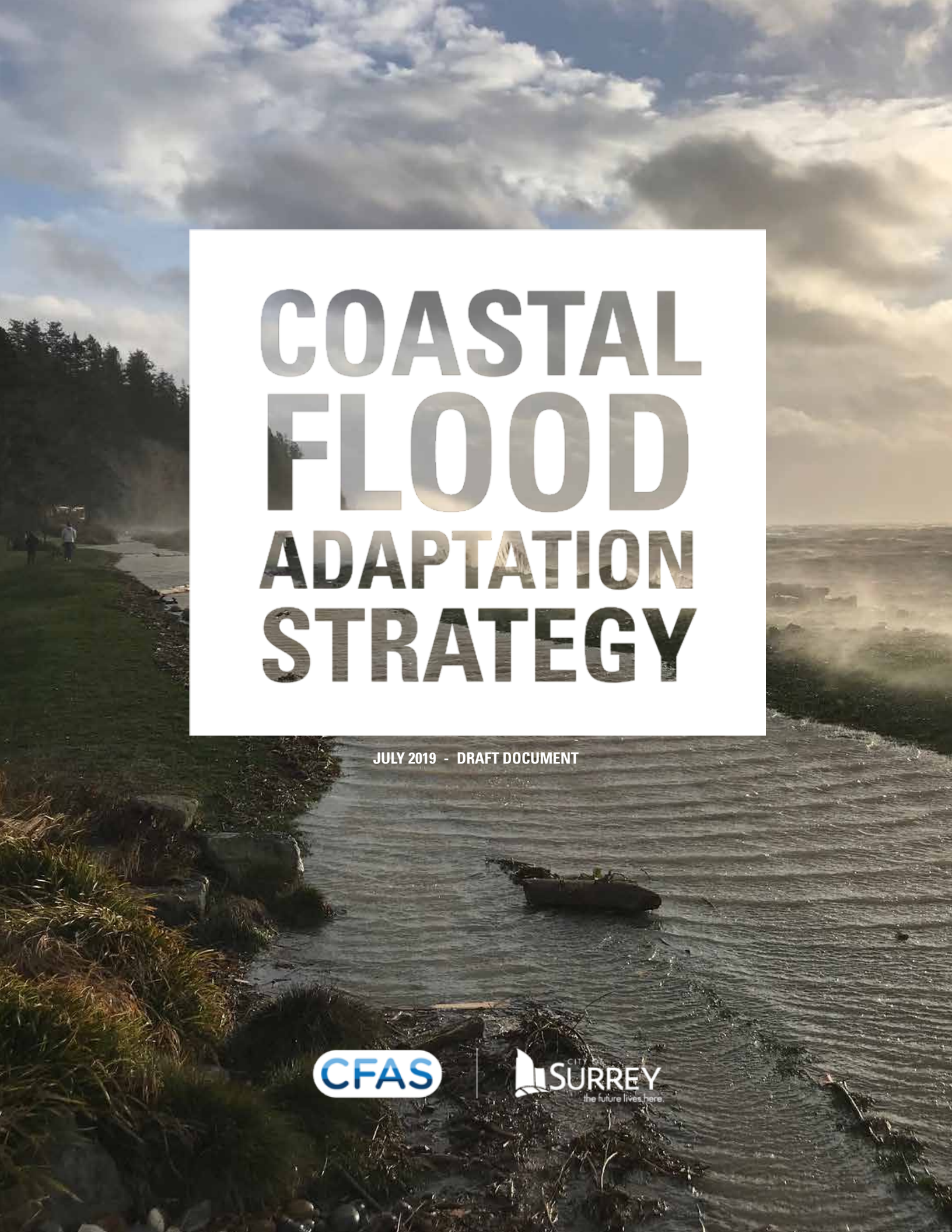


COASTAL FLOOD ADAPTATION STRATEGY

JULY 2019 - DRAFT DOCUMENT

CFAS

CITY OF SURREY
the future lives here.

ACKNOWLEDGEMENTS

The City of Surrey CFAS project team would like to thank the 2,000+ residents, business owners, and other stakeholders and partners who participated in the CFAS project. As a community-driven, participatory project, their time, contributions and unique perspectives helped us create the adaptation approaches and pathways this strategy outlines and supported the community conversations and learning that was a hallmark the initiative. Thank you.

This document features photos from a photo contest that was conducted as part of the CFAS project. The #SurreyCoastal photo contest asked people to share pictures of their favourite places and activities along Surrey's coastline and attracted 220+ submissions. Look for the camera icon that identifies these images. The document also includes quotes from some of the 2,000+ people who participated in the CFAS project that were collected through interviews, project worksheets, and event exit surveys. Thank you.

The City of Surrey would also like to acknowledge and thank the Federation of Canadian Municipalities and their Municipalities for Climate Innovation Program which provided financial support for this work.

Cover photo: Coastal flooding caused by a high wind event in December 2018 in Crescent Beach. Photo by Trevor Roberts, a Crescent Beach resident.

COASTAL FLOOD ADAPTATION STRATEGY

TABLE OF CONTENTS

LIST OF FIGURES

1. EXECUTIVE SUMMARY

To help prepare Surrey for a changing climate and help our coastal communities become more resilient, the City of Surrey developed a Coastal Flood Adaptation Strategy (CFAS). One of the first programs of its kind in Canada, CFAS was a multi-year undertaking that identified the current and potential impacts of climate change on Surrey's large coastal floodplain area and developed a long-term strategy to reduce climate change-driven coastal flooding risks now and into the future.

Launched in 2016, CFAS blended a value-based, participatory planning approach with an innovative structured decision-making component, and deep, robust technical analysis to develop a range of strategic actions to help coastal communities in the CFAS Study Area and the its three distinct Planning Areas -- Mud Bay, Crescent Beach, Semiahmoo Bay -- become more resilient to the challenges ahead.

Comprehensive engagement with internal and external stakeholders and partners was a core project objective and integrated with a structured, value-based planning approach which meaningfully engaged participants in project decision-making. Over the three-year planning process, CFAS actively involved Semiahmoo First Nation, residents, farmers and the agricultural community, community and environmental organizations, business associations and group, provincial and federal agencies and Ministries, and neighbouring jurisdictions. Over 30 organizations, agencies, and governments participated in the project, while over 2,000 residents and other stakeholders attended workshops, open houses, focus groups, or participated through project surveys and other engagement events. Project communications generated major national media coverage and over a quarter million social media impressions.

CFAS communications and engagement also greatly increased shared understanding of the significant challenges ahead for Surrey in the face of climate change-driven coastal flooding, with public appreciation and understanding of the issue noticeably shifting and expanding over the course of the project. Combined with the project's robust and sophisticated technical assessment and modelling component, the community-driven approach also helped Surrey secure the largest ($77.6 million) federal grant the City has ever received through the Disaster Mitigation Adaptation Fund (DMAF).

CFAS presents a total of 46 Actions. These are divided between CFAS Program and Policy Actions CFAS Planning Area-specific Actions. Program and Policy Actions apply across the larger CFAS Study Area and its three distinct Planning Areas (Mud Bay, Crescent Beach, Semiahmoo Bay). Area-specific Actions are primarily infrastructure-related projects to be implemented in specific areas in the CFAS Study Area. Collectively, these Actions are at the heart of CFAS. Individually and together, their implementation will involve numerous City departments, outside agencies, senior levels of government, and community-based organizations over the coming years and decades.

A little paddle in Mud Bay, by Matt Christensen

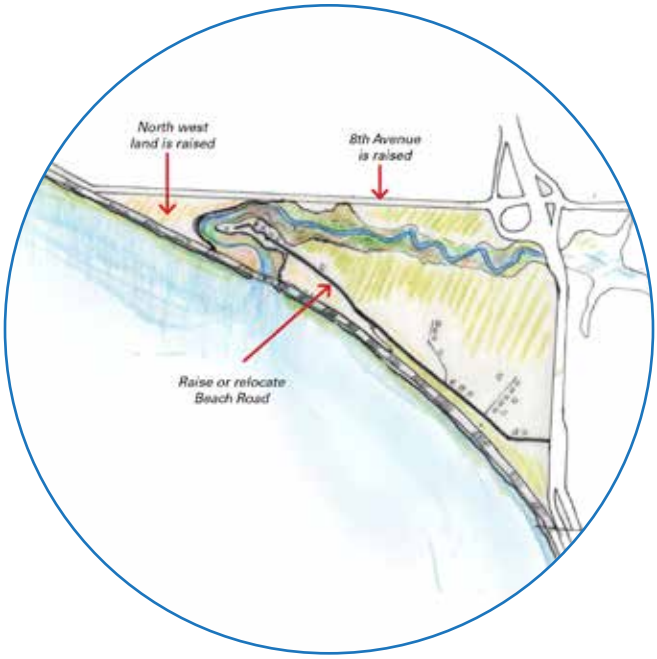
A number of Program and Policy Actions and Planning Area-specific Actions have been prioritized as more tactical, shorter-term to be implemented between 2020 to 2030. Other Actions will be implemented as conditions warrant over the longer-term, with a potential implementation period that stretches to 2080. The shorter-term CFAS Actions collectively represent so-call "low-regret" flood management projects, investments, and policies that will help address current concerns while laying the path for more complex and challenging Strategic Directions over the longer-term. Low-regret projects are defined as relatively low-cost Actions that provide relatively large benefits under predicted future climates that contribute to adaptation while other social, economic and environmental benefits, including climate change mitigation benefits.

The longer-term Strategic Directions are based on an 80-year timeframe (i.e., to 2100) and represent the long-term outlook for flood adaptation for the three CFAS Planning Areas. Developed with input from project partners and stakeholders, the Strategic Directions also included considerable technical analysis by City of Surrey Engineering, project consultants, and supplemented with additional review provided through a unique research component involving UBC and Dutch flood management experts, landscape architects, and engineers (LINT Middelburg, Royal Haskoning DHV). The Strategic Directions are:

- ***Mud Bay – Coastal Works / Highway 99 Strategic Direction***
  The longer-term strategic direction for the Mud Bay Planning Area is to gradually develop new infrastructure and management approaches along the Highway 99 corridor to prepare for increased frequency of flooding. This agricultural area is complex, as there are numerous infrastructure corridors of regional, provincial and national significance. A shared desire to minimize increases in long term flood risk to critical infrastructure will be required for the Strategic Direction to be implemented. Further, extensive coordination between numerous agencies will be necessary.

"We have the opportunity here to really set a precedent for BC and the Pacific Coast on how we adapt to sea level rise and climate change and placing that value in the environment."

– CFAS participant



- ***Crescent Beach – Expanded Edge Strategic Direction***
  For Crescent Beach Planning Area, the longer-term planning challenges are even greater. Shorter-term tactical actions include a series of smaller-scale drainage improvements and regulatory changes (e.g., a higher flood construction level) until such point that sea level rise (observed increase and rate of rise) triggers an "expanded edge" approach. This approach could build up and extend the shoreline towards Boundary/Mud Bay and include additional drainage and flood management works in the Crescent Beach community. Given the technical complexity, archaeological significance and considerable cost considerations, the Strategic Direction will require more detailed planning. External and interconnected issues, such as flood insurance, property values and public risk perception are expected to influence triggers to implement longer-term actions impacting the primarily residential and recreational area.

- ***Semiahmoo Bay – Infrastructure Improvements and Land Raising Strategic Direction***
  For Semiahmoo Bay Planning Area, relatively smaller and less dramatic interventions are envisioned. While many of the actions will need to be linked with the development of land within the Semiahmoo First Nation, there are long term, complicated coordinated works required along 8th Ave\Marine Drive that will require careful coordination and collaboration with Semiahmoo First Nation, the Federal Government, the City of White Rock, and the City of Surrey.

Recognizing the scale and scope of CFAS Strategic Directions and the uncertainties surrounding climate change, and sea level rise in particular (i.e., it could happen faster, it could be more severe, it could happen more slowly), the shorter-term, tactical actions were designed to be flexible and adaptive. Taking an adaptive management approach, CFAS Action implementation will be closely monitored and, where required, adjusted based on both

observed sea level rise and the pace of sea level rise. The approach explicitly recognizes that planning in a dynamic context needs to be flexible and responsive to new drivers and considerations as they emerge. For CFAS, and in addition to observed sea-level rise, this includes:

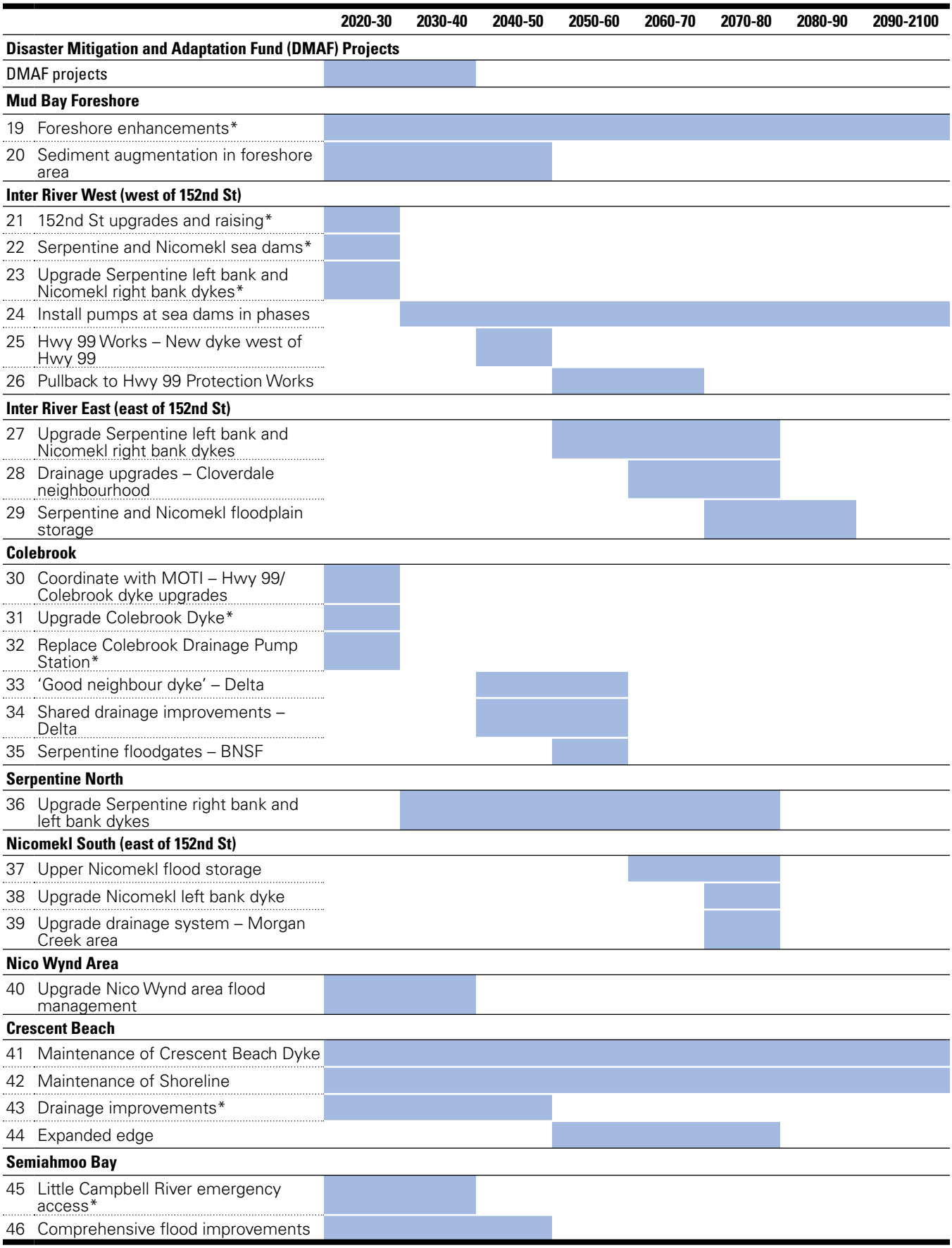
- ***New data -*** and new changes detected in the data
- ***New policies/directives -*** global, national, provincial, regional, local
- ***New participants and collaborations -*** new partners and stakeholders taking new actions
- ***New funding -*** and the requirements/ opportunities that come with them

Figures 1 and 2 summarize the CFAS Program and Policy Actions and Planning Area-specific Actions. The estimated implementation periods for all CFAS Actions based on sea levels continuing to rise at rate of approximately 10cm per decade, a rate of increase that is in accordance with Provincial Guidelines issued in 2010. Implementing most the Actions (Program and Policy Actions and Planning Area-specific Actions) will involve many of the same stakeholders and partners involved in developing the CFAS strategy itself.

FIGURE 1: *CFAS Program and Policy Actions*

		2020-30	2030-40	2040-50	2050-60	2060-70	2070-80	2080-90	2090-2100
Ongoing Education, Communications, and Advocacy Initiatives									
1	CFAS Steering Committee								
2	Internal Updates								
3	CFAS Advisory Group								
4	CFAS Website								
5	Advocacy Partners Workshop								
6	Communications and Media								
Detailing Planning, Studies, and Data Collection									
7	Update hazard bibliography								
8	Update coastal flood hazard assessment								
9	Detailed studies - Strategic Actions								
Regulatory Controls, Design Standards, and Guidelines									
10	Review Development Variance practices								
11	Support flood resilient design and construction								
12	Explore Sea Level Rise Planning Area								
13	Design Standards Guidebook								
Extreme Flood Management									
14	Hazard review								
15	Training and readiness								
16	Improve flood warning systems and communications								
17	Temporary protection measures assessment								
18	Build Back Better program								

FIGURE 2: *CFAS Planning Area-specific Actions*



** Indicates partial scope included in Surrey DMAF program*
Area-specific Actions under $5M capital cost are omitted for clarity

Clouds over Mud Bay Park, by simrandevgun

2. CLIMATE CHANGE AND COASTAL FLOODING IN SURREY

Surrey's coastal floodplain makes up about 20% of Surrey's entire land area. This large, low-lying area stretches from Boundary Bay and Mud Bay along the Nicomekl and Serpentine Rivers towards Cloverdale and Newton. The floodplain also includes the Little Campbell River/Semiahmoo Bay area near White Rock and Semiahmoo First Nation.

FIGURE 3: *Surrey's Coastal Floodplain*

As a natural floodplain, the area has regularly experienced some coastal flooding over the years from high tides and storm surges, and river floods which are typically caused by rain storms and snow melt but can also be influenced by high tides and storm surges.

The two principal causes of increased flooding in Surrey's coastal floodplain are (1) sea level rise and (2) increased magnitude and intensity of rain – both a result of climate change. The effects of sea level rise are anticipated to be greater than those of rainfall in Surrey's coastal floodplain.

- ***Sea Level Rise:*** Global sea level is rising. This is a result of increasing temperatures throughout the world that are melting glaciers and polar ice caps, and that are also increasing the average temperature of ocean waters

causing them to expand. The Province of British Columbia advises municipalities to plan for 1 metre of sea level rise over the next 80 years, and 2 metres by 2200. Figure 4 shows the expected sea level rise that a child born in 2020 will experience by the time they are 80. The lighter blue line represents forecasted sea level rise under a high emissions scenario (1.63 m by 2100). Not depicted, but of note in Surrey's coastal floodplain is ground subsidence, estimated at an additional 2 cm per decade.

- ***Increased Rainfall:*** With the changing climate, we can expect more extreme weather conditions. For example, in Surrey, winters are expected to have fewer wet days, but on the wet days the rainfall amounts will be much greater than in the past. This will result in increased flooding, as more runoff flows into the Nicomekl, Serpentine and Little Campbell Rivers during these storm events. The frequency and intensity of storm events with heavy precipitation are also expected to increase.

In the short-term, Surrey can expect more nuisance flooding and more frequent and severe flooding from storm surges, while over the longer-term we can expect even greater challenges. Projected impacts for Surrey's coastal area include higher sea levels, increased frequency and intensity of storms and storm surges (when water is pushed ashore by wind and waves), more erosion of the coastline, impacts on infrastructure, loss of beaches and coastal ecosystems, soil salinization, and groundwater pooling.

"It affects us all. We can't just sit by and watch what happens."

– CFAS participant

FIGURE 4: *A Lifetime of Sea Level Rise*

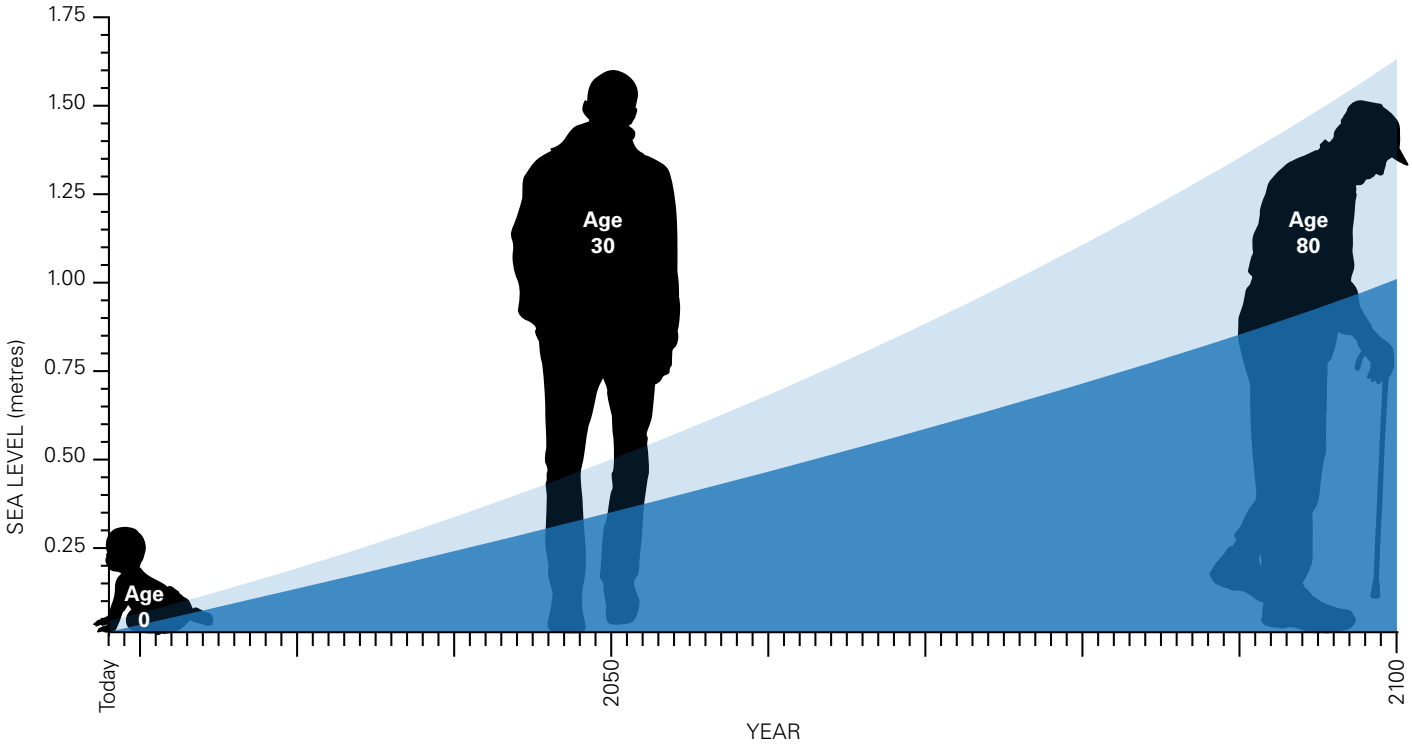


FIGURE 5: *Surrey Coastal Flood Hazard Impacts - Overview*

OCEAN FLOOD HAZARDS

TODAY

- ***High tides***
- ***Storm surges***

FUTURE

- ***High tides***
- ***Storm surges***
- ***Sea level rise***

IMPACTS

- ***Breach or overtopping of dykes***
- ***Temporary inundation***
- ***Coastal erosion***
- ***Potential injuries or loss of life***
- ***Damage to residential, commercial & other development***
- ***Infrastructure & transportation damage & disruption***
- ***Business disruptions***
- ***Agricultural losses (livestock, crops)***
- ***Habitat loss & impacts (with associated impacts to species)***
- ***Cultural & social losses***
- ***Longer duration of sea dam closures, which creates more water backing river, reduced fish passage, and water quality problems***

- ***Long-term inundation***
- ***Salination***
- ***Coastal squeeze***
- ***Same as TODAY but more frequent and more severe consequences***

RIVER FLOOD HAZARDS

TODAY

- ***Long duration and intense rainfall or rain-on-snow event***

FUTURE

- ***Increased and more intense rainfall and runoff***
- ***Reduced sea dam capacity due to sea level rise***

IMPACTS

- ***Activation of spillways and inundation of floodplain***
- ***Sea dams inadequate for drainage***
- ***Potential injuries***
- ***Damage to residential and commercial development***
- ***Business/transportation disruptions***
- ***Some agricultural losses***
- ***Some cultural and social losses***

- ***Frequent activation of spillways and longer-term inundation of fields***
- ***Floodboxes closed for longer periods (combined with higher runoff and longer dam closures)***
- ***Limited land-use potential***
- ***Frequent or permanent transportation disruptions***
- ***Same as TODAY but more frequent and more severe consequences***

FIGURE 6: *A History of River and Coastal Flooding*

COASTAL AND RIVER FLOODING

1870 1880 1890 1900 1910 1920 1930 1940 1950 1960 1970 1980 199

Major Coastal and River Flood Events

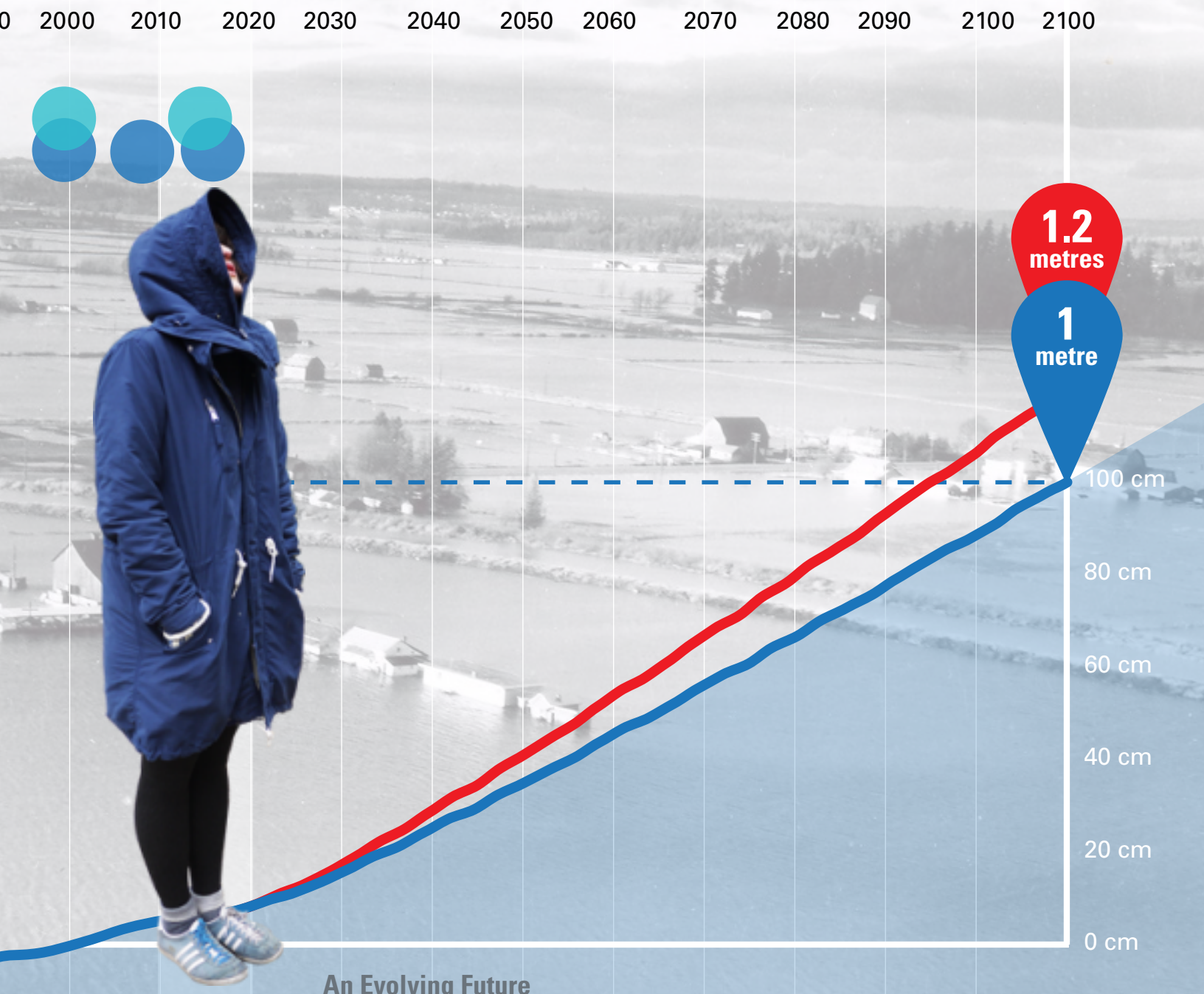
A Changing Shoreline

In 1890, dyking of Mud Bay begins. Shortly afterwards, dyking and damming of the Serpentine and Nicomekl Rivers begins.

By 1953, a timber sea wall at Crescent Beach is constructed.

Since then, residents of Surrey's Coastal Floodplain have relied on a system of dykes and sea dams to protect themselves from ocean and river flooding.

Photos courtesy Surrey Archives and Museum.



An Evolving Future

As our climate continues to change and sea levels continue to rise over the coming years, it is anticipated that the frequency and intensity of major coastal and river floods will also increase.

The Province has directed municipalities to plan for at least 1m sea level rise by 2100. In Surrey, and elsewhere in the Lower Mainland, most drainage systems are not designed for projected changes.

Most of the CFAS Study Area is subject to ground subsidence, which adds up to an additional 20 cm to sea level rise projections as indicated by the red line.

2.1 WHAT'S AT RISK?

The CFAS Planning Area is a large and diverse land area making up about 20% of Surrey's total land area. Some of the principal sectors and areas at risk from climate change are highlighted in this section. Figure 7 provides a summary snapshot of current risks in the Planning Area.

- ***Agriculture and Farming:*** The agriculture and farming sector plays a significant role in Surrey's economy. With over 1/3 of Surrey's land base in the Provincial Agricultural Land Reserve (A Provincial land use zone in which agriculture is recognized as the priority use), the sector generates about a quarter of total gross annual farm receipts in Metro Vancouver, or about $170 million in 2010. The sector also employs hundreds, including farm families and seasonal workers. The Mud Bay CFAS Planning Area includes a large and important part of Surrey's Agricultural sector.
- ***Community and Residential:*** While the CFAS Planning Area is largely agricultural, it is still home to several smaller residential developments and the larger, historic community of Crescent Beach. Beginning as a cottage community, Crescent Beach is one of Surrey's best known and most loved neighbourhoods. Home to about 1,200 people and 400 homes, the community is also home to several commercial businesses and restaurants, Alexandria Neighbourhood House, and the Crescent Beach Swim Club. The Little Campbell River area is home to Semiahmoo First Nation, whose principal reserve is on the mouth of the river.
- ***Environment and Recreation:*** The CFAS Planning Area is home to several popular Surrey and Metro Vancouver parks that include several kilometres of shoreline trails with incredible views of Boundary Bay and Mud Bay. Diverse wildlife habitats, including eelgrass meadows, mud flats, salt marsh, and old fields make it one of the best wildlife viewing areas in the region. It is also home to Provincially and Federally protected wildlife

FIGURE 7: *What's at Risk in Surrey's Coastal Floodplain – A Snapshot*

COMMUNITIES AND PEOPLE
- Many residential areas and neighbourhoods
- Semiahmoo First Nation
- 2,500+ residents
- Approximately 20% of Surrey's land area

PARKS AND ENVIRONMENT
- Destination regional and City parks
- Beaches and recreation areas
- Critical foreshore, coastal, and riparian areas

LOCAL AND REGIONAL ECONOMY
- Over $100M in annual farm gate revenue
- Over $1B in assessed property value
- Almost $25B annual truck and rail freight traffic

INFRASTRUCTURE
- Over 10km of Provincial Highways
- Over 200,000 vehicle trips a day
- Over 30km of railway (freight, passenger)

FOOD SECURITY
- ~60km^2 agricultural land
- ~10% of Metro Vancouver's farmland

Sandpipers on the beach, by Charlie Ng Photography

areas and the species at risk that live there. Thousands of migratory birds use Mud Bay and the larger CFAS Planning Area as a rest stop as they travel along the Pacific Flyway, which is a "highway in the sky" stretching from Alaska and the Canadian Arctic to Central and South America.

- ***Transportation and Infrastructure:*** Major infrastructure, including rail lines, highways, and utility corridors all pass through the CFAS Planning Area. In addition to existing infrastructure, the City of Surrey is currently in the middle of a $25 million comprehensive Stormwater Management Strategy for Crescent Beach to help prepare the community for increased coastal flood. Work includes a new pump station (Maple Pump Station), new storm sewers, and a plan to raise key roads.

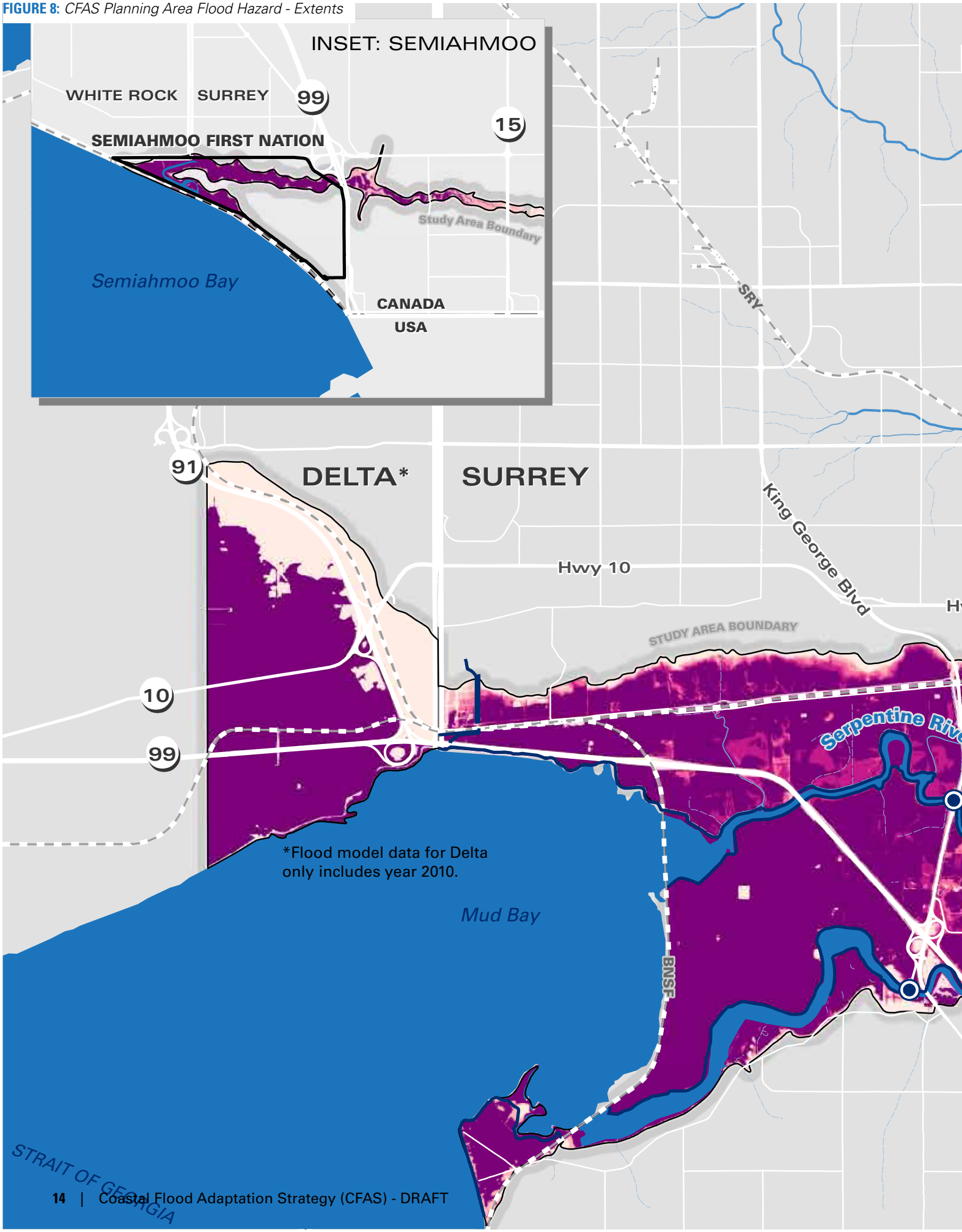
The changing climate and the increased flood hazards it brings means that the historic controls (e.g., dykes, pumps, drainage ditches) put in place by the City of Surrey to limit flood damages will be ineffective in limiting future flood damage as sea levels continue to rise. Today, Surrey maintains the largest dyking network in BC. Sea level rise is projected to significantly increase dyke vulnerability and expose low-lying infrastructure along the shoreline to flooding.

Figure 8 shows the *extent* of flooding that could be expected today and, in the future, if changes and upgrades are not made to the existing system and management approach.

Figure 9 shows flood hazard *depths* (over one metre) that could be expected today and, in the future, if no improvements or changes are made to the existing system. Flood depths of over one metre would flood the ground floor of most buildings and homes, lead to service and utility failures (e.g., electricity), necessitate the evacuation of residents, and could carry vehicles off roadways.

Figure 10 shows that the impacts of sea level rise are greatest closest to the ocean. By 2040, dyke infrastructure nearly 10km inland is expected to become vulnerable.

FIGURE 8: *CFAS Planning Area Flood Hazard - Extents*



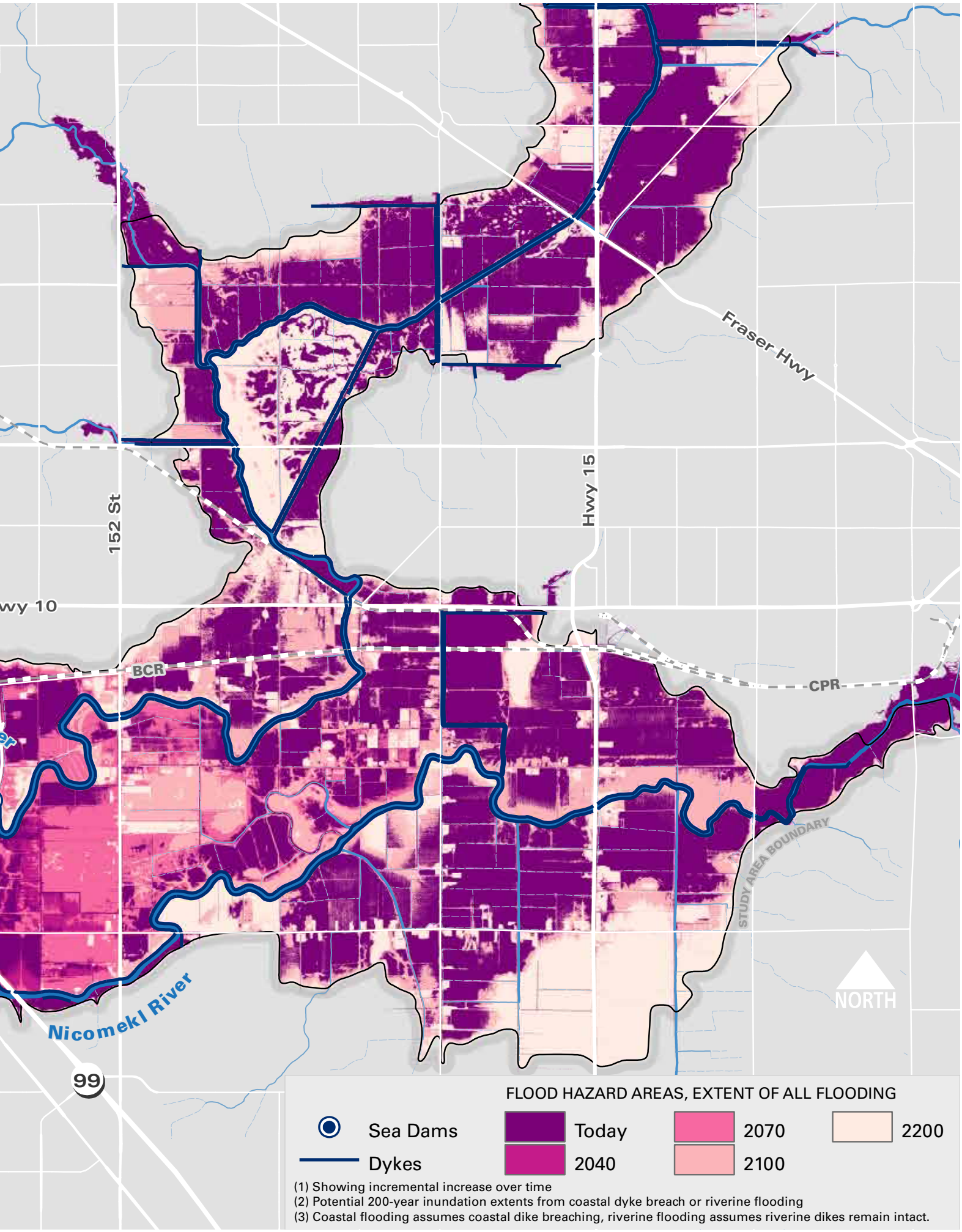
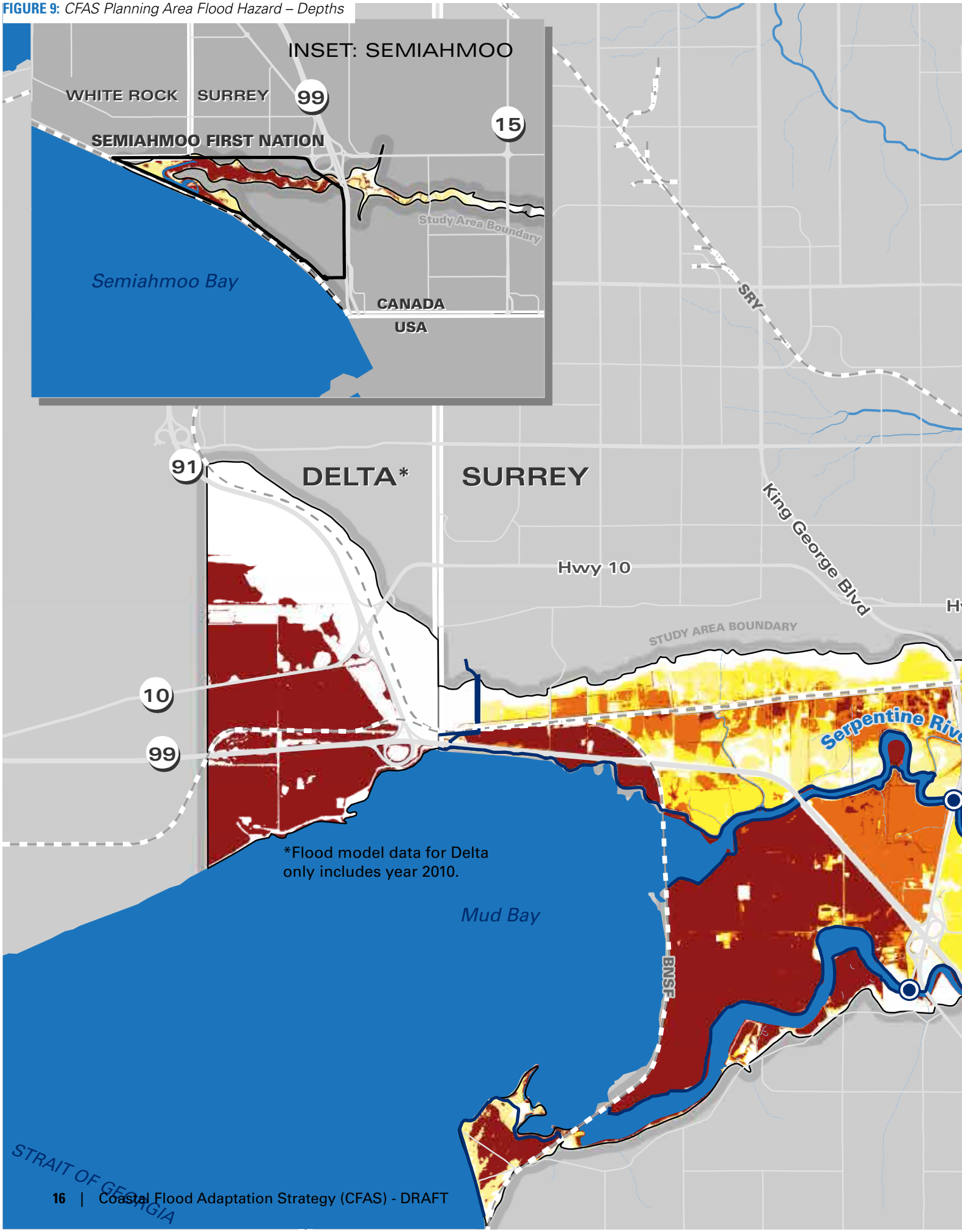

Fraser Hwy
Hwy 15
152 St
wy 10
BCR
CPR
STUDY AREA BOUNDARY
NORTH
Nicomekl River
99
FLOOD HAZARD AREAS, EXTENT OF ALL FLOODING
Sea Dams
Dykes
Today
2040
2070
2100
2200
(1) Showing incremental increase over time
(2) Potential 200-year inundation extents from coastal dyke breach or riverine flooding
(3) Coastal flooding assumes coastal dike breaching, riverine flooding assumes riverine dikes remain intact.

FIGURE 9: *CFAS Planning Area Flood Hazard – Depths*



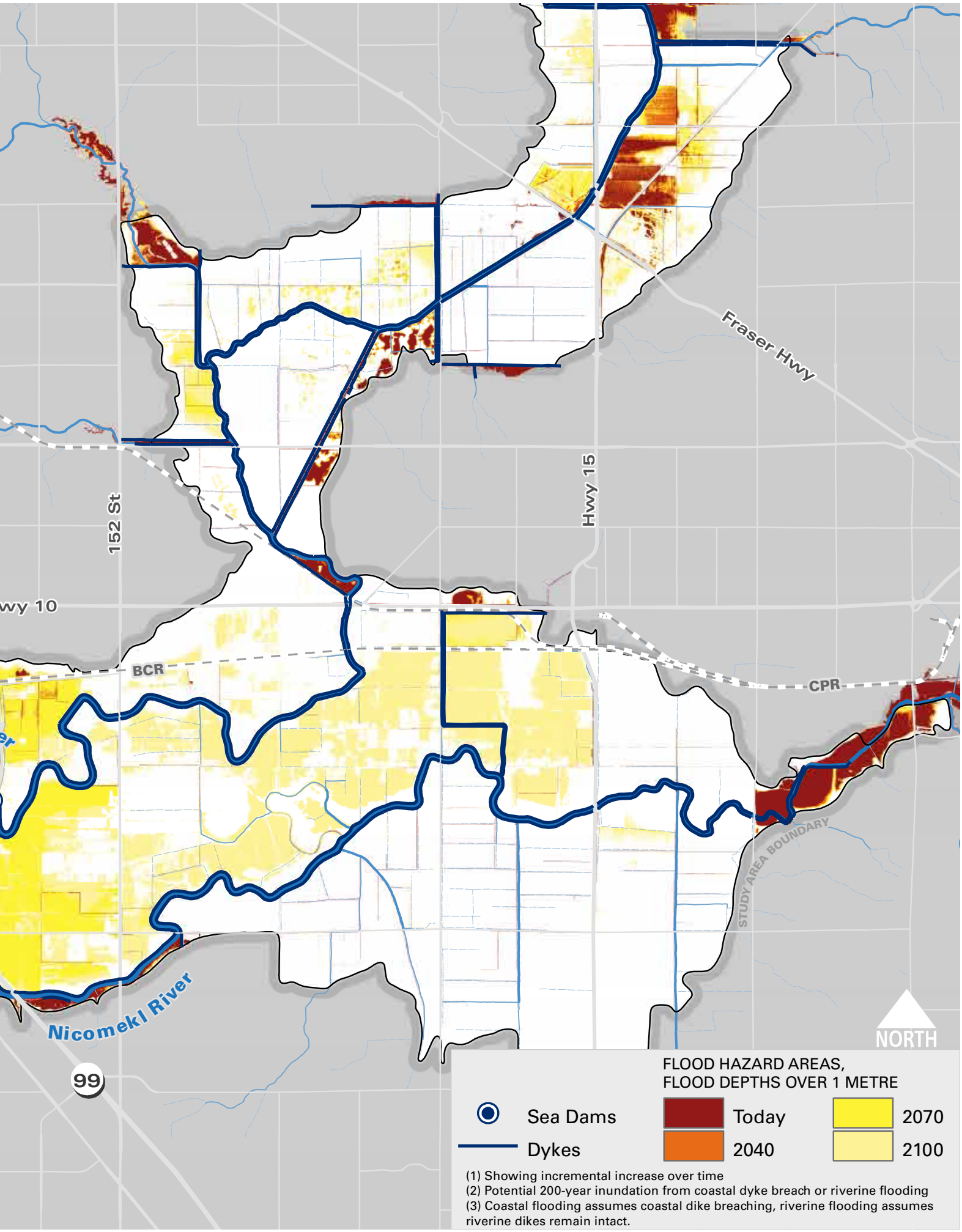
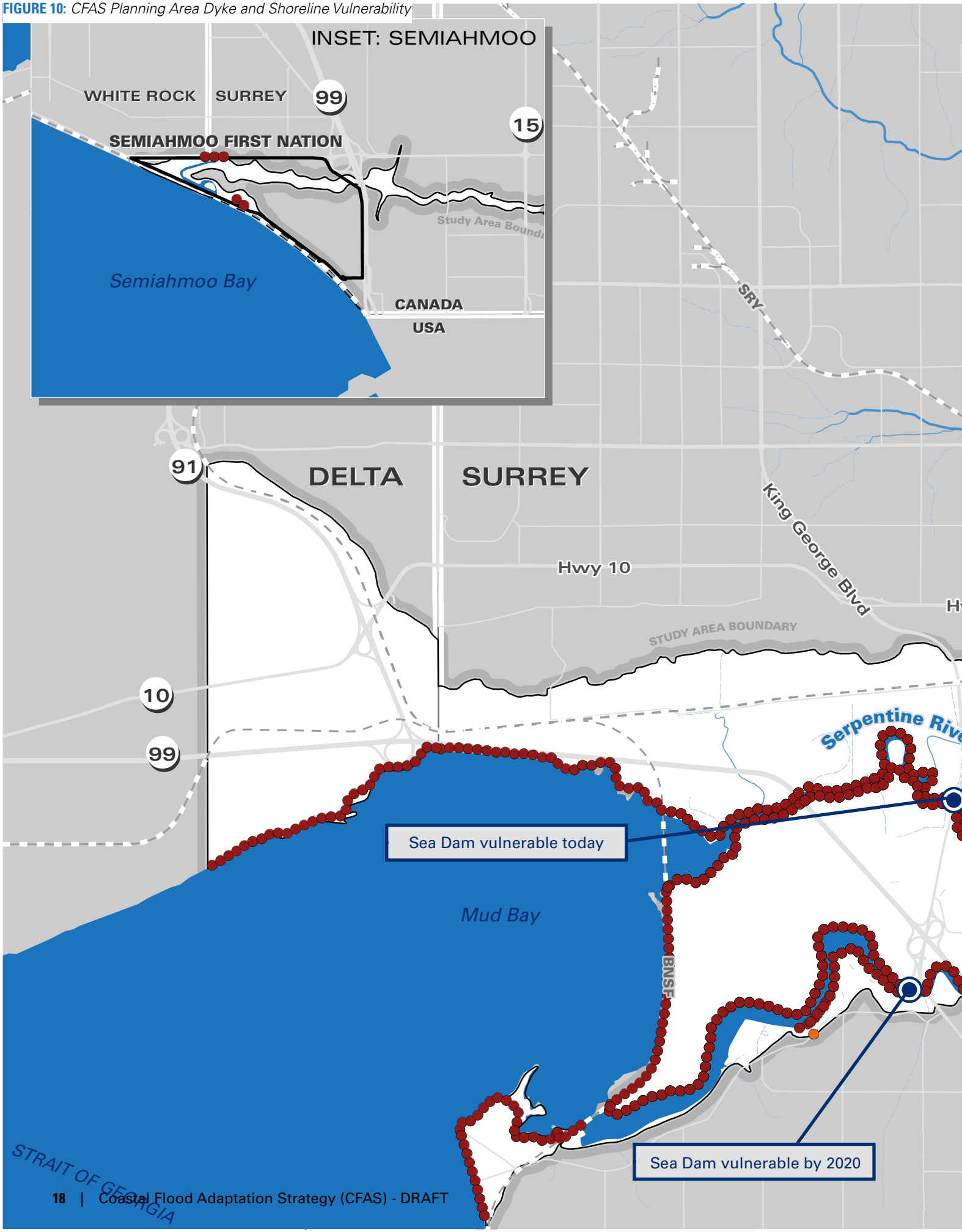
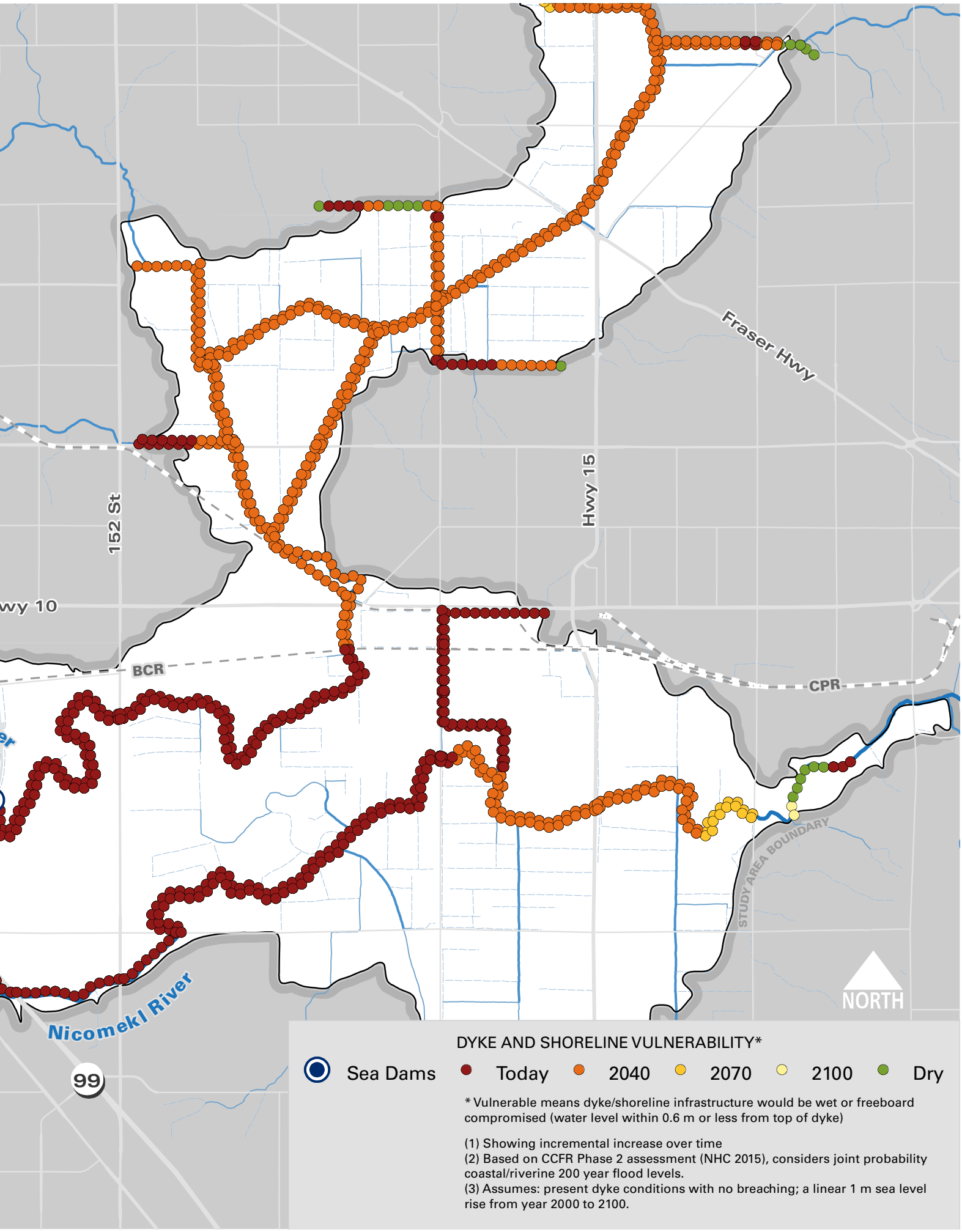

Fraser Hwy
Hwy 15
152 St
wy 10
BCR
CPR
STUDY AREA BOUNDARY
Nicomekl River
99
NORTH
FLOOD HAZARD AREAS,
FLOOD DEPTHS OVER 1 METRE
Sea Dams
Dykes
Today
2040
2070
2100
(1) Showing incremental increase over time
(2) Potential 200-year inundation from coastal dyke breach or riverine flooding
(3) Coastal flooding assumes coastal dike breaching, riverine flooding assumes riverine dikes remain intact.

FIGURE 10: *CFAS Planning Area Dyke and Shoreline Vulnerability*





DYKE AND SHORELINE VULNERABILITY*

Sea Dams · Today · 2040 · 2070 · 2100 · Dry

* Vulnerable means dyke/shoreline infrastructure would be wet or freeboard compromised (water level within 0.6 m or less from top of dyke)

(1) Showing incremental increase over time
(2) Based on CCFR Phase 2 assessment (NHC 2015), considers joint probability coastal/riverine 200 year flood levels.
(3) Assumes: present dyke conditions with no breaching; a linear 1 m sea level rise from year 2000 to 2100.

Photo by Monika Nolte Hamilton

3. STRATEGY OVERVIEW AND BACKGROUND

The City of Surrey developed the Coastal Flood Adaptation Strategy (CFAS) to help prepare for current coastal flooding challenges and to develop a more integrated and coordinated approach to take future action. The strategy outlines the potential future impacts of climate change on Surrey's coastline and the adaptation options available to address them over the short, medium, and longer-terms.

In February 2016, Surrey City Council approved-in-principle the development of CFAS. In developing the strategy, the City of Surrey's objectives were to:

- Establish a preferred approach for adapting to coastal flood hazards through time in which the risks from climate change impacts are minimized;
- Position the City to secure external funding to implement the recommended strategy;
- Strengthen the relationships between the City of Surrey and external stakeholders;
- Align Surrey's work with other regional flood management strategies being developed in the region (e.g., Fraser Basin Council's Lower Mainland Flood Management Strategy);
- Build the adaptive capacity of stakeholders and City staff to respond to the uncertainties inherent in climate change impacts over time; and
- Achieve public support for CFAS directions and short-term tactical actions.

As an initiative, CFAS is one component of Surrey's ongoing climate adaptation and mitigation work. The strategy sits under the City of Surrey's Sustainability Charter 2.0 and Climate Adaptation Strategy (CAS).

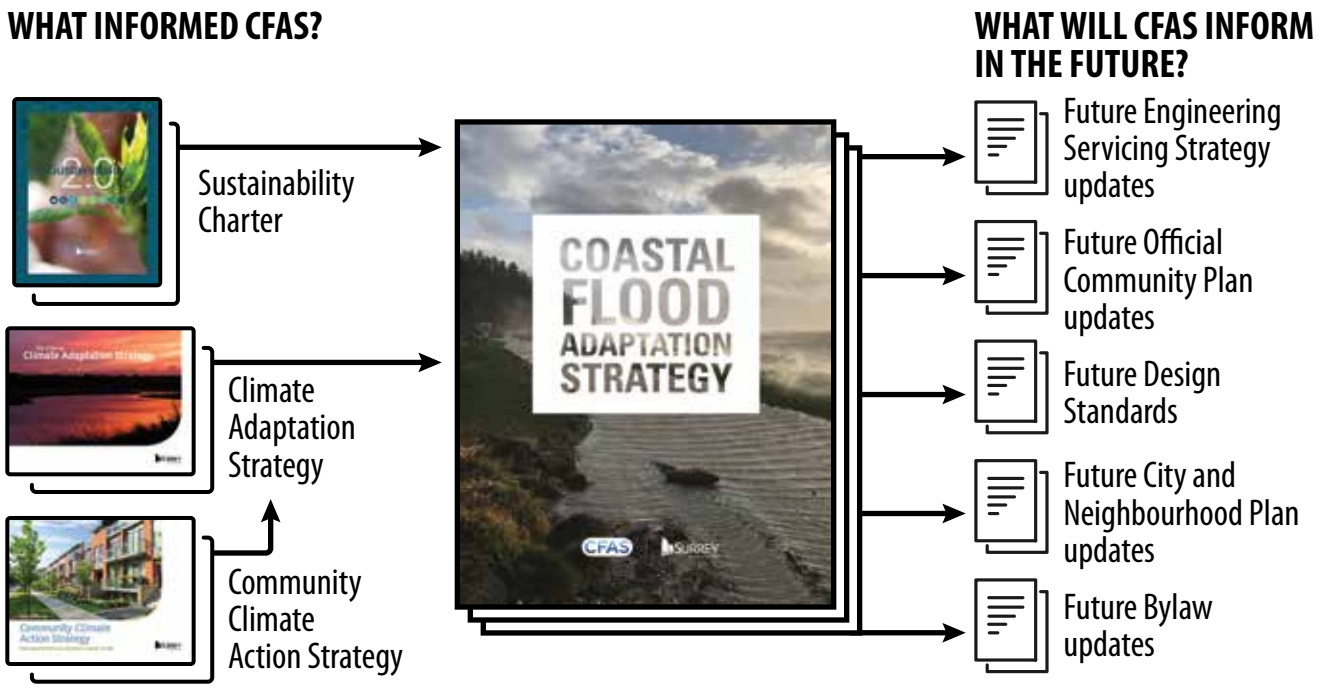
The Sustainability Charter 2.0 established an ambitious 40-year vision for sustainability in Surrey. First developed in 2008 and updated in 2016, the Sustainability Charter guides policy and decision-making to ensure the City always takes into account social, environmental and economic factors.

Aligned with other plans from across the City, the Sustainability Charter directly led to the development of Surrey's Community Climate Action Strategy and CAS under which CFAS was created.

Completed in 2013, CAS identifies how the City may be vulnerable to climate change impacts and proposes actions to mitigate the risks and costs of such impacts. It identified 91 actions of which 11 actions were distinguished as immediate priorities. Among these immediate priority actions were the following:

- ***FL-1.1*** Development of a Regional Flood Management Strategy in coordination with senior levels of government other municipalities, and key stakeholders
- ***FL-2.1*** Detailed analysis on Surrey-specific climate impacts, including the timelines and extent of sea level rise and its related effects on flood construction levels and floodplain designations

FIGURE 11: *CFAS High-level Strategic Alignment and Connections*



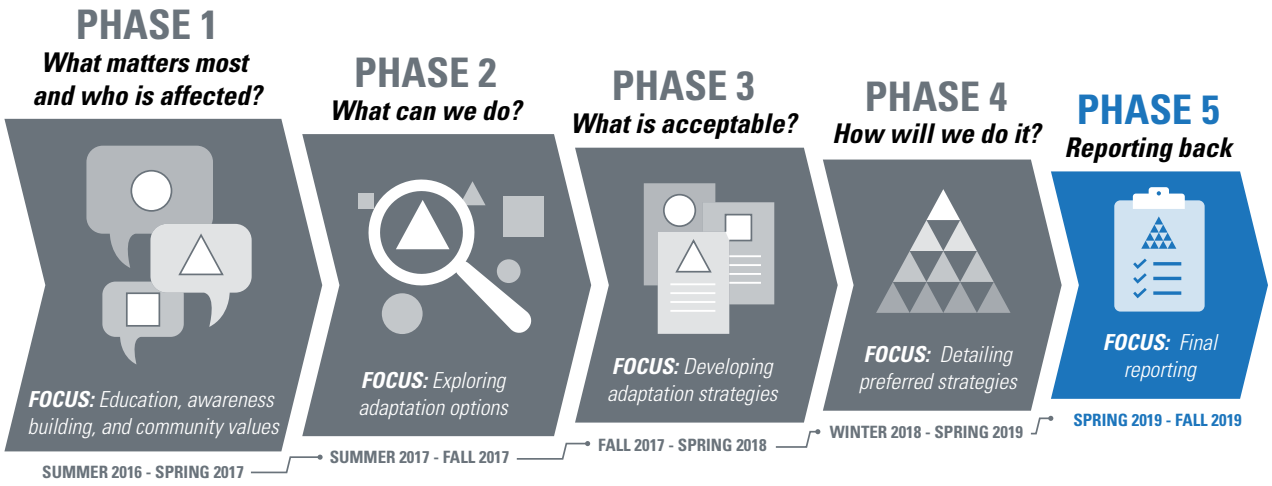
- ***AG-1.2*** Work with all levels of government to evaluate long-term flood management options in response to sea level rise impacts with considerations for agricultural viability

As part of implementing the above three actions, the City committed to developing this Coastal Flood Adaptation Strategy (CFAS).

CFAS was broken into five distinct phases as illustrated in Figure 12.

Phase 1: What matters most and who is affected? This phase reviewed flood hazard issues in general and began exploring what matters to stakeholders (i.e., their values and objectives). At this stage, the project team created scenarios (i.e., plausible outcomes for the future) that illustrated how climate change and sea level rise could impact the coastal flood hazard areas based on the Provincial Sea Level Rise curve. The scenarios were used to help elicit stakeholder values that are at risk and explore how these impacts could potentially be managed through a variety of general adaptation approaches.

FIGURE 12: *CFAS Timeline*

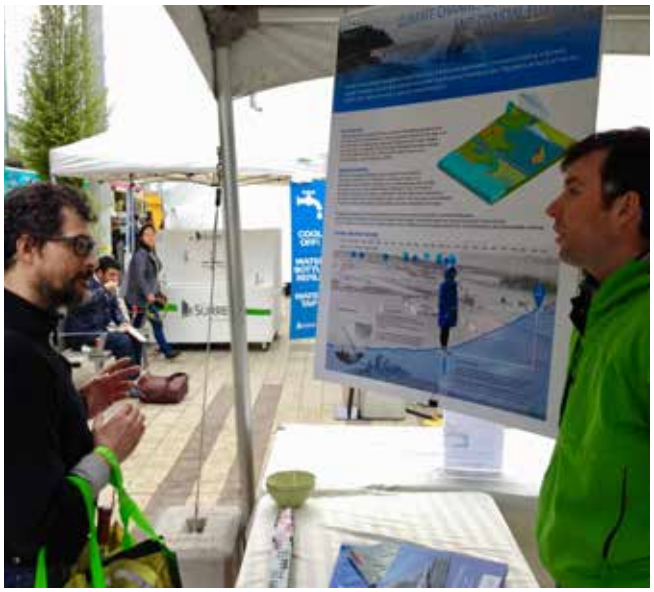


Phase 2: What can we do?
In this phase of work, general adaptation approaches were further developed, modelled and tested, and relevant trade-offs were identified. This phase included a considerable technical component including detailed analysis and modelling. The technical analysis included input from project engineers and City of Surrey staff. Technical analysis was augmented and enriched through a partnership with University of British Columbia School of Architecture and Landscape Architecture and a unique research project which brought in Dutch flood management experts, landscape architects, and engineers (LINT Middelburg, Royal Haskoning DHV).

Phase 3: What is acceptable?
Stakeholder analysis and evaluation continued during this phase, as the project moved from developing adaptation approaches to evaluating them through a participatory, stakeholder-driven process. Supported by illustrations and visualizations, the option evaluation also included broad-based engagement with key stakeholders including regulators and a City-wide survey on short-listed flood adaptation approaches.

Phase 4: How will we do it?
With adaptation directions established for the three planning areas, this phase of work developed more detailed adaptation actions based on cost, funding, and partnership opportunities. This phase was extended to incorporate the federal Disaster Mitigation and Adaptation Funding (DMAF) opportunity (a 9-month process) that arose early in this project phase, leading to the development of a portfolio of more detailed, shovel-ready projects for implementation over the short-term (i.e., 2020 – 2030). Partnership opportunities were advanced as part of developing a DMAF application. This included Semiahmoo First Nation, City of Delta, Metro Vancouver and others.

Phase 5: Reporting back
This phase involved the final development of the CFAS document and an additional round of stakeholder and partner outreach and engagement.



3.1 CFAS STUDY AREA

The CFAS Study Area roughly overlaps Surrey's coastal floodplain and is principally made up of three distinct Planning Areas – Mud Bay, Crescent Beach, and Semiahmoo Bay. The CFAS Study Area lies entirely within the Serpentine River (146 km2) and Nicomekl River (181 km2) watersheds. Both these watersheds extend beyond Surrey's boundaries - while the Serpentine watershed includes parts of the Township of Langley and City of Delta, the Nicomekl watershed includes parts of the Township of Langley and the City of Langley.

The CFAS Study Areas is made up of three distinct Planning Areas – Mud Bay, Crescent Mud Bay, Semiahmoo Bay. Based on the findings of CFAS Phase 2 and Phase 3, it became evident that a wide diversity of adaptation measures would be required for different parts of the Mud Bay Planning Area depending on hydraulic characteristics and land-use. In the interest of efficient organization, the Mud Bay Planning Area was further divided into several distinct Sub-Planning Areas based on shared geographical or coastal flooding characteristics. The seven Mud Bay Sub-Planning areas are Inter River West, Inter River East, Colebrook, Serpentine North, Nicomekl South, the Nico Wynd Area, and the Mud Bay Foreshore. Figure 14 illustrates the CFAS Planning Areas and the Mud Bay Sub-Planning Areas.

FIGURE 13: *Serpentine and Nicomekl Rivers Watershed*

FIGURE 14: *CFAS Planning Areas and Sub-Planning Areas*

3.2 PLANNING APPROACH

Given the complexity of the issues the project addresses, the CFAS planning process was designed to be adaptive and flexible and accommodated new stakeholders and information (project learning) as it moved forward over the three-year planning process.

Project planning included a considerable technical analysis and modelling led by project engineers and supported by City of Surrey staff. Technical analysis was augmented and enriched through a partnership with University of British Columbia School of Architecture and Landscape Architecture and a unique research project which brought in Dutch flood management experts, landscape architects, and engineers (LINT Middelburg, Royal Haskoning DHV).

The decision process interwoven through the project phases was first outlined in a *Decision Support Framework* brief which outlined the use of two methodologies that helped set CFAS apart from conventional flood planning work.

- ***Structured Decision-Making (SDM):*** SDM is an approach for helping groups, stakeholders, technical experts and decision makers to think through complex problems that are layered with uncertainty, involve diverse stakeholders with competing values and preferences, and require a final decision that is embedded with difficult trade-offs. SDM is a rigorous deliberative decision-making process that provides insights about the decision by:
  - Focusing on the things people care about (values);
  - Systematizing what we know about the problem and solutions (facts);
  - Identifying whether any disagreements are about facts (i.e., uncertainty) or values;
  - Allowing for iterative and creative alternative generation; and
  - Allowing groups to transparently explore the trade-offs between choices so that an informed and defensible decision can be made.
- ***Impact scenario planning:*** Scenario planning is an approach for addressing uncertainties in a planning context. It is based around the construction of a small number of contrasting narratives (stories) about what could happen in the future. The goal is not to identify as closely as possible what will happen (i.e., a forecast), or what should be done (e.g., a policy recommendation), but to explore the wide possibilities of what the future can bring, and hence better understand the inherent uncertainty in the problem being addressed. The intent is to provide a mechanism for testing options, strategy, and behaviours under a range of credible future scenarios.

These two methodologies were used throughout the decision process. Scenarios were used to elicit public values and options for addressing coastal flood hazards under a set of different possible futures. The values were then used to develop objectives to evaluate how well flood management options performed across the scenarios.

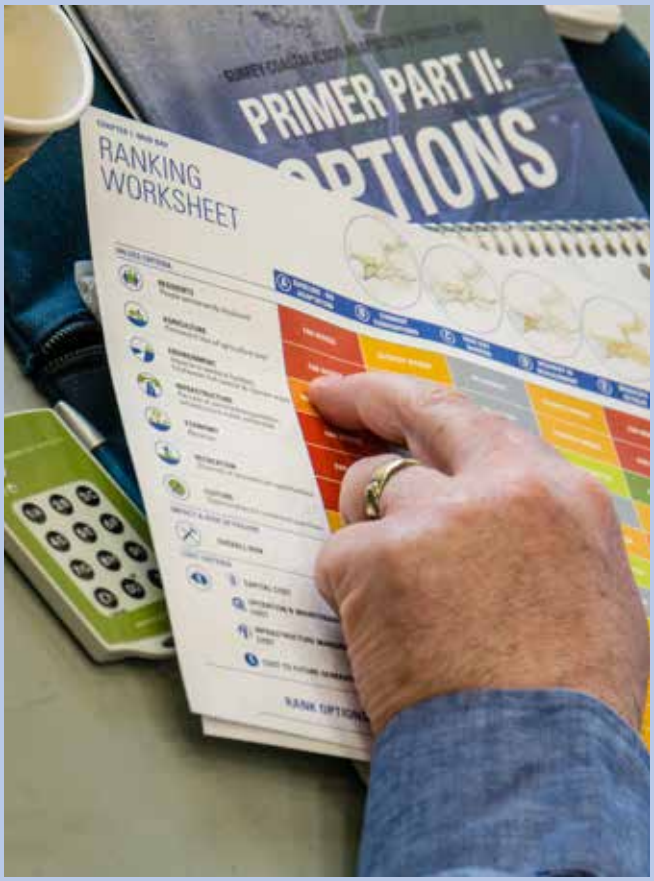
The purpose of utilizing these two methodologies was to provide a rigorous decision framework and common language to support dialogues, debate, and decision-making around the question: "What is the best strategy for adapting to coastal flooding today and into the future?"

> "We were part of the process and part of the decision-making, and that's participatory democracy in action."
>
> *– CFAS participant*

CFAS - A STRUCTURED, VALUES-BASED DECISION-MAKING APPROACH

In undertaking CFAS, the City of Surrey made a conscious decision to take a structured, values-based decision-making approach. The reason for this approach was to ensure that the project team understood what residents, stakeholders, and project partners' values are – what they care about –and how these values influence the development of adaptation approaches and priorities. Here are six reasons why Surrey adopted a values-based decision analysis approach for CFAS.

- ***Facts and values*** – The approach used both technical facts (e.g., cost, feasibility, risk) and community values (e.g., protect farm land, enhance environmental values, maintain public access) to help identify, screen, and prioritize strategy options.
- ***Multiple perspectives*** – The approach facilitated a broader understanding of the variety of perspectives that are important to consider when making the difficult decisions that climate change adaptation presents. This included the review and incorporation of different City plans and strategies.
- ***Holistic*** – By involving a wide range of participants, stakeholders, and the public, the approach was more inclusive and took into account non-material aspects of community wellbeing and quality of life.
- ***Local knowledge*** – The approach used multiple types of knowledge, expertise and qualitative information, alongside the more scientific, quantitative information from technical studies and assessments.
- ***Participatory*** – Acknowledging the different values that people held helped build common ground and enabled a better, shared understanding of present issues and the pressing climate change challenge. Surrey's approach to community planning explicitly recognizes that local stakeholders and residents will more likely support strategy options if they have been meaningfully engaged in the decision process and their local values have helped shape and refine plan options.



3.3 ENGAGEMENT

Comprehensive engagement with internal and external stakeholders and partners was a core project objective and integrated with a structured, value-based planning approach which meaningfully engaged participants in project decision-making. Over the three-year planning process, CFAS actively involved Semiahmoo First Nation, residents, farmers and the agricultural community, community and environmental organizations, business associations and group, provincial and federal agencies and Ministries, and neighbouring jurisdictions. Over 30 organizations, agencies, and governments participated in the project, while over 2,000 residents and other stakeholders attended workshops, open houses, focus groups, or participated through project surveys and other engagement events. Project communications generated major national media coverage and over a quarter million social media impressions.

CFAS communications and engagement also greatly increased shared understanding of the significant challenges ahead for Surrey in the face of climate change-driven coastal flooding, with public appreciation and understanding of the issue noticeably shifting and expanding over the course of the project. Participants were consistently asked a number of questions at CFAS engagement events (workshops, focus groups, open houses) to ensure that their needs were being addressed in the engagement process. The table below summarizes the overall response from all CFAS engagement events.

At the outset of the project three linked frameworks were produced, a Decision Support Framework, a Stakeholder Engagement Framework and an integrated Communications and Media Framework. The Decision Support Framework detailed CFAS's participatory, community values-based planning approach, methods, data needs, and decision points. It was closely integrated with a Stakeholder Engagement Framework, which guided the project team's work in gathering input and feedback for CFAS. The Media and Communications Framework laid out a process to inform the local community and stakeholders and support productive change management given the significant challenges posed by sea level rise.

FIGURE 16: *Integrated Engagement, Communications and Decision-making Frameworks*

FIGURE 15: *CFAS participant feedback*

QUESTION	RESPONSE
You understood the information that was presented	99% Agree
The logistics (location, time) of the Workshop were suitable	97% Agree
You felt your opinion was heard	96% Agree
You will like to continue to be involved in the CFAS planning process	86% Agree
The length of the workshop was just right:	85% Agree

The broad goals of the Stakeholder Engagement Framework were to:

- Ensure engagement was linked to, and integrated with the project's overarching, participatory, decision-making process and Decision Support Framework
- Ensure engagement was consistent with City of Surrey's guiding Consultation Principles.
- Ensure that a broad range of stakeholders were meaningfully engaged, and able to participate at key decision points through the process.
- Set out clear goals and objectives for project engagement and communications at each phase of work so that stakeholders and partners understood how they could participate and how their input was incorporated at key project decision points.
- Educate stakeholders, partners and the public on coastal flood hazards, climate change and sea level rise, and adaptation pathways.

The application of IAP2 (International Association for Public Participation) Best Practices of Engagement also helped implement and achieve City Consultation Principles, and meet Surrey's broader CFAS goals:

- Increase awareness and understanding of climate change and coastal flooding;
- Build adaptive capacity and coastal community resilience; and
- Strengthen relationships with implementation partners and stakeholders.

CFAS engaged a range of stakeholder groups and partners through all project phases using various avenues and approaches. Core groups included the following.

- ***CFAS Steering Committee:*** An internal, interdepartmental City of Surrey project working group made up of senior staff from Engineering (project lead; Drainage, Utilities, Transportation, Communications), Planning & Development (Community Planning), Parks, Recreation & Culture (Parks Planning, Sustainability Office), and Finance & Technology (Risk Management, Finance).
- ***CFAS Advisory Group:*** A volunteer group of representatives from key partner and stakeholder organizations and agencies. The group met several times over the course of the project and were an integral part of the decision-making process. Advisory Group members and the organizations they represented also met through themed sector workshops (e.g., Agriculture and Farming, coastal regulators) or other CFAS initiatives (e.g., Green Shores). Participants included:
  - ***Local Governments:*** Semiahmoo First Nation, City of White Rock, City of Delta, Metro Vancouver, City of White Rock


Sandy beaches, by Janine Hudson

- ***Agencies & Ministries:*** Department of Fisheries and Oceans (DFO), Ministry of Transportation and Infrastructure (MoTI), Ministry of Forest, Lands and Natural Resource Operations and Rural Development (FLNRORD), Fraser Basin Council, BC Climate Action Secretariat, Emergency Management BC (EMBC), Provincial Agricultural Land Commission (ALC)
- ***Environment & Recreation:*** Ducks Unlimited Canada, Friends of Semiahmoo Bay Society, Stewardship Council of BC (Green Shores), Little Campbell Watershed Society, Nicomekl Enhancement Society, Surrey Environmental Partners, Ducks Unlimited Canada, Bird Study Canada
- ***Utilities & Transportation:*** BC Hydro, Metro Vancouver, Ministry of Transportation and Infrastructure
- ***Agricultural:*** Ministry of Agriculture, Delta Farmers' Institute, Hopkins Berry Farm, Kooldale Farms, Lindrian Farms, M&M Pacific Coast Farms, Mud Bay Dyking District, Winners Holstein Ltd.
- ***Residents & Business:*** Crescent Beach Property Owners Association, Surrey Board of Trade, Fraser Valley Real Estate Board, Nicowynd Strata, Anderson Walk Strata, Surrey Heritage Advisory Commission, Westland Insurance Group, Insurance Bureau of Canada, residents at large.
- ***Academic/Other:*** UBC SALA (School of Architecture and Landscape Architecture), Engineers and Geoscientists BC, Kwantlen Park University, University of the Fraser Valley, UBC SCARP (School of Community and Regional Planning), Surrey Schools representatives.

- ***City of Surrey Committees:*** Project staff made introductory presentations and follow up presentations as requested to existing City of Surrey committees and working groups throughout the project. These standing committees included:
  - Transportation and Infrastructure Committee (TIC)
  - Lowland Dyking Stakeholder Group (LDSG)
  - Agriculture and Food Security Advisory Committee (AFSAC) (now the Agriculture and Food Policy Advisory Committee (AFPAC)
  - Environment Sustainability Advisory Committee (ESAC)
  - Parks, Recreation and Sport Tourism Committee (PRSCTC)
  - Development Advisory Committee (DAC)
  - Public Art Advisory Committee (PAAC)
  - Surrey Heritage Advisory Commission (SHAC)
  - Public Engagement Task Force (PETF)

- ***Semiahmoo First Nation:*** With its principal Reserve located on the majority of one study area, and cultural, traditional use, and archeological sites existing throughout the other two CFAS study areas, Semiahmoo First Nation was a core project partner who was engaged through a parallel process, in addition to participating in many CFAS events.

- ***Regulators, Land Stewardship Groups, Asset Owners:*** Workshops were held with land stewardship groups, subject matter experts, coastal regulators, infrastructure owners/operators, and emergency responders that included additional input from many of the organizations involved in the CFAS Advisory Group, but also included: BC Agriculture and Food Climate Action Initiative, Vancouver Fraser Port Authority, Delta Farmland & Wildlife Trust, West Coast Environmental Law, Engineers Canada, BC Ambulance Services, RCMP, Canadian Coast Guard, BC Climate Action Secretariat, FortisBC, Surrey Fire Services, Burlington Northern Santa Fe Railway, A Rocha Canada, Surrey Search and Rescue, Shaw, Ministry of Environment, SRY Rail Link, and Telus.

  The BC Stewardship Centre also hosted Green Shores workshops to engage community members, design professional, regulators, and community groups in exploring Green Shore options for the CFAS Study Area. Ducks Unlimited also brought together experts in the region for a vulnerability workshop that assessed the impacts of sea level rise in Mud Bay on critical bird habitat.

- ***General Public:*** Broader-scale engagement involving general outreach activities and events in both in-person and digital formats, project open houses, pop-up events in the study areas, a travelling community road show (featuring a 5 metre high banner that illustrated the anticipated height for dykes by 2100), and exhibits at community events and festivals throughout Surrey (e.g., Party for the Planet). While children and youth are often not involved or specifically targeted in many municipal outreach activities, project organizers recognized that younger generations will be significantly influenced by the CFAS decisions being made today; therefore, special emphasis was placed on engaging with younger generations. Elementary and secondary school students were engaged through classroom sessions and activities on sea level rise and CFAS adaptation options, while university students (University of British Columbia and University of the Fraser Valley) were invited to collaborate with the CFAS team to gain valuable experience in the fields of human geography, community planning, and landscape architecture, as well as to provide their own feedback on the CFAS project

  Crescent Beach residents were also engaged in a series of interactive workshops to explore potential responses to future coastal flooding risks in the area. West Coast Environmental Law and Simon Fraser University's Adaptation to Climate Change Team (ACT) supported the workshop series. Their ideas were captured in Crescent Beach Community Meeting Series: summary Report on Coastal Flooding and Climate Change.

- ***Property Owner Associations:*** Crescent Beach Property Owners Associations, Nico Wynd Strata, Ocean Park Community Association, Mud Bay Dyking District

In addition to these engagement activities, two PIEVC infrastructure workshops were held. The first workshop used Engineers Canada's PIEVCTM High Level Screening Tool to receive input on infrastructure flood risks and adaptation options. The second PIEVC workshop explored and validated preferred adaptation options, and detailed types of factors, applying triple bottom line principles, that are most important when making decisions.

Figure 17 provides a summary of engagement and outreach highlights during the project's first three phases. A comprehensive summary of Phase 1 to 3 is available in the project's Engagement Summary Report Phases 1-3.

FIGURE 17: *CFAS – Engagement Summary Snapshot*

CFAS | SURREY

www.surrey.ca/coastal
#SurreyCoastal

COMMUNITY, STAKEHOLDER & PARTNER ENGAGEMENT

Developing a direction for coastal adaptation with the community

6
MEETINGS AND SITE VISITS
with Semiahmoo First Nation

3
FOCUS GROUPS
(Agriculture & Farming, Community & Residential, Environment & Recreation)
60+ participants

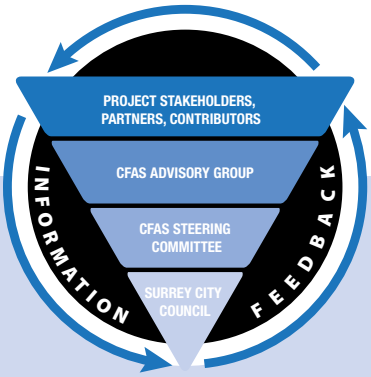
7
TECHNICAL WORKSHOPS
2 Greenshores™ Shoreline Design workshops, 2 PIEVC™ infrastructure operators workshops, 2 Design workshops with Dutch engineering design experts and UBC researchers, Coastal regulators, Coastal stewards

3
CFAS ADVISORY GROUP WORKSHOPS
With project stakeholders and partners, including local governments, infrastructure operators, provincial agencies, organizations, residents and farmers

5
CRESCENT BEACH COMMUNITY WORKSHOPS
140+ attendees

2
BUS TOURS
Site tour and "walk-shops" around the CFAS study area
70+ participants

200+
SURREY YOUTH ENGAGED
5 sessions with high school students, 2 youth events at City Hall, and 80 CFAS postcards completed by elementary school students



2
PROJECT OPEN HOUSES
engaging residents, business owners, and other stakeholders

8
POP-UP PROJECT OUTREACH STATIONS
Crescent Beach, Blackie Spit, SFU Surrey, Surrey Centre/Ocean Park/ Semiahmoo Public Libraries, Surrey City Hall, Alexandra House (Crescent Beach)

500+
WORKSHEETS COMPLETED
At various engagement events and workshops

250,000+
SOCIAL MEDIAL IMPRESSIONS
Instagram & Twitter (200+ #SurreyCoastal mentions), Facebook (100+ CFAS comments), LinkedIn, YouTube (1,000+ hours of CFAS video views), CFAS website and StoryMaps (10,000+ views)

2,000+
COMMUNITY MEMBERS
directly involved to date

200+
COMMUNITY CONVERSATIONS
at Crescent Beach pop-up event hosted with 40+ University of the Fraser Valley Geography and Environment students

1
#SURREYCOASTAL PHOTO CONTEST
200+ submissions on Facebook, Twitter, and Instagram with winners in three categories

1,000+
SURVEYS
Completed online, at CFAS workshops, at community events, and by CitySpeaks Members

600+
CFAS DOOR HANGERS
Hung on Crescent Beach doors

30+
ORGANIZATIONS, AGENCIES, LOCAL GOVERNMENT PARTNERS, CITY OF SURREY COMMITTEES, AND COMMUNITY GROUPS INVOLVED
Keeping partners and stakeholders engaged

10,000
COMMUNITY MAILERS
Sent to Surrey residents in the CFAS study area and beyond

3
PROJECT VIDEOS
Available on-line and shown at community events

6
BIG MEDIA HITS
CBC Early Edition and The Current (national), articles in the Vancouver Sun, The Province, Globe and Mail, and 24 Hours newspaper reaching over 100,000+ Metro Vancouver residents

A COMMUNITY LED, BOTTOM UP APPROACH IDENTIFIED THE VALUES TO PROTECT IN A CHANGING CLIMATE

Economy | Infrastructure | Environment | Communities

"We have the opportunity here to really set a precedent for BC and the Pacific Coast on how we adapt to sea level rise and climate change and placing that value in the environment."

– CFAS participant

"We were part of the process and part of the decision-making, and that's participatory democracy in action."

– CFAS participant

3.4 CFAS ORGANIZATION

The overarching goal of CFAS was to develop a broadly supported strategy to reduce coastal flood risk in Surrey. This primary goal is supported by eight core strategy objectives.

As illustrated in Figure 18, CFAS Program and Policy Actions and Planning Area-specific Actions were informed by and guided by Planning and Design Principles and Flood Management Values that were co-developed with CFAS partners and stakeholders through Phases 1 to 3. Individually and collectively, the Actions are structured to help achieve larger CFAS Objectives. These core strategy components are described in this section.

3.4.1 CFAS Objectives

CFAS Objectives represent the overarching flood management aims for CFAS. Individually and collectively they will help support the achievement of the Strategy's primary goals which was to develop a broadly supported strategy to reduce coastal flood risk in Surrey.

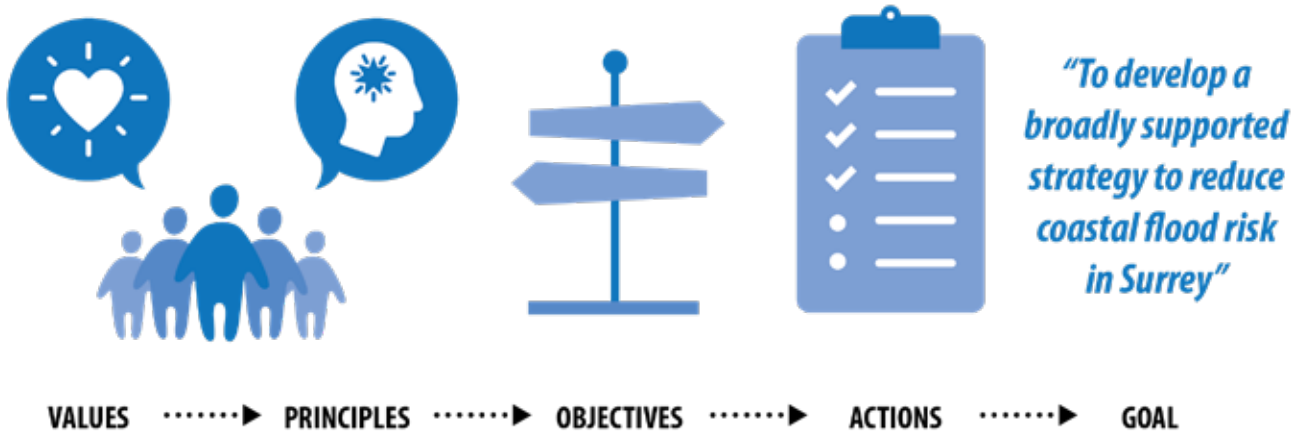
The CFAS planning objectives were first pulled from Surrey's Climate Adaptation Strategy, the overarching plan under which CFAS was developed. The original objectives, which cut across multiple sectoral areas -- Flood Management and Drainage; Infrastructure; Ecosystems and Natural Areas; Urban Trees and Landscaping; Agriculture and Food Security; Human Health and Safety – and were refined through the CFAS process.

Along with CFAS Planning Principles and CFAS Flood Management Values, CFAS Objectives also support detailed planning for short-term Actions, and future decision-making around longer-term Actions and CFAS Updates.

The CFAS Objectives are:

1. *Improve resilience of existing infrastructure*
2. *Ensure new infrastructure is resilient and adaptive*
3. *Update regulatory controls to improve resiliency*
4. *Ensure that flood management infrastructure and programs steward and enhance ecosystems and natural areas where practical and possible*
5. *Coordinate with, and contribute to, regional flood management strategies*
6. *Improve emergency response program for extreme flood events*
7. *Improve coastal flood hazard awareness, education, and communication*
8. *Improve and enhance monitoring and evaluation to keep CFAS up-to-date*

FIGURE 18: *CFAS - Strategy Organization*



3.4.2 CFAS Actions

Actions are projects, programs, and policies that are proposed to be implemented to address coastal flooding and sea level rise, improve resiliency of the floodplain area, and achieve CFAS Goals.

CFAS presents a total of 46 Actions. These are divided between CFAS Program and Policy Actions CFAS Planning Area-specific Actions. Program and Policy Actions apply across the larger CFAS Study Area and its three distinct Planning Areas (Mud Bay, Crescent Beach, Semiahmoo Bay). Area-specific Actions are primarily infrastructure-related projects to be implemented in specific areas in the CFAS Study Area. Collectively, these Actions are at the heart of CFAS. Individually and together, their implementation will involve numerous City departments, outside agencies, senior levels of government, and community-based organizations over the coming years and decades.

A number of Program and Policy Actions and Planning Area-specific Actions have been prioritized as more tactical, shorter-term to be implemented between 2020 to 2030. Other Actions will be implemented as conditions warrant over the longer-term, with a potential implementation period that stretches to 2080. The shorter-term CFAS Actions collectively represent so-call "low-regret" or "no-regret" flood management projects, investments, and policies that will help address current concerns while laying the path for more complex and challenging Strategic Directions over the longer-term. Low-regret projects are defined as relatively low-cost Actions that provide relatively large benefits under predicted future climates that contribute to adaptation while other social, economic and environmental benefits, including climate change mitigation benefits.

Both Planning Area-wide Actions and Sub-Planning Area-specific Actions are presented in Section 4.

3.4.3 CFAS Flood Management Values

The CFAS Flood Management Values represent the community concerns and desires that residents and other stakeholders care about most in the larger CFAS Planning Area.

The Flood Management Values were first identified during community workshops and focus groups with residents, farmers and the agricultural community, environmental organizations, and other stakeholders. These values represented the coastal flood impacts and issues project stakeholders and partners were most concerned about.

Towards the end of the second phase of CFAS, the impacts and concerns were organized into

general thematic categories – Community and Residential, Agriculture and Farming, Environment and Recreation, Transportation and Infrastructure, Local and Regional Economy – and project stakeholders and partners were asked to first confirm and validate the categories and to identify any additional general areas of concern. From this work, Environment and Recreation became individual value areas, while Culture was identified as new and important value area.

Measures or "values criteria" were then developed for the value areas allowing them to be used along with technical engineering criteria to help evaluate potential broad-scale adaptation approaches (i.e., resist, accommodate, move) developed during Phase 3 of the project. The seven values criteria were:

RESIDENTS: *Minimize people displaced*

AGRICULTURE: *Reduce permanent loss of agricultural land*

ENVIRONMENT: *Minimize impacts to wetland habitats and riparian areas*

INFRASTRUCTURE: *Minimize vulnerabilities*

ECONOMY: *Minimize loss of local businesses*

RECREATION: *Maximize recreational opportunities*

CULTURE: *Maximize opportunities for traditional practices*

The use of values in the evaluation of adaptation options helped ensure that the flood adaptation options developed for CFAS incorporate community concerns but will also help support future conversations around potential trade-offs within and between community values during later updates to CFAS and detailed planning for shorter-term CFAS Program and Policy Actions and Planning Area-specific Actions. The use of values in CFAS decision-making also helped ensure that the long-term Strategic Directions incorporate and respond to community concerns. They are also closely associated with CFAS Planning and Design Principles which are outlined in the next sub-section.

Figure 19 illustrates how value criteria were used along with risk and cost criteria to assess options. The figure is from Primer II Mud Bay Options.

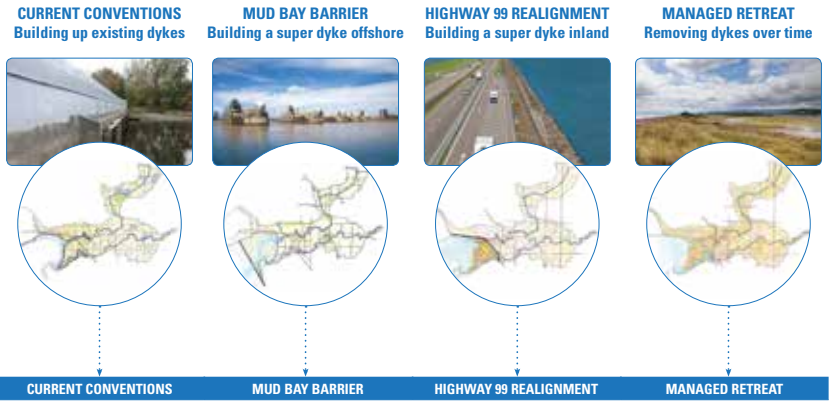
"When you see the area, there's a lot to gain here. There's a probability to restore old natural systems, to create value, not to say that the current land use is not value, but it's a single value, it's simple."

– CFAS participant

FIGURE 19: *Shortlisted Options Mud Bay – value assessment*

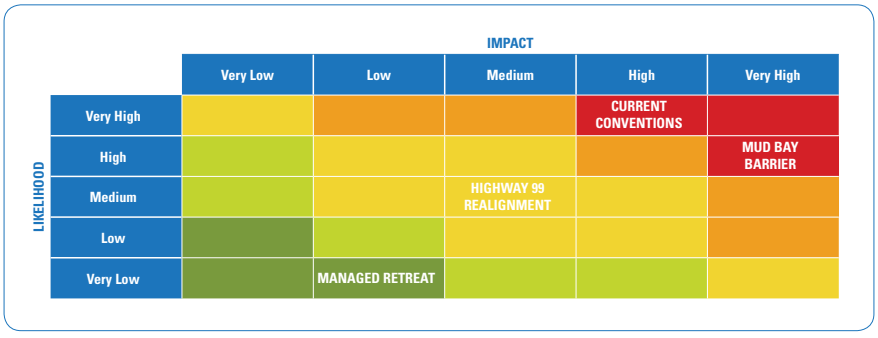
SHORTLISTED OPTIONS – MUD BAY

The summary table compares the short-listed options for the Mud Bay study area. The overview includes a "Baseline" or "No Adaptation" option for reference. Full descriptions of the short-listed options are available in the Primer (Primer Part II: Options).



	BASELINE - NO ADAPTATION	CURRENT CONVENTIONS	MUD BAY BARRIER	HIGHWAY 99 REALIGNMENT	MANAGED RETREAT
VALUES CRITERIA					
RESIDENTS *People permanently displaced*	FAR WORSE	SLIGHTLY WORSE	NO CHANGE	SLIGHTLY WORSE	FAR WORSE
AGRICULTURE *Permanent loss of agriculture land*	FAR WORSE	SLIGHTLY WORSE	NO CHANGE	SLIGHTLY WORSE	FAR WORSE
ENVIRONMENT *Impacts to wetland habitats, freshwater fish habitat & riparian areas*	MODERATELY WORSE	FAR WORSE	FAR WORSE	SLIGHTLY BETTER	FAR BETTER
INFRASTRUCTURE *Percent of service/transportation infrastructure made vulnerable*	FAR WORSE	NO CHANGE	NO CHANGE	NO CHANGE	SLIGHTLY WORSE
ECONOMY *Revenue*	FAR WORSE	SLIGHTLY WORSE	NO CHANGE	SLIGHTLY WORSE	MODERATELY WORSE
RECREATION *Diversity of recreational opportunities*	FAR WORSE	NO CHANGE	SLIGHTLY WORSE	SLIGHTLY BETTER	MODERATELY BETTER
CULTURE *Opportunities for traditional practices*	SLIGHTLY WORSE	NO CHANGE	MODERATELY WORSE	NO CHANGE	NO CHANGE
IMPACT & RISK OF FAILURE					
OVERALL RISK	VERY HIGH	VERY HIGH	VERY HIGH	MEDIUM	VERY LOW
COST CRITERIA					
CAPITAL COST	—	$100M - $1B	MORE THAN $4B	$1B - $4B	$1B - $4B
OPERATION & MAINTENANCE COST	MORE THAN $10M	MORE THAN $10M	$1M - $10M	$1M - $10M	LESS THAN $1M
OTHER INFRASTRUCTURE COST	MORE THAN $100M	$10M - $100M	LESS THAN $10M	$10M - $100M	MORE THAN $100M
FUTURE ADAPTATION COST	$1B - $4B	$1B - $4B	$1B - $4B	$1B - $4B	LESS THAN $100M

RISK ASSESSMENT HEAT MAP



3.4.4 CFAS Planning and Design Principles

CFAS Planning and Design Principles are high-level guidelines that identify how CFAS Actions should be planned, designed, and implemented over time. They were developed post-facto community engagement but help further distill "what matters most" for residents, stakeholders, and partners and will help guide the detailed planning and design work associated with the shorter-term Planning Area and Sub-Planning Area Actions.

Ultimately, the Planning and Design Principles are a further outcome of the project's participatory, values-based planning approach. As guiding principles, they also reflect the accumulated knowledge, learning, and experience the Surrey project staff and consultant team gained over the three-year project cycle. They further reflect knowledge and input gained from external input provided by project partners including a unique partnership with University of British Columbia School of Architecture and Landscape Architecture which brought in Dutch flood management experts, landscape architects, and engineers (LINT Middelburg, Royal Haskoning DHV).

The CFAS Planning and Design Principles will provide direction for future phases of CFAS work, including the development of longer-term (2030 and beyond) flood management options, infrastructure design, and policy.

PLAN FOR MULTIPLE VALUES
Ensure that flood management actions support multiple community values wherever possible (e.g., environment, agriculture, residents, recreation, economy, culture)

PLAN FOR ADAPTABILITY
Develop flexible, adaptive options that can adjust to a wide range of future conditions, including the pace of sea level rise, the height of sea level rise, and future land uses.

DESIGN FOR/WITH NATURE
Protect and steward critical intertidal, foreshore, riparian, and terrestrial ecosystems, habitats, and species that make Surrey's coastal floodplain home, while supporting mitigation.

DESIGN FOR RESILIENCE
Ensure risks to lifeline infrastructure and services are minimized, and that redundant systems are in place in case of failure. And consider additional risks, including seismic and other climate change-related risks including extreme weather events and drought.

PLAN FOR COLLABORATION AND PARTNERSHIPS
Facilitate collective, cumulative action by coordinating and collaborating with project partners and stakeholders, including neighbouring municipalities, Semiahmoo First Nation, Provincial and Federal agencies and Ministries, and non-governmental organizations and associations.

PLAN FOR FOOD SECURITY
Steward and support local agriculture, including supporting adaptive approaches, methods, and new products to preserve the area's agricultural heritage.

Figure 20 illustrates the CFAS Flood Management Values and Values Criteria addressed and/or connected to CFAS Planning and Design Principles.

FIGURE 20: *CFAS Flood Management Values and Planning and Design Principles*

CFAS PLANNING AND DESIGN PRINCIPLES	CFAS FLOOD MANAGEMENT VALUES AND VALUE CRITERIA						
	RESIDENTS *Minimize people displaced*	***AGRICULTURE*** *Reduce permanent loss of agricultural land*	***ENVIRONMENT*** *Minimize impacts to wetland habitats and riparian areas*	***INFRASTRUCTURE*** *Minimize vulnerabilitie*	***ECONOMY*** *Minimize loss of local businesses*	***RECREATION*** *Maximize recreational opportunitie*	***CULTURE*** *Maximize opportunities for traditional practices*
Plan for multiple values							
Plan for adaptability							
Design for/ with nature							
Design for resilience							
Plan for collaboration and partnerships							
Plan for food security							

3.5 STRATEGIC DIRECTIONS

The longer-term Strategic Directions are based on an 80-year timeframe (i.e., to 2100) and represent the long-term outlook for flood adaptation for the three CFAS Planning Areas. Developed with input from project partners and stakeholders, the Strategic Directions also included considerable technical analysis by City of Surrey Engineering, project consultants, and supplemented with additional review provided through a unique research component involving UBC and Dutch flood management experts, landscape architects, and engineers (LINT Middelburg, Royal Haskoning DHV).

Initially, several potential option pathways, or Strategic Directions, were developed through an iterative, participatory and technical process. These are described in CFAS Primer Part II, Options. The longer-term Strategic Directions for each of the three Planning Areas were evaluated and refined by project stakeholders and partners during the third phase of the CFAS project ("What is acceptable?"). The process used for this is summarized in the CFAS Engagement Summary Report.

Final Strategic Directions are summarized next.

"Everyone sees the possibilities that you can create something unique here."

– CFAS participant

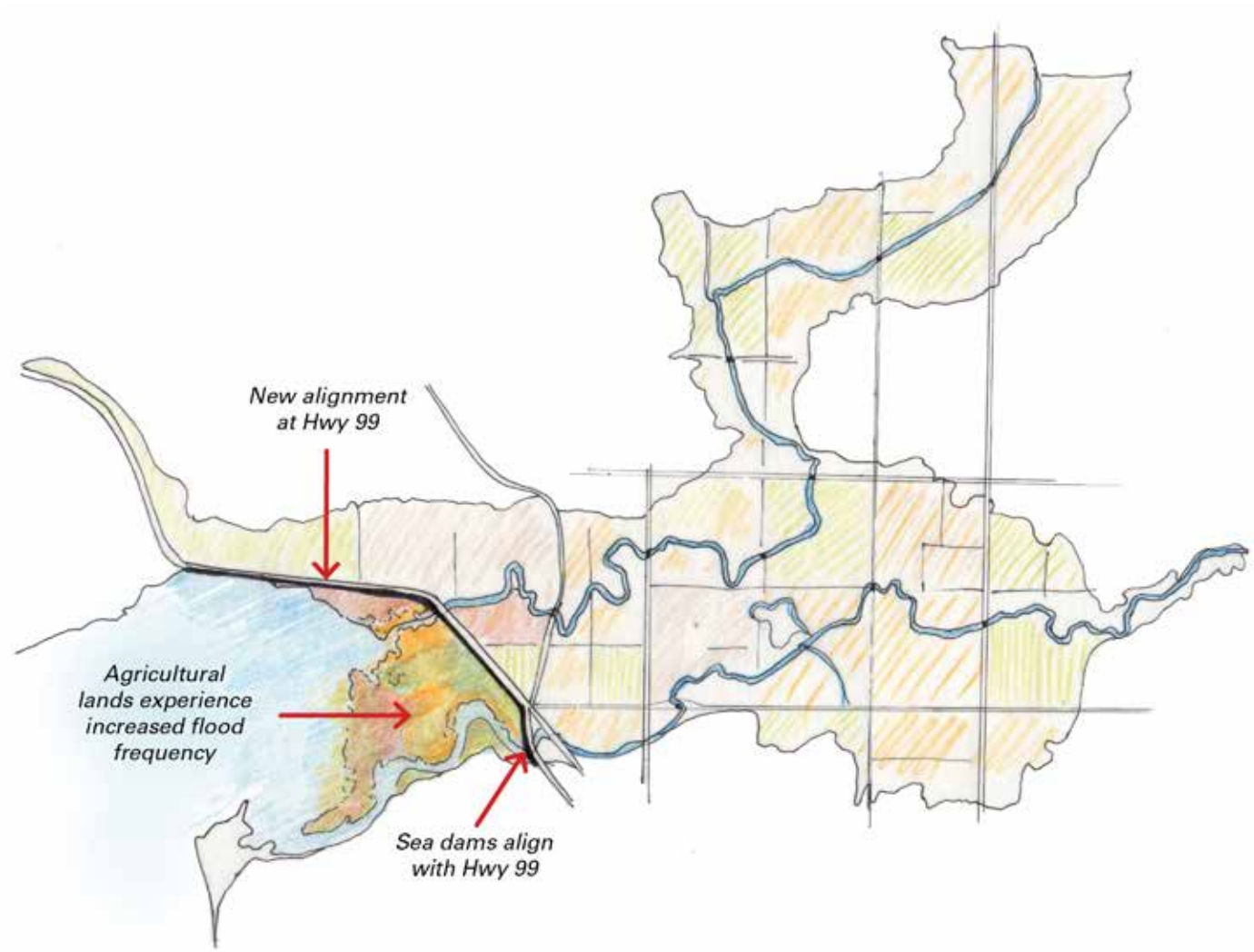
"Doing nothing is my least favourite option."

– CFAS participant

MUD BAY – COASTAL WORKS / HIGHWAY 99 STRATEGIC DIRECTION

The longer-term strategic direction for the Mud Bay Planning Area is to gradually develop new infrastructure and management approaches along the Highway 99 corridor to prepare for increased frequency of flooding. This agricultural area is complex, as there are numerous infrastructure corridors of regional, provincial and national significance. A shared desire to minimize increases in long term flood risk to critical infrastructure will be required for the Strategic Direction to be implemented. Further, extensive coordination between numerous agencies will be necessary.

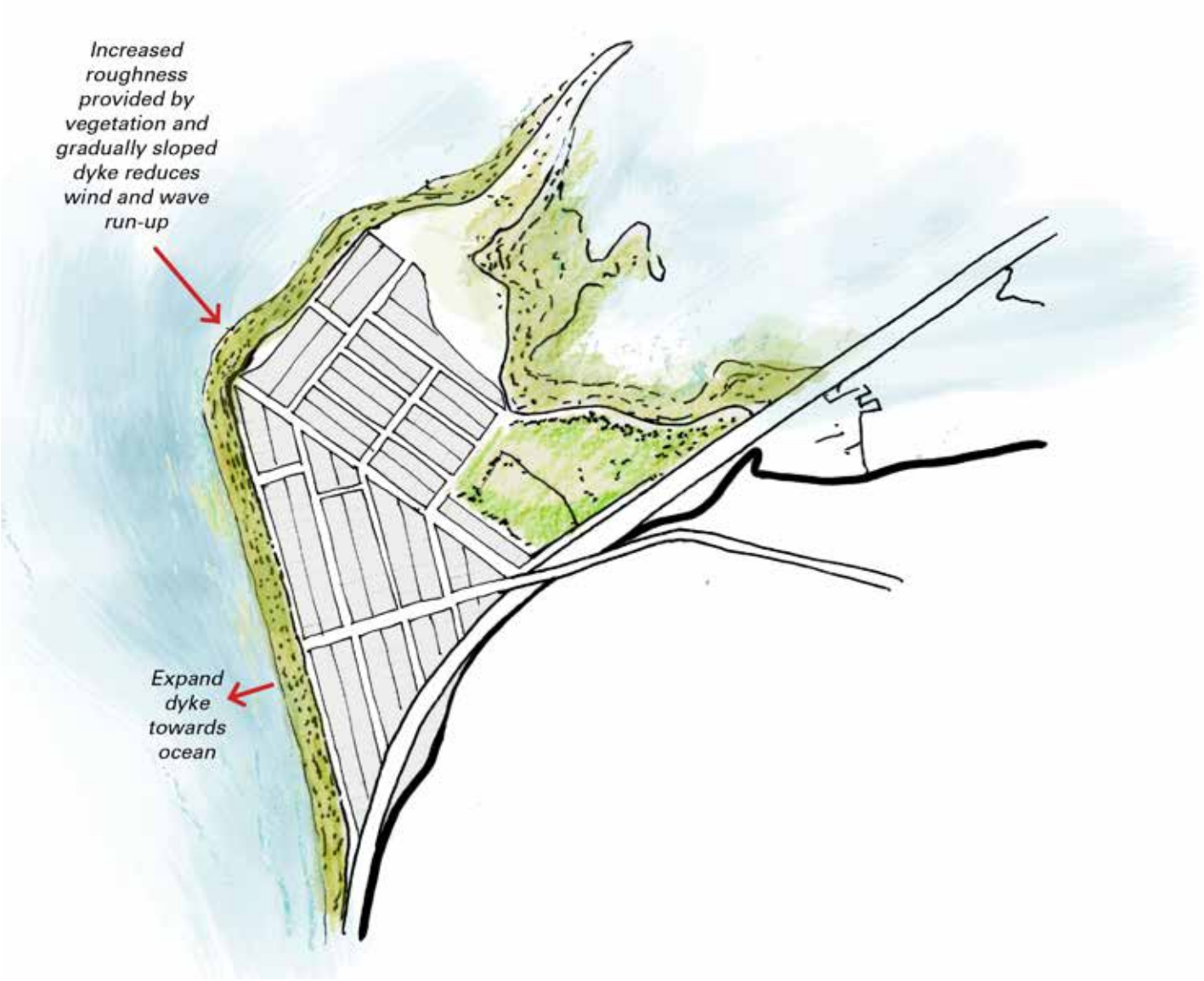
FIGURE 21: *Coastal Works / Highway 99 Strategic Direction*



CRESCENT BEACH – EXPANDED EDGE STRATEGIC DIRECTION

For Crescent Beach Planning Area, the longer-term planning challenges are even greater. Shorter-term tactical actions include a series of smaller-scale drainage improvements and regulatory changes (e.g., a higher flood construction level) until such point that sea level rise (observed increase and rate of rise) triggers an "expanded edge" approach. This approach could build up and extend the shoreline towards Boundary/Mud Bay and include additional drainage and flood management works in the Crescent Beach community. Given the technical complexity, archaeological significance and considerable cost considerations, the Strategic Direction will require more detailed planning. External and interconnected issues, such as flood insurance, property values and public risk perception are expected to influence triggers to implement longer-term actions impacting the primarily residential and recreational area.

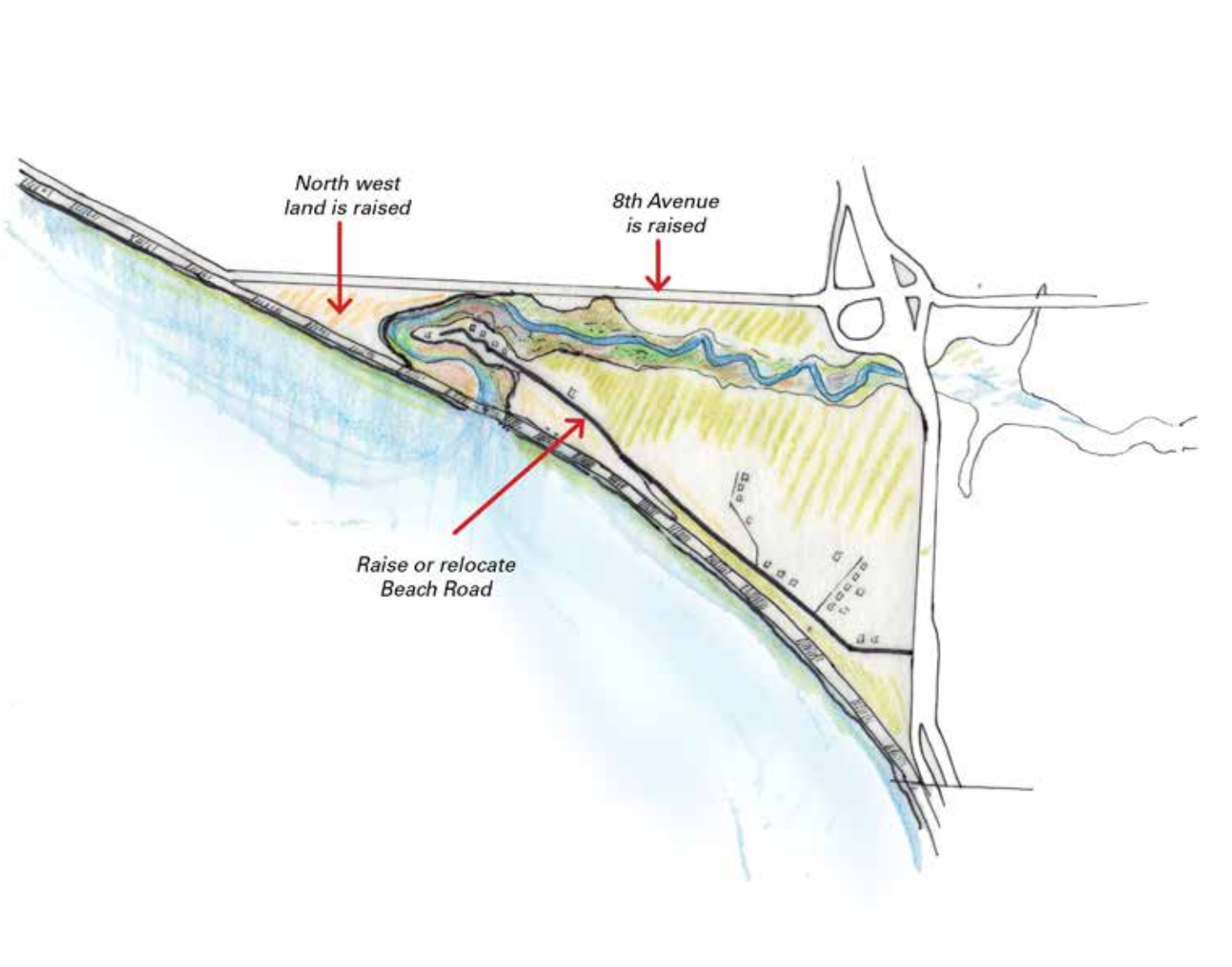
FIGURE 22: *Expanded Edge - Crescent Beach Strategic Direction*



SEMIAHMOO BAY – INFRASTRUCTURE IMPROVEMENTS AND LAND RAISING STRATEGIC DIRECTION

For Semiahmoo Bay Planning Area, relatively smaller and less dramatic interventions are envisioned. While many of the actions will need to be linked with the development of land within the Semiahmoo First Nation, there are long term, complicated coordinated works required along 8th Ave\Marine Drive that will require careful coordination and collaboration with Semiahmoo First Nation, the Federal Government, the City of White Rock, and the City of Surrey.

FIGURE 23: *Infrastructure Improvements & Land Raising – Semiahmoo Bay Strategic Direction*



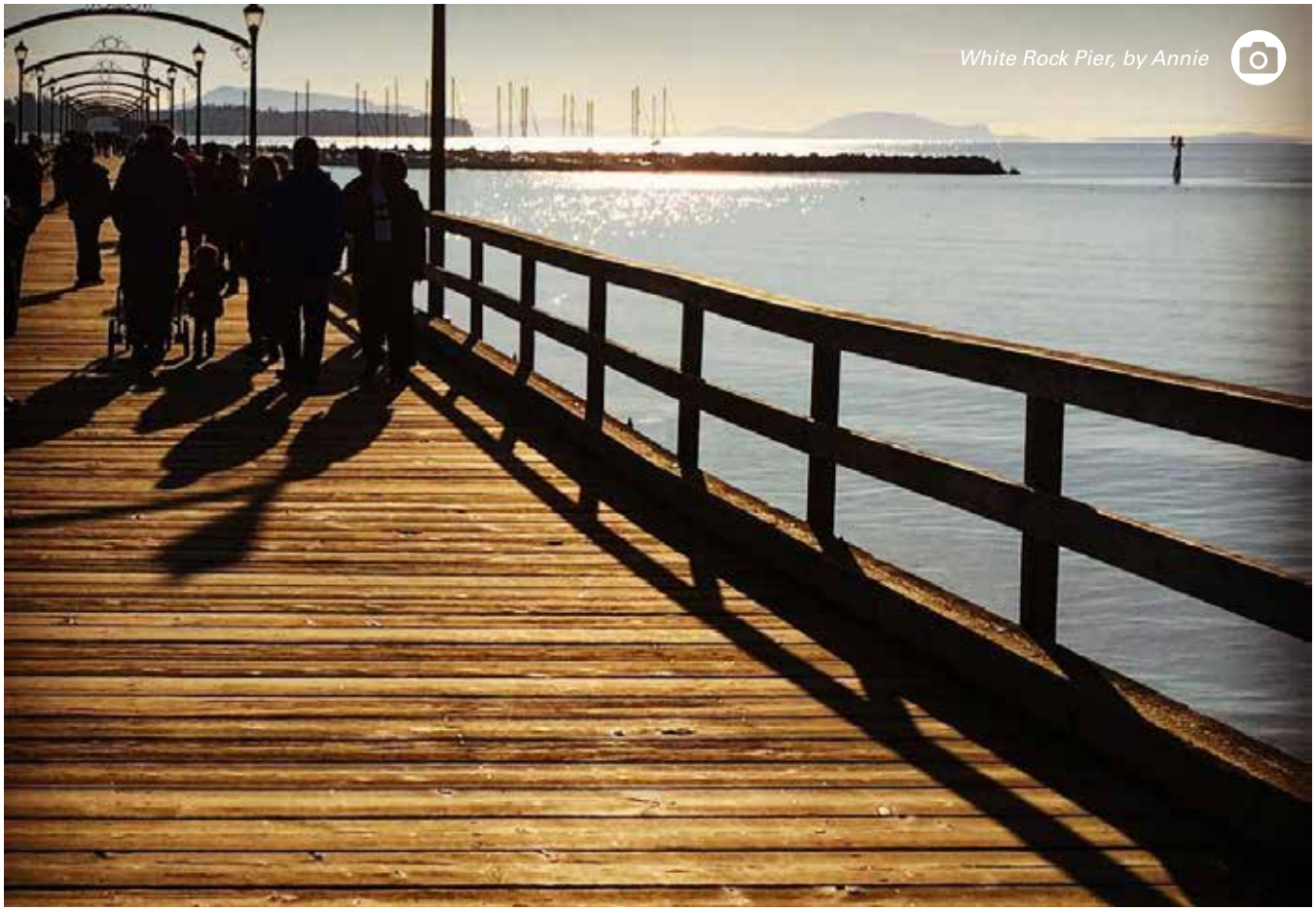
Establishing the final Strategic Directions was especially challenging. The shortlisted adaptation approaches outlined on the following table each involved difficult trade-offs and reaffirmed the fact that there is no silver bullet, win-win approach for sea level rise and coastal flooding. The bolded approaches indicate the approaches that were selected as the strategic direction in each study area. A full summary of the shortlisted options is available in CFAS Primer Part II.

FIGURE 24: *Adaptation Approaches and Preferences*

	MUD BAY	CRESCENT BEACH	SEMIAHMOO BAY
Preference ↑	1. Move (managed retreat) **2. Coastal Works / Highway 99** 3. Mud Bay Barrier 4. Current Conventions (i.e., "do nothing")	**1. Expanded edge** 2. Move (managed retreat) 3. Barrier Island 4. Mud Bay Barrier	1. Expanded Edge* **2. Infrastructure Improvements and Land Raising** 3. Current Conventions (i.e., "do nothing")

** Not within City's authority and not considered further*

In the shorter-term (2020 to 2030), CFAS includes 28 tactical, shorter-term Actions (Program and Policy Actions and Planning Area-specific Actions) which will help lay the groundwork and establish the pathway for the more complex Strategic Directions that will, over time, fundamentally change Surrey's coastline. Implementing these Actions will not always be easy and will involve the stakeholders and partners that helped develop CFAS, continuing to build confidence, capacity, and momentum to move forwards on the CFAS journey.



Taking aim, by ephr.aim

4. ACTIONS

Actions are at the heart of the CFAS. The CFAS Actions proposed here are intended to provide greater detail to the broad, general actions identified in the Climate Adaptation Strategy. This additional detail is provided in the form of proposed implementation approaches and timing, which should be used as a roadmap rather than a specific implementation plan. The projects, programs, and policies that are proposed here should be developed further at the time of implementation.

CFAS presents a total of 46 Actions. These are divided between CFAS Program and Policy Actions and CFAS Planning Area-specific Actions. Program and Policy Actions apply across the larger CFAS Study Area while area-specific Actions are primarily infrastructure-related projects to be implemented in one of its three distinct Planning Areas (Mud Bay, Crescent Beach, Semiahmoo Bay). Individually and together, the implementation of these Action will involve numerous City departments, outside agencies, senior levels of government, and community-based organizations over the coming years and decades.

A number of Program and Policy Actions and Planning Area-specific Actions have been prioritized as more tactical, shorter-term to be implemented between 2020 to 2030. Other Actions will be implemented in the period from 2030 to 2100 as conditions warrant. The shorter-term CFAS Actions collectively represent "low-regret" flood management projects, investments, and policies that will help address current concerns while laying the path for more complex and challenging Strategic Directions over the longer-term. Low-regret projects are defined as relatively low-cost Actions that provide relatively large benefits under predicted future climate scenarios.

Because of the need for upfront actions, it is anticipated that there will be a steep increase in Actions in the first decade (2020-2030). In succeeding decades, sustained implementation activities will have to be performed so that adaptation actions occur ahead of anticipated sea-level rise and corresponding increase in coastal flood risk.

The tables below summarize the Program and Policy Actions and Planning Area-specific Actions to be undertaken and the estimated implementation periods for them based on sea levels continuing to rise approximately 10 cm per decade. A complete table listing all actions and additional details on tools and resources required for implementation are included in Appendix I.

In the spirit of CFAS's participatory planning approach, and to highlight the central importance of partnerships, the tables indicate Action partners and key implementation collaborators.

FIGURE 25: *CFAS Program and Policy Actions - Summary*

		2020-30	2030-40	2040-50	2050-60	2060-70	2070-80	2080-90	2090-2100
Ongoing Education, Communications, and Advocacy Initiatives									
1	CFAS Steering Committee								
2	Internal Updates								
3	CFAS Advisory Group								
4	CFAS Website								
5	Advocacy Partners Workshop								
6	Communications and Media								
Detailing Planning, Studies, and Data Collection									
7	Update hazard bibliography								
8	Update coastal flood hazard assessment								
9	Detailed studies - Strategic Actions								
Regulatory Controls, Design Standards, and Guidelines									
10	Review Development Variance practices								
11	Support flood resilient design and construction								
12	Explore Sea Level Rise Planning Area								
13	Design Standards Guidebook								
Extreme Flood Management									
14	Hazard review								
15	Training and readiness								
16	Improve flood warning systems and communications								
17	Temporary protection measures assessment								
18	Build Back Better program								

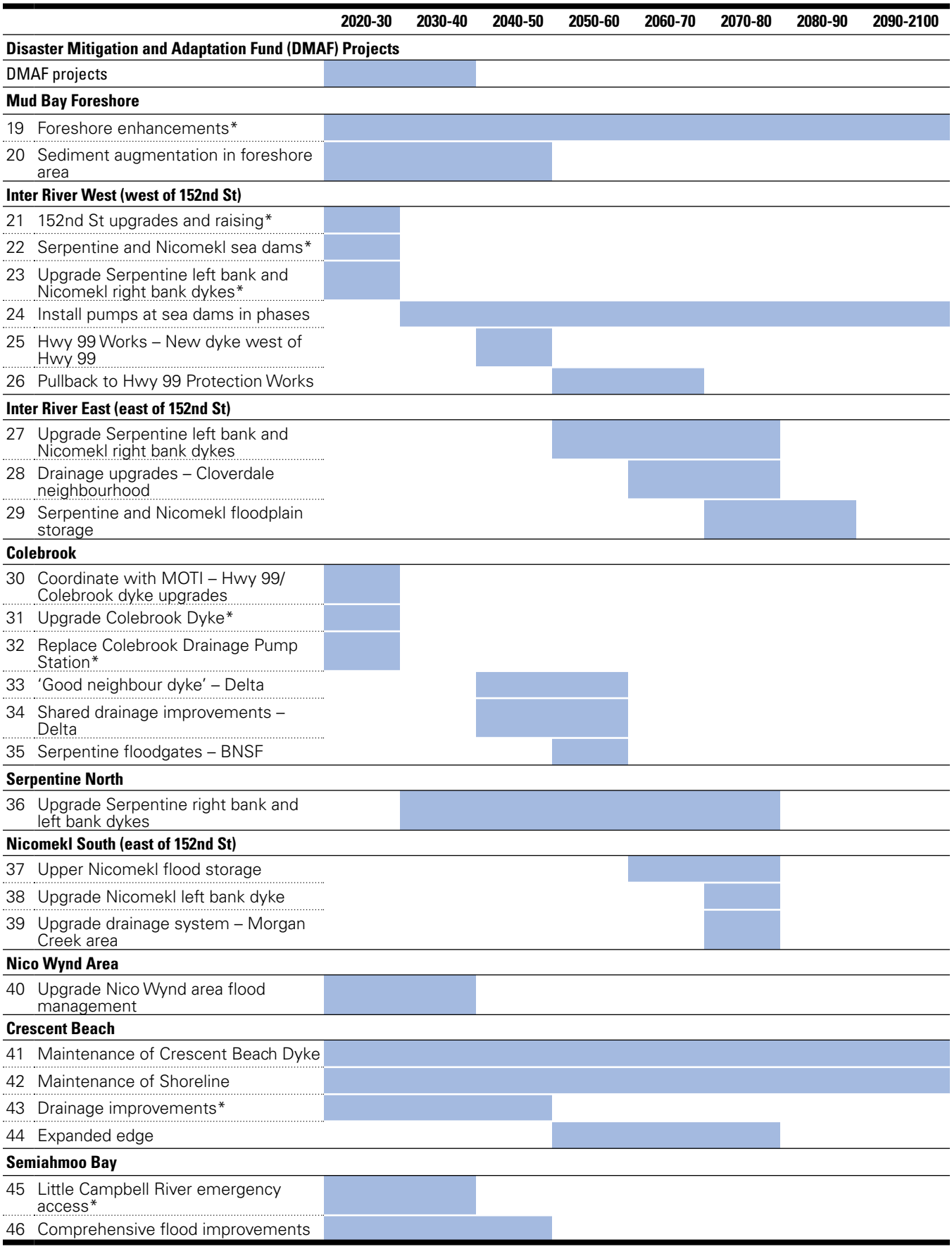
"I think it's a great process to be going through."

– CFAS participant

"There's really a need to do something now…"

– CFAS participant

FIGURE 26: *CFAS Planning Area-specific Actions - Summary*



** Indicates partial scope included in Surrey DMAF program*

Area-specific Actions under $5M capital cost are omitted for clarity

CFAS AND DISASTER MITIGATION AND ADAPTATION FUND (DMAF)

In 2018, during development of CFAS Phase 4, the Government of Canada announced the Disaster Mitigation and Adaptation Fund (DMAF) which aligned well with the objectives of CFAS. The first 3 phases of CFAS development provided a strong foundation to develop a comprehensive funding application and allowed Surrey and partners to compete in the national funding competition. The relationships with partners strengthened during CFAS development allowed for Semiahmoo First Nation, City of Delta and Metro Vancouver to apply for mutually beneficial projects under a single application with City of Surrey as the lead applicant.

Accordingly, a DMAF funding proposal was submitted by Surrey in January 2019 with a total project value of $187 million, supported by a Return on Investment ratio of 126:1. Thirteen mitigation measures were included in the DMAF application, as shown in the map and table in Appendix II (from report to Surrey's Council dated February 11, 2019). These measures are consistent with the long-term Strategic Directions of CFAS.

On Thursday, May 23rd Surrey was awarded DMAF funding, the largest single federal grant received by the City. A total of 13 projects were approved and summary sheets for each project is provided in Appendix II.

FIGURE 27: *DMAF Project Overview*

#	Component	Asset Type	Hazard Mitigation	Community Co-benefits	Values Protected	Partnership Opportunities
1	**Colebrook Dyke Upgrades**	Coastal Dyke		Recreation, bird watching, food security		
2	**Colebrook Drainage Pump Station Replacement**	Drainage Pump Station		Increased agricultural productivity and food security		
3	**Sea Dam – Serpentine River**	Sea Dam (drainage and irrigation)		Agriculture irrigation, fish passage, worker safety		
4	**152 St Road Upgrades and Raising**	Transportation Network		Congestion relief, transportation safety, accommodate growth, cycling, pedestrian		
5	**Nicomekl Riverfront Park - Phase 1**	Flood Storage		Recreation (blue way), nature trails, wetlands, culture, open space		
6	**King George Boulevard Bridge and Nicomekl River Sea Dam Replacement**	Arterial Bridge		Congestion relief, transportation safety, accommodate growth, cycling, pedestrian, integrated to Nicomekl Park, fish passage, agriculture irrigation		
7	**Crescent Beach Storm Sewer System Upgrades - Perforated Piping**	Flood Protection		Street beautification/ road improvements, transportation safety		
8	**Dyking - Lower reaches of Nicomekl and Serpentine**	Flood Protection		Food security and transportation flood safety		
9	**Serpentine SRY Rail Link Bridge Replacement and Dyking**	Flood Protection		Economy (freight and heritage railway), worker safety and goods movement		(Southern Railway of BC)
10	**Burrows Drainage Pump Station Upgrade**	Drainage Pump Station		Increased agricultural productivity and food security		
11	**Stewart Farm Sanitary Pump Station Coastal Flood Proofing**	Sanitary Sewer Network		Sanitation, worker safety and water quality		
12	**Campbell River Pedestrian and Emergency Access Bridge Replacement**	Transportation Network		Emergency access, Multi Use Path		
13	**Foreshore Enhancements**	Flood Control		Wetlands (birds, fish, clams) and food security		

Hazard Mitigation

= flood = seismic = drought

Values Protected

= economy = infrastructure = environment = communities

4.1 CFAS PROGRAM AND POLICY ACTIONS

Program and Policy Actions apply across the CFAS Study Area.

4.1.1 Ongoing Education, Communications, and Advocacy Initiatives

The scale and scope of the challenge of climate change and sea level rise demand not only a fundamental change in the approach to coastal flood management, but also in the education, communications, and advocacy required to bring along stakeholders and partners in the adaptation journey and conversation. Surrey's engagement with stakeholders and partners during CFAS development confirmed that many participants had limited awareness of the existing risk posed by coastal flood events exacerbated by climate change. Engagement also confirmed limited awareness around the effectiveness and standards of Surrey's existing flood management controls (dykes, sea dams).

- ***Education and Communications:*** Education and communications were core components of the CFAS process and included both internally-focused and public-facing education and communications around climate change-driven flood hazards and the adaptation approaches available to address them. While the efforts helped raise general community awareness and understanding, the need for continued education and communications around climate change remains. Because of the complexity of the issue and the corresponding complexity of CFAS Strategic Directions, educational activities and ongoing communications with partners and stakeholders should be a part of both short-term tactical actions and longer-term strategic actions.
- ***Advocacy:*** Surrey may not have authority or control over areas where CFAS stakeholders and partners have a common interest in an action, policy or outcome. This is why Surrey may need to take an advocacy-focused approach wherein the City works with partners and stakeholders to influence decision-makers, utilities, other local governments, and industry associations to help facilitate or expedite changes that may be required to support longer-term CFAS Strategic Directions. Actively participating and partnering with external groups engaged in advocacy will help advance common interests. A number of these groups have been actively engaged in the development of CFAS to-date and will play a role in implementing key aspects moving forward. A specific CFAS Action envisions Surrey encouraging the Province to organize a coastal flooding and sea level rise risk management workshop with a focus on the real estate considerations of CFAS Strategic Directions. At the national level, Surrey should advocate for the National Building Code to include flood tolerant provisions for building construction in floodplains.

ACRONYMS USED IN THIS SECTION

ALC
Agricultural Land Commission

BNSF
Burlington Northern Santa Fe Railway

DFO
Department of Fisheries and Oceans

EMBC
Emergency Management BC

FBC
Fraser Basin Council

FEI
Fortis Energy Inc.

IPREM
Integrated Partnership for Regional Emergency Management in Metro Vancouver

ISC
Indigenous Services Canada

MFLNRORD
Ministry of Forests, Lands, Natural Resource Operations and Rural Development

MOE
Ministry of Environment

MOTI
Ministry of Transportation and Infrastructure

NRC
National Research Council

SHaRP
Salmon Habitat and Restoration Program

FIGURE 28: *Education, Communications, and Advocacy*

ACTION		CITY LEAD	IMPLEMENTATION PARTNERS	TIMING
1	**CFAS Steering Committee:** Maintain CFAS Steering Committee as standing internal working group to meet semi-annually, or as needed.	Engineering		2020-2060
2	**Internal Updates:** Maintain internal City project information updates, including planning and implementation updates	Engineering		2020-2060
3	**CFAS Advisory Group:** Maintain CFAS Advisory Group as a formal, standing external working group to meet annually or as needed. Extend invitations to real estate, insurance, and financial industries.	Engineering	CFAS Stakeholder Groups	2020-2060
4	**CFAS Website:** Maintain and enhance project website and online materials as the primary information and communications portal containing current project information posted for public review, with supporting social media and e-newsletters.	Engineering		2020-2060
5	**Advocacy Partners Workshop:** Encourage the Province to organize a coastal flooding and sea level rise risk management workshop with Municipal Insurance Association of BC, Real Estate Foundation of BC, financial institutions/associations, Local Government Management Association of BC, West Coast Environmental Law, Fraser Basin Council, and other key stakeholder groups with a focus on the real estate considerations of CFAS Strategic Directions.	Sustainability	CFAS Stakeholder Groups	2020-2060
6	**Communications and Media:** Share CFAS updates with key Advisory Group partners (e.g., Fraser Basin Council) to disseminate information materials and updates on CFAS.	Engineering	Surrey Communications CFAS Stakeholder Groups	2020-2060

Priorities – Ongoing Education, Communications, and Advocacy

As indicated by the timeline of the above CFAS Actions, these are long-term activities that lay the groundwork to enable Surrey staff and stakeholders to engage in a productive CFAS implementation process. Therefore, all the above items should be considered high-priority in the first decade of CFAS implementation (2020-2030). Inputs from the steering committee, advisory group, advocacy partners, and stakeholders will be critical in developing effective adaptation solutions.

The first four Actions would all be relatively simple and cost-effective activities that could be implemented immediately. A Memorandum of Understanding could be developed for key partners participating in Advisory Group to help formalize the group and clarify roles and expectations going forward. Actions like the Advocacy Partners Workshop and other short-term CFAS Planning Area-specific Actions could be discussed at the first CFAS implementation meeting for the Advisory Group.

4.1.2 Detailed Planning, Studies, and Data Collection

Update hazard bibliography: Surrey has invested significant efforts over the past decade in understanding coastal flood risk. As much as detailed project planning in the future will rely on then-current studies regarding climatic and hydrologic conditions, it should also leverage the large body of studies that have previously been performed. A bibliography or archive of past work should be maintained and updated periodically throughout the CFAS implementation period.

Update coastal flood hazard assessment: With the completion of several studies over the past decade, Surrey has continued to update its assessment of coastal flood hazards. This process should continue in the future. Further, Surrey's coastal flood construction levels (FCLs) should be updated corresponding to newer flood hazard assessments. The city's current FCLs are based on design water levels computed by in 1994. Flood modeling performed more recently (in 2015) estimated flood levels for both 2010 and 2100 to be lower than the 1994 levels in riverine floodplain areas but higher in coastal and tidally-influenced floodplain areas. This change is caused by a combination of sea-level rise, new developments in the study area, and improved techniques of analysis. Thus, there is a need for updating the FCLs. Because the 1994 work underestimates coastal flood levels, FCL update should be considered a priority for the CFAS.

Detailed studies - Strategic Actions: The purpose of this CFAS document is to recommend adaptation Actions at a strategic level. Given the complexities of flood management in the context of a changing climate, detailed project planning will be required in the future to arrive at final implementation decisions.

FIGURE 29: *Detailed Planning, Studies, and Data Collection*

ACTION		CITY LEAD	IMPLEMENTATION PARTNERS	TIMING
7	**Update hazard bibliography:** Update CFAS bibliography on an as-needed basis such that it reflects the most current understanding of coastal flood hazards in Surrey. Incorporate multi-hazard information on related hazards including seismic, tsunamis, drought and ground subsidence.	Engineering		2020-2030
8	**Update coastal flood hazard assessment:** Update assessment of coastal flood hazards on an as-needed basis	Engineering		2020-2030
9	**Detailed studies - Strategic Actions:** Perform detailed studies of strategic adaptation actions recommended in this Strategy Document.	Engineering		2020-2050

Priorities – Detailed Planning, Studies, and Data Collection

Performing detailed studies for DMAF-funded actions should be considered high priority for the immediate decade. While the CFAS provides a road map, detailed implementation plans are expected to be developed when actions are taken up for implementation. The fact that the DMAF grant has realized the implementation of certain actions in 2020-2030 further underscores the need for detailed studies for these approved projects.

Harmony with nature, by Christina Gauld

4.1.3 Regulatory Controls, Design Standards, and Guidelines

The CFAS engagement process created an environment where difficult, value-laden conversations with residents could take place, and where adaptation options and pathways could be explored and discussed in an open environment. This helped generate a shift in thinking about climate change: people began to understand that homes are at risk from sea level rise in Surrey's coastal floodplain today and that this risk and hazard will continue to grow over time.

For residential areas like Crescent Beach, these discussions gave rise to new understandings of how living there would change over time, but also how it could continue using more resilient building approaches so flooding would cause less (or no) permanent property damage. The CFAS conversations also resulted in some residents beginning to adapt their own properties to be more resilient in the face of rising sea levels.

These conversations, while still in their infancy, have also supported a gradual shift in the regulatory environment currently applied to Crescent Beach towards a system that enables residents to learn, explore, and adopt more resilient best design practices that may help reduce the risks of living in a coastal floodplain.

Updated regulations: The City of Surrey could continue to expand its leadership role, established during the CFAS project, by reviewing and adjusting current development conventions and practices. This could include discontinuing Development Variance Permits for Flood Construction Level (FCL) reductions and replacing them with variances to building height to allow for the construction of more adaptable buildings. Existing zoning bylaws may be amended to specify flood resilient home construction (e.g., construction above FCL or use of wet-floodproofing design and construction). This would improve resilience, reduce risk, and save money for all stakeholders (residents, City of Surrey, and Province of BC) following future extreme flood events. Currently, Development Permit Areas for hazard lands establish regulatory controls, but existing zoning bylaws may benefit from changes to allow for higher homes, while future updates to the Provincial Building Code may also enable more resilient home construction in floodplains.

Updated design standards: Additional regulatory changes to the Surrey Zoning Bylaw and Official Community Plan through new

Development Permit Guidelines could provide new design standards to facilitate and expedite flood-tolerant construction for home owners and businesses in flood hazard areas. New design standards could be linked to the current pilot project underway in Crescent Beach where a resident is designing a more flood-tolerant home after learning about the risk and hazards through the CFAS process. The City of Surrey is currently supporting this pilot initiative through a Rezoning application.

Updated guidelines: Surrey could explore designating special Sea Level Rise Planning Areas which would allow Surrey, by bylaw, to specify flood levels and setbacks to address sea level rise. These areas could be created and implemented in future Official Community Plan updates as identified in Action 11.

FIGURE 30: *Regulatory Controls, Design Standards, and Guidelines*

ACTION		CITY LEAD	IMPLEMENTATION PARTNERS	TIMING
REGULATIONS				
10	**Review Development Variance practices:** Review and update Development Permit Variance Permit (DVP) practices around Flood Construction Level (FCL) reductions, replacing them with DVPs that allow for the construction of more adaptable buildings to improve resilience and mitigate current and future risks to residents.	Planning & Development		2020-2030
11	**Support flood resilient design and construction:** Explore regulatory changes to the Surrey Zoning Bylaw and Official Community Plan through new Development Permit Guidelines that support and encourage flood-tolerant design and construction standards in flood hazard areas.	Planning & Development Engineering		2020-2030
12	**Explore Sea Level Rise Planning Area:** Review Provincial Flood Hazard Area Land Use Management Guidelines for sea level rise and consider establishing a special Sea Level Rise Planning Area. Such an area may be designated as a floodplain under Section 524 of the Local Government Act. If land is so designated, Surrey may, by bylaw, specify special flood construction levels and setbacks to address sea level rise.	Planning & Development		2020-2030
DESIGN STANDARDS AND GUIDELINES				
13	**Design standards guidebook:** Develop toolkit/ guidebook for residents and land owners seeking to renovate or build in flood hazard areas to learn about best practice flood-resilient and waterproof construction. Advocacy for building code updates for flood resilient construction.	Planning & Development	EMBC BC NRC	2020-2030

Priorities – Regulatory Controls, Design Standards, and Guidelines

The actions in this group require Council action and are intended to establish the foundation for the long-term, non-structural aspects of coastal flood adaptation. Thus, while the actions themselves cannot be prioritized or accelerated, it is important that education and advocacy be considered high priority in the 2020-30 decade to enable the actions in this group.

4.1.4 Extreme Flood Event Management

It is estimated that climate change will result in flood events that are more extreme and occur with greater frequency which will place increased demands on the emergency management system, which includes emergency response, temporary flood protection, and post-disaster recovery.

Emergency response: In the context of Surrey's emergency response, climate change and sea level rise will affect several hazards including floods (coastal, riverine, and localized), debris flows, wind storms, and animal/human diseases. In the context of this strategy, the discussion is restricted to coastal flood hazards only. A review of Surrey's flood emergency response plans should be performed to identify stressors in a future scenario where flood events have greater magnitude and frequency. For example, such a 'stress test' may conclude that while emergency resources are capable of handling a single extreme event, the capacity is limited when two or more events occur simultaneously (e.g., dyke breaches in two different parts of the flood management system). Surrey's Flood Management Plan should be revised to address a wider range of future scenarios, which may support corresponding changes in resources allocation. Surrey should also consider a coastal recovery plan that would be focussed on challenges specific to the coastal context.

FIGURE 31: *UK Flood Warning System – A potential model for Surrey*

Updates to Surrey's emergency response program should also be coordinated with regional and provincial initiatives to plan, train, and respond to climate change-aggravated emergencies. For example, the City of Richmond's Flood Protection Management Strategy 2019 stresses the need to adapt current emergency management practices to future climate scenarios, which could provide an opportunity for Surrey and Richmond to exchange insights and identify common concerns, if any.

Existing flood warning and alert systems should also be reviewed to determine whether they have the necessary functionality to be effective in future scenarios where the trigger levels or the frequency of such triggers may be different. Effectiveness of the warning and alert system would rely on it having strong linkage with the local, regional, provincial and federal weather and flood monitoring systems. Mechanisms for broadcasting warnings and alerts should include traditional methods (e.g., electronic roadside warning signs) as well as newer methods such as social media. Any system used in Surrey should be integrated with the BC Emergency Alerting System and National Public Alerting System.

Temporary flood protection: Temporary flood protection (e.g., temporary flood barriers such as sandbags or proprietary panel walls) form an integral part of flood management systems because they help prevent nuisance or incremental flooding at a fraction of the cost of permanent infrastructure. Increased magnitude and frequency of extreme events will affect the characteristics of the flood protection systems (e.g., height of water they are designed for) as well as how frequently they are deployed. The suitability of the existing infrastructure and deployment system to future scenarios could be reviewed, and modifications be made if necessary.

Post disaster recovery: As per the Sendai Framework for Disaster Risk Reduction, the steady growth of disaster risk has highlighted the need to integrate disaster risk reduction measures during recovery, rehabilitation, and reconstruction (i.e., the Build Back Better principle). By adopting the Sendai Framework, both Canada and British Columbia have incorporated aspects of the Build Back Better in disaster response planning. However, under the BC Disaster Financial Assistance Program, only like-for-like costs are currently eligible for partial reimbursement which creates a barrier to increasing resilience post disaster. In its review and revision of its emergency response plan, Surrey could ensure that Build Back Better principles are incorporated in post-disaster planning and advocate for Provincial Disaster Financial Assistance to include provisions for Build Back Better.

FIGURE 32: *Extreme Flood Event Management*

	ACTION	CITY LEAD	IMPLEMENTATION PARTNERS	TIMING
EMERGENCY RESPONSE				
14	**Hazard review:** Review and revise hazard-specific plans to account for anticipated impacts of climate change in all hazard plans	All Departments		2020-2030
15	**Training and readiness:** Participate in regional initiatives for emergency services to simulate, train and respond in coordination in context of climate emergencies. Incorporate community resiliency education as it relates to a changing climate through Surrey Neighbourhood Emergency Program.	Surrey Emergency Program Engineering	EMBC PREM	2020-2030
16	**Improve flood warning systems and communications:** Advocate for public flood warning system and corresponding emergency alert system for coastal flood events. Improve internal emergency alert systems and extreme event monitoring system.	Surrey Emergency Program Engineering	DFO MBC FBC	2020-2100
TEMPORARY FLOOD PROTECTION				
17	**Temporary protection measures assessment:** Assess suitability of City's temporary flood protection infrastructure and modify as needed to meet future demands	Engineering	EMBC	2020-2100
POST-DISASTER RECOVERY				
18	**Build Back Better program:** Include 'Built Back Better' principles in recovery planning	Planning and Development Engineering	EMBC	2020-2100

Priorities – Extreme Flood Event Management

In the first decade of CFAS implementation (2020-2030), Surrey should focus on updating Surrey's Flood Management Plan based on recently-developed estimates of climate change-related coastal flood hazards. Depending on these estimates, a coastal flood recovery plan should be developed in the near term. Surrey should also participate in the February 2022 Coastal Regional Exercise after ensuring that results of recently-developed technical analyses are included and reflected in the scenarios used in the exercise.

The bird lady, by Sue Mukerji

4.1.5 Monitoring and Evaluation

Because of the inter-generational timeline of the CFAS, its successful implementation depends on Surrey being able to continually monitor and evaluate the process so that efforts can be calibrated to meet the intended objective. Monitoring and evaluation are different processes, which work together to assess the performance of adaptive actions over time. Monitoring refers to an on-going assessment of the actions and progress made in achieving set milestones and targets. Evaluation, on the other hand, examines if the community has become better adapted to climate change as a result of the actions, and the extent to which it is now more resilient to climate change.

To ensure the successful implementation of the Adaptation Strategy, it is proposed that the CFAS Steering Committee and Advisory Group collaboratively develop a series of indicators to track the progress of CFAS implementation over time. The indicators should be reviewed periodically to provide the most value in managing risk, within available resources. This CFAS monitoring effort should be aligned with existing reporting efforts, including those associated with Surrey's Climate Adaptation Strategy (CAS). Surrey's Sustainability Office could collect the data to establish a baseline and monitor progress of the monitoring indicators.

Surrey's Enterprise Risk Management (ERM) system should also be utilized to engage departments across the organization to identify and respond to challenges to the fulfillment of CFAS objectives.

Monitoring

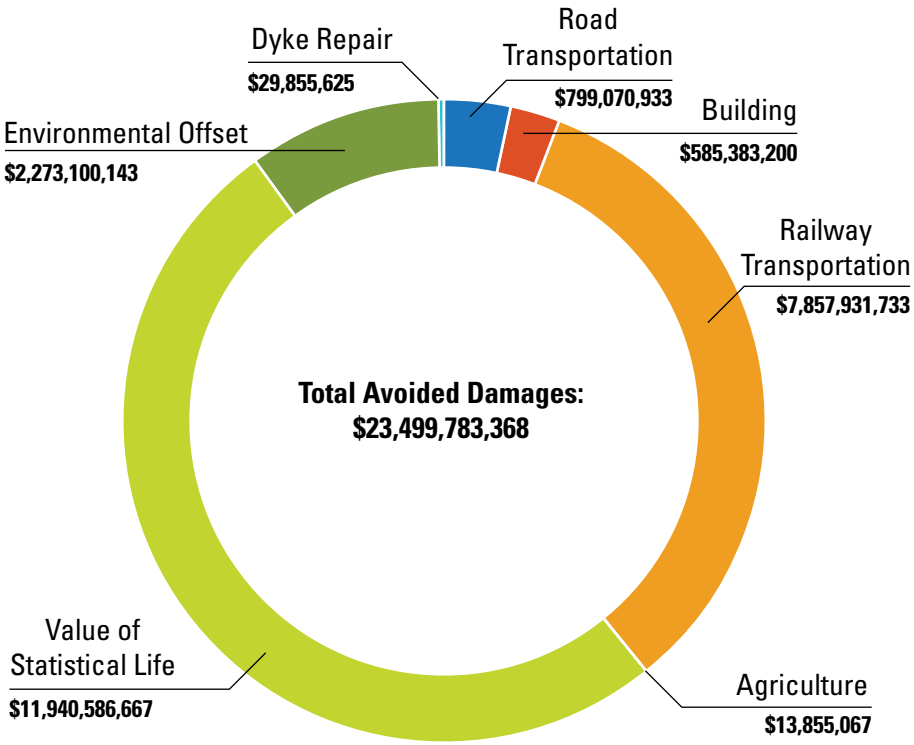
Monitoring refers to an on-going assessment of the intervention and progress made in achieving set milestones and targets. In the context of CFAS implementation, enduring data gathering is critical for long-term monitoring and can enable the development of climate-smart management policies and strategies. The monitoring framework established for the CAS should be utilized to assist in monitoring the implementation of CFAS over time.

A key element of monitoring is feedback received from stakeholder engagement events. Such feedback provides critical indicators that would allow Surrey to adapt CFAS actions to response to public expectations and awareness. For example, during the CFAS development process, the Surrey team continuously monitored feedback from stakeholder engagement events and found that the level of concern about climate change and sea-level rise went up significantly within the control group in the period of less than 2 years over which the engagement took place.

Evaluation

Evaluation is based on an examination of whether set objectives are achieved and if they did so in a cost-effective way. In the context of CFAS actions, evaluation is necessary to establish priorities to define which projects should be undertaken first and the order in which future projects should be done. Such an evaluation should be based on objective and subjective assessments of the extent to which a certain action will help Surrey meet its coastal flood adaptation goals.

FIGURE 33: *Avoided Damages per Sector*



There are several metrics available for evaluating capital investments in the municipal context. One of the often-used metric is Return on Investment (ROI). For example, the set of actions that were funded through DMAF were required, as a condition for the grant, to have a Return on Investment (ROI) higher than 2:1. As part of Surrey's application for the grant, it was demonstrated that implementing certain actions would result in an ROI of 126:1. This was based on an investment of $187 million and avoided damage of approximately $23.5 billion over the lifecycle of the proposed projects. A distribution of avoided damages by sector is shown in Figure 33 and the detailed methodology for determining the ROI is provided in Appendix III.

In the case of future projects during CFAS implementation, the concept of ROI can be a useful metric for evaluation of project success. The widely-accepted ROI of 2:1 can be used as a threshold value to determine viability of projects. Among those projects that meet this ratio, projects with a higher ROI can be prioritized. It should be noted that the ROI calculation includes a monetary translation of the risk of injury and loss of life; thus, the ROI is not only a financial metric, but also accounts for non-economic losses.

Priorities – Monitoring and Evaluation

Monitoring and evaluation actions will occur over an extended period of time, most of them after the immediate decade. However, within the immediate decade, Surrey's Sustainability Office could collect the data to establish a baseline in terms of economic and non-economic indicators. Such baseline data will help Surrey monitor progress of the metrics identified above.

4.2 CFAS PLANNING AREA-SPECIFIC ACTIONS

CFAS Planning Area-specific Actions are primarily infrastructure-related projects to be developed in specific areas. This section contains only summary descriptions for the recommended actions. For further details on the actions, please see the Technical Background Document in Appendix III.

4.2.1 Mud Bay

Mud Bay is the largest CFAS Planning Areas. Flood hazards along Mud Bay and the Serpentine and Nicomekl Rivers downstream of the sea dams are a function of high tides combined with storm surge, waves, and wind effects. Previous work estimated that, as a result of sea level rise, the degree of protection will be reduced over time with some dyke overtopping becoming more common in the future and occurring annually by 2070. Public safety is a concern because of several residential strata developments and subdivisions in addition to many farm houses in this area with over 200,000 vehicle trips per day. Further, significant natural areas including mud flats, wetland areas, and riparian/estuarine habitat in the inter-tidal area are threatened because sea-level rise is anticipated to result in coastal squeeze of marsh land. Thus, it is evident that a wide diversity of adaptation measures would be required for different parts of the larger Mud Bay Sub-Planning Area.

In the interest of efficient organization, the Mud Bay Planning Area was further divided into several Sub-Planning Areas based on shared geographical or coastal flooding characteristics - Inter River West, Inter River East, Colebrook, Serpentine North, Nicomekl South, the Nico Wynd Area, and the Mud Bay Foreshore.

A summary of recommended adaptation actions is provided below. Technical background and detailed discussion of each action is provided in Appendix III.

FIGURE 34: *Mud Bay Planning Area-specific Actions*

ACTION		CITY LEAD	IMPLEMENTATION PARTNERS	TIMING
MUD BAY FORESHORE SUB-PLANNING AREA				
19	**Foreshore enhancements:** Build green infrastructure to mitigate loss of intertidal habitat	Engineering	Ducks Unlimited, MFLNORD, MOE, SHaRP	2020-2100
20	**Sediment retention in foreshore area:** Perform sediment retention in foreshore area. Options include using Fraser River dredgeate.	Engineering	Champion needed	2020-2050
INTER RIVER WEST SUB-PLANNING AREA				
21	**152nd St upgrades and raising:** Retrofit 152nd St to address projected sea-level rise impacts	Engineering	FEI	2020-2030
22	**Serpentine and Nicomekl sea dams:** Replace Serpentine and Nicomekl sea dams	Engineering		2020-2030
23	**Upgrade Serpentine left bank and Nicomekl right bank dykes:** Raise dykes to meet 200-year design level with future sea-level rise to work with the network of spillways	Engineering		2020-2030
24	**Install pumps at sea dams in phases:** Add pumping capacity in phases to newly-replaced sea dams to reduce the flood potential in area upstream of the dams	Engineering	Ministry of Agriculture, MFLNORD	2030-2100
25	**Hwy 99 Protection Works – New dyke west of Hwy 99:** Exact location to be determined based on an adaptive approach in light of observed sea-level rise	Engineering	MOTI, BNSF	2040-2050
26	**Pullback to Hwy 99 Protection Works:** Return floodplain outside the coastal dyke to its original state through a gradual, managed process	Engineering	ALC, MFLNRORD, MOTI	2050-2080
INTER RIVER EAST SUB-PLANNING AREA				
27	**Upgrade Serpentine left bank and Nicomekl right bank dykes:** Both the Serpentine left bank and Nicomekl right bank dykes will need to be raised and upgraded in this area	Engineering		2050-2080

ACTION		CITY LEAD	IMPLEMENTATION PARTNERS	TIMING
28	**Drainage upgrades – Cloverdale neighbourhood:** As sea level rises, the drainage system adjacent to the current floodplain will need to adapt due to tailwater condictions	Engineering		2060-2080
29	**Serpentine and Nicomekl floodplain storage:** Add floodplain storage by sacrificing dykes when upgrades become unfeasible because of sea-level rise in conjunction with sea dam pumping and network of spillways	Engineering	Ministry of Agriculture, ALC	2070-2090
COLEBROOK SUB-PLANNING AREA				
30	**Coordinate with MOTI – Hwy 99 / Colebrook dyke upgrades:** Coordinate with MOTI regarding Hwy 99 to accommodate future Colebrook dyke upgrades	Engineering	MOTI, BNSF	2020-2030
31	**Upgrade Colebrook dyke:** Upgrade Colebrook dyke from western end to 152nd Street	Engineering	MOTI, BNSF, MFLNRORD	2020-2030
32	**Replace Colebrook Pump Station:** Upgrade to incorporate new standards for resilience and climate adaptation	Engineering		2020-2030
33	**'Good neighbour' dyke:** Build 'good neighbour' dyke in collaboration with Delta and MOTI	Engineering	City of Delta, MOTI Railways	2040-2060
34	**Shared drainage improvements – Delta:** Perform drainage improvements on shared drainage facilities in collaboration with Delta	Engineering	City of Delta	2040-2060
35	**Serpentine floodgates - BNSF:** Install floodgate structures on the Serpentine left and right banks at the BNSF railway crossing	Engineering	BNSF Railway	2050-2060
SERPENTINE NORTH SUB-PLANNING AREA				
36	**Upgrade Serpentine right bank and left bank dykes:** To continue maintaining flood safety, regularly make local repairs and raise dykes as needed	Engineering		2030-2080
NICOMEKL SOUTH SUB-PLANNING AREA				
37	**Upper Nicomekl flood storage:** Coordinate improvements with Township of Langley and City of Langley	Engineering	Township of Langley, City of Langley, MFLNRORD, ALC	2060-2080
38	**Upgrade Nicomekl left bank dyke:** If the floodplain combination option is adopted, it would result in the sacrifice of the Nicomekl right bank dyke and efforts can focus on the left bank	Engineering		2070-2080
39	**Upgrade drainage system west of 168th St:** Upgrade drainage system in neighborhoods in this area to be resilient to future hydrologic regime	Engineering		2070-2080
NICO WYND SUB-PLANNING AREA				
40	**Upgrade Nico Wynd area flood management:** Upgrade to provincial standards recommended by prior studies	Engineering	Nico Wynd Strata, Elgin Strata	2020-2040

Priorities – Mud Bay

The highest priority projects in the Mud Bay Planning Area are those which either address an existing coastal flooding issue or set the stage for more complex actions over coming decades. Several of these high-priority projects have fully or partially been funded through DMAF. These actions include Mud Bay foreshore enhancements, sediment retention in foreshore areas, 152nd Street upgrades, Serpentine and Nicomekl sea dams, Serpentine left bank and Nicomekl right bank dykes, Colebrook dyke upgrades, and Colebrook pump station replacement.

Walking on Crescent Beach, by Zaine Rabanillo Curate

4.2.3 Crescent Beach

Situated downstream of Nicomekl sea dam, river flooding is not a concern in the Crescent Beach Planning Area, but it is subject to coastal floods and, by 2070, is expected to flood annually without significant mitigation works. The area is home to about 1,200 residences and over 40 Heritage Sites and includes Blackie Spit which is an important wildlife area that offers some of the best bird watching in Canada. A summary of recommended adaptation actions for Crescent Beach is provided below. Technical background and detailed discussion of each action is provided in the accompanying Background Document in Appendix III.

FIGURE 35: *Crescent Beach Planning Area-specific Actions*

ACTION		CITY LEAD	IMPLEMENTATION PARTNERS	TIMING
41	**Maintenance of Crescent Beach dyke:** Assess the dykes and make local repairs or raise dyke as needed	Engineering		2020-2100
42	**Maintenance of shoreline:** Continue shoreline maintenance that was previously performed	Engineering	DFO	2020-2100
43	**Drainage improvements:** Perform drainage improvements that were previously identified	Engineering		2020-2050
44	**Expanded Edge:** Build the beach in front of the existing shoreline to reduce the slope of the foreshore	Engineering	DFO	2050-2080

Priorities – Crescent Beach

Among the actions recommended for the Crescent Beach Planning Areas, drainage improvements should be considered highest priority since they would address an existing issue that is likely to get exacerbated with sea-level rise. Crescent Beach drainage improvements have also been partially funded through the DMAF grant. Maintenance of Crescent Beach dyke is a long-term action for which an extensive capital program will need to be developed after further monitoring and consultation.

4.3.3 Semiahmoo Bay

A summary of recommended adaptation actions for Semiahmoo is provided below. Technical background and detailed discussion of each action is provided in Appendix III.

FIGURE 36: *Semiahmoo Bay Planning Area-specific Actions*

ACTION		CITY LEAD	IMPLEMENTATION PARTNERS	TIMING
45	**Little Campbell River emergency access:** Raise 8th Avenue and retrofit bridge to enable emergency access	Engineering	Semiahmoo First Nation City of White Rock ISC	2020-2040
46	**Comprehensive flood improvements:** Coordinate with and support Semiahmoo First Nation in undertaking comprehensive flood protection	Engineering	Semiahmoo First Nation	2040-2050

Priorities – Semiahmoo Bay

Providing Little Campbell River emergency access should be considered to be a high-priority action for 2020-30. This project has been approved for funding under the DMAF grant.

Sunset, by Gail Stephan

4.3 ACTION PLANNING AND COLLABORATION

Planning for partnerships and collaboration emerged as a guiding CFAS Principle and was a constant and consistent theme at CFAS Advisory Group workshops. Given the scale, scope, and number of CFAS Actions to be implemented, collaboration and partnerships will remain core components of successfully implementing CFAS Actions. Future stakeholder and partner collaboration and involvement will take many forms, from regulatory approvals and permitting to joint public education and communications initiatives, and from technical planning support to collaborative project funding programs.

In moving forward on collaborative CFAS Action implementation, some challenges will remain as partner organizations continue to develop their own mandates on climate adaptation in general, and climate change and coastal flooding in particular. Priorities of partner organizations may also shift and evolve as the climate crisis continues to evolve and sharpen. Additionally, collaboration will need to consider the limited funding currently available and the need to creatively fund and cost-share some CFAS Actions.

As mandates and priorities emerge and shift, and new funding opportunities arise, it will be critical for CFAS partners to keep other partners up-to-date on their own climate adaptation initiatives and linkages to CFAS. Here, organizations and governments that can facilitate collaboration and cooperation will likely play increasingly larger roles (e.g., Metro Vancouver, Fraser Basin Council, Federation of Canadian Municipalities, professional associations [Engineers Canada, Canadian Institute of Planners], and Stewardship Council of BC). Provincial and Federal partners and stakeholders (e.g., Ministry of Transportation and Infrastructure, Ministry of Forests, Lands, Natural Resource Operations, and Rural Development, Agricultural Land Commission, Department of Fisheries and Oceans) will also play important convening and organizing roles.

Collaboration with key regional organizations like Fraser Basin Council is also important, particularly around the Lower Mainland Flood Management Strategy which is aimed at reducing flood risk and improving the flood resilience of communities along the lower Fraser River and south coast — from Hope to Richmond and from Squamish to White Rock.

On a more local level, ongoing and expanded sub-regional collaboration will be needed to resolve many of the complex CFAS Actions, including raising 8th Avenue (Surrey, White Rock, Semiahmoo First Nation) and the proposed Good Neighbour Dyke (Surrey, Delta).

Lessons learned from early CFAS collaborations, including joint CFAS planning, option identification, and option assessment work carried out with non-governmental partners in the Mud Bay Planning Area will help inform additional and ongoing cooperative CFAS implementation work. Some of the key groups here include the Boundary Bay Health, Conservation, Management Stakeholders Committee, Ducks Unlimited Canada, the Lower Fisheries Alliance, and West Coast Environmental Law.

4.4 COMPLEMENTARY CITY STRATEGIES

Ongoing internal coordination and collaboration will also be required to integrate and "mainstream" CFAS with relevant City-wide strategies as well as neighbourhood plans and strategies. Key City-wide plans and strategies include:

- Climate Adaptation Strategy
- Agriculture Strategy
- 10-Year Servicing Plan
- Surrey Official Community Plan
- Biodiversity Conservation Strategy
- Transportation Strategic Plan

Local level, neighbourhood plans include the Crescent Beach Local Area Plan, South Surrey Land Use Plan, and the King George Corridor – South Local Area Plan.

Additional City bylaws and policies further regulate land development in Surrey and may require amendments and updates based on CFAS Action implementation. These include the Surrey Zoning Bylaw, Drainage Bylaw, and Soil Conservation and Protection Bylaw.

Over the short-term (2020 – 2030), many of these plans and strategies will be updated as

part of regular and scheduled updates. City bylaws and policies are also regularly updated and amended. Linking and coordinating these updates to CFAS will not only support CFAS Action implementation, but also support climate adaptation planning in other areas of Surrey.

4.5 CAPACITY BUILDING AND RESOURCES

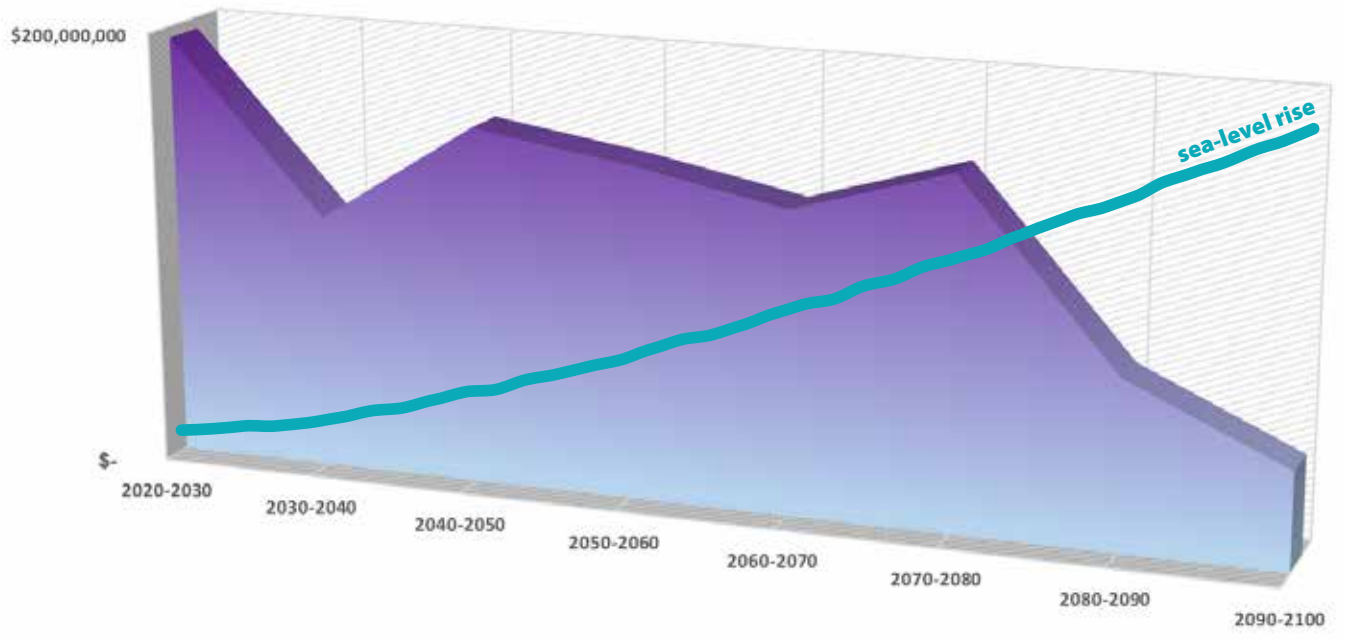
The CFAS proposes actions over the next 80 years that will help Surrey adapt to the increasing coastal flood hazards driven by sea-level rise. Implementing these actions will involve the investment of significant funds in the form of infrastructure costs, costs of communications and policy measures, and staff resources. Because these funds would not have been required in a 'sunny day' scenario (i.e., a hypothetical no sea-level-rise scenario), it is essential for Surrey to take proactive and strategic steps to realize the fund requirement.

An investment strategy should be an integral part of the implementation strategy. Some preliminary work has been done by the province in estimating the future cost of adaptation through the 'Cost of Adaptation - Sea Dikes & Alternative Strategies' report published in 2012. This report estimated the cost of adaptation to a year 2100 sea-level rise scenario to be approximately $9.5 billion (this cost is for 250 km of Metro Vancouver coastal shoreline – including $1.5 billion for Surrey's coastline downstream of the sea dams - and the Fraser River shoreline as far east as the Port Mann Bridge).

The figure below represents a conceptual forecast of costs required over the CFAS period to manage risk from sea level rise. As described above, the shorter-term actions (2020 to 2030) will collectively lay the groundwork and support the path towards the longer-term Strategic Directions outlined in the previous section. Thus, there will be a steep increase in actions in the first decade. In succeeding decades, sustained implementation activities will have to be performed so that adaptation actions occur ahead of anticipated sea-level rise and corresponding increase in coastal flood risk.

Because there are several variables related to future projects, it is difficult to estimate exact costs in certain future decades or years with any certainty. Therefore, it should be recognized that the estimate is oversimplified. Further, it should be emphasized that while Surrey will play the role of champion on several of these actions, the resulting benefits involve benefits to Surrey's neighbouring communities as well as provincial and national interests. Therefore, acquiring resources for CFAS implementation should be closely tied with regional, provincial, and national funding opportunities.

FIGURE 37: *Anticipated CFAS Implementation Cost by Decade, 2020 - 2100*



Snowy Serpentine, by Ana Fisic

5. IMPLEMENTATION

5.1 IMMEDIATE NEXT STEPS (2020-2030)

The actions identified through the CFAS process are too numerous and interdependent for all of them to be taken up immediately for implementation. Thus, it is important to prioritize actions that either address coastal flooding issues that are already present or those that lay the groundwork and point the way to a series of progressively larger, more complex, and more challenging strategic actions. A comprehensive table of all actions is provided in Appendix I.

In Chapters 4, several high-priority, short-term CFAS Actions have been identified that can be taken up for immediate implementation in the 2020-30 decade. Some of these actions, such as establishing an adaptive management pilot for sediment retention in the Mud Bay Foreshore, are intended to result in solutions that Surrey can then apply on a broader scale. Others, such as coordination with MOTI, represent processes that involve external stakeholders and typically take a relatively long time to be resolved. Finally, there are actions such as raising the 8th Avenue Bridge which address an existing flooding issue while serving as a catalyst to advance planning for larger adaptive actions in the area that will require several decades to implement.

5.2 FUNDING

A key factor in successful implementation of CFAS is Surrey's ability to keep up with funding for infrastructure investments, communications and policy measures, and staff efforts.

A funding strategy should be an integral part of the implementation strategy. While Surrey will play the role of champion on several of these actions, the resulting benefits will also accrue to Surrey's neighbouring communities as well as provincial and national interests; therefore, Surrey should plan on utilizing regional, provincial, and national funding opportunities. This opportunity is illustrated by the recent grant obtained by Surrey under DMAF for implementing several CFAS actions.

A regional avenue for funding is the Lower Mainland Flood Management Strategy (LMFMS), a collaborative effort of 25 local governments along with the provincial and federal governments, which is aimed at strengthening flood management policies and practices as well as flood protection works across the Lower Mainland. One of the objectives of the LMFMS is to develop recommendations for a secure, sustained funding model.

> "We have to spend tax dollars well. The costs of protecting and liabilities will be borne out on the shoulders of my children and my grandchildren."
>
> *– CFAS participant*

5.3 DISASTER MITIGATION AND ADAPTATION FUND (DMAF) PROJECTS

In 2018, during development of CFAS Phase 4, the Government of Canada announced the Disaster Mitigation and Adaptation Fund (DMAF) which aligned well with the objectives of CFAS. Accordingly, a DMAF funding proposal was submitted by Surrey in January 2019 with a requested grant of $187 million supported by a Return on Investment ratio of 126:1. The grant application was successful. Thirteen mitigation measures were included in the DMAF application, as shown in the map and table in Appendix II (from report to Surrey's Council dated February 11, 2019). These measures are consistent with the preferred longer-term strategic direction and provide 'low regret' investments that address current priorities. The investment sets the trajectory for infrastructure investment that will be required to keep pace with sea level rise.

5.4 RECOMMENDATIONS AND CONSIDERATIONS

The following recommendations and considerations are intended to help ensure that valuable lessons learned from the CFAS development process are carried forward to help guide future, longer-term coastal flood adaptation actions. They were developed based on an analysis of project outputs and feedback from residents, business owners, asset owners and operators, and other project stakeholders. They are also based on the recognition that the longer-term Strategic Directions entail considerable detailed planning and ongoing engagement with residents, stakeholders, and partners.

- ***Maintain value-based, participatory process through CFAS implementation, future planning, and strategy updates.***
  Participant feedback from the open houses, workshops and other outreach clearly indicates that Surrey's commitment to participatory, values-based planning was appreciated, valued, and strongly supported. Trade-offs and difficult conversations will be inevitable as the project moves towards longer-term Strategic Directions. Maintaining this commitment going forward will be a critical component of ongoing relationship building and transparent decision-making with residents and key project partners. Past participants, including CFAS Advisory Group participants, expressed a keen desire to stay involved in the project with 86% of CFAS participants indicating that they want to stay involved.

- ***Continue to use, revisit, and validate CFAS Values in longer-term work.***
  The community values identified during the first phase will be a critical component of future detailed planning and Action evaluation. It is likely that additional residents, business owners and other stakeholders who did not participate in CFAS will become involved in later phases of planning as tactical Actions are implemented and longer-term directions are refined. With new participants becoming engaged in CFAS, it will be important to continue eliciting, confirming, and refining Values throughout CFAS implementation. Furthermore, over time, and with growing awareness of the climate change-driven coastal flooding and the potential of future extreme flood events, community values and priorities may shift.

- ***Continue to address and manage behavioural barriers.***
  At project outset the CFAS Stakeholder Engagement Framework identified some potential psychological challenges, or barriers, that could be expected as a result of the scale and scope of the complex challenges posed by climate change and coastal flooding. These barriers remain and will need to be managed and incorporated in future project phases:
  - ***Protection motivation:*** The concept that stakeholders and partners may need to feel a certain degree of personal threat before they are motivated to make behavioural changes and/or trade-off decisions around CFAS directions. The behavioural challenge may also support stakeholders and partners in having an anchor bias in protection-based adaptation pathways versus other pathways (i.e., accommodate, move/managed retreat).
  - ***Psychological distancing:*** The concept that stakeholders and partners may distance themselves from large scale, longer-term challenges like climate change and

coastal sea level rise by disconnecting themselves from its implications. For CFAS, stakeholders and partners may want to underestimate the coastal flood risk they face as a means of psychologically managing the challenge.

- ***Displacing risk:*** The concept that stakeholders, particularly people living and working in vulnerable, at-risk areas will tend to direct their attention towards the most immediate concerns (e.g., winter storm protection works) while ignoring the longer-term climate and coastal flooding risks and hazards perceived to be either happening too far in the future or with associated uncertainties.

- ***Continue to engage with all coastal residents, businesses and stakeholders***
With people living, working, and recreating in the floodplain, discussions around longer-term adaptation pathways were often value-laden and sometimes challenging. Across the Planning Areas, longer-term Strategic Directions will require ongoing engagement and discussion given the cost, complexities, and trade-offs each involves. Even with longer-term flood management actions, the Planning Areas will remain in the flood hazard zone and risks will increase as sea-levels rise or if the area experiences an extreme flood event. Recognizing these factors, a carefully considered and ongoing engagement process is required with the community.

- ***Be a coastal flood management advocate.***
Surrey may not have authority over areas where CFAS stakeholders and partners have a common interest in an action, policy, or outcome. This is why Surrey should take an advocacy approach where the City works with partners and stakeholders to influence decision makers and industry groups to bring about the changes that may be required to support longer-term CFAS Strategic Directions, particularly where they may involve the "move" or "managed retreat" pathway. This advocacy work could include encouraging the Province to organize a coastal flooding and sea level rise risk management workshop with Municipal Insurance Association of BC, Real Estate Foundation of BC, financial institutions/ associations, Local Government Association of BC, West Coast Environmental Law, and other stakeholder groups with a focus on longer-term CFAS Strategic Directions.

- ***Continue to collaborate and coordinate with the Lower Mainland Flood Management Strategy.***
The City of Surrey is an active participant in the Lower Mainland Flood Management Strategy (LMFMS), a collaborative initiative with participation of 50 governmental and non-governmental agencies working together to reduce vulnerability and strengthen resilience to river and coastal flooding in the Lower Mainland region. The Fraser Basin Council (FBC) manages and facilitates the initiative. The multi-year undertaking is currently working towards developing a draft strategy which will include an assessment of priorities and options for flood mitigation, decision-making, and cost-sharing. FBC was an active partner in the CFAS process and is keen to integrate and link CFAS with the LMFMS initiative.

Under the Crescent Beach pier, by Gail Stephan

6. UPDATES AND AMENDMENTS

6.1 ADAPTIVE MANAGEMENT

Given the uncertainties surrounding climate change and sea level rise in particular (i.e., it could happen faster, it could be more severe, it could happen more slowly), the larger CFAS process and strategic actions are grounded in an adaptive management approach. This approach recognizes that planning in such a dynamic context needs to be flexible and responsive to new drivers and considerations as they emerge. For CFAS, this includes:

- ***New data*** (and new changes detected in the data)
- ***New policies/directives*** (global, national, provincial, regional, local)
- ***New participants and collaborations*** (new partners and stakeholder taking new actions)
- ***New funding*** (and the requirements/ opportunities that come with them)

FIGURE 38: *CFAS and Adaptive Management Cycle*

Note: modified from Olson, E., Murray C. and Tamburello N. (2017)

> "It's sobering. It's a reality check for sure. I'm more inclined for a slow approach, an incremental approach until we see the acceleration curve we're looking at [with sea level rise]. We need to look at change in five-year horizons."
>
> *– CFAS participant*

6.2 TRIGGERS AND THRESHOLDS

The CFAS has been developed on the basis of information and assumptions related to climate change that were obtained from multiple sources. For example, a climate change-related floodplain review of Serpentine, Nicomekl, and Little Campbell Rivers was based on projections of sea level rise provided by the Province and ground subsidence data from a Surrey-initiated study. The information obtained from such sources is based on a dynamic dataset of prior physical events and is thus subject to change.

In accordance with the adaptive management approach used for the CFAS, it is necessary to make adjustments to the CFAS when new data is available. Some triggers and thresholds which should be monitored for change are listed below. Any significant change in such triggers should result in a review of and, if necessary, adjustments to the CFAS.

> "I live at Crescent Beach. Being a homeowner I'm a little concerned about losing property, but sea level rise is just going to increase, the severity of the storms and water levels will increase."
>
> *– CFAS participant*

FIGURE 39: *CFAS Triggers and Thresholds*

TRIGGER	THRESHOLD
Sea level rise projections	Newer estimates of sea level rise are significantly different than prior estimates
Ground subsidence estimates	Newer studies find subsidence that is substantially different than that found in the 2011 study initiated by Surrey
Precipitation estimates	Newer estimates vary significantly from those used in existing studies
Storm or flow frequency	Hydrologic studies find that frequency of storms or flows has changed significantly than those used for CFAS development
Estimate of damages	Intervening events such as new developments result in damage estimates that are significantly different than those used during CFAS development)

6.3 UPDATES

As a relatively new and rapidly evolving issue, the CFAS will be a living document to be revisited periodically and updated as appropriate. The reviews should be prompted by an external event or every 5 years. The updates required may be major or minor.

Major updates are those which will have a significant impact on the interests of Surrey or other stakeholders. For example, an adjustment to the year 2100 sea level rise projections will significantly affect the underlying assumptions behind CFAS Actions and would necessitate a major update.

A minor update is one which does not materially affect the interests of any party. For example, actions recommended in the current version of the CFAS are assigned to a "City Lead." Changes to the City Lead (e.g., from Engineering to the City Manager's Office) would be a minor update.

7. KEY BACKGROUND REPORTS

Ausenco-Sandwell (2011). Climate Change Adaptation Guidelines for Sea Dykes and Coastal Flood Hazard Land Use: Guidelines for Management of Coastal Flood Hazard Land Use. Report prepared by Ausenco-Sandwell for BC Ministry of Environment. 45 pp.

City of Surrey (2018). Surrey Coastal Flood Adaptation Strategy (CFAS) Engagement Summary Phase 1-3. Available from: https://www.surrey.ca/files/CFAS_Engagement%20Report_05092018.pdf

City of Surrey (2018). Surrey Coastal Flood Adaptation Strategy (CFAS) Primer Part II: Options Chapter 1: Mud Bay. Available from: https://www.surrey.ca/files/CFAS-primerpart2.pdf

City of Surrey (2018). Surrey Coastal Flood Adaptation Strategy (CFAS) Primer Part II: Options Chapter 2: Crescent Beach. Available from: https://www.surrey.ca/files/CFAS-primerpart2CB.pdf

City of Surrey (2018). Surrey Coastal Flood Adaptation Strategy (CFAS) Primer Part II: Options Chapter 3: Semiahmoo Bay. Available from: https://www.surrey.ca/files/CFAS-primerpart2SB.pdf

City of Surrey (2017). Surrey Coastal Flood Adaptation Strategy (CFAS) Primer Part I: Coastal Flooding in Surrey. Available from: https://www.surrey.ca/files/CFAS-primerpart1.pdf

EGBC (2018). Legislated Flood Assessments in a Changing Climate in BC, Version 2.1. Engineers & Geoscientists British Columbia, Burnaby, BC. 192 pp.

KPA Engineering Ltd. (1994). Floodplain Mapping Program Serpentine and Nicomekl Rivers. Design Brief. Prepared by KPA Engineering Ltd. for B.C. Environment Water Managament Division.

NHC (2015). Serpentine & Nicomekl River Climate Change Floodplain Review Phase 2. Draft Report. Prepared for City of Surrey.

Olson, E., Murray C. and Tamburello N. (2017). Reducing Uncertainties in Managing in British Columbia Waters: Applying an Adaptive Management Mindset on the South, Central and North Coasts. Salish Sea Ecosystem Conference. 43. Available from: https://cedar.wwu.edu/ssec/2016ssec/protection_remediation_restoration/43

TRE Canada (2011). Final Report on Ground Movement within the City of Surrey using SqueeSAR.

Urban Systems Ltd. (2009). Crescent Beach Climate Change Adaptation Study.

Several other related documents are available under ' Resource Materials Prepared by CFAS Team' here: https://www.surrey.ca/city-services/21071.aspx

Appendices

Appendix I: Action Implementation

Appendix II: DMAF Actions

Appendix III: Technical Background Document

APPENDICES

APPENDIX I: ACTION IMPLEMENTATION (to be included in Final Strategy Document)

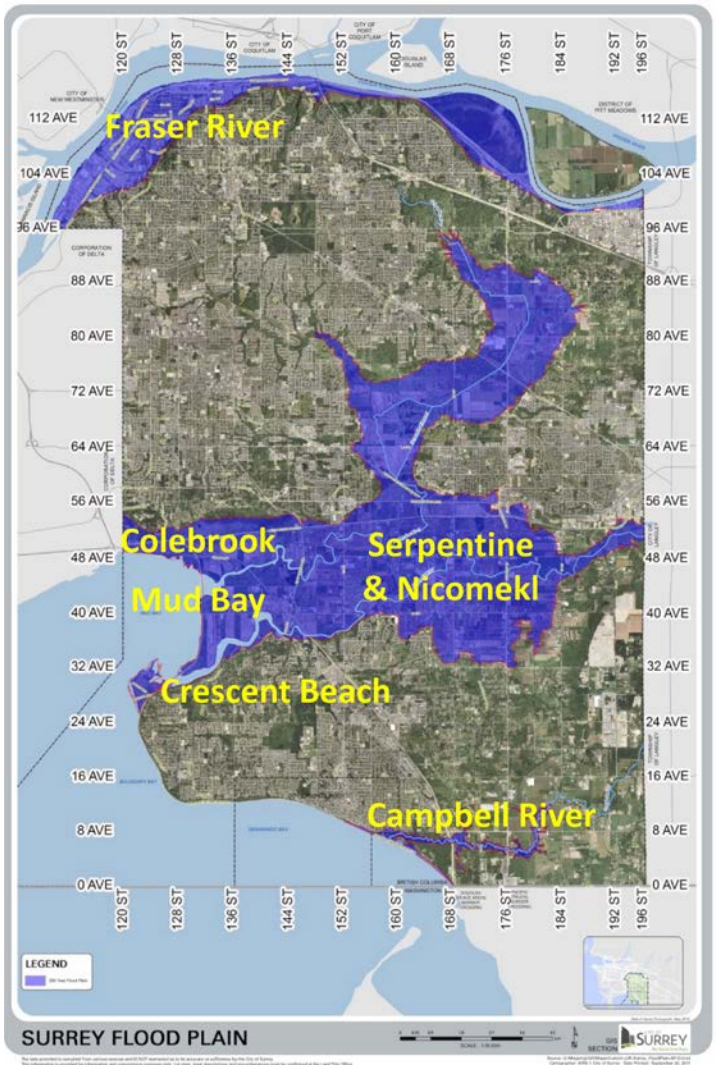
APPENDIX II: DMAF ACTIONS

APPENDIX III: TECHNICAL BACKGROUND DOCUMENT (to be included in Final Strategy Document)

City of Surrey – Colebrook Dyke Upgrades

One third of City of Surrey is within a floodplain and is bordered by the Fraser River to the north and the Salish Sea to the southwest. While regional work in BC is developing a strategy focusing on the Fraser River, Surrey has completed two years of stakeholder engagement in a process to develop the Surrey Coastal Flood Adaptation Strategy (CFAS), part of the Municipalities for Climate Innovation Program. It addresses 20% of the City's land and critical infrastructure of national, regional and local significance that is at risk from sea level rise within Surrey.

Impacts cover the areas depicted as: Colebrook, Mud Bay, Serpentine & Nicomekl, Crescent Beach and Campbell River including Semiahmoo First Nation.



The first phase of Dyke upgrades for the most vulnerable section of Surrey's coast will be shovel ready to commence in 2019. The total value of the proposed Colebrook Dyke upgrades is $20M.

Challenging soil conditions require construction to be phased over five years, to gradually build a wider dyke up to four metres above the surrounding grade, allowing the foundation to adjust to the additional weight.

Colebrook Dyke Existing Crest

The Colebrook Dyke protects critical infrastructure of:

- Hwy 99 regional link to Peace Arch Border
- BC Hydro's primary transmission line to U.S.A.
- Regional sewer and watermains

Colebrook Dyke showing Provincial Guidelines for current (lower black line) and future year 2100 elevation (upper black line) targets

City of Surrey – Colebrook Drainage Pump Station

The Colebrook Pump Station is located on the north bank of the Serpentine River, west of Highway 99, adjacent to Mud Bay. Its purpose is to mitigate coastal flooding by draining the water from Peacock Brook and connecting ditches into the tidally-influenced Serpentine River during high water levels. The existing station was built in 1990 and has now approached the end of its service life and is in pressing need of replacement.

The existing station is well below current flood construction levels and is vulnerable to flood damage in a significant coastal flood. The new pump station design incorporates aspects of climate change and sea level rise adaptation.

Existing Colebrook Drainage Pump Station

Only two out of three pumps are operational and replacement parts are no longer available. The new station will reinstate full pumping capacity and provide for future climate resilience by leaving room for additional future capacity. The overall design of the pump station accommodates observed and projected changes in the environment such as:

- Regional ground subsidence has resulted in an elevation differential between the agricultural fields and base flow water levels controlled by the pump station. The new pump station accommodates the existing elevation differential, as well as to provide flexibility to gradually lower the pump settings to accommodate observed ground subsidence over the life of the pump station;
- The current dyke crest elevation at the pump station of 3.2m will not be sufficient to meet the increasing overtopping requirements imposed by future sea level rise. The updated pump station will be compatible with future dyke upgrades (estimated at 4.84 to 5.13m by 2100).

The project budget is $5 million and is shovel ready. The construction will be phased to commence after the Colebrook Dyke construction is completed. The updated pump station will provide the following community benefits:

- Improved flood protection and drainage and reduced soil salination of agricultural land in Surrey lowlands;
- Proactive climate change adaptation to allow for increased sea levels and precipitation;
- Increased protection of nationally critical infrastructure such as Hwy 99 and Bulk Power Transmission Lines.

Mouth of the Serpentine River with Colebrook Drainage Pump Station (view from south)

City of Surrey –Serpentine Sea Dam

Over one hundred years ago, early settlers constructed two dams to reclaim fertile land for agriculture, provide a source of irrigation and provide transportation crossings for the Semiahmoo Trail.

Throughout the hundred year service life of the dams, Surrey's population has increased by 500,000 and significant regional infrastructure has been built behind the dams in low-lying areas.

The Serpentine Sea Dam will be over topped as a result of projected sea level rise from Climate Change and is a significant coastal flood vulnerability. The dam also poses the largest seismic vulnerability to the City's Drainage System. The complexity of rebuilding the dam after an earthquake would take many years and would be devastating for the community. It would damage the local and regional transportation network, impacting over 200,000 daily trips and billions of dollars of goods movement.

Serpentine Sea Dam at high tide with gates closed

Preliminary design of the dam is complete and incorporates climate and seismic resilience with a higher crest elevation, adjustable flood gates to adapt to rising water levels and a robust foundation and dyke tie-in to resist an extreme earthquake. Community consultation on long-term coastal climate change has identified the preferred locations of the dams. The Class D budget required to replace the dams is $15M. Discussion is underway with Ministry of Transportation and Infrastructure to integrate with Provincial plans.

Today, the dams support a number of important services to the community including:

- *Flood Control*: Keeps out storm surges and high tides from backing up the rivers and flooding 2,000 Ha upstream lands;
- *Irrigation*: Prevents brackish water from mixing with fresh water, supporting 38 authorized water licenses to extract up to 129.6 million cubic metres per year;
- *Transportation*: Provides water crossing for the King George Greenway and protects upstream bridges;
- *Utility and Energy*: Protects upstream utilities.

Additional community benefits of replacement structures will be:

- Better fish passage to upstream habitat;
- Improved drought management;
- Movement for cyclists and pedestrians.

Serpentine Sea Dam at low tide with gates open

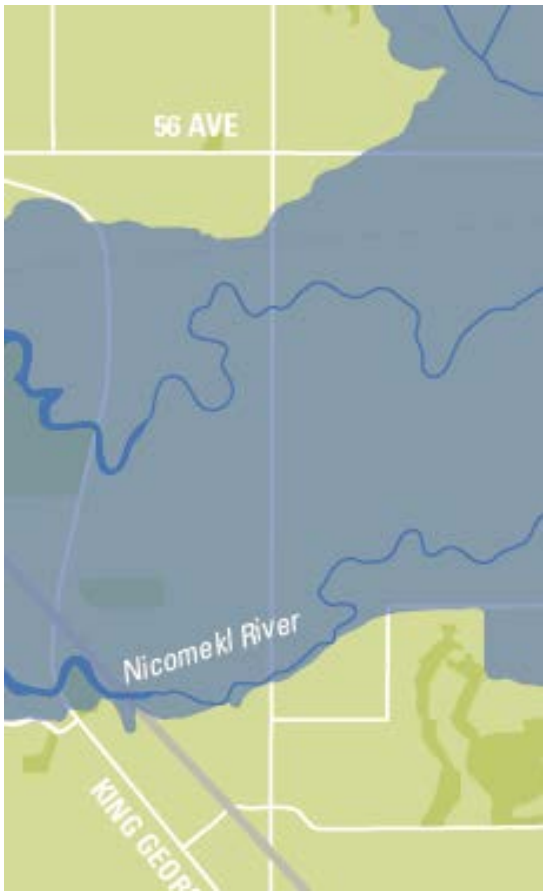
City of Surrey – 152 Street Road Improvements

152 Street is a key transportation corridor in the City of Surrey. It is one of only six routes linking the communities in North Surrey with South Surrey/White Rock (114,000 pop). 152 Street supports approximately 21,800 vehicles per day. 152 Street is also part of TransLink's Major Road Network, acting as a key corridor for goods movement, emergency response, and public transit. 5,150 people per day use public transit on 152 Street – over 1.5million people per year. 152 Street also provides direct connections to the corridors for the Canada/U.S. border crossings.

152nd Street is a key corridor for the movement of goods and people

From 40 Avenue and 50 Avenue, 152 Street is 2-lanes, and built at grade in the floodplain of the Nicomekl River, with no facilities for walking or cycling. Studies have demonstrated this section of 152 Street is a high risk for flood hazards.

Excerpt from the Surrey Coastal Flood Adaptation Strategy (CFAS) April 2018 https://www.surrey.ca/city-services/19888.aspx



A significant flood along this road alignment would have major economic impacts, restrict the region's ability to respond to emergencies and impact the flow of vehicles and people.

The City has plans to widen and raise 152 Street to meet new standards for flood resilience. 152 Street would be widened to 4-lanes including cycling facilities and turning lanes for farm access. Benefits include:

- 152 Street raised to protect against flood risk
- Addition of multi-modal facilities for cyclists
- Improved road capacity for cars, public transit and goods movement

City of Surrey – Nicomekl Riverfront Park

The Nicomekl River is one of three significant river systems in Surrey that are impacted by sea level rise. For the majority of its length, it is bounded on both sides by the Agricultural Land Reserve. Downstream of the crossing at 40th Avenue, the river is bounded on its southern bank primarily by parkland to Mud Bay.

Photo: Coastal portion of Nicomekl River looking upstream

The City has acquired land and the final pieces are currently being secured to provide a continuous 3 km section of parkland along the south side of the River. Parks, Recreation and Culture (PRC) staff have commenced a planning and consultation process to develop the Nicomekl Riverfront Plan which will include concept plans for two larger park sites on either side of King George Boulevard. The approximate park site stretches from the Sea dam at Elgin Road east to 40 Ave. This aligns with the PRC Strategic Plan, which states "*parks will play an increasing role in the mitigation of the impacts of climate change*".

In close proximity to coastal waters, the Nicomekl Riverfront Park is an ideal place to employ innovative climate adaptation and mitigation measures and a test site for design related to sea level rise due to climate change.

Possible adaptation and mitigation measures and their community benefits are:

- *Mitigate flooding* by accepting/conveying flood waters through the park using soft drainage features such as ponds, bioswales, riparian buffers, rain gardens and wetlands;
- *Adapting* ecosystem to be flood tolerant through the addition of wetlands;
- *Improve air and water quality* through implementation of unique ecosystems (wetland, bog, meadow and forest) and biological drainage measures (filtration strips and ponds); and
- *Protect and enhance existing habitat and ecosystems* with restoration plantings, habitat islands, and by limiting public access to natural areas.

Climate adaptation and mitigation measures will be multifunctional, layered with social and recreational spaces, environmental connectivity, and public art and heritage elements to offset impacts from sea level rise and coastal flooding. Additionally, the park may serve as a satellite location of the Surrey Nature Centre by delivering educational programs about climate awareness to improve community resilience. The Park will be a place for daily activity (picnics, walking loops) and a refuge from the urban realm, with access to and onto the river. The total project value is $10 million over ten years.

Photo: Nicomekl Riverfront Park project area outlined in red

City of Surrey – Nicomekl King George Bridge & Sea Dam

The King George Boulevard Nicomekl River Bridge comprises of two separate structures south of the King George Boulevard and Highway 99 Interchange in Surrey, BC. The first structure carries two lanes of traffic (one southbound and one northbound) over the Nicomekl River. A bailey bridge is located immediately east (upstream) of the bridge and carries a second northbound lane of the King George Highway over the Nicomekl River. Built in 1939, the bridge is 56m long and comprises 11 timber trestle spans.

The Nicomekl Bridges provide a key link in the transportation network in Surrey and Metro Vancouver. King George Boulevard is one of only six north south connections between South Surrey and White Rock (total 114,000 pop.) and the rest of the Surrey (450,000 pop). It is a truck route for goods movement, emergency response corridor and forms part of TransLink's frequent transit network and Major Road Network.

The bridges are maintained by the Ministry of Transportation and Infrastructure (MoTI). MoTI have indicated that the life spans of the bridges are around 70 years old and that they are reaching the end of their serviceable life. The City has been working with MoTI to develop a plan to replace the existing bridges with a new modernized six lane structure that reserved transit vehicle lanes and multi-use path in each direction for pedestrians and cyclists.

Due to the ages of the bridges they are susceptible to multiple natural hazards. The existing bridges are projected to be overtopped due to sea level rise and challenging soil conditions making the bridges vulnerable in an earthquake. An adjacent sea dam that mitigates coastal flooding is also increasingly becoming vulnerable to overtopping. Rebuilding the bridges and sea dam after an earthquake would take years and interrupt an essential north-south connection in Surrey and White Rock.

An innovative cost-saving solution that adapts multiple assets for a changing climate is proposed. A new resilient structure is proposed that combines the function of the sea dam structure and needs for a King George Boulevard bridge with a robust foundation that will be fully functional after an extreme earthquake.

The combined replacement sea dam and bridges structure support a number of important services to the community including:

- *Flood Control*: Keeps out storm surges and high tides from backing up the rivers and flooding 2,000 Ha upstream lands;
- *Irrigation*: Prevents brackish water from mixing with fresh water, supporting 52 authorized water licenses to extract up to 4.6 million cubic metres per year; and
- *Essential Transportation*: Provides the King George and Elgin Road water crossings over the Nicomekl and Serpentine with an estimated traffic volume of 26,000 vehicles per day.

Additional community benefits of replacement structures will be:

- Enhanced wildlife and pedestrian access across transportation corridors. Supports connection to a planned 6 km continuous water path to offset reduced beach access from sea level rise and coastal flooding;
- Better fish passage to over 100 km of habitat;
- Improved drought management; and
- Accessible design for cyclists and pedestrians.

Existing Nicomekl Bridge

City of Surrey – Crescent Beach Coastal Drainage Improvements

Situated in South Surrey, Crescent Beach is a dynamic environment that has seen many changes over time. It formed over centuries through the deposit of sediment from coastal bluff erosion. First Nations inhabited the area for thousands of years prior to colonization. In the early 20th century, Crescent Beach began to establish itself as a summer seaside cottage resort. In recent decades, the historic cottages have been gradually converting to permanent and more formal residences.

Today, a combination of sandy porous ground, recent redevelopments and sea level rise is impacting the performance of the outdated groundwater drainage system in the community and impact the safety of approximately 1,400 residents as a result of increasing winter surface ponding impacting the road network.

In 2009, a Crescent Beach Climate Change Adaptation Study was completed to develop the optimal drainage servicing strategy for the area. It was developed with extensive community consultation and provides direction on drainage servicing needs in a changing climate.

Surface ponding following a rainfall event in May 2008

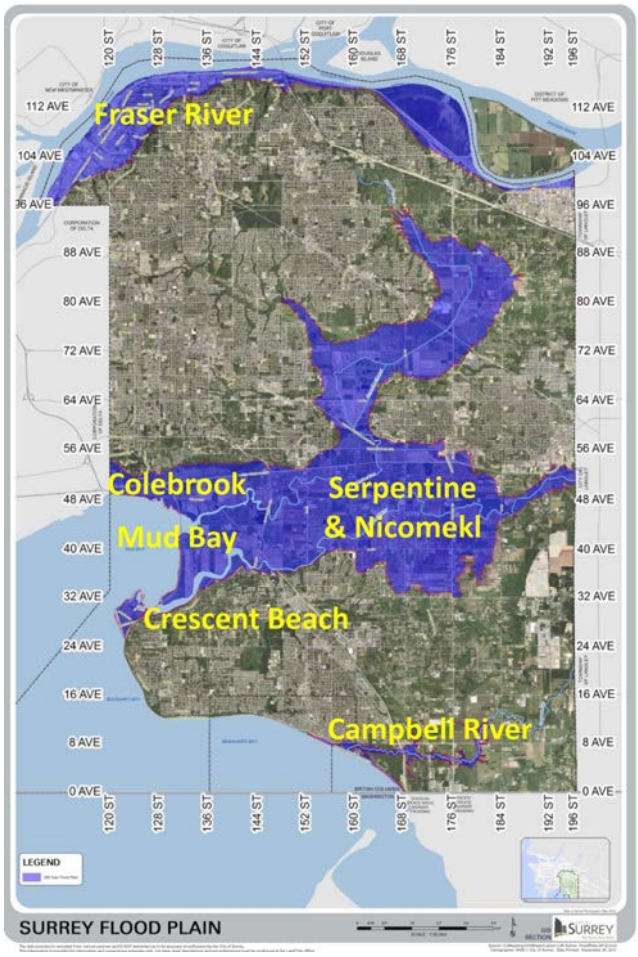
Through the Study, a perforated storm sewer system was chosen as the preferred drainage improvement strategy for Crescent Beach, in conjunction with raising the ground and road. The intent of a perforated storm sewer system is to provide an efficient conveyance system that can manage both stormwater runoff and rising groundwater levels. In the summer (when the groundwater table is typically low), stormwater runoff that enters the sewer system will have an opportunity to exfiltrate out of the pipe through the perforations and recharge the groundwater table. On the other hand, in the winter (when the groundwater table is typically high), groundwater is able to enter the perforated storm sewer system and is conveyed to the Dunsmuir Channel. During winter, the system maintains a relatively constant groundwater table elevation and manages water efficiently to mitigate coastal flooding. Maple Drainage Pump Station was upgraded to accommodate the additional water collected by the drainage system in 2012.

Proposed perforated Storm Sewer System, 2008

The adaptation work is being implemented in phases. Total remaining phases for years 2019-2028 is valued at $11M, including road upgrades to provide more resilient transportation and builds on $9M of adaptation work to-date towards implementing the 2009 Study.

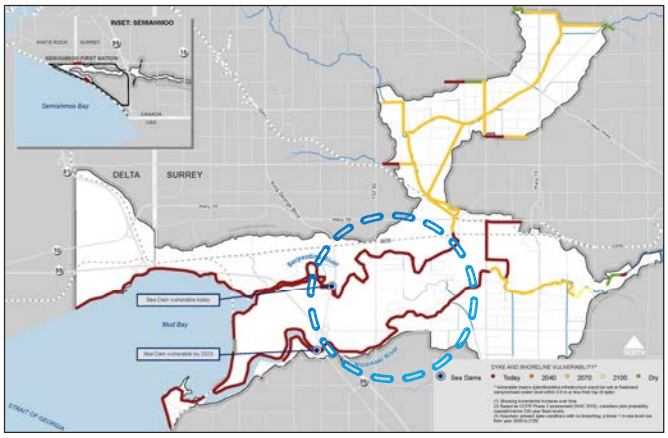
City of Surrey – Dyking – Lower reaches of Nicomekl and Serpentine

One third of City of Surrey is within a floodplain and is bordered by the Fraser River to the north and the Salish Sea to the southwest (see map below). While regional work in BC is developing a strategy focusing on the Fraser River, Surrey has completed two years of stakeholder engagement in a process to develop the Surrey Coastal Flood Adaptation Strategy (CFAS), part of the Municipalities for Climate Innovation Program. It addresses 20% of the City's land and critical infrastructure of national, regional and local significance that is at risk from sea level rise within Surrey.



Impacts cover the areas depicted as: Colebrook, Mud Bay, Serpentine & Nicomekl, Crescent Beach and Campbell River including Semiahmoo First Nation.

A large portion of the dyking system in the floodplain is already vulnerable to flooding, as depicted by red lines on the map below. Lower reaches of Nicomekl and Serpentine Rivers (represented by the blue dashed circle on the map) are among the most vulnerable.



This project will upgrade the dyking system east of 152nd St to increase resilience of sea level rise and protect Surrey lowlands from coastal flooding. It will focus on 3km reach of the Nicomekl River between Elgin Road and 40 Ave Pump Station and isolated low points elsewhere along the two rivers.

The Nicomekl and Serpentine Dykes protect:

- Hwy 99 regional link to Peace Arch Border
- BC Hydro's primary transmission line to U.S.A.
- Agricultural lands
- 152nd Street and other transportation links

Nicomekl River Dyke during high water levels on Dec 13, 2018

City of Surrey – Serpentine SRY Rail Link Bridge Replacement

One third of City of Surrey is within a floodplain and is bordered by the Fraser River to the north and the Salish Sea to the southwest. While regional work in BC is developing a strategy focusing on the Fraser River, Surrey has completed two years of stakeholder engagement in a process to develop the Surrey Coastal Flood Adaptation Strategy (CFAS), part of the Municipalities for Climate Innovation Program. It addresses the coastal floodplains—20% of the City's land—and critical infrastructure of national, regional and local significance that is at risk from sea level rise within Surrey.

Impacts cover the areas depicted as: Colebrook, Mud Bay, Serpentine & Nicomekl, Crescent Beach and Campbell River including Semiahmoo First Nation. Surrey was recently successful in a merit-based grant program from Infrastructure Canada to improve the resilience of crucial infrastructure to coastal flooding, with total value of $187M. Projects include upgrades to the Colebrook and Serpentine-Nicomekl dyking systems, a riverfront park, sea dam and bridge replacements, drainage and pump station upgrades, and foreshore enhancements.

Surrey's extensive floodplain areas

This project aims to replace an existing ageing 40m long timber Serpentine SRY railway bridge, which is vulnerable to overtopping and floatation in flood events.

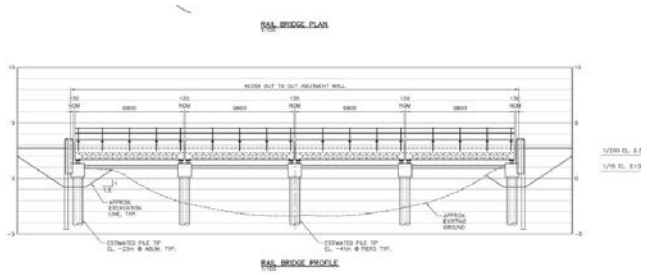
The existing bridge is a low point in the Serpentine-Nicomekl flood control system, which could impact approx. 1 km^2 of adjacent land in case of failure.

Aerial image of the existing Serpentine railway bridge

While the nearby dykes are being upgraded to the Provincial guidelines and flood safety standards, the Serpentine SRY railway bridge remains susceptible to flooding, exposing rail transportation and nearby agricultural fields to the hazard.

Therefore, the proposed single-track Serpentine SRY Rail Link bridge replacement and integration with surrounding dyking updates aims to address this weakness of the system. Additionally, the new structure will provide benefits in increased resilience to seismic and drought hazards. The total value of the proposed bridge replacement is $3M, with a $750,000 contribution from the Federal government secured.

Proposed design of bridge replacement



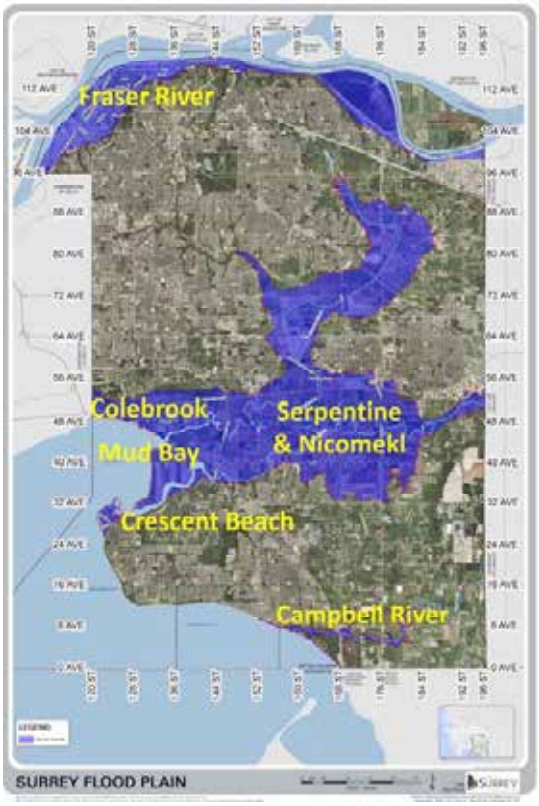
Project will protect the economic, community, agricultural and infrastructure values. It will provide the community co-benefits in protecting the economy (uninterrupted freight and heritage railway traffic), ensuring worker safety and sustaining goods movement.

City of Surrey – Burrows Drainage Pump Station Upgrade

One third of City of Surrey is within a floodplain and is bordered by the Fraser River to the north and the Salish Sea to the southwest. While regional work in BC is developing a strategy focusing on the Fraser River, Surrey has completed two years of stakeholder engagement in a process to develop the Surrey Coastal Flood Adaptation Strategy (CFAS). It addresses 20% of the City's land—and critical infrastructure of national, regional and local significance that is at risk from sea level rise within Surrey.

Impacts cover the areas depicted as: Colebrook, Mud Bay, Serpentine and Nicomekl, Crescent Beach and Campbell River including Semiahmoo First Nation. Surrey was recently successful in a merit-based grant program from Infrastructure Canada to improve the resilience of crucial infrastructure to coastal flooding, with total value of $187M.

Surrey's extensive floodplain areas

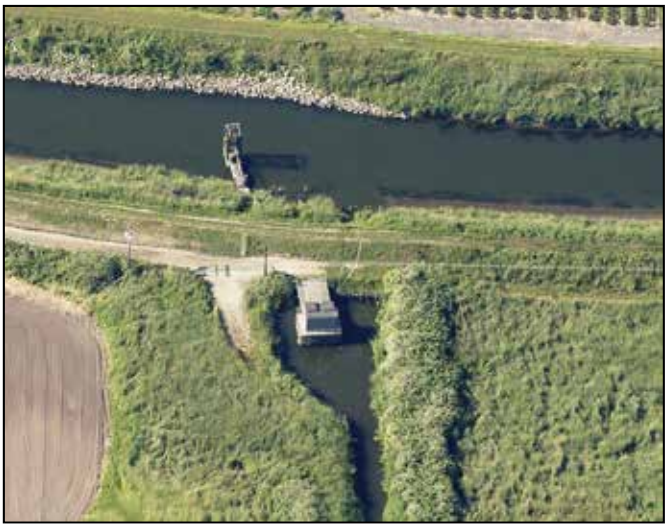


The Burrows Drainage Pump Station is located on the south bank of the Nicomekl River, west of Pacific Highway (Highway 15). Its purpose is to control ditch water levels in the Burrows Drainage Catchment, a part of the Serpentine and Nicomekl floodplain area.

Regional ground subsidence has resulted in an elevation differential between the agricultural fields and base flow water levels controlled by the pump station. The upgrades accommodate the existing elevation differential, as well as to provide flexibility to gradually lower the pump settings to accommodate observed ground subsidence.

The existing pump station plays a double role of managing flooding by draining the ditch waters into the Nicomekl River during heavy rain periods, and providing irrigation benefits during dry summer season (typically June to September) by pumping water in a reverse direction out of the Nicomekl River into the low-lying ditch network within the Burrows Drainage Catchment area.

Aerial image of the existing Burrows Drainage Pump Station



A new pump will be installed to improve the resilience of the, mainly agricultural, floodplain area to flooding. Additionally, the new pump will be less vulnerable to earthquake impacts and will mitigate the drought risk.

The new pump will be fish friendly, thus reducing the overall mortality of fish passing through the pumps.

The total value of the proposed upgrades is $1.5M.

Project will protect the economic, community, agricultural and infrastructure values. It will provide the community co-benefits in sustained agricultural productivity and water quality, and proactive climate change adaptation.

City of Surrey – Stewart Farm Sanitary Pump Station Floodproofing

One third of City of Surrey is within a floodplain and is bordered by the Fraser River to the north and the Salish Sea to the southwest. While regional work in BC is developing a strategy focusing on the Fraser River, Surrey has completed two years of stakeholder engagement in a process to develop the Surrey Coastal Flood Adaptation Strategy (CFAS), part of the Municipalities for Climate Innovation Program. It addresses the coastal floodplains—20% of the City's land—and critical infrastructure of national, regional and local significance that is at risk from sea level rise within Surrey.

Impacts cover the areas depicted as: Colebrook, Mud Bay, Serpentine and Nicomekl, Crescent Beach and Campbell River including Semiahmoo First Nation. Surrey was recently successful in a merit-based grant program from Infrastructure Canada to improve the resilience of crucial infrastructure to coastal flooding, with total value of $187M. Projects include upgrades to the Colebrook and Serpentine-Nicomekl dyking systems, a riverfront park, sea dam and bridge replacements, drainage and pump station upgrades, and foreshore enhancements.

Surrey's extensive floodplain areas

The purpose of this project is to improve the flood resilience of a sanitary pump station, located in the Mud Bay floodplain area.

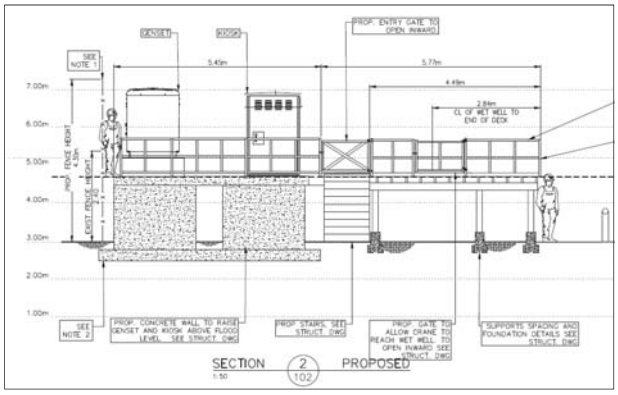
The existing liquid waste lift station is located at low elevation on the south bank of the Nicomekl River. This lower part of the river is tidally influenced, putting the sanitary pump station at risk of being submerged by flood waters during a flood event, which could be damaging to the functioning of the station or cause physical damage to its structures.

Location of the Stewart Farm Sanitary Pump Station on the south bank of the Nicomekl River

This project will raise the existing sanitary pump station infrastructure and floodproof to sustain a 200-year design flood event over the life of the infrastructure. The upgrades will not alter the pump capacity, design, function or operation.

The estimated value of the proposed upgrades is $650,000.

Design of new floodproofed sanitary pump station



Project will protect the economic, environmental and infrastructure values. It will provide the community co-benefits in sustaining sanitation services, ensuring worker safety, and preserving water and environmental quality in flood events.

City of Surrey – Campbell River Pedestrian Bridge Replacement

One third of City of Surrey is within a floodplain and is bordered by the Fraser River to the north and the Salish Sea to the southwest. While regional work in BC is developing a strategy focusing on the Fraser River, Surrey has completed two years of stakeholder engagement in a process to develop the Surrey Coastal Flood Adaptation Strategy (CFAS), part of the Municipalities for Climate Innovation Program. It addresses the coastal floodplains—20% of the City's land—and critical infrastructure of national, regional and local significance that is at risk from sea level rise within Surrey.

Impacts cover the areas depicted as: Colebrook, Mud Bay, Serpentine and Nicomekl, Crescent Beach and Campbell River including Semiahmoo First Nation. Surrey was recently successful in a merit-based grant program from Infrastructure Canada to improve the resilience of crucial infrastructure to coastal flooding, with total value of $187M. Projects include upgrades to the Colebrook and Serpentine-Nicomekl dyking systems, a riverfront park, sea dam and bridge replacements, drainage and pump station upgrades, and foreshore enhancements.

Surrey's extensive floodplain areas

The pedestrian bridge over the Campbell River connects Semiahmoo First Nation with City of Surrey and the City of White Rock.

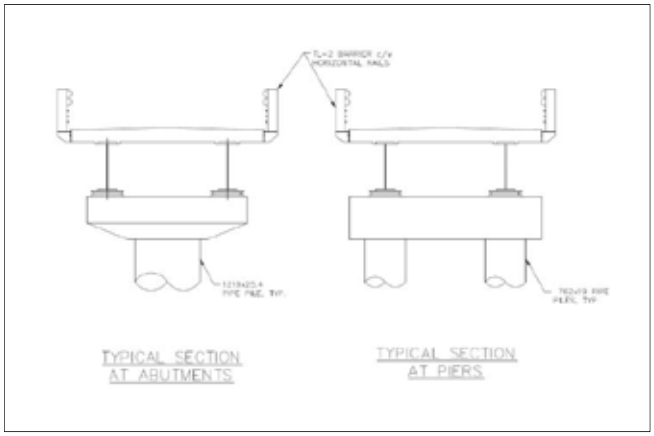
The existing 80m bridge has reached the end of its service life and is at risk of overtopping and floatation in the event of flooding and high water levels in the Campbell River. Currently, the bridge only allows for pedestrian traffic.

Aerial photograph of the Campbell River pedestrian bridge, with Marine Drive/8th Avenue on the left hand side, and Semiahmoo First Nation lands on the right hand side

This project will replace the existing bridge with a new structure, which will be built in accordance with the current flood protection standards and allow for 1m of sea level rise. Additionally, the new structure will include emergency vehicle access provisions—but will otherwise be only open to local pedestrian traffic. The new bridge will be resilient to earthquakes.

The total value of the proposed bridge replacement is $3.8M.

Preliminary typical sections of the replacement bridge



Project will protect the community and infrastructure values. It will deliver community benefits by providing an alternative emergency access route and safely connecting local residents with nearby services and amenities.

City of Surrey & Delta – Boundary Bay Foreshore Enhancements

Effectively adapting to sea level rise requires that Canada innovate with new local techniques. The foreshore enhancements take a collaborative approach to increase adaptive capacity.

Building on work led by numerous partners, an innovative, nature based solution will be implemented at two locations in Boundary Bay to mitigate coastal squeeze damages and coastal flood risk associated with climate change. The "Living Dike" concept, developed with technical, coastal engineering, government and First Nations input since 2016, will be used to enhance habitat and other ecological, cultural and aesthetic values of intertidal and nearshore areas while providing flood regulation services.

Existing salt marsh at risk from coastal squeeze in Boundary Bay

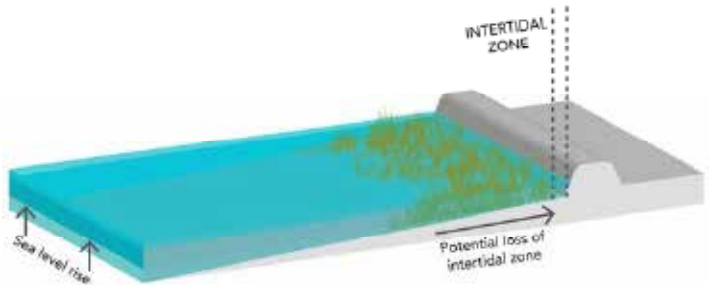
The works will be installed on the foreshore in front of two legislated dykes: one operated by City of Delta and one operated by City of Surrey. Working with natural coastal processes, sediment will be added to mimic natural marsh formation and establish a gentle, vegetated slope. The method will involve creating marsh islands and tidal channels and gradually increasing elevation to adapt to sea level rise of up to 1m. The complex foreshore texture will enhance biodiversity, reduce wave energy and offset the negative ecosystem impacts of coastal squeeze, as documented in multiple studies from coastal jurisdictions in the United States. It will enhance blue carbon sink functionality of the mud flat, to mitigate greenhouse gas emissions.

The City of Surrey Living Dike works will create flood mitigation and ecosystem services for up to 100 m of shoreline adjacent to the Mud Bay Park and include interpretive information. This will complement structural upgrades to the Colebrook Dyke Project in Surrey.

The City of Delta is prioritizing upgrades to 300 to 500 metres of its diking network in Boundary Bay. The original proposal had a flatter slope of 3:1 and granular fills, but DMAF funding will allow foreshore enhancements to incorporate Living Dike concepts for a portion of the project.

The Living Dike restoration methodology is based on successful salt marsh restoration work carried out on Vancouver Island by Project Watershed and K'ómoks First Nation and will involve application of sediment and follow-up monitoring and planting in three to five year cycles. Previous habitat mapping prepared by Friends of Semiahmoo Bay, Ducks Unlimited, City of Surrey and City of Delta will provide supporting information.

Coastal squeeze intertidal impacts (source City of Surrey)



New opportunities to obtain seabed modelling data from the Geological Survey of Canada and shallow water LiDAR from Canadian Hydrographic Services (part of DFO) are being explored. The subject area is within a provincial Wildlife Management Area and the traditional territories of Semiahmoo First Nation and Tsawwassen First Nation. A technical dialogue to support the development of the Living Dike concept has been coordinated by the Lower Fraser Fisheries Alliance (www.lffa.ca) and West Coast Environmental Law, involving BC FLNRORD and the Nations, with participation from staff at DFO, Canadian Wildlife Service and the municipalities.


CFAS
CITY OF
SURREY