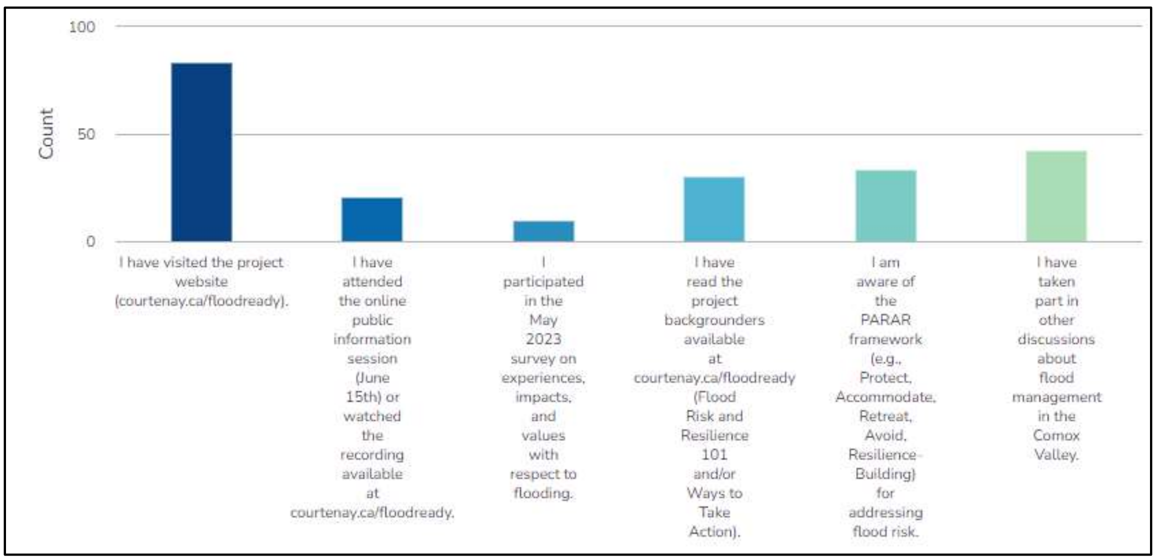


Figure 6-54: Participants' existing knowledge about the City of Courtenay's Flood Management Plan (N=117).

Legend
Very high support (80-100%)
High support (60-79%)
Moderate support (40-59%)
Low support (< 40%)

Survey participants were asked to review and provide feedback on a set of 22 proposed flood management options within the City of Courtenay boundaries. These included a set of options to be applied city-wide, as well as a number of options specific to the Local Areas described in Chapter 6 and Chapter 7. Table 6-31 below provides an overview of the level of support indicated for each of the 22 proposed options. For each set of options there were between 79 (for the city-wide options) and 52 individual responses (response rate dropped off later in the survey). Additional detail and analysis of Survey 2 responses is included in Appendix E. Note that some options listed here were removed or refined, given the feedback from the public survey and partner workshop.

Table 6-31: Level of support for each of the proposed flood management options, as indicated by participants in Survey #2.

	Level of Support
City-Wide Options	
Update Flood Construction Levels (FCLs) so new and renovated structures are built at a higher elevation, accounting for climate change. (short-term)	70%
Encourage design and retrofits of new and existing buildings to reduce damages associated with a flood event. (short-term)	70%
Restrict future land uses to those that are compatible with the flood risk and can accommodate periodic flooding with minimal to no damage. (short-term)	82%
Flood-proof critical infrastructure. (short-term)	66%
Provide education to reduce impacts from contamination sources, and encourage flood-resilient hazardous material storage. (short-term)	61%
Design parks, including landscaping and trails, to accommodate flooding and prevent erosion. (short-term)	93%
Develop maintenance plans for the inspection and recovery of roadways, parks and critical infrastructure after flooding. (short-term)	76%
Notify residents and businesses who are located within the floodplain, and encourage resilience-building among the community through education and emergency preparedness. (short-term)	55%
Engage in long-term planning to relocate residents and commercial uses out of high flood hazard areas as the opportunity arises. (long-term)	48%
Work with K'ómoks First Nation to minimize impacts to archaeological sites. (long-term)	76%
Local Area 1	
Encourage temporary flood barriers at a property level. (short-term)	45%
Work with the agriculture industry and producers to explore mutually beneficial arrangements to accommodate occasional flooding. (long-term)	61%

	Level of Support
Local Area 3	
Replace the Anderton Dike with a naturalized foreshore along Anderton Ave for erosion control. (long-term)	77%
Install temporary flood protection at Condensory and Canterbury. (long-term)	50%
Local Area 4	
Replace the aqua dam and tall wall with a pre-installed temporary barrier along Tsolum Slough. (short-term)	51%
Flood-proof Lewis Centre, the LINC Youth Centre and sanitary lift stations (Puntledge and CVRD Regional). (short-term))	63%
Work with the agriculture industry and producers to explore mutually beneficial arrangements to accommodate occasional flooding. (long-term)	65%
Design an overflow channel and erosion control at Lewis Park. (long-term)	63%
Work with partners to redesign (elevate) Highway 19A to maintain critical transportation and evacuation route for residents. (long-term)	69%
Relocate city owned recreation facilities out of the high flood hazard areas. (long-term)	56%
Local Area 6	
Flood-proof sanitary lift stations. (short-term)	70%
Restore the coastal shoreline, and intertidal zones to minimize erosion. (long-term)	67%

Overall, there was high or very high support for 16 of the 22 options, and moderate support for 6 options. Options with very high support included restricting land uses in floodplains, and designing parks to accommodate flooding and prevent erosion. Options with moderate support related to temporary flood barriers, options for *Retreat*, and options that rely on encouraging action by individuals.

There were many comments in the survey expressing support for restricting future land uses to those compatible with flood risk in those areas. As one person said, this approach is "better and cheaper than trying to save people or property from [a] flood prone area."

In a number of places, responses suggested that the range of tools should be considered and applied in a strategic way. For example, critical infrastructure should be moved out of flood hazard areas where feasible, and flood-proofed where it is not feasible to remove it. Where possible, ecological restoration should be supported and enhanced, in combination with retreat and avoid strategies.

Another common theme was to suggest that “encouraging” individuals (landowners, business owners etc.) to learn more and take action, may not be enough and that incentives and requirements/regulations should also be considered where possible.

Participants also pointed out the connectivity between the local areas identified for this project, for example in relation to emergency preparedness and response. It was shared that children often attend school on one or the other side of the river and can be cut off from family or supports if bridges are impassable. This highlighted the importance of effective city-wide (or region-wide) emergency response planning, and of considering risk transfer across all flood hazard areas, in design of options.

Two options that propose moving structures or uses out of flood hazard areas over the long-term, received moderate support. This is not unusual, as there is a lot of uncertainty and complexity in determining appropriate and effective approaches to managed retreat. As one person stated, “It is difficult, but probably worthwhile.” Participants had questions about who would pay and if the cost is worth it; where structures/uses/people would move to; how to balance this with housing affordability concerns; and the difficulties with implementing this option. A number of comments emphasized that despite the difficulties, this option should be prioritized, and that people need to be engaged early on so that they can prepare. Overall, comments pointed to the importance of being proactive, discerning, and thoughtful in development of plans for relocation; ensuring other types of options such as avoiding development and Green Shores are used first (where appropriate); and the importance of addressing the issue of who pays.

Of note, flood-proofing of some City infrastructure (Lewis Centre, the LINC Youth Centre and sanitary lift stations) received 63% support, but there were a number of comments that questioned the costs and feasibility, and whether relocation might be more appropriate. Overall, feedback suggests that there was lack of clarity for the proposed structural options for Local Area 4 as presented in the survey, and some concerns with these options. The options were revised following the public survey, and the options presented within the Flood Management plan reflect public feedback.

Options proposed in Local Areas 1, 3 and 4 included the use of temporary flood protection of different types, based on specifics in those locations. These received moderate support. There were concerns about cost (and who pays), effectiveness and a desire for more details about these options to assess their suitability. Some people wondered why a temporary option would be chosen rather than permanent. There was also concern that the overall approach for LA 1 requires thoughtful consideration and effective engagement, particularly with respect to Maple Pool and the needs of low-income residents.

The option to "Notify residents and businesses who are located within the floodplain, and encourage resilience-building among the community through education and emergency preparedness. (short-term)" received a number of comments. Some saw the City's role here as limited, and questioned if other partners might be better placed to take on this role. A number of comments suggested "encourage" may not be enough, and perhaps this should be accompanied by incentives or requirements – this was a repeated point of feedback for numerous "encourage" options throughout the survey.

Lastly, similar sentiments as revealed in public survey 2 were already indicated in public survey 1 (which dominantly focused on flood impacts and experiences, see Section 5.2). When asked what we could let go of, that would be of less consequence to future generations, by far the top responses were 1) structures in the floodplain (residential, commercial, infrastructure), and 2) land uses that are not compatible with future conditions. These responses together are consistent with comments elsewhere in the public surveys 1 and 2 that suggested while it will likely be difficult, taking action to relocate or avoid development in the flood hazard areas is perceived as becoming more important and even practical over time, relative to the alternatives.

7 Recommended Flood Management Strategies

This chapter first summarizes an overall plan for flood management in the City, based on the five strategies of *Protect*, *Accommodate*, *Retreat*, *Avoid* and *Resilience-building*. This is followed by specific and actionable recommendations for each of the strategies.

7.1 Overall Strategy

7.1.1 Overarching Framing

We recommend using a suite of strategies (drawing upon the PARAR framework, for which an overview is provided in Section 2.3.1 and which is again summarized below) to reduce flood risk and increase resilience in the City. The box to the right defines key terms related to risk.

The strategies described below are not listed in order of importance. Rather, what is important is that they should be used in combination to address the range of contexts and risk levels that occur in the City (Figure 7-1; Figure 7-2):

- ***Protect***: This strategy aims to reduce the hazard by reducing its presence or power. *Protect* options are best applied to medium risk areas. They can also be associated with potentially catastrophic failure as these options generally will not protect against very high hazard events (e.g., dike structures can be overtopped by an extreme event, and can fail if they are compromised during a smaller event).
- ***Accommodate***: This strategy aims to reduce the vulnerability of the built environment and society to flooding by accommodating the presence and movement of water ('living with the water'). It is best applied for low to medium risk, but it may not be sufficient for extreme events.

Reminder:

Hazard is "a source of potential harm, or a situation with a potential for causing harm, in terms of human injury; damage to health, property, the environment, and other things of value; or some combination of these".

Exposure is the "situation of people, infrastructure, housing, production capacities and other tangible human assets located in hazard-prone areas. Measures of exposure can include the number of people or types of assets in an area."

Vulnerability describes the "conditions determined by physical, social, economic and environmental factors or processes which increase the susceptibility of an individual, a community, assets or systems to the impacts of hazards".

Risk is a "concept that takes into consideration the likelihood that a hazard will occur, as well as the severity of possible impacts to health, property, the environment, or other things of value".

- ***Retreat***: This strategy, also called managed retreat or relocation, reduces exposure by moving existing structures out of flood hazard areas. It is recommended for areas with existing high risk (e.g., residential housing in high hazard areas).
- ***Avoid*****:** This strategy is recommended in cases where new exposure and risk can be avoided by limiting development within the floodplain. This strategy is particularly important for medium to high risk, whereas in lower risk, *Accommodate* and *Resilience-building* strategies may be sufficient.
- ***Resilience-building*****:** This strategy underpins all recommendations, as it focuses on setting communities up to prepare, cope with, and bounce back from flood events. It can address low to high risk, and should always complement other strategies.

The strategy of *Retreat* is most effective for all levels of hazards but is best reserved for high to very high risk hazards due to its high economic and social costs. Similarly, *Avoid s*trategies can be applied across the board, and should be considered for areas of risk. *Protect* strategies often address medium to high risk areas, however they also have a high economic, social, and environmental cost, and are vulnerable to catastrophic failure, so they may not be necessary if the risk can be addressed by other means. *Accommodate* strategies are suitable for low to medium risk areas. *Resilience-building* is effective for all levels of flood risk, helping communities prepare for the next flood event. The five strategies are meant to work together as a combined 'toolbox' to jointly reduce risk (Figure 7-1).

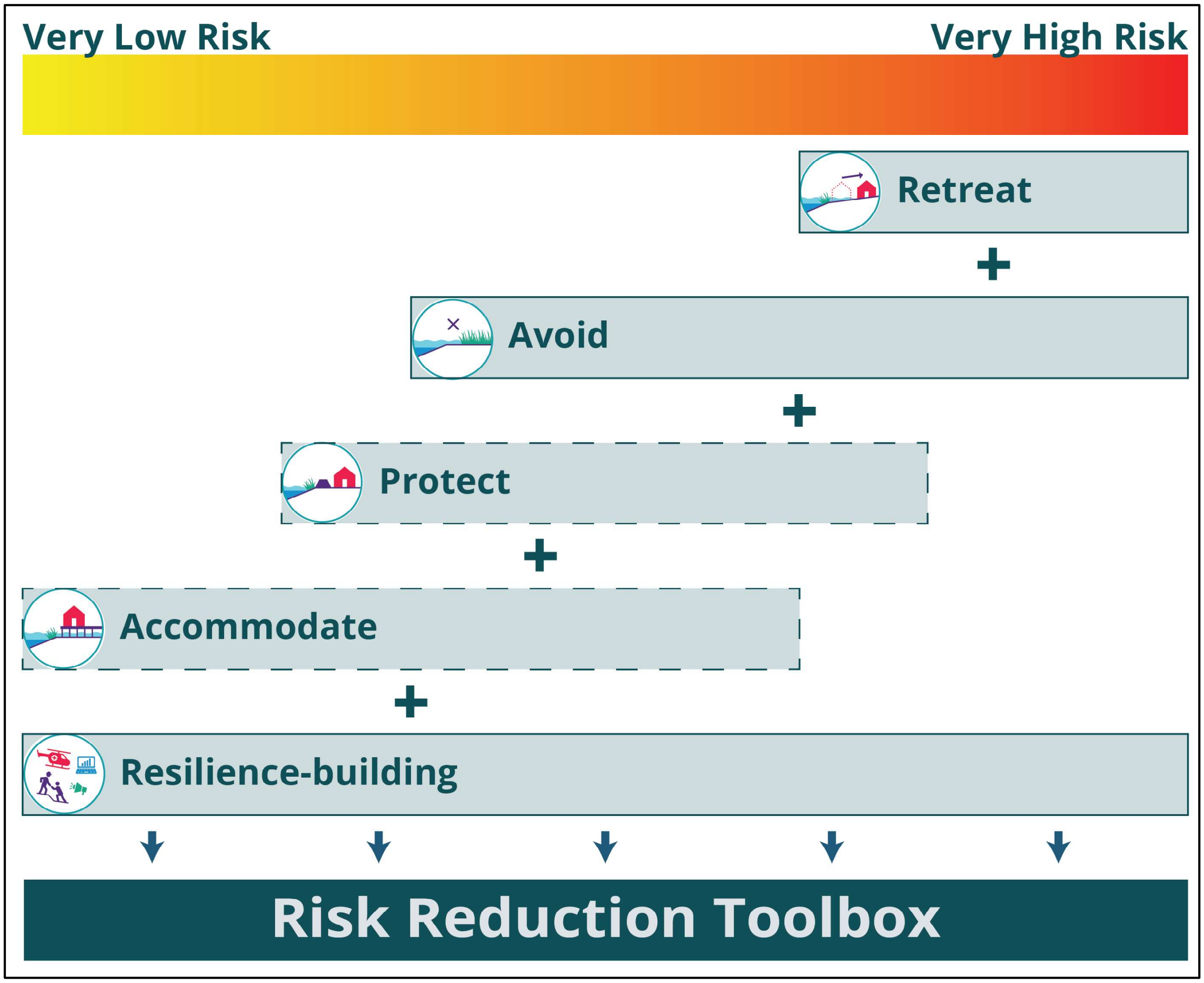


Figure 7-1: Risk Reduction Toolbox – all PARAR strategies (*Protect, Accommodate, Retreat, Avoid, and Resilience-building*) work together to reduce risk.

Figure 7-2 illustrates how the risk reduction toolbox of strategies can be used to reduce the current, or original, risk. The objective is to reduce the original risk, so that the remaining risk is acceptable to the community. This is achieved by reducing hazard, exposure, or vulnerability, and increasing the overall resilience of a community.

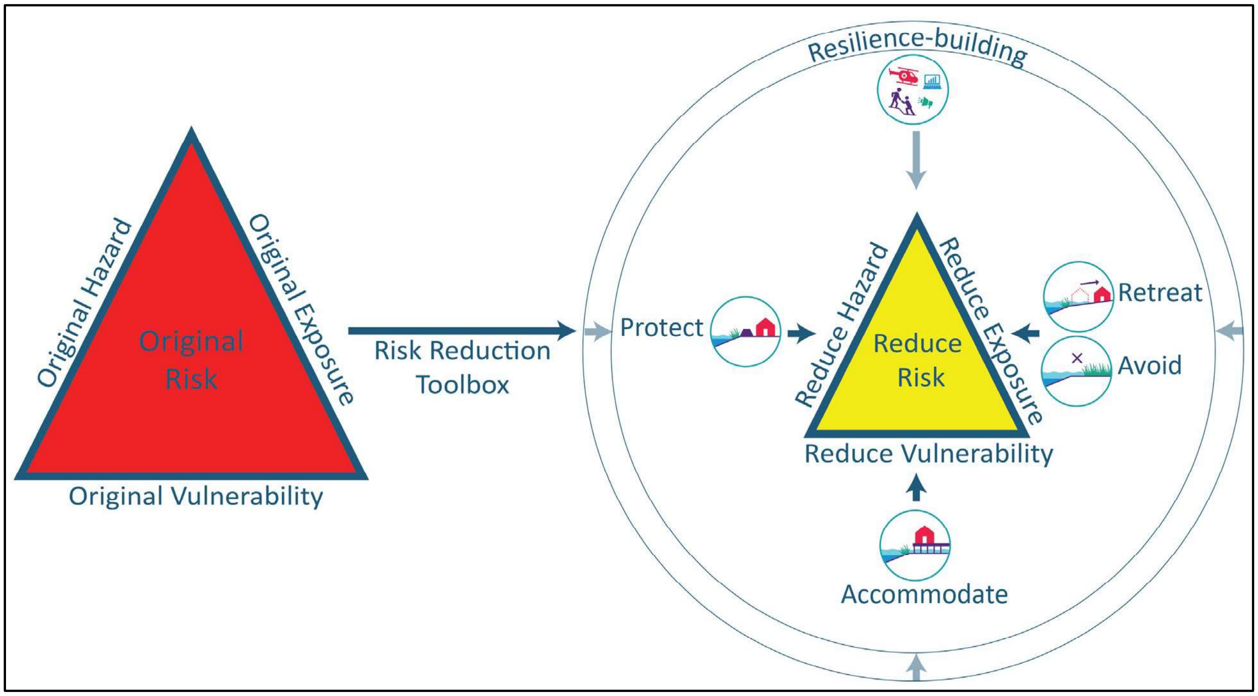


Figure 7-2: The combined strategies of the risk reduction toolbox reduce hazard, exposure, and vulnerability, i.e., risk.

Hazard characteristics are one of the key inputs to risk (see Figure 7-2) above, and areas with a higher hazard, if combined with exposure and vulnerability, will mean higher risk. One way to distinguish higher hazard areas from lower hazard areas is by using a floodway/flood fringe approach (see also Section 4.3.1.3):

- The floodway is the area with the highest hazard and therefore highest risk, and refers to the river channel and shoreline and adjacent areas where water depths, velocities and wave action are greatest and most impactful. The floodway refers here to the present-day - likely scenario (0 m SLR & 0% increase in riverine flows; 5% AEP).
- The flood fringe is the remaining area of the floodplain that are outside the floodway, and the area with lower hazard, i.e., risk. This area may also flood, but likely less often and with less depth, velocity and wave action than within the floodway. The flood fringe refers to the mid-term future - less likely scenario plus freeboard (1 m SLR & 15% increase in riverine flows; 0.5% AEP, plus 0.6 m freeboard).
- Both floodway and flood fringe form together the regulatory floodplain (Figure 7-3).

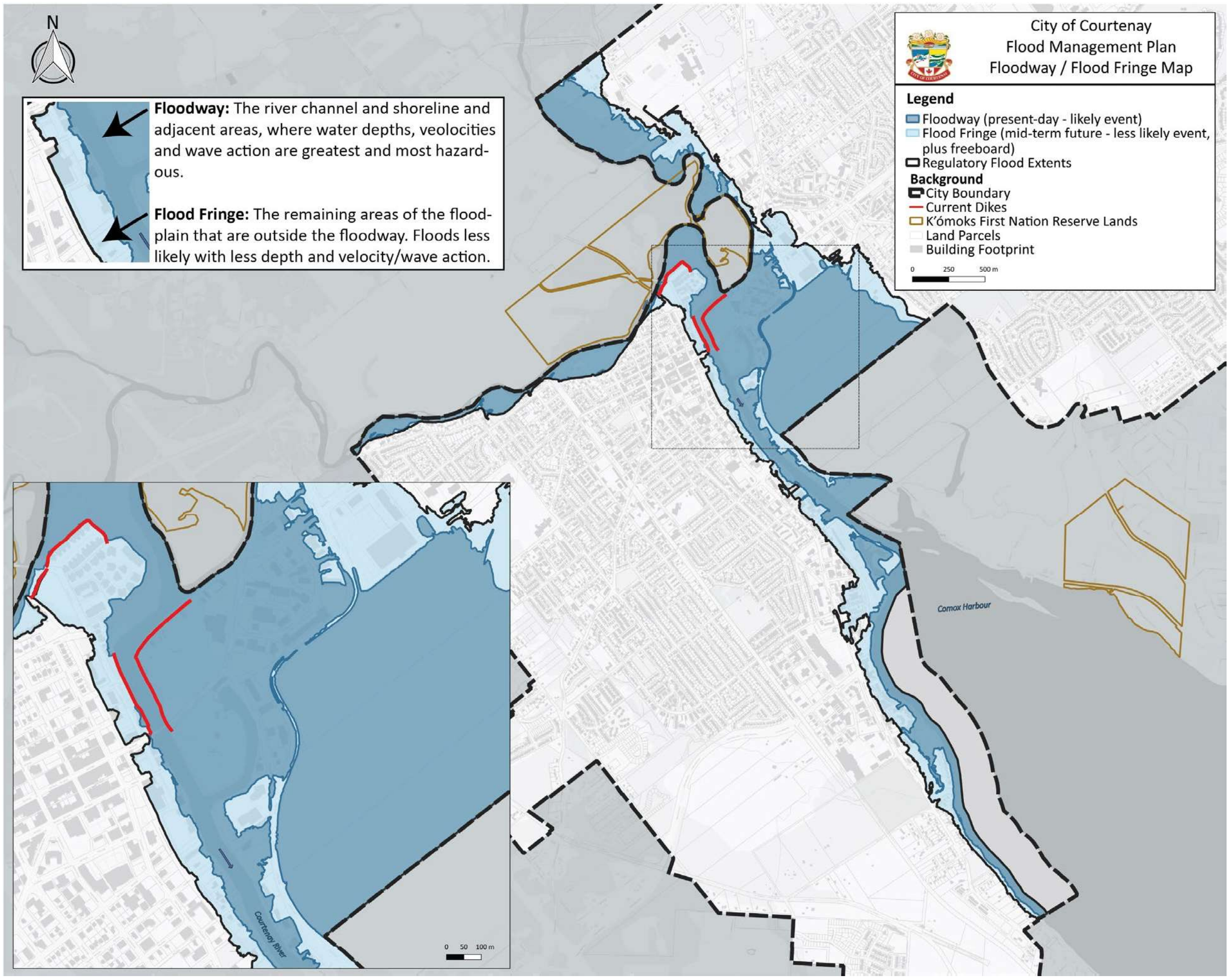


Figure 7-3: Floodway/flood fringe map for the City of Courtenay. Floodway indicated in dark blue, flood fringe in light blue.

7.1.2 Recommendations Overview

Community Values That Guided Recommendations

- Biodiversity
- Recreation and Natural Assets
- Community & Culture
- Social Equity
- Economic Success
- Low carbon
- Public Safety

Based on the above concepts, a set of flood management recommendations was developed for the City. These recommendations draw on information from the previous chapter (6) for the Local Areas and provide implementation details. For information on how these multiple strategies are envisioned to work together at the local level, refer to the sections on 'Suite of Recommended Options' for each Local Area in Chapter 6. The strategies and recommendations were developed with community values in mind, as identified in the OCP and in public engagement for this project (see box to the right).

Figure 7-4 provides an overview of the recommendations, which are grouped by strategy. Overall, the recommendations align with the direction provided in the OCP. These include directing growth away from the floodplain while developing a long-term strategy for managed retreat from vulnerable areas. The OCP stipulates that the appropriate land uses for the floodplain areas are agriculture, parks, and recreation. The OCP also directs development of a zoning bylaw section to formalize shoreline uses and setbacks with a priority on environmental protection and passive recreation and the prevention of hard shorelines while encouraging Green Shores approaches. Taken together, the existing guidelines and OCP policies promote limited, lower risk land uses in the floodplain and prioritize environmental protection, soft edges, and restoration along shorelines and riverbanks. The OCP also directs an update of the floodplain bylaw and application of FCLs to redevelopment, as well as a DPA for protection of development from flood/erosion hazard is called for and the Shoreline zoning addition mentioned above.

City of Courtenay - Flood Management Plan Recommendations Overview

City-wide Recommendations

Avoid

- Develop flood risk-based zoning bylaw.
- Avoid new residential development in the floodway.
- Recommended floodway land uses include: agricultural, recreational, and parks.
- New development in the flood fringe must accommodate flood waters.
- Over the long term, opportunistically acquire land in the floodway .

Retreat

- Develop a managed retreat strategy to convert residential land uses in the floodway to land uses that are compatible with the flood risk.

Protect

- Clarify Provincial expectations for vegetation management on dikes that only offer erosion protection.
- Manage vegetation along all dikes in accordance with Provincial expectations.
- Complete annual inspections for all dikes, as required by the Dike Maintenance Act.

Resilience-Building

- Develop a comprehensive Communications Campaign to educate the public, residents of the floodplain, and property owners in high risk areas about flood risk, and actions to reduce the risk.
- Update monitoring and warning procedures.
- Update emergency response plan.
- Develop flood recovery and post-disaster plans.
- Work with insurance companies to address residual risk.
- Collaborate regionally on emergency preparedness and response.

Accommodate

- Update floodplain bylaw (new flood construction levels & erosion setbacks).
- Consider Development Area Permit for flood and erosion hazards.
- Encourage property-level flood barriers to reduce damages to properties in the floodplain.
- Use temporary flood barriers as an emergency response measure.
- Floodproof City-owned facilities and infrastructure (including lift stations).
- Develop tools to track all flood related covenants registered on property titles. Inform property owners of the covenant requirements and seek enforcement.
- Work with residents, business owners, the Airpark, agricultural producers, and City Operations to minimize contamination sources (septic systems, hazardous material storage).
- Consider regulation of hazardous material storage in floodplain.
- Improve the resiliency of park infrastructure to flooding (through Park Master Plans).
- Work together with K'ómoks First Nation to identify solutions for Indigenous sites at risk that are supported by their community.

Local Area Recommendations

Condensory & Canterbury:

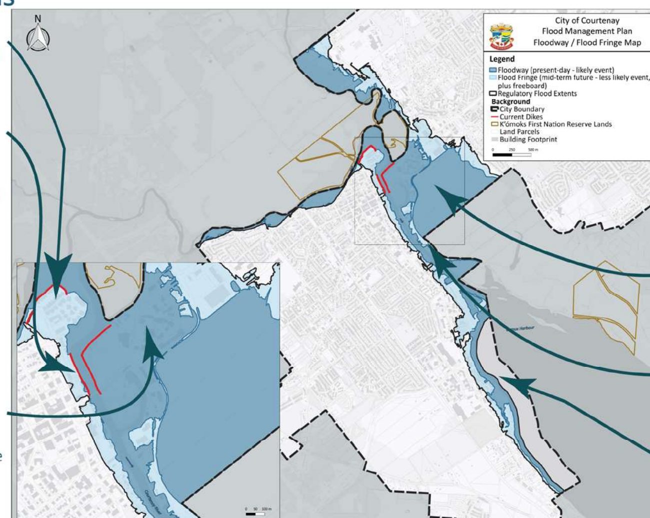
- Resolve the ownership dispute associated with Canterbury Dike by working with the Province and the strata.
- Ensure inspections of Canterbury Dike are conducted, and any required repairs are made.

Anderton Avenue:

- Conduct additional inspections and monitoring needed to ensure public safety.
- Develop plans to remediate Anderton Dike, including removal of the wall and naturalization of the shore.

Puntledge Road Commercial Area:

- Ensure City-owned buildings and infrastructure, including the Lewis Recreation Centre, LINC Youth Centre, Memorial Outdoor Pool, and outbuildings are floodproof and resilient to flood damages.
- Complete repairs of Lewis Park Dike, and consider naturalizing the shore over the long-term.
- Floodproof Puntledge Road lift station.
- Develop a detailed evacuation plan for the area, with a focus on traffic management, signage, and public education.
- Maintain TideFlex valves in the area, and consider the installation of additional TideFlex valves.
- Update, repair, and maintain culverts along the Rye Road Flood corridor, and in Lewis Park.
- Remove tall wall, and replace with a traffic barrier, if required.
- Change Tiger Dam from seasonal deployment in current location to targeted critical infrastructure protection on an event-basis.
- Work with the Ministry of Transportation and Infrastructure on Highway 19A upgrades.



Floodway: The river channel and shoreline and adjacent areas, where water depths, veolocities and wave action are greatest and most hazardous.

Flood Fringe: The remaining areas of the floodplain that are outside the floodway. Floods less likely with less depth and velocity/wave action.

Agricultural Area:

- Communicate flood risk and resources to reduce risk to local agricultural producers as part of communications campaign. Align with the CVRD Comox Valley Agricultural Plan information.
- Encourage minimizing agricultural contamination sources.

Kus-kus-sum Site:

- Continue restoration and naturalization at Kus-kus-sum site.

Coastal Area:

- Restrict new development in coastal erosion setback.
- Continue working with Airpark to avoid potential contamination sources.
- Over the long-term, consider increasing erosion protection given sea level rise and associated coastal erosion, with a Green Shores approach.

16 August 2024

ebbwater

Figure 7-4: Overview of flood management strategies recommended for the City of Courtenay.

Out of the 86 recommendations that were identified in the Flood Management Plan, 81 apply to the short-term (5-Year Capital Plan), and the remaining five apply to the medium- to very long-term.

The City is intended to be the primary owner of the recommendations; however, collaboration with individuals and partners in the region is key to an effective plan implementation. For example, opportunities for potential cooperation with regional jurisdictions are indicated.

Approximate timelines for recommendations are provided in Table 7-1.

Table 7-1: Timeline categories.

Timeline	Years
Immediate	1-2 years
Short-term	2-5 years
Medium-term	5-10 years
Long-term	10-20 years
Very long-term	20+ years

Note the following about the recommendations:

- Foundational actions for risk reduction and resilience-building should be considered as starting points. These include many of the engagement and communication related recommendations.
- We assigned more immediate timelines to recommendations that address areas of high risk.
- Immediate and short-term actions are provided within the 5-Year Capital Plan (see Chapter 8 Implementation Plan, Section 8.1).
- As risk is changing with climate, there is consideration of future ‘tipping points’ when risk will increase substantially (i.e., in the 2050s) and the need to ensure that the City is prepared in time to manage this shift.
- Class “D” (indicative) cost estimates are provided where applicable and where high-level engineering analysis was available. Other cost estimates are based on experience for similar projects, developed with input and review from the City.
- Recommendations are labelled and numbered according to the five strategies (P = *Protect*, AC = *Accommodate*, RE = *Retreat*, AV = *Avoid*, and RB = *Resilience-building*).
- Note that the recommendations are not listed in order of priority, but start with *Protect*, as in consistency with the PARAR acronym. Further note that *Protect* options mostly refer to local area recommendations, whereas most other strategies refer to city-wide recommendations.

Table 7-2 summarizes the total number of recommendations associated with each strategy.

Table 7-2: Summary of the number of recommendations associated with strategy.

Strategy	Number of Recommendations
Protect	26
Accommodate	39
Retreat	3
Avoid	3
Resilience-Building	15
Total FMP	**86**

7.2 Protect

The *Protect* strategy includes topics that range from dikes, temporary flood walls (Tiger Dam and Tall Wall), drainage and culverts, TideFlex valves, to naturalized foreshores in coastal areas. These are discussed in the following sections.

7.2.1 Condensory Dike

The Condensory Dike is recommended to be kept in place as an erosion protection structure, with no additional structural upgrades for flood protection. The City should clarify Provincial expectations for vegetation management on structures that are used only for erosion protection. Once clear direction has been received, vegetation at Condensory Dike should be managed in accordance with Provincial guidance. Ongoing annual inspection and maintenance of the dike is recommended to manage further vegetation growth, erosion, and vandalism. Monitoring should include inspecting the riprap to ensure that proper slope angles are maintained and that there is no erosion or slippage. Tree roots should not be left to undermine the stability of the riprap or berm.

#	Project Name and Description	Timeline	Approx. Budget (Class D Estimate)
P-1	**Condensory Dike vegetation management.** Clarify Provincial expectations for vegetation management on erosion protection structures. Manage vegetation according to Provincial guidance.	Immediate	$15,000
P-2	**Condensory Dike annual inspection and maintenance:** Monitor for erosion, stability, and other issues.	Annual	$5,000/year

7.2.2 Canterbury Dike

The City should clarify Provincial expectations for vegetation management on structures that are used only for erosion protection. Once clear direction has been received, vegetation at Canterbury Dike should be managed in accordance with Provincial guidance. Ongoing annual inspection and maintenance of the dike is recommended to manage further vegetation growth, erosion, and vandalism, in line with Provincial guidance.

Importantly, the ownership of this structure has been disputed, as it was built by the residential development to protect patios, prior to the *Dike Maintenance Act*. After the *Dike Maintenance Act* became law, the Province sought to make the City responsible for the structure. This disputed ownership means that the structure has not been inspected or maintained in accordance with the

Dike Maintenance Act. This represents a substantial risk to both the strata and to the City. It is recommended that the City work with the Province and the strata to resolve the ownership dispute. Once this is settled, a detailed inspection of the structure should be completed, maintenance should be completed, and any required repairs should be made.

Over the very long-term, the City should consider the buy-out of properties located directly behind the structure as they become available, or after a flood event (see also 7.4.1 on Retreat).

#	Project Name and Description	Timeline	Approx. Budget (Class D Estimate)
P-3	**Canterbury Lane Dike vegetation management:** Manage vegetation according to Provincial guidance for erosion protection structures.	Short-term	$15,000
P-4	**Address Canterbury Lane Dike ownership issue:** Work with the Province and strata to resolve the ownership dispute.	Immediate	TBD
P-5	**Canterbury Lane Dike detailed structural assessment**	Short-term	$40,000
P-6	**Canterbury Lane Dike annual inspection and maintenance:** Monitor for erosion, stability, and other issues.	Annual	$5,000/year

7.2.3 Anderton Avenue Dike

Similarly to the other flood protection structures, vegetation management is recommended, along with continued annual inspection and maintenance until further recommendations are implemented.

The removal of the existing structure and the construction of a naturalized foreshore for erosion protection is also recommended, based on McElhanney (2023) (Figure 7-5). This includes relocating the existing Anderton Avenue Sanitary Lift Station and retreating buildings on the riverside of Anderton Ave. It does not include raising the road to the FCL, meaning that buildings on the landside of Anderton Ave would potentially still experience occasional flooding (e.g., shallow water during more extreme floods in the region). Note that buildings on Anderton Ave so far have not experienced flooding. The flood protection condition for buildings on the landside of Anderton Ave would remain unchanged, as the current dike structure is not higher than the land elevation. The existing structure is essentially a retaining wall along the river that offers erosion protection.

As of 31 July 2024, the City has purchased the property directly behind the failing dike structure, and gave notice to tenants to move out by the end of the year due to the high public safety risk, providing monetary compensation and support from housing society to support tenants in their search for new housing[57].

#	Project Name and Description	Timeline	Approx. Budget (Class D Estimate)
P-7	**Anderton Avenue Dike vegetation management.**	Immediate	$15,000
P-8	**Anderton Avenue Dike annual inspection and maintenance:** Monitor for erosion, stability, and other issues.	Annual	$5,000
P-9	**Anderton Ave – Remediation (Naturalized Foreshore):** City to seek grant funding for detailed design and construction.	Immediate to Short-term	~$10,000,000

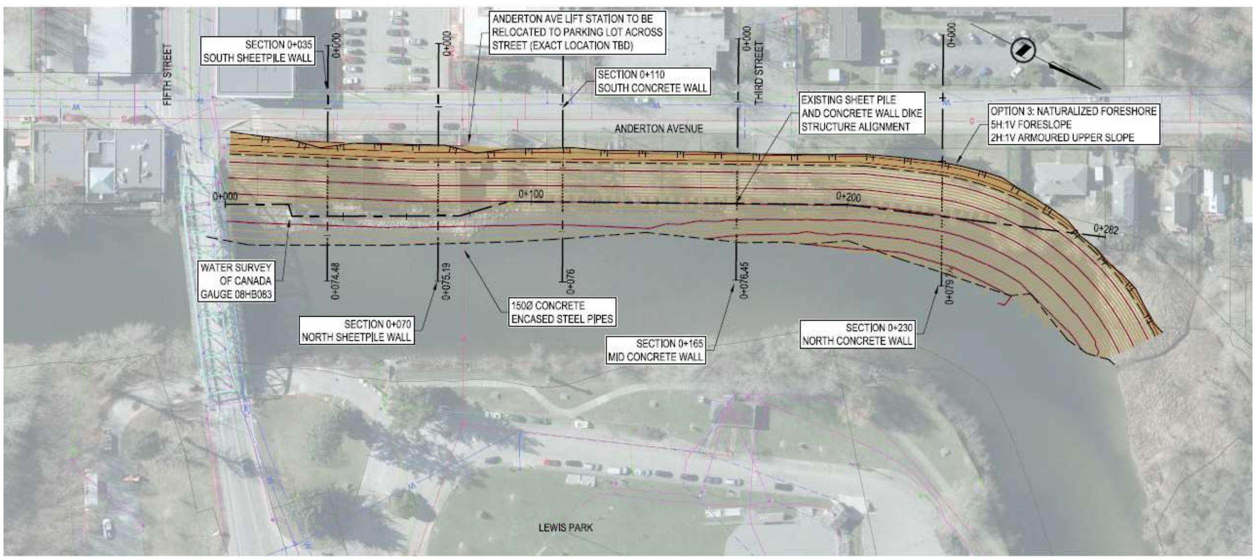


Figure 7-5: Conceptual drawing for a naturalized shore at Anderton Avenue. Design will be refined in follow-up work. (Figure from McElhanney, 2023).

[57] City of Courtenay (2024). City Acquires Anderton Arms to Address Safety Risk. https://www.courtenay.ca/EN/meta/news/news-archives/2024-archives/city-acquires-anderton-arms-to-address-safety-risk.html (published on 31 July 2024; accessed on 16 August 2024).

7.2.4 Lewis Park Dike

In the short term, it is recommended that Lewis Park Dike be repaired and maintained for erosion protection. The City should clarify Provincial expectations for vegetation management on structures that are used only for erosion protection. Once clear direction has been received, vegetation at Lewis Park Dike should be managed in accordance with Provincial guidance. As part of the vegetation management, the removal of vegetation and repair of riprap where it is currently eroded and has failed is recommended within the next 1-2 years. Voids and cracks in concrete should also be repaired, and scour reduction implemented (including investigation of current toe protection to identify ways to reduce turbulence and scour). Annual inspections to monitor for erosion and other issues should also continue.

Lewis Park floods seasonally during times of high water, when the Courtenay Slough backs up, and water enters the park through large culverts. Increasing the height of the dike surrounding Lewis Park will not reduce seasonal flooding because there are multiple sources of flood water ingress.

Over the very long-term, the naturalization of the Lewis Park Dike through a naturalized foreshore, designed for erosion protection, should be considered. This could add additional environmental and recreational benefits. Note that this option has not been fully explored and evaluated (e.g., via option analysis in Chapter 6), as it is a long-term recommendation.

#	Project Name and Description	Timeline	Approx. Budget (Class D Estimate)
P-10	**Lewis Park Dike vegetation management:** Manage vegetation according to Provincial guidance for erosion protection structures. Remove vegetation and repair erosion with riprap where necessary.	Immediate	$15,000
P-11	**Lewis Park Dike repairs:** Repair voids and cracks in concrete.	Short-term	$100,000
P-12	**Lewis Park Dike scour reduction:** Investigate current toe protection to identify ways to reduce turbulence and scour.	Short-term	$50,000
P-13	**Lewis Park Dike annual inspections:** Monitor for erosion and other issues.	Annually	$5,000/year
P-14	**Naturalized Lewis Park Dike:** Consider naturalization for erosion protection.	Long-term	$12,000,000[58]

[58] Estimate based on length and other more detailed estimates for naturalizations.

7.2.5 Tiger Dam and Tall Wall

Tiger Dam: The current operations of the Tiger Dam[59] have been challenging due to setup efforts, costs, and potentially limited effectiveness in the current location (see Section 6.6.2.1 for details). Currently, the Tiger Dam is set up for the first storm/high-water warning each winter. Once it is deployed, it remains up as a flood defense against rainfall events and high tides that occur throughout the winter season. During this seasonal deployment it is subjected to problematic conditions (e.g., vandalism, deflation, and persistent weathering), as it was not designed for seasonal deployment. The operation costs for setup and maintenance of the system throughout the winter are high. The Tiger Dam only protects up to a likely present-day event (5% AEP flood) if it is fully functional and not damaged or deflated. Additionally, flood waters may also go around the ends of the structure. The Tiger Dam is only intended to reduce property damage and cannot ensure public safety. It tends to create an 'illusion of safety' that may cause people to occupy a hazardous area they may otherwise avoid.

Due to the challenges outlined above, it is recommended that the Tiger Dam not be deployed semi-permanently at this site and to instead focus efforts in this area on traffic management and evacuation measures, along with the use of property-level flood barriers. The Tiger Dam can be used for targeted critical infrastructure protection by the City on event-basis (i.e., for specific storms/high tide warnings and emergency response).

Tall Wall: Connecting onwards from the Tiger Dam along Headquarters Road/Tsolum Slough is the so-called 'Tall Wall', consisting of jersey barriers (Section 6.6.2.1). However, jersey barriers are not engineered to provide flood protection (e.g., they do not withhold water, and are not impermeable) and do not meet the Provincial guidelines for Dike Design and Construction. There are major concerns that the wall would not withstand the elevated water pressure from flood waters, falling over and creating a substantial safety hazard. Further, and like the Tiger Dam, the Tall Wall may be overtopped during more extreme events in the present-day. Therefore, the removal of the Tall Wall as a flood protection measure is recommended[60].

Lastly, it is recommended to combine the above two recommendations with a public education campaign to explain why these measures should be eliminated. This should include rationale for how the alternative measures can increase public and property safety. Further, the Flood Operations

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[59] The Tiger Dam replaced the previously used AquaDam in 2023. The AquaDam faced the same issues as the Tiger Dam.

[60] The need for a traffic barrier should be assessed.

Manual should be updated to reflect this change in deployment; for more details on the Flood Operations Manual update, see Section 7.6.3.

#	Project Name and Description	Timeline	Approx. Budget (Class D Estimate)
P-15	**Tiger Dam:** Stop current deployment and switch to targeted critical infrastructure protection on an events-basis.	Annually	$20,000[61]
P-16	**Tall Wall:** Assess the need for a traffic barrier, and otherwise remove structure.	Immediate	TBD
P-17	**Communicate change in use of Tiger Dam/Tall Wall** and what is done instead.	Immediate	As part of communications and engagement campaign (RB-2).

7.2.6 Rye Road Flood Corridor

Rye Road, near one of the known flood first breach points in the City[62], offers a flood water drainage route towards a large stormwater main and onto a ditch near the agricultural fields (see Section 6.5.2.1 for details). While this drainage way does not have sufficient capacity to alleviate larger floods, it can relieve some pressure during high rainfall events.

To ensure the safe conveyance of flood water, we recommend an assessment of the flow path from Rye Road to the discharge point. This includes addressing the following:

- The two twin culverts under Highway 19A, which are an essential part of this flow path, are likely deteriorated and not capable of conveying flood water[63]. Therefore, the City should assess their current capacity and condition, and plan their replacement.
- BC Hydro recently installed infrastructure in the ditch at the end of Rye Road. The City should assess the new capacity of the ditch and determine impacts to infrastructure in a flood event.

[61] Similar annual operating costs as currently assumed.

[62] Based on the Flood Operations Manual of the City (McElhanney, 2022).

[63] According to the City, no inspection was conducted as part of this report.

- The flow path ends in a pond and ditch, which is owned by Ducks Unlimited. The City should work with Ducks Unlimited to assess current conditions and consider vegetation management (considering ecological aspects) to ensure sufficient water holding capacity to avoid backwatering effects. Previously, according to the City, much of Puntledge Road flooded due to the inability of storm water to be conveyed away from the affected area. Therefore, open ditch cleaning in this area behind the Superstore would be likely be helpful.

#	Project Name and Description	Timeline	Approx. Budget (Class D Estimate)
P-18	**Rye Road:** Assess flow path for operability and conveyance (including assessment of current conditions of twin culverts).	Short-term	$2,000
P-19	**Rye Road:** Work with MoTI to replace twin culverts.	Short-term	TBD
P-20	**Rye Road:** Assess impacts of new BC Hydro infrastructure during a flood event.	Short-term	TBD
P-21	**Rye Road:** Work with Ducks Unlimited to assess condition of pond and ditch at end of Rye Road drainage path and conduct open ditch cleaning and vegetation management.	Short-term	$15,000

7.2.7 Lewis Park Culverts

The City should continue to maintain the three Lewis Park culverts that connect from Lewis Park to Courtenay Slough (see Section 6.5.2.1 for details). These were installed to allow flood waters to exit Lewis Park, but they also allow flood waters into Lewis Park via a backwater effect through the Courtenay Slough during times of high-water levels. The City should also explore, e.g., via targeted hydraulic modelling (see Section 7.3.9), to better understand and optimize the use of the culverts (e.g., via modification of culverts with gates or valves to limit backflows).

#	Project Name and Description	Timeline	Approx. Budget (Class D Estimate)
P-22	**Lewis Park Culverts:** Continued maintenance.	Annual	$2,000/year
P-23	**Lewis Park Culverts:** Explore to better understand and optimize use of culverts. For instance, as part of hydraulic modelling, see AC-39	Short-term	TBD

7.2.8 TideFlex Checkmate Valves

The City has installed seven TideFlex Checkmate Valves to prevent stormwater from backing up during high tide and flooding the Puntledge Road area (see Section 6.5.2.1 for details). It is recommended that these TideFlex valves are maintained. Over the long-term, consider if additional TideFlex valves become necessary with rising sea levels.

#	Project Name and Description	Timeline	Approx. Budget (Class D Estimate)
P-24	**TideFlex Valves**: Continued maintenance.	Annual	$1,000/year
P-25	**Additional TideFlex Valves:** Assess if more TideFlex valves become necessary with rising sea levels.	Long-term	TBD

7.2.9 Coastal Area – Erosion Protection via 'Green Shores'

Along the coastline (along Cliffe Avenue south of Mansfield Drive and north of Park Lane), coastal erosion due to rising sea levels combined with storm action is a concern over the very long-term. Over this time period the restoration and naturalization of the coastal shoreline and intertidal zones using a Green Shores approach is recommended (Figure 7-6; Figure 7-7). This will minimize coastal erosion associated with sea level rise and increasing storminess/wave action.

A 'Green Shores' approach can include a vegetated slope with buried erosion protection and armouring on the upper foreshore, which expands on existing measures (current mix of rip rap, flood walls, natural slopes, where needed). Currently, there is a natural foreshore without erosion protection for a long stretch of the coast, which is prone to erosion as sea levels increase. Erosion may also impact parks, archaeological sites, and salmon habitat, which could have further consequences for Indigenous culture.

This measure would be designed for erosion protection alone and not be raised to the 'design flood' level (i.e., it will not stop water from overtopping and reaching the land, but it will reduce the energy associated with coastal events). 'Green Shores' measures, discussed in more detail in Appendix F, can make shorelines more aesthetically pleasing and provide environmental benefits (Stewardship Centre for BC, 2023).

A challenge associated with this action is the need to work with multiple property owners. Therefore, the role of the City would be to coordinate erosion protection that spans a number of properties. The work would also need to include a *DRIPA* lens (BC *Declaration on the Rights of Indigenous Peoples Act*; see Section 2.4.2) and need to ensure construction prevents salmon stranding. It should also be noted that there are many single-family properties along the shoreline in this area, and the City should educate and work with private property owners to realize the benefits of green shores versus seawalls.

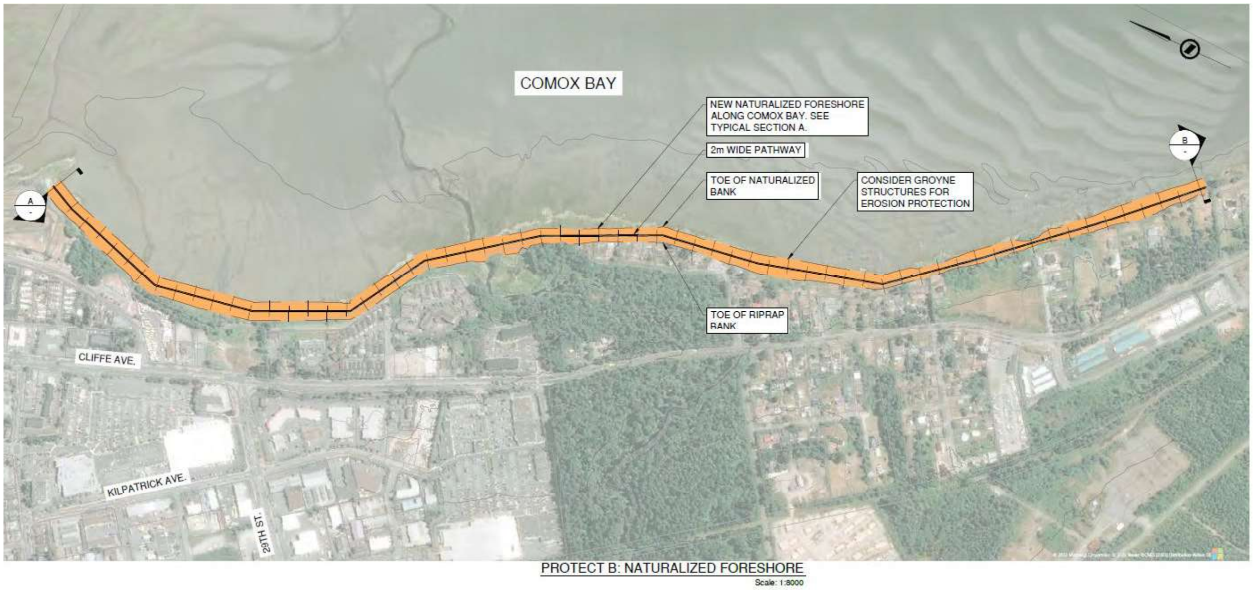

Figure 7-6: Conceptual drawing of proposed naturalized foreshore along coast (Credit: Water Street Engineering).

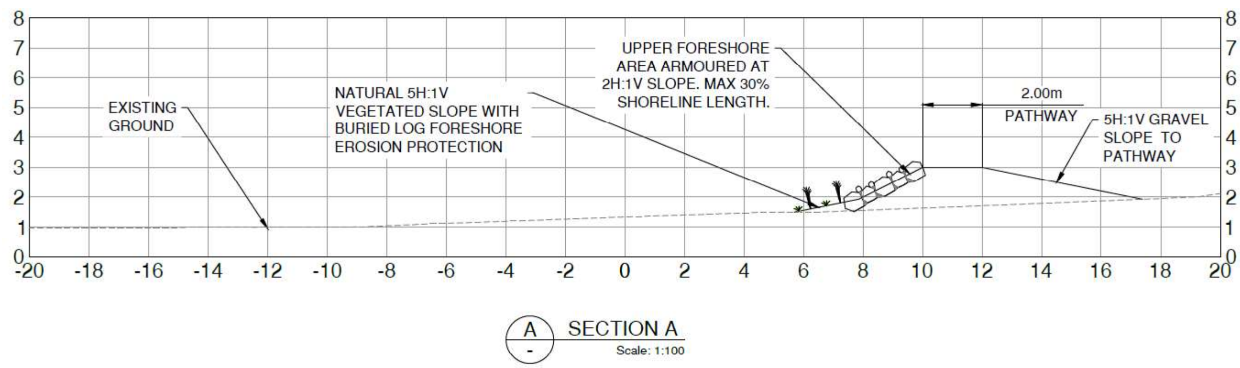

Figure 7-7: Conceptual drawing of proposed naturalized foreshore along coast (Credit: Water Street Engineering).

#	Project Name and Description	Timeline	Approx. Budget (Class D Estimate)
P-26	**Coastal Area – Naturalized Foreshore:** Apply 'Greens Shores' measures for increased coastal erosion protection, given sea level rise. As part of this, the City is recommended to educate and work with private property owners to realize benefits of Green Shores versus seawalls.	Very long-term	$13,000,000

7.3 Accommodate

Accommodation strategies are those that accept that there will on occasion be water present, and the focus is on minimizing damage. The topics discussed under this strategy are planning tools, floodproofing of buildings and infrastructure, encouragement of property-level flood barriers, minimization of contamination sources, encouragement of ongoing adaptation on agricultural lands, redesign of parks and trails, redesign of major transportation routes, and working with K'ómoks First Nation to minimize impacts to Indigenous Sites. Many of these topics are interrelated and where possible these connections and dependencies are noted.

7.3.1 Planning Tools

The *Accommodate* strategy is often tied to stipulated land uses within a flood hazard area through the application of a floodplain bylaw and/or flood hazard development permit area. These act to reduce risk on the floodway/floodplain for instance through elevating habitable areas above anticipated flood levels. This topic contains a range of interrelated recommendations, which are discussed in the following sub-sections.

7.3.1.1 Floodplain Bylaw Update (Flood Construction Levels)

The *Local Government Act* A) section 524 allows local governments to designate land as a floodplain and, by bylaw, specify setbacks and flood construction levels. In making the bylaw, the local government must *consider* provincial guidelines (e.g. Flood Hazard Area Land Use Management Guidelines). The bylaw can make different provisions for different areas, zones, uses, siting circumstances, types of buildings etc. Courtenay's OCP includes direction to update the floodplain bylaw given changes in science and best practice and changes in the provincial guidelines due to the recognized influence of climate change on flooding.

The City has an existing floodplain Bylaw (No. 1743) that designates the floodplain through mapping and sets out FCLs and setbacks. The bylaw requires updating due to the following:

- Updates to the Provincial Flood Hazard Land Use Management Guidelines (FHLUMG) that local governments are legislated to consult when developing flood hazard bylaws.
- The evolution in the practice of professional engineers and geoscientists (i.e. the *Professional Governance Act*).
- The influence of climate change on riverine and coastal flood hazard.

In 2021, the CVRD completed the Phase 1 of the regional CVRD Coastal Flood Mapping (Kerr Wood Leidal Associates Ltd., 2021), which resulted in updated regional coastal and riverine flood hazard maps. These maps have value in determining floodplain bylaw geographic limits, but are not sufficiently accurate to determine local FCLs, especially in the coastal areas.

Proposed updates to the bylaw, discussed with City staff, include revision of designated regulatory floodplain extents to reflect the 2021 work or future mapping. This means that a new bylaw would apply to new areas that were not previously considered in the floodplain. Further, the proposed updates include distinct approaches for coastal and riverine portions of the floodplain. Downstream of 21st Street, coastal conditions are dominant, with wave effects and tides. In contrast, upstream of 21st Street, riverine characteristics are dominant (i.e., while tidal effects are observed, wave effects are limited). This differentiation into riverine and coastal in the floodplain bylaw is to acknowledge and address the difference in the hazards between marine and freshwater systems, as well as to account for the differences in hazard modelling and mapping approaches and associated uncertainties; for example, the coastal flood hazard mapping was conducted at a regional scale with substantial uncertainty. In addition, this allows for distinct approaches to erosion setbacks and flood construction levels (FCLs) which vary between the two zones, consistent with the provincial FHLUMG.

Figure 7-9 indicates the extents of the regulatory floodplain (mid-term future - less likely event, including freeboard), the recommended division into a riverine and coastal zone, as well as the riverine and coastal erosion setbacks. Note that this map has been generated for discussion only and is not a regulatory map.

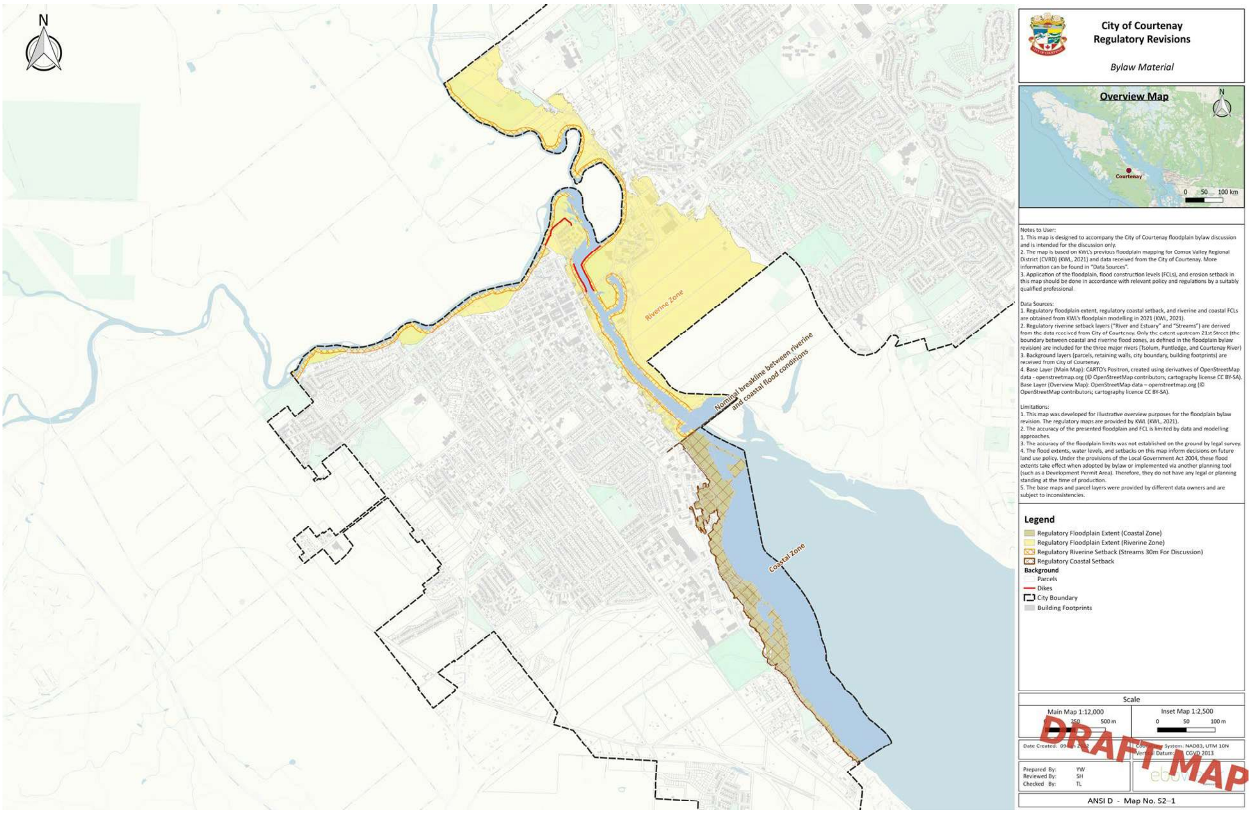

Figure 7-9: Regulatory floodplain extents for discussion purposes (note, this is not a regulatory map).

The existing floodplain bylaw does not include any reference to specific exemptions, or specific requirements such as the main switchgear (i.e., electrical) being above the FCL, which are now best practice in BC floodplain bylaws. It is therefore recommended that updated bylaw language account for this. Further, it is recommended that the new bylaw include a requirement for site specific flood and/or erosion hazard assessments as part of any exemption application (see also further below).

The following paragraphs provide information on additional topics that should be considered within the bylaw update.

Coastal flood modelling: Currently available coastal flood mapping (CVRD Coastal Flood Mapping; Kerr Wood Leidal Associates Ltd., 2021) uses a regional approach to define coastal FCLs. Relatively large coastal reaches for which a uniform coastline was assumed and the same FCL recommended. This regional approach can be challenging at the very local level of FCLs, as large uncertainties exist based on the actual coastline at a parcel, and the current regional FCLs may substantially over- or underestimate the actual flood level. Therefore, updated local coastal flood modelling with a focus on implementation for FCLs is recommended. The coastal area of the City should be the focus, but could also be completed in cooperation with the Town of Comox and the CVRD for Comox Estuary. Modelling could also be combined in a riverine-coastal model.

Contamination Sources: Public engagement completed during this project highlighted the concern with sources of contamination within the floodplain. Regulating contamination sources may be addressed in floodplain bylaw, or a DPA, or otherwise (see Section 7.3.1.3). Consideration of the direct management of contamination sources within flood regulations is recommended.

Regional alignment: Given that the City borders the CVRD, and especially that over time, the City may expand further in lands currently regulated by the CVRD, regional alignment of the floodplain bylaw approach is important to ensure consistency in the region. Therefore, collaboration with the CVRD is recommended.

Site-specific Flood and Erosion Hazard Assessments:

In dealing with building regulations, the Community Charter establishes the authority to require geotechnical reports if flood hazard exists completed by Professional Engineers or Geoscientists. The *Land Title Act Section 86* outlines that a subdivision approving officer can refuse approval of a subdivision plan if the land is subject to, or could reasonably be expected to be subject to flooding, erosion or land slip. The approving officer can require a report certified by a Professional Engineer or Geoscientist that the land is safe for the use intended and require entry into a section 219 covenant. Similar provisions are available under the *Strata Property Act* and the *Bare Land Strata Regulations*. The new bylaw may refer to Professional Engineers or Geoscientists undertaking assessments of site specific flood and/or erosion hazard. The City of Courtenay can develop a terms of reference specific to these assessments to guide the reporting and increase the consistency and ease of review. The District of Squamish has a terms of reference for flood hazard assessments[64]. The Fraser Valley Regional District developed an assurance statement[65] for geohazards in collaboration with Engineers and Geoscientist of BC (EGBC). This includes a checklist for the professional to ensure reporting is consistent and comprehensive. Although the approach of using qualified professionals is common and is supported under legislation as well as by Engineers and Geoscientists BC (EGBC), it can be

[64] District of Squamish (2022). Terms of reference for natural hazard and/or risk assessments. https://squamish.ca/assets/Planning-forms/20220912-Terms-of-reference-flood-hazard-assessments.pdf (Accessed 16 August 2024).

[65] Fraser Valley Regional District. Geohazard Assurance Statement for Development Approvals. https://squamish.ca/assets/Planning-forms/20220912-Terms-of-reference-flood-hazard-assessments.pdf (Accessed 16 August 2024).

challenging to implement. There are a limited number of qualified professionals, especially those working specifically in coastal environments with knowledge of the east coast of Vancouver Island, and it can be hard to retain the services of an appropriately qualified professional.

Restrictive covenants:

Requirements for restrictive covenants are recommended to be specified within the bylaw as well. LGA S. 524(7) allows for a local government (LG) to exempt a person from the bylaw in relation to a specific parcel, use, building or structure if a Professional Engineer or Geoscientist submits a report certifying the land is *safe for the use intended*. In granting an exemption, the LG can require a section 219 restrictive covenant in favour of the LG.

City of Courtenay staff relay that placing Section 219 restrictive covenants in favour of the municipality on land title in the floodplain has been common practice. This means that flood hazards are disclosed on property title, with the intent to require that all parcels within a hazard area have disclosure on title, and not only those with exemptions or variances. Additional covenants will be required with the added extents of designated floodplains that accompany the proposed bylaw update. Site-specific flood and erosion hazard assessments that are completed as required should be appended to the covenants.

It is recommended that the covenant specify conditions that would enable the land to be safely used for the use intended. Attaching the hazard assessment report stipulating the conditions that the land can be used safely is recommended. In addition, the following conditions should be included:

- Waiver of liability in favour of the LG.
- Priority over any financial charges requested against the property.
- Covenant modification agreement.
- Affidavit for witness.

It is recommended that required covenant conditions are specified via the floodplain bylaw.

The City is not aware of which properties have current covenants. Therefore, the City should develop tools to track and manage covenants already in place for parcels within the floodplain. Along with this, the City should inform property owners about the covenants, in case property owners are not aware.

Further, the City should expand the covenant on title for the extents of the new regulatory floodplain, to require that location in regulated floodplain be disclosed on title. Local realtors should also be educated to communicate this information to their clients (see engagement related to bylaw update mentioned below).

Overall, the City should ensure compliance with existing covenants, such as for example, the 2015 covenant[66] for Maple Pool RV Park, by working with the property owners.

Engagement for updated bylaw: It is recommended that policy and regulation specific engagement be carried out in either a targeted manner with impacted stakeholders or more broadly with the community. For example, engagement with developers and property owners in the expanded floodplain area where the existing floodplain bylaw did not apply previously, is recommended ahead of adopting the floodplain bylaw.

Accompanying education and awareness campaigns: Accommodating land uses within the floodplain should be accompanied by raising awareness and education about floodplain extents, the environmental development permit area guidelines, appropriate storage below FCLs and preparedness for flood events.

Local realtors should be provided with information to pass on to prospective home buyers through webinars, lunch and learn events, etc. Engagement with agrologists and industrial land users within the floodplain should focus on hazardous chemicals and waste and how to best store them to avoid contamination of flood waters.

#	Project Name and Description	Timeline	Approx. Budget (Class D Estimate)
AC-1	**Update Floodplain Bylaw:** Collaborate with CVRD to align floodplain bylaws in the region. Consider distinct riverine and coastal approaches. Explore inclusion of specific exemptions, requirements and hazardous materials storage, approach for ensuring quality by qualified professionals (e.g., assurance statement), and restrictive covenants.	Immediate	$30,000
AC-2	**Conduct targeted engagement before updated bylaw adoption:** Inform impacted stakeholders (i.e., property owners) before bylaw adoption.	Immediate	$20,000
AC-3	**Targeted education and awareness campaigns after bylaw adoption:** E.g. for local realtors and industry representatives.	Immediate	$20,000
AC-4	**Update coastal mapping for FCL:** Complete detailed hydrodynamic mapping for Comox Estuary to ensure high-quality maps for coastal FCLs. This could be	Short-term	$200,000

66 Land Title Act, Section 219, Covenant, from 16 November 2015 between owner of RV Park and City of Courtenay.

#	Project Name and Description	Timeline	Approx. Budget (Class D Estimate)
	developed in cooperation with Town of Comox and CVRD, as well as combined with potential modelling for Anderton Ave. Updated coastal FCLs would require a bylaw amendment, should the floodplain bylaw be updated before this becomes available.		
AC-5	**Covenant data management:** Develop tools and start tracking and managing existing covenants for parcels in the floodplain and inform property owners about covenants. Work with property owners to ensure compliance with existing covenants.	Short-term	$10,000
AC-6	**Add covenants:** Expand covenant on title for the extents of the new regulatory floodplain. Require that the location in regulated floodplain be disclosed on property title. This would apply whenever the opportunity arises.	Immediate	$2,000

7.3.1.2 Development Permit Area for Flood and Erosion Hazard

Section 488 of the *Local Government Act* permits a local government to designate development permit areas (DPAs) for several purposes. One of those purposes is the protection of development from hazardous conditions and another is the protection of the natural environment. The latter is reflected in the existing Courtenay DPA for environmental protection. The current OCP directs establishment of a DPA for the protection of development from flood and erosion hazard.

Courtenay's proposed DPA for flood and erosion hazard would need to be consistent and integrated with the floodplain bylaw, soil movement bylaw, development procedures bylaw, fees and charges bylaw, tree protection regulations and the flood hazard management plan. The DPA could provide a consistent framework for permitting of development activity in flood prone areas. The DPA should have clear guidelines that apply to marine foreshore versus riverine and areas of flood hazard versus erosion hazard. Reviewing examples of flood/foreshore DPAs reveals that the general themes they cover include:

- Living space and electrical/mechanical systems above FCL (as per Floodplain Bylaw).
- Specifications for fill required to meet the FCL.
- Landscaping and appropriate erosion protection measures (i.e. soft approaches).
- Riparian zone protection.
- Stormwater management.

The District of Squamish's DPA for Flood Hazard (see OCP page 197[67]) separates the hazard into primary and secondary floodway and debris flow hazard areas and detailed guidelines in addition to the floodplain bylaw. Other examples include Parksville DPA #11 and #12[68] and District of West Vancouver Foreshore DPA[69].

#	Project Name and Description	Timeline	Approx. Budget (Class D Estimate)
AC-7	**Development Permit Area for Flood and Erosion Hazard**	Short-term	$30,000

7.3.1.3 Regulate Hazardous Material Storage in Floodplain

During public engagement, concerns with sources of contamination within the floodplain were highlighted and strong support for monitoring and regulating hazardous material storage in floodplain were voiced. Hazardous materials include septic fields, fuel tanks in commercial areas, industrial chemical storage, and agricultural chemicals and waste. One option to monitor and regulate these potential sources of contamination is to tie hazardous material storage to business licensing. Two potentially more effective options are listed below, and it is recommended that they be explored.

1. **Floodplain bylaw:** Add to section 7 of the bylaw (application of floodplain specifications) a statement such as, "No hazardous or toxic substances shall be stored below flood construction levels specified in this bylaw"[70]. The advantage of this approach is that it applies uniformly across the floodplain and the City can refer to the bylaw during public engagement to build awareness. The challenge is that it is difficult to enforce, as this is not something that building permit staff have capacity to monitor. It may also unduly penalize agricultural storage.

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[67] District of Squamish (2018). Squamish 2040 – Official Community Plan. https://squamish.ca/yourgovernment/ocp/. Accessed 16 August 2024.

[68] City of Parksville. Development Permit Areas. https://parksville.civicweb.net/document/6647/. Accessed 16 August 2024.

[69] District of West Vancouver. Foreshore Development Permits. https://westvancouver.ca/climate-environment/natural-environment-and-hazard-development-permit-areas/foreshore-development-permits. Accessed 16 August 2024.

[70] The statement "unless stored in floodproofed storage" could also be added for specificity, but the statement could also confuse interpretation.

2. **DPA for flood and erosion hazard lands:** During the development of the DPA for flood and erosion hazard lands, guidelines around storage of toxic and hazardous material could be added. The advantage is that it is an opportunity to engage with industry and agricultural operations in the floodplain to discuss storage and develop appropriate guidelines. DPA guidelines can include more information than a bylaw. The disadvantage is that a DPA is potentially not as enforceable as a bylaw.

See also Section 7.3.3 on minimizing contamination sources.

#	Project Name and Description	Timeline	Approx. Budget (Class D Estimate)
AC-8	**Explore options to regulate hazardous material storage:** Options may include developing a floodplain bylaw or DPA for flood and erosion hazard lands.	Immediate	$5,000

7.3.2 (Permanently) Floodproof Buildings and Infrastructure

The goal of floodproofing is to minimize damage, should floodwaters reach buildings (see examples in Table 7-3). This can also be combined with property-level flood barriers that limit flood waters reaching buildings on a more temporary basis (see Section 7.3.3). Floodproofing can be achieved through dry and wet floodproofing, as follows:

1. **Dry floodproofing**: These measures are designed to stop water from entering buildings through existing openings or by penetrating walls. They include the following general categories:
    - Permanent: These measures include installing flood doors, repairing cracks in walls to minimize water entry, or sealing entry points for service wiring/plumbing.
    - Temporary: These measures are deployed with appropriate warning times. They can include door barriers or window hatches. Their effectiveness is dependent on the resources needed to deploy them, including proper forecasting tools to inform timely warnings.
2. **Wet floodproofing:** These measures aim to reduce damage and recovery time, should floodwaters enter the building. This can include flood-tolerant building materials (e.g., water-resilient replacements for drywall). It also includes raising electrical sockets and other features that are particularly vulnerable to water damage. A challenge with these measures is that the building will be unusable during flooding, meaning that alternate temporary accommodation is needed.

All these floodproofing measures have a high potential to reduce damages. However, they are relatively novel approaches for Canada and implementation issues related to regulations, building codes, materials and suppliers may be obstacles.

More Resources (from Ebbwater Consulting Inc. (2021)):

Edward Barsley (2020). Retrofitting for flood resilience – a guide to building and community design. Detailed architectural and design book with ideas for many variations of floodproofing.

Flood Resilient Homes Program from Brisbane, Australia. This program provides inspections and advice to homeowners on how to permanently or temporarily protect their homes from floodwaters.

BRE Flood House, from UK. This is a joint industry and academic project to build and flood model homes to better understand the susceptibility of various materials to flood damage.

ASCE 24-05 Flood Resistant Design and Construction Standard. This US guideline provides practical advice and design standards for property-level flood protection.

BSI 851188 The British Standard for Flood Resistant Products provides a minimum standard for building materials used for floodproofing. No similar standards exist in Canada.

Hazard and Hope YouTube channel for retrofitting guidance. This provides tips, aimed at homeowners, on why they should retrofit their homes and what they can easily do themselves.

UK Homeowners Guide to Property Flood Resilience. This UK publication provides simple guidance, aimed at homeowners, on why they should retrofit their homes and what they can easily do themselves.

City of New York Retrofitting Buildings for Flood Risk Design Manual.

Table 7-3: Examples of flood-proofing strategies (Credit: Flood Control Canada).

 Flood Doors	 Door Barrier

 Door Barrier	 Window Covers

Specific recommendations and actions related to floodproofing are described below:

7.3.2.1 Encourage Floodproofing of Buildings-at-Large

It is recommended that the City make property owners in the floodplain aware of the flood risk and support a discussion of individual actions property owners and tenants can take to reduce their own risk. The City should consider collaborating with other local/regional governments (and the Provincial government) to develop guidance and communications materials. There may also be interest from insurance companies, or the Provincial/Federal government to provide financial incentives to support floodproofing mechanisms. This will reduce damages and, therefore, insurance or DFAA payouts in case of flooding. It is recommended that floodproofing be prioritized for properties with the greatest flood risk.

Along with permanent buildings, there are mobile homes and RVs within the floodplain. Many of the floodproofing mechanisms recommended above for permanent buildings can also be considered for mobile homes. However, there are specific challenges associated with mobile homes/RVs. For example, these dwellings are lighter and weaker than typical structures, and may not be able to withstand the forces of floodwaters, such as buoyancy, erosion, and scour which may lead to movement of the home and other damages (FEMA, 2009). Therefore, most mobile homes and RVs remain unsafe during flood events. Some mobile homes/RVs may not conform to the current zoning, so major renovations would be restricted, and floodproofing would not be a worthwhile investment.

Floodproofing actions to secure personal belongings, and avoid contamination of floodwaters (e.g., elevating propane and fuel tanks above the FCL and anchoring them against flotation; FEMA, 2009) could be implemented by current residents to reduce the damage of a flood event (see Section 7.3.4.2).

#	Project Name and Description	Timeline	Approx. Budget (Class D Estimate)
AC-9	**Develop guidance and communication around building floodproofing and encourage floodproofing of buildings in floodplain:** Collaborate with other local/regional government (and the Provincial government) to develop guidance and communications material.	Immediate	As part of communications campaign (RB-2).
AC-10	**Explore incentives related to floodproof buildings:** Consider collaborating with insurance companies and the Provincial/Federal government, or obtain grants to provide financial incentives.	Short-term	$5,000

7.3.2.2 Floodproof City-Owned Buildings

For City-owned buildings in the floodplain, such as the Lewis Park Recreation Centre, the Florence Filberg Centre, and the LINC Youth Centre, the City should assess and implement dry- and wet-floodproofing measures. This will not only reduce damage at these sites but will have the co-benefit of providing tangible examples of flood proofing measures that Courtenay residents can witness.

The flood depth figures provided in Chapter 6 will guide the depth of water to plan for given the building use and life expectancy. Detailed site surveys are required to determine the most suitable types of flood proofing for each structure.

For the Lewis Park Centre, there were concerns raised in the public engagement about the daycare that is located onsite. It will be important to ensure that the daycare is safe, and that appropriate plans for closures with flood warnings, evacuations, and emergency response plans are in place (see also Section 7.6.3).

The general recommended approach is to:

1. Floodproof existing City-owned facilities in the floodplain to minimize damages from a flood event.
2. Conduct long-term planning for all City-owned facilities in the floodplain. This should be done as part of regular asset management planning, and flood information should be explicitly considered in any asset management plans.

#	Project Name and Description	Timeline	Approx. Budget (Class D Estimate)
AC-11	**Floodproof all buildings in Lewis Park:** Conduct detailed building assessment, develop plan, and floodproof.	Short-term	Investigation costs: ~$25,000
AC-12	**Floodproof Florence Filberg Centre:** Conduct detailed building assessment, develop plan, and floodproof.	Short-term	Investigation costs: ~$25,000
AC-13	**Floodproof LINC Youth Centre:** Conduct detailed building assessment, develop plan, and floodproof.	Short-term	Investigation costs: ~$25,000
AC-14	**Conduct long-term facility and service planning for all civic facilities in the floodplain**, as part of asset management planning. Flood information should be explicitly considered in all relevant asset management plans.	Short-term	As part of asset management planning.

7.3.2.3 Floodproof Sanitary System

The City should implement floodproofing for the Lift Stations that may experience substantial flooding, such as the Puntledge and the Sandpiper Lift Stations[71]. All future lift stations should be placed outside the floodplain, wherever possible. In circumstances where this is not possible, the lift stations should be designed to be floodproof.

The flood depth figures for Lift Stations provided in Chapter 6 can guide technical constraints for floodproofing. Note that only a subset of lift station components are vulnerable to flood waters (e.g., control panel) and require floodproofing, ideally above the FCL. Backflow preventers should also be considered, where applicable.

The CVRD has already initiated work on the CVRD Regional Lift Station, through the Comox Valley Sewer Conveyance Project. There are plans to floodproof this lift station by relocating it across the roadway from the Courtenay River and Comox Estuary. It will also be designed to modern floodproofing and post-disaster rated standards. The detailed design is led by the CVRD with minimal input from City of Courtenay.

The City generally has separated stormwater and sanitary sewer systems. Therefore, concerns related to floodwaters entering the sewer system leading to backups into homes and businesses, and potential contamination of floodwaters, are relatively limited. Some stormwater inflows into the sanitary system may occur due to manhole pick holes and missing clean-out caps. The City tries to

[71] See for instance the City of Calgary's Wastewater Lift Station Design Guidelines (2016) and the City of Regina Design Standard for Wastewater Lift Stations (2021) that specifically discuss floods.

eliminate these issues by using Smoke Testing in various areas. The City should continue testing and reduce the potential sources of stormwater inflows into the sewer system within the floodplain.

There are a few locations where there are cross-connections between the stormwater and sanitary systems. One of these locations within the floodplain is at the LINC Youth Centre, located near Old Island Highway and Ryan Road (see Section 6.6.2.3 for map and details). At this location, the stormwater catchbasins in the LINC Youth Centre parking lot drain into the sanitary system, which is a low spot in the gravity-drainage sanitary system. During flood events, there is a risk that stormwater could overwhelm the sanitary system via the catchbasins, backing up sewage and leading to potential contamination of surface water (stormwater/floodwater). Backing up of sewage has not occurred so far at this location, but the large volume of water ingress into the sanitary system is problematic. The City typically now covers the catchbasins with rubber matting and sandbags, to reduce the amount of inflow towards the Puntledge Lift Station (however, note, as discussed below in Section 7.3.3, sandbags may not be better replaced with other, temporary flood barriers). The City also tends to shut down the nearby Puntledge pump station during periods of high stormwater ingress, to avoid pumping flood waters[72], and in the Flood Operations Manual (McElhanney, 2022), a temporary sand bag dike is also recommended to be implemented around the pump station.

It is recommended that a long-term robust solution be studied and implemented. Such an approach is preferrable to short-term measures such as deploying sandbags and shutting down the pump station. Measures could include the installation of valves/backflow preventers and regrading the parking lot so that stormwater flows into another catchbasin that has a connection to the stormwater system. Another option is to consider green infrastructure solutions to reduce stormwater runoff. These solutions include rainwater source control, and storage such as rain gardens and ponds, which increase on-site water infiltration and storage) and reduce the peak of stormwater runoff[73].

#	Project Name and Description	Timeline	Approx. Budget (Class D Estimate)
AC-15	**Floodproof Puntledge Lift Station:** Conduct detailed assessment, plan, and floodproof.	Short-term	Investigation costs: $5,000[74]

[72] This is normal practice and is done based on the judgement of the operations staff to minimize potential contamination and damage.

[73] Green infrastructure solutions, however, will have limited effectiveness in reducing flood waters resulting from riverine flooding.

[74] Unless there is a need for major redesign (as opposed to quick fixes).

#	Project Name and Description	Timeline	Approx. Budget (Class D Estimate)
AC-16	**Floodproof Sandpiper Lift Station:** Conduct detailed assessment, plan, and floodproof.	Short-term	Investigation costs: $5,000
AC-17	**Support CVRD in their efforts to floodproof the regional station where relevant:** Project underway and led by CVRD, with minimal input required from the City.	Immediate	$0
AC-18	**Design new Anderton Lift Station in a floodproof manner:** Conduct detailed assessment, plan, and floodproof.	Immediate	~$3,500,000[75]
AC-19	**Floodproof sanitary system:** Continue testing for and reducing stormwater inflows into the sewer system for the network within the floodplain.	Annual	In-house (budget covered by staff salaries)
AC-20	**Floodproof catchbasin at LINC Youth Centre** (to avoid stormwater entering into sanitary system). This should be done as part of any redevelopment at or near the site.	Short-term	$25,000

7.3.2.4 Floodproof or Decommission Groundwater Wells

There are two groundwater wells mapped within the floodplain (see Section 6.5.2.2, and 6.6.2.3 for details, as well as Section 5.1.5 for locations on map). The following are details obtained from the Provincial Groundwater Wells Registry for each.

- **Well tag number 12545:** This well is located within the agricultural fields and was established in 1950. According to the registry, it is used for irrigation.
- **Well tag number 85130:** This well is located behind Condensory Dike and was set up in 2004 as a testing well. It is not clear if the well is still being actively used; however, no information on it being decommissioned is provided in the registry.

There may also be more private wells that are not registered. It is recommended that the City work with well owners to ensure that wells in the floodplain are either decommissioned (ideally) or are capped and sealed during flood events to minimize entry of potentially contaminated floodwaters into the groundwater. This should be conducted as part of the flood risk communications campaign.

#	Project Name and Description	Timeline	Approx. Budget (Class D Estimate)
AC-21	**Groundwater wells:** Reach out to registered well owners and encourage well owner to decommission or seal wells	Immediate	$5,000

[75] Cost estimate provided by the City.

	to prevent groundwater contamination. Assess if further private wells may exist within floodplain.		
AC-22	**Groundwater wells:** Communicate need for sealing of wells to well owners via the communications campaign.	Immediate	As part of communications campaign (RB-2).

7.3.3 Temporary Property-level Flood Barriers for Property Owners/Residents and City infrastructure

We recommend that the City encourage property owners and residents to protect single/multiple buildings or mobile homes with property-level flood barriers. Flood barriers can also be used by the City as part of emergency response plans, to protect City buildings and critical infrastructure.

Property-level flood barriers provide efficient and more effective alternatives to sandbags in the case of flooding. Concerns regarding traditional sandbags include (Barsley, 2020):

- Need to be manually filled and set up (takes time).
- Sandbag structures need to be built appropriately to function, for which training is needed.
- Leakage can be a concern, in particular if not built correctly.
- Post-flood sandbags are considered contaminated (toxic waste) and need to be disposed appropriately to not contaminate ecosystems.

AquaDam or Tiger Dam approaches (discussed in Section 6.6.2.1) present some advantages due to their longer lifespan, but they also have drawbacks (e.g., they require training and manual filling, and they can leak and be damaged[76]). Other types of barriers, such as self-closing/self-rising (passive) systems, can solve some of these issues.

Further examples of property-level flood barrier systems include[77] (Table 7-4):

[76] When these barriers are employed on an events-basis but are left in place over a season, they can potentially be damaged (as experienced with the seasonal deployment of the Tiger Dam/AquaDam at Lewis Park).

[77] Flood barrier feasibility and testing is outside the realm of Ebbwater's expertise. These solutions are provided as examples only, recognizing that many other systems also exist. Ebbwater does not take any responsibility for functioning of these systems.

- **Self-rising barrier**[78]: These permanent installations are passive systems that are activated and operate via water pressure during a flood event (Flood Control Canada, 2023); therefore, they do not require manual operation. The barrier sits in a concrete basin, and rises and lowers automatically in response to water pressure.
- **Demountable barrier**[79]: These semi-permanent stop log systems are designed to provide similar levels of protection compared to permanent installations (Flood Control Canada, 2023). The demountable barrier consists of a fully removable slot-in structure that can be quickly installed during periods of high flood hazard. The structure can be installed on concrete walls and slab foundations; anchors are installed upon pre-installation. The anchors then form the foundation for all posts and corner posts. In the event of a flood warning, the posts can be placed on anchors and fastened. The stop logs are then installed between the posts to the designed height (Flood Control Canada, 2023).
- **Passive automatic flood barriers**[80]: These barriers are self-closing as they automatically flip-up. They require limited maintenance and no human-activation in case of emergency. Approaching flood waters trigger the barrier to raise.
- **Floodstop Barrier Boxes**[81]: This system consists of pods, which are weighted with universal keys, that fill during rising flood waters. Sections can be connected and the system can be deployed rapidly.

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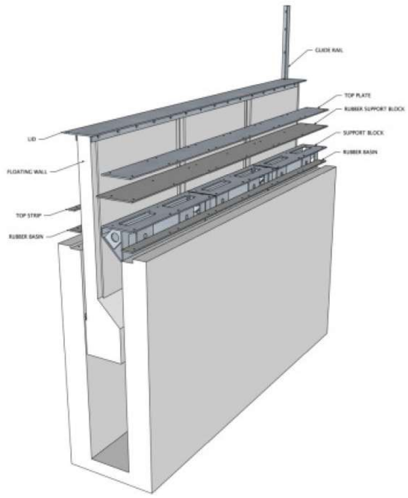
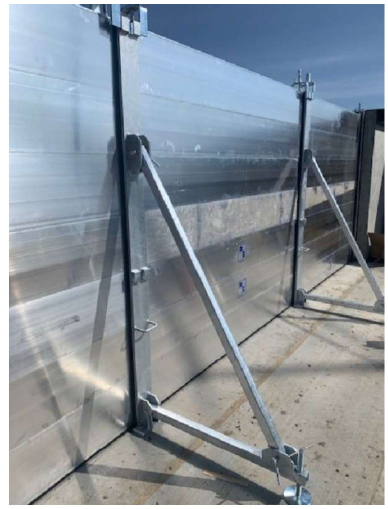
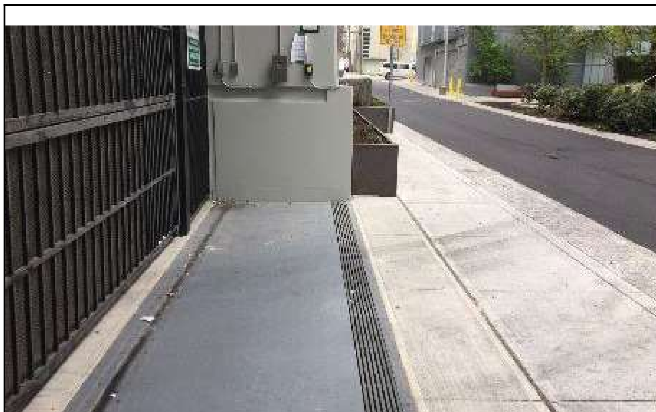
78 https://www.floodcontrolcanada.com/
79 https://www.floodcontrolcanada.com/
80 https://floodbreak.com/
81 https://floodbarrierscanada.ca/

Table 7-4: Examples of property-level flood barriers systems.

 Concrete Basin of Self-Rising Barrier (Credit: Flood Control Canada)	 Demountable Flood Barrier (Credit: Flood Control Canada)
 FloodBreak barrier, not activated. (Credit: FloodBreak)	 FloodBreak barrier, activated. (Credit: FloodBreak)

 FloodBreak barrier (not activated) at Mountain Equipment Company, Vancouver. (Credit: FloodBreak).	 FloodBreak barrier (not activated) at Block 100, Vancouver. (Credit: FloodBreak).
 Floodstop Barrier Box (Credit: Floodstop Barrier)	

Passive barrier systems are commonly used elsewhere in the world, and are becoming more common in Canada; they were extensively used in 2019 in Quebec and Ontario to respond to flooding from the Ottawa River. However, these measures are currently financed by property owners, lack standards, and are only effective for a limited height.

The City could consider information campaigns to encourage property owners or tenants to invest in these types of solutions. This could include collaboration with insurance providers, other local governments, and senior governments.

#	Project Name and Description	Timeline	Approx. Budget (Class D Estimate)
AC-23	**Encourage use of property-level flood barriers:** City to communicate property-level flood barriers for floodplain. Could consider implementing a property-level flood barrier program. Collaborate with insurers and other governments to develop an approach.	Immediate	As part of communications campaign (RB-2).
AC-24	**Incorporate property-level flood barriers into City's emergency response:** Consider the inclusion of flood barriers to replace sandbags for the City's emergency response to protect City buildings and critical infrastructure. This could include repurposing of the Tiger Dam, as well as acquiring new flood barriers as needed.	Short-term	~$1,000/m[82]

7.3.4 Minimize Contamination Sources

While flooding is a natural process and is a necessary part of ecosystem function, floodwaters are often heavily contaminated. This can lead to substantial risks for both ecosystems and human health. For instance, a study found major contamination of pesticides, fecal bacteria, nutrients, metals, and drugs in fish habitat in the Sumas Prairie impacted by the November 2021 atmospheric river floods (Ross *et al.*, 2021). Recommendations to minimize contamination include floodproofing/restriction of septic systems, minimizing potential industrial/commercial contamination sources, and minimizing agricultural contamination sources.

7.3.4.1 Floodproof/Restrict Septic Systems

There is a high risk of flood water contamination should septic systems become flooded. While it is best to avoid locating septic systems in the floodplain, there are also actions that can be taken to minimize potential impacts, through preparation, during an emergency event, and after the event. Some relevant resources include the Canadian Centre for Disease Control and Prevention: Septic and Onsite Wastewater Systems[83].

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[82] Based on approximate costs for Flood Control Canada, demountable flood barrier, not including installation costs. Actual costs would vary per type and length needed.

[83] Canadian Centre for Disease Control and Prevention. Septic and Onsite Wastewater Systems. https://www.cdc.gov/disasters/foodwater/septic.html?CDC_AA_refVal=https%3A%2F%2Fwww.cdc.gov%2Fhealthywater%2Femergency%2Fsanitation-wastewater%2Fseptic.html. Accessed 29 September 2023.

Risk mitigation measures include preparation actions such as keeping the septic system in a good working order (a well-maintained and well-constructed system will be able to better withstand flooding) and ensuring regular inspections[83.] And, if there is a flood warning, sealing the manhole and/or inspection ports to keep excess water out of tank. As floodwater contamination due to septic systems is a concern throughout the region, collaboration with First Nation, local, and regional governments to develop education materials and guidance is recommended.

While there are some ways to reduce failure of septic systems during floods, they are not guaranteed, especially for more extreme floods. Therefore, avoidance of the siting of septic systems near waterbodies should be the first course of action.

The City should include information on the floodproofing of septic systems in their communications campaign. Further, the City should invest in extending the existing sanitary system to areas not connected, where currently septic systems prevail. As part of this, the City should build support with homeowners to be connected.

Further, it is recommended that the City coordinate regionally with the CVRD on this to ensure regulations are consistent across the region.

#	Project Name and Description	Timeline	Approx. Budget (Class D Estimate)
AC-25	**Encourage septic systems floodproofing:** This should be included in the communications campaign.	Short-term	As part of communications campaign (RB-2).
AC-26	**Coordinate septic systems floodproofing regionally:** An approach should be developed with the CVRD for septic systems in floodplain.	Short-term	In-house (budget covered by staff salaries)
AC-27	**Expand Sanitary Sewer Service** to properties within the City that are currently on septic systems.	Medium-term	TBD

7.3.4.2 Minimize Potential Industrial/Commercial (and Residential) Contamination Sources

Another major potential contamination source in the floodplain, in particular within the Puntledge Road Commercial Area, are auto dealers, repair shops, body shops, former and present gasoline/diesel bulk plants and outlets. These businesses may have storage of fuel, paints, and other contaminants, that could leak into floodwaters, if not appropriately contained. Similarly, some residential homes may also have potential contamination sources (such as propane and fuel tanks) stored.

Figure 7-8: Chemical containment barrier (Credit: Flood Control Canada).

Locating such materials above the FCL and appropriately anchoring storage containers can reduce the risk of leakage into floodwaters. Alternately products such as chemical containment barriers can be purchased and used (Figure 7-8).

Again, the City can play an important role in communicating the risk of not securing contaminants and the benefits and methods to do so. Further, as discussed in the Planning Tools (Section 7.3.1.3), the City should explore mechanisms to regulate hazardous material storage in the floodplain.

Fuel storage at the Airpark also poses a contamination risk. The City currently works with the Airpark Association regarding an environmental assessment of fuel storage tanks. New tanks had been installed in 2005, and the lease holder (the Airpark Association) was required to do a baseline investigation at the most recent lease renewal. The lease requires a re-test every 4 years in advance of lease renewal (or if required through reasonable evidence that there might be a leak). It is recommended that the City continue to work with the airpark on appropriate fuel storage.

Lastly, the City should evaluate its own storage of chemicals at their facilities. One of these concerns is chemical (e.g., chlorine) storage at the Memorial Outdoor Pool at the Lewis Centre, which is located in the floodplain (see Section 7.4.2 on Memorial Pool recommendations).

#	Project Name and Description	Timeline	Approx. Budget (Class D Estimate)
AC-28	**Encourage floodproofing of hazardous materials for businesses (and residents):** Communicate risk and measures to reduce risk.	Immediate	As part of communications campaign (RB-2).

#	Project Name and Description	Timeline	Approx. Budget (Class D Estimate)
AC-29	**Continue working with the Airpark** to ensure fuel storage tanks do not become a source of contamination during flood events.	Immediate	In-house (budget covered by staff salaries)
AC-30	**Evaluate City's storage of hazardous materials at civic facilities in floodplain.**	Short-term	$10,000

7.3.4.3 Minimize Agricultural Contamination Sources

Agriculture is a source of multiple pollutants (nitrogen, phosphorus, and pathogens) and can also contribute to shoreline erosion (e.g., if livestock are given access to the riparian area). This is a particular concern if agricultural lands are flooded, and floodwaters become contaminated (e.g., from manure/compost piles, fuel storage, etc.).

The intent of these actions are to reduce contamination during floods, but there are often co-benefits associated with these actions that can be used to leverage the return on investment for these actions. A few measures include[84]:

- Improve drainage systems to divert floodwaters from manure and compost piles or placing these in areas with a higher elevation/further away from waterbodies.
- Site fuel, fertilizer and pesticide, and other potential contaminants at a higher elevation in floodproofed storage tanks.
- Implement buffer strips along riparian areas to manage nutrients, pathogens, and erosion during floods. Co-benefits include improved aquatic and terrestrial ecosystem habitat.

The City should communicate the potential risks of action/inaction, as well as these measures and available resources to the agricultural producers in the floodplain as part of the communications campaign. Further, they should explore regulatory tools for the safe storage of hazardous materials (see Section 7.3.1.3). As discussed in more detail in the next section (7.3.5,), related engagement as part of the Comox Valley Agricultural Plan should be leveraged for this work.

#	Project Name and Description	Timeline	Approx. Budget (Class D Estimate)
AC-31	**Encourage floodproofing of hazardous material storage for agricultural operators via communications campaign.**	Immediate	As part of communications campaign (RB-2).

[84] Measures are taken from the Climate Change Adaptation Program: Farm Flood Readiness Toolkit. https://www.bcclimatechangeadaptation.ca/library/farm-flood-readiness-toolkit/. Accessed 6 October 2023.

7.3.5 Encourage Ongoing Adaptation on Agricultural Lands

A substantial amount of agricultural land is located within the floodplain. Adaptation measures specific to agricultural producers can reduce on-farm flood damages.

Most of the agricultural lands within the City are located on the Agricultural Land Reserve (ALR) and are regulated by the Provincial Agricultural Land Commission (ALC). Therefore, the City has limited authority to encourage adaptation on these lands. However, the City should educate the farmers about the flood risk in this area as part of their communication campaigns, and share relevant resources for farmers (such as the Farm Flood Readiness Toolkit[85]). Farmers on the Courtenay Flats are used to occasional flooding and may already have implemented some adaptation measures.

The CVRD is currently updating the Comox Valley Agricultural Plan. The Background Report for the CVRD Agricultural Plan Update, from 2022[86], includes a section on coastal and riverine flooding and agriculture. The website includes a presentation on Emergency Planning and Agriculture. It is recommended that communications from the City are aligned with this ongoing work.

#	Project Name and Description	Timeline	Approx. Budget (Class D Estimate)
AC-32	**Encourage agriculture sector adaptation:** Communicate flood risk and resources to local agricultural producers as part of the communications campaign. Align this initiative with the CVRD Comox Valley Agricultural Plan update.	Immediate	As part of communications campaign (RB-2).

7.3.6 Develop Resiliency for Parks and Trails

Many parks in the City are located within the floodplain. These include Bear James Park, Puntledge Park, McPhee Meadows Park, Condensory Park, Riverside Park, First Street Park, Lewis Park, Simms Millenium Park, Airpark/Rotary Skypark, Courtenay Riverway, and Courtenay Marina Park. While parks offer a good use of floodplain and are generally less vulnerable to flooding, the City should assess the infrastructure in Parks, including trails, for their resiliency to flooding.

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[86] CVRD Comox Valley Agricultural Plan update process. https://www.comoxvalleyrd.ca/projects-initiatives/strategies/comox-valley-agricultural-plan. Accessed 8 May 2024.

The following specific measures can be considered for park infrastructure and areas:

- Floodproof washroom buildings.
- Anchor benches and picnic tables.
- Establish flood-resilient ecosystems.

For areas such as Lewis Park, where occasional flooding is anticipated, extra steps may be taken to ensure infrastructure and ecosystems can accommodate flooding. For example, electrical lighting in the park has been impacted before by floods (according to City staff) and should be upgraded to ensure it is not damaged by floodwaters in future. The Lewis Park Master Plan will be renewed soon by the City, which presents an opportunity to integrate flood management measures. In general, all Park Master Plans should be informed by flood risk information to increase resiliency.

#	Project Name and Description	Timeline	Approx. Budget (Class D Estimate)
AC-33	**Assess park resiliency:** For parks in general, assess resiliency, floodproof amenities and establish flood-resilient ecosystems.	Short-term	Initial Planning Project: ~$20,000[87]
AC-34	**Integrate park resiliency into Park Master Plans** (for parks in floodplain): Develop a plan to ensure park amenities located within the floodplain are designed to be resilient to damages from floodwater. The current Lewis Park Master Plan is an example for where this should be implemented.	Immediate	As part of Park Master Plan Updates
AC-35	**Resilient park infrastructure:** Complete capital projects to ensure City park infrastructure located in the floodplain is resilient to damages from floodwater. An example is to upgrade lighting in Lewis Park to ensure it is not damaged by floods.	Immediate	TBD following detailed analysis

7.3.7 Redesign of Major Transportation Routes

Major transportation and evacuation routes are located within the floodplain, in particular the Island Highway (Highway 19A) from 17th Street Bridge to Ryan Road. The highway serves as a vital connection for local and regional transportation, and also connects the downtown core to the hospital and fire station. It is used as an evacuation route for all hazards and emergencies, in the absence of an

[87] Work to complete upgrades would be part of a future capital project.

alternate route designed specifically to operate under flood hazard conditions (see also Section 7.6.3 on the Emergency Response Plan for further discussion and recommendations regarding evacuation routes).

Highway 19A is operated by MoTI. There have been multiple preliminary assessments evaluating the raising of the highway to avoid flood impacts. The effects of the raised road are similar to a dike structure, which can transfer risk. If culverts are added to the design to mitigate these issues, the required culvert sizes are so large as to essentially turn the raised road into a series of bridges. The raised road would also affect access to the road for adjacent properties and businesses. The discussion of these issues is ongoing, and it is recommended that the City work with MoTI and regional partners to determine a suitable height for the road.

In combination with this issue, the City should work regionally to establish evacuation routes from the floodplain area (see Section 7.6.3 for evacuation routes recommendations).

There is an ongoing decision process led by the CVRD to address the flood risk associated with the stretch of Comox Road south of 17th Bridge. The project has the goal to bring the City of Courtenay, the CVRD, K'ómoks First Nation, and the City of Comox together to develop a shared strategy. It is recommended that the City engage in that process to consider multi-jurisdictional trade-offs for road upgrades.

#	Project Name and Description	Timeline	Approx. Budget (Class D Estimate)
AC-36	**Work with MoTi and regional partners to determine a suitable height of Highway 19A,** from the 17th Street bridge to Ryan Road.	Immediate	TBD
AC-37	**Engage in Regional Collaborative Initiative related to Comox Road:** Engage in Comox Road project to ensure a shared multi-jurisdictional strategy and consider trade-offs.	Immediate	Within existing budgets

7.3.8 Work with K'ómoks First Nation to Minimize Impacts to Indigenous Sites

Throughout the City, there are many Indigenous archaeological sites within the floodplain. Many of these are in the subsurface and may not be directly impacted by flooding. But associated erosion and other processes such as climate change and sea level rise may cause impacts. The potential loss of archaeological sites due to sea level rise is a concern for many coastal cultural sites around the world (Anderson et al., 2017). UNESCO has also recognized the potential threat of climate change on world heritage properties (UNESCO, 2008; Anderson *et al.*, 2017). Preservation of archaeological sites in the face of sea level rise may require prioritization of sites (Fatorić and Seekamp, 2019). Each Nation has the right to determine whether and how to protect sites within their Territory.

The K'ómoks First Nation Cultural Heritage Policy[88] provides an overview of locations of archaeological potential and locations with a previously recorded archaeological site. The shoreline and floodplain areas have archaeological potential. This policy outlines the requirements for a Cultural Heritage Investigation Permit (CHIP), which is required for all developments within an area determined to have high archaeological potential. The City will work to ensure the CHIP permit process is followed within municipal boundaries, and impacts to archaeological sites are managed with the support of the K'ómoks First Nation.

#	Project Name and Description	Timeline	Approx. Budget (Class D Estimate)
AC-38	**Work with the K'ómoks First Nation.** Ensure the Cultural Heritage Investigation Permit (CHIP) permit process is followed within municipal boundaries, and impacts to archaeological sites are managed with the support of the K'ómoks First Nation.	Immediate	Ongoing

7.3.9 Hydraulic Modelling

The City should update existing hydraulic modelling over the medium-term. Current flood mapping relies on an older riverine model and flow data, and coastal flood modelling was conducted at a regional level. Both these issues have introduced uncertainties into the understanding of flood conditions in the City (see Section 4.3.1 and Appendix B for details). Further, as flow records become longer, and new climate change projections are emerging, regular updating of flood mapping is recommended. Hydraulic modelling could support the development of planning and design of naturalized shorelines, as well as updated Coastal Flood Modelling (see Section 7.3.1.1).

#	Project Name and Description	Timeline	Approx. Budget (Class D Estimate)
AC-39	**Update existing hydraulic modelling** to account for changing conditions and improved data. Could be combined with modelling associated with Anderton Dike Remediation and coastal modelling for FCLs.	Medium-term	$250,000

[88] K'ómoks First Nation Cultural Heritage Policy: https://www.comoxvalleyrd.ca/sites/default/files/2023-10/KFN%20Cultural%20Heritage%20Policy%2020201002.pdf

7.4 Retreat

The City's OCP indicates support for a long-term strategy for managed retreat from hazardous areas. This FMP and associated deliverables can be used to support the development of a list of priority parcels that are identified as the most vulnerable to flood and erosion hazard (within the floodway and coastal erosion setbacks). With this information, the City can pursue opportunistic buy-outs and/or develop approaches that rely on land swaps or density bonuses for development in less hazardous locations.

Managed retreat is a complicated issue that many local authorities in BC are challenged to address in part because more guidance and tools are required. It is recommended that the City collaborate with other jurisdictions and First Nations to share lessons learned and ways to address this in the future.

The retreat approach can be accomplished through several potential pathways. The following are context-specific examples:

- **Pre-Disaster, Long-term**: Also practiced in the USA is the application of rolling easements. Over time, site level protected measures would be regulated and removed allowing the water to move in. Structures could be removed at the owner or government expense with potential for compensation.
- **Post-Disaster:** Following the 2018 floods in Grand Forks, BC, funding from Public Safety Canada (PSC) (through the Federal Disaster Mitigation and Adaptation Fund) was used to relocate properties from the flood hazard area to upland areas. Relocation can include physical relocation or some transfer of property rights. Since this event, PSC also established a 'Task Force on Flood Insurance and Relocation[89] whose recent report on 'Buying out the floodplain – Recommendations for strategic relocation programs in Canada' (Thistlethwaite *et al.*, 2023)[90] provides further resources.

The recommendations for the City addressed under this strategy are the retreat of residential buildings in the floodway over the long-term and relocation or redesign of Memorial Outdoor Pool. These are discussed in the following sections.

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[89] Public Safety Canada (2024). Task Force on Flood Insurance and Relocation. https://www.publicsafety.gc.ca/cnt/mrgnc-mngmnt/dsstr-prvntn-mtgtn/tsk-frc-fld-en.aspx. Accessed 16 August 2024.

[90] Thistlethwaite et al. (2023): 'Buying out the floodplain – Recommendations for strategic relocation programs in Canada. https://uwaterloo.ca/partners-for-action/sites/default/files/uploads/documents/buyingouttheflodplainreport_en_1.pdf. Accessed 25 November 2023.

7.4.1 Retreat Residential Buildings in Floodway

One of the priorities for flood risk management is public safety. Residential buildings present a significant flood risk, because people spent the majority of time in their homes (i.e., they sleep at home as well as spend waking hours there) and residents may need to be evacuated in the event of a flood. Evacuation is likely to cause safety risks for first responders, and be highly disruptive to residents, and the community. Commercial buildings would also need to be evacuated, but people could seek temporary shelter in their residence, outside the flood hazard area.

Some of this risk can be managed by avoiding building new residential buildings in the floodplain via zoning (see Section 7.5.1). However, this can only address new developments, and the risk remains for already existing residential buildings. While other strategies play an important role to reduce risk for residential buildings, managed *Retreat* is an excellent long-term strategy for high risk where these other strategies (e.g. *Accommodate* and *Protect*) may not be enough. This is especially relevant for residential properties in the floodway, where most frequent flooding and deepest floodwaters can be expected, and damages will add up cumulatively over time. It is recommended that the City (or other governments/agencies) purchase high-risk residential buildings opportunistically over the long-term as they become available. Buy-outs can also occur after a disaster. However, this requires preparation ahead of a flood and consideration of potential strategies for buy-outs in a post-disaster plan (see Section 7.6.4).

In particular when the City is working with residents facing intersectional disadvantages (social vulnerability, see Section 2.1.2.3), any solutions that consider retreat or relocation must be viewed through an equity lens to ensure that residents have access to alternative adequate and affordable housing that is safe from flood hazards.

The City should collaborate with current residents in the floodway to ensure they are prepared for the next flood event, and ask for their input on the development of a long-term retreat strategy of residential dwellings in the floodway, including RV parks and mobile homes. The plan should include an approach to relocate vulnerable residents in an equitable way, and contemplate future land uses of the floodway,

Overall, it is important to plan how to use the land once it is 'retreated'. This can be through normal or special planning processes to provide compelling visions for its use. For instance, many locations offer opportunity for conversion to public recreational use like a park. As an interim measure, if only some parcels are owned by the City, it may be possible to activate these smaller public spaces like small markets and food truck areas. Some areas might also offer opportunity to be turned into agricultural land for sustainable food production, or be converted to natural habitat to increase biodiversity and potentially even to increase flood resilience. An example for the latter is the Kus-kus-sum project, where an old sawmill is being replaced with important habitat along the shore, which also supports flood resilience.

There are a total of 25 residential buildings and an RV park in the City located within the present-day - likely flood scenario (floodway), which could be considered over the long-term for retreat.

#	Project Name and Description	Timeline	Approx. Budget (Class D Estimate)
RE-1	**Develop a Managed Retreat/Relocation Strategy:** Develop a long-term strategy for retreat of residential dwellings in the floodway, including RV parks and mobile homes. The plan should contemplate future land uses of the floodway, and an approach to relocate vulnerable residents in an equitable way.	Short-term	$50,000
RE-2	**Buy-out properties:** Opportunistically buy out residential housing properties that are located in the floodway, as they become available, and convert to other land uses.	Long-term/ very long-term	TBD (high property costs)

7.4.2 Relocate or Redesign Memorial Outdoor Pool

The Memorial Outdoor Pool at the Lewis Park Centre is located within the floodway and is at risk of being damaged by flooding. The pool is also approaching the end of its lifespan. The City has passed a recent Council resolution to complete an options analysis to determine the future of the pool. The City should ensure that future plans for the pool are informed by the existing flood risk and its implications. Factors to consider include:

- The height of the FCL in this location is prohibitively high, meaning that building up to FCL is not likely feasible or recommended.
- If the pool stays in its current location, it would require major floodproofing to limit damages to pool infrastructure. Chemical storage would be key to reduce the risk of contaminated floodwaters. To reduce chemicals stored on site, more natural pool systems could be considered, which require less chlorine use.
- The outdoor pool is used in the summer, while most floods occur from fall to spring. But floodwaters could still lead to repeated damages, and flood damage to pool infrastructure can be costly (pers. comm with City of Vancouver staff regarding Kitsilano Pool which has been flood damaged).

#	Project Name and Description	Timeline	Approx. Budget
RE-3	**Complete options analysis for Memorial Pool, and ensure the flood risk is managed in the future plans.**	Immediate	TBD as part of options analysis.

7.5 Avoid

The City's OCP is clear that the community's intention is to locate growth away from the floodplain and allow only low risk uses within the floodplain. The OCP describes low risk uses as agriculture and parks and recreation.

Limiting density and higher risk uses on the floodplain could take a regulation-based approach by removing higher risk uses via zoning (development of a Shoreline zone as stipulated in the OCP or other zoning bylaw changes), and acquiring undeveloped land. These are described in the following sections.

7.5.1 Develop Flood Risk-based Zoning Bylaw

A revision to the zoning bylaw (Zoning Bylaw No. 2500) to reduce high risk land use (i.e., in particular residential use) from the floodplain is recommended. Recent changes from the Province (new Provincial Bill 44 *Housing Statutes (Residential Development) Amendment Act*, 2023) require higher density residential zoning. However, there is also an option to exclude hazardous areas from higher density residential zoning. It is recommended to exclude parcels in the floodplain, and in particular within the floodway, from any increases in residential density.

The overall recommendation is to locate any future residential and commercial development away from the regulatory floodplain. Acceptable uses, within the current OCP, of the regulatory floodplain are agricultural and recreational use.

Higher and lower flood hazard areas within the regulated floodplain should also inform zoning, with more restrictive zoning applied to the areas with highest flood hazards. The present-day floodway comprises this higher hazard zone, as it refers to the river channel and shoreline and adjacent areas where water depths, velocities and wave action are greatest and most dangerous. The flood fringe is the remaining area of the regulatory floodplain that is outside the floodway. This area may also flood, but likely less often and with less depth, velocity and wave action than within the floodway. See Figure 7-3 in Section 7.1.1 for a floodway/flood fringe map for the City.

Zoning recommendations based on locations in the floodway and flood fringe are presented in Table 7-5; for coastal areas the erosion and setback areas can be used in a similar manner. In general, more restricted zoning is recommended for the floodway, where no future residential and commercial/industrial zoning is recommended. For the Puntledge Road Commercial Area, commercial development, that is developed at FCL or otherwise floodproofed, may be considered appropriate if it is within the current commercial zoning.

Table 7-5: Zoning recommendations based on floodway/flood fringe location.

Floodplain Component	Recommendations
Floodway	• Recommended floodway land uses: Agricultural, recreation, parks. • No future residential, commercial/industrial development in the floodway. • Floodway land uses to be considered for specific locations (e.g., Puntledge Road Commercial area): Commercial, industrial (but in existing zoning locations only). • Any new development must be built to sufficient FCL and be designed to accommodate floodwaters. FCL and setbacks must be followed for all permitted developments.
Flood Fringe	• Recommended flood fringe land uses: Agricultural, recreation, parks, commercial, industrial. • Preferably: Exclude any high economic value commercial/industrial development, and development with high risk for contamination of flood waters. Apply risk lens to development proposals. • Preferably: No residential development in flood fringe. If residential development is permitted in flood fringe for specific areas, it should include a special DPA and covenant. • Any new development must be built to sufficient FCL and be designed to accommodate floodwaters. FCL and setbacks must be followed for all permitted developments.

An interim policy that applies to a range of applications from building permit to subdivision and rezoning could also be implemented. This could begin the process of limiting densification in flood prone areas in advance of developing further implementation mechanisms.

#	Project Name and Description	Timeline	Approx. Budget (Class D Estimate)
AV-1	**Zoning: Densification related to Bill 44:** Limit residential densification within the floodplain, and in particular, avoid it within the floodway.	Immediate	In-house (budget covered by staff salaries)
AV-2	**Revise Zoning Bylaw:** revise zoning bylaw to align with recommendations for floodplain land use.	Short-term	In-house (budget covered by staff salaries)

7.5.2 Acquire Undeveloped Land

Where possible, it is recommended that the City acquire any undeveloped land in the floodway to sterilize the area, thereby reducing future assets at risk. Some of these lands could be acquired in cooperation with other potential land and park owners (e.g., Ducks Unlimited, land trusts, etc.) for agricultural or ecological use and benefit. Land can be used for the public good, such as in the form of parks and recreational areas.

#	Project Name and Description	Timeline	Approx. Budget (Class D Estimate)
AV-3	**Acquire undeveloped land in floodplain.**	Opportunistic	TBD

7.6 Resilience-Building

The recommendation topics discussed below related to the *Resilience-building* strategy are to build flood awareness and education in the community, update monitoring and warning procedures, update the emergency response plan, develop flood recovery and post-disaster plans, build resilience at the neighbourhood level, work with insurance companies to address residual risk, and collaborate regionally on emergency planning and preparedness.

7.6.1 Build Flood Awareness and Education in the Community

It is recommended that the City develop a Flood Risk and Resilience Communications Plan. This should be targeted at residents and property owners, commercial business owners and operators, as well as agricultural producers in the floodplain, and include both an initial communications campaign, as well as annual flood risk communications.

Initial Communications Campaign: In the initial communications campaign, the City should communicate the results of the Flood Management Plan, along with general awareness raising on flood risk in the communities and actions that can be taken to reduce risk. The initial communications should highlight City-led actions as well as individual actions. This can be achieved via social media campaigns, printed material, public sessions, and webinars.

Targeted campaigns should include:

1. Residents in the floodplain should be informed of their risk and provided with actions they can take to increase their personal resilience (e.g., flood proofing, insurance). Information to residents should be presented in a way that is accessible and easy to understand.
2. Campaigns should be developed for specific high-risk areas in the City, that are facing unique challenges, and campaigns should consider diverse communities, with a range of socio-economic and intersectional backgrounds.
3. Commercial business owners should be provided with information on floodproofing and reducing contaminant sources.
4. Agricultural operators should be provided with information on specific actions to reduce contamination and to adjust operations to increase flood resilience.

In addition to the targeted communications, generally applicable information should be shared with the public. This would include increasing knowledge about:

1. Flood risks. Engage the general public and inform on potential indirect consequences of flooding (closure of transportation routes, service interruptions, etc.).
2. Personal flood preparedness actions. Share educational material on the role of all residents (i.e. all of society) in preparing for a flood, and on how individual actions (e.g., flood proofing or temporary property-level barriers) and reduce flood risks.
3. Personal flood emergency actions. Share educational material to support people/businesses to build their own emergency response plans. This action is closely related to the updating of the Emergency Response Plan (see Section 7.6.3). This should include reminders for the public to sign up to the local emergency notification system (through Connect Rocket[91]), implemented by the CVRD, Courtenay, Cumberland, Comox, and the K'ómoks First Nation.
4. Flood Insurance. Despite government and personal actions to reduce flood risk there will always be some residual risk. The financial residual risks can be managed through public and private insurance, where public insurance such as the Disaster Financial Assistance[92] Program provides emergency funds in the case no private insurance is available. The purchase of private insurance requires that people are aware of the need for flood insurance, and opt-in to the coverage. Thus, as part of the Flood Risk and Resilience Communications campaign, it is recommended to encourage people to consider flood insurance.

Note that in the Implementation Plan (Section 8.1.2), all recommendations discussed throughout this Chapter 7 are compiled to provide an overview of aspects that should be considered in the targeted and general public communications.

Annual Flood Risk Communications: The City should also conduct annual flood risk communication campaigns before flood season, to keep the topic in the mind of people. Some of the recommended changes may take some years to implement.

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91 https://www.comoxvalleyrd.ca/connect/hot-topics/get-notified-0

92 The Federal and Provincial Disaster Financial Assistance Arrangements are slated to be changed in April 2024, and no information on the changes is currently public. Given that this program as well as the balance between private and public insurers is in flux only general recommendations are provided in this report.

#	Project Name and Description	Timeline	Approx. Budget (Class D Estimate)
RB-1	**Develop Flood Risk and Resilience Communications Plan.**	Immediate	$30,000
RB-2	**Conduct targeted and general public Communications:** Build flood risk awareness & reach out to floodplain residents, commercial business owners, and agricultural operators. Build flood risk awareness for general public.	Immediate	To be determined as part of plan (RB-1)
RB-3	**Annual flood risk communications campaign.**	Annual	$20,000

7.6.2 Update Monitoring and Warning Procedures

A warning system is a program or automated system that provides a warning of impending flooding (hours to days prior to onset). A warning system on its own does not reduce risk to all elements in the floodplain, but when paired with flood response plans and temporary flood protection (such as building-level flood barriers, or the Tiger Dam), it can be very effective at mitigating risks (Ebbwater Consulting Inc., 2021).

The recent Flood Operations Manual (McElhanney, 2022) provides detailed information on monitoring water levels, action steps, and when a flood warning is needed. This should be reviewed for consistency with the updated information from the Flood Management Plan, and should be updated for the most recent flood hazard information from Kerr Wood Leidal Associates Ltd. (2021). Note that the updating the Flood Operations Manual is included in the following Section 7.6.3 as a recommendation.

For a city-wide warning system, the 'Connect Rocket' emergency notifications by text message and voice calls can be used to alert the public. This can also be used for emergency response messaging to property owners and residents to avoid delays in evacuations.

The City should explore the option to add sirens in areas of a high flood risk (such as the Puntledge Road Commercial Area) to support road closures and evacuations. These could be tested at regular intervals, which would have the benefit of raising more awareness about flood risk. These could be accompanied by the use of flood zone warning signs, similar to the tsunami zone warning signs used on the west coast of Vancouver Island).

#	Project Name and Description	Timeline	Approx. Budget (Class D Estimate)
RB-4	**Review current monitoring and warning systems and update.**	Short-term	In-house (budget covered by staff salaries)
RB-5	**Add warning signs:** These can be added in high flood risk areas to raise awareness about flooding.	Short-term	$15,000
RB-6	**Add sirens:** These can be considered for high flood risk areas, along with conducting regular testing to raise awareness about flooding.	Short-term	TBD

7.6.3 Update Flood Operations Manual (Emergency Response Plan)

A flood emergency response plan enables a community to efficiently respond during a flood emergency and limit loss and damages. A plan should include consideration of aims and objectives, triggers and activation, known hazards and risks, etc. Flood response plans must be updated frequently to incorporate new information and to familiarize responders with materials. Trained and up-to-date personnel are necessary for successful flood response. An updated emergency response plan should also consider the modernization of *EDMA*.

The Flood Operations Manual (McElhanney, 2022) provides information on monitoring water levels, action steps, and when a flood warning is needed. This emergency response plan should be updated to include more information as developed in this FMP, and as well as refer to the most recent flood hazard data from Kerr Wood Leidal Associates Ltd. (2021). Specifically, the update should address who/what is at risk in each area, and who would need special attention in case of an emergency. Results from the risk assessment (see Chapter 5) can support this process.

Examples include consideration to manage the following issues:

- Evacuation at the RV Park (for which specific strategies already exist in the Flood Operations Manual), as well as for other floodplain residents.
- Operation of critical infrastructure such as lift stations.
- Management or closure of relevant commercial areas for business to limit the amount of people who may be stranded due to flooding of major transportation routes (e.g., Highway 19A). An example is the closing of daycares (e.g., at Lewis Centre) to avoid stranding children in those facilities, and the need for family members to pick-up / drop-off.
- Change in deployment of Tiger Dam for emergency purposes.

Currently, there are no designated evacuation routes for flooding. The City should evaluate routes, in particular to provide access/egress from the Puntledge Road Commercial Area. This discussion should happen in collaboration with MoTI. The stretch of road currently serves as an evacuation route for other hazards, but in its current design, it would be flooded.

Some City recreation facilities are near, or are within, the floodplain (e.g., exhibition grounds, Lewis Park Centre). Therefore, they are unsuitable as evacuation centres during floods. Alternate facilities could potentially be made available through mutual aid agreements. Such facilities include those from School District - 71 facilities, CVRD, the Town of Comox and the Village of Cumberland.

Overall, coordination with the Comox Valley Emergency Program and Regional Emergency Operations Centre is recommended.

#	Project Name and Description	Timeline	Approx. Budget (Class D Estimate)
RB-7	**Review and update the Flood Operations Manual (Emergency Response Plan):** This should include newest hazard information, information on risk and resilience from this FMP, and coordination with the Comox Valley Emergency Program.	Short-term	$25,000
RB-8	**Explore and designate flood evacuation routes**.	Immediate	$25,000
RB-9	**Evaluate locations of flood evacuation centres:** Potentially set up new aid agreements for facilities outside the floodplain.	Short-term	In-house (budget covered by staff salaries)

7.6.4 Develop Flood Recovery and Post-Disaster Plans

The development of flood recovery and post-disaster plans can guide the City in bouncing back from a flood event and minimize disruptions. The recovery plan should outline the steps that would follow the initial emergency response, while the post-disaster plan should lay out the 'big changes' that could and should happen and may be more possible post-disaster. The plans are interconnected, and each is discussed more below.

Flood Recovery Plan: After the initial emergency response during a flood event has subsided, the recovery activities begin. While this process can take months to years, a flood recovery plan can increase effectiveness by prioritizing actions such as restoring critical infrastructure and roads, dealing with damages to buildings and infrastructure, and supporting people returning to their homes. While the details of flood recovery will be based on actual damages incurred, there are many general recovery actions that can be developed ahead of time, using the information provided in the risk assessment. For the development of the flood recovery plan, collaboration with the Comox Valley Emergency Management team is recommended, as many impacts may occur regionally.

Post-Disaster Plan: In contrast to the flood recovery plan, the post-disaster plan looks at longer-term actions that may be implemented opportunistically following a flood event. During this time, the public is aware of flood issues and may be more willing to support actions to reduce flood risk. The goal of a post-disaster plan is to encourage 'Build Back Better', which is the fourth priority of the Sendai Framework for Disaster Risk Reduction. For example, the retreat from the floodway should be clearly spelled out within a post-disaster plan. This would include specifics on what properties would not be restored to a pre-disaster state, and how they would be transformed into public spaces. These types of plans provide a vision for owners of property in the floodplain to allow them to make investment decisions. They also enable the City to make substantial changes that will reduce risk and create value. These changes might otherwise be challenged in a post-event context where emotions can lead to reactive decisions and a desire to return to normal. The post-disaster plan would be led by the City, as it would likely target parcels and properties within City boundaries.

#	Project Name and Description	Timeline	Approx. Budget (Class D Estimate)
RB-10	**Collaborate with the Comox Valley Emergency Management team to develop a flood recovery plan.**	Short-term	In-house (budget covered by staff salaries)
RB-11	**Develop a Post-Disaster Plan.**	Short-term	In-house (budget covered by staff salaries)

7.6.5 Contribute to Neighbourhood Resilience-Building

During and after a disaster, communities will generally recover faster, if there are community systems in place, and people care about each other and know how to support each other (Ebbwater Consulting Inc., 2021). These neighbourhood-level resources will support not only in the recovery of disasters related to flood hazard, but also other hazards such as heat waves and earthquakes. Therefore, they can provide many co-benefits for the health and well-being of the general population.

#	Project Name and Description	Timeline	Approx. Budget (Class D Estimate)
RB-12	**Engage with the community and community organizations for Neighbourhood resilience-building/ Neighbourhood hubs.**	Short-term	As part of communications campaign (RB-2).

7.6.6 Work with Insurance Companies to Address Residual Risk

There will always be some residual risk, even if all other flood management strategies are implemented. To manage residual risk for financial losses, private insurance can be used. Insurance and re-insurance companies, with premiums paid by both the public and private sector, can cover some financial losses after a flood event. This however generally requires that potential policy holders are aware of the need for flood insurance, and then opt-in to the coverage.

On this topic the City could play two roles. First, they could include insurance information in their public education campaigns to encourage property owners in the floodplain to obtain insurance coverage. Second, the City should ensure maintaining flood insurance for City facilities in the floodplain and demonstrating efforts to reduce risk. Working with insurance companies may also facilitate the implementation of incentives for flood risk reduction measures (e.g., accommodate actions such as floodproofing). Flood insurance in Canada is a complex field and is evolving rapidly.

#	Project Name and Description	Timeline	Approx. Budget (Class D Estimate)
RB-13	**Encourage property owners in floodplain to obtain flood insurance.** This can be achieved as part of a communications campaign.	Short-term	As part of communications campaign (RB-2).
RB-14	**Maintain flood insurance for City facilities and demonstrate efforts to reduce the risk.**	Short-term	TBD

7.6.7 Collaborate Regionally on Emergency Preparedness and Response

The City of Courtenay, along with the Communities of Comox, Cumberland and the K'ómoks First Nation are located within the CVRD. A large flood event is likely to impact the entire community. Regional collaboration on resilience-building and response planning will ensure an effective emergency response. The CVRD is currently developing a Memorandum of Understanding with the CVRD, Comox, Cumberland, and the K'ómoks First Nation to define ways they will work together on regional complex water-based issues.

#	Project Name and Description	Timeline	Approx. Budget (Class D Estimate)
RB-15	**Continue to collaborate regionally on emergency preparedness and response.**	Short-term	TBD

8 Implementation Plan

The implementation plan summarizes the recommendations from Chapter 7. Immediate and short-term actions are organized within the 5-Year Capital Plan (Section 8.1), whereas medium to very long-term actions are provided in Section 8.2. The 5-Year Capital Plan is divided into operational activities (should occur annually), special projects (planning and other projects that are not reoccurring), and capital projects (projects that need to be designed and built).

Identified actions are targeted to the City, although for instance, the communications campaign should trigger further actions by landowners and others. Cooperation with regional jurisdictions are also indicated where relevant.

Further, note the following:

- Recommendations are labelled and numbered according to the five strategies (P = *Protect*, AC = *Accommodate*, RE = *Retreat*, AV = *Avoid*, and RB = *Resilience-building*).
- All cost estimates are provided at a high-level, (Class "D" Indicative Estimate) at most (where high-level engineering analysis was available). Other estimates are based on experience for similar projects, developed with input from the City.
- Approximate timelines for recommendations are provided in Table 8-1.

Table 8-1: Timeline categories.

Timeline	Years
Immediate	1-2 years
Short-term	2-5 years
Medium-term	5-10 years
Long-term	10-20 years
Very long-term	20+ years

8.1 5-Year Capital Plan

The 5-Year Capital Plan is divided into operational activities (should occur annually), special projects (planning and other projects that are not reoccurring), and capital projects (projects that need to be designed and built).

8.1.1 Operational Activities

Operational activities include actions that should occur annually.

#	Action (Operational Activities)	Timeline	Total Budget (Class D Estimate)
Protect/Accommodate **- Infrastructure Related Operational Activities**			
P-2, P-6, P-8, P-13	**Annual inspection and maintenance for Condensory, Canterbury Lane, Anderton Ave, and Lewis Park Dikes:** Monitor for erosion, stability, and other issues.	Annual	$20,000/year (all dikes)
P-15	**Tiger Dam:** Stop current deployment and switch to targeted critical infrastructure protection on an events-basis.	Annual	$20,000/year
P-22	**Lewis Park Culverts:** Continued maintenance.	Annual	$2,000/year
P-24	**TideFlex Valves:** Continue maintenance.	Annual	$1,000/year
AC-19	**Floodproof sanitary system:** Continue testing for and reducing stormwater inflows into the sewer system for the network within the floodplain.	Annual	In-house (budget covered by staff salaries)
Resilience-Building **- Annual Flood Risk Communications**			
RB-3	Annual flood risk communications campaign.	Annual	$20,000

8.1.2 Special Projects

These are planning and special projects that are not recurring.

#	Action (Special Projects)	Timeline	Total Budget (Class D Estimate)
***Protect* - Dike Vegetation Management**			
P-1, P-7, P-10	**Vegetation management for Condensory, Anderton Ave, and Lewis Park Dikes:** Clarify Provincial expectations for vegetation management on erosion protection structures. Manage vegetation according to Provincial guidance.	Immediate	$45,000
P-3	**Vegetation Management for Canterbury Lane Dike:** Manage vegetation according to Provincial guidance for erosion protection structures.	Short-term	$15,000
***Protect* - Special Projects**			
P-4	**Address Canterbury Lane Dike ownership issue:** Work with the Province and strata to resolve the ownership dispute.	Immediate	TBD
P-5	**Canterbury Lane Dike detailed structural assessment**	Short-term	$40,000
P-16	**Tall Wall:** Assess the need for a traffic barrier, and otherwise remove structure.	Immediate	TBD
P-18	**Rye Road:** Assess flow path for operability and conveyance (including assessment of current conditions of twin culverts).	Immediate	$2,000
P-19	**Rye Road:** Work with MoTI to replace twin culverts.	Short-term	TBD
P-20	**Rye Road:** Assess impacts of new BC Hydro infrastructure during a flood event.	Short-term	TBD

#	Action (Special Projects)	Timeline	Total Budget (Class D Estimate)
P-21	**Rye Road:** Work with Ducks Unlimited to assess condition of pond and ditch at end of Rye Road drainage path, and conduct open ditch cleaning and vegetation management.	Short-term	$15,000
P-23	**Lewis Park Culverts:** Explore to better understand and optimize use of culverts. For instance as part of hydraulic modelling, see AC-39	Short-term	TBD
***Accommodate* – Floodplain Bylaw Update**			
AC-1	**Update Floodplain Bylaw:** Collaborate with CVRD to align floodplain bylaws in the region. Consider distinct riverine and coastal approaches. Explore inclusion of specific exemptions, requirements and hazardous materials storage, approach for ensuring quality by qualified professionals (e.g., assurance statement), and restrictive covenants.	Immediate	$30,000
AC-2	**Conduct targeted engagement before updated bylaw adoption:** Inform impacted stakeholders (i.e., property owners) before bylaw adoption.	Immediate	$20,000
AC-3	**Targeted education and awareness campaigns after bylaw adoption:** E.g. for local realtors and industry representatives.	Immediate	$20,000
AC-4	**Update coastal mapping for FCL:** Complete detailed hydrodynamic mapping for Comox Estuary to ensure high-quality maps for coastal FCLs. This could be developed in cooperation with Town of Comox and CVRD, as well as combined with potential modelling for Anderton Ave. Updated coastal FCLs would require a bylaw amendment, should the floodplain bylaw be updated before this becomes available.	Short-term	$200,000
AC-5	**Covenant data management:** Develop tools and start tracking and managing existing covenants for parcels in the floodplain and inform property owners about covenants. Work with property owners to ensure compliance with existing covenants.	Short-term	$10,000
AC-6	**Add covenants:** Expand covenant on title for the extents of the new regulatory floodplain. Require that the location in regulated floodplain be disclosed on property title. This would apply whenever the opportunity arises.	Immediate	$2,000

#	Action (Special Projects)	Timeline	Total Budget (Class D Estimate)
***Accommodate* – Further Planning Tools**			
AC-7	**Development Permit Area for Flood and Erosion Hazard**	Short-term	$30,000
AC-8	**Explore options to regulate hazardous material storage:** Options may include developing a floodplain bylaw or DPA for flood and erosion hazard lands.	Immediate	$5,000
***Accommodate* – Floodproofing & Redesigning Planning**			
AC-10	**Explore incentives related to floodproof buildings:** Consider collaborating with insurance companies and the Provincial/Federal government, or obtain grants to provide financial incentives.	Short-term	$5,000
AC-14	**Conduct long-term facility and service planning for all civic facilities in the floodplain, as part of asset management planning.** Flood information should be explicitly considered in all relevant asset management plans.	Short-term	As part of asset management planning.
AC-17	**Support CVRD in their efforts to floodproof the regional station where relevant:** Project underway and led by CVRD, with minimal input required from the City.	Immediate	$0
AC-21	**Groundwater wells:** Reach out to registered well owners and encourage well owner to decommission or seal wells to prevent groundwater contamination. Assess if further private wells may exist within floodplain.	Immediate	$5,000
AC-26	**Coordinate septic systems floodproofing regionally:** An approach should be developed with the CVRD for septic systems in floodplain.	Short-term	In-house (budget covered by staff salaries)
AC-29	**Continue working with the Airpark** to ensure fuel storage tanks do not become a source of contamination during flood events.	Immediate	In-house (budget covered by staff salaries)
AC-30	**Evaluate City's storage of hazardous materials at civic facilities in floodplain.**	Immediate	In-house (budget covered by staff salaries)

#	Action (Special Projects)	Timeline	Total Budget (Class D Estimate)
AC-33	**Assess park resiliency:** For parks in general, assess resiliency, floodproof amenities and establish flood-resilient ecosystems.	Short-term	Initial Planning Project: ~$20,000[93]
AC-34	**Integrate park resiliency into Park Master Plans** (for parks in floodplain): Develop a plan to ensure park amenities located within the floodplain are designed to be resilient to damages from floodwater. The current Lewis Park Master Plan is an example for where this should be implemented.	Immediate	As part of Park Master Plan Updates
AC-35	**Resilient park infrastructure:** Complete capital projects to ensure City park infrastructure located in the floodplain is resilient to damages from floodwater. An example is to upgrade lighting in Lewis Park to ensure it is not damaged by floods.	Immediate	TBD following detailed analysis
AC-36	**Work with MoTi and regional partners to determine a suitable height of Highway 19A**, from the 17th Street bridge to Ryan Road.	Immediate	TBD
AC-37	**Engage in Regional Collaborative Initiative related to Comox Road:** Engage in Comox Road project to ensure a shared multi-jurisdictional strategy and consider trade-offs.	Immediate	Within existing budgets
***Accommodate* – Property-level Flood Barriers**			
AC-24	**Incorporate property-level flood barriers into City's emergency response:** Consider the inclusion of flood barriers to replace sandbags for the City's emergency response to protect City buildings and critical infrastructure. This could include repurposing of the Tiger Dam, as well as acquiring new flood barriers as needed.	Short-term	~$1,000/m[94]

[93] Work to complete upgrades would be part of a future capital project.

[94] Based on approximate costs for Flood Control Canada, demountable flood barrier, not including installation costs. Actual costs would vary per type and length needed.

#	Action (Special Projects)	Timeline	Total Budget (Class D Estimate)
Work with K'ómoks First Nation			
AC-38	**Work with the K'ómoks First Nation.** Ensure the Cultural Heritage Investigation Permit (CHIP) permit process is followed within municipal boundaries, and impacts to archaeological sites are managed with the support of the K'ómoks First Nation.	Immediate	Ongoing
***Retreat* - Special Projects**			
RE-1	**Develop a Managed Retreat/Relocation Strategy:** Develop a long-term strategy for retreat of residential dwellings in the floodway, including RV parks and mobile homes. The plan should contemplate future land uses of the floodway, and an approach to relocate vulnerable residents in an equitable way.	Short-term	$50,000
***Avoid* – Special Projects**			
AV-1	Zoning: Densification related to Bill 44: Limit residential densification within the floodplain, and in particular, avoid it within the floodway.	Immediate	In-house (budget covered by staff salaries)
AV-2	Revise Zoning Bylaw: revise zoning bylaw to align with recommendations for floodplain land use.	Short-term	In-house (budget covered by staff salaries)
***Resilience-Building* - Communications and Engagement Campaign**			
RB-1	**Develop Flood Risk and Resilience Communications Plan.**	Immediate	$30,000
RB-2	**Conduct targeted and general public Communications:** Build flood risk awareness & reach out to floodplain residents, commercial business owners, and agricultural operators. Build flood risk awareness for general public. Specific components for consideration within plan and communications roll out are noted below. Action numbers have been italicized to note that they are intended to be part of the communications plan.	Immediate	To be determined as part of RB-1.

#	Action (Special Projects)	Timeline	Total Budget (Class D Estimate)
P-17	**Communicate change in use of Tiger Dam/Tall Wall** and what is done instead.	Immediate	Part of RB-2
AC-9	**Develop guidance and communication around building floodproofing and encourage floodproofing of buildings in floodplain:** Collaborate with other local/regional government (and the Provincial government) to develop guidance and communications material.	Immediate	Part of RB-2
AC-22	**Groundwater wells:** Communicate need for sealing of wells to well owners via the communications campaign.	Immediate	Part of RB-2
AC-23	**Encourage use of property-level flood barriers:** City to communicate property-level flood barriers for floodplain. Could consider implementing a property-level flood barrier program. Collaborate with insurers and other governments to develop an approach.	Immediate	Part of RB-2. Higher costs if incentives are included.
AC-25	**Encourage septic systems floodproofing:** This should be included in the communications campaign.	Immediate	Part of RB-2
AC-28	**Encourage floodproofing of hazardous materials for businesses (and residents):** Communicate risk and measures to reduce risk.	Immediate	Part of RB-2
AC-31	**Encourage floodproofing of hazardous material storage for agricultural operators** via communications campaign.	Immediate	Part of RB-2
AC-32	**Encourage agriculture sector adaptation:** Communicate flood risk and resources to local agricultural producers as part of the communications campaign. Align this initiative with the CVRD Comox Valley Agricultural Plan update.	Immediate	Part of RB-2
RB-12	**Engage with the community and community organizations for Neighbourhood resilience-building** / Neighbourhood hubs.	Short-term	Part of RB-2
RB-13	**Encourage property owners in floodplain to obtain flood insurance.**	Short-term	Part of RB-2

#	Action (Special Projects)	Timeline	Total Budget (Class D Estimate)
***Resilience-Building* - Special Projects**			
RB-4	**Review current monitoring and warning systems and update.**	Short-term	In-house (budget covered by staff salaries)
RB-7	**Review and update the Flood Operations Manual (Emergency Response Plan):** This should include newest hazard information, information on risk and resilience from this FMP, and coordination with the Comox Valley Emergency Program.	Short-term	$25,000
RB-8	**Explore and designate flood evacuation routes.**	Immediate	$25,000
RB-9	**Evaluate locations of flood evacuation centres:** Potentially set up new aid agreements for facilities outside the floodplain.	Short-term	In-house (budget covered by staff salaries)
RB-10	**Collaborate with the Comox Valley Emergency Management team to develop a flood recovery plan.**	Short-term	In-house (budget covered by staff salaries)
RB-11	**Develop a Post-Disaster Plan.**	Short-term	In-house (budget covered by staff salaries)
RB-14	**Maintain flood insurance for City facilities and demonstrate efforts to reduce the risk.**	Short-term	TBD
RB-15	**Continue to collaborate regionally on emergency preparedness and response.**	Short-term	TBD

8.1.3 Capital Projects

These are projects that need to be designed and built.

#	Action (Capital Projects)	Timeline	Budget (Class D Estimate)
***Protect* - Capital Projects**			
P-9	**Anderton Ave – Remediation (Naturalized Foreshore):** City to seek grant funding for detailed design and construction.	Immediate to Short-term	~$10,000,000
P-11	**Lewis Park Dike repairs:** Repair voids and cracks in concrete.	Short-term	$100,000
P-12	**Lewis Park Dike scour reduction:** Investigate current toe protection to identify ways to reduce turbulence and scour.	Short-term	$50,000
P-20	**Rye Road:** Work with MoTI to replace twin culverts.	Short-term	TBD
***Accommodate* - Floodproofing - Capital Projects**			
AC-11	**Floodproof all buildings in Lewis Park:** Conduct detailed building assessment, develop plan, and floodproof.	Short-term	Investigation costs: ~$25,000
AC-12	**Floodproof Florence Filberg Centre:** Conduct detailed building assessment, develop plan, and floodproof.	Short-term	Investigation costs: ~$25,000
AC-13	**Floodproof LINC Youth Centre:** Conduct detailed building assessment, develop plan, and floodproof.	Short-term	Investigation costs: ~$25,000

#	Action (Capital Projects)	Timeline	Budget (Class D Estimate)
AC-15	**Floodproof Puntledge Lift Station:** Conduct detailed assessment, plan, and floodproof.	Short-term	Investigation costs: $5,000[95]
AC-16	**Floodproof Sandpiper Lift Station:** Conduct detailed assessment, plan, and floodproof.	Short-term	Investigation costs: $5,000
AC-18	**Design new Anderton Lift Station in a floodproof manner:** Conduct detailed assessment, plan, and floodproof.	Immediate	~$3,500,000
AC-20	**Floodproof catchbasin at LINC Youth Centre** (to avoid stormwater entering into sanitary system). This should be done as part of any redevelopment at or near the site.	Short-term	$25,000
AC-27	**Expand Sanitary Sewer Service** to properties within the City that are currently on septic systems.	Medium-term	TBD
***Accommodate or Relocate* - Capital Projects**			
RE-3	**Complete options analysis for Memorial Outdoor Pool**, and ensure the flood risk is managed in the future plans.	Immediate	TBD as part of options analysis.
***Avoid* - Capital Projects**			
AV-3	**Acquire undeveloped land in floodplain.**	Oppor-tunistic	TBD

[95] Unless there is a need for major redesign (as opposed to quick fixes).

#	Action (Capital Projects)	Timeline	Budget (Class D Estimate)
***Resilience-Building* - Capital Projects**			
RB-5	**Add warning signs:** These can be added in high flood risk areas to raise awareness about flooding.	Short-term	$15,000
RB-6	**Add sirens:** These can be considered for high flood risk areas, along with conducting regular testing to raise awareness about flooding.	Short-term	TBD

8.2 Medium-to Long-term Actions

These are actions that have a longer than 5-year timeline.

#	Action	Timeline	Budget (Class D Estimate)
AC-39	**Update existing hydraulic modelling** to account for changing conditions and improved data. Could be combined with modelling associated with Anderton Dike Remediation and coastal modelling for FCLs.	Medium-term	$250,000
P-14	**Naturalized Lewis Park Dike:** Consider naturalization for erosion protection.	Long-term	$12,000,000[96]
P-25	**TideFlex Valves:** Assess if additional TideFlex valves become necessary with rising sea levels.	Long-term	TBD
RE-2	**Buy-out properties:** Opportunistically buy out residential housing properties that are located in the floodway, as they become available, and convert to other land uses.	Long-term/ very long-term	TBD (high property costs)
P-26	**Coastal Area – Naturalized Foreshore:** Apply 'Greens Shores' measures for increased coastal erosion protection, given sea level rise. As part of this, the City is recommended to educate and work with private property owners to realize benefits of Green Shores versus seawalls.	Very long-term	$13,000,000

[96] Estimate based on length and other more detailed estimates for naturalizations.

9 Conclusion

This report provides a detailed Flood Management Plan for the City of Courtenay. The plan was developed based on risk, and considers recommendations for *Protect*, *Accommodate*, *Retreat*, *Avoid*, and *Resilience-building* actions across the City. This is an important step forward for reducing flood risk and increasing resilience in the City.

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