



SURREY COASTAL FLOOD ADAPTATION STRATEGY (CFAS)

Improving Coastal Flood Adaptation Approaches
(ICFAA)

Stakeholder Workshop



Associated
Engineering

GLOBAL PERSPECTIVE.
LOCAL FOCUS.

Workshop

Introductions and Opening Remarks

Our objectives for the day

- To explore what impacts selected adaptation options may have on key infrastructure and land-use located in the Mud Bay Study Area.
- To gain a better understanding of:
 - Sea level rise and its impacts on coastal
 - The Coastal Flood Adaptation Strategy (CFAS) project
 - **How to develop and improve adaptation options for the study area including complementary options**
 - Next steps and continued engagement in the CFAS project

Our objectives for the day

- Considerations:
 - Large cross section of stakeholders with difference interests, experiences and goals
 - Respectful all discussion (no right or wrong comments)
 - Focus on today's process - don't get lost in the detail
 - Make this a 'safe' discussion
 - Without prejudice
 - No 'got you' comments
 - Be mindful of your technology - breaks will be provided
 - Serious topic but we will try to enjoy the process and our day
 - Video and interviews
 - Thank everyone for their time and commitment

Agenda

9:00 - 9:15	Introductions and Opening Remarks
9:15 - 10:15	CFAS Update <ul style="list-style-type: none">- CFAS Overview- March 2017 PIEVC Vulnerability Workshop- Study Tour Overview- Preliminary Adaptation Options
10:15 - 10:30	Break
10:30 - 10:45	PIEVC Engineering and Triple Bottom Line Analysis
10:45 - 12:15	Adaptation Introduction and Group Exercise 1 <ul style="list-style-type: none">- Adaptation Option 1: Coastal Realignment to 152nd Street- Group Discussion
12:15 - 1:00	Lunch
1:00 - 2:45	Group Exercise 2 <ul style="list-style-type: none">- Adaptation Option 2: River Realignment- Group Discussion
2:45 - 3:00	Break
3:00 - 3:45	Exercise 3 <ul style="list-style-type: none">- Option Evaluation and Next Steps
3:45 - 4:00	Closing Remarks

Disclaimer

Please note that this workshop shall not be construed as an acceptance or assumption of risk, responsibility, or liability by or on behalf of the City for the ongoing safe construction, operation, use, and maintenance of infrastructure. The full and complete responsibility and liability to ensure the ongoing safe construction, operation, use, and maintenance of infrastructure has been and continues to remain with infrastructure owners.

Workshop

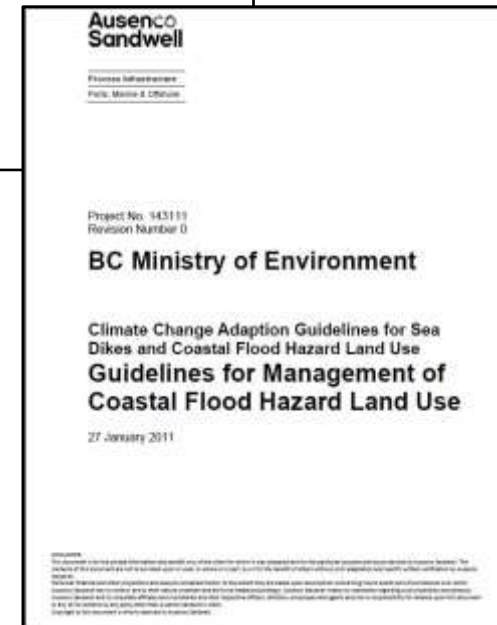
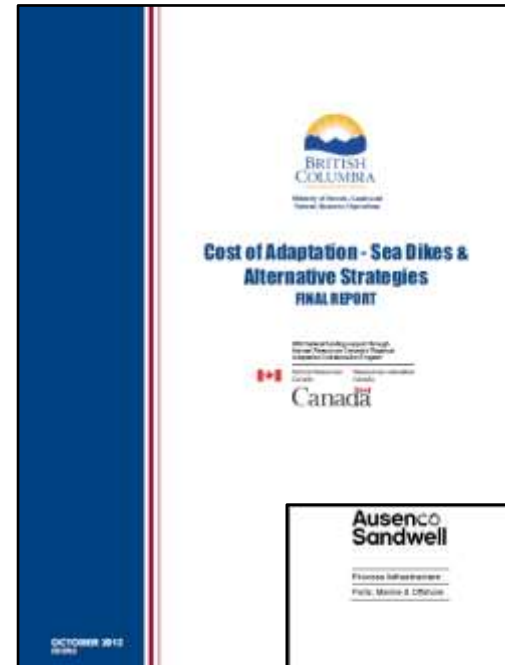
CFAS Update

Background

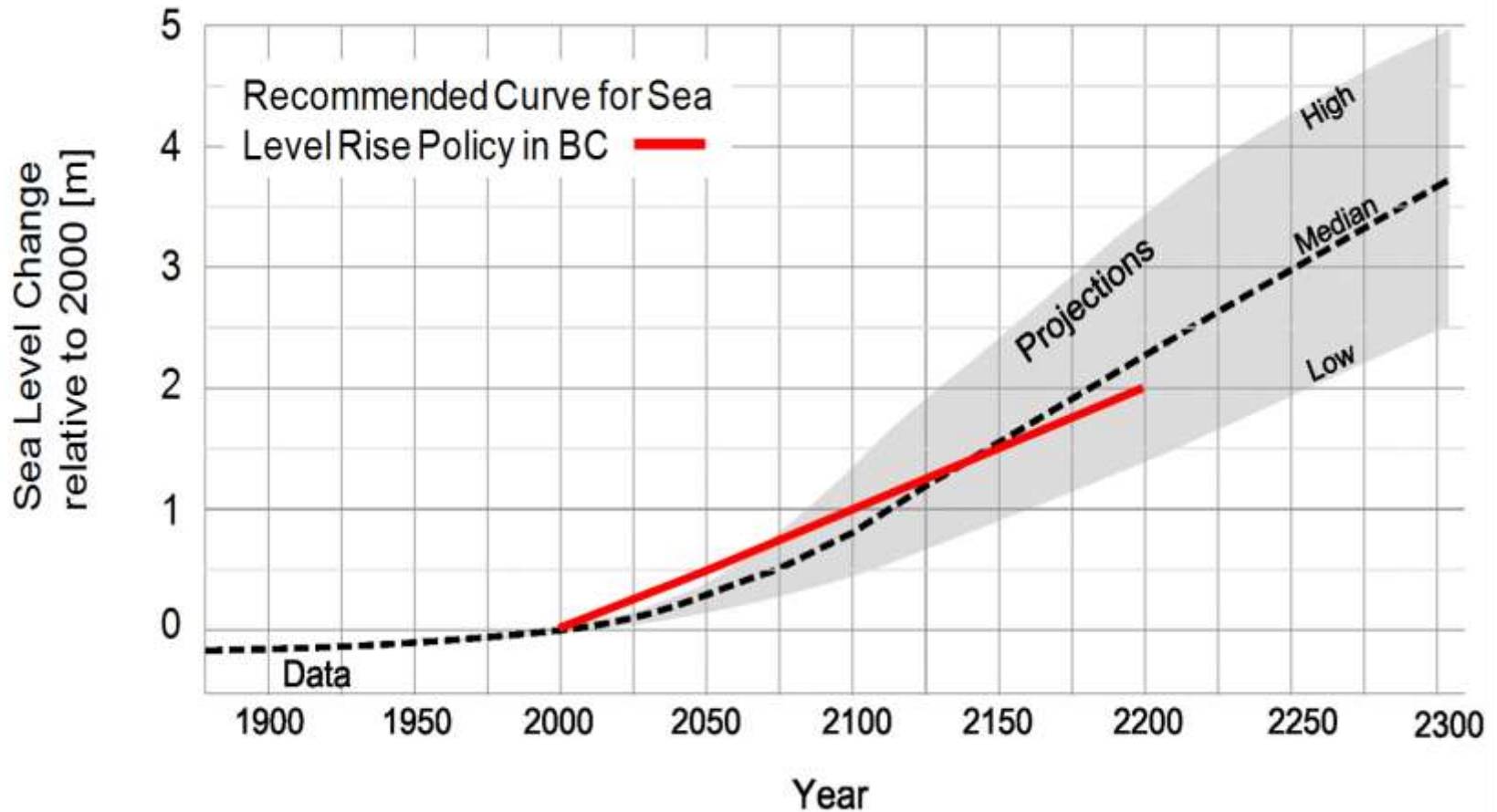
April 8 2013 R054 – Responsibility for the Colebrook Dyking District & Mud Bay Dyking District

The report outlined:

- dissolution of 2 dyking districts;
- Provincial reports regarding the estimated costs to address the impacts of sea level rise and other coastal hazards in Surrey (\$1.6 billion); and
- change in Provincial dyke design standards (2011).



Provincial Recommended Sea Level Rise Curve (2011)



City of Surrey Actions

Priority Actions:

“Conduct detailed analysis on Surrey-specific climate impacts, including timelines and extent of sea level rise and its related effects on flood construction levels and floodplain designations”



Adopted Nov. 2013

SURREY COASTAL FLOOD ADAPTATION STRATEGY (CFAS)

- Mayor & Council adopted recommendations to develop a Coastal Strategy Feb 22, 2016 under Corporate Report No. R034;2016
 - Continuing commitment to participatory planning
- CFAS anticipated to be complete by end of 2018
- Large study area with many communities, stakeholders and partners



The map displays the Fraser River and its tributaries, including the Chilliwack River and the Fraser Inlet. A red dashed line outlines the ICFAA Study Area, which covers a large portion of the city's coastal and inland areas. A white arrow points to the CFAS Study Area, which is a smaller, more specific region within the larger study area. The map also shows various streets and landmarks, such as the Strait of Georgia and the City of Delta.

ICFAA STUDY AREA

CFAS STUDY AREA

Workshop

CFAS Overview

March 2017 PIEVC Vulnerability Workshop

Vulnerability Assessment

- As part of the CFAS engagement process, Mud Bay infrastructure operators, owners & emergency service providers participated in a one day workshop on March 28, 2017.
- Workshop included 66 participants from 28 organizations
- Workshop utilized the PIEVC Protocol
- 43 assets identified & assessed



Vulnerability Assessment



Vulnerability Assessment



Vulnerability Assessment



Vulnerability Assessment



Vulnerability Assessment



Vulnerability Assessment



Flood Scenario A – Coastal Flood with Dyke Breach



Flood Scenario A – Coastal Flood with Dyke Breach



PIEVC Risk Assessment

- Risk Summary
 - Flood Scenario A – **Coastal Flood with Dyke Breach**
 - Current risks are mostly low and medium

		Flood Scenario A - Current
Low Risk		20
Medium Risk		21
High Risk		2

PIEVC Risk Assessment

- Risk Summary
 - Flood Scenario A – **Coastal Flood with Dyke Breach**
 - Current risks are mostly low and medium
 - Future risks increase to mostly medium and high

	Flood Scenario A - Current	Flood Scenario A - Future
Low Risk	20	6
Medium Risk	21	15
High Risk	2	22

PIEVC Risk Assessment

- Risk Summary
 - Flood Scenario B – **Riverine Flood (dykes remain intact)**

		Flood Scenario B - Current
Low Risk		43
Medium Risk		0
High Risk		0

PIEVC Risk Assessment

- Risk Summary
 - Flood Scenario B – **Riverine Flood (dykes remain intact)**
 - Current risks are all low
 - Future risks increase to medium and with a few high risks

	Flood Scenario B - Current	Flood Scenario B - Future
Low Risk	43	14
Medium Risk	0	22
High Risk	0	7

Workshop

CFAS Overview Video

Video Available:

<https://youtu.be/Q3hYUtQQhAc>

Workshop

Study Tour Overview

Study Area Bus Tour – What Did We Hear?

(A brief sample)

- Regional and interjurisdictional coordination is needed
- Significant costs associated with both options, opportunity for cost-sharing important
- Need to get regulators on board and have political will
- Consider overall resilience of solutions to multiple hazards
- Adaptability over time



Regional Flood Strategy

- The Joint Program Committee of the Fraser Basin Council is developing a regional approach to flood management.
 - **Phase 1** investigated the risk, vulnerabilities and consequences of a large flood event including effects of sea level rise.
 - **Phase 2** will entail the development of a regional strategy and potential funding.



Workshop

CFAS Preliminary Options

SURREY COASTAL FLOOD ADAPTATION STRATEGY (CFAS)

WORKSHOP BACKGROUND

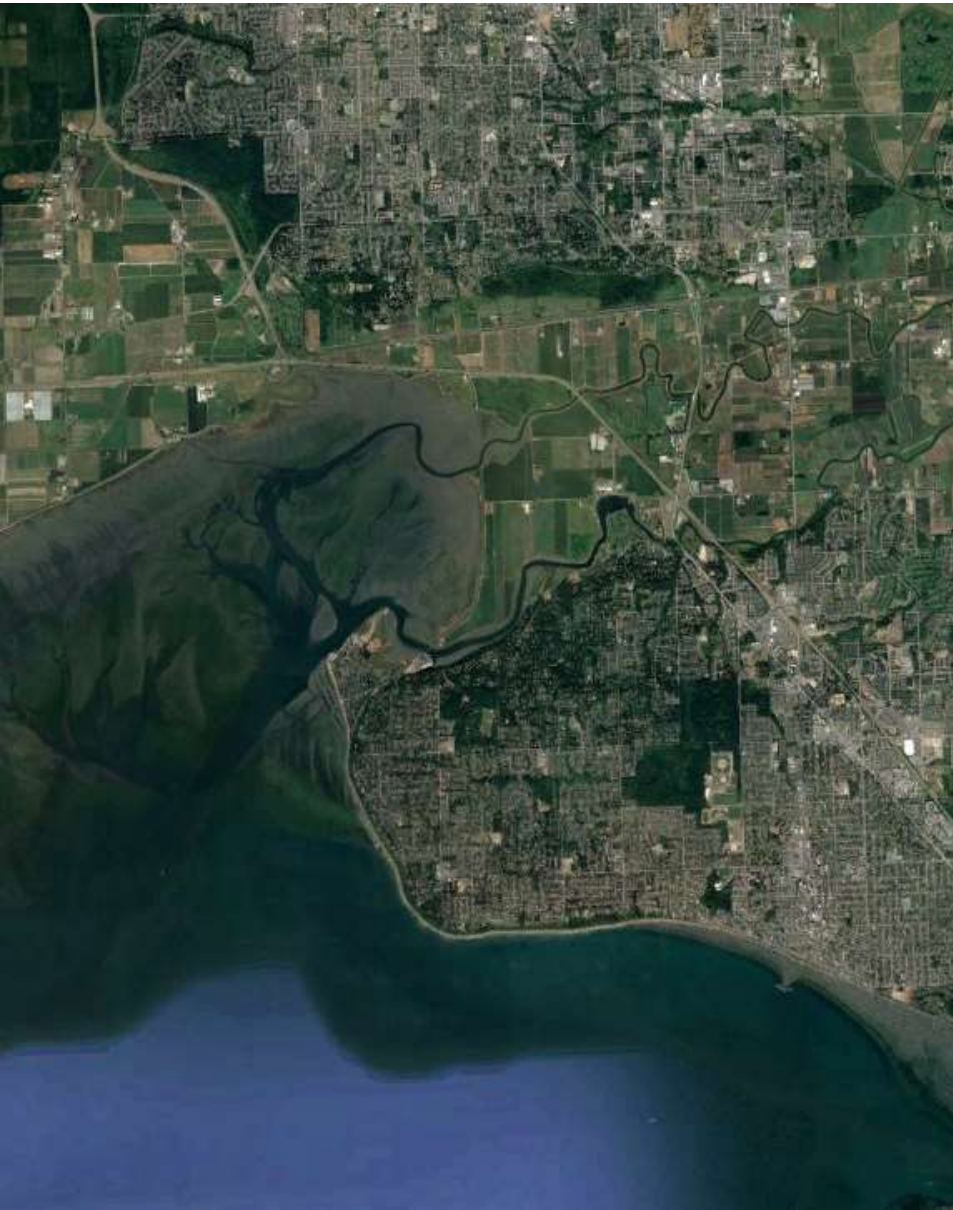
Infrastructure Owners, Managers
and Emergency Responders

OCTOBER 10, 2017

CFAS |  CITY OF SURREY

CFAS Preliminary Options

Preliminary Options Overview



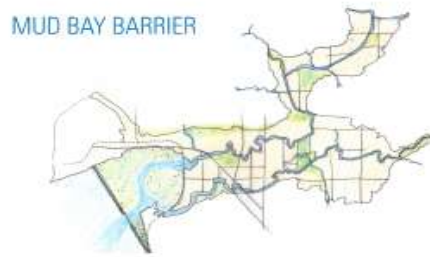
- Developed with stakeholder input and in collaboration with UBC-LINT (Dutch Firm)
- 10,000 ft view: Large area with many possibilities/options
- Only presenting options that are significantly different from each other
- Options are preliminary and not public
- Details and phasing come at a later point

Preliminary Options Overview

CURRENT CONVENTIONS



MUD BAY BARRIER



RIVER REALIGNMENT



COASTAL REALIGNMENT
(HIGHWAY 99)



COASTAL REALIGNMENT
(152ND STREET)



EDGE REALIGNMENT



MANAGED RETREAT



NO ADAPTATION



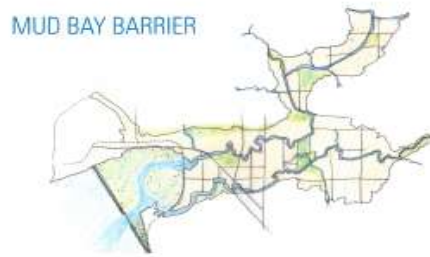
1. Current Convention
2. Mud Bay Barrier
3. River Realignment
4. Coastal Realignment to Highway 99
5. Coastal Realignment to 152nd Street
6. Edge Realignment
7. Managed Retreat
8. No Adaptation

Preliminary Options Overview

CURRENT CONVENTIONS



MUD BAY BARRIER



RIVER REALIGNMENT



COASTAL REALIGNMENT (HIGHWAY 99)



COASTAL REALIGNMENT (152ND STREET)



EDGE REALIGNMENT



MANAGED RETREAT



NO ADAPTATION



- Options selected as they affect infrastructure in substantially different ways and will aid in a greater understanding of the implications the options have on infrastructure located in the study area

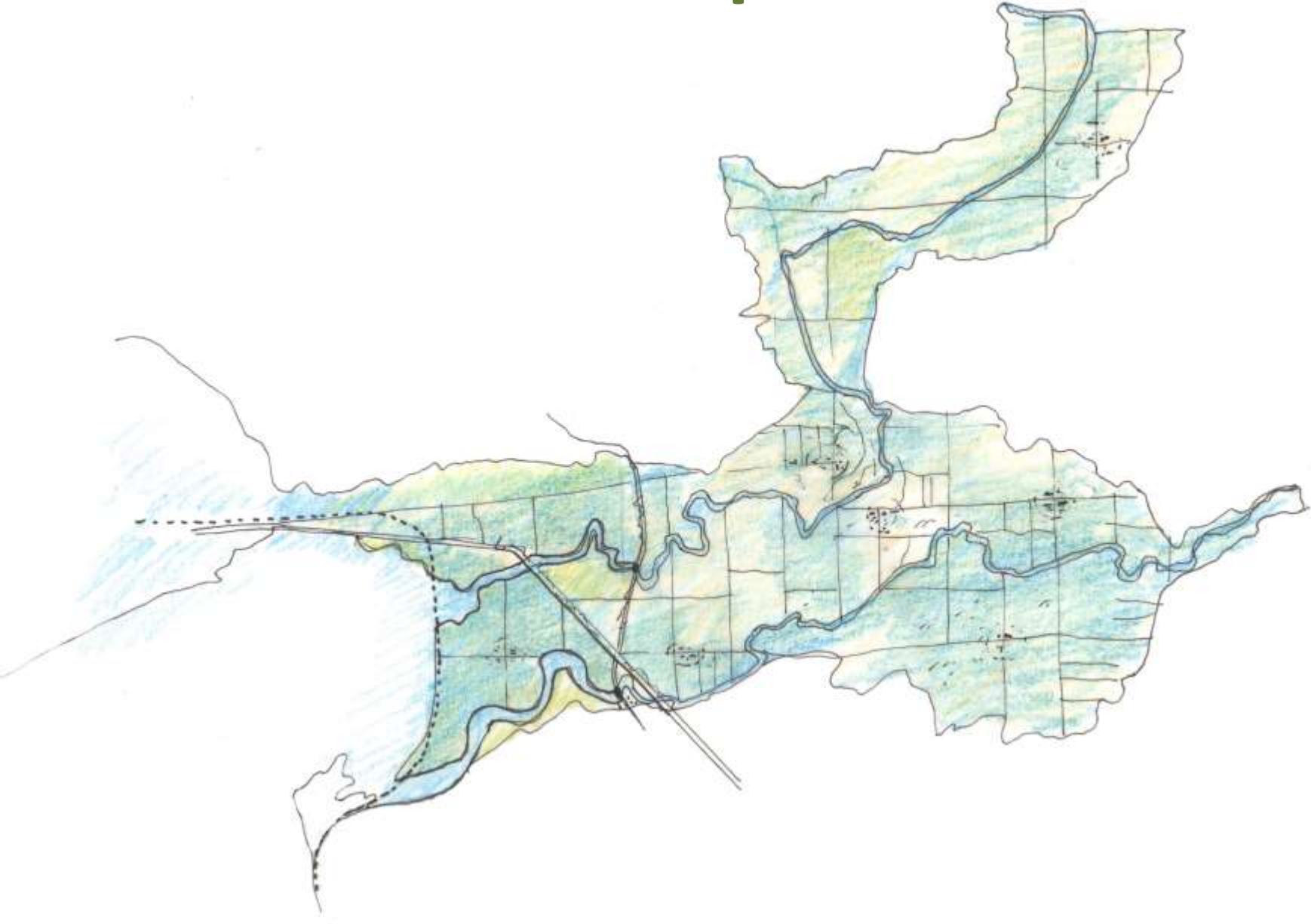
Workshop

CFAS Preliminary Options

Mud Bay

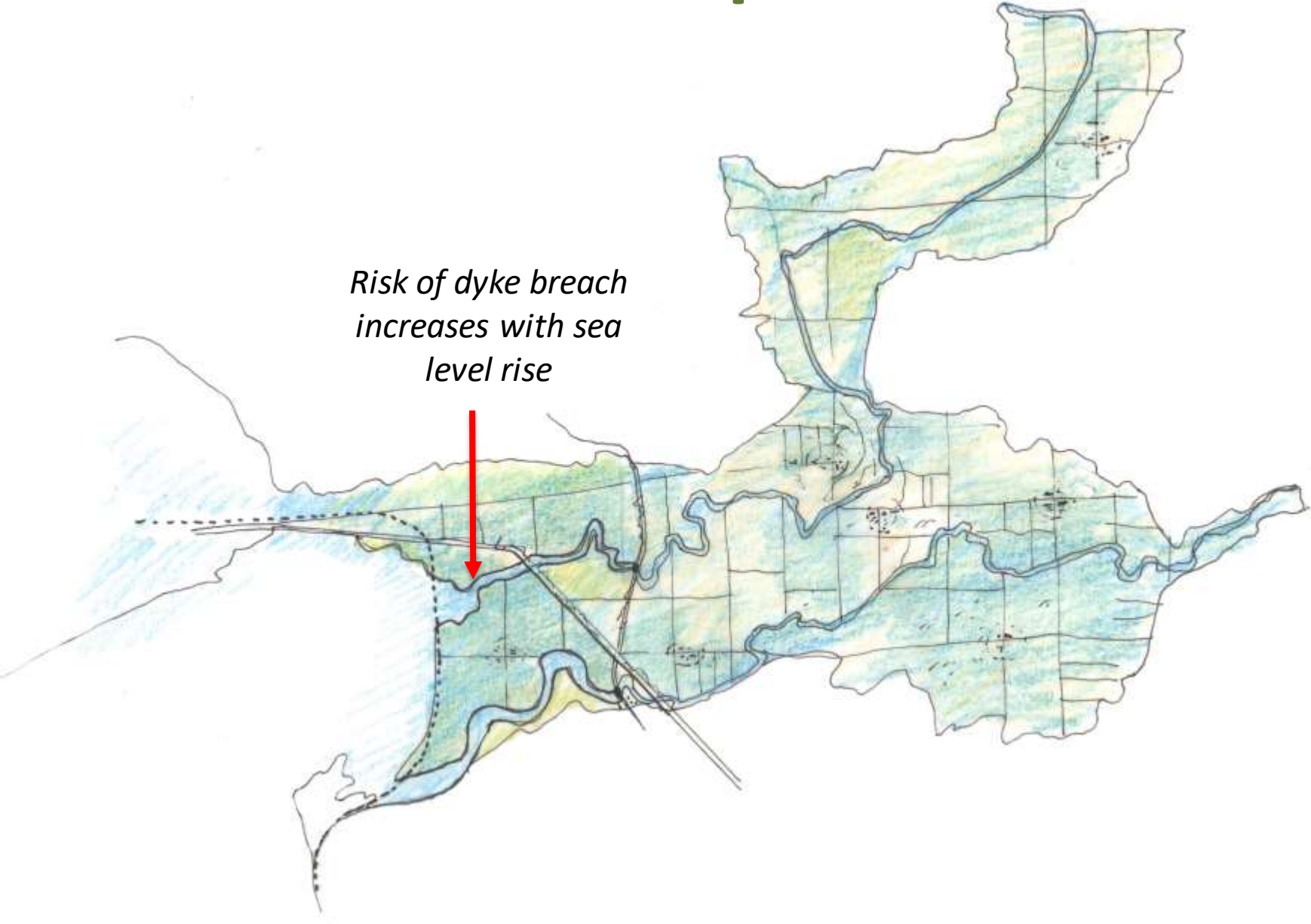
No Adaptation

No Adaptation

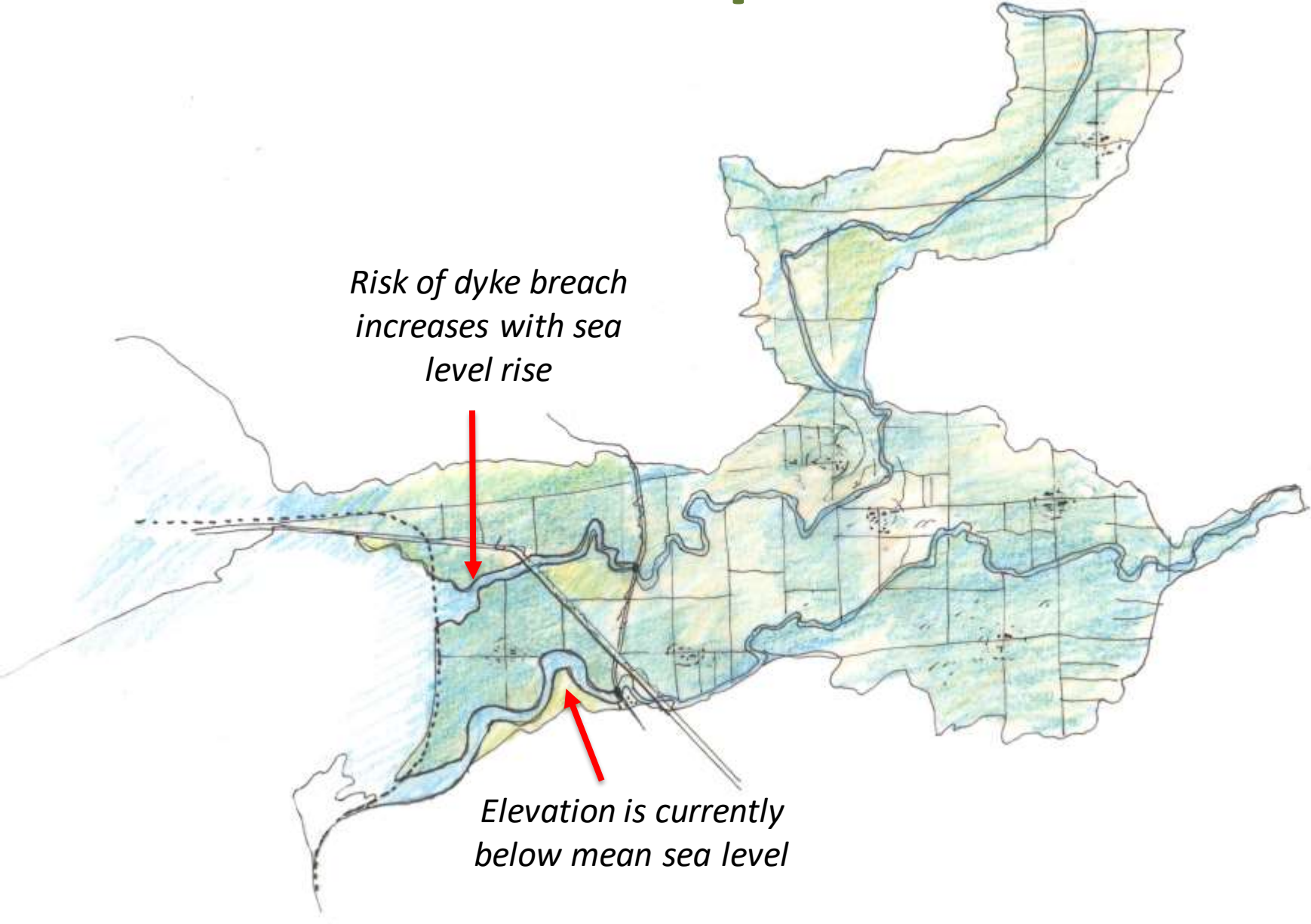


No Adaptation

Risk of dyke breach increases with sea level rise



No Adaptation



Risk of dyke breach increases with sea level rise

Elevation is currently below mean sea level

No Adaptation

WHAT THIS COULD LOOK LIKE



Removable flood barriers



Evacuation routes

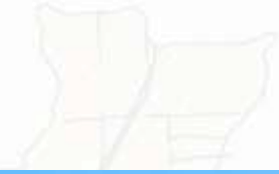
No Adaptation

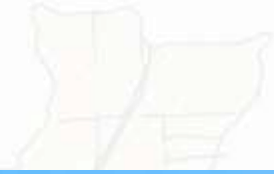


Colebrook Dyke

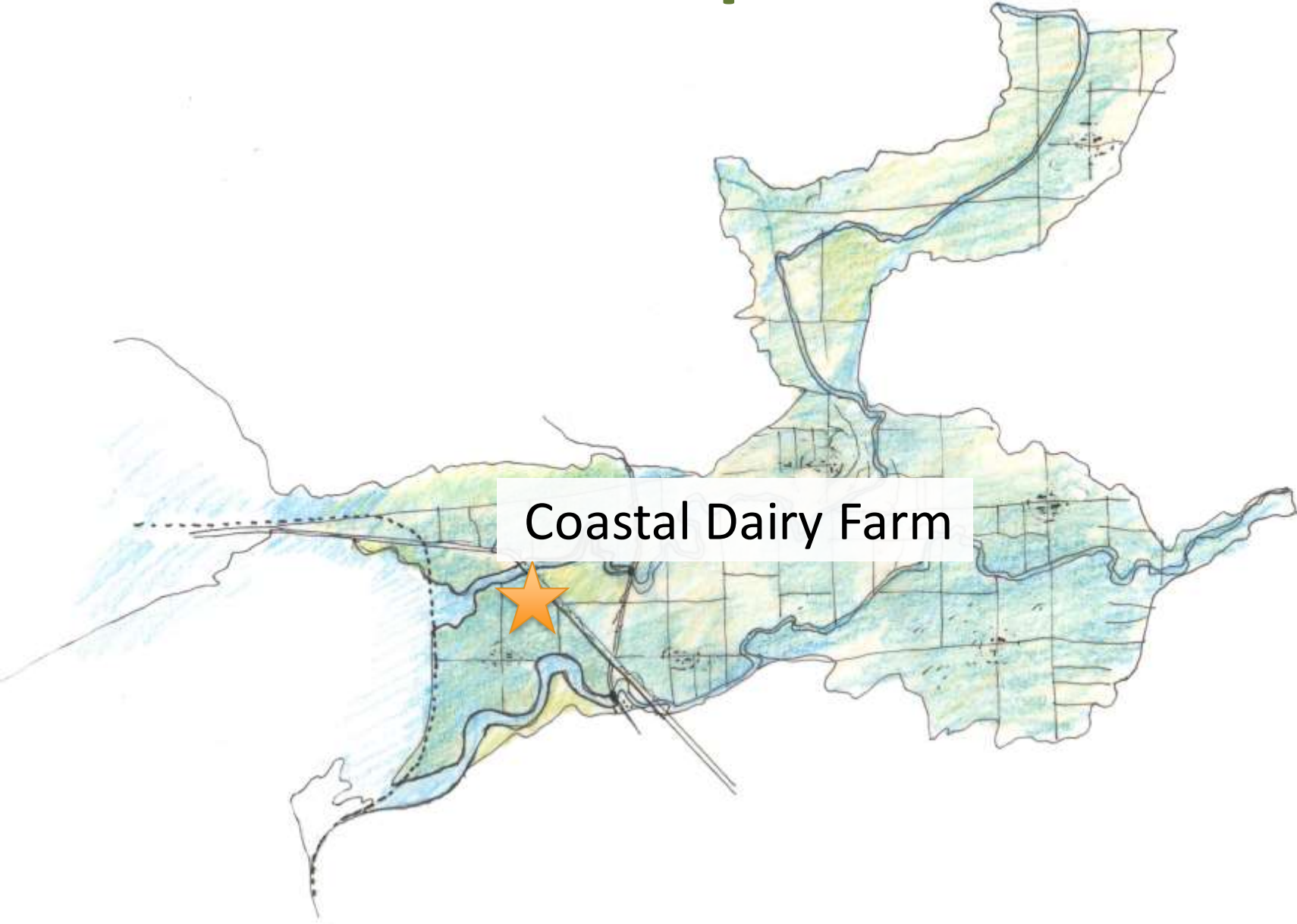




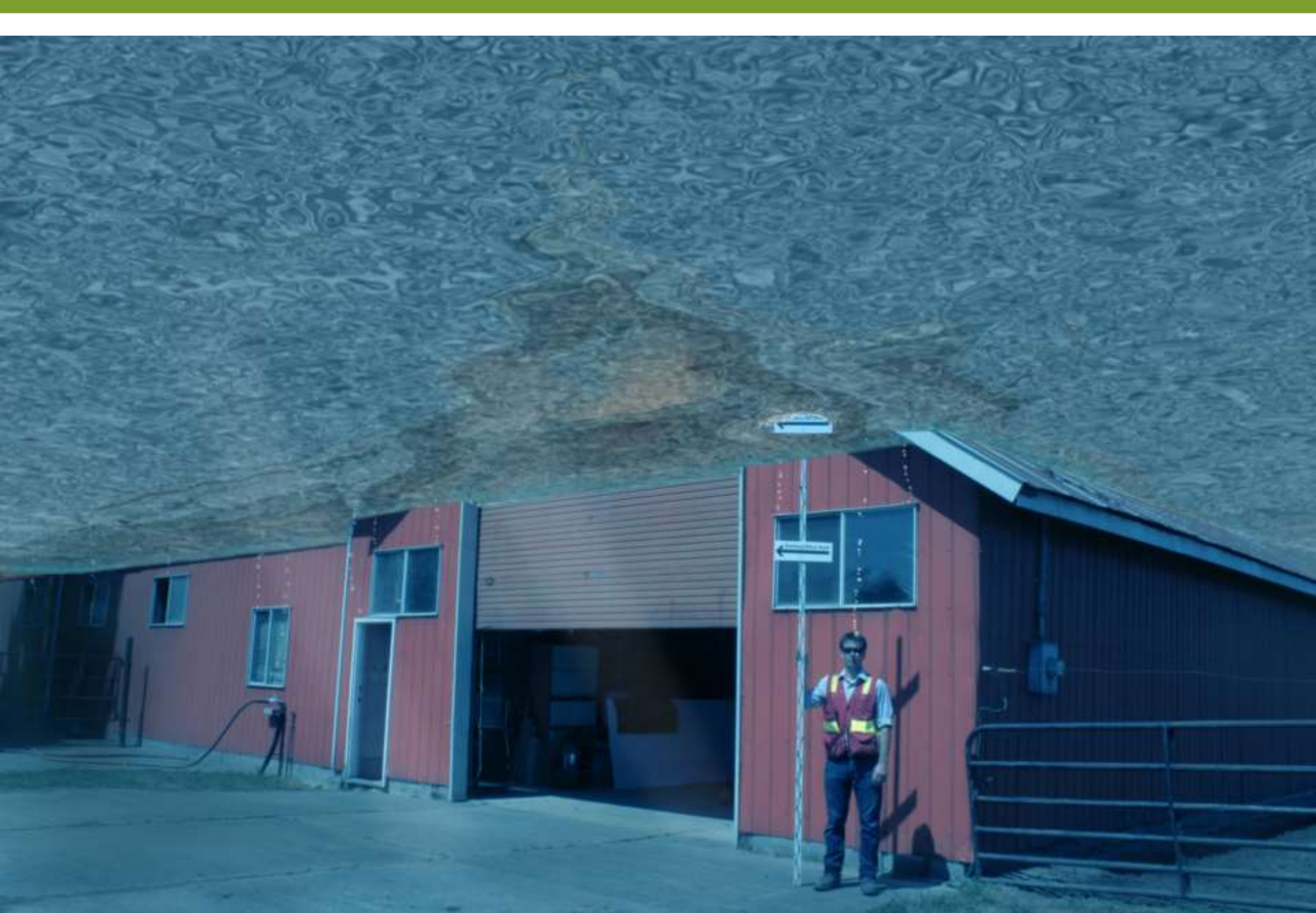




No Adaptation





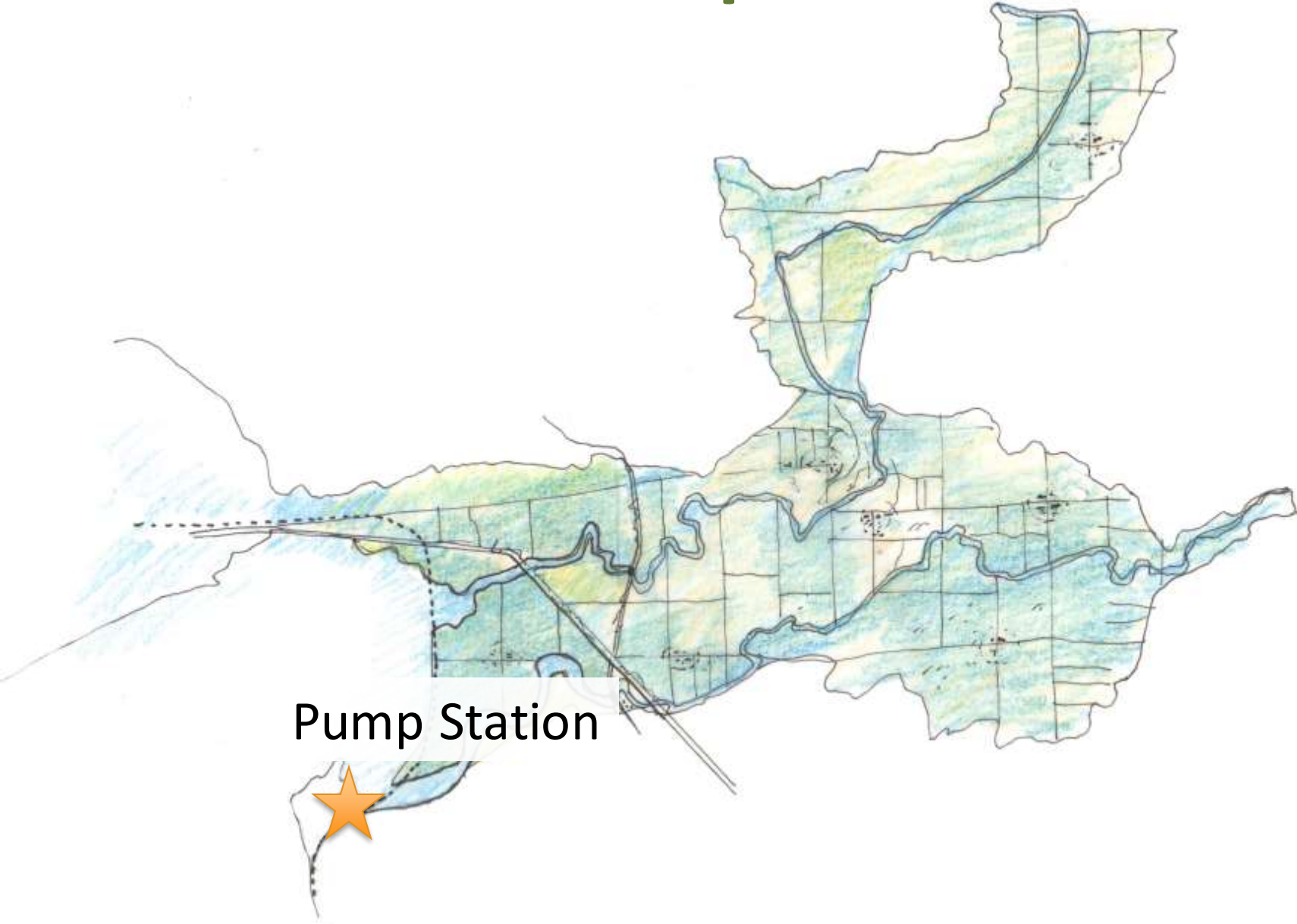








No Adaptation



Pump Station



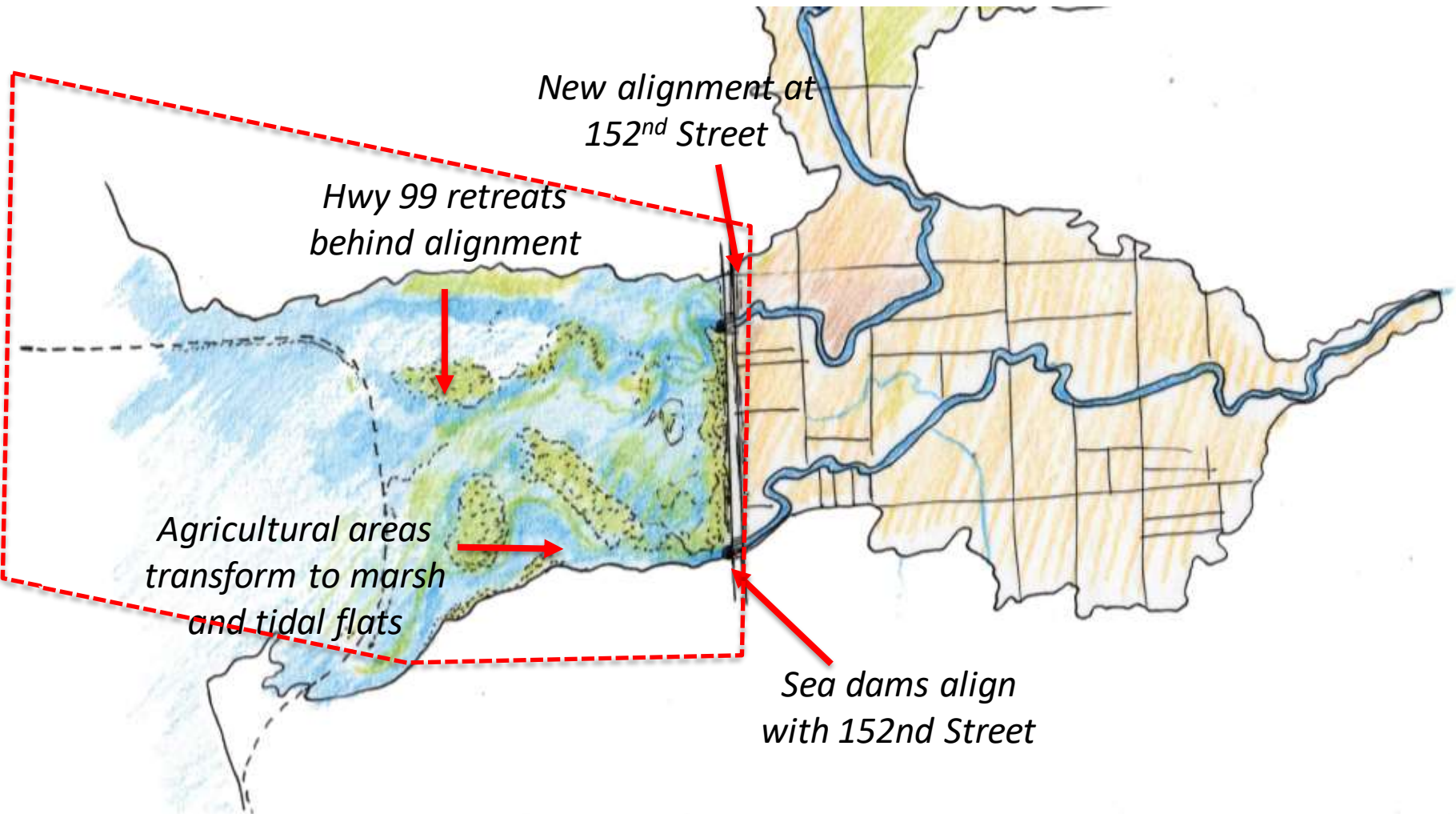




Mud Bay

Coast realignment to 152nd Street

Coast Realignment (152nd St)



Coast Realignment (152nd St)

WHAT THIS COULD LOOK LIKE



Newly created marsh becomes wind and wave buffer for new dyke

Coast Realignment (152nd St)

WHAT THIS COULD LOOK LIKE



Coast Realignment (152nd St)

WHAT THIS COULD LOOK LIKE

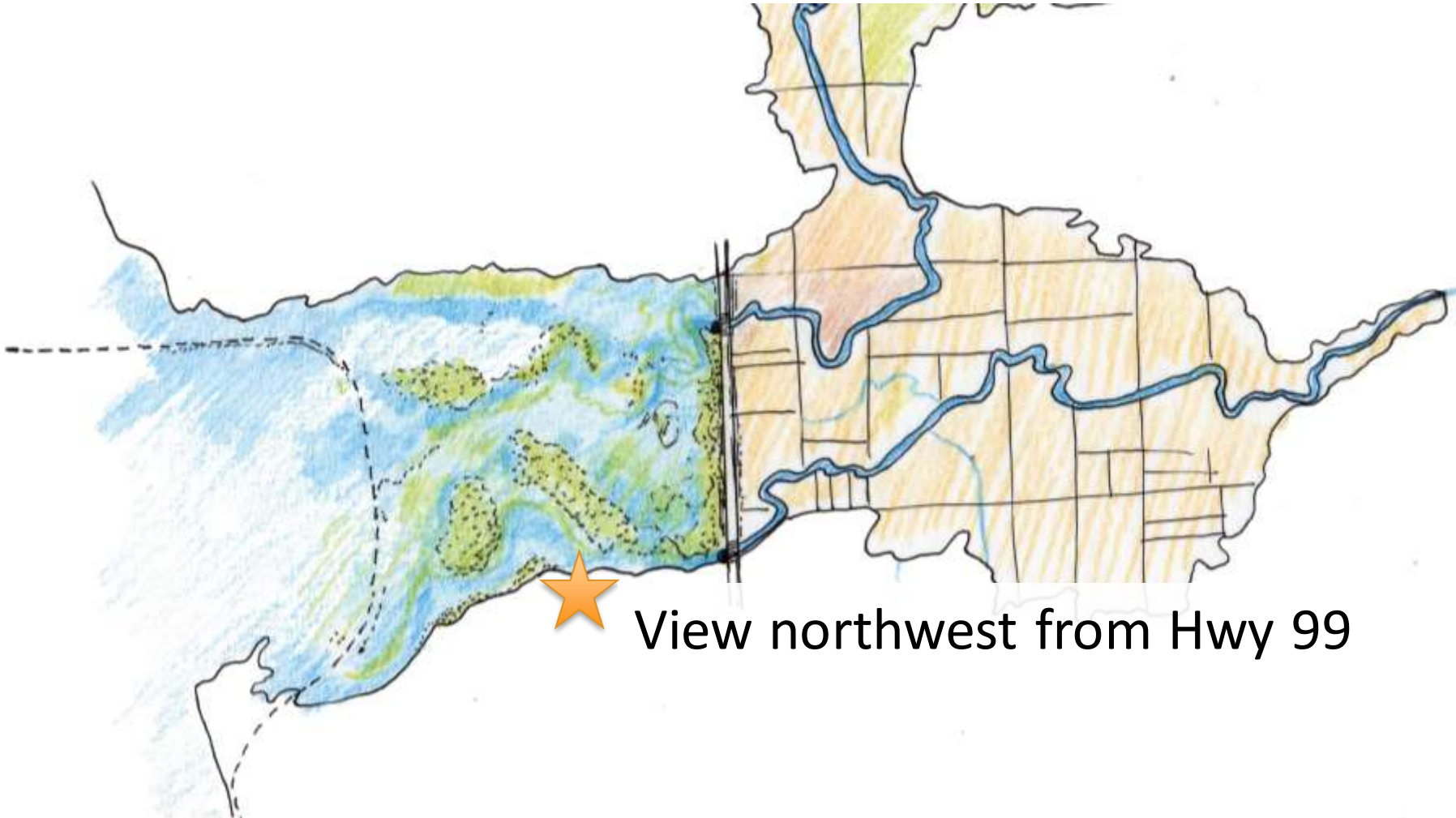


Fly Over (circling east to south to west)

Realignment to 152nd St



Coast Realignment (152nd St)



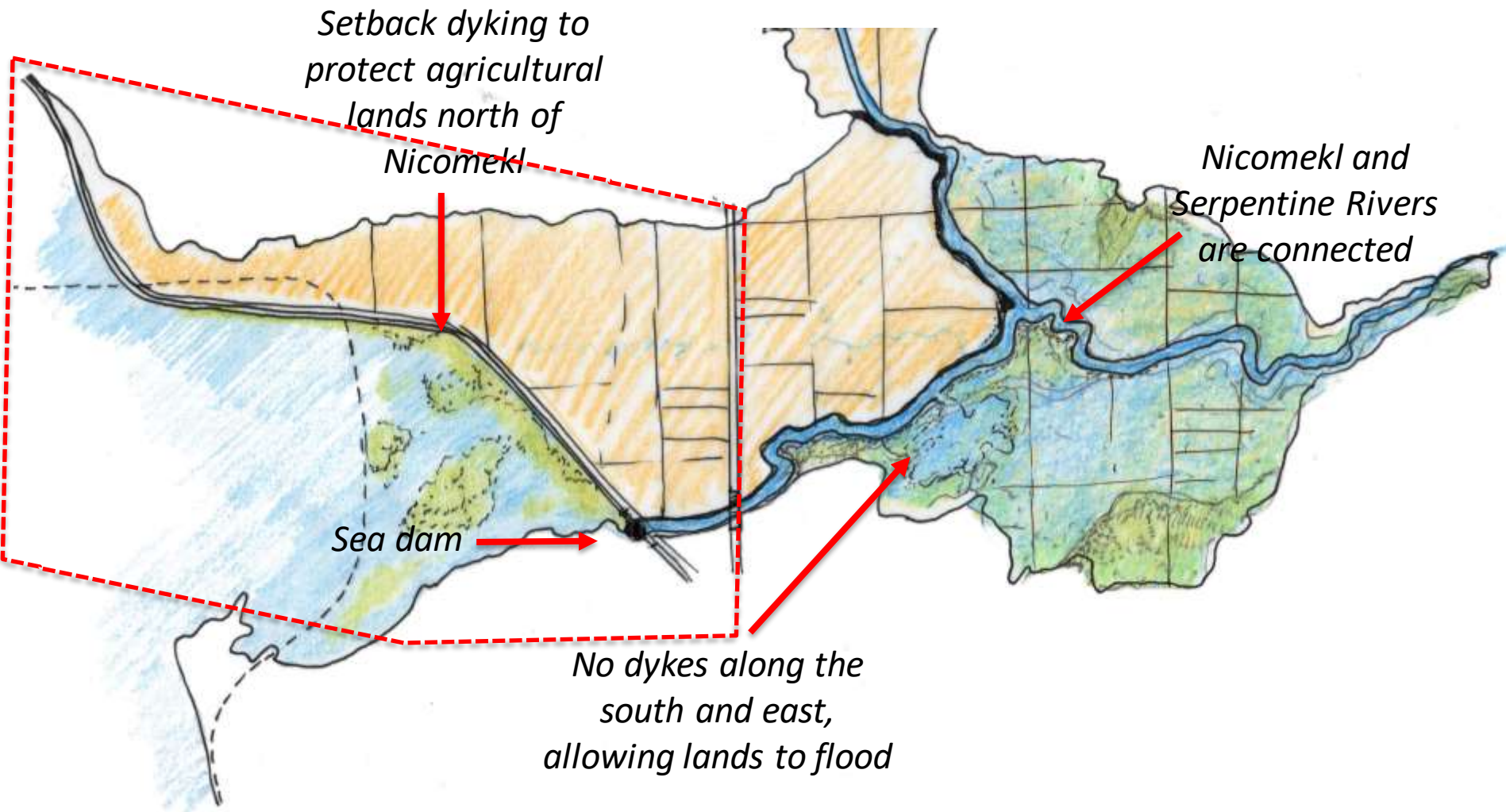




Mud Bay

River Realignment

River Realignment



River Realignment

WHAT THIS COULD LOOK LIKE



Improved Riparian Corridors



Inundation of Hunze River, NL

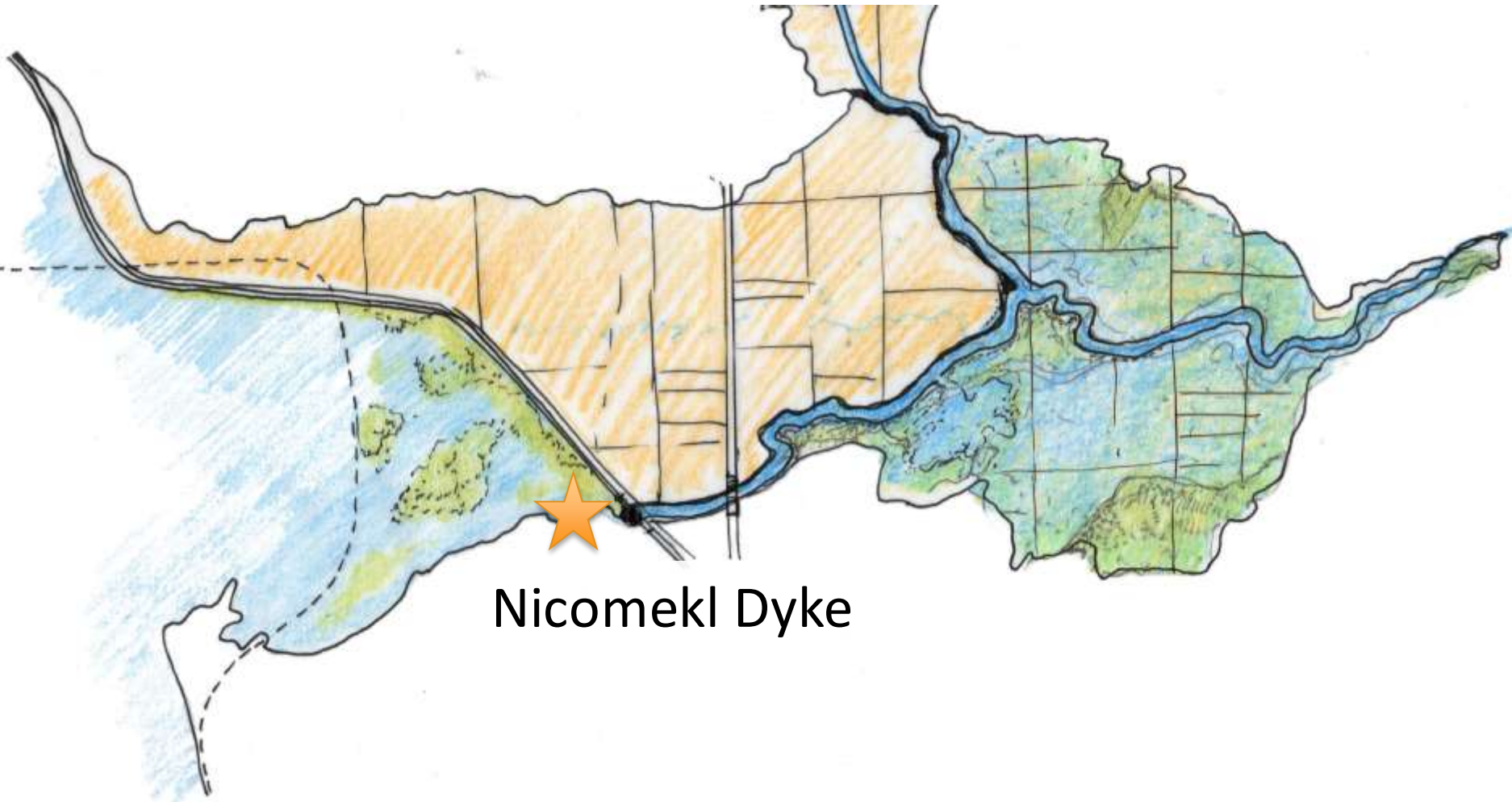
River Realignment

WHAT THIS COULD LOOK LIKE AT HIGH TIDE



Google Earth

River Realignment







Fly Over (West to East via Hwy 99)

River Realignment Option

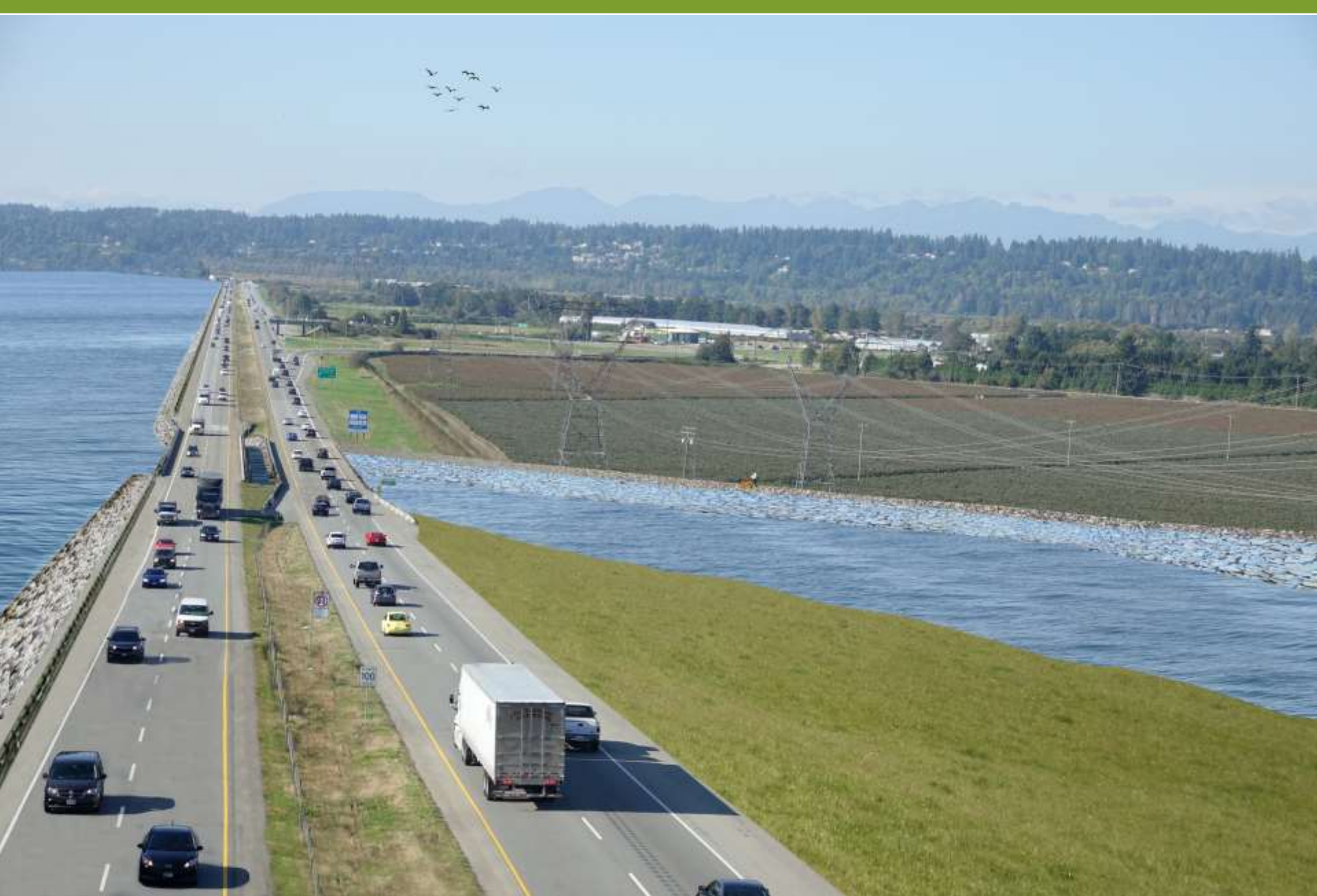


River Realignment



View northwest from Hwy 99





Preliminary Options Overview

CURRENT CONVENTIONS



BARRIER ISLAND



EXPANDED EDGE (LAND SIDE)



EXPANDED EDGE (OCEAN SIDE)



MUD BAY BARRIER



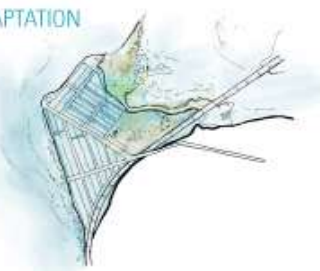
FLOOD TOLERANT ARCHITECTURE



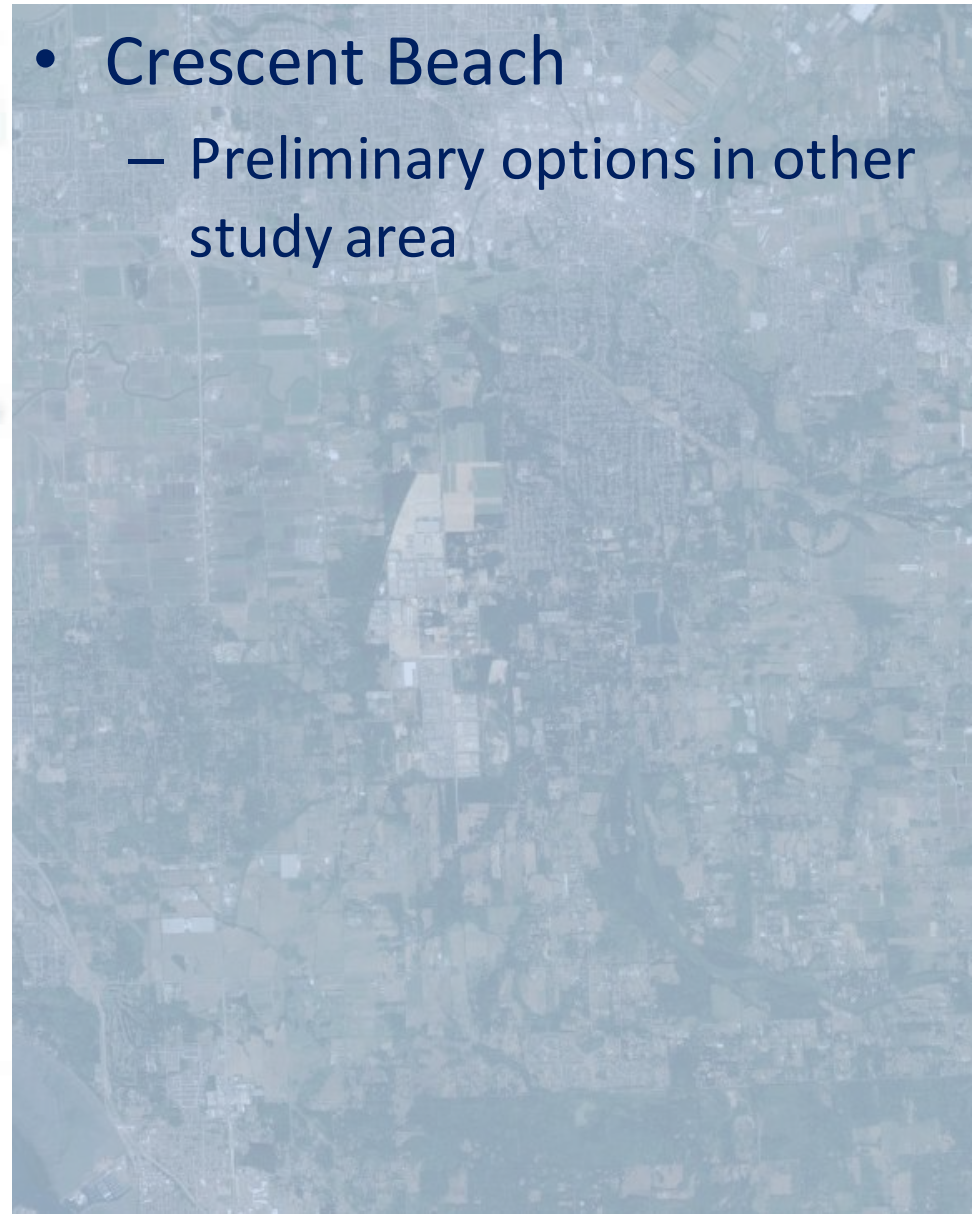
MANAGED RETREAT



NO ADAPTATION



- Crescent Beach
 - Preliminary options in other study area



Workshop

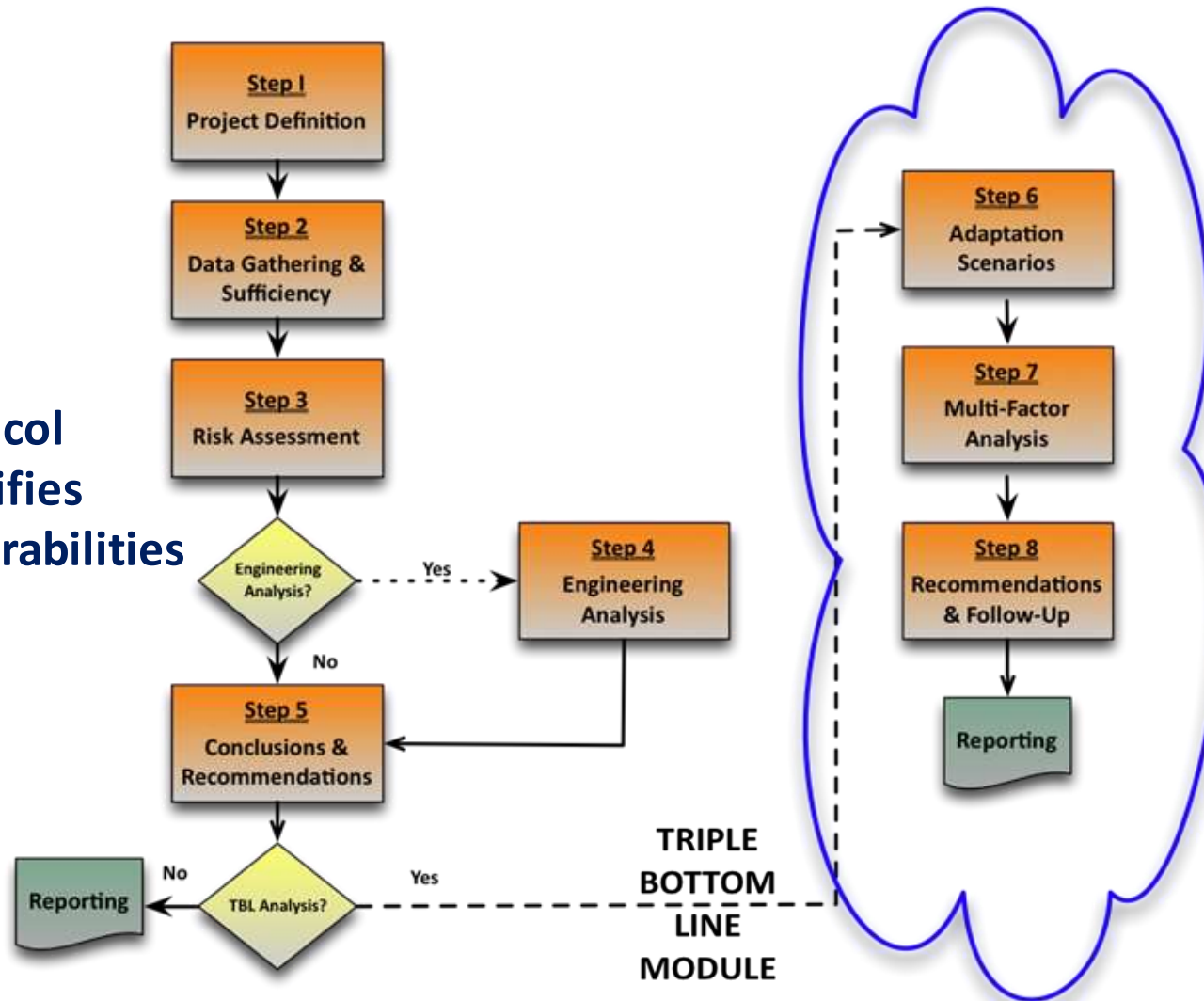
PIEVC Engineering and Triple Bottom Line Analysis Orientation

PIEVC Engineering and Triple Bottom Line Analysis

- **Adaptation decisions** must be made on technical criteria, but also involve social, environmental and economic (triple bottom line - TBL) considerations
- Engineers Canada incorporated a TBL decision support tool to supplement the PIEVC Engineering Protocol

PIEVC Protocol

Protocol identifies vulnerabilities



Triple Bottom Line analysis develops and assess potential solutions based on criteria

TBL Methodology

- TBL analysis employs multi-factor analysis as core analysis framework

1. PIEVC Step 6

- Define options to address infrastructure vulnerabilities
- Consider policies, technical requirements, issues

2. PIEVC Step 7

- Define and execute multi-factor analysis
- Introduce and evaluate TBL based factors, weighting

3. PIEVC Step 8 (In later CFAS Steps)

- Make recommendations
- Follow-up actions, monitoring
- Reporting



TBL Evaluation Factors

INFRASTRUCTURE WORKSHOP OUTCOMES



ENVIRONMENTAL SUSTAINABILITY

Current outcomes:

- Involvement of environmental conservation organization such as Ducks Unlimited Canada
- Provides framework for discussions of potential co-benefits to manage flood risk with biodiversity conservation strategy
- Advanced understanding of past flood risk
- Involvement of City of Surrey Parks Managers
- Evaluated Green Infrastructure risk
- Improved flood risk understanding related to regional and local Parks
- Protection of Green Infrastructure considered in development of adaptation options
- Strengthened planning linkages to 10-year Parks, Recreation and Culture Strategic Plan and Biodiversity Conservation Strategy
- Strengthened planning linkages to railway relocation planning underway

Projected outcomes:

- Adaptation approaches identified might provide positive co-benefits related to protection of important environmental features
- Identification of co-benefits for ecosystem servicing and biodiversity conservation and exploration of coastal buffers using green infrastructure

- Establish decision making criteria using triple bottom line approach for environmental perspective
- Triple Bottom Line approach accounts for the often-overlooked environmental considerations in asset management planning and decision making
- Consider potential environmental contamination from flood risk



SOCIAL SUSTAINABILITY

Current outcomes:

- Identification of vulnerable critical infrastructure for mobility and community connectivity
- Advanced inter-governmental collaboration
- Advanced collaboration between emergency managers (fire, police, ambulance, coast guard) and capital planners (local government and provincial)
- Identified \$15 million of annual dairy sales from 2,500 head of cattle
- Identified up to 10-yr recovery time for extensive blueberry farms
- Strengthened partnerships with University of British Columbia's School of Architecture and Landscape Architecture by involving graduate students

- Improved safety through Emergency Service involvement and knowledge exchange
- Involved local land owners through a site tour with stakeholders

Projected outcomes:

- Establish risk tolerance around level of service provision and asset lifecycle from social perspective
- Adaptation of infrastructure identified as vulnerable will ensure services provided by these assets are not interrupted (benefits to local and regional communities)
- Proactively manage and adapt to the impacts of sea level rise: over 10km of Provincial Highways, which account for over 200,000 vehicle trips per day
- Protect sewage and water services to over 100,000 Surrey residents
- Establish decision making criteria using triple bottom line approach



ECONOMIC SUSTAINABILITY

Current outcomes:

- Identified critical importance of twin 500kV electrical intertie to United States of America to entire BC Hydro System integrity
- Identified cascading effects of infrastructure vulnerability to economy

- Identified that 53 % of currently low/medium risk infrastructure sectors become high risk by year 2100 with sea level rise.

Projected outcomes:

- Increased awareness of infrastructure that protects over \$100 million in annual farm gate revenues through flood control and irrigation service delivery
- Increased resilience and recover of billions of dollars of critical infrastructure through emergency service provider input and education
- Economically sound infrastructure management based on understanding of the vulnerability of infrastructure assets
- Identification of thresholds for adapting infrastructure
- Exploration of integrated design of critical infrastructure across asset owners
- Identification of shared responsibility to reduce service interruption and recovery costs from coastal flooding
- Protection of transportation infrastructure which provides over \$20 billion in annual truck and rail freight traffic (over 10 km of Provincial Highways and over 30 km of railway)
- Protection of primary electrical connection to the United States of America with annual electrical flow valued well over \$100 million
- Establish risk tolerance around level of service provision and asset lifecycle from economic perspective

TBL Evaluation Factors

- **Environmental Factors**



- Regulatory compliance
- Effects on biodiversity and habitat
- Climate change mitigation and adaptation

- **Social Factors**



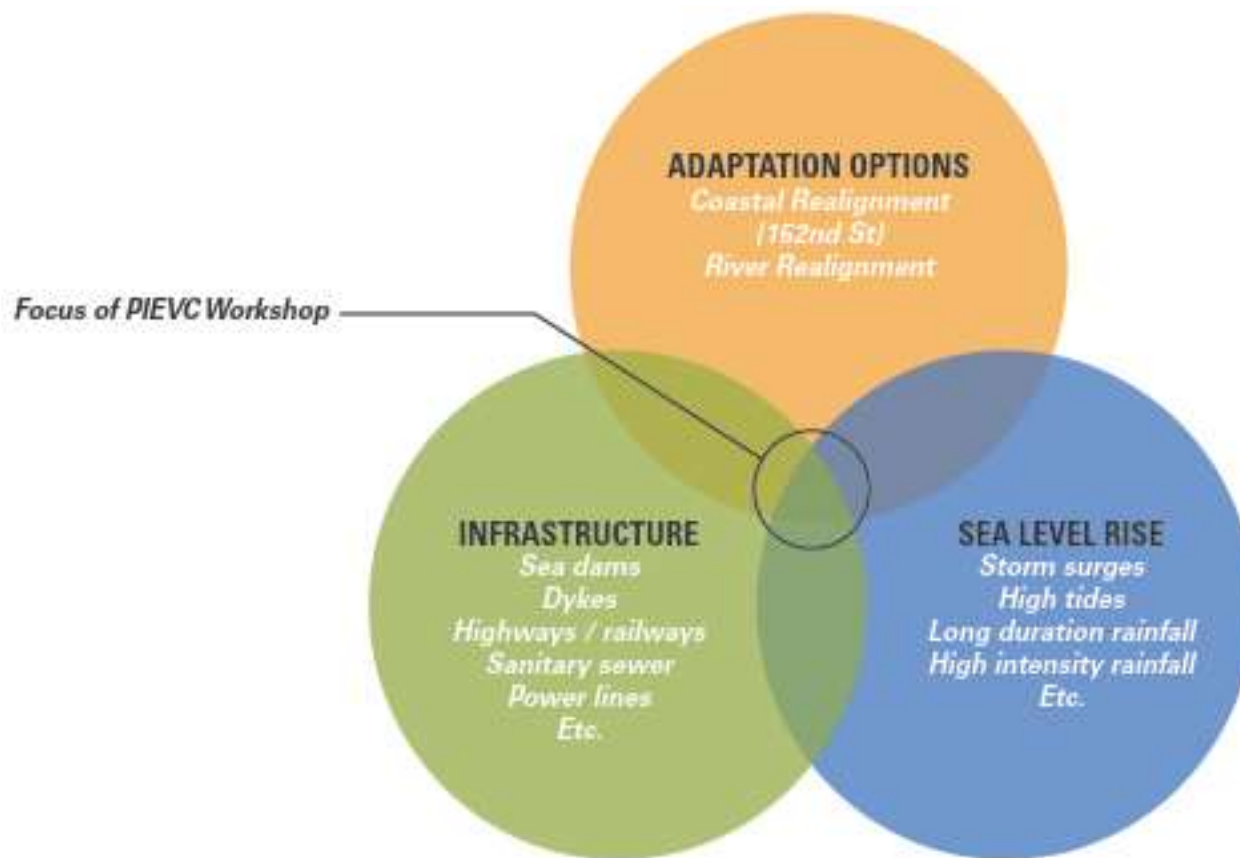
- Public perception
- Sense of community involvement
- Maintenance of an acceptable level of service and public risk
- Emergency response
- Agricultural impacts

- **Economic Factors**



- Capital cost
- Cost-sharing and collaboration between different types of assets
- Resilience and maintainability
- Disruption of commerce
- Risk tolerance around level of service provision and asset lifecycle from economic perspective

PIEVC Engineering and Triple Bottom Line Analysis Orientation



Workshop

Adaptation Introduction and Group Exercise 1



Associated
Engineering

GLOBAL PERSPECTIVE.
LOCAL FOCUS.



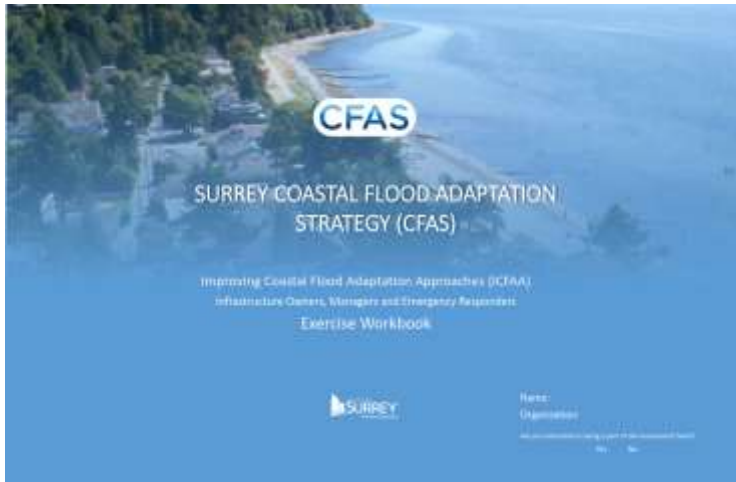
Adaptation Introduction

- **Backgrounder**



Adaptation Introduction

- Worksheets



This is a worksheet titled 'Exercise 1: Adaptation Option 1 - Coastal Adaptation to Wind Waves'. It is part of the CFAS workbook. The worksheet is structured as a table with several columns: 'Infrastructure Management', 'Adaptation Option and Description', 'Assessment', 'Costs', and 'Benefits'. The 'Assessment' column is further divided into 'Physical', 'Operational', and 'Financial'. The 'Costs' column is divided into 'Capital' and 'Operational'. The 'Benefits' column is divided into 'Physical', 'Operational', and 'Financial'. The table contains several rows of text, likely representing different infrastructure assets and their associated adaptation options, costs, and benefits.

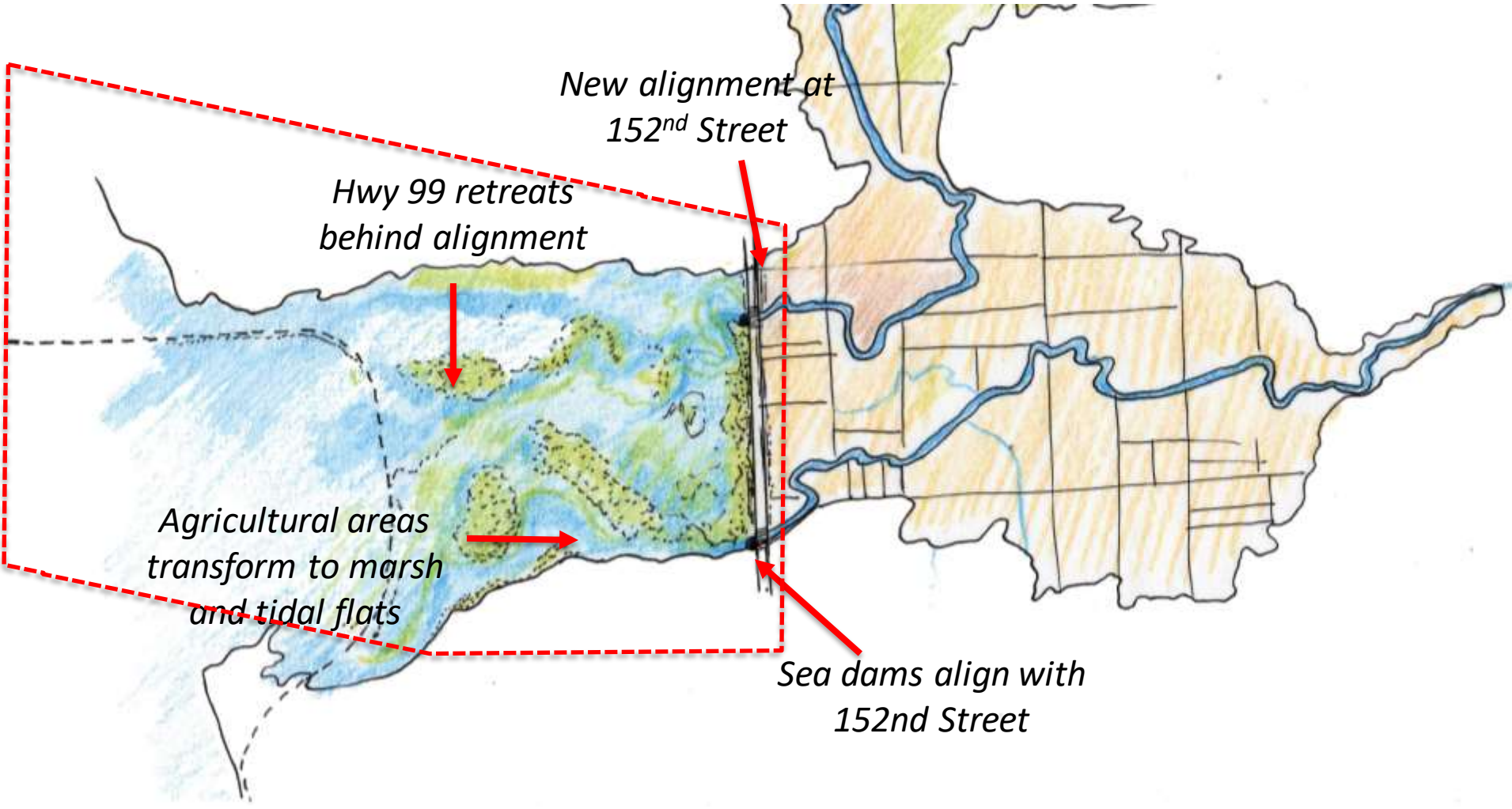
This is a worksheet titled 'Exercise 2: Adaptation Option 2 - Other Adaptations'. It is part of the CFAS workbook. The worksheet is structured as a table with several columns: 'Infrastructure Management', 'Adaptation Option and Description', 'Assessment', 'Costs', and 'Benefits'. The 'Assessment' column is further divided into 'Physical', 'Operational', and 'Financial'. The 'Costs' column is divided into 'Capital' and 'Operational'. The 'Benefits' column is divided into 'Physical', 'Operational', and 'Financial'. The table contains several rows of text, likely representing different infrastructure assets and their associated adaptation options, costs, and benefits.

COAST REALIGNMENT (152ND ST)

OPTION DESCRIPTION:

- This option sets flood protection back from the ocean. An alignment parallel to 152nd Street would be shorter and less costly than the current alignment.
- However, Highway 99 and King George Boulevard would need to be raised and/or relocated.
- The loss of farmland to ocean/salt marsh would be significant (about 16 km²) and include farm residences.
- A total of about 30 km of dykes along the Serpentine/ Nicomekl Rivers would no longer need to be maintained or upgraded.
- A form of managed retreat, the option would provide some environmental benefits, while maintaining a portion of land for agricultural uses.

Coast Realignment (152nd St)



Group Exercise 1 Coastal Realignment to 152nd Street

Backgrounder

1. Review / Read Adaptation Option

Worksheets

2. Review each Infrastructure Component
3. Review Adaptation Details and Considerations
4. Review TBL Factors

1. Identify which Factor are considered in making a decision.

2. Indicate the degree of importance

High (H) / Medium (M) / Low (L)

5. Provide overall comments and on option and identify thresholds

Step 1



Infrastructure Components	Adaptation Details and Considerations	TBL Factors (High / Medium / Low)										Comments	
		Environment	Social	Economic	Health & Safety	Energy	Water	Land Use	Transportation	Infrastructure	Community		
Major Road	Major Road												
Water Main	Water Main												
Rising Infrastructure	Rising Infrastructure												
Sanitary Sewer	Sanitary Sewer												

Step 2

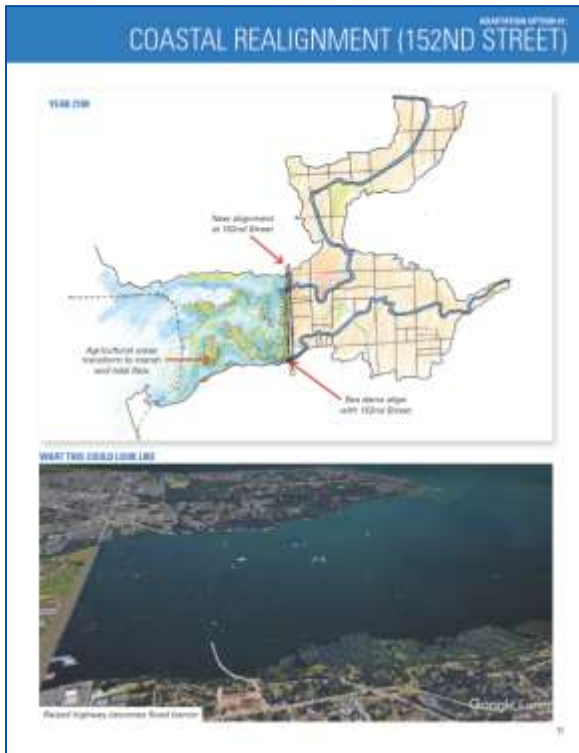
Step 3

Step 4

Step 5

Group Exercise 1 Coastal Realignment to 152nd Street

1. Review / Read Adaptation Option



ADAPTATION OPTION in COASTAL REALIGNMENT (152ND STREET)

Newly created marsh between old and new dykes for new dyke

LEAD-UP

A long-range plan to retreat to 152nd Street is advanced, gradually removing all infrastructure and development, returning lands between 152nd Street and Mud Bay to saltmarsh. The option would be introduced as follows:

- A super-dyke is built irregularly west of 152nd Street. A strip of land must be left between the toe of the dyke and the toe of the road embankment to avoid settlement issues. The dyke is built to projected end of century flood levels with an allowance for future rising (i.e. with an oversized base width). The land for the super-dyke footprint is purchased and development is cleared from the strip. Any east-west roads are detoured. The ground is preloaded to meet geotechnical criteria. The ocean-side has a side-slope of 3H:1V (to reduce future wave run-up) and the land-side a slope of 3H:1V, resulting in 6m of width for every 1m increase in height. Erosion protection is installed on the ocean side.
- New sea-dams are constructed in line with the super-dyke on the Serpentine and Nicomekl Rivers. The dams will be designed for end of century conditions and include significant purging capacity to limit increases in agriculture flooding.
- Highway 99, King George Boulevard and 152nd Street are razed into one thoughtline located on top of the super-dyke with bridges at the two sea-dams. Outside the floodplain, new approach roads will be built. (Land will need to be acquired and culverts provided for cross-directional creek flows.
- Cooperation and cost-sharing between MOTI and Surrey is envisioned. Operation and maintenance agreements will need to be developed.
- Support plans are presented to residents, farmers and businesses located west of the new dyke alignment.
- SNDP is informed that inundation will become the norm on both sides of the red-line and geotechnical problems such as erosion may result. The red line may look at adaptation through building a continuous trail across the coastal floodplain or relocating east of 152nd Street. Similarly, the Roberts Bank Railway is considering elevating or relocating their tracks outside of the floodplain.
- Water, sewer and transmission line owners will need to decide on appropriate action to

ADAPTATION OPTION in COASTAL REALIGNMENT (152ND STREET)

prepares for regular inundation which will require maintenance and emergency response to the infrastructure, accelerate corrosion and increase erosion.

- A clean-up of potential contaminants will be carried out west of the dyke alignment. Highway 99 and King George Boulevard road embankments will be removed and the RR used to optimize habitat values. As sea levels continue to rise, modifications to the marsh area may be required. East-west roads (eg. Colchester Road) within the floodplain will be abandoned. The old sea-dams will be demolished and removed.
- Strategic openings will be introduced in the present flood protection to allow saltwater inflow and habitat improvements to gradually take place. At high tides, the ocean will expand to the north and south edges of the floodplain and to the new super-dyke to the west.
- River dykes upstream of the new sea-dams are improved as required to meet ARCGA standards throughout the century.

Main advantages:

- Slightly 30 km of sub-standard dykes will no longer be maintained or upgraded and is replaced by a 4 km long super-dyke built to future standards near 152nd Street. The sea-dams are replaced by modern structures, also near 152nd Street. A few isolated pump stations are abandoned, and the existing sea dams removed. Surrey and the Mud Bay Drying District no longer own or maintain flood protection in this difficult to protect area.
- Flood risks are significantly reduced.
- Environmental values within a portion of the Surrey floodplain can gradually be increased and habitat improvements introduced. Carefully developed plans would be required to optimize environmental and recreational values of the area.

Main disadvantages:

- Slightly 16 km² of farmland would be taken out of production and some 250 residences relocated. Families who have lived in the area a long time would need to move. Some businesses and marinas would also be impacted.
- The cost of the new dyke, sea-dams, combined Highway with new approach roads and clean-up/ habitat improvements would be very high.

THE FLOOD

Flood conditions identical to the "No Adaptation" scenario are assumed.

THE OUTCOME

Assuming all construction is completed before the flood, damage would be limited. There would be some natural rearrangement of the saltmarsh west of the super-dyke and possible erosion of any razed land areas. Depending on the pumping capacity of the new sea-dams and river-dyke improvements, introduced upstream of the sea-dams, ARCGA standards may be fully met.

THE AFTERMATH

Overall losses are minimal. Some additional habitat and recreational area improvements may be required.

Group Exercise 1 Coastal Realignment to 152nd Street

2. Review each Infrastructure Component



Group Exercise 1 Coastal Realignment to 152nd Street

2. Review each Infrastructure Component
3. Review Adaptation Details and Considerations

Infrastructure Components	Adaptation Details and Considerations
Group Exercise 1 - Adaptation Option 1 - Coastal	
Major Roads King George Boulevard Highway 99 152 Street	Merge 152 Street and King George Boulevard, protected by, or located on top of super-dyke. Highway 99 either merged with 152 st. and King George Blvd., or raised (earthen embankment with several equalization culverts, or a supported 'wetland' structure). Issues include land available for interchanges, mixing conflicting traffic classifications. Regional context needed to consider Highway 51; Ladner Trunk Road; future traffic needs
Major Roads Roads within Corporation of Delta Highway 91 Highway 99 Ladner Trunk Road	Raise, or reroute; coordinate regional planning needs.
Railway Infrastructure BNSF embankment Trestles Swing Bridge BCRC Embankment	Continuous trestle over flooded area, raised embankment with several equalization culverts, or regional relocation east of 152 Street

Group Exercise 1 Coastal Realignment to 152nd Street

4. Review TBL Factors

1. Identify which Factor are considered in making a decision.
2. Indicate the degree of importance

High (H) / Medium (M) / Low (L)

5. Provide overall comments and on option and **identify thresholds**

Infrastructure Components	Adaptation Details and Considerations	TBL Factors (High / Medium / Low)												Comments		
		Environmental			Social				Economic							
		Regulatory Compliance	Biodiversity / Habitat	Mitigation and Adaptation	Public Perception	Community Involvement	Acceptable Level of Service and Risk	Emergency Response	Agricultural Impacts	Capital Cost	Cost-sharing and collaboration	Resilience and Maintainability	Disruption of Commerce		Risk Tolerance / Asset Lifecycle	
Drainage Pump Stations, Ditches, Floodboxes	Ditches, pump stations, and floodboxes west of 152 Street abandoned or drastically reconfigured															



Workshop

GROUP EXERCISE 2 -



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Engineering

GLOBAL PERSPECTIVE.
LOCAL FOCUS.

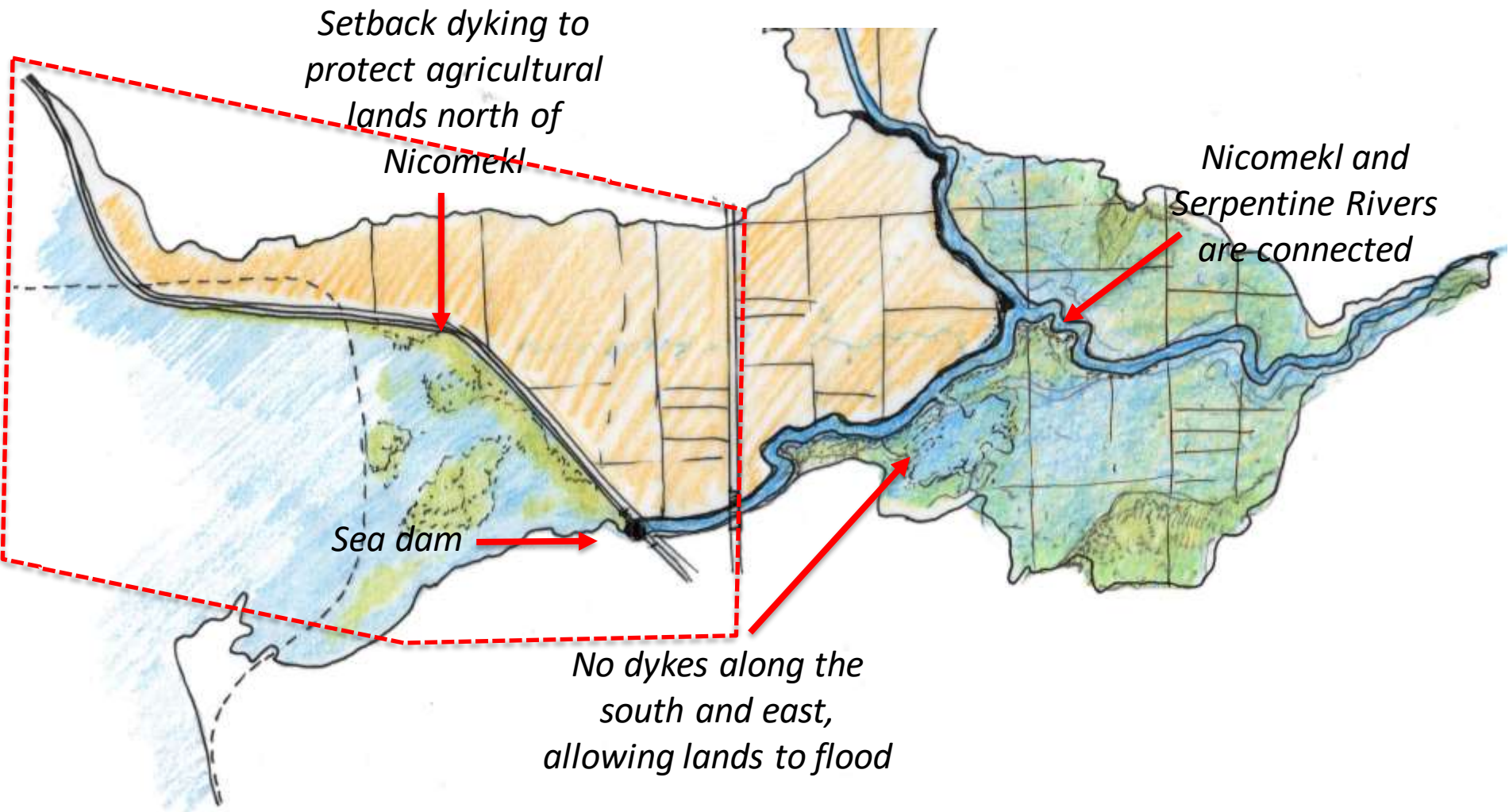


RIVER REALIGNMENT

OPTION DESCRIPTION:

- This option would convert the land west of Highway 99 into tidal flats, connect the Serpentine River with the Nicomekl at roughly 168th Street, dyke and protect land between King George Boulevard and the diversion (north of the Nicomekl), and see the conversion of other floodplain lands south and east of the diversion into a lake.
- The dyked area would be used for agriculture.
- Only one sea dam would be required (on the Serpentine, in the vicinity of 56th Ave). The mid and upper Serpentine would be unchanged. The total length of dyking required would be significantly reduced.
- A form of managed retreat, the option would provide some environmental benefits, while maintaining a portion of land for agricultural uses.

River Realignment



Group Exercise 2 River Realignment

RIVER REALIGNMENT

YEAR 2010



WHAT THE PEOPLE CAN LIVE



Inclusion of River Bend, A1



Coastal Marshes, B1



Banking of study area at high tide, 2009

HEAD-UP

A long-range plan is introduced to orient to Highway 99, gradually removing development and primary lands between the Highway and Mud Bay to attract the Serpentine River to merge with the Nicomekl River at roughly 100th Street and a lake is allowed to form south of the river confluence. The option would be introduced as follows:

- A super-dyke is built immediately east of west of Highway 99 and the highway is located on top of the dyke. If the dyke is built on the east side, the old embankment becomes a levee buffer. If the dyke is built on the west side, the dyke will extend into Mud Bay at the north end of the bay. In either case, there will be challenges at the BNSF rail crossing and relocating the railway would be encouraged. A strip of land must be left between the toe of the dyke and the top of the road embankment to avoid settlement issues. The dyke is built to projected end of century flood design levels with an allowance for future raising (a serviced base width). Note that raising the dyke is more challenging with the highway located on top of the dyke. The land for the super-dyke footprint (approx. 300m wide if incorporating 75 lanes plus road shoulders) is purchased and development is cleared from the strip. Any east-west roads are destroyed. The ground is prepared to meet geotechnical criteria. The ocean-side has a side-slope of

RIVER REALIGNMENT

5H: 1V to reduce future wave run-up and the east-side a slope of 3H: 1V, resulting in 5m of width for every 1m increase in height. Erosion protection is installed on the ocean side as required. Provision for widening the Nicomekl River is made and a new bridge is built across the river at the future highway location. A gap, to be filled in later, is left at the Serpentine River.

A higher set-back dyke is built along the north bank of the Nicomekl. The dyke is continued along the proposed Serpentine diversion channel to near the south end of Rebe Island and is tied into high ground. Necessary land purchases take place. An opening is left in the dyke at the Serpentine River. Provision is made for future widening of the Nicomekl River by crossing a portion of the south dyke. Based on a preliminary geomorphic analysis, a stable channel width of 80 m, with minimum 40 m wide floodplain slopes on each side are envisioned (total width of 165 m).

- King George Boulevard and 122nd Street are merged into one thoroughfare at 152nd Street and a new (longer) bridge is built at the Nicomekl River.
- Residential and businesses in the future Nicomekl Lake area (east of 100th Street) are relocated. The Nicomekl Lake future outlet channel is reconstructed and given a natural appearance (meanders are maintained, strips of natural floodplain are introduced on each side adhering with "room for rivers" concepts).
- A new sea-dam is constructed in line with the super-dyke at Highway 99 (Nicomekl Lake becomes a primarily freshwater pond). The dam will be designed for end of century conditions and may need to include pumping capacity, working in conjunction with the water storage provided by Nicomekl Lake to maintain ARDRA drainage for agriculture. (Nicomekl Lake provides additional agricultural irrigation storage throughout the summer.)
- Cooperation and cost-sharing between MOTL,

RIVER REALIGNMENT

environmental groups, other stakeholders and Surrey is envisioned. Operation and maintenance agreements will need to be developed.

- Water, sewer and transmission line owners decide on appropriate action for their affected infrastructure. (With the widening of Nicomekl River, a transmission tower may be impacted.)
- A 1,100 m long diversion channel is dug for the Serpentine River from the sharp bend near the corner of 52nd Avenue and 106th Street to near the corner of 50th Avenue and 160th Street. The channel is given a natural appearance and a minimum width similar to the existing Serpentine channel. Any development in the path of the channel is relocated.
- Existing development within the Nicomekl Lake area is removed and a clean-up completed. Landscaping is performed in preparation of inundation.

A clean-up of potential contaminants will be carried out west of the super-dyke alignment. As sea levels continue to rise modifications to the marsh area may be required.

- During low flows, the old Nicomekl north dyke (from ocean to the Serpentine diversion channel) and the Nicomekl south dyke (from ocean to about 194th Street) are removed and the lake begins to fill. The plug from the Serpentine diversion channel is removed and the Serpentine flows start draining south. The old Serpentine channel is blocked off, and the old Serpentine sea-dam is permanently closed. The Serpentine opening in the new set-back dyke is filled in. The Serpentine sea-dam is demolished and the super-dyke opening at the Serpentine channel is filled. The Serpentine abandoned channel is filled in using adjacent dyke material. The old Nicomekl sea-dam is demolished and removed.

Strategic openings will be introduced in the present flood protection downstream of Highway 99 to allow seawater inflow and habitat improvements to gradually take place. At high tide, the ocean will extend to Highway 99.

Main advantages:

- Roughly 17 km of sub-standard dykes along the Serpentine and 19 km of substandard dykes along the Nicomekl no longer need to be maintained or upgraded. New dykes would include 8 km of super-dyke and 8 km of set-back dyke, capable of withstanding future design events. The sea-dams are replaced by one modern structure. A number of leveed pump stations can be abandoned or some relocated to the flood protected area north of the Nicomekl.
- Flood risks are reduced.
- Environmental values within a portion of the Surrey floodplain can gradually be increased and habitat improvements introduced. Carefully developed plans would be required to optimize environmental and recreational values of the coastal and lateral basin areas.

Main disadvantages:

- Roughly 58 km² of farmland would be taken out of production and about 300 residences relocated. Families who have lived in the area a long time would need to move. Some businesses and tourism would also be impacted.
- The cost of the new dykes, sea-dam, road improvements, excavated channels and clean-up would be very high.

THE FLOOD

Flood conditions identical to the "No Adaptation" scenario are assumed.

THE OUTCOME:

Assuming all construction is completed before the flood, damage would be limited. There would be some natural rearrangement of the salt marsh west of the super-dyke and possible recession of raised level areas. Depending on the pumping capacity at the new sea-dam the current level of drainage capacity (ARDRA standards) may be fully met in the upstream areas.

THE AFTERMATH:

Overall costs are minimal. Some additional habitat and recreational area improvements may be required.

Workshop

GROUP EXERCISE 3 -



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GLOBAL PERSPECTIVE.
LOCAL FOCUS.



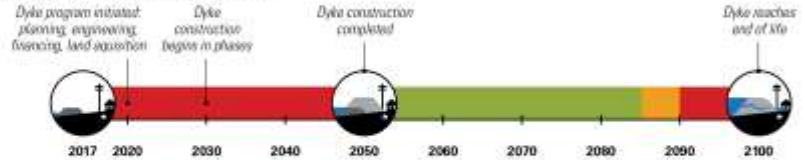
Exercise 3 - Option Evaluation and Next Steps

- Considerations:
 - Monitoring Risks
 - Thresholds and Triggers
 - Decision and implementation
 - What factors were of higher importance
 - Collaboration
 - Area solutions / Regional solutions

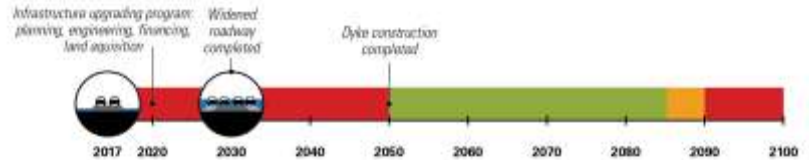
WHAT IS OUR RISK OF FLOODING?

LOW RISK MEDIUM RISK HIGH RISK

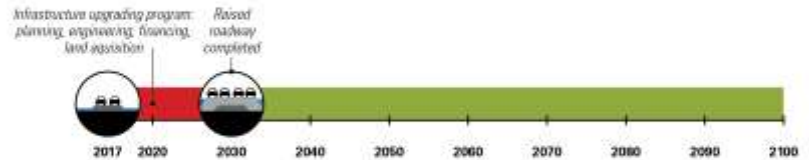
Risk of Flooding from Dyke Failure



Risk to Adjacent Infrastructure WITHOUT Adaptation




Risk to Adjacent Infrastructure WITH Adaptation



NOTE: WITHOUT ADAPTATION, ADJACENT INFRASTRUCTURE IS EXPOSED TO MANY DECADES OF INCREASING RISK OF FLOODING. IS THIS RISK EXPOSURE ACCEPTABLE?

Exercise 3 - Option Evaluation and Next Steps

- Considerations:
 - Monitoring Risks
 - Thresholds and Triggers
 - Decision and implementation
 - What factors were of higher importance
 - Collaboration
 - Area solutions / Regional solutions

<ul style="list-style-type: none">• Environmental Factors <ul style="list-style-type: none">– Regulatory compliance– Effects on biodiversity and habitat– Climate change mitigation and adaptation• Social Factors <ul style="list-style-type: none">– Public perception– Sense of community involvement– Maintenance of an acceptable level of service and public risk– Emergency response– Agricultural impacts	<ul style="list-style-type: none">• Economic Factors <ul style="list-style-type: none">– Capital cost– Cost-sharing and collaboration between different types of assets– Resilience and maintainability– Disruption of commerce– Risk tolerance around level of service provision and asset lifecycle from economic perspective
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Exercise 3 - Option Evaluation and Next Steps

- Work in Groups to please write down your comments into the workbook
- Table facilitator will summarize comments on flip charts
 - Table Discussion (20 min)
 - Group Discussion (25 min)



Group Exercise 3 - Evaluation and Next Steps

CFAS

Write down
comments

Workshop

CLOSING REMARKS AND NEXT STEPS



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Engineering

GLOBAL PERSPECTIVE.
LOCAL FOCUS.



Workshop Next Steps

- Collect the workbooks and notes
- Compile the comments of the workshop and complete the workshop report
 - Receive comments from City and Assessment Team
 - Finalize Reporting November 2017
- Use the results to inform next steps of the CFAS project.



CFAS Phase 2 & 3 Next Steps

- Regulators Workshop (Oct 17)
- Land Stewardship and Co-Benefits Workshop
- Semiahmoo Bay Workshop
- Other engagement (City committees, stakeholder and partners, broad community engagement, etc.)
- Additional review (Advisory Group, technical, City, partners & stakeholders)

CFAS Phase 2 & 3 Next Steps

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- Semiahmoo Bay Workshop
- Other engagement (City committees, stakeholder and partners, broad community engagement, etc.)
- Additional review (Advisory Group, technical, City, partners & stakeholders)



CFAS Next Round of Consultation

- Purpose of next round of consultation:
 - Validate reviewed options and evaluation of options for Mud Bay, Crescent Beach and Semiahmoo Bay
 - Discuss trade-offs across case study areas, options and sectors
 - Rank options
- Date
 - November-February
- Conclude with Open House to present Findings in February 2018

Online Story Map under development

- Summarize the history of the area focusing on transportation infrastructure as an illustrative component.
- Explain infrastructure vulnerability and potential service area disruption in an interactive way.





SURREY COASTAL FLOOD ADAPTATION STRATEGY (CFAS)

Thank you!



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