

**SURREY COASTAL FLOOD ADAPTATION STRATEGY (CFAS)**

# **PRIMER PART II: OPTIONS**

**Chapter 3: Semiahmoo Bay**

**April 2018**

**CFAS**



# PRELIMINARY OPTIONS PRIMER



## SURREY COASTAL FLOOD ADAPTATION STRATEGY (CFAS)

*Climate change is driving some big changes on Surrey's coastline. Our changing climate means that the historic controls that have been put in place to limit flood damages will be ineffective in limiting future flood damage as sea levels continue to rise. In the short-term, we 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.*

To help prepare Surrey for a changing climate and help make our coastal communities more resilient, we are developing a Coastal Flood Adaptation Strategy (CFAS). To be completed in late 2018, the final strategy will outline the potential future impacts of climate change on Surrey's coastline and the best adaptation options available to address them over the short-, medium, and longer-terms.

Launched in 2016, the project is taking a community-based, participatory approach and engaging residents, stakeholders, and other partners in the project, including First Nations, community and environmental organizations, business associations and groups, senior governments, farmers and the agricultural community, and neighbouring jurisdictions.

For more information about CFAS and flooding risk in Surrey's coastal areas see Primer Part I: Coastal Flooding in Surrey [www.surrey.ca/files/CFAS-primerpart1.pdf](http://www.surrey.ca/files/CFAS-primerpart1.pdf).

## FLOOD ADAPTATION OPTIONS EVALUATION

This Options Primer presents 11 shortlisted coastal flood adaptation options developed for the three CFAS study areas — Mud Bay (Chapter 1), Crescent Beach (Chapter 2), and Semiahmoo Bay (Chapter 3). The options were developed and shortlisted through extensive community consultation, technical analysis from project engineers and City of Surrey staff, and with input through a partnership with UBC and Dutch landscape architects and engineers.

The Options Primer provides a short summary description of each option. Images of similar

adaptation approaches from other areas and jurisdictions are provided along with a sketch plan of the option that illustrates potential conditions in 2100, which is when sea levels are projected to have risen by 1 metre.

For each study area, a summary Technical Overview is provided that highlights the technical merits of the options. For each option, the following information is provided:

**INFRASTRUCTURE, EARTHQUAKE & LANDUSE CHANGES & DESIGN:** a summary of how each option impacts the following:

- **Reduction in dyking:** length of river and coastal dykes that can be decommissioned over time
- **New dyke:** length of new river and coastal dykes required
- **Changes to sea dams:** replacement, decommissioning or relocation needs for existing sea dams
- **Earthquake design:** option performance in an earthquake event
- **Re-purposed land:** land area where the current land uses would change from existing uses
- **Relocated roads and rail lines:** the primary transportation corridors that would need to be raised, relocated, or otherwise adapt
- **Runoff management:** option ability to address river flooding

**VALUES ASSESMENT:** a summary of how each option performs against seven "values criteria" that capture what people and partners in the study area care about most. The values were

developed through an extensive engagement process in the winter and spring of 2017, which included: residential, agricultural and environmental stakeholder focus groups; a special workshop with infrastructure operators and owners; Semiahmoo First Nation; meetings with agriculture and environmental stakeholders (e.g., South Nicomekl Irrigation District, Friends of Semiahmoo Bay, Ducks Unlimited); outreach at community events like Surrey's Earth Day celebration (Party for the Planet); input from high school and elementary school students in the study area; an on-line survey using Surrey's CitySpeaks platform; and other outreach. The seven values criteria are:

- **Residents:** Number of people permanently displaced by the option and anticipated health and safety impacts
- **Agriculture:** Amount of agricultural land permanently lost due to the option
- **Environment:** Anticipated impact (positive and negative) to wetland habitats, freshwater fish habitat and riparian areas that could be expected from the option
- **Infrastructure:** Transportation and utilities service disruptions that could be expected from the option
- **Economy:** Permanent loss of businesses that could be expected from the option
- **Recreation:** The diversity of recreation opportunities (positive and negative) that could be expected from the option
- **Culture:** Semiahmoo First Nation cultural impacts that could be expected from the option

**COST ASSESMENT:** a high-level overview of the cost of implementing the option, including:

- **Capital Cost:** Capital infrastructure cost, estimated land purchasing costs, decommissioning existing infrastructure and land remediation costs

- **Operation & Maintenance Cost:** The yearly operations and maintenance costs
- **Other Infrastructure Cost:** The additional cost of adapting non-flood related infrastructure (e.g., roads & highways, hydro lines, water & sewage mains, etc.)
- **Future Adaptation Cost:** Estimated costs of continued adaptation requirements from both upgrading flood protection infrastructure beyond 1 metre of sea level rise and future replacement costs of aging flood protection infrastructure

**IMPACT & RISK OF FAILURE:** recognizing that all flood protection infrastructure carries some risk of failure, a description of the anticipated impacts to community values from a failure of an option's flood protection infrastructure is provided. To quantify this risk, the likelihood of a failure of an option to provide flood protection was assessed (see appendix) with the consequence that failure would have on identified community values. For each option, a detailed description of the anticipated impacts to community values is provided using a scale from Very Low to Very High.

- **Impact of a Failure:** A description of the consequences to a given value from a catastrophic flooding event due to the failure of the option to provide protection
- **Likelihood of Failure of Option:** Provides a summary evaluation of how likely the option is to fail in the future
- **Risk:** The combination of the likelihood that an option will fail with the impact its failure would have on the value
- **Overall Risk:** The overall risk across all identified community values

A summary table comparing the options for each study area (Mud Bay, Crescent Beach, Semiahmoo Bay) is provided at the end of each chapter.



Semiahmoo Bay is a relatively small area included in CFAS that is occupied largely by Semiahmoo First Nation and the Campbell River. Outside of Semiahmoo First Nation, a portion of 8th Avenue and a few adjacent homes and municipal assets are vulnerable to flooding.

### TECHNICAL OVERVIEW

The Semiahmoo flood hazard area is located at the mouth of Campbell River. The roughly 1.5 km<sup>2</sup> area belongs to the Semiahmoo First Nation and is populated with about 60 dwellings. To the south, the BNSF railway embankment provides a raised buffer between the ocean and the reserve. On the north side, the 8th Avenue roadway provides some flood protection to lands north of the street. However, a low section of road has flooded in the past and flooding is expected to worsen over time.

Severe flooding of the area is caused by high ocean levels. The Campbell River floodplain is relatively narrow and the channel slope steepens upstream of Highway 99. Considering the significant river flows and minimal flood storage, a sea dam similar to the Serpentine and Nicomekl sea dams would be unlikely to reduce flood levels. Dyking around low-lying land is not recommended due to stormwater pumping and land requirements.

The First Nation has observed material build-up near the mouth of the river and has inquired about the feasibility of reducing water levels by providing a cut-off channel, with a more direct route to the ocean. While this would increase flow velocities and reduce river levels at low to medium tides, it would not lower extreme flood levels caused by the ocean. A cut-off channel would cause significant erosion, reduce valuable habitat areas, and is not recommended.

The housing development on the Semiahmoo First Nation land is distributed across two main areas, the western terminus of Beach Road and the Middle/Upper Beach Road areas. Both developments are on relatively high ground and not within the year 2100 floodplain. However, a roughly 600 m long section of Beach Road is at risk of flooding, along with a few buildings outside the main centres. The main flood concern is that access/egress from the western area would be impacted.

### VALUES IMPACTED

#### RESIDENTS



The area is home to Semiahmoo First Nation. There are about 60 dwellings located on the reserve. Approximately 5-10 homes are directly affected by flooding. Along 8th Avenue, there is a home and the 1st floor of an apartment building in the City of Surrey that are directly affected by flooding.

#### ENVIRONMENT



The Campbell River estuary is an important natural area with very high biodiversity values. Unlike the Nicomekl and Serpentine Rivers, the Campbell River does not have a sea dam regulating tidal flows, which has benefits to coastal processes and habitat migration. There are no dykes along the Campbell River.

#### INFRASTRUCTURE



Beach Road is vulnerable to flooding and could pose a challenge to any evacuation efforts for some homes in Semiahmoo First Nation, as it is the only access road to the community. The BNSF rail runs along the shoreline. On 8th Avenue, a sewage pump is located within the flood hazard area. Footbridge has water and gas utilities under it and only has a 2-year lifespan left.

#### ECONOMY



Semiahmoo First Nation reserve lands have substantial potential for economic development. However, several land parcels are within low-lying lands that are vulnerable to flooding.

#### RECREATION



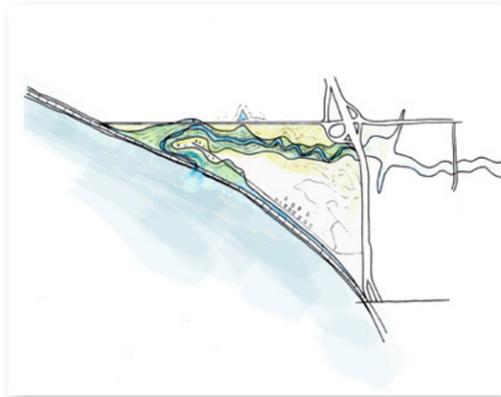
The BNSF runs across the ocean side of Semiahmoo First Nation reserve lands and highly limits ocean access. Park lands within the reserve are also within low-lying lands that are vulnerable to flooding. The Campbell River has become siltier over time and with the river mouth constraint by the rail line the silt deposits and impedes canoe access to the ocean on low tides.

#### CULTURE



Semiahmoo First Nation cemetery is located within low-lying lands that are vulnerable to flooding. Access to traditional food and medicinal plants have been impacted by development and pollution.

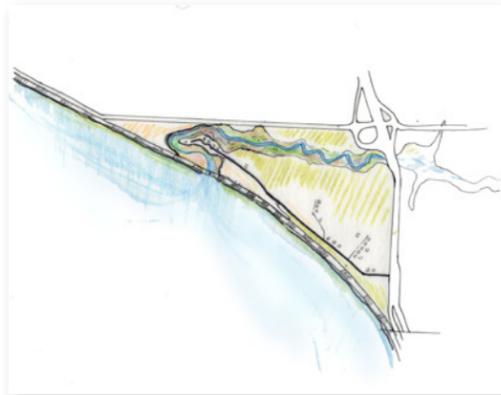
# TECHNICAL OVERVIEW



### NO ADAPTATION

Access to west portion of reserve is cut off during floods, and a portion of 8th Avenue, in the vicinity of the footbridge is affected. Northwest corner of reserve is occasionally inundated and development restrictions apply.

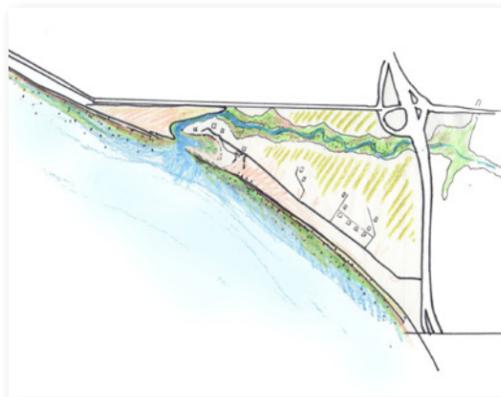
**OVERALL ASSESSMENT:** *Option is not viable in the long term.*  
**TECHNICAL RANKING:** 3rd



### ROAD & LAND RAISING

Raising roads and lands eliminates access concerns to west portion of reserve. By raising the northwest corner of the reserve, development can proceed without it being at risk of flooding.

**OVERALL ASSESSMENT:** *Option is viable in the long term.*  
**TECHNICAL RANKING:** 2nd



### EXPANDED EDGE

This option is similar to the Road & Land Raising option, but the railway embankment would be repurposed as an expanded edge. Access to the ocean from the reserve would be highly improved.

Key areas of the railway embankment must be left intact as a wave barrier. River flow benefits of larger opening to be determined based on modelling.

**OVERALL ASSESSMENT:** *Same as Road & Land Raising option, but with habitat and recreational improvements.*  
**TECHNICAL RANKING:** 1st

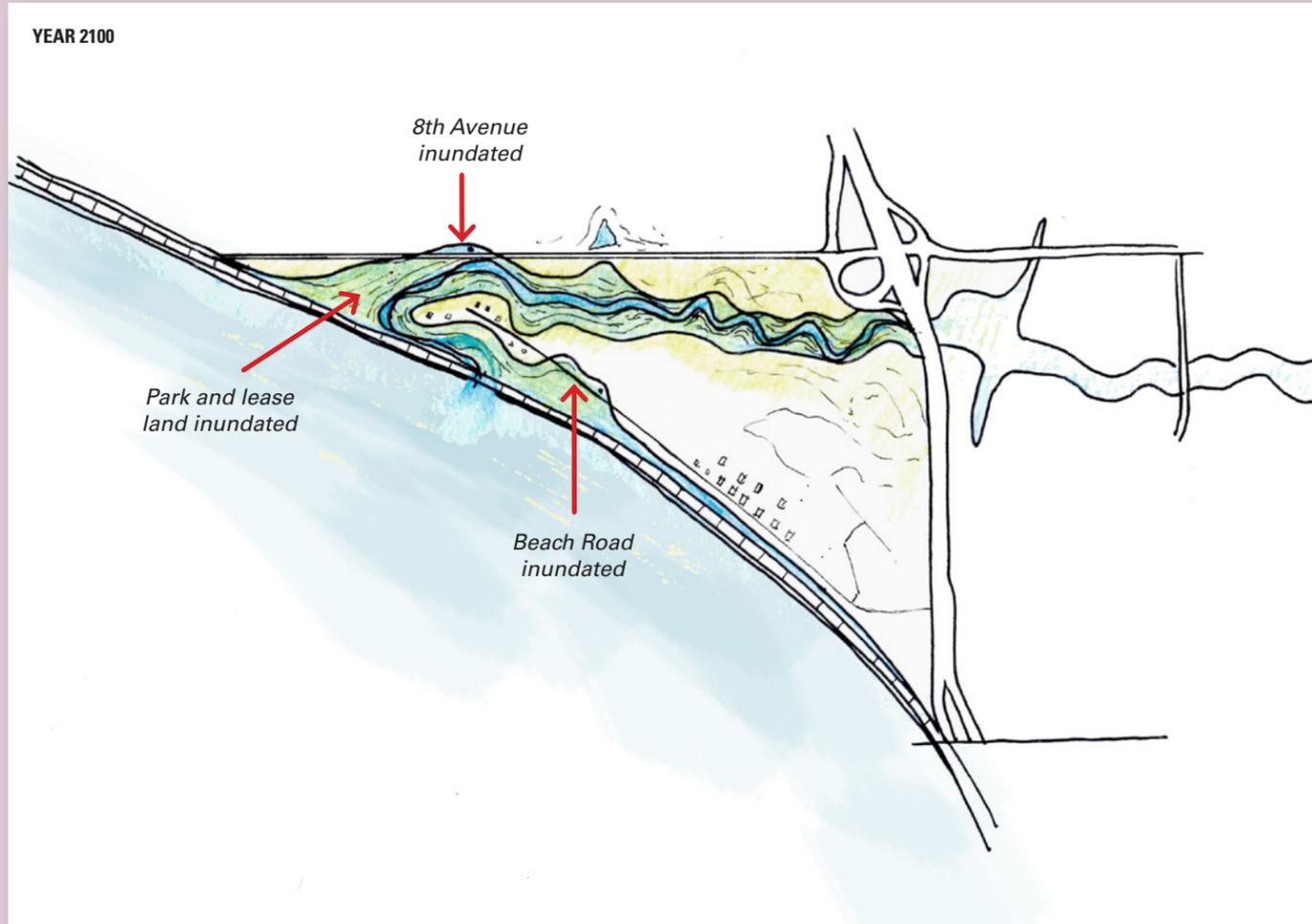
### RISK ASSESSMENT HEAT MAP

The table below provides a high-level overview of risk for each option. Risk is defined as the combination of the likelihood that an option will fail with the impact its failure would have on identified community values. A detailed description of how the likelihood of a failure was calculated is included in the appendix. A detailed description of the impact of the failure of an option on community values is provided for each option description.

		IMPACT				
		Very Low	Low	Medium	High	Very High
LIKELIHOOD	Very High					
	High					
	Medium					
	Low			NO ADAPTATION		
	Very Low		LAND & ROAD RAISING and EXPANDED EDGE			

*Note: While the raising of 8th Ave east of 160th Street is within the jurisdiction of City of Surrey, the majority of works are outside of Surrey's jurisdiction.*

# OPTION 1: NO ADAPTATION



### OPTION DESCRIPTION

Unlike most of Surrey's floodplain, the Semiahmoo Bay area does not rely on flood infrastructure, such as dykes and sea dams, to prevent flooding. As such, this option maintains the "no adaptation" approach by allowing floodplain areas to flood over time. The concept assumes temporary flood protection is provided as required and emergency response is improved. Flood forecasts (ocean and river) become a valuable tool. If necessary over time, housing can be relocated to higher ground. Limited adaptation of municipal infrastructure may be possible under existing budgets during capital renewal cycles.

### WHAT THIS COULD LOOK LIKE



Temporary flood walls in the UK  
CC-by-sa, Henry Burrows, flickr.com



Increased flooding



Develop evacuation routes and communication

### INFRASTRUCTURE, EARTHQUAKE & LANDUSE CHANGES & DESIGN

**Reduction in dyking:** None.

**New dykes:** None.

**Earthquake design:** Not applicable.

**Re-purposed land:** None.

**Relocated roads/rail lines:** None.

# OPTION 1: NO ADAPTATION

VERY LOW    LOW    MEDIUM    HIGH    VERY HIGH

## VALUES CRITERIA

FAR WORSE ← NO CHANGE → FAR BETTER

<b>RESIDENTS</b>	On Semiahmoo First Nation land, Beach Road would experience regular flooding and 20 or more homes could become isolated during a flood event. On 8th Avenue, one home and one apartment building could experience regular flooding.	<i>Indicator: People permanently displaced</i> SLIGHTLY WORSE
<b>ENVIRONMENT</b>	Increased erosion and loss of riparian areas could result from higher water levels and increased flooding. Beach road contains creosote contamination that would leach in a flood event, as would the septic fields. The option would allow the area to adapt to changing conditions over time, although some environmental values would be impacted.	<i>Indicator: Impacts to wetland habitats, freshwater fish habitat &amp; riparian areas</i> SLIGHTLY WORSE
<b>INFRASTRUCTURE</b>	Sections of 8th Avenue and Beach Road could become inundated. Flooding of Beach Road limits access to the western area of Semiahmoo First Nation reserve and challenges evacuation efforts. Underground utilities and the BNSF rail line would be affected.	<i>Indicator: Percent of service/transportation infrastructure made vulnerable</i> MODERATELY WORSE
<b>ECONOMY</b>	Current lands and buildings that Semiahmoo First Nation gains revenue from would experience regular flooding and would likely negatively impact the revenue stream. Several land parcels that could potentially be developed would be regularly flooded.	<i>Indicator: Revenue</i> MODERATELY WORSE
<b>RECREATION</b>	Access to the ocean would continue to be restricted by the BNSF rail line. Park lands within the reserve would be regularly flooded.	<i>Indicator: Diversity of recreational opportunities</i> SLIGHTLY WORSE
<b>CULTURE</b>	The Semiahmoo First Nation cemetery would be regularly flooded and no longer suitable. Access to traditional food and medicinal plants would continue to be negatively impacted by development and pollution in the surrounding areas.	<i>Indicator: Opportunities for traditional practices</i> NO CHANGE

## IMPACT & RISK OF FAILURE

Impact of Failure on Value x Likelihood of Failure of Option = Risk

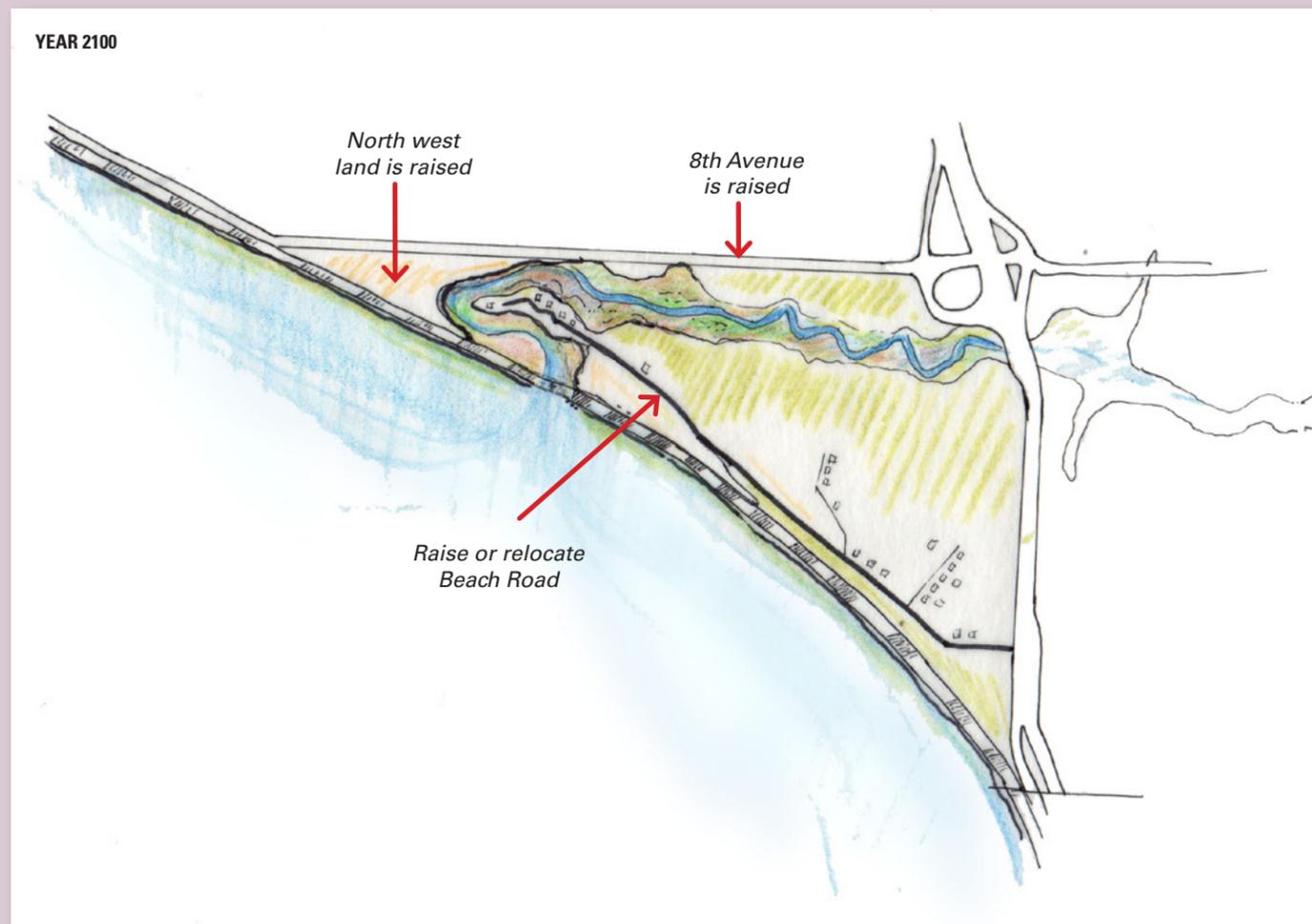
<b>RESIDENTS</b>	Houses in the area are generally above flood levels, but some could be impacted on 8th Avenue. Unlikely that loss of life occurs from a flood event.	●	●	●
<b>ENVIRONMENT</b>	Possible debris washed into streams. Sewage lift station could be impacted causing contamination. Watermains could be damaged creating some spillage of chlorinated water.	●	●	●
<b>INFRASTRUCTURE</b>	Approximately 100 metre section of 8th Avenue and 230 metre section of Beach Road would be inundated. The pedestrian bridge would be washed out, including the attached utilities.	●	●	●
<b>ECONOMY</b>	A large flood event would negatively impact the existing commercial buildings located in the northwest corner of the reserve. Any future buildings or development in the area would likewise be impacted.	●	●	●
<b>RECREATION</b>	Temporary loss of shoreline trails.	●	●	●
<b>CULTURE</b>	Cemetery would be flooded and possibly expose human remains.	●	●	●

Overall Risk: ●

## COST CRITERIA

CAPITAL COST	OPERATION & MAINTENANCE COST	OTHER INFRASTRUCTURE COST	FUTURE ADAPTATION COST
—	\$100K - \$1M	less than \$1M	\$10M - \$100M

# OPTION 2: ROAD & LAND RAISING



## WHAT THIS COULD LOOK LIKE



Beach road is raised or rerouted to remain on higher elevated areas.

### OPTION DESCRIPTION

In this option, Beach Road would be raised. The small section of 8th Avenue that is vulnerable to flooding would also be raised. Lands in the northwest corner of the reserve would be raised to meet Flood Construction Levels. Land vulnerable to flooding in the southeast corner would be raised to meet Flood Construction Levels.

### INFRASTRUCTURE, EARTHQUAKE & LANDUSE CHANGES & DESIGN

**Reduction in dyking:** None.

**New dykes:** None.

**Earthquake design:** Not applicable.

**Re-purposed land:** Land in northwest corner becomes developable once raised to above Flood Construction Levels, which entails adding approximately 2 metres of fill over most of area, as well as creating erosion protection along river. The raising of 8th Avenue and Beach Road to Flood Construction Levels will slightly increase the road footprints. Along 8th Avenue, there may be minor negative impacts to the river bed from erosion protection installed.

**Relocated roads/rail lines:** None. The low sections of 8th Avenue and Beach Road would be raised. The footbridge would be replaced and raised. Erosion protection would be added along the low sections of 8th Avenue, and the sewage pump station would be floodproofed.

# OPTION 2: ROAD & LAND RAISING

VERY LOW    LOW    MEDIUM    HIGH    VERY HIGH

## VALUES CRITERIA

FAR WORSE ← NO CHANGE → FAR BETTER

*Indicator: People permanently displaced*



*Indicator: Impacts to wetland habitats, freshwater fish habitat & riparian areas*



*Indicator: Percent of service/transportation infrastructure made vulnerable*



*Indicator: Revenue*



*Indicator: Diversity of recreational opportunities*



*Indicator: Opportunities for traditional practices*



### RESIDENTS



No residents are relocated.

### ENVIRONMENT



The option would have a low impact on this relatively undisturbed area.

### INFRASTRUCTURE



Road infrastructure is raised or partly relocated. Utilities are protected by the raised road or relocated to high ground alongside the relocated road. Footbridge is upgraded and built to allow vehicle emergency access and additional utilities (water and gas) are added underneath it. The BNSF rail line would continue to experience flooding.

### ECONOMY



Current lands and buildings that Semiahmoo First Nation gains revenue from would be raised and future development would be built to flood construction levels and be protected from flooding.

### RECREATION



Access to the ocean would continue to be restricted by the BNSF rail line. However, park lands within the reserve would be raised.

### CULTURE



The Semiahmoo First Nation cemetery would be filled and headstones would be raised to avoid future flooding. Access to traditional food and medicinal plants would continue to be negatively impacted by development and pollution in the surrounding areas.

## IMPACT & RISK OF FAILURE

Impact of Failure on Value x Likelihood of Failure of Option = Risk

### RESIDENTS



Houses in the area are generally above flood levels, but some could be impacted on 8th Avenue. Unlikely that loss of life occurs from a flood event.



### ENVIRONMENT



Possible debris washed into streams.



### INFRASTRUCTURE



No expected impact as all roads and services would be raised.



### ECONOMY



No impacts expected as all the commercial land and buildings would be raised above flood construction levels.



### RECREATION



Temporary loss of shoreline trails.



### CULTURE



No impact expected as cemetery would be filled above flood construction levels.



Overall Risk:



## COST CRITERIA



CAPITAL COST

less than \$10M



OPERATION & MAINTENANCE COST

less than \$100K



OTHER INFRASTRUCTURE COST

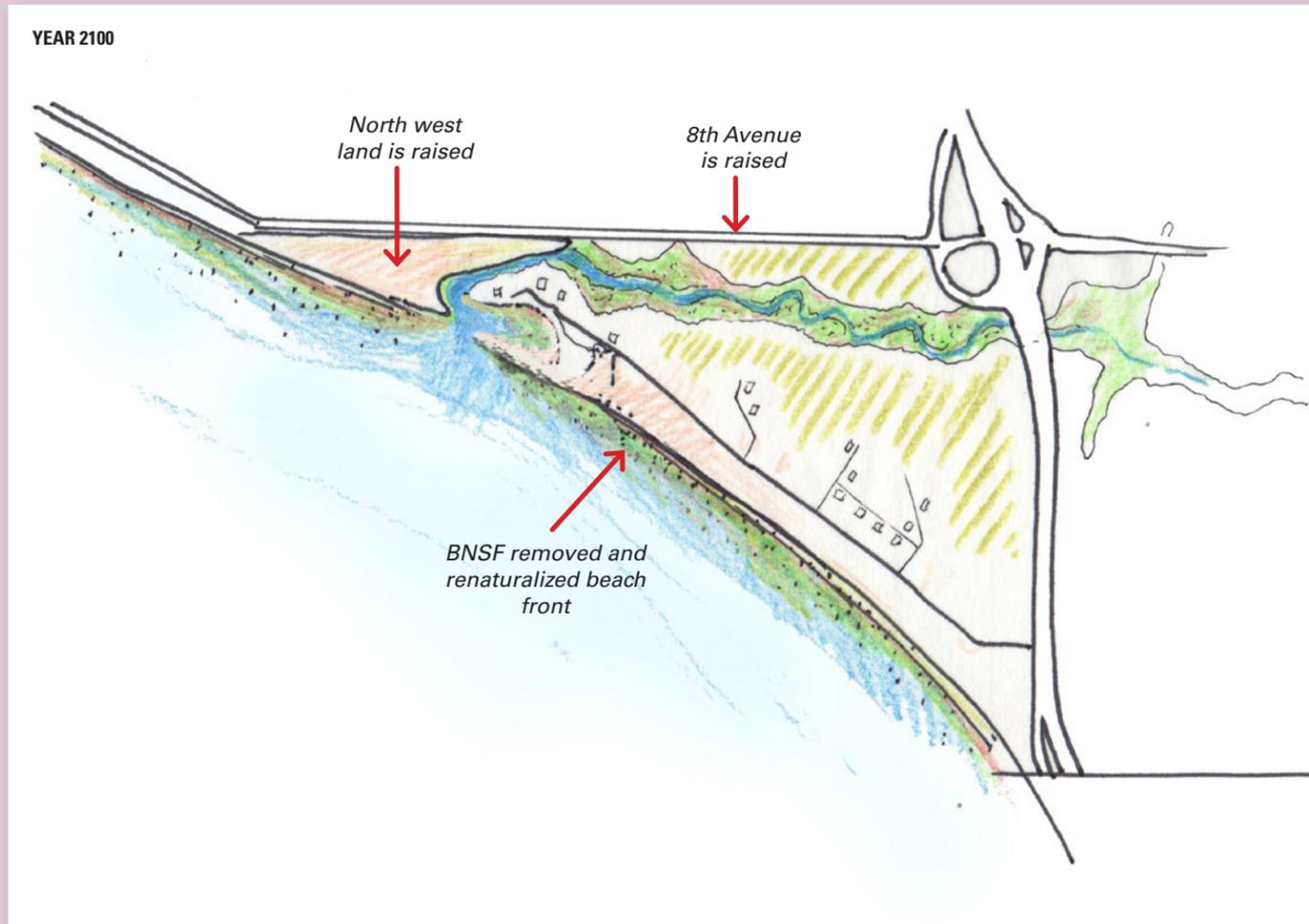
\$1M - \$10M



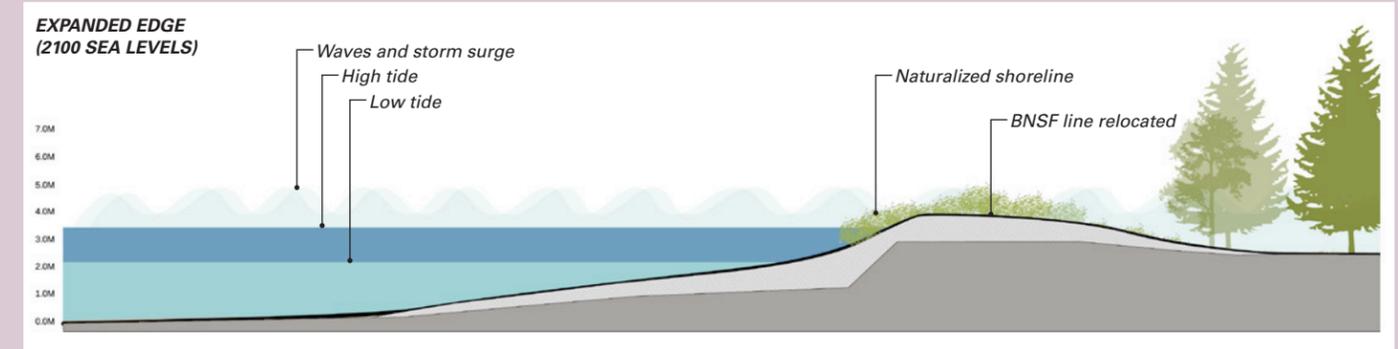
FUTURE ADAPTATION COST

less than \$10M

# OPTION 3: EXPANDED EDGE



## WHAT THIS COULD LOOK LIKE



Section of expanded edge



Expanded edge protects from storm surge and accommodates trails and other uses. Image courtesy of BC Parks



Vegetated expanded edge reduces wind and wave run up

### OPTION DESCRIPTION

This option proposes raising 8th Avenue and Beach Road and low-lying lands, as well as building the beach out in front of the existing shoreline to reduce the slope of the foreshore and, in turn, reduce wave run-up. Using a Green Shores approach, traditional indigenous shoreline access would be restored and habitat values could be significantly improved. This option is possible in the event of inland relocation of the BNSF railway.

### INFRASTRUCTURE, EARTHQUAKE & LANDUSE CHANGES & DESIGN

**Reduction in dyking:** None.

**New dykes:** None.

**Earthquake design:** Not applicable.

**Re-purposed land:** Some of the railway embankment is converted to naturalized shoreline. Land in northwest corner becomes developable once raised above Flood Construction Levels, which entails adding approximately 2 metres of fill over most of area, as well as creating erosion protection along the river. The raising of 8th Avenue and Beach Road to Flood Construction Levels will slightly increase the road footprints. Along 8th Avenue, there may be minor negative impacts to the river bed from installing erosion protection.

**Relocated roads/rail lines:** BNSF line relocated away from reserve shoreline. Erosion protection may be required where the rail embankment is removed (to be determined). The low sections of 8th Avenue and Beach Road would be raised. The footbridge would be replaced and raised. Erosion protection would be added along the low sections of 8th Avenue, and the sewage pump station would be floodproofed.

# OPTION 3: EXPANDED EDGE

VERY LOW    LOW    MEDIUM    HIGH    VERY HIGH

## VALUES CRITERIA

FAR WORSE ← NO CHANGE → FAR BETTER

### RESIDENTS



No residents are relocated.

Indicator: People permanently displaced



NO CHANGE

### ENVIRONMENT



The option would create additional areas for new riparian areas, coastal vegetation, and tidal flows.

Indicator: Impacts to wetland habitats, freshwater fish habitat & riparian areas



MODERATELY BETTER

### INFRASTRUCTURE



Any infrastructure located within flood hazard areas is relocated. Footbridge is upgraded and built to allow vehicle emergency access and additional utilities (water and gas) are added underneath it.

Indicator: Percent of service/transportation infrastructure made vulnerable



FAR BETTER

### ECONOMY



Current lands and buildings that Semiahmoo First Nation gains revenue from would be raised and future development would be built to flood construction levels and be protected from flooding. Furthermore, with the removal of the BNSF line the area would likely attract more interest and investment.

Indicator: Revenue



FAR BETTER

### RECREATION



With the removal of the BNSF rail line access to the ocean and beach would be highly improved. Potentially the silt accumulation on the river mouth would lessen and canoe access improve. Park lands prone to flooding within the reserve would be raised.

Indicator: Diversity of recreational opportunities



FAR BETTER

### CULTURE



The Semiahmoo First Nation cemetery would be filled and headstones would be raised to avoid future flooding. Access to traditional food and medicinal plants would continue to be negatively impacted by development and pollution in the surrounding areas.

Indicator: Opportunities for traditional practices



NO CHANGE

## IMPACT & RISK OF FAILURE

Impact of Failure on Value x Likelihood of Failure of Option = Risk

### RESIDENTS



Houses in the area are generally above flood levels but some could be impacted on 8th Avenue. Unlikely that loss of life occurs from a flood event.



### ENVIRONMENT



Possible debris washed into streams.



### INFRASTRUCTURE



No expected impact as all roads and services would be raised.



### ECONOMY



No impacts expected as all the land and buildings would be raised above flood construction levels.



### RECREATION



Temporary loss of shoreline trails.



### CULTURE



No impacts expected as cemetery would be raised above flood construction levels.



Overall Risk:



## COST CRITERIA



CAPITAL COST

less than \$10M



OPERATION & MAINTENANCE COST

less than \$100K



OTHER INFRASTRUCTURE COST

\$1M - \$10M



FUTURE ADAPTATION COST

less than \$10M



**NO ADAPTATION****Likelihood of Failure**

- **Dyke overtopping:** N/A - No dykes.
- **Dyke erosion failure:** High - There are no dykes but there would be erosion along 8th Avenue at bank of Campbell River.
- **Earthquake failure:** N/A - No dykes.
- **Mechanical failure:** N/A - No pump stations.
- **Seepage Increase:** N/A - Because of topography there is no risk.
- **Precipitation flooding:** High - With sea level rise and increased precipitation there is potential of flooding of low lying areas.

**Costs**

- **Capital Cost of Implementation:** None.
- **O&M Cost:** Over time, some clean up after flood events. Rebuild 8th Avenue and Beach Road.
- **Other Infrastructure Cost:** Replace footbridge and utilities at crossing as needed.
- **Future Adaptation Cost:** In the long term, may need to relocate some housing. And access limitations may become a significant concern. Significant upgrades to 8th Avenue and Beach Road will be required.

**ROAD & LAND RAISING****Likelihood of Failure**

- **Dyke overtopping:** N/A - No dykes.
- **Dyke erosion failure:** N/A - There are no dykes but 8th Avenue will require riprap to protect from river erosion.
- **Earthquake failure:** N/A - No dykes.
- **Mechanical failure:** N/A - No pump stations.
- **Seepage Increase:** N/A - Because of topography there is no risk.
- **Precipitation flooding:** Low - raising roadways will eliminate access problems.

**Costs**

- **Capital Cost of Implementation:** Low area in northwest corner of reserve is raised by bringing in fill and providing some erosion protection along river. Raise 8th Avenue low sections and protect with riprap. The sewage lift station on 8th avenue would be flood proofed.
- **O&M Cost:** Some occasional maintenance and inspections of roads and footbridge.
- **Other Infrastructure Cost:** Raise low sections of Beach Road and replace footbridge and utilities at crossing as needed. Over time, raise or floodproof potentially affected houses.
- **Future Adaptation Cost:** In long term, there may be the need to relocate some housing.

**EXPANDED EDGE****Likelihood of Failure**

- **Dyke overtopping:** N/A - No dykes.
- **Dyke erosion failure:** N/A - No dykes.
- **Earthquake failure:** N/A - No dykes.
- **Mechanical failure:** N/A - No pump stations.
- **Precipitation flooding:** Low - raising roadways will eliminate access problems. Creating openings in the rail embankment may or may not reduce peak flood levels in the lower Campbell River.

**Costs**

- **Capital Cost of Implementation:** Habitat restoration of shoreline. Remnants of the railway embankment is left in place to provide wave protection. Erosion protection at railway opening may be required. Low area in northwest corner of reserve is raised by bringing in fill and providing some erosion protection along river. Raise 8th Avenue low sections and protect with riprap. The sewage lift station on 8th avenue would be flood proofed.
- **O&M Cost:** Some occasional maintenance and inspections of roads and footbridge.
- **Other Infrastructure Cost:** Raise low sections of Beach Road and replace footbridge and utilities at crossing as needed. Relocate BNSF railway.
- **Future Adaptation Cost:** In long term, there may be the need to relocate some housing.

## MORE INFORMATION

*For more information, please contact:*

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**[www.surrey.ca/coastal](http://www.surrey.ca/coastal)**

**CFAS**

