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Eagle Viewing Area / Siyich'em Reserve Dike Master Plan

Final Report
October 27, 2020
KWL Project No. 463.341-300

Prepared for:
District of Squamish and Squamish Nation

SQUAMISH

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Squamish Nation

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1. Introduction

1.1 Purpose

The Eagle Viewing Area / Siyich'em Dike Master Plan (DMP) identifies and describes the preferred upgrading concept for a 2.5 km reach of the Squamish River dike in Squamish, BC which is located in the unceded traditional territory of the Squamish Nation. The DMP also serves as a resource for implementation of the preferred upgrading concept by identifying next steps and implementation phasing.

Development of a DMP for this area was identified as a high-priority action in the Squamish Integrated Flood Hazard Management Plan (IFHMP) (KWL, 2017). A DMP is required for this reach of the Squamish River dike because of several factors, including long-standing land tenure issues, which make dike upgrading planning more complex than other dike reaches within Squamish. These issues are discussed further in Section 2 (Background Information and Context).

1.2 Study Area

The study area location in context to Howe Sound and the Squamish River watershed is presented on Figure 1-1. The study area features are presented in Figure 1-2.

The DMP study area focuses on the Squamish River and adjacent lands between the Squamish Nation Aikwuks and Kowtain Reserves.

The following key features are located within the study area:

- the Eagle Viewing Area (a recreational area on top of the existing dike);
- the Squamish Nation Siyich'em Reserve;
- the Eagle Run Drive/Maple Crescent residential area;
- Fisherman's Park (managed by the District of Squamish);
- a large forested island is located on the water-side of the dike along the northern portion of Siyich'em Reserve dike and along the Eagle Run Drive/Maple Crescent residential area; and
- Jimmy Jimmy (Judd) Slough is a side channel of the Squamish River that runs between the large forested island and the existing dike from Fisherman's Park to where it joins the Squamish River near the south end of Siyich'em Reserve.

The legal name of the Siyich'em Reserve is "Seaichem I.R. No. 16", but the Squamish Nation approved spelling is presented to the right. This report is formatted in Arial font and uses the spelling "Siyich'em" in place of the Squamish Nation approved spelling which requires a different font.

Siy̓ích'em

Additional information on the study area is provided in Section 2.

The study area was originally defined as ending at the north end of Siyich'em Reserve (i.e. not including the Eagle Run Drive/Maple Crescent residential area and Fisherman's Park), but was expanded to Fisherman's Park due to the dike upgrading alignment concepts generated during the project. This is discussed further in Section 3 (Options Identification and Shortlisting) and Section 4 (Conceptual Design and Feasibility of Shortlisted Options).

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District of Squamish

Eagle Viewing Area / Siyich'em Reserve Dike Master Plan

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N

Legend

- Watershed
- Municipal Boundary
- First Nation Reserve

Elaho River

Squamish River Watershed

Cheakamus River

Squamish River

Study Area

Mamquam River

District of Squamish
Municipal Boundary

Howe
Sound

Service Layer Credits: GIS data from the District of Squamish Open Data Catalogue downloaded March, 2020. Basemap Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community

Coordinate System: NAD 1983 UTM Zone 10N

Scale Disclaimer: The map scale of 1:400,000 is only valid on a 11"x17" print.

Project No. 463-341

Date October 2020

Scale 1:400,000 0 2.5 5 10 (km)

Squamish River Watershed

Figure 1-1

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District of Squamish / Squamish Nation

Squamish River Dike Master Plan - Eagle Viewing/Siyich'em

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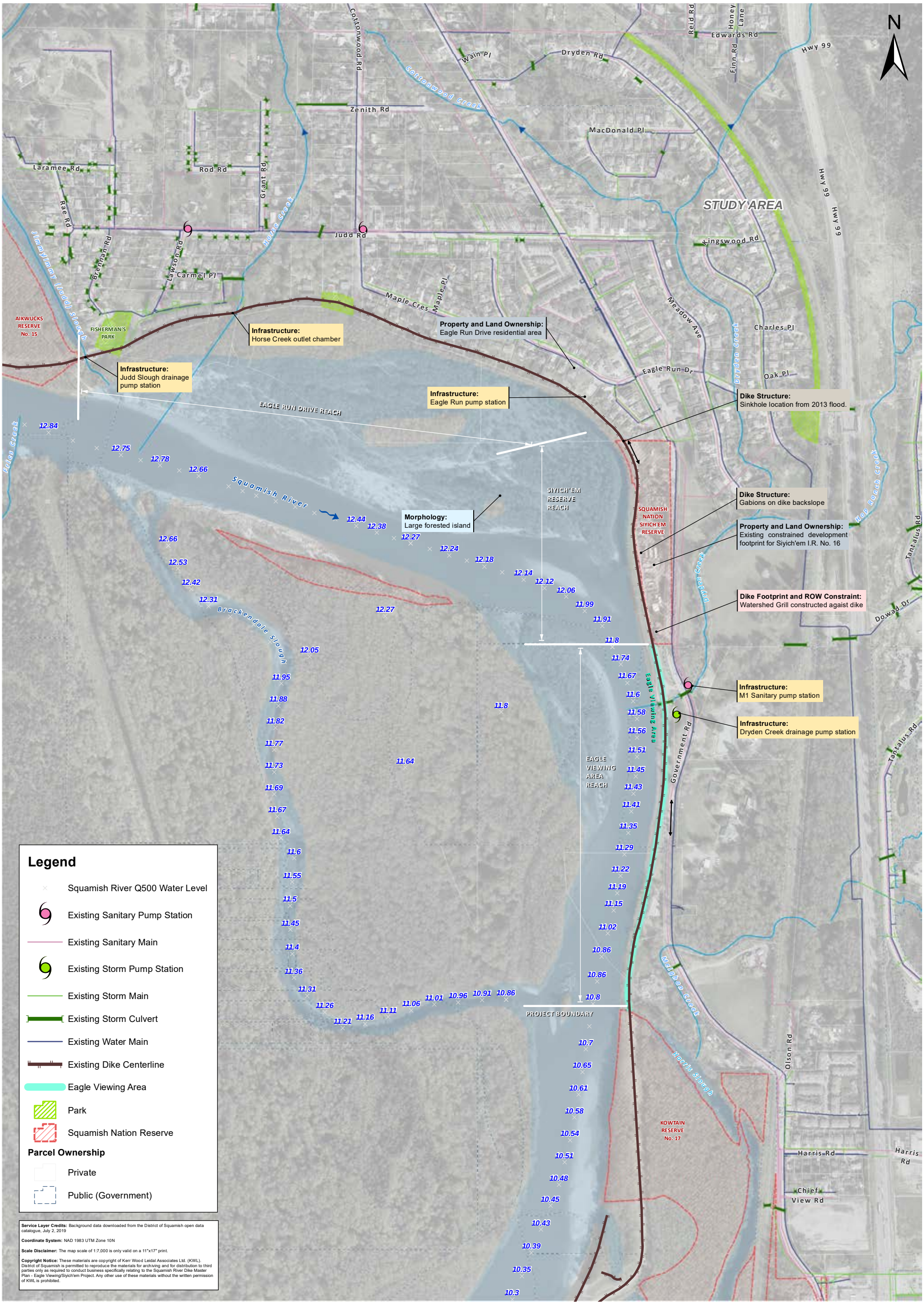

Legend

- Squamish River Q500 Water Level
- Existing Sanitary Pump Station
- Existing Sanitary Main
- Existing Storm Pump Station
- Existing Storm Main
- Existing Storm Culvert
- Existing Water Main
- Existing Dike Centerline
- Eagle Viewing Area
- Park
- Squamish Nation Reserve

Parcel Ownership

- Private
- Public (Government)

Service Layer Credits: Background data downloaded from the District of Squamish open data catalogue, July 2, 2019

Coordinate System: NAD 1983 UTM Zone 10N

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Study Area Features

Figure 1-2

1.3 Project Administration and Team

The DMP project is jointly administered by the District of Squamish (District) and the Squamish Nation (Nation). The project is funded by the National Disaster Mitigation Program (NDMP) administered by the Government of Canada and the Government of British Columbia. The project was initiated in summer 2019 and completed in fall 2020.

The District and the Nation retained a consulting team led by Kerr Wood Leidal Associates Ltd. (KWL) to develop the DMP in collaboration with the District and Nation. KWL is providing project management, hydrotechnical and civil engineering, environmental biology, and engagement services. The consulting team also includes a geotechnical engineering subconsultant firm (Thurber Engineering Ltd., Thurber) and a landscape architecture subconsultant firm (Hapa Collaborative, Hapa).

The DMP project is managed through a Steering Committee comprising District staff and councillors and Nation staff, members, and councillors. While the project and the committee are both led by the District and the Nation, the committee also includes a representative from the Government of Canada's Indigenous Services Canada department. Steering Committee members are listed in Table 1-1.

Table 1-1: Project Steering Committee Members

Name	Organization
David Roulston	District of Squamish
Chris Wyckham	District of Squamish
Gary Buxton	District of Squamish
John French	District of Squamish
Armand Hurford	District of Squamish
Paul Wick	Squamish Nation
Bob Sokol	Squamish Nation
Austin Chandler	Squamish Nation
Michelle George	Squamish Nation
Joshua Joseph	Squamish Nation
Chris Lewis	Squamish Nation
Chief Richard (Dick) Williams	Squamish Nation
Peter Baker	Squamish Nation
Monica Jacobs	Squamish Nation
Brent Baron	Indigenous Services Canada

The key consulting team members are listed in Table 1-2.

Table 1-2: Consultant Team Key Staff

Name	Organization	Role(s)
Erica Ellis	KWL	Lead Consultant Project Manager
Mike Currie	KWL	Technical Reviewer
David Roche	KWL	KWL Advisor to District
Jeff Derer	KWL	KWL Advisor to Nation
Amir Taleghani	KWL	Project Engineer (report author)
Shona Robinson	KWL	Junior Engineer
Heather Kingcott	KWL	Project Biologist
Patrick Burke	KWL	Project Biologist
Steve Coulter	Thurber	Thurber Project Manager/Geotechnical Engineer
Lukas Holy	Hapa	Hapa Project Manager/Landscape Designer
Allison Tweedie	Hapa	Landscape Designer

1.4 Dike Master Plan Development Process

The DMP has been developed through the following six phases:

- Phase A: Initiation, information gathering, and context;
- Phase B: Visioning, brainstorming, and shortlisting options;
- Phase C: Conceptual design and engagement on shortlisted options;
- Phase D: Structured options evaluation and selection;
- Phase E: Draft master plan; and
- Phase F: Final engagement and final master plan.

The project scope is structured to develop a dike upgrading concept which is preferred by both the District and the Nation, and to pursue consensus on the concept across a wide range of groups including Squamish Nation members, community stakeholder groups, and regulatory stakeholders.

The option development and selection process was initiated with identifying common interests between the District and Nation for the project. These common interests were used to brainstorm several high-level concepts. The concepts were refined to enable shortlisting of distinct options for conceptual design. Following engagement on the shortlisted options, additional comparison information including on cost and other feasibility factors were developed and the preferred option was identified by the Steering Committee and presented to District and Nation councils. A final round of engagement was conducted between June 2020 and September 2020 prior to finalizing the master plan for presentation to District and Nation councils.

Each project phase involved one or more meetings with the Steering Committee to confirm direction and make decisions to allow initiation of subsequent phases. Several presentations were also made to District and Nation councils during the project to provide project information updates and to confirm key decisions.

A project charter document was developed shortly after project initiation to provide a reference for the Steering Committee, guide decision making, and outline proposed meeting dates and other key milestones. The project charter is provided in Appendix A as a general reference.

1.5 Squamish Nation and Stakeholder Engagement

Engagement with Squamish Nation members and stakeholder groups is an important component of the DMP process. Engagement activities were guided by a stakeholder engagement plan developed shortly after project initiation; this document is provided in Appendix B as a general reference.

The primary objectives of stakeholder engagement are to:

1. listen to and understand stakeholder values and desires for the study area with respect to flood protection and stakeholder-specific non-flood protection topics;
2. involve stakeholders in the review and refinement of flood protection options under consideration by the District and the Nation; and
3. foster collaboration between the District of Squamish, Squamish Nation, and stakeholders to find mutually agreeable design solutions.

In support of these objectives, the level of stakeholder engagement is generally to be at the 'involve' level as defined by the International Association for Public Participation's (IAP2) engagement spectrum, presented in figure below.

Figure 1-3: IAP2 Engagement Continuum

Groups to engage with were identified with the help of the Steering Committee and were organized in the following categories:

- Squamish Nation Siyich'em Reserve families and residents;
- private (off Siyich'em Reserve) landowners and businesses (including a restaurant located on Siyich'em Reserve);
- community groups;
- regulators; and
- District and Nation internal departments.

Engagement activities were conducted as described in three of the project phases as noted below.

- Phase A: Initiation, information gathering, and context:
    - launched joint District-Nation project website;
    - installed signage at the Eagle Viewing Area; and
    - launched initial online survey #1 requesting information on how people use the site and what their concerns are.
- Phase C: Conceptual design and engagement on shortlisted options:
    - targeted meetings with Squamish Nation members (Siyich'em Reserve families and residents) and community groups;
    - correspondence with regulatory authorities; and
    - public open house and online survey #2.
- Phase F: Final engagement and final master plan:
    - targeted meeting with Squamish Nation members (Siyich'em Reserve families and residents);
    - online survey #3; and
    - correspondence with stakeholder groups.

Engagement activity results and their influence on the preferred option selection and implementation steps are discussed in Section 5 (Preferred Option) and Section 6 (Implementation). Engagement materials, meeting minutes, and survey results are provided in Appendix H.

2. Background Information & Context

This section provides a summary of relevant background information to set the context for the dike master plan. The section begins by introducing the Squamish River watershed, and then describes several factors in the master plan study area that are very influential to the process. The latter includes Siyich'em Reserve land tenure, other land uses and infrastructure, and environmental habitat.

2.1 Watershed and Flood Hazard Background Information

The Squamish River drains a watershed of over 3,800 km² that is covered by extensive glaciers and forested valleys into Howe Sound which is connected to the Strait of Georgia / Salish Sea and the Pacific Ocean.

Elevations in the watershed range from mountain peaks of over 3,000 m above sea level down to tidewater at Howe Sound. The river has its source in the Pemberton Icefields, and about 20% of the watershed is glaciated (Paige and Hickin, 2000).

About 50 km upstream of Howe Sound, the Squamish River is confined within a canyon. Downstream of the canyon reach, the river assumes a steep, multi-channel braided morphology. It is likely that much of the coarse sediment delivered to the river from upstream sources is stored in this reach. As the river slope declines downstream, the river transitions from braided to wandering to meandering planform.

Major rivers flowing into the Squamish River include the Elaho River, the Cheakamus River, and the Mamquam River. BC Hydro operates a major storage-supported hydroelectric generation facility at Daisy Lake on the Cheakamus River, about 13 km upstream of the District boundary (flow is diverted from Daisy Lake through a tunnel to a powerhouse along the Squamish River). The Cheekeye River, a major tributary of the Cheakamus River, is subject to extremely large debris flow events, and has built a substantial fan located 12 km upstream of Howe Sound (the Cheekeye Fan stretches from the Cheekeye River confluence with the Cheakamus River southward to the community of Brackendale).

Downstream of the Cheekeye Fan, two major side channels (Brackendale Slough and Baynes Slough) provide flood conveyance through the right bank floodplain. Two major side channels on the left bank (Judd Slough and Harris Slough) and other smaller side channels have been cut off from the river mainstem by the Squamish River dike.

Squamish is exposed to a variety of flood hazards, including river flood hazards, debris flood and debris flow hazards, and coastal flood and tsunami hazards.

As presented in Figure 1-2, the Eagle Viewing Area / Siyich'em Reserve DMP study area is located on the Squamish River, downstream of the confluence with the Cheakamus River and upstream of the confluence with the Mamquam River . The study area is primarily exposed to Squamish River flood hazards, but is also on the fringe of Cheekeye Fan and associated debris flow hazard.

The DMP project does not focus on the Cheekeye River debris flow hazard, but commentary is made in this report about how that hazard and on-going mitigation planning by others needs to be coordinated with implementing dike upgrades in the study area. There is a significant body of research into the Cheekeye River, with particular emphasis on the fan feature and the processes governing its formation. A comprehensive listing is provided by Clague et al. (2014).

The DMP study area is not affected by coastal flooding or tsunami hazards, however there is a minor tidal influence on river water levels within in the study area during periods of low flow.

Most Squamish River floods occur in the fall and early winter when large and intense multi-day storms create high flows on the local rivers, and when precipitation falling as rain throughout the watershed can bring additional runoff from alpine snowmelt. Sediment aggradation gradually or periodically increases the flood risk in some areas by filling in river channels.

In October 2003, significant flooding occurred on the Squamish River and Cheakamus River. Rainfall totalling 369 mm in 4 days caused the largest flood since continuous hydrometric records began on these rivers in the 1950s. The flood caused evacuations and damage to flood protection structures. In general, dikes considered "standard" dikes (i.e., designed for a 200-year return period or 0.5% annual exceedance probability floods) were not overtopped; however, freeboard at some locations was as little as 0.5 m, including at the Siyich'em / Eagle Viewing Area dike.

2.2 Integrated Flood Hazard Management Plan

The District adopted an Integrated Flood Hazard Management Plan (IFHMP) in 2017 following a three-year process involving significant technical work and community engagement, including engagement with the Squamish Nation.

The IFHMP provides recommendations and actions to guide a variety of policy, land use, infrastructure, and emergency preparedness/response programs for the District. In developing the IFHMP, new flood hazard and regulatory flood maps were established through 1-dimensional and 2-dimensional hydraulic modelling. The underlying analysis considered the anticipated climate change impacts to flood hazards, including increased precipitation and sea level rise.

Guided by the IFHMP, the District has initiated a dike design and construction program which will upgrade Squamish River dikes and construct a new sea dike to protect downtown Squamish. The District has recently upgraded the highest-priority dike reach identified in the IFHMP (Upper Judd Slough).

The IFHMP also identifies the Eagle Viewing Area / Siyich'em Reserve area as a high-priority area for dike upgrading. However, a preferred upgrading concept was not developed as part of the IFHMP because of several factors (e.g., Siyich'em Reserve land tenure issues) requiring further attention than the IFHMP could offer. Accordingly, the IFHMP recommended that a dike master plan be developed for the area to identify a preferred upgrading concept and guide implementation.

The IFHMP identified the following general design criteria for Squamish River dike upgrades:

- raising of the existing dike crest to the 500-year return period (0.2% annual exceedance probability) clear-water flood level including climate change allowances as per the IFHMP plus 0.6 m freeboard – flood level elevations without freeboard are presented on Figure 1-2;
- extension of riverside erosion protection works to the raised dike crest;
- widening the dike crest to the 6 m (20 foot) standard crest width used for mainstem river dikes in California (to support emergency response and reduce seepage);
- introduction of bioengineered erosion protection works on the dike backslope to mitigate the likelihood of failure (due to erosion) during shallow overtopping events;
- construction of a toe drain (similar to those incorporated in 2013 and 2015 upgrading projects) to intercept seepage and control hydraulic exit gradient; and

- expansion of the standard right-of-way (SROW), adopting the larger of the recommended minimum 7.5 m offset from each toe of a provincial standard dike, or a recommended minimum 3 m offset from the future toe of the dike.

The DMP used the above criteria from the IFHMP as part of the foundation for developing upgrading concepts. The design criteria for the preferred upgrading concept is presented in Section 5 and discussion is provided on its alignment with the criteria from the IFHMP.

2.3 Siyich'em Reserve Land Tenure

Squamish lies within the unceded traditional territories of the Squamish Nation and the Tsleil-Waututh Nation. Ten Squamish Nation Reserves located throughout the Squamish River valley create an inseparable common interest in flood protection for the District and the Nation.

Many dikes in Squamish were constructed without the consent or involvement of the Squamish Nation, including the portion of the Squamish River dike which runs in trespass without land tenure through the Siyich'em Reserve. Additionally, dikes were constructed on alignments which did not protect the full extent of all Squamish Nation Reserves from flooding.

The diking-related land tenure issue is particularly significant on the Siyich'em Reserve, and has been a topic of discussion between the Squamish Nation and all levels of government for decades.

A review of historical reserve maps provided by the Government of Canada shows that the reserve was mapped in 1881 (NRCan 2014, BC249 CLSR BC) with a total area of 68 acres (27 hectares) comprising two land parcels:

- an island parcel (30 acres or 12 hectares) located east of the Squamish River main channel and west of a side channel adjacent to the mainland; and
- a mainland parcel (38 acres or 15 hectares) bounded by the side channel and a straight-line north-south boundary which intersects with the current Government Road (which was likely a road at the time of mapping).

A portion of the 1881 map is reproduced with spatial reference annotations in Figure 2-1.

Current Government of Canada reserve mapping shows the reserve has a total area of 9.8 acres (4 hectares) comprising of two land parcels:

- a narrow strip of land (3.2 acres or 1.3 hectares) located on the forested gravel bar immediately west of the Squamish River main channel; and
- a parcel of land (6.6 acres or 2.7 hectares) on the east side of the Squamish River main channel and west of the eastern edge of Government Road.

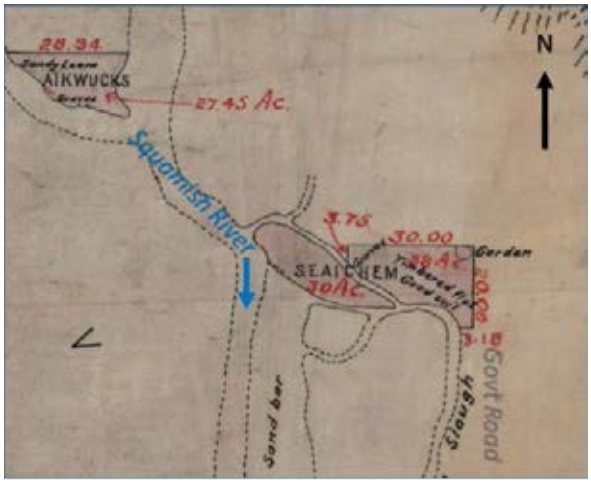

Figure 2-1: Reproduction of 1881 E. Mohun Survey Map of Reserves in the Squamish Valley

Comparing the two areas shows that the reserve size was reduced by more than 85%. This change is the result of the Squamish River main channel alignment changing and of Government of Canada reserve mapping policies (discussed below).

Historical reports indicate that Judd Slough and Brackendale Slough (see Figure 1-2) were part of the main river channel until 1908, when a logging barge ran aground near the inlet of what is now Brackendale Slough. This disruption, combined with other factors, such as upstream diking, natural river morphology, logging practices, and watershed changes, caused debris to accumulate within Judd Slough. Subsequently, the main flow of the river was diverted into the present-day channel farther to the west. Near the south end of Judd Slough, the bouldery Stoney Creek fan redirected flow from the new main channel into Schonover Slough, which eroded to the east to become the present-day channel through Siyich'em.

Figure 2-2 presents a side-by-side comparison of the 1918 map and two historic aerial photos (1949 and 2008) which shows the transition of the Squamish River main channel from west to east. On each photo, a red arrow points to approximately the same location. From left to right, the comparison shows that the main channel has migrated from the west side of the red arrow to the east side of the red arrow, eroding much of the Siyich'em Reserve.

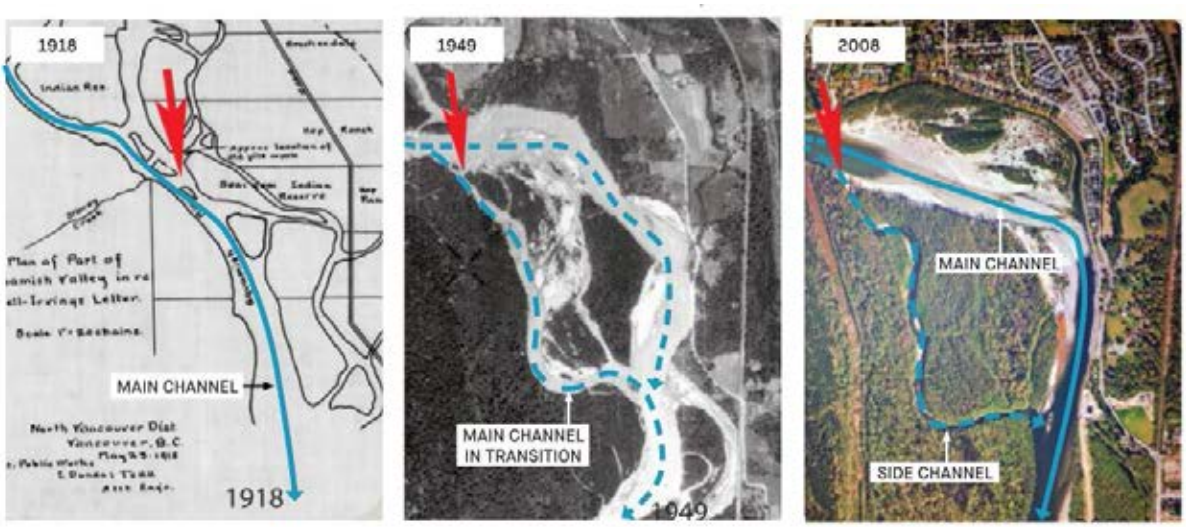

Figure 2-2: Squamish River Main Channel Alignment Change

Feeney (1950) measured land loss for five Squamish Nation reserves (Waiwakum I.R. No. 14 Aikwucks I.R. No. 15, Seaichem I.R. No. 16, Kowtain I.R. No. 17, and Yekwaupsum I.R. No. 18) and found a total loss of over 90 acres (37 hectares) to river erosion prior to 1950. The most extreme loss occurred at Siyich'em, where Feeney (1950) calculated a loss of 39 acres (16 hectares) at that time.

Subsequent construction of the flood protection dikes followed the river channel, which had remained relatively stable since the mid-1900s (e.g., Feeney, 1950). By isolating Judd Slough and Harris Slough, the dike created hydraulic conditions that continue to favour the current river alignment, making it unlikely that the river will naturally return to its pre-1908 course without major intervention. The Squamish Nation has expressed concerns about the dike alignment and its impacts for reserve lands, particularly because it "locks in" past losses while leaving unprotected parts of the riverbank vulnerable to continued flooding and further erosion.

Figure 2-3 presents an overlay comparison of the current reserve mapping (solid red line) and historic mapping (dashed orange line - possibly the 1881 survey) accessed through the Government of Canada reserve mapping website.

Figure 2-3: Comparison of Current (solid red line) and Historic (orange dashed line) Siyich'em Reserve Boundaries

This comparison shows that the Squamish River shifted east and eroded the majority of the Reserve land such that only a narrow strip of the original island parcel remains and less than half of the original mainland parcel remains.

It is understood that under Government of Canada reserve mapping policy, a reserve boundary may be defined as the ordinary high-water mark of a watercourse and erosion of the land overtime would lead to reserve size reduction as the ordinary high-water mark moves into remaining land. Appendix C provides the Government of Canada Surveyor General's legal description report for the Siyich'em Reserve which provides additional information on the historical surveys and changes in mapped reserve boundaries. It is understood that new land formed by the deposition of river sediments does not result in an addition to the reserve under Government of Canada reserve mapping policy; this is discussed in Appendix C.

In addition to the significant loss of land through erosion, the existing dike further limits the available land on Siyich'em Reserve. The existing dike runs through the reserve without land tenure. The dike is maintained by the District with permission from the Nation.

In addition to the dike, a portion of Government Road also runs through Siyich'em Reserve without land tenure. The portion of Government Road in trespass through the Reserve is highlighted on Figure 2-4.

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District of Squamish / Squamish Nation

Squamish River Dike Master Plan - Eagle Viewing/Siyich'em

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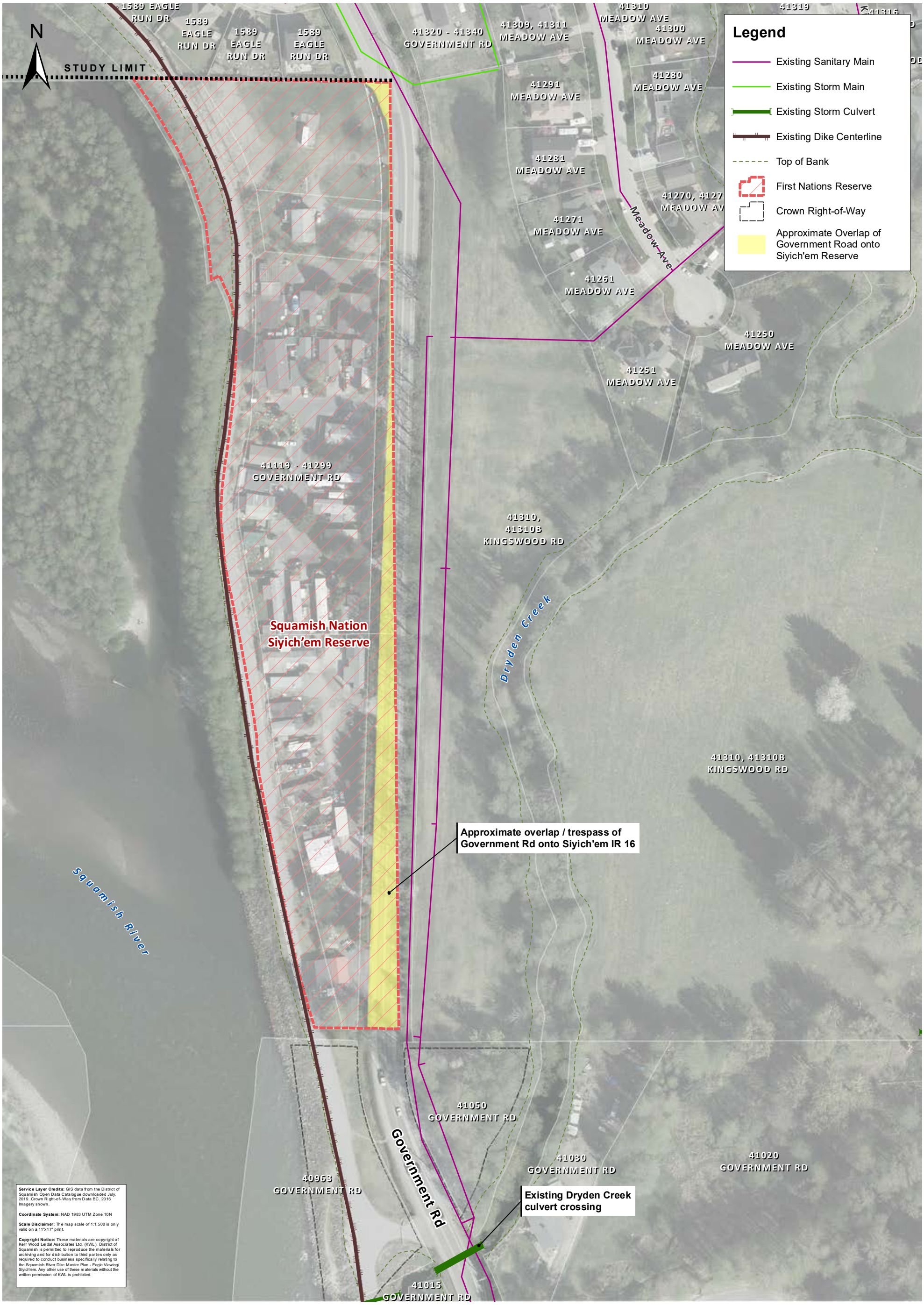

Service Layer Credits: GIS data from the District of Squamish Open Data Catalogue downloaded July, 2019. Crown Right-of-Way from Data BC. 2016 Imagery shown.

Coordinate System: NAD 1983 UTM Zone 10N

Scale Disclaimer: The map scale of 1:1,500 is only valid on a 11"x17" print

Project No. 463.341

Date October 2020

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Government Road Alignment

Figure 2-4

2.4 Existing Flood Protection and Drainage Infrastructure

The existing dike alignment, drainage infrastructure, and adjacent features are presented on Figure 1-2.

Many deficiencies have been noted with the existing dike as part of previous projects and this project.

These deficiencies include:

- insufficient crest elevation based on IFHMP dike upgrading criteria (500-year return period flood level (including climate change considerations) plus 0.6 m freeboard);
- a history of seepage, particularly on the Siyich'em Reserve, which is understood to cause seasonal, nuisance flooding for residents;
- internal instability (piping) issues as noted during the 2003 flood;
- non-standard dike geometry (including gabion basket retaining walls as part of the land-side slope), as compared to provincial guidelines listed in Section 2.7;
- structures attached to and/or on the dike crest which impede access for regular or emergency activities (including a restaurant building on Siyich'em Reserve which is attached to the dike crest, and the Eagle Viewing Area picnic shelter and related structures);
- lack of land tenure and/or standard setback distance between dike toe and structures, particularly on the Siyich'em Reserve, in the Eagle Run Drive residential area, and at a private residence south of the Eagle Viewing Area;
- seismic performance which does not meet the provincial seismic guidelines listed in Section 2.7 (this is discussed further later in the report); and
- deep river scour holes adjacent to the dike toe, particularly near the Dryden Creek pump station.

The existing dike through the study area also includes several drainage structures which convey creek flow and urban runoff into the Squamish River. These include:

- floodbox and pump station at Jimmy Jimmy (Judd) Slough;
- floodbox at Horse Creek, connected to Jimmy Jimmy (Judd) Slough behind the dike by a culvert;
- Eagle Run Drive urban stormwater pump station; and
- floodbox and pump station at Dryden Creek.

The most recent comprehensive master drainage plan for the study area (KWL, 1992) is considered out of date. An updated master drainage plan is required to provide commentary on the condition of the existing drainage infrastructure. However, in general and based on KWL's familiarity with several of the drainage structures, it is assumed that all of the drainage structures would require replacement in the future for the purposes of the dike master plan.

2.5 Land Use, Ownership, and Other Infrastructure

Figure 2-5 presents land ownership and District of Squamish land use zoning for the study area.

Land use along study area includes:

- residential (Siyich'em Reserve, Eagle Run Drive residential area);
- agricultural (a ranch/farm stand property located east of Government Road near the Eagle Viewing Area);
- commercial (a restaurant located on the Siyich'em Reserve);
- recreational (the Eagle Viewing Area);
- institutional (Easter Seals camp located east of Government Road near the Eagle Viewing Area); and
- provincial park (Brackendale Eagles Provincial Park is located on the west side of the Squamish River main channel).

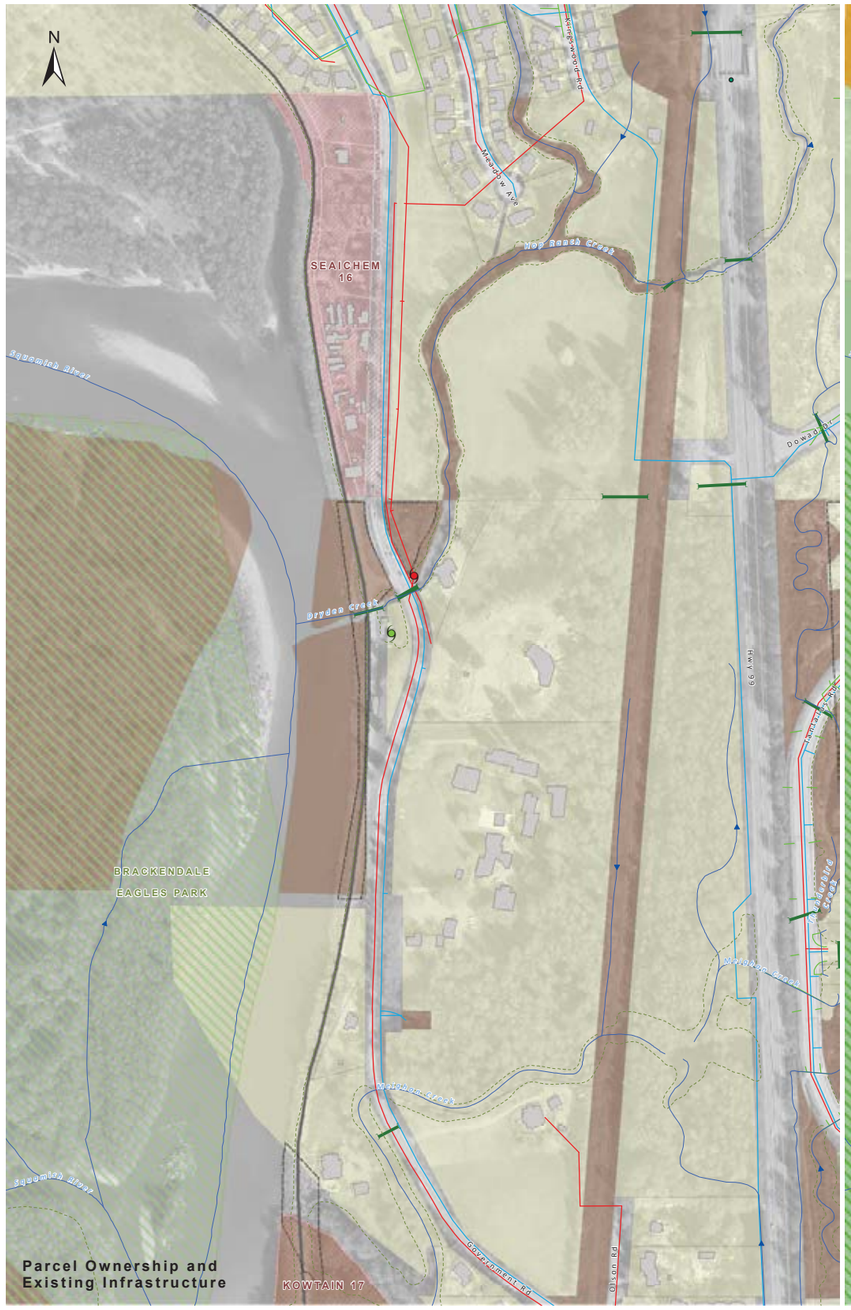
Other, non-flood/drainage-related infrastructure along the study area are presented on Figure 1-2 and include:

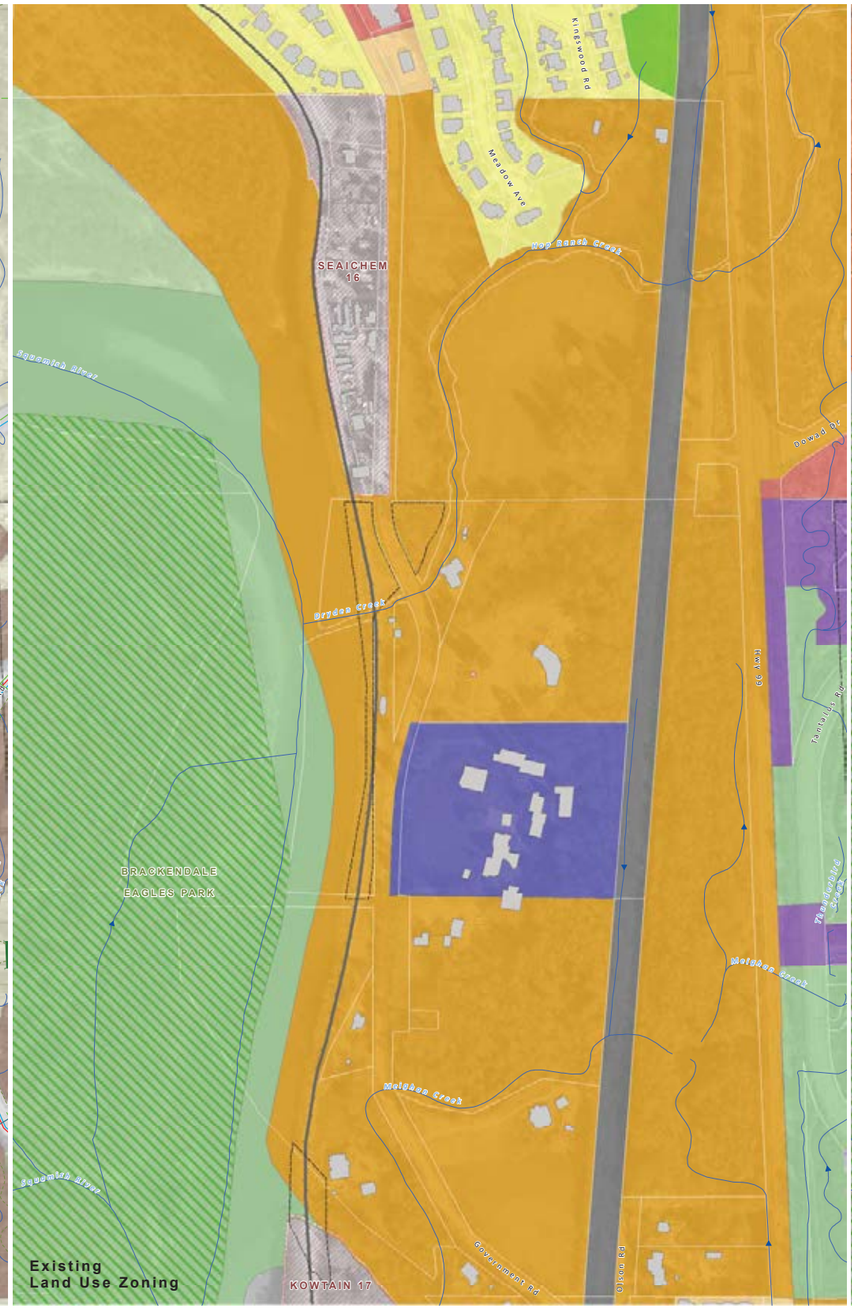
- Government Road;
- watermain within Government Road;
- Easter Seals (M1) sanitary lift station, near Dryden Creek; and
- sanitary main which is partially located parallel and east of Government Road through a right-of-way along private properties.

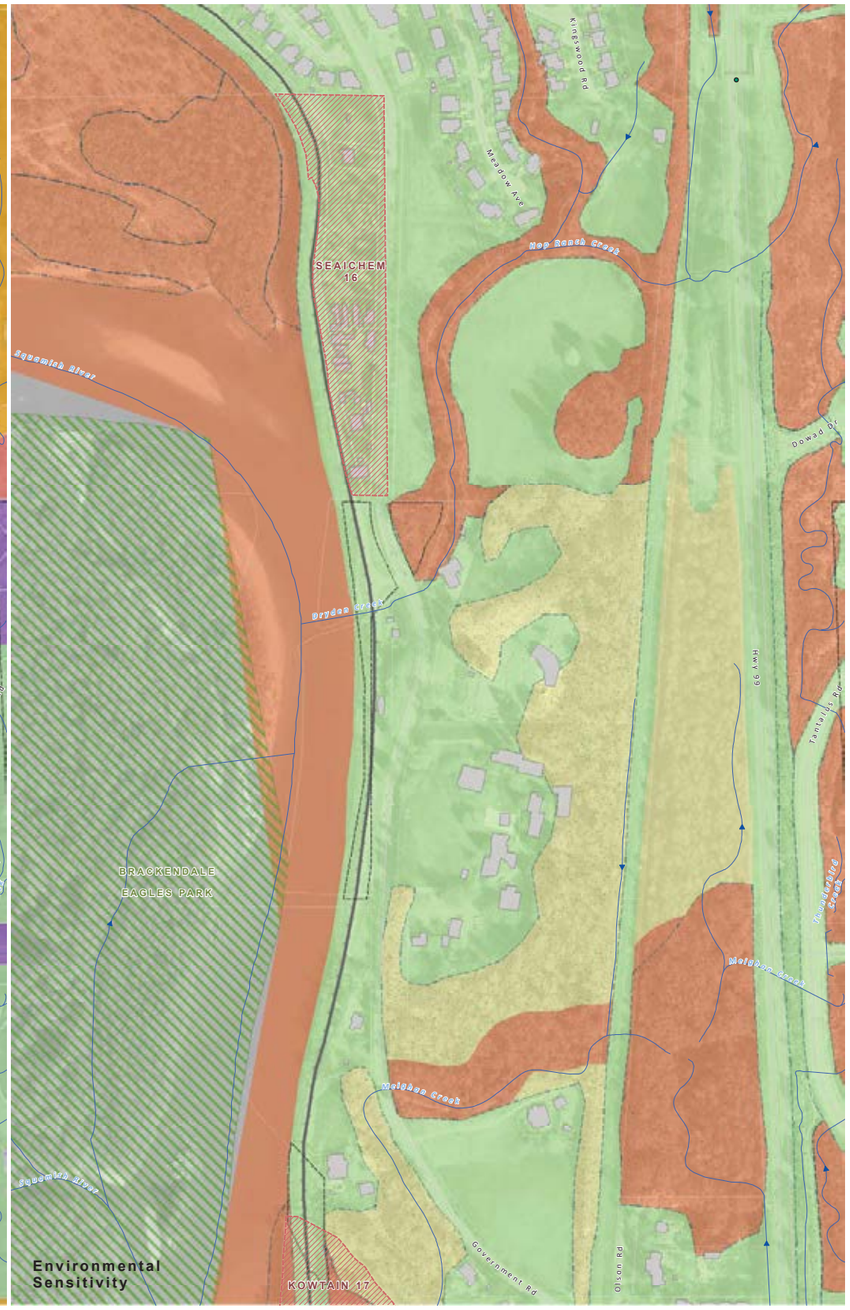
District of Squamish / Squamish Nation

Squamish River Dike Master Plan - Eagle Viewing/Siyich'em

KERR WOOD LEIDAL consulting engineers







Service Layer Credits: GIS data from the District of Squamish and Squamish Nation. Orthophotography © Ocean Highway Way from Esta BC, 2018 Imagery shown.

Coordinate System: NAD 1983 CTM Zone 10N

Scale Disclaimer: The map scale of 1:3,000 is only valid on a 30"x36" print.

First Nations Reserve
Provincial Park
Crown Right-of-Way
Building Footprint
Dike Centerline
Existing Storm Pump Station
Existing Sanitary Lift Station
Existing Storm Main
Stm_Culvert
Existing Watermain
Existing Sanitary Main
Top of Bank
Watercourse

Parcel Ownership
Government (Federal, Provincial, Municipal)
Private
Reserve

First Nations Reserve
Provincial Park
Building Footprint
Crown Right-of-Way
Dike Centerline
Watercourse

Zoning
Comprehensive Development
District Assembly
Ecological Reserve
Local Commercial
Park and Public Use
Rail Transportation
Resource
Residential
Multiple Family Residential
Rural Residential

First Nations Reserve
Provincial Park
Crown Right-of-Way
Building Footprint
Dike Centerline
Watercourse
Wetland

Environmental Sensitivity (ESA Level)
Low
Medium
High

Project No. 463.341
Date October 2020
Scale 1:3,000 (0 15 30 60 (m))

Land Use and Ownership

Figure 2-5

2.6 Environmental Considerations

This sub-section provides an introduction to habitat values within the Squamish River watershed as a whole and a summary of the baseline habitat review conducted for a portion of the study area.

Squamish River Watershed

The Squamish River watershed area falls within the Coastal Western Hemlock, Mountain Hemlock, and Alpine Tundra biogeoclimatic zones.

The watershed offers feeding, spawning, and rearing habitat for four listed aquatic species, including Green sturgeon (*Acipenser medirostris*), Cutthroat trout (*Oncorhynchus clarkii*), coho salmon (*Oncorhynchus kisutch*), and bull trout (*Salvelinus confluentus*). The Squamish River and its tributaries also support regionally-important anadromous runs of Chinook (*Oncorhynchus tshawytscha*), pink (*Oncorhynchus gorbuscha*), and chum salmon (*Oncorhynchus keta*), and steelhead (*Oncorhynchus mykiss*).

Species of conservation concern in the watershed include eight mammals, three amphibians, and two reptiles. This includes the federally endangered Pacific water shrew (*Sorex bendirii*) and two federal species of special concern, the grizzly bear (*Ursus arctos*) and the coastal tailed frog (*Ascaphus truei*). The watershed provides important wintering, migration, feeding and/or breeding habitats for a variety of migratory and resident waterfowl, shore birds, raptors, and song birds, including the federally endangered northern spotted owl (*Strix occidentalis caurina*), the great blue heron (*Ardea herodias fannini*), a federal species of special concern, and fourteen other listed bird species.

Low elevation habitat within the watershed has been significantly altered by past and present human use. Anthropogenic pressures include residential and industrial developments, hydroelectric power projects, railway corridors, mercury contamination, former garbage dumps, invasive species, and development of the local dike system. Historic construction of flood protection dikes isolated former side channels like Judd Slough, Harris Slough, Whittaker Slough, and Crescent Slough.

Study Area Habitat Review

Baseline habitat conditions were reviewed during both a desktop study and a brief, one-day site visit. The habitat review was limited in overall spatial scope and did not cover the entire study area, including the north/west of Siyich'em Reserve, as those areas were added to the DMP study area after the baseline habitat review was completed. The habitat review identifies and describes aquatic habitats (including a list of probable fish species), vegetation and terrestrial habitats, and birds and terrestrial wildlife. The assessment also identified several species of conservation concern which may be present within the study area, including fish species (bull trout, cutthroat trout, and green sturgeon), vegetation (15 plant species), birds (15 species), mammals (8 species including the Pacific water shrew), and amphibians/reptiles.

Appendix D provides a report describing the habitat review and results in additional detail.

Figure 2-5 also provides sensitive habitat mapping for the study area.

2.7 Relevant Guidelines

The provincial and local guidelines that have been considered in developing the DMP are listed below.

- Dike Design and Construction Guide, Best Management Practices for British Columba – Ministry of Water, Land, and Air Protection, July 2003. (Amended in 2011).
- Riprap Design and Construction Guide – Ministry of Environment, Lands, and Parks, March 2000.
- Environmental Guidelines for Vegetation Management on Flood Protection Works to Protect Public Safety and the Environment – Ministry of Environment, Lands, and Parks, and Department of Fisheries and Oceans Canada, March 1999.
- Seismic Design Guidelines for Dikes 2nd Edition – Ministry of Forests, Lands, and Natural Resource Operations, 2014.

3. Options Identification and Shortlisting

This section describes the approach taken by the project team and the Steering Committee to identify and shortlist dike upgrading options in the study area.

3.1 District and Nation Common Interests

Several complex and potentially conflicting factors influencing the project arise out of the context discussed in Section 2. These factors include Squamish Nation loss of land and land tenure issues relating to historic diking decisions, the District's lack of a right-of-way or sole authority to upgrade the dike through Siyich'em Reserve, and transportation and parking pressures in the study area related to the Eagle Viewing Area and commercial businesses.

While the DMP is focused on upgrading flood protection, it acknowledges that planning for future flood protection in the study area needs to be done within the context of other issues and ideally with a view to start to address other issues where reasonable to do so.

To guide the process, the project team worked with the Steering Committee to develop a list of common interests as a lens through-which to weigh and consider options.

(1) Address Public Safety

- Provide flood protection that meets the intent of the Squamish Integrated Flood Hazard Management Plan.
- Avoid transfer of flood risk.
- Incorporate pedestrian and traffic safety.

(2) Recapture Squamish Nation Land and Enable Beneficial Use

- Facilitate historical reserve land restoration.
- Enable Nation use and enjoyment of land.

(3) Optimize Project Costs

- Funding to work within the context of the District's diking capital plan.
- Consider sustainable life-cycle funding for all project components.

(4) Minimize Impacts to Environmental Habitat

- Minimize impacts to habitat.
- Incorporate habitat enhancement and historical restoration where possible.

(5) Address Immediate Flood Risk while Enabling Long-term Approaches

- Address immediate flood risk with an option that is feasible for early implementation.
- Enable long-term (generational) approaches, including potential river channel migration and land recapture. This reflects a concept put forward by the Squamish Nation to relocate the Squamish River main channel into its historic channel to the west. While not directly a dike upgrading concept, the ability to accommodate a future change is considered in developing diking options.

(6) Acknowledge Site History and Culture

- Reflect Siyich'em Reserve land history in the plan and in option development.

(7) Enable Future Collaboration on Access Issues

- Enable future collaboration on District access for dike maintenance.
- Enable future collaboration on issues related to public access.

3.2 High-Level Concepts (Original Study Area)

As previously stated, the original study area for the project was limited to the area between the north boundary of the Kowtain Reserve and the north boundary of the Siyich'em Reserve.

KWL and Hapa developed several high-level dike upgrading concepts for the original study area focusing at first on dike alignment and footprint. The concepts were reviewed with the Steering Committee and refined into the following list of concepts (visualizations used to discuss the majority of these high-level concepts are provided in Appendix E). It is important to note that these high-level concepts are not all distinct or complete dike upgrading options. This list of concepts was used to advance discussion with the Steering Committee as an intermediate step towards shortlisting distinct options, which is discussed in the following sub-section.

1. **Minimize Dike Fill** – The dike would be raised on its existing footprint using land-side retaining walls to avoid further impacting Siyich'em Reserve and other development.
2. **Raise Siyich'em Reserve** – The land encompassing Siyich'em Reserve would be raised to dike height at the river side of the Reserve, sloping down towards Government Road. This concept would apply only to the reserve and could be paired with the above concept south of Siyich'em Reserve.
3. **Straighten Government Road** – Government Road would be straightened so it is off the Siyich'em Reserve, and Dryden Pump Station would be replaced at a new location during the road works. This concept is not a standalone dike alignment and could be paired with other approaches.
4. **Relocate Government Road** – Government Road would be dramatically realigned, along the railway corridor several hundred metres east of its current location. The existing road area would form part of the new dike and could be paired with the concept to raise Siyich'em Reserve.
5. **Raise Government Road** – Government Road would be raised along the reach to function as the dike. This could be paired with the concept to raise Siyich'em Reserve.
6. **Reclaim the Slough** – For the reach along Siyich'em Reserve, the dike would be raised by expanding the footprint to the water-side (west), into Jimmy Jimmy (Judd) Slough, minimizing impacts on the Siyich'em Reserve.
7. **New Dike Alignment to Restore Reserve Land** – In the reach along Siyich'em Reserve, the dike would be realigned to the west, joining the existing dike at Fisherman's Park. This would create dike protection for the large forested island next to Siyich'em Reserve, with potential to address historic loss of land and land tenure issues through restoring reserve land.
8. **Realign the Squamish River** – While not directly a diking option, it was requested that the concept to realign the Squamish River main channel to its historic alignment to the west be noted as a concept. As discussed as part of the common interests, this is not a dike upgrading option that

would directly satisfy the primary purpose of the DMP. However, the concept of long-term river alignment change is acknowledged in the DMP and compatibility discussed for advanced options.

3.3 Shortlisting of Options (Original Study Area)

Two Steering Committee meetings were used to advance from the list of high-level concepts presented in Section 3.2 to a shortlist of distinct options for conceptual design and engagement. The options refinement and shortlisting process was conducted through facilitated discussions with reference to the common interests presented earlier.

The original study area was divided into 2 reaches (Siyich'em and the Eagle Viewing Area) and the following options were shortlisted by the Steering Committee. Conceptual design and feasibility information for the shortlisted options is provided in Section 4.

Siyich'em Reach

Three (3) options were shortlisted in the Siyich'em reach which covers the Reserve area. Figure 3-1 summarizes the conceptual alignment of the shortlisted options in the Siyich'em reach.

The options are briefly described below. Additional information is provided in Section 4.

Option A – Retaining Wall

Option A was developed based on high-level concept #1 (minimize dike fill). This option would involve raising the existing dike and minimizing the footprint to the existing dike footprint on the reserve by retaining the dike fill on the land-side with a vertical wall.

Option B – Land Raising

Option B was developed based on high-level concept #2 (raise Siyich'em Reserve). This option would involve removing existing structures on the reserve, filling the land to the dike crest elevation and regrading the land the to accommodate replacement structures, infrastructure, and utilities. It may not be possible to raise the entire footprint of the reserve to the dike crest elevation. Detailed grading would depend on future redevelopment form and could be optimized through detailed design.

Option C – New Dike Alignment to Recapture Land

Option C was developed based on high-level concept #7 and would involve constructing a new dike which would diverge from the existing dike near the southern portion of the Siyich'em Reserve, cross Jimmy Jimmy (Judd) Slough and be routed on the large forested island along an alignment setback from the Squamish River. Unlike Option A and Option B, this option would not tie into the existing dike on the northern boundary of the Siyich'em Reserve. Option C would tie into the existing dike at Fisherman's Park and would act as a replacement for the existing dike along the Eagle Run Drive residential area between Fisherman's Park and the north boundary of Siyich'em. As discussed in Section 4, the original study area was expanded to Fisherman's Park to accommodate contemplation of Option C and comparison against Option A and Option B. The new dike alignment would partially disconnect a large, forested island from the Squamish River and the option is shortlisted with the concept that partial connection could be maintained via a new fish-friendly pump station at the outlet of Jimmy Jimmy (Judd) Slough.

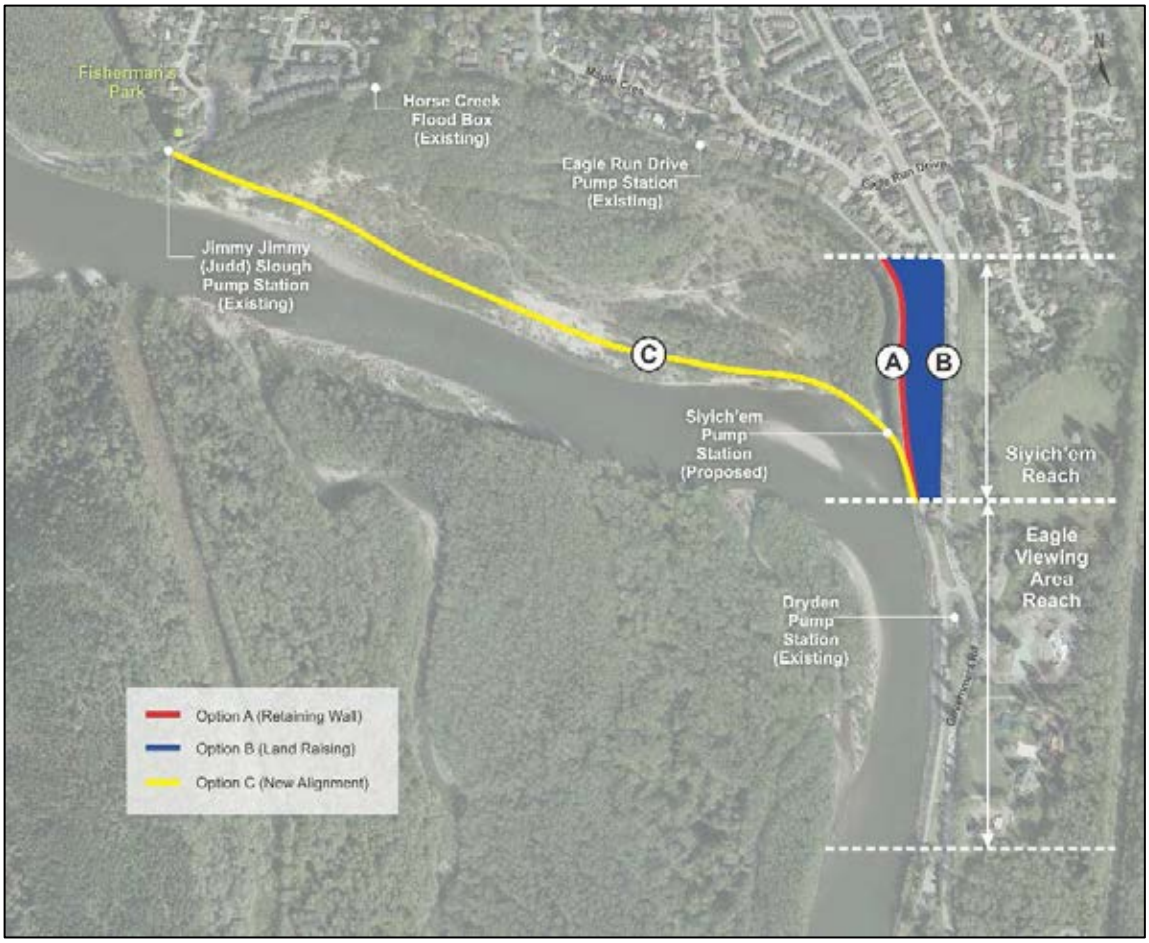


Figure 3-1: Conceptual Alignments of Shortlisted Options in the Siyich'em Reach

Eagle Viewing Area Reach

Only one option was shortlisted for the Eagle Viewing Area which covers the area between the southern boundary of Siyich'em Reserve and the northern boundary of the Kowtain Reserve.

The shortlisted option is **Land-side Raise** which refers to raising the dike crest and expanding the footprint towards the land-side (east) wherever there is space. This essentially involves a conventional dike raising approach with the footprint expanding towards Government Road. Where Government Road or other structures obstruct the expansion, the work could include retaining walls or a partial raising of Government Road. These sub-options are discussed further in Section 4 and Section 5.

The rationale for shortlisting only one option for the Eagle Viewing Area is that it became apparent through the options development and shortlisting process that the Siyich'em reach is more complex and is likely to be a relatively higher cost component of the overall dike upgrading project. Based on this and the common interest to manage costs, the project scope was more focused on the Siyich'em reach options. The land-side raise approach is believed to be the simplest and lowest cost concept for the Eagle Viewing Area, and was deemed to be appropriate through the options development and shortlisting process.

4. Conceptual Design & Feasibility of Shortlisted Options

This section describes the conceptual design and feasibility considerations developed for the shortlisted options. Section 4.1 describes how and why the original study area was expanded to Fisherman's Park after the shortlisting of options for conceptual design. The remainder of the sub-sections describe the conceptual design criteria and the conceptual design options reach-by-reach. Class D construction cost estimates developed for all options are compared at the end of this section.

4.1 Study Area Expansion and Inclusion of Eagle Run Drive Dike

As described in Section 3, the development and shortlisting of Option C (New Dike Alignment to Recapture Land) in the Siyich'em reach necessitated an expansion of the study area because Option C extends beyond the Siyich'em Reserve and ties into the existing dike at Fisherman's Park.

To provide a defensible comparison of Options A, B, and C, the limits need to be the same. Accordingly, the study area was expanded to Fisherman's Park to consider the Eagle Run Drive dike reach.

Based on discussions with the District, it was assumed that if Option A or Option B is selected as the preferred option in the Siyich'em reach, the logical future upgrading north of the Siyich'em Reserve would involve raising the existing dike along Eagle Run Drive. This is presented as a new option, named ERD for convenience.

Figure 4-1 presents the high-level conceptual alignments for all of the shortlisted options.

The figure shows how Option A and Option B would be linked with ERD, while Option C is a standalone option. Option C would negate the need for future upgrading of the existing dike along Eagle Run Drive. This has potential infrastructure and community advantages which are discussed in this section.

The only shortlisted option in the Eagle Viewing Area (Land-Side Raise) is named EVA for convenience in links with any of Option A + ERD, Option B + ERD, or Option C to complete the study area.

The conceptual design options are described by reach in the following sub-sections.

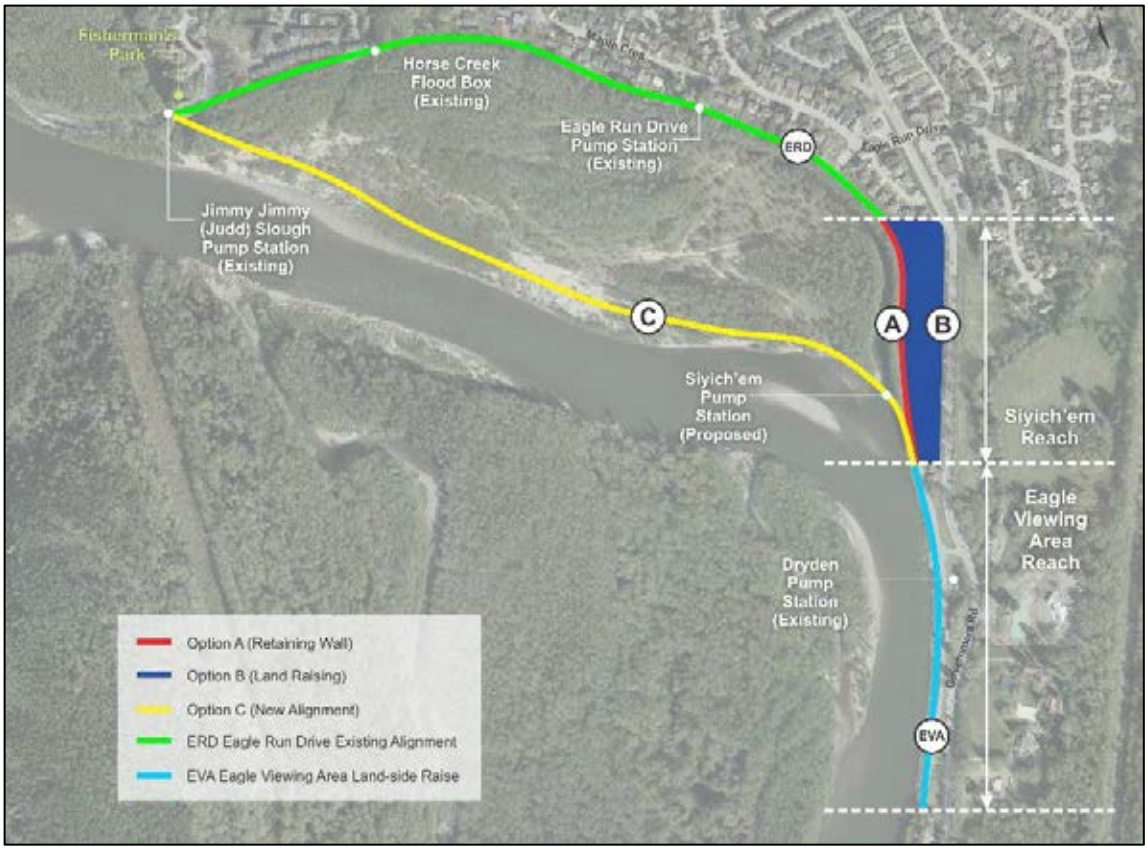


Figure 4-1: Conceptual Alignments of Shortlisted Options

4.2 Conceptual Design Criteria and Geotechnical Analysis

The relevant guidelines referenced in Section 2.7 were considering in identifying the following design criteria which were used to develop conceptual designs for the shortlisted options:

- Crest elevation based on the 500-year return period (0.2% annual exceedance probability) Squamish River flood level including climate change allowances plus 0.6 m freeboard. The flood level was extracted from the Squamish River hydraulic modelling results from the IFHMP and are presented on Figure 1-2.
- Minimum 6 m width for dike crest as referenced in the IFHMP.
- Maximum 3H:1V slope for dike fill land-side slopes (except where retaining walls are used).
- Maximum 2H:1V slope for bank protection dike water-side slopes.
- Adequate factors of safety for geotechnical stability (discussed further below) considering:
    - Static (flood condition) stability.
    - Seepage and internal erosion (piping).
    - Seismic (non-flood condition) stability.
- Bank protection up to the dike crest as referenced in the IFHMP.

- Dike toe scour protection (e.g., self-launching riprap toe).
- Dike access criteria including:
    - Access ramps spaced at a maximum of 2 km.
    - Turnouts provided every 300 m to 500 m (unless an access ramp is provided in between).
- Preferred land tenure in favour local diking authority (as discussed in the following sections, this may not be achievable for Option A and Option B which maintain the existing alignment through Siyich'em Reserve).

Geotechnical Analysis and Design Input

Thurber conducted geotechnical analysis focusing on static stability, seepage, and seismic performance to support input into the conceptual design of the shortlisted options. The DMP focuses on conceptual design and generally does not involve analysis to support detailed design. However, a geotechnical field investigation and high-level numerical analysis calculations were included in the scope of the project to indicate whether and to what extent seepage control and ground improvement measures for seismic performance would need to be incorporated into the conceptual design. These components can have a significant impact on the overall cost of flood protection upgrading and were assumed to be required based on previous experience on Squamish River dikes.

The geotechnical field investigation, which involved drilling on the dike, was conducted before the original study area was expanded and no geotechnical information was collected upstream of Siyich'em Reserve. Thurber was able to expand their numerical analysis to provide some commentary for the expanded area, as presented in their report, but the uncertainty of results is higher due to a lack of site-specific data. Thurber assumed that the ground conditions on the new alignment could be represented by the ground conditions along the drilled locations. This is an untested assumption that adds uncertainty.

The geotechnical analysis and design input are documented in a Thurber report provided in Appendix F. The design input was incorporated into the conceptual design of the shortlisted options and is discussed reach-by-reach in the following sub-sections.

4.3 Conceptual Design and Feasibility Considerations by Reach

In this section, the conceptual design of shortlisted options and related feasibility considerations are described by reach.

For each shortlisted option, the following items are provided:

- general description of option and design components;
- conceptual alignment (previously provided in Figure 4-1);
- typical cross-section;
- discussion of compatibility of option with respect to the District and Nation common interests presented in Section 3.1; and
- discussion of technical and administrative feasibility considerations.

Class D cost estimates are provided in the following section.

Discussion of community engagement activities is provided in Section 5.

Eagle Run Drive Reach

As described in Figure 4-1, the Eagle Run Drive reach extends from Fisherman's Park to the northern boundary of the Siyich'em Reserve.

There are two shortlisted options in this reach:

- ERD – Raising the existing Eagle Run Drive dike on its existing alignment; and
- Option C – Constructing a new dike from the southern portion of the Siyich'em Reserve to Fisherman's Park.

ERD Option

As previously discussed, the ERD option was added to the project when the original study area was expanded to Fisherman's Park triggered by the identification and shortlisting of Option C. Accordingly, the ERD option would be likely implemented in this reach if Option A or Option B is selected in the Siyich'em reach. The ERD option would involve raising the existing dike along Eagle Run Drive by 1 m to 1.5 m and using a retaining wall on the land-side edge of the 6 m wide dike crest to minimize the dike footprint to minimize encroachment onto private properties located along Eagle Run Drive.

Refer to Figure 4-1 for the conceptual alignment and to Figure 4-2 for a typical cross-section.

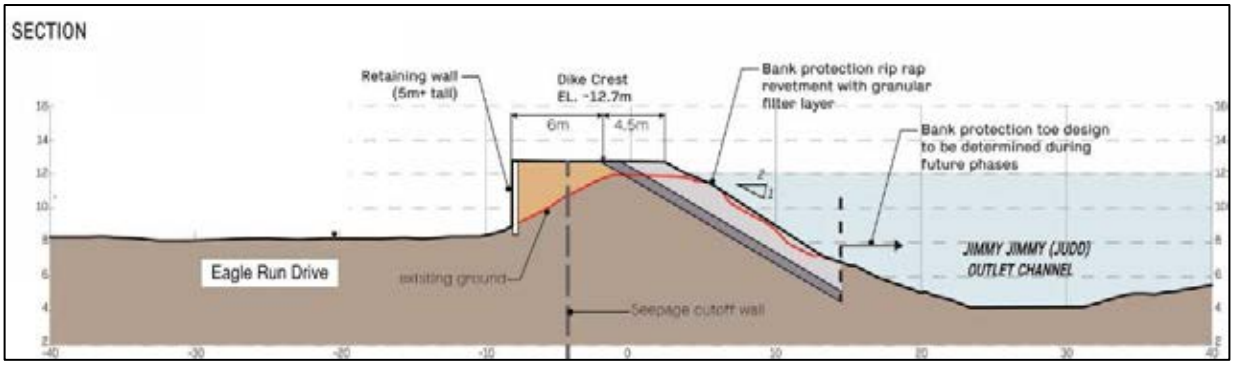


Figure 4-2: Eagle Run Drive Existing Dike Upgrade (ERD) Typical Cross-section

The water-side slope of the dike would be surfaced with a 2H:1V slope riprap revetment with toe landing near or into Jimmy Jimmy (Judd) Slough. Accordingly, the construction may involve instream works in Jimmy Jimmy (Judd) Slough to enable dike construction and to restore the channel following dike construction. As described in the geotechnical report provided in Appendix F, a 16 m tall seepage cutoff wall would be incorporated into the dike. For efficiency, this could likely be combined with the land-side edge retaining wall as a single steel sheetpile wall. Additionally, ground improvement works involving a 7 m wide and 4.5 m deep zone of ground improvements (soil mixing panels) would be required along the water-side edge of the dike to achieve provincial seismic performance criteria.

Three existing drainage structures (Judd Slough pump station, Horse Creek floodbox, and Eagle Run Drive pump station) are located along the ERD option and would need to be upgraded in the future, either directly as part of the dike upgrading project or in a phased approach.

The ERD option was assessed with respect to the common interests described in Section 3.1. Findings are summarized in Table 4-1.

Table 4-1: ERD Option Compatibility with District and Nation Common Interests

Common Interest	ERD
Address Public Safety	• Provides flood protection that meets the intent of the Squamish Integrated Flood Hazard Management Plan. • Avoids transfer of flood risk. • No change to internal floodway capacity behind the dike.
Recapture Squamish Nation Land and Enable Beneficial Use	• No land recapture is achieved.
Optimize Project Costs	• Refer to Class D construction cost estimates for capital cost (Section 4.4). • Operation and maintenance includes two pump stations and 3 floodboxes along Eagle Run Drive.
Minimize Impacts to Environmental Habitat	• Jimmy Jimmy (Judd) Slough habitat will be disturbed during rip rap construction and ground improvements. • Some tree removal during dike raising and rip rap refurbishment. • Pump stations & floodboxes can be re-built to be "fish-friendly". • Public access will be low, similar to existing.
Address Immediate Flood Risk while Enabling Long-term Approaches	• Compatible with potential future approaches to realign Squamish River main channel to historic alignment.
Acknowledge Site History and Culture	• No major change – landscaping would provide potential to reflect site history and culture.
Enable Future Collaboration on Access Issues	• District already has a right-of-way over the ERD dike which may need to be expanded. • Public trail connectivity is broken through Siyích'em Reserve.

ERD was also assessed with respect to technical and administrative feasibility considerations. Findings are summarized in Table 4-2.

Table 4-2: Technical and administrative feasibility summary for ERD

Feasibility Topic	ERD Impact
Construction Impacts to Residents/Stakeholders	• Disturbance to Eagle Run Drive residents includes backyard / landscaping impacts and potential for vibration near structures.
Constructability & Phasing	• ERD involves challenging construction conditions along existing dike due to existing structures and Jimmy Jimmy (Judd) Slough. • Complex ground improvement works near Jimmy Jimmy (Judd) Slough. • Better suited to phasing of upgrades, as this involves improvement of an existing dike.
Environmental Permitting	• Water Sustainability Act – routine, moderately complex. • Fisheries Act – routine, moderately complex; will require habitat compensation. • Species at Risk Act – potentially complex permit for Pacific water shrew and Roell's brothella. However, this option does not directly intersect with critical habitat.
Dike Maintenance Act Permitting	• Some challenges expected on right-of-way and seismic performance issues.
Hydraulics & geomorphology	• No significant impact on Squamish River hydraulics and geomorphology.
Geotechnical	• Ground improvements conceptual design was developed without site-specific drilling information which adds high uncertainty.
Operations & Maintenance	• Operation and maintenance includes two pump stations and 3 floodboxes along Eagle Run Drive. • Bank protection is setback from the Squamish River requiring less maintenance.

Option C

This option involves constructing a dike on a new alignment heading north-west from Siyich'em Reserve along and set back from the active Squamish River bank and connecting to the existing dike at Fisherman's Park. This approach would enable the Squamish Nation to recapture historic reserve land and unceded land which was eroded and then rebuilt through deposition over several decades.

The Option C alignment features are presented in Figure 4-3.

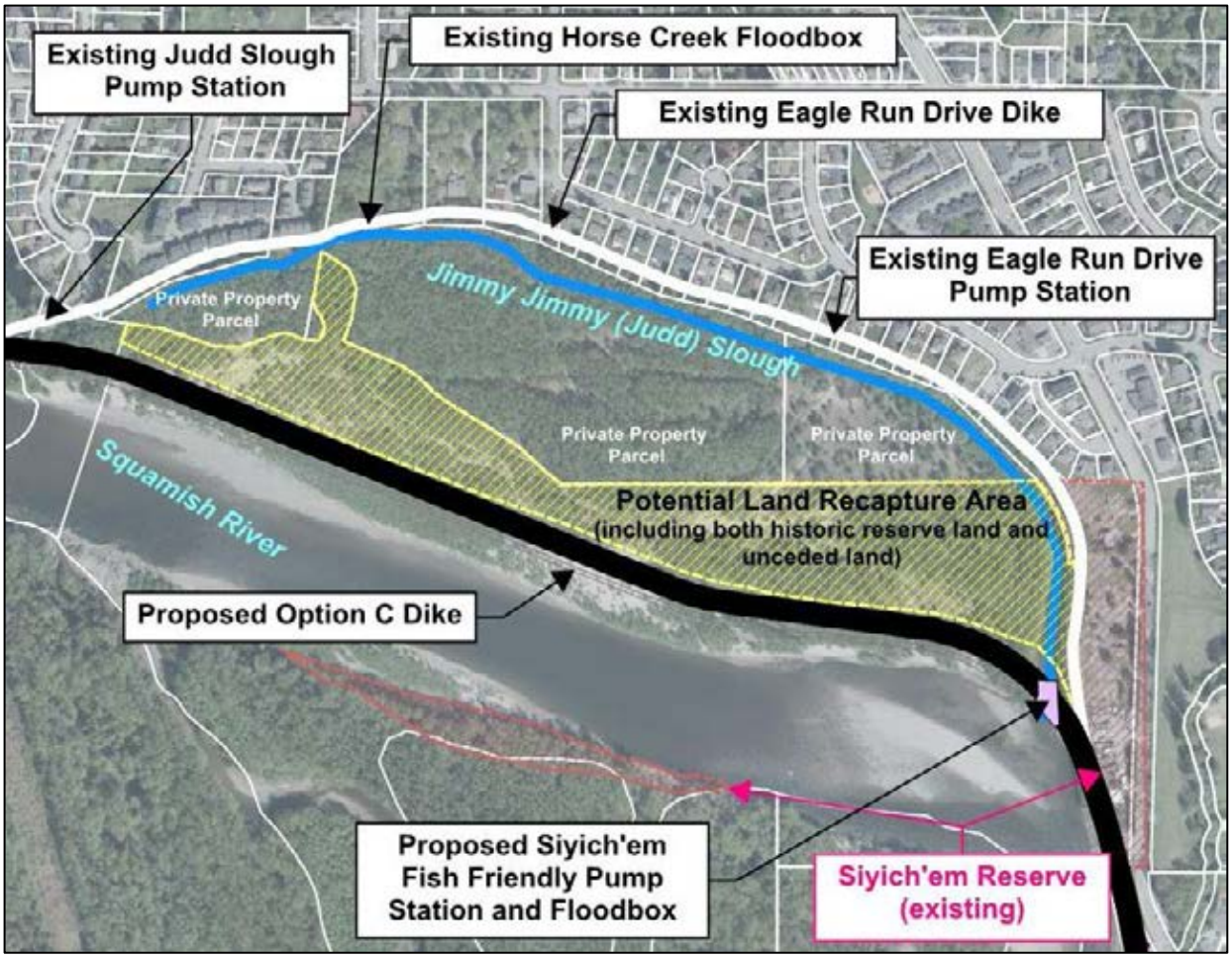


Figure 4-3: Option C Alignment and Features (not to scale)

The Option C dike would newly protect all of the land between the Option C dike and the existing Eagle Run Drive dike. These lands are a mixture of private land parcels based on historic land surveys and Crown land. At the same time, these lands are also part of the unceded traditional territory of the Squamish Nation.

It is understood that there are legal and administrative tools for the Squamish Nation to recapture land to add to the Siyich'em Reserve. These legal and administrative processes are outside the scope of this project. Figure 4-3 shows a polygon of land labelled as "Potential Land Recapture Area"; however, this presented polygon is for discussion purposes only. The polygon includes all land between the existing dike and the proposed Option C alignment, with the exception of private property parcels.

The area of the potential land recapture polygon is approximately 9.8 hectares which represents approximately 36% of the historic Siyich'em Reserve size and more than 245% of the current Siyich'em Reserve size. The DMP does not contemplate or prescribe any future land uses for the potential recaptured land which would be under the Nation's discretion for the beneficial use of the Squamish Nation.

Option C also provides significant opportunity for the resolution of dike land tenure and access issues. This approach minimizes dike footprint within the existing Siyich'em Reserve boundary; however, the existing restaurant building structure on reserve which is attached to the dike would need to be removed. The new alignment provides the opportunity for the District and Nation to start discussions on whether the new dike would be located on reserve land with an agreement to allow for District maintenance, or for the dike to be located on Crown land with a right-of-way for District maintenance, or other potential approaches.

Figure 4-4 provides a typical cross-section for Option C.

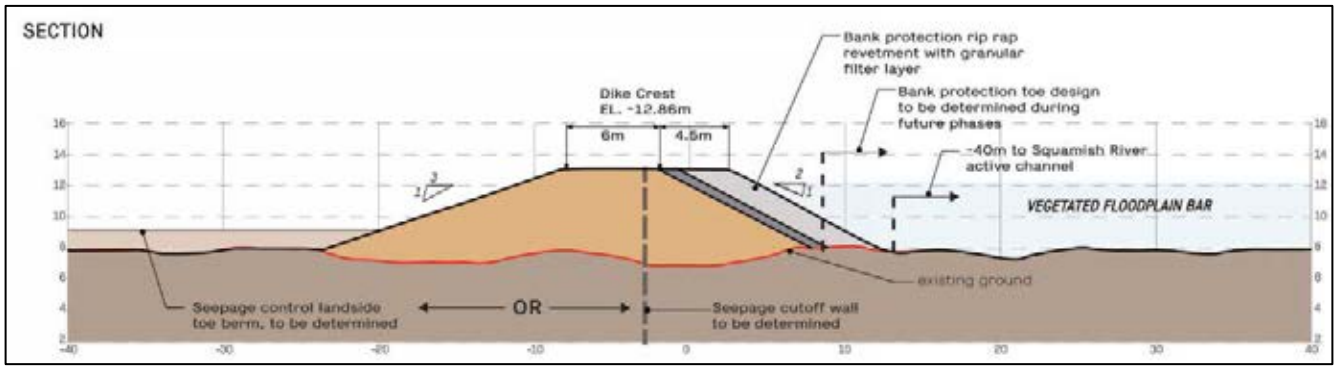


Figure 4-4: Option C Typical Cross-section

The conceptual design involves a 3H:1V land-side slope, a 6 m wide dike crest, and a riprap revetment for bank protection sloped at 2H:1V. For Option C, there are two alternatives to provide seepage control for dike stability. The first is a 16 m deep steel sheetpile seepage cutoff wall that could be embedded into the dike core; the second would involve a land-side toe berm which would extend 15 m from the land-side slope toe. The height of the land-side toe berm would be approximately 1.5 m. The latter approach is much more cost-effective. However, it would need to be coordinated with the Squamish Nation as it would extend into the potential reserve recapture land. This is not expected to a major obstacle as a variety of land uses could be accommodated on top of the land-side toe berm.

Option C also requires ground improvement works to achieve provincial seismic performance criteria. Within the Eagle Run Drive reach, the requirement is estimated to be the same as the ERD option, involving a 7 m wide and 4.5 m deep zone of ground improvements (soil mixing panels) would be required along the water-side edge of the dike. Along the portion of Option C in the Siyich'em reach (i.e. downstream end of Option C), the requirement is higher, involving two zones of ground improvement on either side of the dike. On the water-side, the zone of ground improvement is estimated to be 24 m wide

and 16 m deep. On the land-side, the zone is estimated to be 10 m wide and 6.5 m deep. Additional information is provided in the geotechnical report by Thurber in Appendix F.

As the Option C alignment encroaches into the Squamish River primary floodway, high-level hydraulic modelling was conducted using the existing Squamish River 1-dimensional hydraulic model to investigate the potential for Option C to transfer flood risk. The analysis focused on the design flood event (500-year return period / 0.2% annual exceedance probability Squamish River flood with climate change allowances as per the IFHMP).

The investigation revealed that the Option C alignment could result in:

- a maximum 0.3 m water level rise along the Option C dike alignment;
- a maximum 0.3 m water level rise extending to 500 m upstream of Fisherman's Park; and
- a maximum 0.1 m water level extending further upstream and gradually reducing to zero approximately 2 km upstream of Fisherman's Park.

The hydraulic modelling analysis results are uncertain due to the complexity of the river channel and side channels. The uncertainty can be reduced through a 2-dimensional hydraulic modelling analysis.

These impacts are considered manageable as part of the District's ongoing dike upgrading program and do not represent an insurmountable feasibility issue.

In addition to upstream dike upgrading, it would be important to review the impact of the new alignment on dike breach and internal floodway hydraulics which influence flood construction levels as guided by the IFHMP.

The new dike alignment would partially disconnect a large, forested island from the Squamish River. Partial connection could be maintained via a fish-friendly pump station at the outlet of Jimmy Jimmy (Judd) Slough. The dike alignment would be set back from the active river channel by 30 m or more, except for the connection points at Fisherman's Park and at the existing dike near the south edge of Siyich'em Reserve.

Additional future work is required to better understand the impact of the partial disconnection on environmental habitat. Specifically, 2-dimensional hydraulic modelling and/or potentially physical modelling would help quantify the frequency that the forested island is inundated under current conditions. The frequency of inundation that would be disrupted by Option C can be used to quantify the aquatic habitat value of the island.

As part of engagement on the shortlisted options (refer to Section 5), Fisheries and Oceans Canada (DFO) provided written feedback (refer to letter in Appendix H) highlighting concerns around habitat impacts related to the partial disconnection and the need for additional work to quantify the impact.

Future work can also provide additional commentary on the potential for Option C to impact Squamish River fluvial geomorphology. Option C appears to be highly compatible with the Squamish Nation supported concept to realign the Squamish River to its historic channel alignment. Additional hydraulic and fluvial geomorphology studies could improve the understanding of how the Squamish River would respond to Option C, including potential erosion and deposition transfer of risk and how Option C could be linked with a potential future river realignment concept.

As Option C would replace the existing dike along Eagle Run Drive, the option provides the opportunity to replace the existing 3 drainage structures along Eagle Run Drive with one new fish-friendly pump station and floodbox at the outlet of Jimmy Jimmy (Judd) Slough.

Option C was assessed with respect to the District and Nation common interests presented in Section 3.1. Findings are summarized in Table 4-3.

Table 4-3: Option C Compatibility with District and Nation Common Interests

Common Interest	Option C
Address Public Safety	• Provides flood protection that meets the intent of the Squamish Integrated Flood Hazard Management Plan. • Minor flood risk transfer upstream can be managed through on-going dike upgrading program and future upgrades to flood construction level policies. Additional 2-dimensional hydraulic modelling analysis can reduce uncertainty.
Recapture Squamish Nation Land and Enable Beneficial Use	• Significant opportunity to address Siyich'em Reserve loss of land. • Compatible with potential Government Road realignment.
Optimize Project Costs	• Refer to Class D construction cost estimates for capital cost (Section 4.4). • O&M includes 1 new fish-friendly pump station floodbox at the outlet of Jimmy Jimmy (Judd) Slough. • Bank protection maintenance would be higher than ERD option due to higher exposure to Squamish River.
Minimize Impacts to Environmental Habitat	• Lower Jimmy Jimmy (Judd) Slough habitat will be disturbed considerably at south end for dike crossing & pump station. Ecological conditions in Jimmy Jimmy (Judd) Slough and on the large, forested island will be altered by construction of a new dike. Additional work is required to better understand the habitat impacts. • Considerable tree removal on the large, forested island, but most existing trees along dike would not be impacted. • New pump station & floodbox will be "fish-friendly".
Address Immediate Flood Risk while Enabling Long-term Approaches	• Highly compatible with potential future approaches to realign Squamish River main channel to historic alignment.
Acknowledge Site History and Culture	• Land recapture provides more significant opportunities to reflect site history and culture.
Enable Future Collaboration on Access Issues	• Opportunity for District of Squamish to establish a formal right-of-way for dike maintenance. • Significant opportunity for District and Nation to discuss potential for trail connectivity from Eagle Viewing Area to Fisherman's Park on new dike crest.

Option C was also assessed with respect to technical and administrative feasibility considerations. Findings are summarized in Table 4-4.

Table 4-4: Technical Feasibility Summary for Option C

Feasibility Topic	Option C
Construction Impacts to Residents/Stakeholders	• Less disturbance to Siyich'em Reserve during construction than Option A and Option B, though existing restaurant would be impacted. • No disturbance to Eagle Run Drive residents due to nearby works.
Constructability & Phasing	• Challenging construction where footprint is near active river channel. • Ground improvement implementation is routine (more space than ERD). • Bank protection works are routine. • Least suited to phasing, as this is a new dike.
Environmental Permitting	• Water Sustainability Act – complex; substantial change from existing conditions. During a WSA Change Approval, changes to water use, impacts to habitat, and impacts to provincially listed species at risk may be considered. • Fisheries Act – complex; will require considerable habitat compensation. Subject to uncertainty related to habitat value of vegetated island in the Squamish River that would be partially disconnected from the river. Refer to engagement response letter provided by DFO in Appendix H. • Species at Risk Act – potentially complex permit for Pacific water shrew. However, this option does not directly intersect with critical habitat.
Dike Maintenance Act Permitting	• Major challenges expected on justifying potential floodplain impacts, potential flood risk transfer and seismic performance issues.
Hydraulics & Geomorphology	• Results in an increase in water levels which can be managed through dike upgrading program. Additional work required to better understand impacts to dike breach and internal floodway hydraulics which influence flood construction levels. • May result in scour and other morphologic changes. • Potential increase in risk of river blockage, debris jam, and ice jam concerns due to less space. Potential debris issue downstream if side channel widens. High uncertainty – requires future analysis to assess feasibility issues (2-D modelling, etc.) • Encroaching on the Squamish River primary floodway is not in line with global river engineering and floodplain management best practices of providing more room for river floods and geomorphic processes.
Geotechnical	• Ground improvements conceptual design was developed without site-specific drilling information which adds high uncertainty.
Operation & Maintenance	• Fewer pump stations and floodboxes to maintain than ERD. • More significant bank protection close to Squamish River active channel to maintain. Higher inspection effort required (visual, bathymetric, etc.) • River changes may require additional bank protection along the Squamish River if the setback between the Option C dike and the Squamish River natural bank is reduced over time in the future.

Siyich'em Reach

As described in Figure 4-1, the Siyich'em reach is located between the Eagle Run Drive reach and the Eagle Viewing Area reach.

There are three shortlisted options in this reach:

1. Option A (dike raise with retaining wall on Siyich'em);
2. Option B (raising the land on Siyich'em Reserve); and
3. Option C (a new dike alignment from the southern portion of Siyich'em Reserve to Fisherman's Park).

Option C was previously described as part of the Eagle Run Drive reach and the following focuses only on Option A and Option B.

Option A

This combination involves raising the existing dike through Siyich'em Reserve by approximately 1.5 m while limiting the dike footprint to the existing footprint by using retaining walls to contain the raised dike.

Option A would result in a total retaining wall height will be 5 m or more and the wall would disrupt views for existing structures on the Reserve. This approach aims to prevent any further dike encroachment onto Siyich'em land; however, the existing restaurant building structure on Reserve which is attached to the dike would need to be removed.

Provincial dike design guidelines discourage structures within 7.5 m of the dike toe and therefore following the guidelines would suggest not reconstructing the structure as-is. However, it is important to note that the existing dike and the upgrade under Option A would still be on the Reserve and outside of provincial Dike Maintenance Act jurisdiction.

A typical cross-section is provided in Figure 4-5.

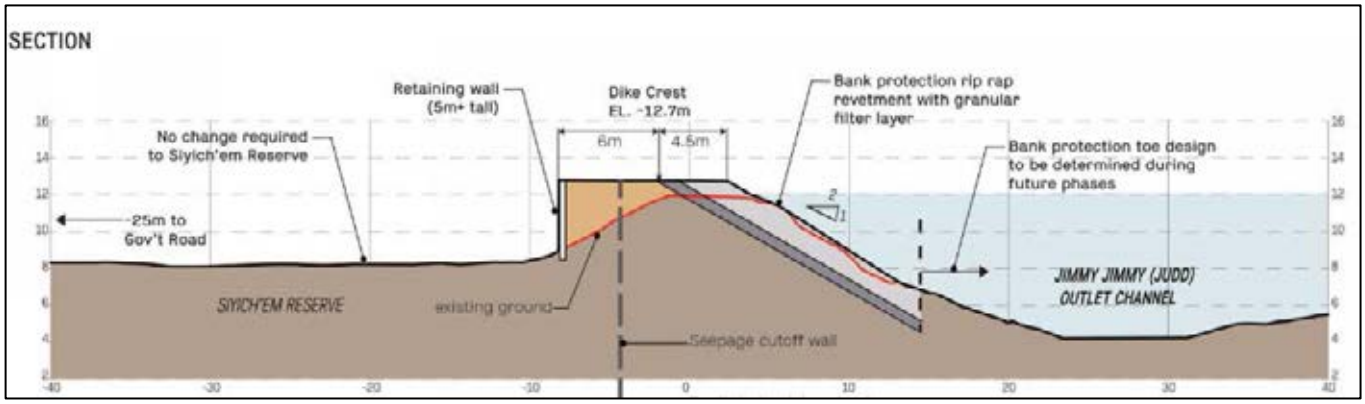


Figure 4-5: Option A Typical Cross-section

In the Siyich'em Reserve area, a 16 m deep steel sheetpile cutoff wall would be incorporated into the dike for seepage control, with the exposed portion acting as a retaining wall. The seepage cutoff wall can be combined with the land-side retaining wall.

Ground improvement works are also required for Option A to achieve provincial seismic performance criteria. As per the geotechnical report by Thurber (Appendix F), a zone of ground improvement approximately 24 m wide and 18 m deep would be required along the water-side edge of the alignment.

Existing riprap bank protection may require upgrades, which would involve limited work in Jimmy Jimmy (Judd) Slough, and the Squamish River, to provide adequate protection against river scour. Based on Thurber's analysis, ground improvement measures would likely be required to improve seismic performance of the proposed dike upgrade.

Land tenure for dike maintenance (e.g., a right-of-way) does not currently exist along the Siyich'em Reserve and the preferred right-of-way width, including extending 7.5 m from the dike toe, would not be possible given the location of existing structures on Siyich'em.

Option A was assessed with respect to the District and Nation common interests presented in Section 3.1. Findings are summarized in Table 4-5.

Table 4-5: Option A Compatibility with District and Nation Common Interests

Common Interest	Option A
Address Public Safety	• Provides flood protection that meets the intent of the Squamish Integrated Flood Hazard Management Plan. • Avoids transfer of flood risk.
Recapture Squamish Nation Land and Enable Beneficial Use	• No land recapture is achieved. • No further encroachment onto Siyich'em, but the proposed retaining wall will be an imposing dike structure which will further disrupt views and space around structures. • Compatible with potential Government Road realignment.
Optimize Project Costs	• Refer to Class D construction cost estimates for capital cost (Section 4.4). • Bank protection is sheltered through lower Jimmy Jimmy (Judd) Slough, so maintenance should be lower than for Option C.
Minimize Impacts to Environmental Habitat	• Full reach of lower Jimmy Jimmy (Judd) Slough habitat will be disturbed during rip rap construction and ground improvements. • Some tree removal during dike raising and rip rap refurbishment.
Address Immediate Flood Risk while Enabling Long-term Approaches	• Compatible with potential future approaches to realign Squamish River main channel to historic alignment.
Acknowledge Site History and Culture	• No major change.
Enable Future Collaboration on Access Issues	• No improvement to existing access issues, due to dike trespassing through Siyich'em Reserve. • Public trail connectivity is broken through Siyích'em Reserve.

Option A was also assessed with respect to technical and administrative feasibility. Findings are summarized in Table 4-6.

Table 4-6: Technical Feasibility Summary for Option A

Feasibility Topic	Option A
Construction Impacts to Residents/Stakeholders	• Some disturbance to Siyich'em Reserve during construction including impacts to the existing restaurant.
Constructability & Phasing	• Option A involves challenging construction conditions along Siyich'em due to existing structures • Challenging ground improvement and bank protection works construction. • Better suited to phasing of upgrades, as this involves improvement of an existing dike.
Environmental Permitting	• Water Sustainability Act – routine, moderately complex. • Fisheries Act – routine, moderately complex; will require habitat compensation. • Species at Risk Act – potentially complex permit for Pacific water shrew. However, this option does not directly intersect with critical habitat.
Dike Maintenance Act Permitting	• Some challenges expected on right-of-way and seismic performance issues.
Hydraulics & geomorphology	• No significant impact on river hydraulics and geomorphology.
Geotechnical	• No major issues.
Operations & Maintenance	• Lack of land tenure for dike maintenance. • ERD extension has more pump stations and floodboxes to maintain than Option C • Less bank protection close to Squamish River active channel to maintain than Option C

Option B

This option involves raising as much of the Siyich'em Reserve as is practical to the design dike crest elevation. The raised land would slope down gradually, or through the use of retaining walls, to meet Government Road. This approach would require removal and replacement of all existing structures and services on the Reserve, resulting in short-term disruption; however, this may benefit the Reserve in the long-term as the replacement structures (and future development) would be significantly more protected from seasonal seepage issues and afforded a better vantage over the river.

A typical cross-section is provided in Figure 4-6.

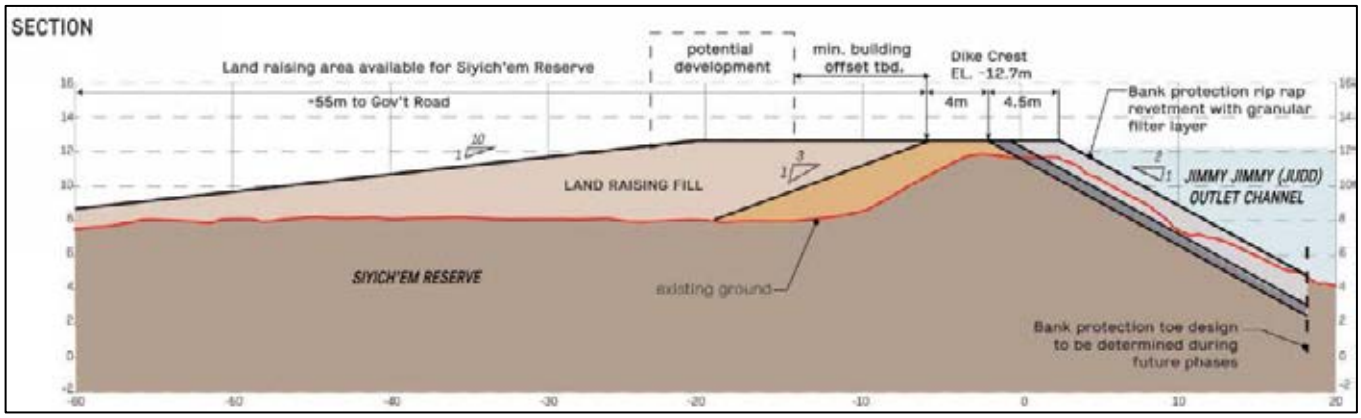


Figure 4-6: Option B Typical Cross-section

The land raising would negate the need for a deep cutoff wall within the dike for seepage control, as structures would be raised to high enough elevations to avoid seepage.

Under this approach, the entire raised land area would serve as flood protection. However, for regulatory purposes, the dike could be defined as only the portion of land raising above the existing dike. The conventional setback requirement, extending 7.5m from the dike toe, could be considered for relaxation given the area of raised land acting as part of the dike. However, it's important to note that existing dike maintenance land tenure issues would not be resolved under this option.

Existing riprap bank protection may require upgrades, which would involve limited work in Jimmy Jimmy (Judd) Slough, and the Squamish River, to provide adequate protection against river scour. Based on Thurber's analysis, ground improvement measures would likely be required to improve seismic performance of the proposed dike upgrade. It is estimated that the ground improvements would be implemented on a 24 m wide and 18 m zone along the water-side edge of the dike.

Option B was assessed with respect to the District and Nation common interests presented in Section 3.1. Findings are summarized in Table 4-7.

Table 4-7: Option B Compatibility with District and Nation Common Interests

Common Interest	Option B
Address Public Safety	• Provides flood protection that meets the intent of the Squamish Integrated Flood Hazard Management Plan. • Avoids transfer of flood risk.
Recapture Squamish Nation Land and Enable Beneficial Use	• No land recapture is achieved. • Temporary but significant disruption of beneficial use during construction, over a longer window than for Option A. • Dike remains on Siyich'em Reserve, but is at grade, improving long-term beneficial use of dike. • Compatible with potential Government Road realignment.
Optimize Project Costs	• Refer to Class D construction cost estimates for capital cost (Section 4.4).
Minimize Impacts to Environmental Habitat	• Full reach of lower Jimmy Jimmy (Judd) Slough habitat will be disturbed during rip rap construction and ground improvements. • Same tree removal as A, plus removal of all trees on Siyich'em Reserve.
Address Immediate Flood Risk while Enabling Long-term Approaches	• Compatible with potential future approaches to realign Squamish River main channel to historic alignment.
Acknowledge Site History and Culture	• No major change.
Enable Future Collaboration on Access Issues	• No improvement to existing access issues, due to dike trespassing through Siyich'em Reserve. • Public trail connectivity is broken through Siyích'em Reserve.

Option B was also assessed with respect to the technical and administrative feasibility. Findings are summarized in Table 4-8.

Table 4-8: Technical Feasibility Summary for Option B

Feasibility Topic	Option B
Construction Impacts to Residents/Stakeholders	• All Siyich'em Reserve occupants are displaced during construction & homes/structures are re-built. • Disturbance to Eagle Run Drive residents includes garden impacts, vibration near structures. • Requires more fill placement than Option A, so higher traffic volumes.
Constructability & Phasing	• Option B is less challenging than Option A due to removal of structures for land raising. • Ground improvements and bank protection works will be challenging. • Potentially suited to phasing with development of Siyich'em Reserve.
Seepage Control	• Provides minimal seepage control during flooding events, compared with status quo; however, structures are raised so would not be impacted.
Environmental Permitting	• Water Sustainability Act – routine, moderately complex. • Fisheries Act – routine, moderately complex; will require habitat compensation. • Species at Risk Act – potentially complex permit for Pacific water shrew. However, this option does not directly intersect with critical habitat.
Dike Maintenance Act Permitting	• Some challenges expected on right-of-way and seismic performance issues.
Hydraulics & Geomorphology	• No significant impact on river hydraulics and geomorphology.
Operation & Maintenance	• Lack of land tenure for dike maintenance. • ERD extension has more pump stations and floodboxes to maintain than Option C • Less bank protection close to Squamish River active channel to maintain than Option C

Eagle Viewing Area Reach

The Eagle Viewing Area reach is located south of the Siyich'em Reserve as shown on Figure 4-1.

Eagle Viewing Area (EVA) Land-side Raise

The only shortlisted option in this reach involves raising the existing dike crest by approximately 1.5 m between Siyich'em Reserve and the north boundary of Kowtain I.R. No. 17.

A typical cross-section is provided in Figure 4-7.

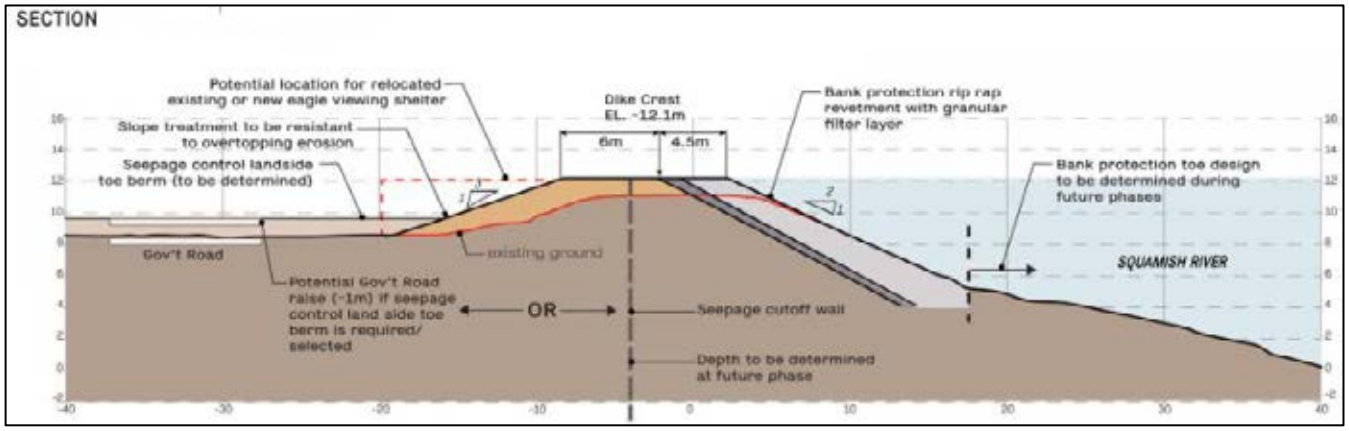


Figure 4-7: Eagle Viewing Area Land-side Dike Raise Typical Cross-section

In general, the dike footprint would be expanded towards the land (east) with a vegetated slope at a gradient of 3 horizontal to 1 vertical. Retaining walls would be used to limit the footprint in areas with limited space due to existing infrastructure and/or structures. Existing riprap bank protection may need to be upgraded which would involve work in the Squamish River to provide adequate protection against river scour.

Seepage control would be provided using either an internal, deep seepage cut-off wall or a land-side toe berm (approximately 15 m wide, 1.5 m thick), depending on whether space is available in given sections of the reach. Government Road could also be partially raised to accommodate the land-side toe berm, if cost effective.

Based on analysis by Thurber (Appendix F), ground improvement measures may be required to improve seismic performance of the proposed dike upgrade. It is estimated that one zone of ground improvement (14 m wide and 9 m deep) along the water-side edge of the dike would be required.

Existing eagle viewing facilities (shelter, interpretative signage, etc.) and benches would be removed and replaced/upgraded.

Dryden Creek pump station would likely need to be replaced at time of dike upgrading.

The Eagle Viewing Area land-side dike raise was assessed with respect to the District and Nation common interests presented in Section 3.1. Findings are summarized in Table 4-9.

Table 4-9: Eagle Viewing Area Land-side Raise Compatibility with District and Nation Common Interests

Project Value	Eagle Viewing Area Reach Impact
Address Public Safety	• Provides flood protection that meets the intent of the Squamish Integrated Flood Hazard Management Plan. • Avoids transfer of flood risk.
Recapture Squamish Nation Land and Enable Beneficial Use	• This reach does not impact Squamish Nation Land, as it is south of Siyich'em Reserve.
Optimize Project Costs	• Refer to Class D construction cost estimates for capital cost (Section 4.4). • O&M includes 1 pump station and 1 floodbox at Dryden Creek. • Rip rap maintenance would be higher than Siyich'em Reach due to direct river exposure.
Minimize Impacts to Environmental Habitat	• Some tree removal during dike raising and rip rap refurbishment. • Pump station & floodbox will be re-built "fish-friendly". • Improved access will increase human presence in the area.
Address Immediate Flood Risk while Enabling Long-term Approaches	• Compatible with long-term river realignment concept.
Acknowledge Site History and Culture	• Potential for educational signage describing site history.
Enable Future Collaboration on Access Issues	• Opportunity for District of Squamish to establish a formal right-of-way for dike maintenance across existing private property.

The Eagle Viewing Area land-side dike raise option was also assessed with respect to technical and administrative feasibility. Findings are summarized in Table 4-10.

Table 4-10: Technical Feasibility Summary for Eagle Viewing Area Reach

Technical Feasibility Topic	Eagle Viewing Area Reach Commentary
Construction Impacts to Residents/Stakeholders	• Impacts private property at 40813 Government Road during construction.
Constructability & Phasing	• Ground improvements in vicinity of existing development are relatively challenging. • Bank protection works are more challenging given direct exposure to the Squamish River. • Possible to upgrade dike incrementally, for example, immediate dike raising followed by future rip rap upgrades.
Environmental Permitting	• Water Sustainability Act – routine, moderately complex. • Fisheries Act – routine, moderately complex; will require habitat compensation. • Species at Risk Act – potentially complex permit for Pacific water shrew. Proposed alignment overlaps with shrew critical habitat.
Dike Maintenance Act Permitting	• Some challenges expected on right-of-way and seismic performance issues.
Hydraulics & Geomorphology	• Limited impact on river hydraulics and geomorphology.
Geotechnical	• Dike reach has limited drilling data; local heterogeneity may impact ground improvement requirements.
Operation & Maintenance	• One pump station and floodbox to maintain at Dryden Creek. • Significant bank protection close to Squamish River active channel to maintain. Higher inspection effort required (visual, bathymetric, etc.).

4.4 Construction Cost Estimates

Class D cost estimates have been prepared for each option. The complete cost estimates are presented in Appendix G. This sub-section describes the cost estimating approach and limitations, and presents a comparison of the cost estimates to support option evaluation.

Approach and Limitations

Class D construction cost estimates have been prepared with limited site information, such as geotechnical investigations and area drainage plans, and as such indicates the approximate magnitude of the cost of the capital tasks, for project planning purposes only. The estimate has been derived from unit costs for similar projects.

The cost estimates include the following components:

- general items (mobilization, demobilization, bonding, etc.);
- site preparation;
- ground improvement for seismic performance;
- dike construction;
- utilities (including drainage structure upgrades);
- restoration, finishes, and amenities; and
- allowances and contingences (including professional services, habitat impact compensation, and construction risk contingencies).

Approach and limitations for major items are discussed below.

Ground Improvement for Seismic Performance

Based on the geotechnical report (Appendix F) reflecting Thurber's analysis, the following levels of ground improvement were applied in the cost estimate.

- Option A – 430 m^3/m.
- Option B – 430 m^3/m.
- Option C – 113 m^3/m.
- Eagle Run Drive – 30 m^3/m.
- Eagle Viewing Area – 130 m^3/m.

Based on input from Thurber, ground improvement was estimated at a unit rate of \$50/m^3.

Dike Construction

Dike fill for the conceptual design and cost estimate was assessed based on adding dike fill to the existing ground profile based on the typical cross-sections presented in this section. Fill was also allotted for access ramps and turnarounds along the dike, as per the BC Dike Design & Construction Guidelines (refer to Section 2.7).

Rip rap upgrades to a 2 m thick layer were assumed along the water-side of the dike. Additional rip rap installation volumes were allotted to provide a self-launching toe, which would provide erosion protection in the case of river deepening. Land-side dike finishing included an allowance for hydroseeding, where applicable. The granular crest surface pathway includes railings in areas where retaining walls are present.

Utilities

Option C and Eagle Run Drive both impact flood infrastructure related to Jimmy Jimmy (Judd) Slough. For Option C, a fish-friendly pump station and floodbox is proposed at the south end of the reach, to replace all existing floodboxes/pump stations between Siyich'em Reserve and Fisherman's Park. For Eagle Run Drive, existing flood infrastructure in the dike includes: Horse Creek floodbox, Eagle Run pump station and floodbox, and Judd Slough pump station and floodbox. Replacement of these structures was costed assuming that Judd Slough and Horse Creek infrastructure would be fish-friendly. Required flow rates for the pump stations were assumed based on an assumed 0.018 m^3/s/ha design flow, including a climate change allowance. The assumed design flow input was based on previous KWL experience with Squamish pump stations.

Dryden Creek pump station and floodbox replacement would be required for compatibility with the proposed dike design in the Eagle Viewing Area reach. This cost was based on a 2012 cost estimate by KWL, adjusted for inflation and with a 30% premium for fish-friendly design.

All of the above flood infrastructure upgrades are considered at a conceptual level; drainage studies are necessary for more accurate assessment of projected upgrade costs.

In addition to drainage infrastructure, an allowance was included for new utility servicing to Siyich'em Reserve for Option B.

Restoration, Finishes & Amenities

For all options along Siyich'em Reserve, an allowance was included for removal and replacement of the existing restaurant on the Siyich'em Reserve as this structure is built directly on the existing dike and must be removed for any of the proposed options.

For Option A, a small allowance was included for landscaping restoration next to the new retaining wall.

For Option B, replacement of the single-family homes and mobile homes on Siyich'em Reserve was considered, including an 8-month residential displacement compensation for households.

For Option C, water access ramps were included for Squamish Nation beneficial use.

The Eagle Run Drive ERD option includes an allowance for restoration, landscaping, and trail furniture, while the Eagle Viewing Area includes a bare-minimum landscaping allowance and EagleWatch program shelter re-installation allowance.

Allowances and Contingencies

A 30% contingency was applied to cost estimates for Option A, Option B, and the Eagle Viewing Area cost estimates, as these are relatively conventional approaches & involve minimal access challenges. However, a 40% contingency was applied for Option C, due to challenging work near active Squamish river channel, and Eagle Run Drive, which are more challenging than A & B due to space limitations & more interface with private properties.

A 5% allowance for habitat enhancement as compensation for habitat impacts was incorporated into each option, with the exception of Option C which is expected to have a higher level of impacts and was accordingly assigned a 10% allowance.

Construction Cost Comparison of Shortlisted Options

Table 4-11 provides a comparison of the construction cost estimates. Full cost estimates for each option are provided in Appendix G.

The table is organized to provide a direct comparison of the distinct options for the full study area:

- Option A + ERD + EVA;
- Option B + ERD + EVA; and
- Option C + EVA.

Table 4-11: Summary of Class D Cost Estimate Findings for Entire Study Area

Components	Option A + ERD + EVA	Option B + ERD + EVA	Option C + EVA
Length	**2.5 km**		**2.2 km**
Siyich'em Reach Option A, B, or C cost	$ 28 M	$ 34 M	$ 74 M
ADD Eagle Run Drive Existing Alignment to Options A and B	$ 38 M		-
ADD Eagle Viewing Area Land-side Expansion Option all options	$ 40 M		
Total for Comparison ($ million)	$ 106 M	$ 113 M	$ 114 M

The comparison shows that dike upgrading construction cost is expected to be on the order of approximately $100 million within the study area, regardless of which distinct option is selected.

As revealed in detail in Appendix G, the key items contributing to magnitude of the cost estimates are ground improvements for seismic performance, bank protection, seepage control, and drainage structure upgrades.

There may be potential approaches to phase works to manage costs but it is not expected to change the cost comparison in support of option selection. Phasing concepts are discussed in Section 6 for the implementation of the preferred option.

While the difference between the lowest cost option (Option A + ERD + EVA) and the highest cost option (Option C + EVA) is $8 million, the general finding of the comparison is that cost is not a significant distinguishing factor for the option selection given the high amount of uncertainty involved the conceptual design and cost estimates. Interpreted another way, the comparison suggests that the preferred option selection should focus on other factors. This is discussed further in Section 5.

5. Engagement and Preferred Option Selection

This section provides a summary of the community engagement activities conducted on the conceptual design of the shortlisted options and documents the preferred option selection.

5.1 Engagement on Shortlisted Options

Section 1.5 provides an overview of the Squamish Nation and stakeholder engagement activities conducted in support of the DMP.

In addition to the project website launch and initial online survey on values and concerns for the study area, several engagement activities were conducted to get feedback on the shortlisted options.

These activities include:

- a meeting with Squamish Nation Siyich'em residents/families;
- a meeting with community and environmental groups;
- a meeting with private land-owners in the study area (outside of Siyich'em Reserve);
- correspondence with key regulatory stakeholders including Fisheries and Oceans Canada (DFO), BC Inspector of Dikes Office, and BC Parks; and
- a public open house hosted on December 5, 2019 at the Squamish Adventure Centre.

The public was also invited to respond to a second online survey requesting input on the shortlisted options.

Appendix H provides the key engagement materials and a summary of feedback from the targeted meetings, correspondence from regulators, and a summary of online survey results. The feedback from regulators (DFO, BC Inspector of Dikes Office, and BC Parks) includes questions and areas of uncertainty that need further clarification for the regulators to provide additional input. The project risk associated with the uncertainty was considered in the selection of the preferred option and the implementation plan (Section 6) includes next steps to address these items.

5.2 Preferred Option Selection

The preferred option for the DMP is **Option C + EVA**, as depicted in Figure 4-1, reproduced (with emphasis) to the right. The preferred option was identified through discussion between the Steering Committee members. The primary factor in selecting this option was the potential for Option C to address historic wrongs related to land tenure, loss of land via erosion, and dike trespass issues on Siyich'em Reserve, while still having a similar construction cost to the other options.

The preferred option was unanimously endorsed as the preferred option with next steps identified for advancing the option by both the District council and Nation council in February 2020. A copy of the District report to council is provided in Appendix I.

5.3 Refined Conceptual Design and Other Features

The conceptual design involved in the development and evaluation of shortlisted options was limited to high-level alignment and general form. Following options evaluation, the conceptual design for the preferred dike option was refined and is presented on a series of plan figures presented in Appendix J.

The plan figures show the approximate footprint of the preferred option and indicate approximately where retaining walls, internal seepage cut-off walls, and seepage control land-side toe berms would be used. The refined conceptual design is the starting point for advancing towards preliminary and detailed design of the preferred option. Implementation actions and sequencing are discussed in Section 6.

Preliminary and detailed design stages may result in changes to the preferred option design footprint as additional information, analysis, and engagement influences the project. In particular, additional design work aided by topographic survey is required to better understand and explore the detailed design of the dike within the southern portion of Siyich'em Reserve as the new dike alignment turns to the north-west (southern end of Option C in the shortlisted designs). The dike alignment presented in Appendix J attempts to limit encroachment of the dike into the Squamish River, and uses a retaining wall to limit the footprint to not further encroach onto Siyich'em Reserve and the existing restaurant building.

It may be possible to shift the alignment to the west to reduce the dike trespass on Siyich'em Reserve at this location, but that would increase the potential habitat impacts of the project and add further complexity to the environmental permitting and compensation requirements. The interaction between the dike and the existing restaurant building will also require additional investigation to be led by the Squamish Nation. While it is generally not preferred to have structures attached to dikes, it may be possible to develop a special design to modify the dike and the existing restaurant building to accommodate each other. Next steps related to this are also discussed further in Section 6.

Additionally, a preliminary public amenity concept plan has been prepared for the Eagle Viewing Area to show how eagle viewing infrastructure, parking, washrooms, and other features discussed through the design and engagement phases can be incorporated into the preferred dike option. The preliminary public amenity concept plan is presented in Appendix K.

Finally, a conceptual design to relocate Government Road to resolve the historic trespass of the road on Siyich'em Reserve has been prepared and is presented in Appendix L. To resolve the trespass through the reserve, the road corridor would be shifted to the east which encroach onto private property located on the east side of the road. The District would require land tenure on the edge of the private property to implement the realignment. This has not been explored as part of this project, but is listed as a next step for implementation in Section 6.

5.4 Final Round of Engagement

A final round of engagement was conducted between June 2020 and September 2020 to get feedback on the preferred option and the draft master plan. The engagement results were primarily used to update the master plan implementation steps (refer to Section 6) to address comments and concerns raised in the engagement as part of future work.

The final round of engagement did not include any in-person meetings due to the coronavirus pandemic (COVID-19). Internet-based engagement was conducted in accordance with COVID-19 public health requirements and best practices.

The final round of engagement included the following activities:

- virtual meeting with Siyich'em families / residents on September 23, 2020;
- public online survey #3 (hosted on project website between June 2020 and September 2020);
- written correspondence exchange with the Squamish River Watershed Society; and
- written correspondence from the BC Whitewater Society.

Table 5-1 provides a summary of the engagement results. The results are also documented in meeting minutes, survey results analysis, and correspondence records provided in Appendix H.

Table 5-1: Summary of Final Round of Engagement

Engagement Activity / Correspondence	Key Feedback Themes
Virtual meeting with Siyich'em families / residents (September 23, 2020)	• General support for the preferred option between the Siyich'em reserve and Fisherman's Park involving the new dike alignment that would enable land recapture for the Squamish Nation. • Suggested that future archaeological investigations include existing Siyich'em reserve land parcel on the west side of the Squamish River. • Questions regarding Government Road realignment concept to address trespass and request to be included in future planning and negotiations. • Request to be updated on dike master plan finalization and implementation.
Public online survey #3 (June 2020 to September 2020)	• 56 respondents including 49 District of Squamish residents (16 residing within the study area and 33 residing outside of the study area). • Majority of respondents do not support the preferred option between the Siyich'em reserve and Fisherman's Park involving the new dike alignment. Common themes reflected in the comments are: o Concern for habitat and ecosystem impacts. o Concern for impacts to and loss of access to recreational areas. o Concern about enabling development of green/natural areas. o Suggestions of addressing/compensating Squamish Nation land tenure issues through off-site land transfer or other approaches. • Majority of respondents support the preferred option in the Eagle Viewing Area (raise existing dike alignment). • Support for various public amenity features at the Eagle Viewing Area, including improving parking and maintaining EagleWatch program infrastructure.
Written correspondence with Squamish River Watershed Society (SRWS) Letter from SRWS dated July 7, 2020.	<u>SRWS letter (July 7, 2020):</u> • SRWS expressed their opposition to the preferred option between the Siyich'em reserve and Fisherman's Park (new alignment) based on concerns related to: o Loss of active floodplain area for natural flood management. o Loss or degradation of aquatic and riparian habitat (depending on future land use). o Flood and erosion risk transfer, including potential impacts to fish habitat.

Engagement Activity / Correspondence	Key Feedback Themes
Response letter from District of Squamish and Squamish Nation dated July 14, 2020.	• SRWS requested information on: o Whether the District has contacted the federal and provincial governments to address the Siyich'em land tenure issues through other off-site land parcels. o Environmental and habitat assessment reports for the project. <u>District of Squamish and Squamish Nation response letter (July 14, 2020):</u> • The District and Nation provided clarifying information in regard to 3 items in the SRWS letter: o Loss of active floodplain area: It was clarified that preliminary analysis conducted as part of the master plan has shown the new dike alignment would raise the flood profile by up to 0.3 m. This is considered manageable. Refer to Section 4.3 of the master plan for additional discussion. o Loss or degradation of aquatic and riparian habitat: It was clarified that: ▪ Future implementation would require habitat compensation for impacts. ▪ The proposed dike is to be set back from the Squamish River with a minimum 30 m setback. ▪ A proposed fish-friendly pump station at the outlet of Jimmy Jimmy (Judd) Slough would maintain fish access. ▪ Future land use behind the proposed dike has not been determined as part of the master plan. ▪ The alternative option of upgrading the dike along Eagle Run Drive (ERD, not selected) would also impact habitat due to the limited space for dike upgrading between exiting private property/houses and Jimmy Jimmy (Judd) Slough. o Flood and erosion risk transfer: It was clarified that the dike master plan implementation steps (refer to Section 6) includes additional analysis to study this issue further. • The District and Nation also responded to SRWS' questions in regard to off-site land tenure and environmental assessments: o It is not the District's role to interact with federal and provincial governments on Squamish Nation land tenure issues. It was clarified that a representative from the Government of Canada (Indigenous Services Canada) was part of the project steering committee. The baseline habitat review (Appendix D) was provided to SRWS. It was clarified that the master plan implementation (refer to Section 6) includes additional analysis to enable a formal habitat impact assessment.
Written correspondence from BC Whitewater E-mail from the BC Whitewater Society dated July 11, 2020	• The BC Whitewater Society notified the project team by e-mail that there is an existing access point to the Squamish River along the existing dike within the Siyich'em reserve reach. • The BC Whitewater Society requested that the master plan incorporate a formal river access point into the selected option design.

6. Implementation

This section identifies next steps to advance the preferred option towards implementation, and discusses potential funding and phasing considerations.

6.1 Next Steps

A series of next steps is required to advance the master plan towards implementation (construction).

The next steps have been organized into the following categories listed below and are discussed in more detail in the following sections:

- land tenure administrative processes;
- additional analysis and feasibility assessments;
- preliminary design and engagement;
- regulatory engagement;
- detailed design, engagement, and permitting; and
- construction, operation, and maintenance.

Land Tenure Administrative Processes

- Initiate legal administrative process for Siyich'em Reserve land recapture. This next step would be led by the Squamish Nation.
- Explore land tenure required to realign Government Road off Siyich'em Reserve. This next step would be led by the District of Squamish.
- Initiate additional discussions on land tenure and maintenance authority for new dike alignment.
- District of Squamish to review zoning of two private land parcels located between ERD dike and Option C to ensure consistency with flood management and environmental protection objectives.
- Address land tenure issues related to dike upgrading through the private property located near the south end of the Eagle Viewing Area (40813 Government Road). This next step would be led by the District of Squamish.

Additional Analysis and Feasibility Assessments

- Conduct additional geotechnical investigation and seismic performance analysis for the new dike alignment. Refine conceptual design for ground improvement and associated cost estimates.
- Conduct a comprehensive bathymetric survey of the Squamish River and side channels within the study area to support a hydrotechnical and geomorphic assessment (see below).
    - This could also contribute to a larger survey program that would support sediment assessment and modelling for future updating of the IFHMP.
- Conduct a hydrotechnical and geomorphic assessment involving 2-dimensional hydraulic / morphodynamic modelling to address the following questions:
    - What is the current frequency of inundation for the forested island that would be partially disconnected from the Squamish River by the preferred option?

  - What are the potential impacts of the preferred option on flow velocities and erosion/deposition, in particular for the current side channel (with and without an associated log jam removal at the side channel entrance)?
  - What are the potential impacts of the preferred option on dike breach and internal floodway hydraulic patterns, and is there a need to update flood construction levels outside of future IFHMP updating cycle?
- Related to the hydrotechnical assessment, conduct a review of options for the fate of the existing Eagle Run Drive dike and the advantages and disadvantages of maintaining it, removing it, and other options.
- Assess area-specific feasibility of dike riprap upgrading, with emphasis on the toe component.
- Conduct an environmental habitat impact assessment with input from the hydrotechnical and geomorphic assessment to better understand the potential habitat impact associated with changes to ecological condition and function within Jimmy Jimmy (Judd) Slough and the forested island. The assessment should also include:
  - Development of habitat impact compensation concepts; and
  - Identification of potential measures and associated cost to reduce the frequency/impact of disconnection of the forested island from the Squamish River (i.e. through features at the pump station and/or additional flow exchange culverts, etc.).
- Update the Brackendale Master Drainage Plan and define the design criteria for replacement of Dryden Creek pump station and the proposed Jimmy Jimmy (Judd) Slough pump station. Update cost estimates for drainage works to Class C level (including decommissioning of the existing Jimmy Jimmy (Judd) Slough pump station, the Horse Creek floodbox, and the Eagle Run Drive pump station as part of this next step). This assessment may also involve structural, geotechnical, and electrical assessments of the existing Dryden Creek pump station facility to confirm whether or not a full replacement is required.
- Consider the potential debris flow hazard posed by the Cheekeye Fan, which will likely factor into pump station design criteria, as well as the fate of the existing ERD dike.
- Consider the need for an archaeological assessment, particularly along the new dike alignment and including the existing Siyich'em Reserve land parcel located on the west side of the Squamish River.
- Engage key groups, including the Siyich'em Reserve families / residents on the outcomes of the above analyses and assessments.

Preliminary Design and Engagement

- Review design options at the south end of the Siyich'em Reserve and in particular at the interaction of the dike and the existing restaurant building. Ideally, a long term vision for the area and specifically for the restaurant building would be provided by the Squamish Nation based on engagement to allow the development of dike design details to incorporate the vision.
- Conduct additional design and engagement on public amenity improvements for the Eagle Viewing Area.
- Initiate scoping of material sources for dike fill and riprap, including potential reopening of Squamish Nation quarry (i.e. Cheekeye Quarry on Squamish Valley Road).

- Prepare preliminary design drawings and specifications based on the additional analysis and feasibility assessments. The preliminary design should be developed based on a complete ground-based topographic and bathymetric survey of the site. Update cost estimates to Class-C or Class-B level.
- Prepare preliminary design drawings and specifications for the drainage station upgrades, based on the outcome of the updated Brackendale Master Drainage Plan.
- Conduct additional engagement with Squamish Nation (including the Siyich'em reserve families / residents), community stakeholders, and the public to consult and gather feedback on the preliminary design.
- Conduct a constructability review to determine construction constraints including construction access issues, environmental construction windows (bird and aquatic), and water level related construction windows.
- Consider incorporating a new and formal river access point into the new dike alignment. Discuss location, access, and maintenance authority with District and Nation, and key stakeholders including the BC Whitewater Society.

Regulatory Engagement

- Meet with environmental regulatory agencies to provide an update on the project and seek feedback and level of support prior to initiating the permitting process. Discuss habitat impact compensation needs and potential approaches, including both on-site, off-site, and previously conducted enhancement projects.
- Meet with the BC Inspector of Dikes Office to provide an update on the project and seek feedback and level of support prior to initiating the permitting process. Discuss land tenure issues, including lack of right-of-way for maintenance through Squamish Nation Reserve lands. Ideally, the District and the Nation have identified a generally preferred approach for land tenure and maintenance authority for the new dike alignment ahead of this engagement.

Detailed Design, Permitting, and Engagement

- Prepare detailed design drawings and specifications for dike works as well as related civil works.
- Initiate environmental and administrative permitting processes.
- Conduct a final round of engagement with Squamish Nation members and the public to provide information on the detailed design and final opportunities for input.

Construction, Operation, and Maintenance

- Construct the works – funding and phasing considerations are discussed in the following sub-section.
- Develop operation and maintenance (O&M) procedures, agreements, and manuals for the dike works and associated infrastructure such as drainage pump stations.

6.2 Funding and Phasing Considerations

Cost sharing opportunities with other levels of government will define the phasing considerations for the master plan.

In general, two high-level approaches are possible based on what funding opportunities are available:

1. A full program funded approach; and
2. A phased funding approach.

Under a full program funded approach, a large funding grant would be sought to fund the entire master plan implementation, which would occur over a multi-year period. The prime example of a funding opportunity for this approach is the Disaster Mitigation and Adaptation Fund (DMAF) administered by the Government of Canada through Infrastructure Canada. DMAF provides up to 75% cost sharing for indigenous recipients and the Squamish Nation would be able to apply for other federal funding programs for a total federal contribution of up to 100%. Municipal governments are eligible for up to 40% cost sharing by the federal government. DMAF targets large projects and has a minimum required cost threshold of $20 million. Additionally, DMAF allows for bundling of project components that work in a complementary manner to reduce risk. DMAF-funded projects need to be implemented by 2028 under the current program.

Under a phased funding approach, the master plan would be implemented through individual funding applications. The number of phases would depend on the funding sources available. Smaller funding programs would require several successful applications to implement portions of the master plan. For example, the provincial Community Emergency Preparedness Fund (CEPF) administered by the Union of British Columbia Municipalities (UBCM) provides funding for structural flood protection with a current maximum contribution of $750,000 per application. Under this approach, full implementation would likely take longer than a decade. Phasing is best suited for the Eagle Viewing Area reach of the master plan and is not well suited for the proposed new dike alignment between Fisherman's Park and Siyich'em Reserve.

A hybrid approach involving both of the above approaches may be possible as well. For example, a phased approach could be initiated immediately for the Eagle Viewing Area while additional analysis and feasibility assessments which mostly focus on the Siyich'em reach are conducted.

Direct engagement with funding agencies and Indigenous Services Canada can help the Nation and the District determine the best approaches to undertake in pursuing support and funding for implementation of the master plan. This engagement should also include the coordination of drainage station replacement into the proposed dike upgrades, which may be funded separately.

Report Submission

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Statement of Limitations

This document has been prepared by Kerr Wood Leidal Associates Ltd. (KWL) for the exclusive use and benefit of the District of Squamish and the Squamish Nation for the Eagle Viewing Area / Siyich'em Reserve Dike Master Plan. DISTRICT OF SQUAMISH / SQUAMISH NATION are permitted to reproduce the materials for archiving and for distribution to third parties as required to conduct business specifically relating to Eagle Viewing Area / Siyich'em Reserve Dike Master Plan

This document represents KWL's professional judgement based on the information available at the time of its completion and as appropriate for the project scope of work. Services performed in developing the content of this document have been conducted in a manner consistent with that level and skill ordinarily exercised by members of the engineering profession currently practising under similar conditions. No warranty, express or implied, is made.

Revision History

Revision #	Date	Status	Revision	Author
0	October 27, 2020	FINAL	Final report (added summary of final round of engagement)	ATAL
C	June 25, 2020	DRAFT FINAL	Draft final report (DoS comments addressed)	ATAL/SJR
B	May 29, 2020	DRAFT FINAL	Draft final report (section 6 added)	ATAL/SJR
A	March 31, 2020	DRAFT	Partial draft report (sections 1 to 5)	ATAL/SJR

OQM CERTIFIED

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Appendix A

Project Charter

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Project Charter

DATE: **November 14, 2019**

RE: **DISTRICT OF SQUAMISH & SQUAMISH NATION**
Eagle Viewing Area / Siyich'em Reserve Dike Master Plan
KWL File: 0463.341

This is a high-level document to guide the administration of the Eagle Viewing Area – Seaichem Reserve Dike Master Plan. The charter documents the overall objectives, roles, communication protocols, and key decision points and responsibilities.

1. Overview and Objectives

The District of Squamish (District), in partnership with the Squamish Nation (Nation), has retained Kerr Wood Leidal Associates Ltd. (KWL) to develop a master plan for flood protection upgrades in the Eagle Viewing Area/ Siyich'em[1] Reserve reach of the Squamish River Dike, located between the north end of the Nation's Seaichem I.R. No. 16 and Harris Slough. The District and the Nation are collaborating closely on the master plan project and are considered project partners who will work together on stakeholder engagement, options evaluation, and decision-making for the master plan.

Based on the District's recently completed Integrated Flood Hazard Management Plan (IFHMP), the Eagle Viewing Area/Siyich'em Dike reach is one of the highest-risk reaches of the dike and is a priority for upgrading.

The Eagle Viewing Area/ Siyich'em Reserve Dike Master Plan project will develop flood protection upgrading options. The project will use a stakeholder-engagement-driven process to review, refine, and evaluate the options with the aim to identify an option that is preferred by the District and the Nation, and which achieves consensus with stakeholders. The master plan will also provide implementation considerations and next steps for the preferred option to enable the District and the Nation to advance the concept to detailed design in the future.

2. Scope and Schedule

The overall dike master plan scope comprises the following core phases:

- Phase A: Initiation, information gathering, and context;
- Phase B: Visioning, brainstorming, and shortlisting options;
- Phase C: Conceptual design and engagement on shortlisted options;
- Phase D: Structured options evaluation and selection;
- Phase E: Draft master plan; and
- Phase F: Final engagement and final master plan.

At a high level, the scope involves brainstorming up to five flood protection upgrading options, shortlisting three options for an initial round of stakeholder engagement, evaluating the options to select a preferred option, preparing a draft master plan, and conducting a final round of engagement prior to finalizing the plan.

[1] Siy̓ích'em

The stakeholder engagement plan, a separate document, describes the proposed engagement activities.

Additional detail on the scope is provided in the work program table from KWL's original proposal, which is attached to this document.

The proposed project schedule is also attached. The current schedule is the same as the schedule presented in KWL's proposal. The schedule delivers a draft master plan by the end of March 2020 to meet the National Disaster Mitigation Program's funding grant deliverable deadline. A final round of engagement will be conducted prior to finalizing the master plan by end of May 2020.

3. Roles and Communication

The project scope involves a series of core meetings between the consultant team and project partners (District and Nation).

3.1 Project Steering Committee

The District and Nation steering committee comprises the District's project manager and a staff representative from the Nation, and additional representatives from the District and the Nation who may participate if and when required.

District and Nation council members may also participate in steering committee meetings at certain points to facilitate coordination with council.

Table 1 presents the steering committee members.

Table 1: Project Steering Committee Members

Name	Organization
David Roulston	District of Squamish
Chris Wyckham	District of Squamish
Gary Buxton	District of Squamish
Paul Wick	Squamish Nation
Austin Chandler	Squamish Nation
Michelle George	Squamish Nation
Joshua Joseph	Squamish Nation
Chris Lewis	Squamish Nation
Dick Williams	Squamish Nation
Peter Baker	Squamish Nation
Monica Jacobs	Squamish Nation
Brent Baron	Indigenous Services Canada

3.2 Consultant Team

KWL leads the consultant team, which also includes Thurber (geotechnical engineering), and Hapa (landscape architecture/engagement). Two senior KWL staff have been designated as project advisors to the District and Nation. The project advisors will focus on expressing the District's and the Nation's perspectives.

Table 2 presents the key consultant team members.

Table 2: Consultant Team Key Staff

Name	Organization	Role(s)
Erica Ellis	KWL	Lead Consultant Project Manager
Mike Currie	KWL	Senior technical Reviewer
David Roche	KWL	KWL Advisor to District
Jeff Derer	KWL	KWL Advisor to Nation
Amir Taleghani	KWL	Project Engineer
Steve Coulter	Thurber	Thurber Project Manager/Geotechnical Engineer
Lukas Holy	Hapa	Hapa Project Manager/Landscape Designer
Allison Tweedie	Hapa	Landscape Designer

3.3 Communication Protocol

The following protocol should be used for general correspondence for the project:

- All correspondence to the consultant team should include Erica Ellis (KWL) and Amir Taleghani (KWL). All correspondence to Hapa should include Lukas Holy and Allison Tweedie;
- All correspondence to the District and Nation should be directed to David Roulston and Paul Wick; and
- KWL's organizational quality management program involves a digital e-mail filing system which is implemented through 'carbon copying' (c.c.) of e-mails to 'file@kwl.ca' with a project-specific text code ('KWL File No. 0463.341' in this case) included in the e-mails. Please do not remove 'file@kwl.ca' from the e-mail chain c.c. list when replying all.
- PDFs should be 'unsecured' for ease of commenting and copy/pasting.

3.4 Steering Committee Meetings

In accordance with the scope work program (attached), Table 3 provides a summary of the proposed steering committee meetings, including general purpose and tentative timeline. The primary Project Manager (David Roulston) and the lead consultant Project Manager (Erica Ellis) will collaborate to schedule the meetings. Meetings will be located in Squamish (District or Nation office), North Vancouver (Nation office), or Burnaby (KWL office), to be decided during scheduling.

Table 3: Steering Committee Meetings

Meeting # and Name	Tentative Date	Location	Description
1. Initiation	August 20, 2019	Squamish (District Hall)	Project kickoff meeting and site walkthrough.
2. Visioning/ Brainstorming	September 13, 2019	Squamish (District Hall)	Meeting to develop vision, shared values, and evaluation criteria for options development and selection. Options brainstorming and consolidation into up to five options.
3. Options Shortlisting	September 27, 2019	Squamish (Totem Hall)	Meeting to review high-level conceptual design and feasibility of five options, and to shortlist three options.
4. Options Evaluation	January 27, 2020	Squamish (TBD)	Structured, semi-quantitative evaluation of shortlisted options to identify recommended preferred option to take to councils.
5. Draft Master Plan Review	March 9, 2020	Teleconference	Meeting to review and discuss feedback on draft master plan.
6. Final Review	April 27, 2020	Teleconference	Meeting to review final engagement round results and to confirm final changes for master plan.

4. Key Decision Points and Council Involvement

The project scope is structured to develop a flood protection upgrading concept which is preferred by both the District and the Nation, and to pursue consensus on the option across a wide range of stakeholders. This is an ambitious goal given the challenges and constraints of the site and the large number of stakeholders. Key decision points have been identified and District and Nation Council involvement is required for major decisions.

Table 4 presents the key decision-making points in the project and the proposed level of responsibility for the decision.

Table 4: Key Decision Points and Responsibility

Decision Point	Responsibility Level for Decision	Relevant Meeting and Tentative Timeline
Brainstorm up to five options	Consultant team and steering committee	Steering committee meeting #2 September 13, 2019
Shortlist up to three options	Steering committee	Steering committee meeting #3 September 27, 2019
Confirm shortlisted options.	Councils	Council presentations September 30, 2019 – October 11, 2019
Semi-quantitative evaluation to rank three options	Steering committee	Steering committee meeting #4 January 27, 2020
Select preferred option	Councils	Council presentations February 3, 2020 – February 14, 2020
Endorse draft master plan	Councils	Council presentations March 16, 2020 – March 27, 2020
Accept final master plan	Councils	Council presentations May 4, 2020 – May 15, 2020

Attachments:

1. Scope Work Program Table (Reproduced from KWL Proposal)
2. Project Schedule

Revision #	Date	Status	Revision Description	Author
D	Nov. 14, 2019	Draft	Updated based on Nation feedback at PCPC meeting.	ATAL/SJR/EE
C	Oct. 15, 2019	Draft	Updated based on District and Nation review and comment.	ATAL/SJR/EE
B	Sep. 4, 2019	Draft		SJR
A	Aug.19, 2019	Draft	For initial District and Nation review and discussion at kickoff meeting	ATAL

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Appendix B

Stakeholder Engagement Plan

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Stakeholder Engagement Plan

DATE: **October 15, 2019**

RE: **DISTRICT OF SQUAMISH & SQUAMISH NATION**
Eagle Viewing Area/Seaichem Reserve Dike Master Plan
KWL File: 0463.341

VERSION: **Draft B** (updated based on District and Nation review and input)

1. Overview

The District of Squamish (District), in partnership with the Squamish Nation (Nation), has retained Kerr Wood Leidal Associates Ltd. (KWL) to develop a master plan for flood protection upgrades in the Eagle Viewing Area/ Seaichem Reserve reach of the Squamish River Dike, located between the north end of the Nation's Seaichem I.R. No. 16 and Harris Slough.

Based on the District's recently completed Integrated Flood Hazard Management Plan (IFHMP), the Eagle Viewing Area/Siyich'em[1] Dike reach is one of the highest risk reaches of the dike and is a priority for upgrading.

The Eagle Viewing Area/Siyich'em Reserve Dike Master Plan project will develop flood protection upgrading options. The project will use a stakeholder-engagement-driven process to review, refine, and evaluate the options with the aim to identify an option that is preferred by the District and the Nation, and which achieves consensus with stakeholders.

The overall project objectives and key decision points for the District and Nation are summarized in the Project Charter.

The overall dike master plan scope comprises the following core phases:

- Phase A: Initiation, information gathering, and context;
- Phase B: Visioning, brainstorming, and shortlisting options;
- Phase C: Conceptual design and engagement on shortlisted options;
- Phase D: Structured options evaluation and selection;
- Phase E: Draft master plan; and
- Phase F: Final engagement and final master plan.

Additional detail on the scope is provided in KWL's original proposal.

The stakeholder engagement plan, this document, describes the stakeholder engagement objectives and level of engagement, identifies the major stakeholders, and provides general information and a schedule for planned engagement activities. The stakeholder engagement plan is considered a living document during the project and will be updated as the engagement activities proceed.

[1] Siy̓ích'em.

2. Engagement Objectives and Level of Engagement

The primary objectives of stakeholder engagement are to:

1. Listen to and understand stakeholder values and desires for the study area with respect to flood protection and stakeholder-specific non-flood protection topics;
2. Involve stakeholders in the review and refinement of flood protection options under consideration by the District and the Nation; and
3. Foster collaboration between the District of Squamish, Squamish Nation, and other stakeholders to find mutually agreeable design solutions.

In support of these objectives, the level of stakeholder engagement will generally be at the 'involve' level as defined by the International Association for Public Participation's (IAP2) engagement spectrum, presented below.

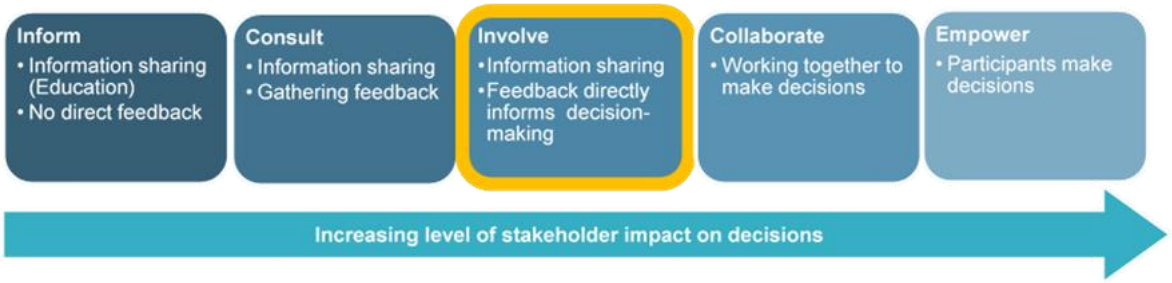
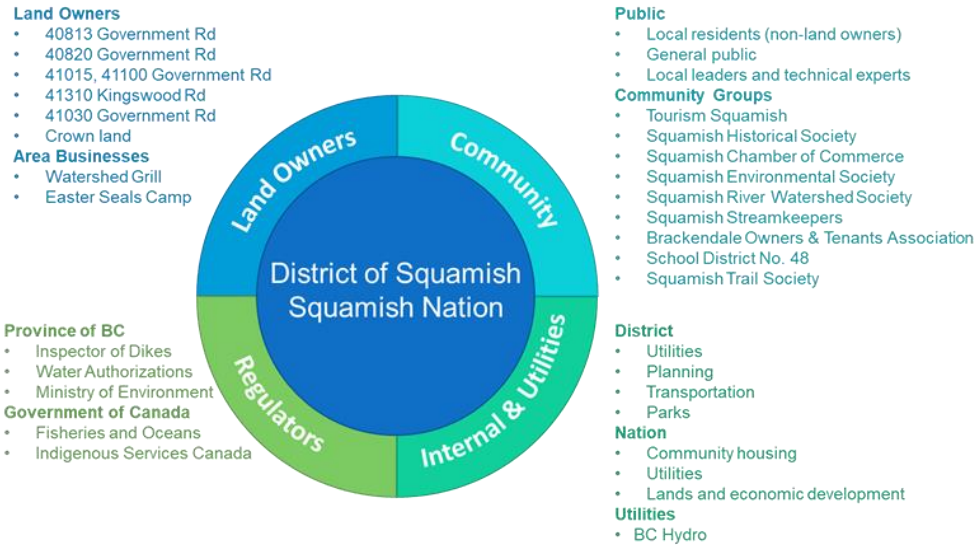


Figure 1: IAP2 Engagement Continuum

3. Stakeholders

There are many stakeholders who have an interest in the Eagle Viewing Area – Seaichem Reserve Dike reach, ranging from private landowners to community groups to external regulators. The stakeholders have been grouped into four categories and are summarized on the graphic below.



It should be noted that while District and Nation councils are not listed as stakeholders, they will be informed and involved at key points during the project, including before and after stakeholder engagement. This is discussed further in Section 6.

The perceived main motivations of each stakeholder group and the proposed types of engagement activities are summarized in Table 1 below.

Table 1: Perceived Stakeholder Motivations and Questions

Stakeholder Group	Perceived Motivations	Proposed Types of Engagement Activities
Landowners	• Flood risk and safety • Erosion and land loss • Land tenure impacts • Future re-development impacts • Access and privacy • Property value and insurance impacts • Views and aesthetics • Traffic and parking • Business impacts	• Targeted group workshops
Community	• Flood risk and safety • Access and trails • Views and aesthetics • Habitat impacts • Tourism impacts and opportunities • Education and cultural impacts and opportunities • Construction disruption and impacts	• Project notification signage • Website and online survey • Open houses
Internal and Utilities	• Flood risk and safety • Utility relocations and upgrades • Parks and trails impacts and opportunities • Land use planning impacts and opportunities • Economic development impacts and opportunities	• Targeted group workshops
Regulators	• Flood risk and Dike Maintenance Act permitting • Water Sustainability Act permitting • Provincial park and eagle habitat considerations • Fish Act permitting • First Nation flood protection and infrastructure considerations	• Targeted group workshops

These motivations guide the development of engagement activities for each group to effectively respond to anticipated questions and gather input into the master planning process. Details of these activities are described in the next section.

4. Proposed Engagement Activities and Roles

Sixteen (16) engagement activities are proposed in accordance with the overall dike master plan scope, presented on Table 2 on the following page.

Activities are coordinated such that information is shared out and input is gathered at the following milestones:

1. Project initiation;
2. Review of three shortlisted options; and
3. Review of draft dike master plan for preferred option.

At project initiation, the engagement objective is to notify stakeholders of the project and the opportunities for them to be involved in the project. Additionally, stakeholders will be invited to express their high-level values, interests, and concerns for the site through a project website and an online survey. This process will provide an informal opportunity for stakeholders who may have ideas on dike upgrading options to contribute them to the project team prior to formal options development.

Following project initiation, the project team will work with the project partners (District and Nation) to develop up to three shortlisted dike master plan options which will be taken to the stakeholders for comment and the opportunity to be involved in refining the options. Additional detail on the process to develop the three shortlisted options is presented in the project charter document, and in KWL's proposal. Engagement activities will include four targeted workshops with stakeholder groups, a public open house, and an online public survey. Content for these activities will include graphics and text describing the qualities of shortlisted options. Workshops may be formatted as a conventional presentation followed by questions and discussion, or as a facilitated, interactive activity as appropriate for each stakeholder group.

The three shortlisted options will be evaluated by the project team and project partners and presented to councils to pursue selection of a preferred option. A draft dike master plan document will be produced for the preferred option and a final round of engagement activities will present the results to stakeholders for a final opportunity to influence the master plan. This round will also include four targeted workshops with stakeholder groups, a public open house, and an online public survey. Content for these activities will focus on the conceptual design for the preferred option and the plan implementation considerations relevant for each stakeholder group.

Table 2 presents a brief description and tentative timeline for each of these engagement activities. The timeline is dictated by the overall project schedule, which is described further in the project charter and KWL's proposal.

Given the large number of stakeholders identified by the project partners and the project team, engagement activities are organized to combine specific groups where reasonable (e.g., Province of BC and Government of Canada). This grouping should be reviewed, discussed, and confirmed with the project partners. Additionally, a preferred approach should be identified with the project partners in response to potential additional stakeholders identified or arising through the project (e.g., additional workshops, direct communication by partners, etc.).

Table 2: Proposed Engagement Activities and Schedule

Item # & Name	Tentative Date and Location	Targeted Stakeholder Group	Description
Phase A: Initiation, Information Gathering, and Context			
1. Project Signage	September 13 Physical Signs	Landowners Community	Signage to notify of project and refer to website.
2. Launch Project Website	September 13 Online	Landowners Community	Project website with background information and a high-level survey (values, concerns, etc.).
Phase C: Conceptual Design and Engagement on Shortlisted Options			
3. Public Survey on Shortlisted Options	Week of October 20 Online	Landowners Community	Public survey on three short-listed options for website.
4. Regulators Workshop	Week of November 17 Burnaby/Surrey	Regulators	Two-hour workshop with Province of BC and Government of Canada to review and discuss shortlisted options.
5. Landowners Workshop	Week of November 17 Squamish	Landowners	Two-hour workshop with landowners to review and discuss shortlisted options.
6. ~~District and Nation Internal Departments Workshop~~ 40813 Government Rd Meeting	Week of November 17 Squamish	~~Internal & Utilities~~ Landowners	~~Two-hour workshop with internal department stakeholders from both District and Nation~~ Two-hour meeting with landowners of 40813 Government Rd to review and discuss shortlisted options.
7. Billy & Williams families Meeting	Week of November 17 Squamish	Landowners	Two-hour meeting with Billy and Williams families to review and discuss shortlisted options.
8. Community Groups Workshop	Week of November 17 Squamish	Community (groups)	Two-hour workshop with organized community groups who have expressed a direct interest in being involved to review and discuss shortlisted options.
9. Public Open House	Week of December 1 Squamish	Community (general public)	Four-hour open house to present and get feedback on shortlisted options.
Phase F: Final Engagement and Final Master Plan			
10. Public Open House	Week of April 5 Squamish	Public	Four-hour open house to present and get feedback on draft master plan.
11. Public Survey on Master Plan	Week of April 5 Online	Landowners Community	Public survey on draft master plan.
12. Regulators Workshop	Week of April 5 or 12 Burnaby/Surrey	Regulators	Two-hour workshop with Province of BC and Government of Canada to review and discuss draft master plan.
13. Landowners Workshop	Week of April 5 or 12 Squamish	Landowners	Two-hour workshop with landowners to review and discuss draft master plan.

Item # & Name	Tentative Date and Location	Targeted Stakeholder Group	Description
14. ~~District and Nation Internal Departments Workshop~~ 40813 Government Rd Meeting	Week of April 5 or 12 Squamish	~~Internal & Utilities~~ Landowners	~~Two-hour workshop with internal department stakeholders from both District and Nation~~ Two-hour meeting with landowners of 40813 Government Rd to review and discuss draft master plan.
15. Billy & Williams families Meeting	Week of April 5 or 12 Squamish	Landowners	Two-hour meeting with Billy and Williams families to review and discuss draft master plan.
16. Community Groups Workshop	Week of April 5 or 12 Squamish	Community (groups)	Two-hour workshop with organized community groups who have expressed a direct interest in being involved to review and discuss draft master plan.

5. Roles and Responsibilities

The following are the anticipated responsibilities of the consulting team (KWL and their landscape architecture sub-consultant Hapa) for the engagement activities:

1. Produce digital copy of project signage for project site;
2. Provide technical content (text and photos) for public websites and online surveys;
3. Produce (print) materials for engagement activities, including workshops and open houses; and
4. Facilitate, present, and record minutes at targeted workshops.

The following are the anticipated responsibilities of the District and Nation for the engagement activities:

1. Produce (print), install, and maintain project signage on the project site;
2. Prepare general non-technical content for website;
3. Launch and host project website. (Note: KWL is supporting the District with the project survey, including downloading results);
4. Gather and manage contact information for stakeholders;
5. Schedule workshops and open houses, including venue logistics;
6. Attend and provide owner's perspective at engagement activities;
7. Gather and summarize input at open houses; and
8. Lead coordination of engagement activities with District and Nation councils (discussed further in Section 6).

6. Stakeholder Engagement Coordination with Councils

It is anticipated that both District and Nation Councils will have an interest in being informed of and understanding the proposed engagement activities before they are conducted.

KWL's scope includes a total allowance of four rounds of presentations to District and Nation Councils (i.e., eight presentations in total). Two of these rounds are intended to obtain Council approval to move ahead with in-person engagement activities. These are summarized with tentative timelines in Table 3 below.

The intent of the other rounds of presentations to Councils is described in the Project Charter and KWL's proposal.

Table 3: Proposed Council Presentations to Coordinate Stakeholder Engagement

Tentative Timeline	Description
September 30, 2019 – October 11, 2019	Presentations to District and Nation Councils to obtain approval for launch of in-person engagement events with three shortlisted options.
March 16, 2020 – March 27, 2020	Presentations to District and Nation Councils to obtain approval for launch of in-person engagement events with draft master plan.

The District has indicated that presentation to District Council will be undertaken once technical work and public consultation is complete.

7. Next Steps

The following are the relevant next steps for the development of the stakeholder engagement plan at this time:

1. Confirm timelines for proposed activities and begin to organize (gather contact info, scheduling, venue logistics, etc.).

Revision History

Revision #	Date	Status	Revision Description	Author
B	October 15, 2019	Draft	Updated based on District and Nation responses.	SJR/ATAL/EE
A	August 19, 2019	Draft	For initial District and Nation review and discussion at kickoff meeting	SJR/ATAL

KERR WOOD LEIDAL
consulting engineers

Appendix C

Surveyor General Legal Description Report for the Siyich'em Reserve

Surveyor General Branch

Legal Description Report for

SEAICHEM INDIAN RESERVE No. 16

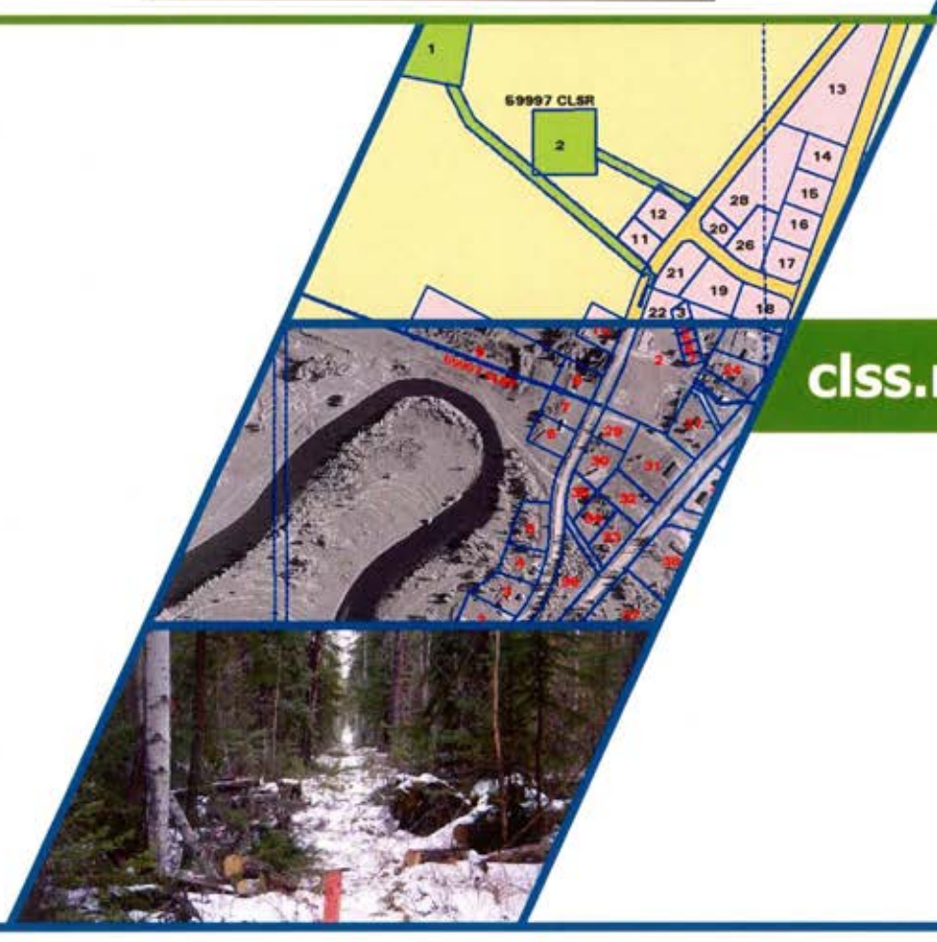
Squamish First Nation

Prepared under First Nations Land Management

CANADA LANDS SURVEYS RECORDS

FB 38514

Date: February 28, 2011



clss.nrcan.gc.ca

Natural Resources Canada | Ressources naturelles Canada

Canada

CANADA LANDS SURVEYS RECORDS

FB 38514

DATE: February 28, 2011

Legal Description Report
for
Seaichem Indian Reserve No. 16
Squamish First Nation

British Columbia

Prepared under
First Nations Land Management

Prepared on: January 13, 2011

Table of Contents

1. Introduction

As part of the implementation of the *First Nations Land Management Act* for the Squamish First Nation Reserves, the Surveyor General Branch has prepared a legal description describing the extent of the Reserve lands as required under Section 6.1(a) of the Act for Seaichem Indian Reserve No. 16 .

Outstanding issues related to the jurisdictional boundaries of the Reserve or to the legal description contained in this Report are explained in Section 2.

The legal description contained in Section 3 deals with the extent of the Reserve lands that will be subject to the Land Code of the Squamish First Nation under the *First Nations Land Management Act* and is not intended to prejudice any of this First Nation's claim to lands beyond the Reserve.

The legal description is based on a review of the Indian Lands Registry and other documents pertaining to the extent of title to the Reserve, which are included in Section 5 of this Report. The legal description is not a legal interpretation of those documents. As there may be different legal interpretations of the documents, legal assistance may be required to determine the nature of the legal interests. There is no guarantee that the research is accurate and complete as there may be other documents, not yet found and reviewed, that may affect the nature of ownership.

Section 6 outlines the methodologies used in the preparation of this legal description as well as any other non-boundary related issues encountered during the research of this Report.

This Legal Description Report was prepared by Steven J. Minnie, BCLS, CLS, of Surveyor General Branch, per the Guidelines established under the authority of the Surveyor General of Canada and in collaboration with Indian and Northern Affairs Canada, and the Squamish First Nation.

Certified Correct as to the legal description contained in Section 3 of this Report.

Steven J. Minnie BCLS, CLS
Surveyor General Branch

January 13, 2011
Date

2. Boundary Issues

A) Portion of Government Road Encroaches upon Reserve.

On a survey of the rectilinear boundaries of the reserve, shown on Plan 60943 CLSR, a portion of the travelled road known as Government Road encroaches onto the reserve. There has been no formal taking from the reserve for this road. Section 6(B)(iii)

B) Dyke located on Reserve

There is no registered interest for the existing dyke located along the Squamish River through the reserve. Section 6(F)

3. Legal Description

Seaichem Indian Reserve No. 16

Legal Description of the Extent of Reserve Lands that will be subject to the Land Code of the Squamish First Nation under the First Nations Land Management Act.

Reserve Lands within the Province of British Columbia, Canada

In New Westminster District, described as follows:

Lands: a parcel bounded by;

Firstly;
The exterior rectilinear boundaries of Seaichem Indian Reserve No. 16, as shown on Plan 60943 recorded in the Canada Lands Surveys Records (CLSR), and;

The ordinary high water mark (OHWM) of the Squamish River as surveyed on Plan 60943 CLSR.

Secondly;
The exterior boundary of Seaichem Indian Reserve No. 16 as shown on Plan 94277 CLSR.

Total lands containing 3.86 hectares, (9.54 acres) more or less.

The above described Reserve Lands are subject to:

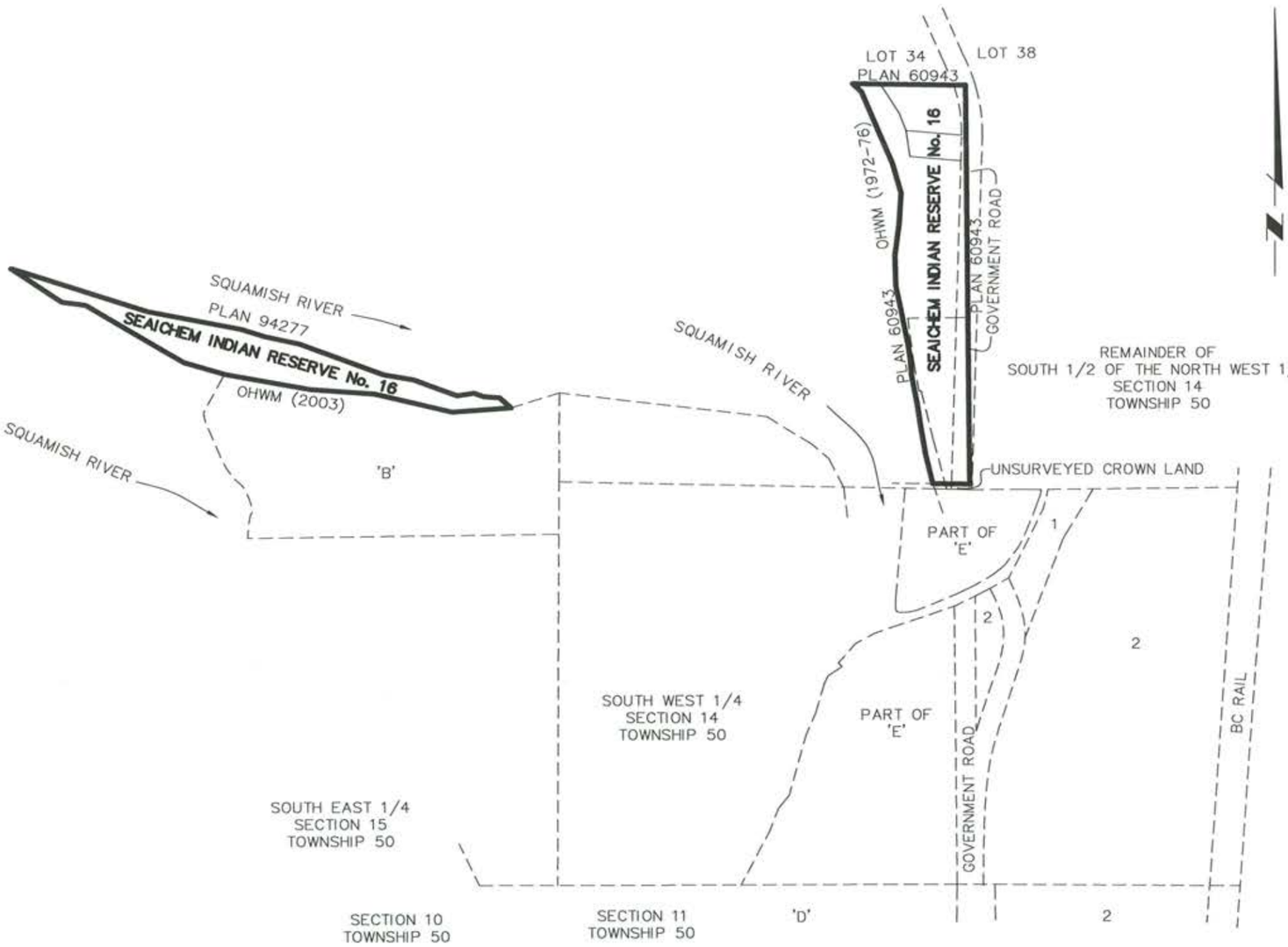
The rights and reservations contained in provincial Order in Council 1938-1036, registered in the Indian Lands Registry (ILR) as No 8042, transferring the land from the Province of British Columbia to Canada, as amended by provincial Order in Council 1969-1555, registered in the Indian Lands Registry as No. 4111-118.

Notes

1. Administrative Sketch, Section 4, illustrates this legal description.
2. Refer to the pertinent survey plans and instruments for authoritative boundary definition and nature of the interest in the land.
3. The ordinary high water mark (OHWM) of the Squamish River forms a natural boundary of the Reserve. Its location may have moved since the date that it was surveyed and may continue to move. Consequently the area of the Reserve may have changed since the date of survey and may continue to change
4. Neither the extent nor the rights of Oil and Gas are dealt with in this description.
5. Mines and minerals are managed according to the British Columbia Indian Reserves Mineral Resources Act 1943-44 c.19.

4. Administrative Sketch

(Attached)



ADMINISTRATIVE SKETCH

ILLUSTRATION OF THE DESCRIPTION OF LANDS
THAT WILL BE SUBJECT TO THE LAND CODE OF THE
SQUAMISH FIRST NATION UNDER THE FIRST NATIONS LAND
MANAGEMENT ACT.

SQUAMISH FIRST NATION

SEAICHEM INDIAN RESERVE NO. 16

NEW WESTMINSTER DISTRICT

PROVINCE OF BRITISH COLUMBIA

LAT: 49°45' LONG: 123°08'

PREPARED ON THE 16TH OF JUNE, 2008 BY STEVEN J. MINNIE, BCLS, CLS

SCALE: 1:5000 100 50 0 50 100 150 200 250 METRES

All Plan numbers are Canada Lands Surveys Records (CLSR) Plan numbers unless otherwise stated.

Reserve boundary shown thus.....

The Bank of the Squamish River forms a natural boundary of the Reserve. It's location may have moved since the date it was surveyed, and may continue to move. Consequently the area of the Reserve may have changed since the date of survey and may continue to change.

This illustration depicts the lands described in the description of lands that will be subject to the land code of the Squamish First Nation. The pertinent survey plans and instruments are to be referred to for authoritative boundary definition and the nature of the interests in the land

TABLE SHOWING HOW AREAS WERE DERIVED	
Plans	Area
60943	2.56 ha.
Plan 94277	+ 1.30 ha.
TOTAL HECTARES	3.86 ha
TOTAL ACRES	9.54 ACRES

Available From:
Natural Resources Canada
Surveyor General Branch
British Columbia Client Liaison Unit
Telephone: 604-666-5313

Natural Resources Canada Ressources naturelles Canada

5. Research

A) Indian Lands Registry Reserve General Abstract

(Attached)

Indian and Northern Affairs Canada | Affaires indiennes et du Nord Canada

INDIAN LANDS REGISTRY SYSTEM

Reserve General Abstract Report

Printed on: 2011/01/06 06:15 pm

Reserve: 07980 - SEAICHEM 16

Region/Province: British Columbia/BRITISH COLUMBIA
Band: 555 - Squamish

MINUTES OF DECISION

Instrument Date:	1876/11/27	Term:	
Registration Number:	15135	Effective Date:	
Registration Date:	1969/Nov/27	Expiry Date:	
OCPC/MO Number:		Purpose:	
		Area:	20.000 Acres
Land Affected:	NEAR LEFT BANK SKWAWMISH RIVER BELOW MOUTH OF CHEAHKAMIST RIVER		
Grantor(s):	JOINT RESERVE COMMISSION		
Grantee(s):	555 Squamish		
Remarks:	ALLOTMENT. SEE PLAN OF SURVEY REG #15252		

MINUTES OF DECISION

Instrument Date:	1916/05/13	Term:	
Registration Number:	112954	Effective Date:	
Registration Date:	1987/Jul/20	Expiry Date:	
OCPC/MO Number:		Purpose:	
		Area:	68.000 Acres
Land Affected:	ON LEFT BANK OF KOWTAIN SLOUGH SQUAMISH RIVER		
Grantor(s):	ROYAL COMMISSION		
Grantee(s):	CROWN CANADA		
Remarks:	CONFIRMS RESERVE PAGE 690		

PROV OC

Instrument Date:	1923/07/26	Term:	
Registration Number:	92925	Effective Date:	
Registration Date:	1984/Feb/20	Expiry Date:	
OCPC/MO Number:		Purpose:	
		Area:	68.000 Acres
Land Affected:	ON LEFT BANK OF KOWTAIN SLOUGH SQUAMISH RIVER		
Grantor(s):	CROWN BRITISH COLUMBIA		
Remarks:	OC #911 CONFIRMS & ACCEPTS MINUTES OF DECISION REG #112954		

INDIAN LANDS REGISTRY SYSTEM

Reserve General Abstract Report

Printed on: 2011/01/06 06:15 pm

Reserve: 07980 - SEAICHEM 16

Region/Province: British Columbia/BRITISH COLUMBIA
Band: 555 - Squamish

OCPC

Instrument Date:	1924/07/19	Term:	
Registration Number:	12073	Effective Date:	
Registration Date:	1969/Aug/11	Expiry Date:	
OCPC/MO Number:	PC #1265	Purpose:	
		Area:	68.000 Acres
Land Affected:	ON LEFT BANK OF KOWTAIN SLOUGH SQUAMISH RIVER		
Grantor(s):	CROWN CANADA		
Remarks:	PC #1265 CONFIRMS RESERVE		

PROV OC

Instrument Date:	1938/07/29	Term:	
Registration Number:	8042	Effective Date:	
Registration Date:	1969/Feb/14	Expiry Date:	
OCPC/MO Number:		Purpose:	
		Area:	68.000 Acres
Land Affected:	ON THE LEFT BANK OF KOWTAIN SLOUGH SQUAMISH RIVER CLSR BC249		
Grantor(s):	CROWN BRITISH COLUMBIA		
Grantee(s):	CROWN CANADA		
Remarks:	OC #1036 TRANSFERS MANAGEMENT & CONTROL SEE REG #4111-118		

ACT

Instrument Date:	1943/07/24	Term:	
Registration Number:	1499	Effective Date:	
Registration Date:	1968/May/09	Expiry Date:	
OCPC/MO Number:		Purpose:	
Land Affected:	WHOLE OF RESERVE		
Grantor(s):	CROWN BRITISH COLUMBIA CROWN CANADA		
Remarks:	THE BRITISH COLUMBIA INDIAN RESERVES MINERAL RESOURCES ACT RATIFIES MEMORANDUM OF AGREEMENT BETWEEN CANADA & BRITISH COLUMBIA DATED 26 JANUARY 1943 RE MINES & MINERALS		

INDIAN LANDS REGISTRY SYSTEM

Reserve General Abstract Report

Printed on: 2011/01/06 06:15 pm

Reserve: 07980 - SEAICHEM 16

Region/Province: British Columbia/BRITISH COLUMBIA
Band: 555 - Squamish

PERMIT

Instrument Date:	1969/02/07	Term:	5y 0m 0d
Registration Number:	9591-324	Effective Date:	1969/02/01
Registration Date:	1971/Nov/29	Expiry Date:	1974/01/31
OCPC/MO Number:		Purpose:	DYKE
Land Affected:	AS SHOWN OUTLINED IN RED ON SKETCH ATTACHED		
Grantor(s):	CROWN CANADA		
Grantee(s):	THE DISTRICT OF SQUAMISH		
Remarks:	TO CONSTRUCT A DYKE & OTHER EROSION CONTROL WORKS. BCR ATTACHED		

PROV OC

Instrument Date:	1969/05/13	Term:	
Registration Number:	4111-118	Effective Date:	
Registration Date:	1971/Feb/26	Expiry Date:	
OCPC/MO Number:		Purpose:	
Land Affected:	WHOLE OF RESERVE		
Grantor(s):	CROWN BRITISH COLUMBIA		
Grantee(s):	CROWN CANADA		
Remarks:	OC #1555 WAIVES REVERSIONARY INTEREST IN PROVINCIAL ORDER IN COUNCIL REG #8042		

PERMIT

Instrument Date:	2008/01/24	Term:	
Registration Number:	354909	Effective Date:	2008/01/24
Registration Date:	2008/Mar/04	Expiry Date:	
OCPC/MO Number:		Purpose:	UTILITIES
Land Affected:	AS DESCRIBED IN DOCUMENT		
Grantor(s):	CROWN CANADA		
Grantee(s):	BRITISH COLUMBIA HYDRO AND POWER AUTHORITY TELUS COMMUNICATIONS INC		

INDIAN LANDS REGISTRY SYSTEM

Reserve General Abstract Report

Printed on: 2011/01/06 06:15 pm

Reserve: 07980 - SEAICHEM 16

Region/Province: British Columbia/BRITISH COLUMBIA
Band: 555 - Squamish

SURVEY PLAN

Instrument Date:	2008/06/02	Term:	
Registration Number:	******	Effective Date:	
Registration Date:	2008/Jul/07	Expiry Date:	
OCPC/MO Number:		Purpose:	
Land Affected:	CLSR 94277		
Remarks:	SURVEY OF PART OF EXTERIOR RESERVE BOUNDARY		

--- END OF REPORT ---

B) Indian Lands Registry Review

i. Creation of Reserve Documents

1. Document No. 15135 is a true copy of the minutes of decision, dated November 27, 1876 describing the reserve as "*Skowishin – (Skwawmish Tribe) – On an island near left bank of the Skwawmish river, about three and a half miles below the mouth of the Che-ah-ka-mist river. The present village on the island being in danger on inundation, a reserve of twenty acres has been granted, in addition, for a new site. This is to contain the old graveyard, and may be twenty chains on the river and ten chains deep* ". There is no sketch included with the minutes of decision. Page 12 of Field Book FBBC 406A, prepared by E. Mohun in 1877, is a copy of the Minutes of Decision and includes a sketch of the reserve. The Field Book includes at the end of the description, "the Island is also reserved".
2. Original boundary of reserve was surveyed by E. Mohun in September of 1881 with his field notes recorded as FBBC295 CLSR and the plan recorded as BC249 CLSR. The plan shows the island portion of the reserve having 30 acres and the mainland portion having 38 acres.
3. Minutes of Decision of the Royal Commission, dated May 13, 1916 (Document No. 112954 page 690), confirm the reserve having an area of 68.00 acres as shown on the official survey plan.
4. The Royal Commission report is accepted by provincial Order in Council 1923-911 (Document No. 92925) and federal Order in Council 1924-1265 (Document No. 12073)(except lands within the railway belt). Provincial Order in Council 1938-1036 dated July 29, 1938 (Document No. 8042), transfers administration and control of the reserve to Canada. The OIC 1938-1036 lists the reserve having an area of 68.00 acres. Provincial Order in Council 1969-1555, dated May 13, 1969 (Document No. 4111-118), amends OIC 1938-1036 by waiving the province's reversionary interests.

ii. Additions to Reserve Documents

1. No Additions.

iii. Formerly Reserve Documents

1. No formal takings.

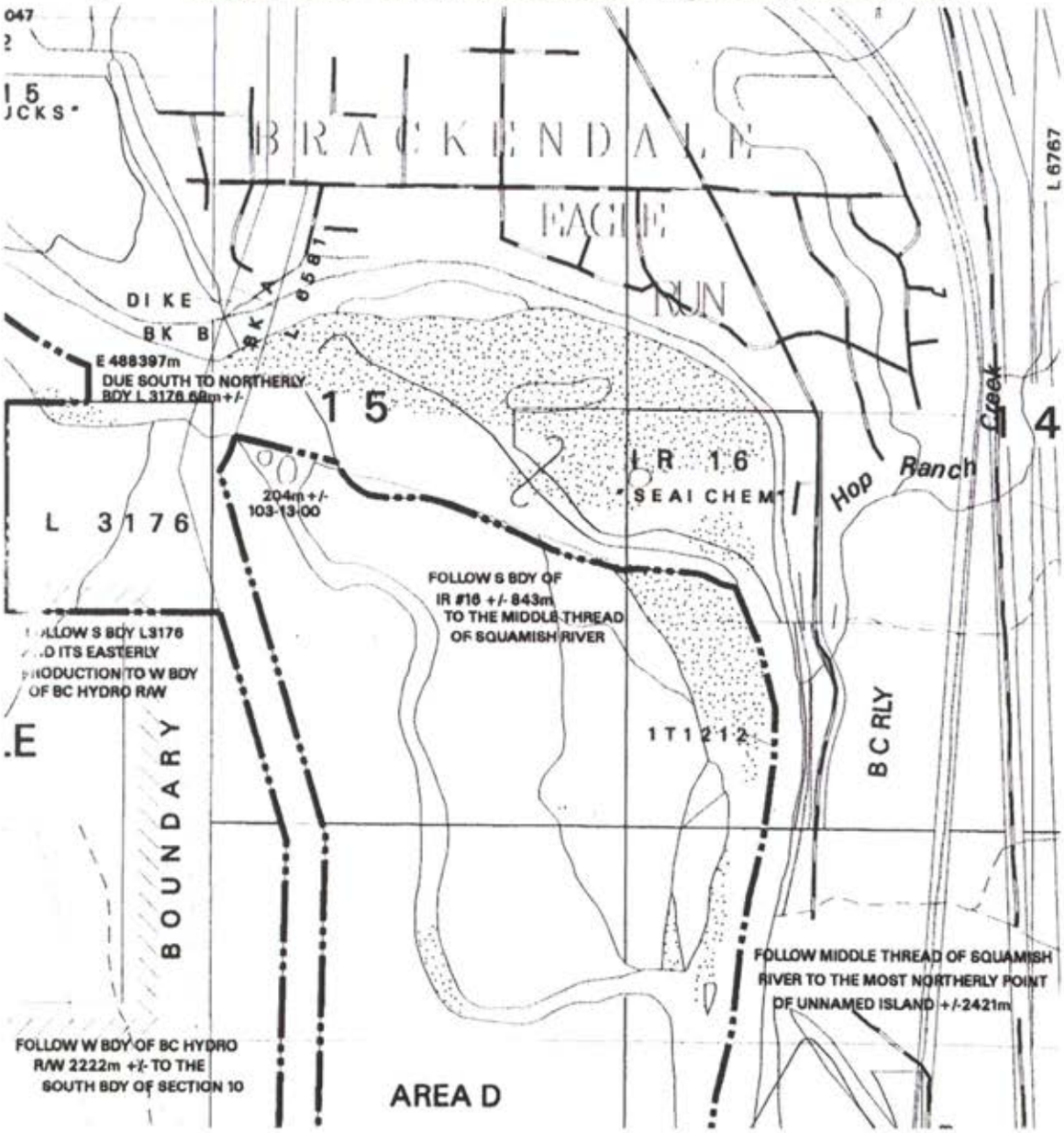
iv. Third Party Interest Documents

1. None.

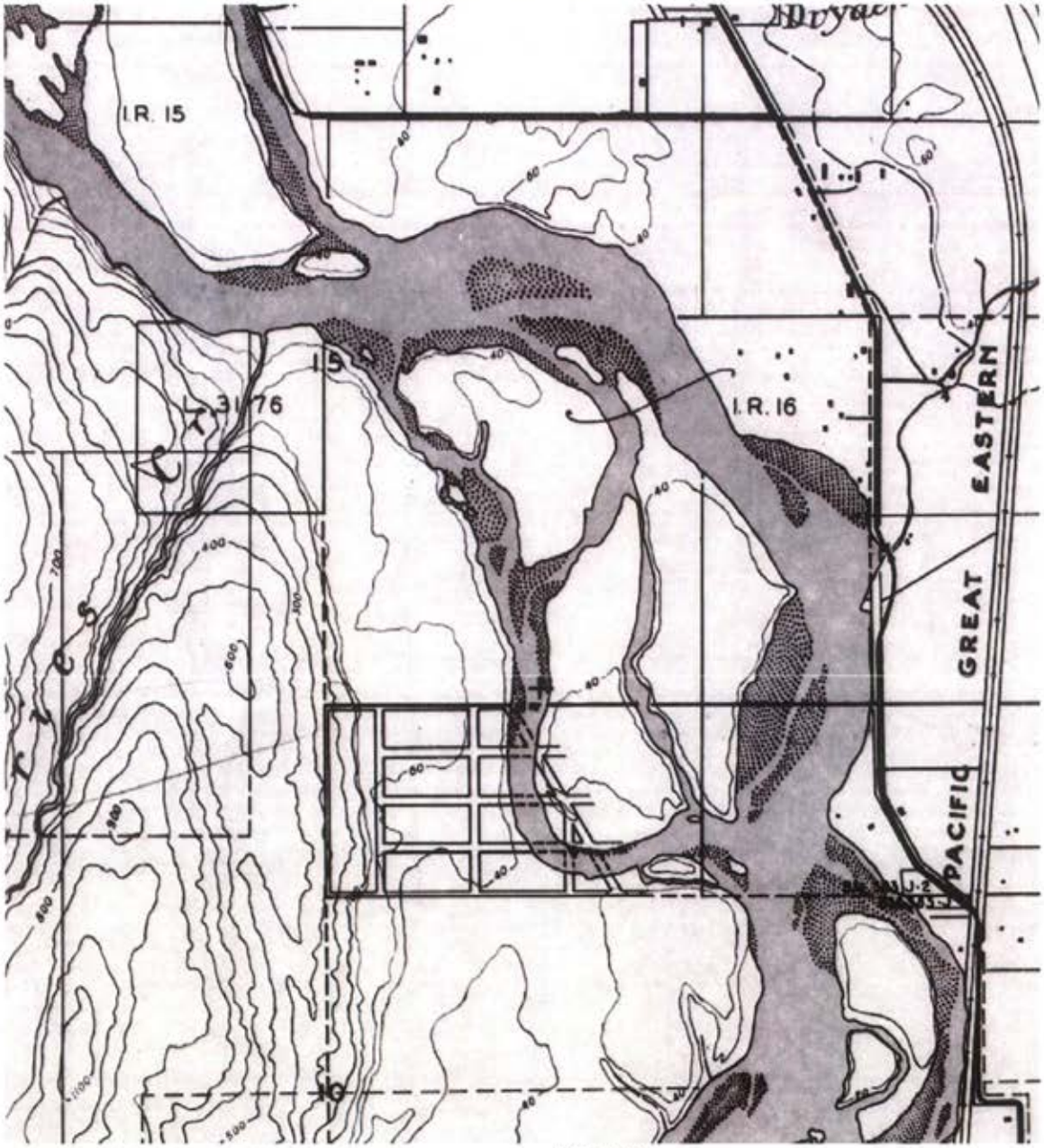
(Easements / Permits for service or distribution lines are not noted)

C) Crown Land and Land Registry Office Documents

i. Crown Land Plan of Brackendale Eagles Provincial Park



ii. 1950s Map of Squamish Valley



Aerial Photography by B.C. Government 1950.
Detailed Control Survey by S. H. de Jong, B.C.L.S., 1949.
Topography by Multiplex Section, Compilation and Drawing by Interim Map Section, Air Survey Division, 1952, Surveys and Mapping Branch, Lands Service, Department of Lands and Forests, Victoria, B.C.

Published August 1, 1952.

This map area is completely within New Westminster Land District.

LOWER
SQUAMISH VALLEY

SCALE—20 chains (1320 ft.) to 1 inch

D) Surveyor General Branch Files

i. **Minutes of Decision, Vol 3 Federal Collection**

Decision Nov. 27, 1876

Se-aich-em.

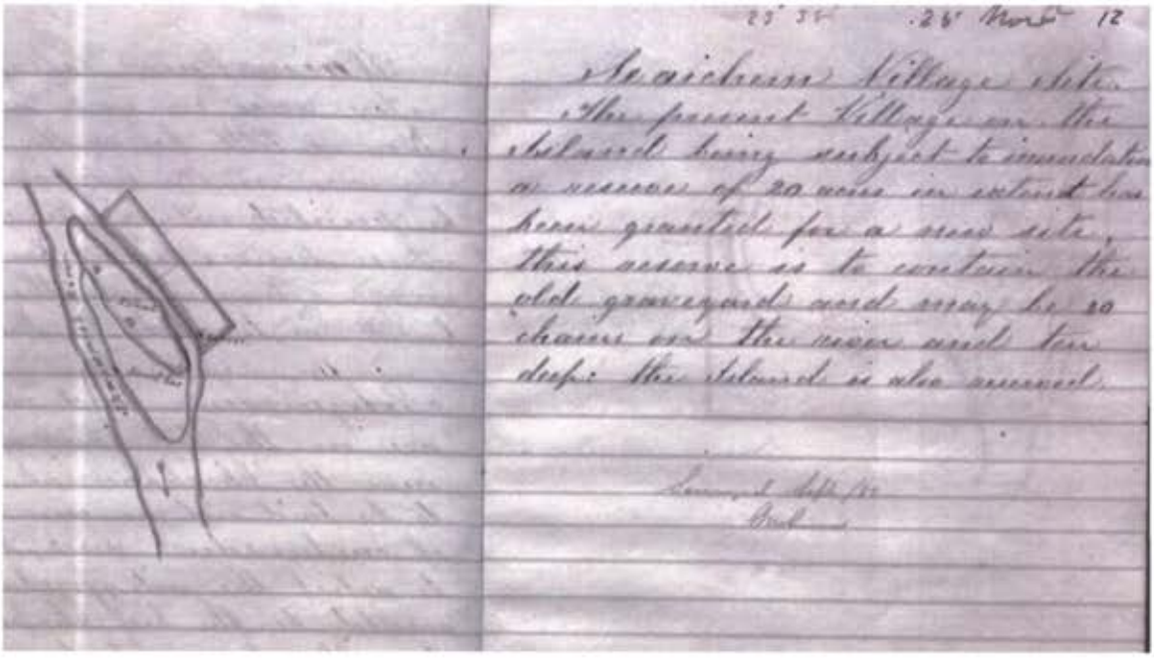
(Skwawmish Tribe.)

16 On an island, near left bank of the Skwawmish river, about three and a half miles below the mouth of the Che-ah-ka-mist river.

The present village on the island being in danger of inundation, a reserve of twenty acres has been granted, in addition, for a new site.

This is to contain the old graveyard, and may be twenty chains on the river and ten chains deep.

ii. Field Book FBBC406A, by Mohun in 1877

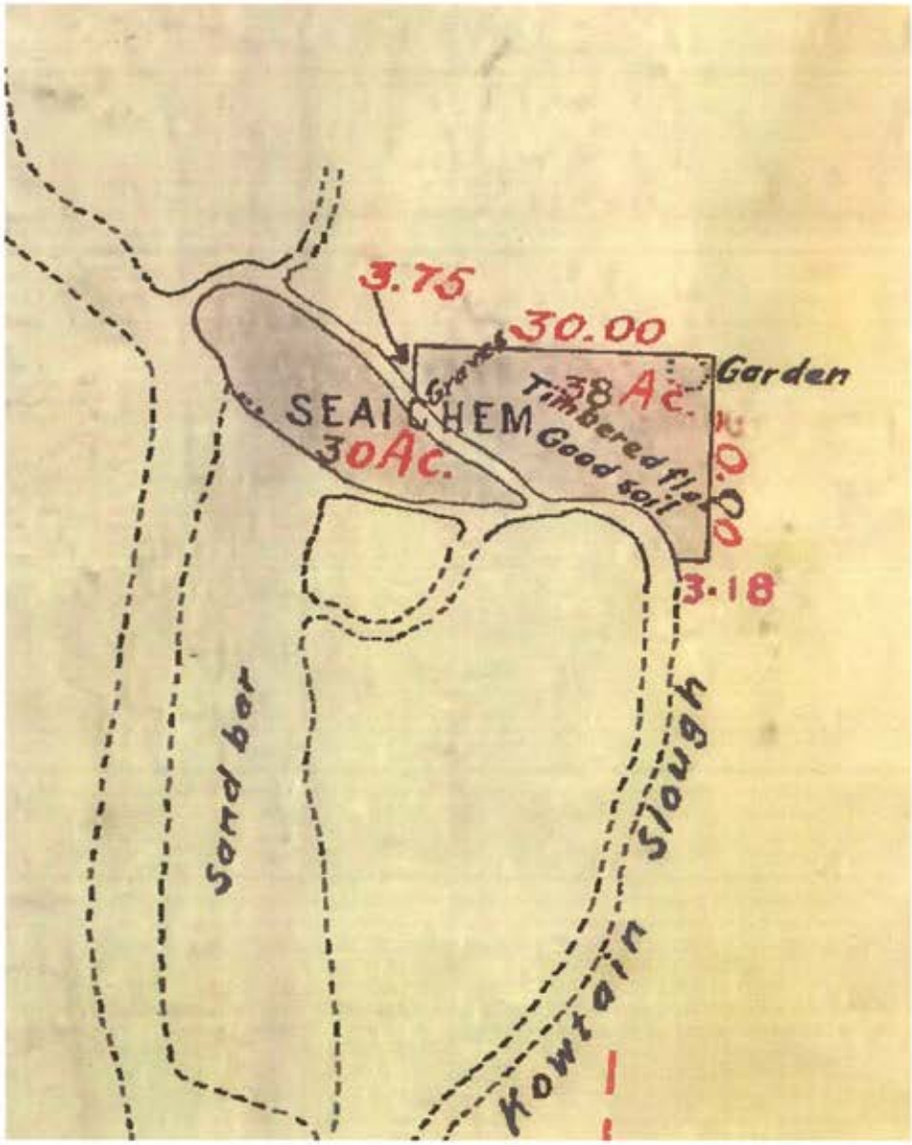


23 54 .24 Nov 12

Saiciburn Village site.
The present Village on the
Island being subject to inundation
a reserve of 20 acres in extent has
been granted for a new site,
this reserve is to contain the
old graveyard and may be 20
chains on the river and ten
deep. The Island is also surveyed.

Surveyed Sept 12
Mohun

iii. Plan BC 249 CLSR



iv. Survey Records Index Report

(Attached)

Plan Search Results

Total Records: 14 | PAGE: 1 Of 1

BC249 CLSR BC

Download [TIFF 173 KB]

Surveyor:	MOHUN, E.
Surveyed:	1881-01-01
Canada Land(s):	MAMAQUUM ISLAND 20 AHTSAM 23 SKWULWAILUM 22 SQUAMISH ISLAND 21 CHEAKAMUS 11 YOOKWITZ 12 POQUIOSIN & SKAMAIN 13 WAIWAKUM 14 AIKWUCKS 15 SEAICHEM 16 KOWTAIN 17 YEKWAUPSUM 18 YEKWAUPSUM 19 STAWAMUS 24
Description:	MUTILATED, TBC249 IS OFFICIAL PLAN.;CANVAS
Related Documents:	

TBC249 CLSR BC

Download [TIFF 180 KB]
Download [DJVU 549 KB]

Surveyor:	MOHUN, E.
Surveyed:	1881-01-01
Canada Land(s):	MAMAQUUM ISLAND 20 AHTSAM 23 SKWULWAILUM 22 SQUAMISH ISLAND 21 CHEAKAMUS 11 YOOKWITZ 12 POQUIOSIN & SKAMAIN 13 WAIWAKUM 14 AIKWUCKS 15 SEAICHEM 16 KOWTAIN 17 YEKWAUPSUM 18 YEKWAUPSUM 19 STAWAMUS 24
Description:	SQUAMISH IR's 11-24, SIGNED FC GREEN
Related Documents:	L249 BCSG BC

FBBC295 CLSR BC

Download [DJVU 1479 KB]

Surveyor:	MOHUN, E.
Surveyed:	1881-01-01
Canada Land(s):	MAMAQUUM ISLAND 20 WAIWAKUM 14 SEAICHEM 16

KOWTAIN 17
YEKWAUPSUM 18
YEKWAUPSUM 19

Description: VOL 3 FN's FOR IR's 14 & 16-20 ON TBC249

Related Documents:

FBBC406A CLSR BC

Download [DJVU 1925 KB]

Surveyor: MOHUN, E.

Surveyed: 1877-01-01

Canada Land(s):
KITSILANO 6
MAMAQUUM ISLAND 20
AHTSAM 23
MUSQUEAM 1
SKWULWAILUM 22
SQUAMISH ISLAND 21
BURRARD INLET 3
SECHELT LANDS NO. 1
SECHELT LANDS NO. 2
SECHELT LANDS NO. 4
SECHELT LANDS NO. 6
SECHELT LANDS NO. 7
SECHELT LANDS NO. 8
SECHELT LANDS NO. 9
SECHELT LANDS NO. 10
SECHELT LANDS NO. 11
SECHELT LANDS NO. 12
SECHELT LANDS NO. 13
SECHELT LANDS NO. 14
SECHELT LANDS NO. 15
SECHELT LANDS NO. 16
SECHELT LANDS NO. 17
SECHELT LANDS NO. 18
SECHELT LANDS NO. 19
SECHELT LANDS NO. 20
MISSION 1
SEYMOUR CREEK 2
CAPILANO 5
SKOWISHIN 7
CHEAKAMUS 11
YOOKWITZ 12
POQUIOSIN & SKAMAIN 13
WAIWAKUM 14
AIKWUCKS 15
SEAICHEM 16
KOWTAIN 17
YEKWAUPSUM 18
YEKWAUPSUM 19
STAWAMUS 24
KAIKALAHUN 25
CHEKWELP 26
SEA ISLAND 3

Description: COMMISSIONER'S ROUGH FN's ON IR's NEAR VANCOUVER

Related Documents:

FBBC408A CLSR BC

Download [DJVU 3062 KB]

Surveyor: MOHUN, E.

Surveyed: 1881-01-01

Canada Land(s):
POPLAR ISLAND
SKOWISHIN 7
CHEAKAMUS 11
YOOKWITZ 12
POQUIOSIN & SKAMAIN 13
WAIWAKUM 14
AIKWUCKS 15
SEAICHEM 16
KOWTAIN 17
STAWAMUS 24

Description: TRAVERSES OF HOWE SOUND & FRASER R. IR's

Related Documents:

FBBC411A CLSR BC

Download [DJVU 948 KB]

Surveyor: UNKNOWN,

Surveyed: 1878-01-01

Canada Land(s):
KITSILANO 6
SKWULWAILUM 22
SQUAMISH ISLAND 21
COWICHAN 1
HALALT 2
LYACKSON 3
GABRIOLA ISLAND 5
QUALICUM
INLAILAWATASH 4
SECHELT LANDS NO. 4
SECHELT LANDS NO. 6
SECHELT LANDS NO. 7
SECHELT LANDS NO. 8
SECHELT LANDS NO. 9
SECHELT LANDS NO. 10
SECHELT LANDS NO. 11
SECHELT LANDS NO. 12
SECHELT LANDS NO. 13
SECHELT LANDS NO. 15
SECHELT LANDS NO. 16
SECHELT LANDS NO. 18
SECHELT LANDS NO. 19
SECHELT LANDS NO. 20
SECHELT LANDS NO. 25
SEYMOUR CREEK 2
CAPILANO 5
SKOWISHIN 7
CHEAKAMUS 11
YOOKWITZ 12
POQUIOSIN & SKAMAIN 13
WAIWAKUM 14
AIKWUCKS 15
SEAICHEM 16
KOWTAIN 17
YEKWAUPSUM 18
KAIKALAHUN 25
SEA ISLAND 3

	Description:	ROUGH FN's & REPORTS ON BDYs OF MANY IR's
	Related Documents:	
FB1877EM CLSR BC	**Surveyor:**	MOHUN, E.
	Surveyed:	1877-01-02
	Canada Land(s):	KITSILANO 6 SKWULWAILUM 22 SQUAMISH ISLAND 21 OYSTER BAY 12 CHEMAINUS 13 HALALT 2 LYACKSON 3 SHINGLE POINT 4 NANAIMO TOWN 1 GABRIOLA ISLAND 5 NANOOSE TSUSSIE 6 PENELAKUT ISLAND INDIAN RESERVE NO. 7 TENT ISLAND 8 COMOX 1 INLAILAWATASH 4 SECHELT LANDS NO. 1 SECHELT LANDS NO. 6 SECHELT LANDS NO. 6A SECHELT LANDS NO. 7 SECHELT LANDS NO. 8 SECHELT LANDS NO. 9 SECHELT LANDS NO. 10 SECHELT LANDS NO. 11 SECHELT LANDS NO. 12 SECHELT LANDS NO. 12A SECHELT LANDS NO. 15 SECHELT LANDS NO. 16 SEYMOUR CREEK 2 SKOWISHIN 7 SKOWISHIN GRAVEYARD 10 CHEAKAMUS 11 YOOKWITZ 12 POQUIOSIN & SKAMAIN 13 WAIWAKUM 14 SEAICHEM 16 KOWTAIN 17 YEKWAUPSUM 18 YEKWAUPSUM 19 STAWAMUS 24 SEA ISLAND 3
	Description:	WORK DONE IN BC- 1876-77
	Related Documents:	
3302R RSBC BC Download [TIFF 214 KB]	**Surveyor:**	CLENDENNING, R.D.
	Surveyed:	2000-10-26
	Canada Land(s):	SEAICHEM 16
	Description:	REG PL & FNS OF LTS 3,4, & 5 (RD)

	Related Documents:	
FB32481 CLSR BC	**Surveyor:**	COLLINS, M.H.
	Surveyed:	1976-01-01
Download [DJVU 642 KB]	**Canada Land(s):**	SEAICHEM 16
	Description:	AIR PHOTO OF IR 16, SUPPORT FOR 60943
	Related Documents:	
FB32482 CLSR BC	**Surveyor:**	VARIOUS,
	Surveyed:	
Download [DJVU 2226 KB]	**Canada Land(s):**	SEAICHEM 16
	Description:	SUP FOR 60943, Tp., RDs & D.L.'s
	Related Documents:	
60943 CLSR BC	**Surveyor:**	COLLINS, M.H.
	Surveyed:	1976-01-01
Download [TIFF 207 KB]	**Canada Land(s):**	SEAICHEM 16
	Description:	RESURV OF PART RECT (PART N & S & E) BDYs
	Related Documents:	MIS16773 LTOVA BC
66839 CLSR BC	**Surveyor:**	DRAFTING,
	Surveyed:	1980-01-01
	Canada Land(s):	WAIWAKUM 14 AIKWUCKS 15 SEAICHEM 16
	Description:	REFERENCE PLAN - SUPERSEDED
	Related Documents:	
80519 CLSR BC	**Surveyor:**	MACDONALD, P.C.
	Surveyed:	1997-01-24
Download [TIFF 129 KB]	**Canada Land(s):**	SEAICHEM 16
	Description:	L.'s 1 & 2
	Related Documents:	
94277 CLSR BC	**Surveyor:**	MACDONALD, P.C.
	Surveyed:	2003-02-24
Download [TIFF 221 KB]	**Canada Land(s):**	SEAICHEM 16
	Description:	PLAN AND FIELD NOTES OF SURVEY OF PART OF THE EXTERIOR BOUNDARY OF SEAICHEM INDIAN RESERVE NUMBER 16 BRITISH COLUMBIA
	Related Documents:	BCP 36891

v. Survey Instructions for Survey of Island Portion of Reserve

Natural Resources Canada
Ressources naturelles Canada

Legal Surveys Division
1501- 1138 Melville Street
VANCOUVER, British Columbia
V6E 4S3
Telephone/Téléphone: (604) 666-5313
Fax/Télécopieur: (604) 666-0522

Division des Levés Officiels
1501-1138, rue Melville
VANCOUVER, Colombie Brittanique
V6E 4S3

Your file / Votre référence

Date of Issue: January 17, 2003
SSR No. 02049

Our file / Notre référence
SM8210-07980

Direct Survey Instructions - Project 2002 10 158
(Quote the Project Number on all correspondence)

Issued to: **Cam MacDonald, CLS, BCLS**
Hobbs, Winter & MacDonald
113-828 Harbourside Drive
North Vancouver, BC, V7P 3R9

Description: Plan and Field Notes of
Survey of Part of the Exterior Boundary of
Seaichem IR 16
New Westminster District
British Columbia
BCGS No.92G.075

Plan Required: Official Plan under Section 29 of the Canada Lands Surveys Act. (Prepare Field Notes in the most suitable plan form for clarity and completeness)

Statutory Authority And Instructions: Canada Lands Surveys Act and the Manual of Instructions for the Survey of Canada Lands - (**Third Edition**).

Field Liaison: You must obtain permission to enter the Indian Reserve: See Chapter C5:29 of the Manual.

1) Ruth Nahanne, Land Policy Office
Squamish Nation
P.O. Box 86131
320 Seymour Blvd
North Vancouver, BC, V7L 4J5
Tel 604-980-4553
Fax 604-980-4180

2) Steve Minnie, B.C. Client Liaison Unit, Legal Surveys Division, Natural Resources Canada. He is to be consulted regarding survey matters at 604-666-3517
Fax: 604-666-0522

Purpose: First Nation Land Management Act implementation

Special Remarks: These Instructions are for the survey of part of the natural boundaries of the reserve. If there is conflict between the band's requirements and these instructions contact this office before proceeding.

Canada

Geomatics Canada • Géomatique Canada
Earth Sciences Sector • Secteur des sciences de la Terre

The location of the natural boundary must be surveyed in accordance with sections 76 to 81 of the Manual of Instructions. The plan shall include the relative local coordinates or UTM coordinates of the natural boundary, preferably in table format.

Thorough research must be undertaken to determine the true natural boundary of the reserve. This research must include a review of historical aerial photos, existing survey plans and reports of the reserve and of abutting fee simple properties, and a ground inspection of the area. Details of this research and reasoning behind the conclusions drawn must be included in the Survey Report.

The surveyor should be aware there may be areas of the natural boundary that have changed significantly from the boundaries shown on the original survey. These changes may be the result of natural accretion and erosion, man made dykes, or the result of the river jumping its channel. In the case of natural accretion or erosion the surveyor must include adequate information in the Survey Report to justify this opinion.

For the purposes of illustrating significant changes in the natural boundary of the reserve, the Survey Report must include a series of historical aerial photos and surveys that show the changes in the boundary over time. An example of the presentation of such a series of photos is included in the Survey Report included in the supporting information. This series of photos is only for illustrative purposes and may be scanned from hardcopy photos. It may be beneficial to add the final surveyed boundary and comments as an overlay to the photos.

The Survey Report prepared with this survey shall include details regarding any encroachments over the reserve boundary.

Any significant permanent feature near a monument placed or a boundary being surveyed must be tied in and shown on your plan and field notes, as per Chapter D1, Section 95 (i).

Returns must also include copies of any relevant research information acquired that was not initially provided by Legal Surveys Division. This includes any provincial Land Title Office or Crown Land plans.

It is our preference, and the prescribed CLS practise, that all posts be marked, however if you feel that it is impractical to mark BCLS standard iron posts, then you will not be required to do so.

Returns Required:

You must submit the survey returns as required in Chapter D1 Section 123 and D15 of the manual. The returns are to be sent to the address listed below for examination and should include three (3) copies of your survey report; eight (8) prints of combined plan and field notes or eight (8) prints of the plan and four (4) of the field notes are required. Paper prints are to be folded, preferably, to fit 8.5 x 14" in size and sent to:

Submit your Returns by March 1, 2003
S.L. Howard, Head, Cadastral Survey Services
Western Regional Operations Centre,
9700 Jasper Avenue, Suite 605, Edmonton Alberta, T5J 4C3
Phone: (780) 495-7347 Fax: (780) 495-4052

Please note: One of the plan prints must be signed, dated, sealed and have a sticker affixed per ACLS requirements. A completed ACLS Monument Surcharge Report Form is also required.

Submit your final invoice to Head, BC Client Liaison Unit as per Appendix B of the Articles of Agreement

NOTE: It is the surveyor's responsibility to obtain all the other necessary information required to carry out this survey. You can order plans online at www.lsd.nrcan.gc.ca or by contacting our Records room at (604) 666-5329 for additional information.

Blair Smith, CLS, BCLS
Head, B.C. Client Liaison Unit

Date: January 17 2003

vi. Survey Report for Plan Prepared by C.MacDonald BCLS, CLS under Project No. 2002-10-158

Hobbs, Winter & MacDonald
BRITISH COLUMBIA LAND SURVEYORS
CANADA LANDS SURVEYORS
~~200-1100 East Third Street, North Vancouver, B.C. V7J 1B8~~ • Phone 604-986-1371 Fax 604-986-5204 Email: hwmsurveys@telus.net
113-828 Harbourside Drive, North Vancouver, B.C. V7P 3R9

ALLAN WINTER, B.C.L.S.
CAM MacDONALD, B.C.L.S., C.L.S.
DAN MACHON, B.C.L.S.

Your File: SM8210-07980

Project: 2002 10 158

SURVEY REPORT

Plan and Field Notes of
Survey of part of the Exterior Boundary of Seaichem Indian Reserve No.16
British Columbia
BCGS 92G.075

This Survey was initiated at the request of Steve Minnie C.L.S., B.C.L.S., O.L.S. (Ret) of the Legal Survey Division of Natural Resources Canada in Vancouver. The purpose of the Survey is to determine the Boundary of what is left of a portion of Indian Reserve No.16, namely an Island in the Squamish River.

The Island in question lies between two branches of the Squamish River. The Easterly branch of the two is the larger, and is diked on its Easterly bank. The Westerly branch is a narrower secondary branch.

The site is flat. There is an evident top of bank, which rises sharply 1 to 2 metres above the rocks and silt of the river channel. There are 2 to 5 centimetres of topsoil on the site. Beneath that is river silt. The site is forested with cottonwood (20 - 50 cm diameter), alder (10 - 30 cm diameter) and a few cedar (to 20 cm diameter).

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BACKGROUND (Survey)

Seaichem Indian Reserve No.16 was originally surveyed in 1881 by E. Mohun (Plan TBC 249, depicting the area surveyed, is enclosed). The surrounding lands (Township 50) were surveyed in 1889. A Plan depicting the area surveyed in the Township Survey is Plan 1728 (portion of Plan enclosed) in the Vancouver Land Title Registry. Portions of Township 50 were Crown Granted, and subsequent surveys were done to create Titles to portions of Sections 14 and 15, Township 50. Two surveys of note are Reference Plan 651 and Reference Plan 866 (both enclosed) Vancouver Land Title Registry). Both of these surveys lie immediately South of the Island portion of Seaichem Indian Reserve No.16 surveyed in 1881.

METHODOLOGY

The 1881 Field Notes were plotted, and there was relatively small mathematical misclosure of 2.7 metres found in closing the traverse. From the traverse, the 1881 bank of the Island was plotted.

I next attempted to reconstruct the boundaries of Reference Plan 651 and Reference Plan 866. The survey for Reference Plan 651 is based on the Section corner between Sections 10, 11, 14 and 15. The Surveyor found the old bearing trees from 1889, set a post at the Section corner and ran the line to the North-East corner of Section 15. He planted a post at the South-East corner of Lot "B" (the subject of the survey) and planted posts on the South bank of the Indian Reserve No.16 Island.

In Reference Plan 866, the Surveyor found the old post on the South bank of the Indian Reserve No.16 Island, and created a parcel to the East of Reference Plan 651. It is interesting to note that the 1881 Field Notes refer to a slough lying South of the Indian Reserve No.16 Island, and both Reference Plan 651 and Reference Plan 866 done in 1912 and 1913 respectively, also show a slough lying South of the Indian Reserve No.16 Island. The question arises: how well does the position of the bank of the slough, surveyed in 1889, compare to the 1912 and 1913 surveys?

To answer this question, I located survey evidence East of the Squamish River, and to the South of Indian Reserve No.16. There is a Survey Plan, Reference Plan 865 (enclosed) done in 1913, which shows the relationship between the Section 14/15 Section line, and the B.C. Rail Line to the East. We located survey evidence in the area, as shown on the enclosed Plan and Field Notes. There is a very tight correspondence between modern survey evidence and the angles and distances as shown on Reference Plan 865. Therefore, I was able to arrive at a confident search position for the Section corner between Sections 10, 11, 14 and 15. The search proved to be successful, turning up bearing trees from 1881. A capped iron post (type 4 B.C.L.S.) was set at the Section corner.

. . . . 3

METHODOLOGY (continued)

Based upon the Section corner position, and the line of the Section shown on Reference Plan 865, I have plotted the positions of Reference Plan 651 and Reference Plan 866, including the bank of the slough as shown on those Plans. The plotting of this bank matches extremely well with the plotting of the 1881 bank position.

In the field, we traversed more or less through the position of the old slough until we came out to the branch of the river lying West of the Island. We located the water line of the river to the West of the Island, and the ordinary high water mark of the river on the North side of the Island. This information is shown on the enclosed Plan and Field Notes.

ADJOINING TITLES

There are Certificates Of Title (enclosed) for the lands depicted on Reference Plan 651 and Reference Plan 866. The bold outline on Reference Plan 651 goes to the North bank of the slough (ie: the Southerly limit of the Indian Reserve No.16 Island). There is some question as to whether or not the slough is included in the title of Reference Plan 651, as the Plan accompanying the Crown Grant (Crown Grant 2588/101) (Plan enclosed) shows the slough marked in blue. If the slough is not included in the title to Reference Plan 651, then it would have remained Provincial Crown Land.

ACCRETION ISSUE

The area which was slough is now dry land. As well, to the West of Reference Plan 651, there is land lying South of the 1881 boundary. Is there a case to be made that these are lands which have accreted to the Island portion of Indian Reserve No.16? We have examined this area for traces of the banks of the slough, and found none. Examining the aerial photo from 1936 - 40 shows the Island broken up by several channels of the river. Therefore, the slough was probably wiped out at this time (or perhaps sooner). In my opinion, any land now present where the slough used to be cannot be considered accretion (regardless of whether or not it is in the Title to Lot "B", Reference Plan 651). Land is there by virtue of the river changing its course, and filling in the slough. I believe this to be the case for the portion of land now lying in what was the Squamish River in 1889. As well, examining the series of photos from 1936 - 40 to 1996 (enclosed), it is apparent the river has changed its course often, with dramatic results. Land has been wiped out. Land appears where no land was before, and if it stays put for a few years, vegetation takes hold. I do not believe this situation is conducive to accretion taking place.

. . . . 4

ACCRETION ISSUE (continued)

The process of accretion must be gradual and imperceptible. Examining the aerial photos suggests a gradual and imperceptible process has not taken place. In addition, the growth of the accretion must be outward from the bank. There is no evidence that such an outward growth has taken place. To the contrary, there is an abrupt top of bank present, bearing no sign of accretion. Therefore, I have defined what is left of the Island portion of Seaichem Indian Reserve No.16 to be that portion of land lying between the present ordinary high water mark of the Squamish River (to the North) and the top of bank from the 1881 Field Notes of the Survey of Indian Reserve No.16 (to the South).

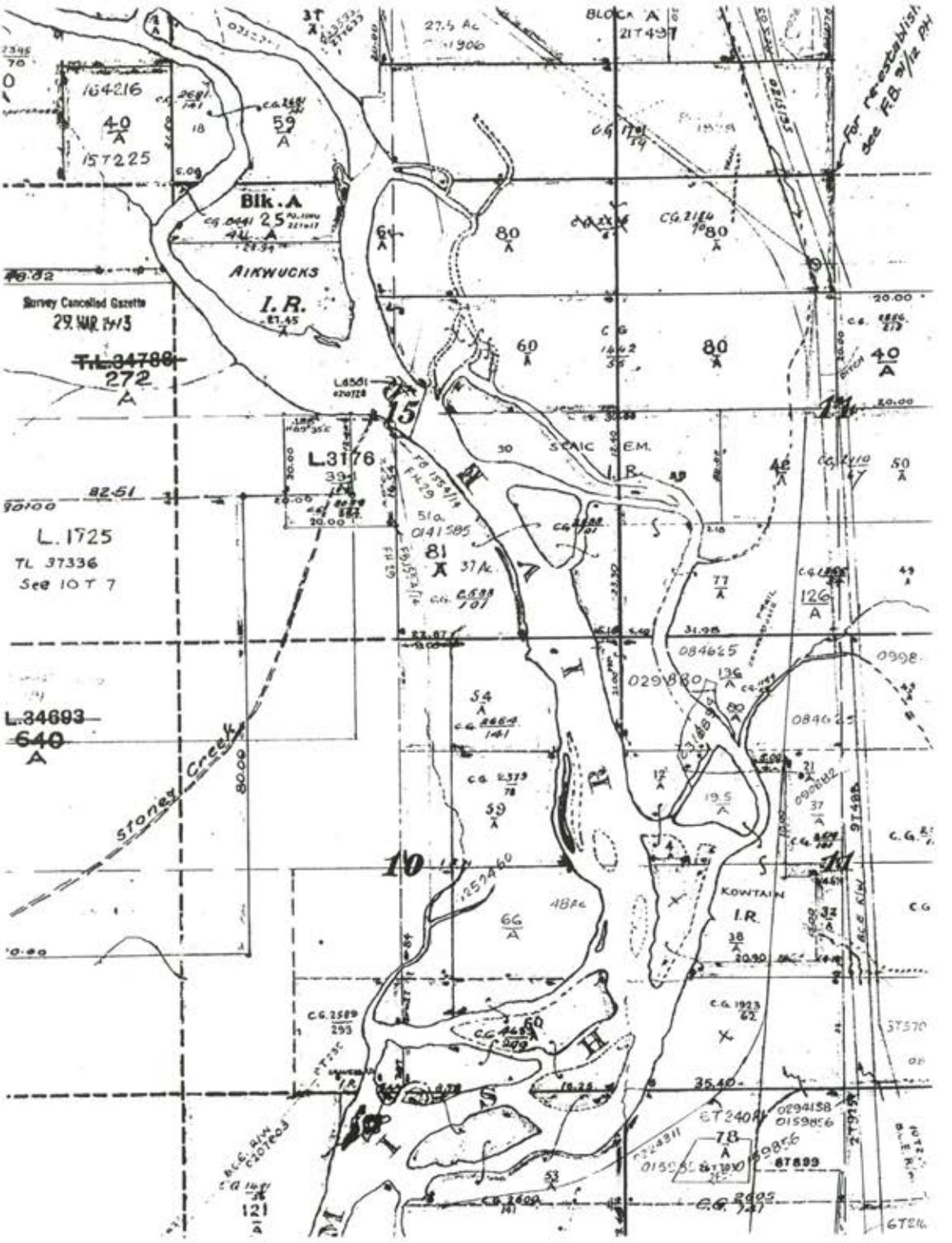
C. MacDonald

P.C. MacDonald, C.L.S., B.C.L.S.

26 February 2003

Date

. . . . 5

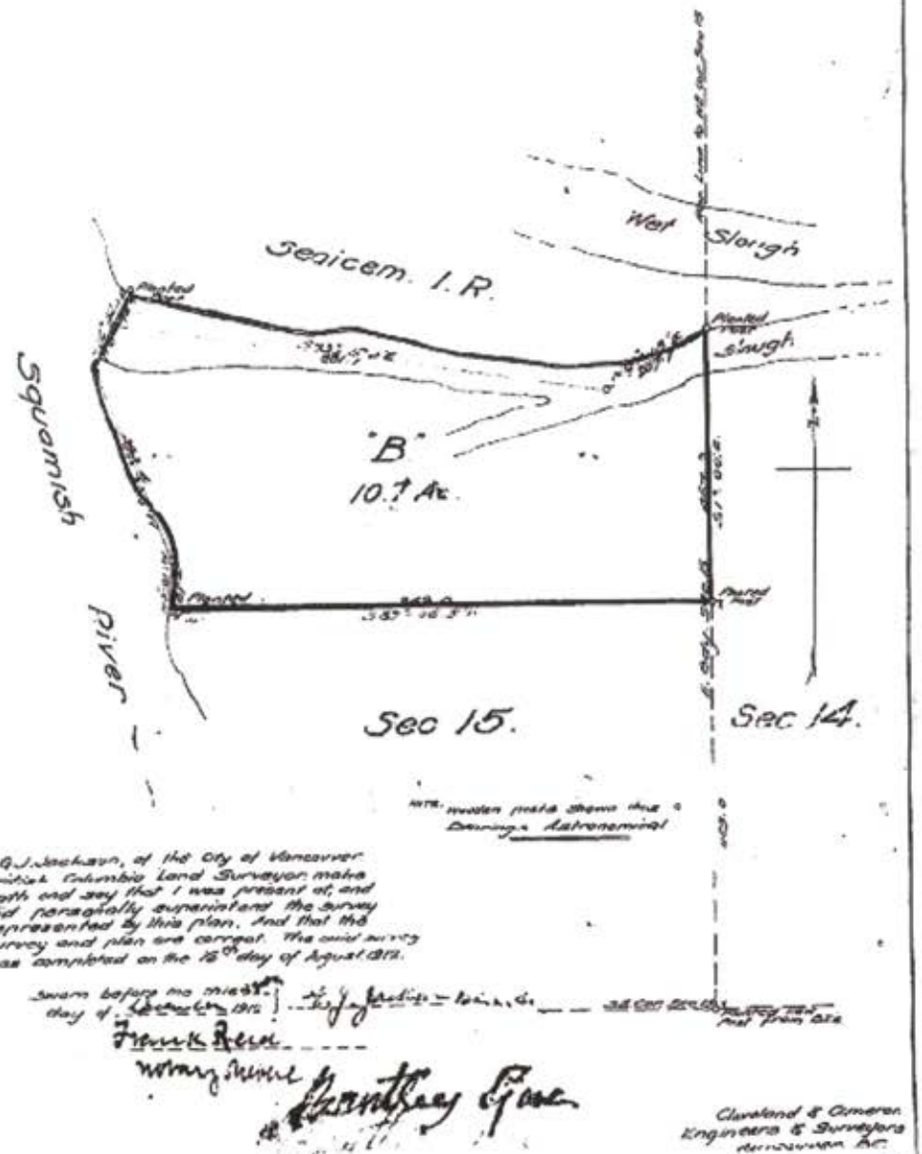

Blk. A
AIKWUCKS
I.R.
Survey Cancelled Gazette
29 MAR 1913
L.1725
TL 37336
See IOT 7
L.34693
640
Stoney Creek
L3176
KOWTAIN
I.R.
for re-establish
see F.B. 9/12 PH

151

PLAN OF

Part of SE¼ Sec 15. Tp 50. N.W.D.

Scale: 200 feet - 1 inch.



NOTE: Wooden posts shown thus ○
Bearings Astronomical

I, G.J. Jackson, of the City of Vancouver, British Columbia Land Surveyor make oath and say that I was present at, and did personally superintend the survey represented by this plan, and that the survey and plan are correct. The said survey was completed on the 18th day of August 1911.

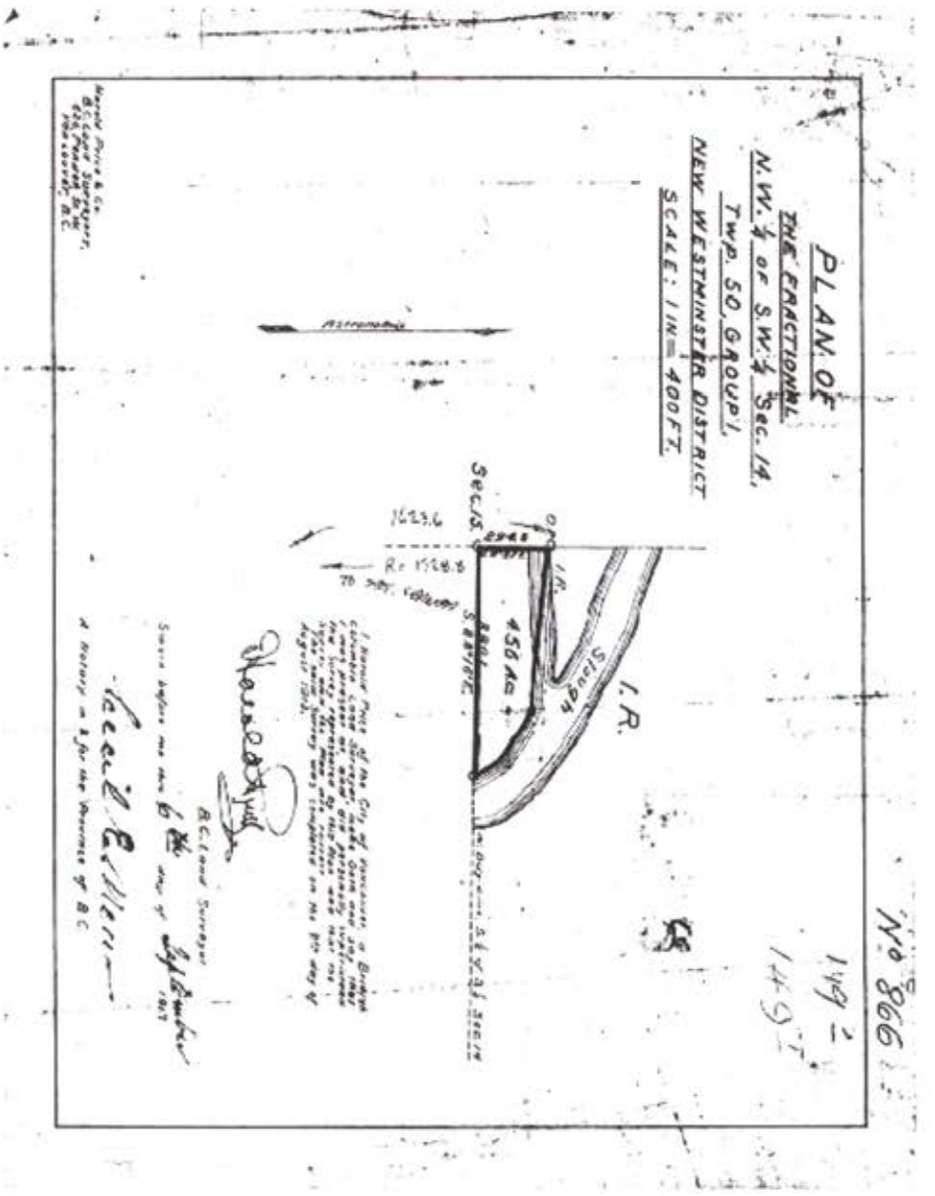
Sworn before me at [illegible] this [illegible] day of [illegible] 1911.

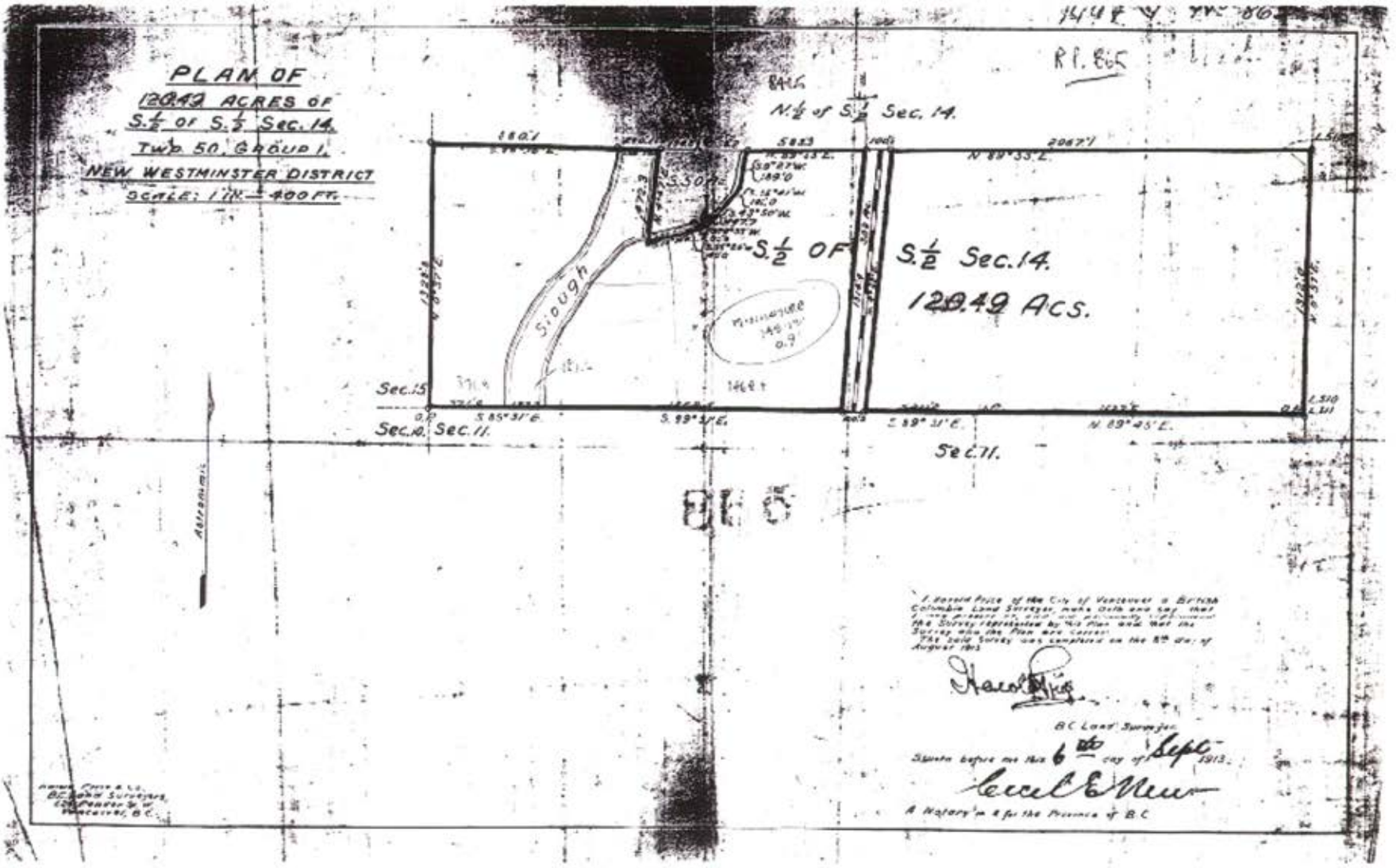
Frank Read

A Notary Public in and for the Province of British Columbia

G.J. Jackson

Cleveland & Cameron
Engineers & Surveyors
Vancouver, B.C.


PLAN OF
INC. FRACTIONAL
N.W. ¼ OF S.W. ¼ SEC. 14,
TWP. 50, GROUP 1,
NEW WESTMINSTER DISTRICT
SCALE: 1 IN = 400 FT.
Sec 13
Sec 14
I.R.
Slough
I.R.
No 866


PLAN OF
12049 ACRES OF
S.½ OF S.½ SEC. 14.
TWP 50. GROUP 1.
NEW WESTMINSTER DISTRICT
SCALE: 1 IN. = 400 FT.
N.½ of S.½ Sec. 14.
S.½ OF S.½ Sec. 14.
12049 ACS.
Slough
Sec. 15
Sec. 10.
Sec. 11.
Sec. 11.
I, Harold Price of the City of Vancouver a British Columbia Land Surveyor, make Oath and say that
August 1913
BC Land Surveyor
Sworn before me this 6th day of Sept. 1913.
A Notary Public for the Province of B.C.

Date: 03/02/05 TITLE SEARCH PRINT - VANCOUVER Time: 08:54:28
Requestor: (PC13025) HOBBS, WINTER & MACDONALD Page: 001
TITLE - BP78931

VANCOUVER LAND TITLE OFFICE TITLE NO: BP78931
FROM TITLE NO: 149I

APPLICATION FOR REGISTRATION RECEIVED ON: 06 APRIL, 2000
ENTERED: 11 APRIL, 2000

REGISTERED OWNER IN FEE SIMPLE:
EDWARD BALL
ROBERT BALL
IN TRUST

TAXATION AUTHORITY:
DISTRICT OF SQUAMISH

DESCRIPTION OF LAND:
PARCEL IDENTIFIER: 024-342-777
FRACTIONAL NORTH WEST 1/4 OF THE SOUTH WEST 1/4 OF SECTION 14 TOWNSHIP 50
SHOWN ON REFERENCE PLAN 866 NEW WESTMINSTER DISTRICT

LEGAL NOTATIONS:

FRACTIONAL NORTH WEST 1/4 OF THE SOUTH WEST 1/4 SECTION 14 IN
REFERENCE PLAN 866, FORFEITED TO CROWN SEE DF14680

CHARGES, LIENS AND INTERESTS:
NATURE OF CHARGE
CHARGE NUMBER DATE TIME

TAX SALE NOTICE
67745 1924-12-09 10:00
REMARKS: FRACTIONAL NORTH WEST 1/4 OF THE SOUTH WEST 1/4 OF
SECTION 14 IN REFERENCE PLAN 866

"CAUTION - CHARGES MAY NOT APPEAR IN ORDER OF PRIORITY. SEE SECTION 28, L.T.A."

DUPLICATE INDEFEASIBLE TITLE: NONE OUTSTANDING

TRANSFERS: NONE

PENDING APPLICATIONS: NONE

*** CURRENT INFORMATION ONLY - NO CANCELLED INFORMATION SHOWN ***

British Columbia.

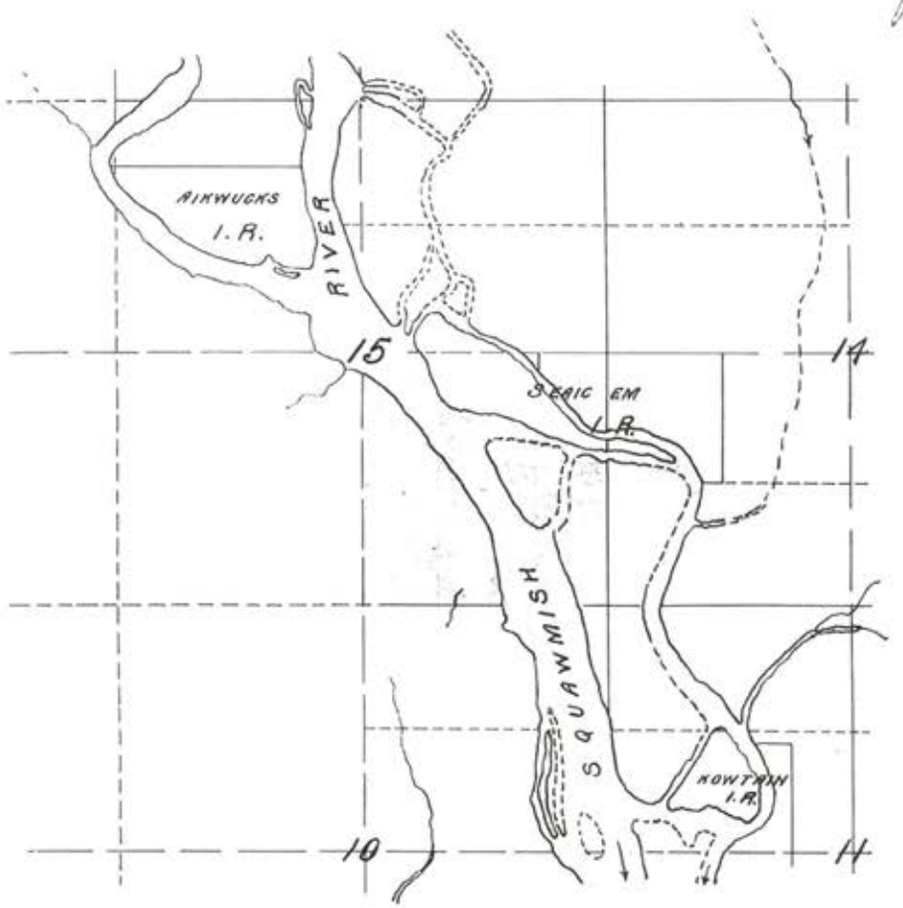
Crown Grant No. 2698 101

NEW WESTMINSTER DISTRICT.

Howe Sound.

Scale, 20 Chains One Inch.

T.P 50.



vii. Report on review of Natural Boundaries of Reserve

Specific Issue Report
Purpose: Review of Natural Boundary of Reserve
Reserve / Lands Reviewed: Seaichem IR 16
Researcher: Steven J. Minnie, BCLS, CLS
Date: 1/13/2011

Issue

The Squamish Nation asked our office to review the natural boundaries of Seaichem IR 16, as part of their acquisition of administration of reserve lands under the First Nation Land Management Act. A cursory comparison between present aerial photos and the original survey of the reserve show that much of the reserve has been lost to erosion. The slough shown on the original survey separating the main part of the reserve and the island portion is now the main channel of the Squamish River. It is necessary to review the changes that have taken place to the location of the river since the original survey, to determine where the present natural boundary of the reserve is located.

Chronology of Events

- The reserve was first surveyed in 1881 by E.Mohun and shown on Plan BC249 CLSR. Mohun's field notes for this survey are filed as FBBC295 CLSR. A tracing of Plan BC249 was made and is file as Plan TBC249 CLSR and is considered to be a true copy of the original plan. The reserve was surveyed as a 30-acre island and 38 acres on the mainland, separated by a slough later referred to as Kowtain Slough.
- Land surrounding the reserve was surveyed in 1890 as Township 50. This survey is recorded in the provincial Crown Land Registry 10Tr03 and in the Land Title Office as Plan VAP1728.
- In 1912 and 1913, the land south of the reserve and west of Kowtain Slough was surveyed and shown on Reference Plans VAP651 and VAP866 respectively.
- In 1918 a brief engineering report was prepared to address concerns regarding erosion caused by the Squamish River. Part of this report includes a sketch of the river and islands in the area of the reserve.
- In 1976 a survey of the rectilinear boundaries was prepared and filed as Plan 60943 CLSR. This plan showed the original natural boundaries and the present shoreline but did not attempt to resolve the present natural boundaries of the reserve.

Evaluation

The surveys and sketches available between the original survey of the reserve up to the engineering sketch of 1918 show the main channel of the Squamish River located west of the island portion of the reserve. By 1940, as shown on an aerial photo taken between 1936 and 1940, the main channel of the river has switched sides and been diverted to the slough known as Kowtain Slough. Part of this diversion has cut through the middle of the island portion of the reserve leaving smaller islands on either side. This 1936-40 aerial photo shows that approximately the northeast half of the island portion of the reserve and approximately 150 metres of the mainland portion of the reserve has been lost to the main channel of the river. In this photo the island portion of the reserve consists of a small island that was originally the southeast tip of the original island, and a larger island, which is the remains of the western portion of the original island. There also appears to be a few smaller islands remaining just south of the main

channel of the river. These are likely remains of the original island portion of the reserve.

The reasons for this diversion may be outlined in correspondence accompanying the 1918 sketch of the river, prepared by the Public Works Department. This correspondence states "The main channel of the Squamish River originally followed the Western bank but recently, owing to boulders and other detritus carried in by Stoney Creek during freshets, a bar has been gradually extended until the main channel has been forced over against the Seaicem (sic) Indian Reserve. The tendency of this bar is to force the flow of water more and more in the direction of the location of the old pile work shown on the plan. The danger is that the main channel will follow the slough which bisects the Indian Reserve and possible out across to the Mamquam River which runs East of the P.G.E.Railway." (INAC file RG10, Vol 4051, file 365,640-1) By 1940 it appears this prediction has come true.

Subsequent aerial photos in 1947, 1948, and 1952 show little significant change in the direction or location of the river and channels flowing through the island portion of the reserve and show the left bank of the (now) main channel of the river continues to gradually erode the mainland portion of the reserve. The western island takes on a defined shape by 1952 and grows slightly by accretion to its northeast shore.

In a 1957 aerial photo, it appears that a significant portion of the mainland portion of the reserve has eroded since the 1952 photo. In the 1957 photo approximately 300 metres of land has been lost since the original survey (measured along the north boundary of the reserve). The larger western island and the smaller islands continue to grow as the channel that bisected the original island in the 1936 photo, continues to diminish.

In a 1964 aerial photo, the mainland portion of the reserve has continued to erode and is located very close to the present natural boundary of the reserve (as seen in 1996 photography). The island portion of the reserve has returned to approximately the southern two thirds of the original island.

In 1970 and 1982 photography, the shoreline remains relatively stable with little or no change to the mainland shoreline and slight erosion to the north boundary of the island portion of the reserve. A sandbar begins to form west of the mainland portion of the reserve and within the original reserve boundary however this sandbar is entirely surrounded by the river and has formed from the bed of the river and therefore is not part of the reserve.

In the 1996 aerial photo, the north boundary of the island portion of the reserve has eroded away to almost the original south boundary of the island.

Returning to the 1936-40 aerial photo, consideration must be given to the abutting parcels south of the reserve and how accretions have affected those boundaries. The 1912 and 1913 survey of these parcels, (Plans VAP651 and VAP866 respectively) agree with one another reasonably well and with the 1918 engineering sketch of the river.

The boundary between these two parcels and the reserve to the north is shown on the noted survey plans as a slough. The eastern extent of this slough appears to be visible in the 1936-40 photo and in subsequent photos until about 1964. The visible slough on these photos would be the boundary between the reserve and the parcel defined by Plan 866.

The western of these two parcels (Lot B on Plan 651) lies immediately west of Plan 866. The western extent of Lot B extends to the left bank of the west channel of the Squamish River. Overlaying plan 651 onto the 1936-40 photo shows that most of this lot is bisected by the middle channel of the river, however part of the parcel remains on either side of this middle channel.

Conclusion

As a result of the main channel of the Squamish River switching from the west channel to Kowtain Slough sometime between 1918 and 1940, much of the island portion and mainland portion of the reserve was lost to erosion. The slough between the island and mainland portions of the reserve is a natural boundary and therefore any natural changes to the river will change the location of the boundary.

The mainland portion of the reserve continued to suffer erosion especially between the periods of 1918 to 1936, 1952 to 1957, and 1957 to 1964. It appears in the 1970 photo that some work has been done to stabilize the shoreline and as a result subsequent photos show little change to the shoreline location. The 1976 survey of the rectilinear boundaries of the reserve located this natural boundary and can likely be relied upon to reflect this present natural boundary of the reserve.

The island portion of the reserve suffered the same dramatic effects of erosion between 1918 and 1940 losing approximately three quarters of its landmass due to erosion. As the river became settled in its new location along the eastern channel, and continued to push eastward against the mainland portion of the reserve, the island grew back with accretion to its northeast shore. By 1964 the island was approximately two thirds its original size. Between 1964 and 1982 the north shore of the island began to erode again and between 1982 and 1996 much of the original land mass of the island was lost.

The present boundaries of this island portion of the reserve will be the present north shore or the right bank of the main channel of the Squamish River. The western boundary will be the present left bank of the west channel of the river.

The south boundary of this portion of the reserve is more difficult to determine. The eastern portion of this boundary will be the slough separating the reserve and Plan 866 and Lot B of Plan 651 to the south. As noted above this slough appears to exist in the photos as late as 1957 and it is possible there may still be evidence of this slough on the ground. Otherwise the boundary will need to be determined using historic aerial photos.

Presuming the western extent of Lot B, Plan 651 was not completely eroded away between 1918 and 1940, the south boundary of the reserve will be the slough abutting the north boundary of Lot B as shown on Plan 651. Based upon the 1936-40 aerial photo, it appears that the western boundary of Lot B, abutting the left bank of the west channel of the Squamish River, has not been eroded away. A field survey may confirm this by locating the posts shown along the west boundary of Lot B on the survey plan. Since most evidence of this slough along the north boundary of Lot B has likely been washed away, it will be necessary to re-establish the location of this slough using measurements shown on Plan 651, unless better evidence can be found on the ground.

Alternatively, a field survey may indicate all of the western part of Lot B was in fact washed away and that the western island shown in the 1936-40 photos was land accrete to the original reserve. In this case, subsequent accretion to the island will add to the reserve until the islands southern extent becomes somewhat stabilized around 1964.

List of Enclosures

Reduced partial copy of Plan BC249 CLSR
Reduced partial copy of Plan TBC249 CLSR
Field Notes of the original survey by Mohun, FBBC295 CLSR
Partial copy of Plans VAP651 VAP866
Excerpts form correspondence in INAC files related to 1918 engineering sketch
Plot of aerial photos from 1936-40, 1947, 1948, 1952, 1957, 1964, 1970, 1982, and 1996.

SIGNED

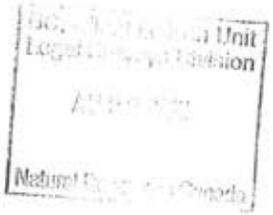
January 13, 2003

Steven J. Minnie, BCLS, CLS
BC Client Liaison Unit, Legal Surveys Division

Date

viii. Comments from BC Surveyor General's Office on Boundary Survey by MacDonald

BRITISH COLUMBIA



VANCOUVER 2010 CANDIDATE CITY

IT'S OUR TIME TO SHINE

Our File: 12495-20-21

Your File: 2002 10 158

August 26, 2003

S. J. Minnie, B.C.L.S.
Legal Surveys Division
Natural Resources Canada
1501-1138 Melville St
Vancouver BC V6E 4S3

Dear S. Minnie:

Re: Provisional Survey of Part of the Natural Boundary of Seaichem Indian Reserve No. 16

Thank you for your letter of March 17, 2003, requesting comments on the above noted survey.

I reviewed your report and the report prepared by Cam MacDonald, B.C.L.S., C.L.S. As stated in the reports, the natural boundaries of Indian Reserve No. 16 have changed significantly since the original survey. As Cam MacDonald found the southeast corner of section 15 and other pertinent evidence, it appears that the re-establishment of the northerly boundary of Lot B, Reference Plan 651, which is adjacent to part of the southerly boundary of the island part of the reserve, is very sound.

The aerial images supplied show the dramatic changes in the river course at various epochs from 1936 to 1996. Parts of the subject island appear to exist in all photos, however, we do not have any photographic evidence showing the island between the time of the 1890 Township survey and 1936 photograph. The 1918 letter identified the cause of the river being diverted as boulder and log debris buildup from discharges from Stoney Creek and points out that if nothing is done, then the change of the river course would dramatically erode the reserve lands over the coming years. The 1920, 1934 and 1935 letters talk about a dam as a remedy to the erosion problem, however, nothing was done. Although the river changes were very dramatic, they do appear to be natural.

../2

Ministry of Sustainable Resource Management

Registries Department
Surveyor General Branch

Mailing Address:
PO Box 9375 Stn Prov Govt
Victoria BC V8W 9M5

Telephone: (250) 952-5021
Facsimile: (250) 387-1830

Location:
3400 Davidson Ave
Victoria BC V8Z 3P8

Cam MacDonald states that he did not find any traces of the bank of the slough. I examined the 1891 Crown grant tracing of the Fractional Southeast Quarter of Section 15 and the slough is distinct and not included within the grant. This questions the validity of Plan 651 including the slough within the limits of the parcel. This raises the question whether there may be a valid claim to the middle thread of the slough.

As parts of the island appear to exist in all photos, there may be a claim to accretion to the south-westerly boundary of the reserve. Cam MacDonald states in his report that *"Examining the aerial photos suggests a gradual and imperceptible process has not taken place. There is no evidence that such an outward growth has taken place. To the contrary, there is an abrupt top of bank present, bearing no sign of accretion."* I believe that one must consider the individual watercourse when considering the application of the "slow and imperceptible" rule when adjudicating accretions. As the Squamish River is very dynamic, the period of time considered "slow and imperceptible" must accordingly be less than for other more placid water bodies. It may be prudent to re-visit this issue with Cam MacDonald and discuss it in more detail to further document the reasoning behind his boundary decision and to more clearly determine whether this new land may be claimed as accretion by the reserve. I acknowledge that Cam MacDonald was on-site and is therefore in the best position to assess all the data.

Please note that I am enclosing a copy of Brackendale Eagles Provincial Park official plan 1 Tube 1764. You will note that the park boundary is adjacent to some of the island part of the reserve.

Thank you for the opportunity to comment on this survey. Please contact me if you have any questions.

Yours sincerely,

Jeff Beddoes, B.C.L.S.
A/Deputy Surveyor General
Telephone No. (250) 952-5324
E-mail: jeff.beddoes@gems6.gov.bc.ca

JES:pm

Encl.

ix. Correspondence regarding Status of Old Road

(2)

File: 23/262.83.412-10CD
Date of Issue: 7/7/70 A

Survey Instructions - Item 13-70, B.C.
(Authorized Project System No. 300028)

Issued to: Mr. I.M.D. Fox, D. & B.C.L.S.

Description: Resurvey of Boundaries of Seaichem I.R. No. 16 and Survey of Parcel(s) of Adjoining Crown Canada Land, B.C. (See Special Remarks).

Statutory Authority and Instructions: C.L.S. Act and Manual supplemented by Appendices A, A-2, E and O, Standard Instructions.

Plan Required: Official plan under Section 43 of the C.L.S. Act.

Field Liaison: Mr. D.M. Hett, Supervisor, Fraser Indian District, 304-326 Howe St., Vancouver 1, B.C.

Special Remarks: In discussion with Mr. Hett please ascertain what the survey requirements are and survey accordingly.

Mr. Chapman of the District Office indicated that all boundaries were to be resurveyed and that the new course of the river should be surveyed.

We assume that the blue lines on enclosure one are meant to represent the existing banks of the Squamish River. This may mean that adjoining Crown Land will be surveyed. If so, please designate by parcel number(s) and show an acreage for each parcel.

Enclosures: Copies of the following:

1. Sketch received from Indian Affairs.
2. C.L.S.R. FB 295 - Pages 30 to 37.
3. Band Council Resolution dated May 19, 1970.
4. Survey Request Form undated.
5. N.T.S. 92G/14 East (Cheakamus River) Scale 1:50,000.
6. N.T.S. 92G/11 East (Squamish) Scale 1:50,000.
7. C.L.S.R. TBC 249 - Plan of Squamish Reserves by Mohun in 1881.

L. D. Garey

R. Thistlethwaite,
Surveyor General,
Legal Surveys Division.

c.c. Regional Director
c.c. Supervisor, Fraser Indian District
c.c. Head, Land Titles Section, Ottawa.

(12)

Surveyor General

5210-S26

M.H. Collins, D. & B.C.L.S. 20 Nov. 1975

SEAICHEM I.R. NO. 16

Resurvey of Exterior Boundaries
Item 13-70, B.C.
Your Memo June 6, 1973
My Memo May 23, 1973

The Department of Highways maintain that the Squamish Highway is just there. In other words there is no Gazette notice or transfer in their records. However, the highway is shown on L.R.O. Reference Plan 2244 as the Squamish Waggon Road. This plan is dated June 1928 so that highway has been in existence for at least 47 years.

The plan and field notes of the subject resurvey has been completely redrawn to show the original high water mark and the present high water mark of the reserve. When the survey of the rectilinear boundaries was made in 1972 the island on the north boundary was partly inside the reserve (see check print). This is an indication of how the Squamish river is shifting about in this area.

I have enclosed a xerox print of part of Davidson's provisional plan which will explain some of the mysterious posts shown on my plan. He set posts which he apparently decided not to show on his final plan. He also set posts which he did not show on his provisional or final plan.

I think it goes without saying that there are no field notes for L.R.O. Plans, particularly reference plans of the vintage of 865.

L.R.O. reference plan 866 was shown for information pertaining to nearby property, but does not relate directly to the reserve boundary.

The east boundary of the reserve has been shown in the position I believe to be correct as explained in my subject memo, but it has only been drawn in pencil.

MHC:pl

Enclosures :
1. Check print.
2. Redrawn Plan & Field Notes of subject resurvey.
3. Print of L.R.O. Plan 1728.
4. Certified enlargement of part of air photo BC7558-005.
5. Xerox print of part of Davidson's provisional plan.

MEMORANDUM

CLASSIFICATION

TO / A: Mr. M.H. Collins, D. & B.C. L.S.

YOUR FILE No. / Votre dossier:

OUR FILE No. / Notre dossier: 5210-S26 (L8)
13-70, B.C.

DATE: January 14, 1976

FROM / De: Surveyor General and Director,
Legal Surveys Division.

JAN 16 REC'D

SUBJECT / Sujet: Your memo November 20, 1975
Resurvey of the Exterior Boundaries
of Seaichem I.R. No. 16

As mentioned by Mr. Mortimer when he discussed this project with you on January 13, 1976, we do not agree with your re-establishment of the South boundary of this Reserve, so as to eliminate the gap of 18.58 feet between that boundary and the property to the south. Our basic reasons are firstly, no adjacent surveys were ever tied to that portion of the boundary and secondly, the I.R. was surveyed in 1882 whereas the township survey was done around 1908, both locations being established from distant starting point. We therefore feel that it is highly improbable that the lines in question would be coincidental.

The south boundary of the Reserve should be reestablished on the basis of the evidence of the southeast corner created by Davidson in 1972.

In addition to the foregoing we would like you to produce a plan of that part of the Squamish Highway affecting the I.R., suitable to the B.C. Dept. of Highways. This plan should show the original east boundary of the I.R. and the extra areas required inside the I.R. but outside the 21 foot travelled road.

After the road plan has been made, the boundary plan can then be amended to reflect a new east boundary common with the west limit of the highway.

Enclosed is a print of your boundary plan with certain additional amendments required noted in red, and the print of Davidson's plan (14611 LRO). Please return these when they have served your purpose.

R. T. McCurdy

D.R. Slessor.

Encl.

CGSB – 6GP22D 7540-21-798-8998

(14)

Indian and Northern Affairs / Affaires indiennes et du Nord

Vancouver Indian District
400 - 1155 Robson Street
Vancouver, B. C.
V6E 1B9

March 16, 1976

Energy, Mines and Resources
Legal Surveys
700 West Georgia
V7Y 1B6

MAR 18 RECD

Your file / Votre référence

Our file / Notre référence 987/30-7

Attention: Mr. M.H. Collins

Dear Sirs:

Re: Plan and Field Notes of Resurvey of
Rectilinear Boundaries of
Seaichem I.R. No. 16
Squamish Band

We appreciate your efforts in discussing the subject survey with us and bringing our attention to the boundary of the reserve coinciding with the existing Squamish Highway. You further commented that the subject Highway has not been gazetted, and furthermore you were unable to find any record of the road in question.

We have discussed this subject overlap with Chief Philip Joe of the Squamish Band and I have been requested to advise you to survey the reserve showing the true boundaries of the reserve as it was laid out initially and also to show the exact overlap of the highway on the said Indian Reserve.

As stated above please do not amend the survey plan but show the boundaries of the reserve as first set out. We would appreciate if you would consult with our office upon the completion of the field notes and preliminary plan in order for us to be able to discuss and obtain the assent of the Band Council to the confirmation of the plan.

Yours very truly,

Sam Sebo
Real Estate Advisor
Vancouver Indian District

SS/rf

(15)

Surveyor General

Attention: Mr. R.T. McCurdy

5210-S26

M.H. Collins

21 April 1976.

Resurvey of Exterior Boundaries
SEAICHEM I.R. No. 16
Item 13-70, B.C.
Your memo January 14, 1976

Enclosed is a copy of a letter from Sam Sebo, of the Vancouver Indian District. The attitude of the Band toward the highway is quite evident in the letter.

I approached the Department of Highways about the plan mentioned in paragraph 3 of your subject memo. They said it would require a right-of-way plan for transfer. They also said they would be glad to have the road formalized, but were not prepared to pay for it out of hand without first having an application from the Band and then only maybe.

In connection with the 18.58 foot strip mentioned in the first paragraph of your letter, I inquired at the Land Registry Office if this strip was part of Township 50 and therefore in the register. The answer was no. I then asked if it was not in the register what was it, and their answer was that it was Vacant Crown Provincial Lands. I brought up the subject of Davidson's plan and the fact that he shows this strip as not being part of the reserve. Their reaction was that this part of his plan was only scenery and had no legal standing from their point of view. They did not necessarily agree with what Davidson had shown on his plan in that area, but since he was only dealing with the south half of the northwest quarter of Section 14, Township 50, no objection was made.

I next sought the Acting Surveyor General's opinion on the strip and the methods used in the survey of the township. He said he wouldn't be surprised if the township fitted the reserve since it was probably arranged that way, and it was no doubt the intention, since it is shown that way on the offical plan of the township (L.R.O. plan 1728). It was also his contention that the survey of the township constituted a resurvey of the reserve. Therefore, the strip, if we intend to disown it, would be Vacant Crown Provincial Land.

MHC:pl

Encl.

x. Correspondence Related to Movement of River

3167-10

63-167

SQUAMISH BAND MINUTES OF COUNCIL MEETING HELD SEPTEMBER 24, 1945.

xx xx xx

The graveyard at Poquiosin Reserve, according to August Jack, is washing away due to erosion by the Squamish River, and he reports that there are two boxes of remains and 10 other separate graves, 91 bodies in all, which should be moved half a mile to Waiwakum Reserve graveyard.

MOVED by Councillor Denny Paull
SECONDED by " Alfred Jacob

THAT $200 be spent from Band funds in moving 91 bodies from Poquiosin Reserve to Waiwakum Reserve graveyard, with August Jack in charge of the work.

CARRIED UNANIMOUSLY

x x x

416 Federal Building,
Vancouver, B.C.
Sept. 25th, 1945.

x x x

2. The matter was reported by August Jack of damage being done Seaichem Reserve (No. 16) by the Squamish River. A dam has been formed in the river and has changed the course of it so that it is now causing erosion of the Reserve. However, more damage is being done to private property adjoining the Reserve and I am taking up this matter with the owners and the Public Works Department, recommending that the dam be blown out. Squamish River is a turbulent one and there is much forest debris carried down by it and these dams are continually forming and changing the course of the river.

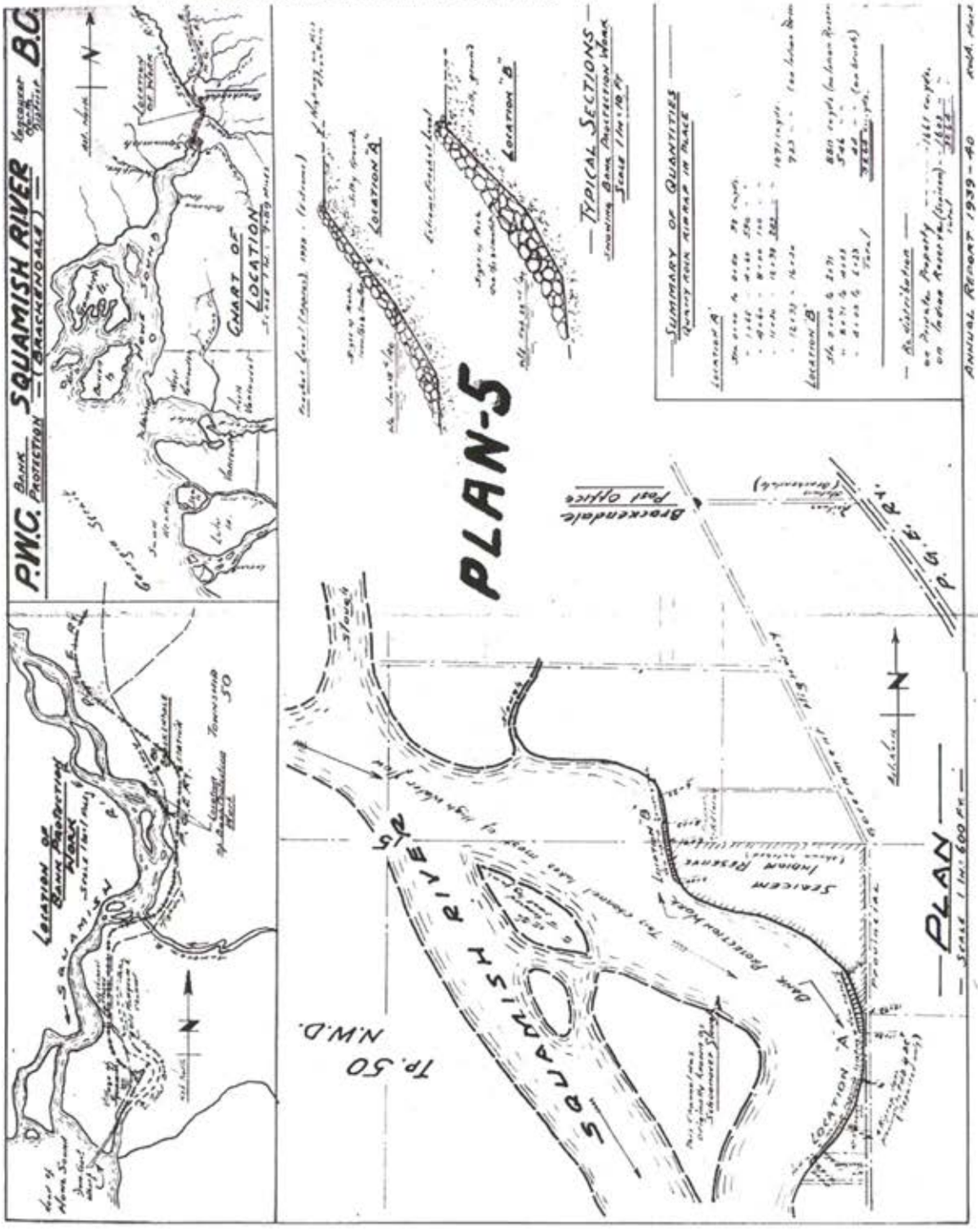
xx xx xx

Fred. J.C. Ball,
Indian Agent.

Indian Affairs File RG10, Volume 8095, File 987/36-7-7-13 pt. 1

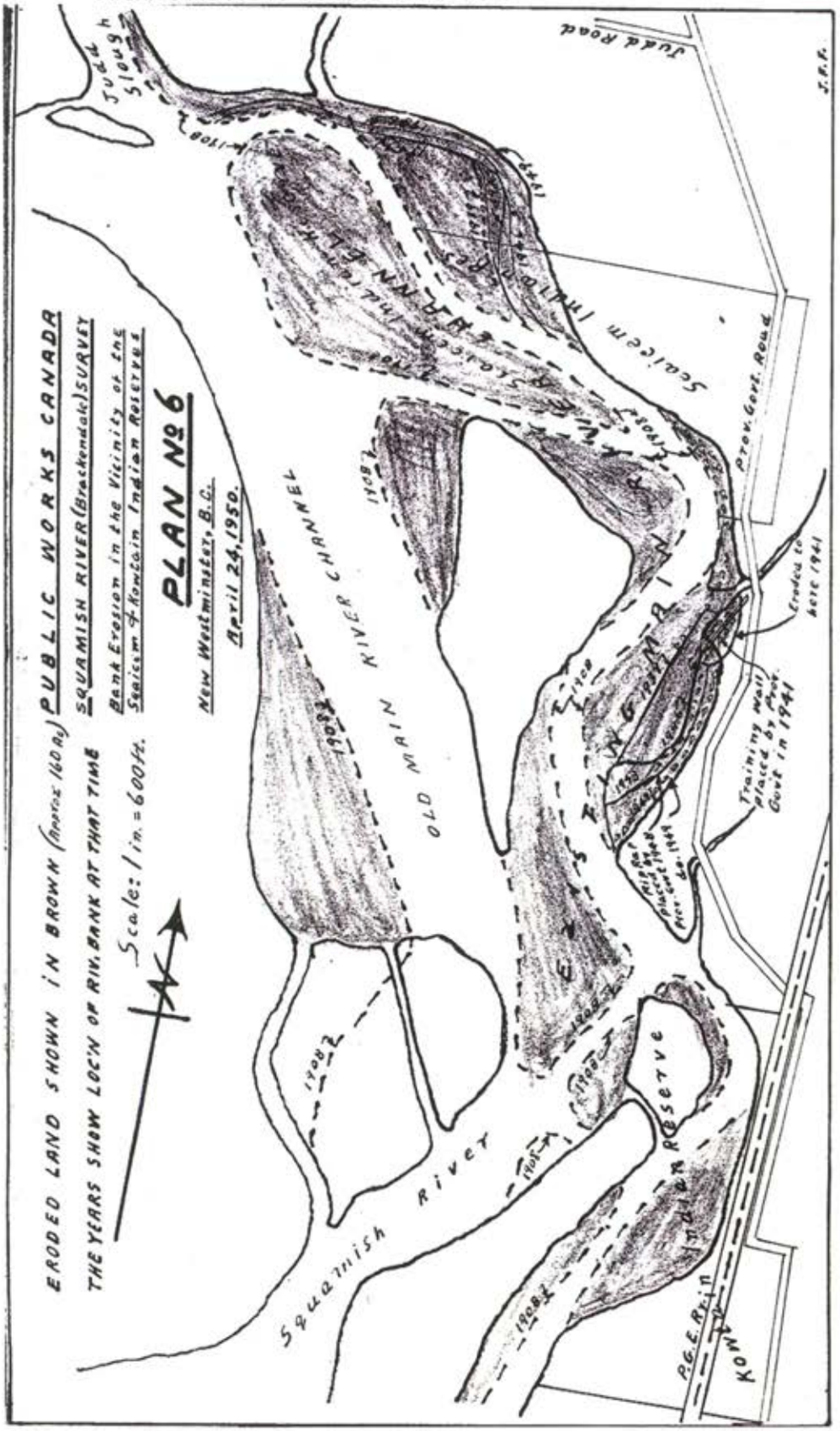
xi. Plan 5 from Fenney Report of 1950 on Squamish Flooding

Archive file RG10 Volume 4304 File 41



xii. Plan 5 from Fenney Report of 1950 on Squamish Flooding

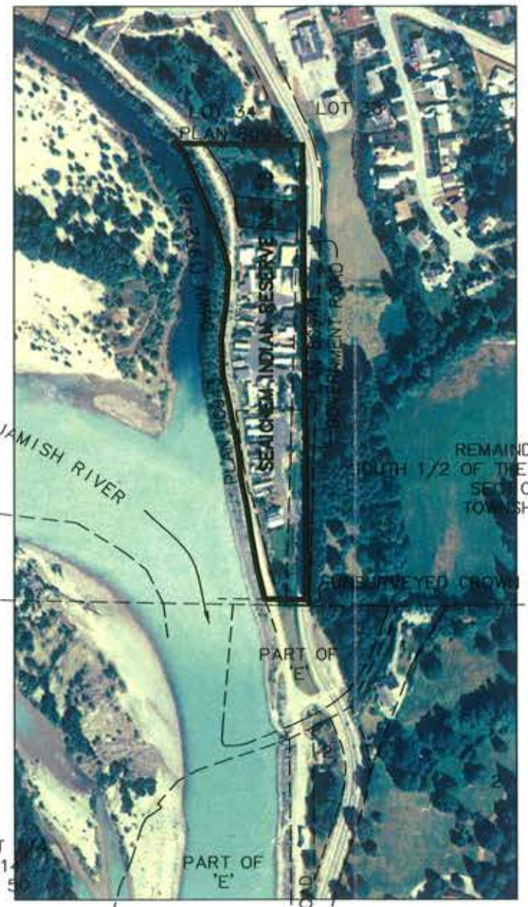
Archive file RG10 Volume 4304 File 41

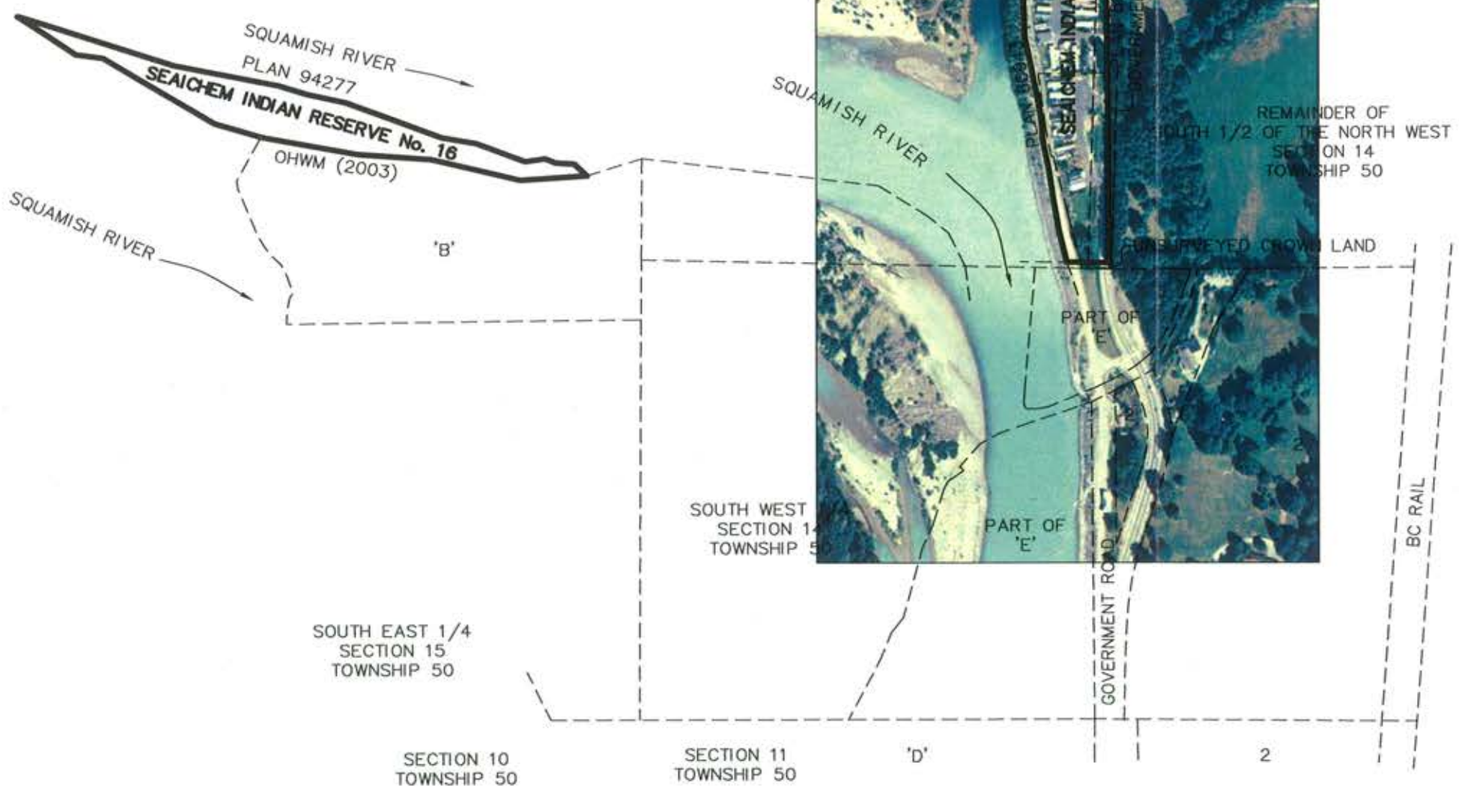


E) Other Research

i. **1999 orthophoto mapping of the reserve area.**
(Attached)

ORTHO





SQUAMISH FIRST NATION

SEAICHEM INDIAN RESERVE NO. 16

NEW WESTMINSTER DISTRICT

PROVINCE OF BRITISH COLUMBIA

LAT: 49°45' LONG: 123°08'

PREPARED ON THE 16th. OF APRIL, 2004

100 50 0 50 100 150 200 250 METRES

All Plan numbers are Canada Lands Surveys Records (CLSR) Plan numbers unless otherwise stated.

Reserve boundary shown thus.....

Ortho Mapsheet 92G.075, Date of Photography 1999

Available From:
Natural Resources Canada
Surveyor General Branch
British Columbia Client Liaison Unit

Natural Resources Canada

Ressources naturelles Canada

6. Description Preparation

A) General Overview

The reserve was first surveyed in 1881 by E.Mohun and shown on Plan BC249 filed in the Canada Lands Surveys Records (CLSR). A clear copy of Plan BC249 is recorded as Plan TBC249 CLSR. Mohun's field notes for this survey are filed as FBBC295 CLSR. Plan BC249 shows the reserve having an area of 68.00 acres.

The reserve was transferred to Canada by OIC 1938-1036, ILR No. 8042. The reserve is described in the OIC as having an area of 68.00 acres.

B) Analysis of Jurisdictional Boundary Information

i. Review of Rectilinear Boundaries of the Reserve

The rectilinear boundaries of the reserve were resurveyed in 1976 and shown on Plan 60943 CLSR. This survey also tied in the natural boundary of the mainland portion of the reserve but did not include this boundary as part of the heavy outline on the plan.

Plan 60943 also shows the original boundaries (both rectilinear and natural) of the reserve plotted from Mohun's 1881 survey, and the existing course of the Squamish River plotted from aerial photos. This plan clearly shows the large extent of the reserve lost to the river.

ii. Review of Natural Boundaries of the Reserve

The history of the natural boundary of the reserve was reviewed in-house based upon existing documents and plans (See Report in Section 5(D)(viii). As a result of this review, a survey of the natural boundary of the island portion of the reserve was contracted to Cam MacDonald BCLS, CLS. This survey is recorded as Plan 94277.

iii. Review of Status of Old Road along East Boundary

During the survey of the rectilinear boundaries in 1976, shown on Plan 60943, the issue of the old road along the east boundary was reviewed (See correspondence Section (D)(ix)). The results of this review were that the province claims the road as theirs, presumably since it existed in 1938 when the reserve was transferred to Canada. No evidence of the existence of the road was supplied.

A 1913 survey of the land immediately south of the reserve, shown on Land Title Reference Plan 865, shows a 3.5-acre parcel abutting the entire south boundary of the mainland portion of the reserve and does not show a road through the parcel. A later Land Title Plan, No. 19974 dated 1984, shows the same parcel as Lot E, also with no road through it. On this plan, the Government Road is shown running through the parcel south of Lot E.

C) Analysis of Mines and Minerals Tenure

Mines and minerals are managed according to the British Columbia Indian Reserves Mineral Resources Act 1943-44 c.19.

D) Analysis of Third Party Interests

There are no third party interests on the reserve.

E) Area Derivation

The area was calculated using Plan 94277 for the island portion surveyed by MacDonald and the rectilinear boundary and natural boundary of the mainland portion shown on Plan 60943 CLSR. The area of the island portion is quoted on MacDonald's plan as 1.30 ha. The area of the mainland portion was calculated from Plan 60943 to be 2.56 ha.

The area(s) specified in the legal description has/have been rounded accordingly to conform to the area guidelines set out in Schedule E3-1 of the General Instructions for Surveys of Canada Lands e-Edition.

F) Other Issues

There is a dyke located along the natural boundary of the mainland portion of this reserve. In 1969 a permit was issued to the District of Squamish (Document No. 9591-324) for the construction and maintenance of a dyke and access road, for a period of 5 years. The permit expired in 1974 and has not been renewed. There are no surveys or other interests registered on the reserve for this dyke.

KERR WOOD LEIDAL
consulting engineers

Appendix D

Baseline Habitat Review

KERR WOOD LEIDAL
consulting engineers

Greater Vancouver
200 - 4185A Still Creek Drive
Burnaby, BC V5C 6G9
T 604 294 2088
F 604 294 2090

Eagle Viewing Area / Siyich'em Reserve Dike Master Plan

Final Report
October 27, 2020
KWL Project No. 463.341-300

Prepared for:
District of Squamish and Squamish Nation

SQUAMISH

Sḵwx̱wú7mesh Úxwumixw
Squamish Nation

Table of Contents

Tables

Figures

Appendices

1. Description of the Biophysical Environment

1.1 Study Area

This Appendix describes the biophysical environment within the Eagle Viewing Area / Siyich'em Dike Master Plan (DMP) study area along the Squamish River and adjacent lands between the Squamish Nation Aikwuks and Kowtain Reserve.

The following key biophysical features are located within the study area:

- the Squamish River;
- Dryden and Meigan Creeks;
- Harris Slough;
- a large forested island along the northern portion of Siyich'em Reserve dike and along the Eagle Run Drive/Maple Crescent residential area; and
- Jimmy Jimmy (Judd) Slough is a side channel of the Squamish River that runs between the large forested island and the existing dike from Fisherman's Park to where it joins the Squamish River near the south end of Siyich'em Reserve.

For the purposes of the present report, the biophysical area assessed includes the study area described in the Eagle Viewing Area / Siyich'em DMP report, but also additional areas outside the study area that are connected ecologically or provide habitat function to resources within the study area. Section 1.2 describes aquatic and riparian fish habitat. Section 1.3 describes terrestrial vegetation communities including bird and wildlife habitat. Section 1.4 addresses species of conservation concern likely found in the study area.

1.2 Aquatic Environment

Methods

To characterize the aquatic environment within the DMP study area, KWL completed a desktop study of available historical data and conducted a field visit on September 10, 2019. The field visit did not include fish sampling or a level 1 fish habitat assessment of any of the watercourses within the study area. Aquatic habitat features within portions of the watercourses in the study area were documented to determine general habitat suitability for fish. The following habitat conditions were assessed in the field:

- Condition of existing crossing structures;
- Potential barriers to fish passage or migration;
- Dominant cover type;
- Habitat types;
- Channel substrate characteristics;
- Riparian vegetation communities; and
- In-situ water quality.

Aquatic Fish Habitat Characteristics

Fish habitat occurs throughout the study area, in stream systems and riparian communities. This section describes the fish habitat within creek and riverine aquatic systems, as well as fish habitat provided by riparian communities.

Judd Slough

Judd Slough is a predominately groundwater-fed stream approximately 3.4 km in length. In 1967 a spur dike crossed the upstream end of the channel to protect the area from flooding (Lister et al. 1980). In 1975 an intake valve in a constructed flood control dike allowed Squamish River flow to be introduced to Judd Slough for short periods in the fall during chum salmon (*Oncorhynchus keta*) migration (Lister et al. 1980). The upper 1.5 km of Judd Slough has received habitat restoration improvements by DFO in 1978 and 1979. The slough provides spawning habitat for chum and coho salmon (*Oncorhynchus kisutch*) as well as rearing habitat for coho salmon and trout species (Lister et al. 1980).

The confluence at the southern end of Judd Slough retains a natural connection to the Squamish River. High value fish habitat occurs along the lower reaches of the slough, adjacent to a low, forested island. During the field visit, only the southern 650 m of Judd Slough was surveyed. The observed reach consisted of moderate velocity, moderate depth (0.5 m) run habitat dominated by fine substrates and gravels (Photo Log 1; Photo 1). Low- to moderate-cover was provided primarily by small woody debris (Photo Log 1; Photo 2). At the point of measure (approximately 650 m upstream of the confluence), the wetted width of Judd Slough was 4.8 m and channel width 8.5 m. Near the start of the gravel pathway system on top of the existing dike (approximately 330 m upstream of the confluence), Judd Slough channel width increases to range from 25 to 30 m with wetted widths of 10 to 20 m reaching maximum width towards the confluence with the Squamish River (Photo Log 1; Photo 5). Habitat in this area is slower velocity run or flatwater habitat with depths up to 1.0 m (Photo Log 1; Photo 6).

Riparian vegetation along the surveyed reach of Judd Slough consists of deciduous forest with canopy species dominated by black cottonwood (*Populus balsamifera ssp. trichocarpa*) and red alder (*Alnus rubra*) and understory dominated by salmonberry (*Rubus spectabilis)* and thimbleberry (*Rubus parviflorus*) (Photo Log 1; Photo 2). Within the surveyed area, a network of dirt trails bordering Judd Slough were actively used by dog walkers during the time of survey. Evidence of erosion likely resulting from dogs and dog walkers was observed approximately 500 m upstream of the confluence (Photo Log 1; Photo 3). A small section of shallow (0.15-0.20 m) riffle habitat with bed materials dominated by small and large gravels was also observed in this area (Photo Log 1; Photo 4).

No crossing structures or barriers to fish passage were observed along the lower reach of Judd Slough during the field survey. It is possible that in the area of the trail network a crossing structure is in place for recreational users. A pump station associated with the dike structure is located at Fisherman's Park, approximately 1.4 km upstream of the Squamish River confluence (Photo Log 1; Photo 8). Fish passage appeared possible at the time of survey however more detailed information on passage and water flow control through this structure would be useful.

During the time of survey Judd Slough in-situ water quality measurements were: 8.68 mg/L DO, pH 6.33, conductivity 108 µS/cm, and water temperature of 9.5 Cº (Table 1).

Table 1: In-situ Water Quality Data Recorded in the Study Area

Watercourse Name	Time	Zone	Easting; Northing	Dissolved Oxygen (mg/L)	pH	Temperature (Cº)	Conductivity (µS/cm)
Dryden Creek	11:12	10 U	489896; 5511163	9.27	6.31	10.9	129
Judd Slough	8:45	10 U	489362; 5511784	8.68	6.33	9.5	108
Meighan Creek	13:07	10 U	489848; 5510611	6.51	6.34	14.9	164
Squamish River	12:13	10 U	489792; 5511105	10.93	6.74	11.2	15

Squamish River

The Squamish River drains a mountainous area of 3,650 km^2, flowing approximately 90 km from its headwaters in the Pemberton Icefields to the Pacific Ocean at the head of Howe Sound (ARL 2002). The Eagle Viewing Area / Siyich'em DMP study area includes a 2 km reach of the Squamish River characterized as a high velocity run (Photo Log 1; Photo 9 – 11). Channel width in the reach is approximately 120 m with wetted width of approximately 100 m. Observations of substrates within the river was limited to side and mid bars due to the high turbidity resulting from glacial silt. Substrate in these areas consisted of a mixture of fines (glacial silts and sand), cobbles and gravels.

A section of backwater habitat approximately 40 m in length by 12 m in width occurs near the outlet of Dryden Creek, associated with a small riprap groin upstream of the outlet structure (Photo Log 1; Photo 12).

During the time of survey, the Squamish River in-situ water quality measurements were: 10.93 mg/L DO, pH 6.74, conductivity 15 µS/cm, and water temperature of 11.2 Cº (Table 1).

Dryden Creek

The watercourse draining Alice Lake and discharging into the Squamish River is referred to as Dryden Creek in this report, as it is locally known. On provincial maps, the stream is also known as Hop Ranch Creek (MOE 2019a). Dryden Creek is approximately 3.7 km in length.

At the time of survey, the observed reach consisted of moderate velocity, moderate depth (0.5 m) run habitat, dominated by fine substrates (Photo Log 1; Photo 14). Moderate cover was provided primarily by instream vegetation and small woody debris with small amounts of boulder and large woody debris (Photo Log 1; Photo 15). At the point of measure (approximately 130 m upstream of the confluence) the wetted width was 3.6 m and channel width 7.4 m.

Riparian vegetation along the surveyed reach of Dryden Creek consisted of deciduous forest with canopy species dominated by red alder (*Alnus rubra*) and bigleaf maple (*Acer macrophyllum*) and understory dominated by salmonberry (*Rubus spectabilis).* A hedgerow of planted coniferous species was present along the left downstream bank at the point of transect (Photo Log 1; Photo 16). The riparian width was narrow, (8.0 m) along the left downstream bank due to residential land use at the point of transect, with a 50 m riparian width along the right downstream bank prior to a paved parking lot. Beginning approximately 40 m upstream from the point of transect, access to the creek is restricted due to exclusion fencing on either side of the creek as it runs through the agricultural grazing land of Hop Creek Farms for approximately 500 m upstream (Photo Log 2; Photo 5).

During the time of survey Dryden Creek in-situ water quality measurements were: 9.27 mg/L dissolved oxygen (DO), pH 6.31, conductivity 129 µS/cm, and water temperature of 10.9 Cº (Table 1).

Three crossing structures were observed on Dryden Creek. One 1500 mm corrugated steel pipe of 30 m in length conveying flow under Government Road (Photo Log 1; Photo 13); one 1500 mm corrugated steel pipe of 30 m in length conveying flow under the existing dike structure (Photo Log 1; Photo 17); and one 15 m long clearspan bridge approximately 340 m upstream of the confluence within the Hop Creek Farm's property (Photo Log 2; Photo 5). While the clearspan bridge was not able to be viewed as it was on private property, no major restrictions to fish passage through the culverts were observed. Both culvert inlets and outlets were well embedded with laminar flow at all points with the exception the culvert inlet under Government Road which is currently a higher gradient change associated with high velocity over coarse substrate (Photo Log 2; Photo 13). At the time of observation, passage of large-bodied fish would not be expected to be impeded.

Harris Slough (Squamish River Side Channel)

Harris Slough was not surveyed during the field visit due to restrictions to access as a result of private property in the vicinity of the watercourse. No historical fish and fish habitat information was available for Harris Slough (MOE 2019a, MOE 2019b, MOE 2019c, MOE 2019d).

Meigan Creek

Meigan Creek flows south from its headwaters for approximately 1.5 km to the crossing structure at Government Road. From the crossing, Meigan Creek travels south along Government Road for approximately 150 m; however, from this point to the confluence, the location and character of the stream was unable to be observed due to access restrictions. Based on satellite imagery, Meigan Creek appears to discharge into Harris Slough, which has connection to the Mamquam River. Ground truthing would be necessary to determine with certainty no other connection of Meigan Creek and the Squamish River is currently present as historical mapping (MOE 2019a) shows a direct connection.

At the time of survey, the observed reach consisted of predominately low velocity, shallow (0.25 m) run habitat, dominated by fine substrates with gravels subdominant and small amounts of boulders and cobbles (Photo Log 2; Photo 18). Moderate cover was provided primarily by overhanging vegetation and large and small woody debris. At the point of measure (approximately 20 m upstream of the culvert inlet) the wetted width was 3.8 m and channel width 5.2 m. Approximately 150 m upstream of the culvert inlet wetted with narrows to approximately 2.0 m and channel substrates consist entirely of fine materials (Photo Log 2; Photo 21). Approximately 80 m downstream of the culvert inlet habitat continues to be characterized by shallow, low velocity run habitat (Photo Log 2; Photo 22).

Riparian vegetation along the surveyed reach of Meigan Creek consisted of deciduous forest in the vicinity of the culvert with canopy species dominated by red alder (*Alnus rubra*) and bigleaf maple (*Acer macrophyllum*) and understory dominated by salmonberry (*Rubus spectabilis),* ferns and red-osier dogwood (*Cornus stolonifera*) (Photo Log 2; Photo 12). Approximately 70 m upstream of the culvert inlet, the riparian vegetation transitions into a mature mixedwood forest dominated by Western red cedar (*Thuja plicata*) and black cottonwood (*Populus balsamifera ssp. trichocarpa*) (Photo Log 2; Photo 13).

During the time of survey, Meighan Creek in-situ water quality measurements consisted of; 6.51 mg/L DO, pH 6.34, conductivity 164 µS/cm and water temperature of 14.9 Cº (Table 1).

One crossing structure was observed on Meigan Creek. Twin, 1000 mm corrugated steel pipes of 15 m length convey flow under Government Road. Fish passage through the crossing structure was unimpeded at the time of survey (Photo Log 2; Photo 20).

Fish Species Presence

Twenty-two species of fish have been documented within the watercourses of the study area and are presented in Table 2. All species were documented within the Squamish River, with 10 species documented within Meigan and Dryden Creeks, and 2 species documented within Judd Slough (Table 2). No historical information regarding fish species within Harris Slough was available at the time of reporting. Three fish species of conservation concern potentially occur in the study area: bull trout (*Salvelinus confluentus*), coastal cutthroat trout (*Oncorhynchus clarkii clarkia*) and green sturgeon (*Acipenser medirostris*). Additionally, all five species of Pacific salmon occur within the study area.

Table 2: Fish Species Recorded within the Study Area Watercourses

Common Name	Scientific Name	Code	Watercourse
American shad	*Alosa sapidissima*	SH	Squamish River
Atlantic salmon	*Salmo salar*	AS	Squamish River
Bull trout	*Salvelinus confluentus*	BT	Squamish River
Chinook salmon	*Oncorhynchus tshawytscha*	CH	Squamish River
Chum salmon	*Oncorhynchus keta*	CM	Squamish River, Meigan Creek, Dryden Creek, Judd Slough
Coastal cutthroat trout	*Oncorhynchus clarkii clarkii*	CCT	Squamish River
Coastrange sculpin (formerly Aleutian Sculpin)	*Cottus aleuticus*	CAL	Squamish River
Coho salmon	*Oncorhynchus kisutch*	CO	Squamish River, Meigan Creek, Dryden Creek, Judd Slough
Cutthroat trout	*Oncorhynchus clarki*	CT	Squamish River, Meigan Creek, Dryden Creek
Dolly varden	*Salvelinus malma*	DV	Squamish River, Meigan Creek
Green sturgeon	*Acipenser medirostris*	GSG	Squamish River
Lamprey	*Lampetra Unknown spp.*	L	Squamish River, Meigan Creek, Dryden Creek
Mountain whitefish	*Prosopium williamsoni*	MW	Squamish River
Pacific amprey	*Lampetra tridentata*	PL	Squamish River
Pink salmon	*Oncorhynchus gorbuscha*	PK	Squamish River, Dryden Creek
Prickly sculpin	*Cottus asper*	CAS	Squamish River
Rainbow trout	*Oncorhynchus mykiss*	RB	Squamish River, Meigan Creek, Dryden Creek
Sculpin (General)	*Cottus spp.*	-	Squamish River, Meigan Creek, Dryden Creek

Common Name	Scientific Name	Code	Watercourse
Sockeye salmon	*Oncorhynchus nerka*	SK	Squamish River
Steelhead	*Oncorhynchus mykiss*	ST	Squamish River, Meigan Creek, Dryden Creek
Stickleback (General)	*Gasterosteus* spp.	-	Squamish River, Meigan Creek, Dryden Creek
Threespine stickleback	*Gasterosteus aculeatus*	TSB	Squamish River, Meigan Creek, Dryden Creek
Sources: MOE 2019d, ARL 2002, Golder 2005			

Invasive Species

American shad (*Alosa sapidissima)* and Atlantic salmon (*Salmo salar)* have been documented within the Squamish River (MOE 2019d).

Aquatic Environment Data Gaps

Additional desktop and field reviews should address the following data gaps with respect to aquatic environments at the Eagle Viewing Area / Siyich'em DMP study area:

- Complete fish habitat assessment of all aquatic habitats potentially affected by project works;
- Assessment of fish habitat value of forested island adjacent to Judd Slough; and
- Assessment of fish passage potential along all stream reaches.

1.3 Terrestrial Environment

Methods

KWL characterized the terrestrial environment within the DMP study area using desktop and field-based methods. A KWL biologist delineated terrestrial cover types in GIS using 2019 orthoimagery. Vegetation was mapped for the eastern part of the study area, between the Siyich'em 16 and Kowtain 17 Reserves. The distribution of cover types within the study area was determined by professional judgement based on a visual assessment and refined following a field visit. On 10 September 2019, KWL conducted a site visit to verify habitat boundaries and collect incidental data on wildlife presence. No systematic sampling or species surveys were included as part of the field visit. KWL characterized the bird and mammal community in the DMP study area using publicly available data.

Vegetation Mapping

The study area is located within the Coastal Western Hemlock biogeoclimatic zone, dry maritime subzone (CWHdm) (MOE 2019a). Figure 1 shows the distribution of vegetation cover types identified within the study area. Photos documenting each habitat type are provided in Photo Log 2. Table 3 provides descriptions of each identified habitat and general location.

District of Squamish / Squamish Nation

Eagle Viewing Area / Siyich'em Dike Master Plan - Baseline Habitat Review

KERR WOOD LEIDAL consulting engineers

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STUDY LIMIT

STUDY LIMIT

Legend

Terrestrial Cover Types

ITEM

- Agricultural Grazing
- Deciduous Forest
- Ditch
- Hedgerow - Treed
- Maintained Grass
- Maintained Grass - Trees
- Mature Mixedwood Forest
- Mixedwood Forest
- Modified
- Riprap Armouring
- Sandbar
- Shrub
- Stream
- Transitional

Service Layer Credits: GIS data from the District of Squamish Open Data Catalogue downloaded July, 2019. Crown Right-of- Way from Data BC. 2016 Imagery shown.

Coordinate System: NAD 1983 UTM Zone 10N

Scale Disclaimer: The map scale of 1:5,000 is only valid on a 11"x17" print.

Project No. 463.341

Date May 2020

Scale 1:5,000 0 20 40 80 (m)

Terrestrial Cover Types

Figure 1

Table 3: Terrestrial Cover Types Present Within the Study area and Adjacent Areas

Cover Type	Description	Major Locations
Agricultural Grazing	Area of pasture grasses with mixed agricultural grazing of sheep and pig paddock.	• East of Government Road and Siyich'em Reserve (Hop Creek Farm)
Deciduous Forest	Riparian area with canopy dominated by black cottonwood (*Populus balsamifera ssp. trichocarpa*) and red alder (*Alnus rubra*) with some bigleaf maple (*Acer macrophyllum*). Understory species dominated by salmonberry (*Rubus spectabilis),* thimbleberry (*Rubus parviflorus*), and red-osier dogwood (*Cornus stolonifera*).	• Riparian area bordering Judd Slough • Riparian area surrounding Dryden Creek east of Government Road • Riparian area surrounding Meigan Creek near Government Road culvert inlet • Bordering pathway on dike at start of private land (gate southward)
Ditch	Dugout area associated with the Dryden Creek storm pump station consisting of native and non-native grasses in an area of shallow standing water.	• Dryden Creek storm pump station
Hedgerow – Treed	Linear treed habitat found primarily along the eastern border of the Siyich'emSiyich'em Reserve between modified habitats (e.g. residential and Government Road). Tree species are a mix of coniferous and deciduous species of native and ornamental variety.	• Eastern boundary of Siyich'em Reserve
Maintained Grass	Areas of grass maintained by mowing.	• Linear strip between dike gravel path and Government Road from Siyich'em Reserve southern boundary extending south • Residential property at southern extent of study area
Maintained Grass – Trees	Areas of grass maintained by mowing with occasional trees (red alder (*Alnus rubra*), black cottonwood (*Populus balsamifera ssp. trichocarpa)*, fir (*Abies* spp.), big leaved maple (*Acer macrophyllum*).	• South of Dryden Creek pump station between dike pathway and Government Road
Mature Mixedwood Forest	Riparian area on North bank of Meigan Creek dominated by a mature stand of Western red cedar (*Thuja plicata*) and black cottonwood (*Populus balsamifera ssp. trichocarpa*).	• Meigan Creek east of Government Road

Cover Type	Description	Major Locations
Mixedwood Forest	Riparian area canopy dominated by black cottonwood (*Populus balsamifera ssp. trichocarpa*) and red alder (*Alnus rubra*) with occasional Western red cedar (*Thuja plicata*) and Fir (*Abies* spp.). Understory species dominated by salmonberry (*Rubus spectabilis),* thimbleberry (*Rubus parviflorus*), and red-osier dogwood (*Cornus stolonifera*).	• Southern extent of study area west of Government Road surrounding Meigan Creek
Modified	Ares of no vegetation or residential landscaping of non-native species. Consists of areas of bare ground, pavement, residential structures, residential landscaping, gravel pathways, and parking lots.	• Dike pathway (gravel) • Government Road (pavement) • Paved and gravel areas, yards and residents within Siyich'em Reserve • Residence at southern end of study area
Riprap Armouring	Linear area extending along the western length of the dike composed of riprap armour with small amounts of low lying native and non-native herbaceous species.	• Southern extent of Siyich'em Reserve extending south to private residence at southern end of study area
Sandbar	Depositional bar of sand associated with the Judd Slough confluence with the Squamish River.	• Judd Slough outlet
Shrub	Area of intermittent shrub cover (*Salix* spp.*)* over riprap armouring.	• Small patch on riprap armouring of dike just north of fence line marking private property in southern end of study area.
Stream	Lotic (flowing) aquatic habitat	• Judd Slough • Dryden Creek • Meigan Creek
Transitional	Areas of gravel lot, road, driveway, or pathways with a mixture of native, ornamental and non-native shrubs, grasses and herbaceous plants with areas of open space.	• Northern half of Siyich'em Reserve • Private property at southern end of study area

Invasive Species

No provincial priority invasive plant species classified as high-risk were observed within the study area during the field visit (Government of British Columbia 2020). Historical records from the Invasive Alien Plant Program (MOE 2019e) indicate the presence of the following species *within* the study area:

- **Yellow flag-iris (*Iris pseudacorus*) –** Occurrence documented in the vicinity of the Dryden Creek outlet near the ditch habitat.
- **Scotch broom (*Cytisus scoparius*)** – Occurrence documented at the transition of deciduous forest and riprap armouring habitats west of Siyich'em Reserve.
- **Himalayan blackberry (*Rubus armeniacus*)** – Occurrence documented at the transition of deciduous forest and riprap armouring habitats west of Siyich'em Reserve.

Historical records from the Invasive Alien Plant Program (MOE 2019e) indicate the presence of the following species *in the vicinity of* the study area:

- **Yellow flag-iris (*Iris pseudacorus*)** – Approximately 280 m northwest of the northern study area boundary, 300 m west of the northern study area boundary.
- **Scotch broom (*Cytisus scoparius*)** – Approximately 200 m southwest of the northern study area boundary.
- **Himalayan blackberry (*Rubus armeniacus*)** – Approximately 70 m northwest of the northern study area boundary, approximately 280 m northwest of the northern study area boundary, approximately 200 m southwest of the northern study area boundary.
- **Japanese knotweed (*Fallopia japonica*)** – Occurrences documented approximately 50 m and 150 m directly south of the southern study area boundary and 500 m east of the southern study area boundary, 300 m west of the northern study area boundary.
- **Butterfly bush (*Buddleja davidii*)** – Approximately 280 m northwest of the northern study area boundary, approximately 200 m southwest of the northern study area boundary.
- **English holly (*Ilex aquifolium*)** – Approximately 280 m northwest of the northern study area boundary, approximately 200 m southwest of the northern study area boundary.
- **Policeman's helmet / himalayan balsam (*Impatiens glandulifera*)** – Approximately 280 m northwest of the northern study area boundary.

Birds and Terrestrial Wildlife

Birds

Within the coast and mountain ecoprovince and CWH zone, 150 bird species have been documented (Atlas of the Breeding Birds of British Columbia 2019). These species are presented in Table 4. Nearby in Brakendale Eagles Provincial Park, 148 bird species have been documented throughout the year (Armstrong et. al 1999). The park's namesake, the bald eagle (*Haliaeetus leucocephalus*), congregates in large numbers to feed on spawned salmon between mid-October and late March (Armstrong et. al 1999). Within the study area, few potential eagle roosting and perching trees were observed. A handful of low-quality habitat trees, with thin branching and high foliage, occur at the southern end of Siyich'em Reserve. One stand of moderate-quality roosting trees was observed within the maintained grass-treed habitat unit south of the Dryden Creek Pump Station (Photo Log 3; Photo 1-2).

Table 4: Bird Species with Potential to be Present Within the Study Area

Bird Species with Potential to be Present Within the Study Area		
Alder Flycatcher	Golden-crowned Kinglet	Red-breasted Nuthatch
American Crow	Gray Jay	Red-breasted Sapsucker
American Dipper	Gray-cheeked Thrush	Red-eyed Vireo
American Goldfinch	Great Blue Heron	Red-naped Sapsucker
American Kestrel	Greater Yellowlegs	Red-tailed Hawk
American Pipit	Green-winged Teal	Red-throated Loon
American Redstart	Hairy Woodpecker	Red-winged Blackbird
American Robin	Hammond's Flycatcher	Rhinoceros Auklet
American Three-toed Woodpecker	Harlequin Duck	Ring-necked Duck
Arctic Tern	Hermit Thrush	Rock Pigeon
Bald Eagle	Hooded Merganser	Ruby-crowned Kinglet
Band-tailed Pigeon	House Finch	Ruffed Grouse
Barn Swallow	House Sparrow	Rufous Hummingbird
Barred Owl	Hutton's Vireo	Sandhill Crane
Barrow's Goldeneye	Killdeer	Savannah Sparrow
Belted Kingfisher	Lazuli Bunting	Semipalmated Plover
Bewick's Wren	Least Flycatcher	Sharp-shinned Hawk
Black Oystercatcher	Lincoln's Sparrow	Solitary Sandpiper
Black Swift	MacGillivray's Warbler	Song Sparrow
Black-capped Chickadee	Magnolia Warbler	Sooty Grouse
Black-headed Grosbeak	Mallard	Sora
Blackpoll Warbler	Marbled Murrelet	Spotted Sandpiper
Black-throated Gray Warbler	Marsh Wren	Spotted Towhee
Blue-winged Teal	Merlin	Spruce Grouse
Brewer's Blackbird	Mew Gull	Steller's Jay
Brown Creeper	Mountain Chickadee	Swainson's Thrush
Brown-headed Cowbird	Mourning Dove	Tennessee Warbler
Bullock's Oriole	Nashville Warbler	Townsend's Solitaire
Canada Goose	Northern Flicker	Townsend's Warbler
Cassin's Vireo	Northern Goshawk	Tree Swallow
Cedar Waxwing	Northern Pygmy-Owl	Trumpeter Swan
Chestnut-backed Chickadee	Northern Rough-winged Swallow	Turkey Vulture
Chipping Sparrow	Northern Saw-whet Owl	Varied Thrush
Clark's Nutcracker	Northern Waterthrush	Vaux's Swift

Bird Species with Potential to be Present Within the Study Area		
Cliff Swallow	Northwestern Crow	Veery
Common Goldeneye	Olive-sided Flycatcher	Violet-green Swallow
Common Loon	Orange-crowned Warbler	Virginia Rail
Common Merganser	Osprey	Warbling Vireo
Common Nighthawk	Pacific Wren	Western Kingbird
Common Raven	Pacific-slope Flycatcher	Western Screech-Owl
Common Yellowthroat	Pelagic Cormorant	Western Tanager
Cooper's Hawk	Peregrine Falcon	Western Wood-Pewee
Dark-eyed Junco	Pied-billed Grebe	White-crowned Sparrow
Downy Woodpecker	Pigeon Guillemot	White-winged Crossbill
Dusky Flycatcher	Pileated Woodpecker	Willow Flycatcher
Eurasian Collared-Dove	Pine Grosbeak	Wilson's Snipe
European Starling	Pine Siskin	Wilson's Warbler
Evening Grosbeak	Purple Finch	Wood Duck
Fox Sparrow	Red Crossbill	Yellow Warbler
Glaucous-winged Gull	Red-breasted Merganser	Yellow-rumped Warbler

Source: Atlas of the Breeding Birds of British Columbia (2019) – Coast and Mountains Ecoprovince, Costal Western Hemlock Biogeoclimatic Zone.

Mammals

As many as 55 mammal species may occur within the Brakendale Eagles Provincial Park (Armstrong et. al 1999). These species may occur within the DMP study area as well. Historical occurrences of mammals within the study area and vicinity include the Long-tailed Vole (*Microtus longicaudus),* Cinereus Shrew (*Sorex cinereus*) and North American Deer Mouse (*Peromyscus maniculatus*) (MOE 2019a). These occurrences were documented during a 2014 small mammal trapping survey conducted by Cascade Environmental (MOE 2019c). Pacific water shrew (*Sorex benderii*) is an endangered mammal likely present in the DMP study area.

Reptiles and Amphibians

Approximately 11 amphibian and 5 reptile species may occur within the Brakendale Eagles Provincial Park (Armstrong et. al 1999). Given the proximity of the study area to the park, these species likely utilize areas of suitable habitat within the DMP study area.

Terrestrial Environment Data Gaps

Additional desktop and field reviews should address the following data gaps with respect to terrestrial environments at the Eagle Viewing Area / Siyich'em DMP study area:

- Assessment of project effects on populations and habitats of species of conservation concern present in the DMP study area.

1.4 Species of Conservation Concern

Species of conservation concern, or species-at-risk, are plants and animals that have been identified to be at risk of extinction. Some species that are rare or have declining populations are protected by regulation. Section 2 below summarizes statutes relevant to species of conservation concern with legal protection.

Information presented here was collected from online databases. No field surveys for species of conservation concern were conducted as part of this report. Table 5 summarizes species of conservation concern with historical occurrences or critical habitat within or near the Eagle Viewing Area / Siyich'em DMP study area. As many as thirty-one species of conservation concern may occur within the study area.

Fish

Three provincially or federally listed fish species may occur within the watercourses of the study area including: bull trout (*Salvelinus confluentus)*, coastal cutthroat trout (*Oncorhynchus clarkii clarkia*), and green sturgeon (*Acipenser medirostris)*. While several distinct populations of chinook salmon, sockeye salmon, coho salmon and steelhead throughout the province are listed, the Squamish River watershed populations of these species do not have a provincial or federal recognized status. More details regarding the status of salmon and steelhead stocks within the Squamish River are available in the Squamish River Watershed Salmon Recovery Plan (Golder Associates 2005).

Vegetation

A total of fifteen provincially or federally listed plant species composed of 5 vascular and 10 non-vascular species occur within the CWH zone of the Squamish Forest District (MOE 2019f, MOE 2019g). Of these species, only the endemic Roell's brothella (*Brotherella roelli*) has a record of historical occurrence within the vicinity of the study area (COSEWIC 2010, MOE2019f, Table 5). The 2006 occurrence was documented within the study area along trails within the mid-reach of Judd Slough near Birken Road (MOE2019f; exact location not provided).

Birds and Terrestrial Wildlife

Within the CWH biogeoclimatic zone of the Squamish Forest District, there are fifteen provincially or federally listed bird species (MOE 2019f, MOE 2019g). Of these species, the only species with critical habitat within the vicinity of the study area is the Marbled Murrelet (*Brachyramphus marmoratus*). Critical habitat for the Marbled Murrelet is identified outside the study area, near the southern study boundary East of highway 99 (Figure 2).

Nine species of provincially or federally listed mammals occur within the CWH biogeoclimatic zone of the Squamish Forest District (MOE 2019f, MOE 2019g, ECCC 2015). At the southern extent of the study area, critical habitat for the Pacific Water Shrew is present surrounding Harris Slough extending southward, and Meigan Creek extending eastward (Figure 2, MOE 2019f). Two historical occurrences of Pacific Water Shrew were documented in April of 2008 outside the study area, east of Highway 99 within shallow creeks of a golf course (MOE 2019f; exact location not provided). The federally listed bat little brown myotis (*Myotis lucifugus*) likely forages within the study area (ECCC 2015). A large maternity roost for the species occurs within 2.5 km of the study area.

Two provincially or federally listed amphibian and two reptile species occur within the CWH biogeoclimatic zone of the Squamish Forest District (MOE 2019g). No critical habitat or historical occurrence records of these species was found within the study area (MOE 2019f).

Table 5: Species of Conservation Concern with Potential to be Present Within the Study Area

Common Name	Scientific Name	Conservation Status			Relevance	Potential Presence within Study Area	Historical Records
		Provincial (BC List)	COSEWIC	SARA			
Fish							
Bull trout	*Salvelinus confluentus*	Blue – Special Concern	Special Concern (2012)	-	Potential spawning habitat in study area	**Moderate –** Require cold, often below 12°C water in complex stream habitat (deep pools, LWD, overhanging banks, connectivity between habitats for all life stages. (COSEWIC 2012).	Recorded in Squamish River
Coastal cutthroat trout	*Oncorhynchus clarkii clarkii*	Blue – Special Concern	-	-	Potential spawning habitat in study area	**Moderate –** Require small, low gradient coastal streams, well shaded with temperatures below 18°C. Spawns in streams on clean, small gravel substrates. (Moyle 1989).	Recorded in Squamish River
Green sturgeon	*Acipenser medirostris*	Blue – Special Concern	Special Concern (2013)	Schedule 1 – Special Concern (2006)	Potential spawning habitat in study area	**Moderate –** Restricted to the Squamish River. Preferred spawning habitat ranges from clean sand to bedrock in high velocity freshwater of depths over 3 m. Access to estuary and marine habitat for marine life history (Fisheries and Oceans Canada 2017).	Recorded in Squamish River

Common Name	Scientific Name	Conservation Status			Relevance	Potential Presence within Study Area	Historical Records
		Provincial (BC List)	COSEWIC	SARA			
Birds							
Marbled murrelet	*Brachyramphus marmoratus*	Blue – Special Concern	Threatened (2012)	Schedule 1 - At Risk (2005)	Area containing critical habitat located within 400 m of southern extent of study area	**Low –** Restricted to small mature mixed wood habitat type outside study area. Prefers 30 m or taller conifers with large mossy limbs in the canopy within 50 km of the ocean for nesting (Environment Canada 2014a).	No historical occurrences recorded within study area.
Plants							
Roell's brothella	*Brotherella roelli*	Red – Candidates for Extirpated, Endangered, or Threatened status	Endangered (2010)	Schedule 1: Endangered (2018)	Occurs on hardwoods and rotten logs within the study area	**High –** Found in humid mixed forests on alder, maple, and dogwood trees, often within urban parks.	Recorded along Judd Slough
Mammals							
Pacific water shrew	*Sorex bendirii*	Red – Candidates for Extirpated, Endangered, or Threatened status	Endangered (2016)	Schedule 1: Endangered (2003)	Study area overlaps critical habitat at southern extent of study area (Harris Slough, Meigan Creek)	**High –** Riparian corridors and streams, up to 100 m of each side of a watercourse with downed wood for cover, nesting, and foraging substrate (Environment Canada 2014b).	Historical occurrence recorded ~1km northeast of study area.
Little brown myotis	*Myotis lucifugus*	Yellow – Secure	Endangered (2013)	Schedule 1: Endangered (2014)	Roost locations in anthropogenic structures are not currently identified as critical habitat.	**High –** Species forages over water and has known roosts near the study area.	No historical occurrences recorded within study area.

Path: \\kwl.ca\bby\0000-0999\0400-0499\463-341\430-GIS\MXD-Wk\AppendixD\463341_Wk_Fig2_PRWB.mxd Date Saved: 5/29/2020 8:23:14 AM | Author: PBurke

District of Squamish / Squamish Nation

Eagle Viewing Area / Siyich'em Dike Master Plan - Baseline Habitat Review

KERR WOOD LEIDAL consulting engineers

N

STUDY LIMIT

STUDY LIMIT

Legend

Terrestrial Cover Types

Terrestrial Cover Types

Critical Habitat

SCNTFC_NM

- Accipiter gentilis laingi
- Brachyramphus marmoratus
- Pinus albicaulis
- Sorex bendirii

Service Layer Credits: GIS data from the District of Squamish Open Data Catalogue downloaded July, 2019. Crown Right-of- Way from Data BC. 2016 Imagery shown.

Coordinate System: NAD 1983 UTM Zone 10N

Scale Disclaimer: The map scale of 1:10,000 is only valid on a 11"x17" print.

Project No. 463.341

Date May 2020

Scale 1:10,000 0 20 40 80 (m)

Critical Habitat Within the DMP Study Area

Figure 2

2. Environmental Regulatory Context and Requirements

2.1 Federal Statues

Fisheries Act

Projects near water must ensure that activities do not adversely affect fish or fish habitat. The modernized *Fisheries Act* [RSC, 1985, c. F-14] prohibits obstructing the free passage of fish (§ 34.3 (2)); causing the death of fish (§ 34.4 (1)); causing the harmful alteration, disruption or destruction of fish habitat (§ 35 (1)); depositing deleterious substances in waterbodies (§ 36 (3)); and other actions. The Fish and Fish Habitat Protection Program of the Department of Fisheries and Oceans (DFO) oversees projects near water. A *Fisheries Act* Authorization can be obtained from the Minister of Fisheries, Oceans and the Canadian Coast Guard.

Species at Risk Act

Wildlife species are protected on federal lands and gazetted critical habitat is protected across all jurisdictions. The *Species at Risk Act* [SC 2002, c. 29] prohibits killing or harassing species listed on Schedule 1 of the Act (§ 32 (1)); damage or destruction to a residence of a species listed on schedule 1 of the Act (§ 33); destruction of critical habitat (§ 58(1)); and other actions. Critical habitat is identified for species listed as Endangered or Threatened under the *Species at Risk Act* as critical to the survival or recovery of listed species (§ 2).

The Species at Risk (SAR) Program oversees protection for terrestrial and aquatic species at risk. A *Species at Risk Act* Authorization under Section 73 can be obtained from the relevant minister.

Migratory Birds Convention Act, 1994

Migratory birds are protected by the *Migratory Birds Convention Act, 1994* [SC 1994, c. 22] and the Migratory Birds Regulations [CRC, c. 1035]. Under the *Migratory Birds Convention Act*, it is unlawful to deposit a substance that is harmful to migratory birds. Under the Migratory Birds Regulations, it is prohibited to disturb, destroy, or take a nest or egg of a migratory bird.

The Canadian Wildlife Service provides nesting calendars to avoid impacts to breeding birds (Government of Canada 2020). Trees and vegetation in the Lower Mainland that may contain birds should not be disturbed during the regional nesting period between late March and mid-August.

Other Federal Regulatory Considerations

- *Canadian Navigable Waters Act* [RSC 1985, c. N-22]: Navigation Protection Program (NPP) of Transport Canada approves and sets terms for works in navigable waters.
- *Impact Assessment Act* [SC 2019, c. 28, s. 1]: Major projects must be reviewed by the federal Impact Assessment Agency of Canada which includes a public consultation process. Projects are designated according to the list of activities in the Regulations Designating Physical Activities (SOR/2012-147).

2.2 Provincial Statutes

Water Sustainability Act

Changes in and about a stream (or river) in British Columbia require authorization by the Ministry of Forests, Lands, Natural Resource Operations and Rural Development under the *Water Sustainability Act* [SBC, 2014, c. 14]. Major works require a Change Approval under Section 11 of the Act, which includes regulatory conditions set by the habitat officer with respect to water use, habitat, contaminants, and general environmental protection. Approval timelines range widely and may take up to twelve months depending on the complexity of the proposed works.

Projects in and about a stream should be planned to occur within regional timing windows when risk to fish and wildlife is lowest. Periods of least risk to fish and fish habitat in the Lower Mainland occur in late summer, between July and October.

Wildlife Act

The *Wildlife Act* [RSBC 1996, c. 488] decrees all wildlife in the British Columbia as property vested in the provincial government. The Act also outlines statutory requirements for killing or taking wildlife. The Act contains prohibitions against taking or disturbing birds, their eggs, and some nests.

The Canadian Wildlife Service provides nesting calendars to avoid impacts to breeding birds (Government of Canada 2020). Trees and vegetation in the Lower Mainland that may contain birds should not be disturbed during the regional nesting period between late March and mid-August.

Other Provincial Regulatory Considerations

- *Dike Maintenance Act* [RSBC 1996, c. 95]: An approval will be required by the provincial Inspector of Dikes.
- *Heritage Conservation Act* [RSBC 1996, c. 187]: Archeological permits may be required through the Forests, Lands, Natural Resource Operations & Rural Development.
- *Environmental Assessment Act, 2018* [SBC 2018, c. 51]: Major water management projects must be reviewed by the Minister of Environment and Climate Change Strategy and the Minister of Municipal Affairs and Housing.

Submission

KERR WOOD LEIDAL ASSOCIATES LTD.

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Senior Biologist

2020-10-27

HLK/prwb

Photo Log 1: Aquatic Environment Photos
Photo Log 2: Vegetation and Terrestrial Habitat Photos
Photo Log 3: Birds and Terrestrial Wildlife Photos

Statement of Limitations

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Revision History

Revision #	Date	Status	Revision Description	Author
0	October 27, 2020	Final	Issued as final for client copy.	HLK/PRWB

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Photo Log 1

Aquatic Environment Photos

Photo 1 – Judd Slough - Looking upstream from the transect and water quality location on Judd Slough.

Photo 2 – Judd Slough- Looking downstream from the transect and water quality location on Judd Slough.

Photo 3 – Judd Slough - Area of erosion within dog use area on Judd Slough.

Photo 4 – Judd Slough - Area of potential salmonid spawning habitat.

Photo 5 – Judd Slough - Looking upstream from the confluence with the Squamish River.

Photo 6 – Judd Slough - Looking north at the confluence with the Squamish River.

Photo 7 – Judd Slough - Looking south at the confluence with the Squamish River.

Photo 8 – Judd Slough – Looking downstream from the dike and pump station at Fishermans Park.

Photo 9 – Squamish River - Looking upstream from the dike pathway near Watershed Grill.

Photo 10 – Squamish River - Looking towards the left downstream bank near Watershed Grill.

Photo 11 – Squamish River - Looking downstream from the Watershed Grill.

Photo 12 – Squamish River – Looking at the backwater habitat near Dryden Creek outlet.

Photo 13 – Dryden Creek – Culvert inlet conveying flow under Government Road.

Photo 14 – Dryden Creek - Looking upstream from transect location.

Photo 15 – Dryden Creek - Looking downstream from transect location.

Photo 16 – Dryden Creek – Looking at left downstream bank at transect location.

Photo 17 – Dryden Creek – Culvert inlet conveying flow under existing dike.

Photo 18 – Meigan Creek - Looking upstream from transect location.

Photo 19 – Meigan Creek - Looking downstream from transect location.

Photo 20 – Meigan Creek – Culvert inlets conveying flow under Government Road.

Photo 21 – Meigan Creek – Habitat present at the upstream extent of survey.

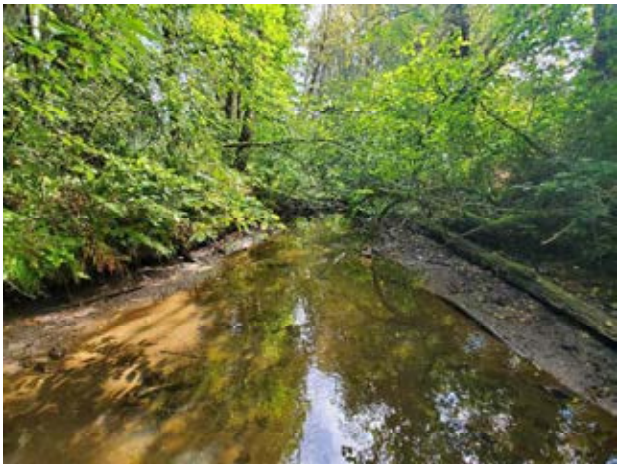

Photo 22 – Meigan Creek – Habitat present at the downstream extent of survey.

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Photo Log 2

Vegetation and Terrestrial Habitat Photos

Photo 1 – Deciduous Forest – Typical canopy in deciduous forest associated with Judd Slough riparian area.

Photo 2 – Modified Habitat – Residental property within Siyich'em I.R. 16.

Photo 3 – Transitional Habitat – Example at boundary with modified habitat within Siyich'em I.R. 16.

Photo 4 – Transitional Habitat – Example at northern assessment area boundary.

Photo 5 – Agricultural Habitat – Example at Dryden Creek clear span crossing within Hop Creek Farms.

Photo 6 – Ditch Habitat – Example associated with the Dryden Creek pump station.

Photo 7 – Modified Habitat – Example of gravel pathway on top of existing dike.

Photo 8 – Modified Grass Habitat - Treed – Example between dike pathway and Government Road.

Photo 9 – Riprap Armouring Habitat – Example of herbaceous species of vegetation on riprap.

Photo 10 – Shrub Habitat – Example at southern end of assessment area.

Photo 11 – Deciduous Forest - Looking south from start of private land.

Photo 12 – Deciduous Forest – Example of habitat associated with Meigan Creek riparian area.

Photo 13 – Mature Mixedwood Forest – Example of habitat associated with Meigan Creek riparian area.

Photo 14 –Mixedwood Forest – Example of habitat associated with Meigan Creek riparian area.

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Photo Log 3

Birds and Terrestrial Wildlife Photos

Photo 1 – Eagle Tree Assessment – Deciduous trees assessed as low value roosting and perching habitat.

Photo 2 – Eagle Tree Assessment – Coniferous trees assessed as moderate value roosting and perching habitat.

Photo 3 – Incidental Wildlife – Black bear (*Ursus americanus*) print at Judd Slough outlet.

Photo 4 – Incidental Wildlife –Frog (species unconfirmed) at Meigan Creek riparian area.

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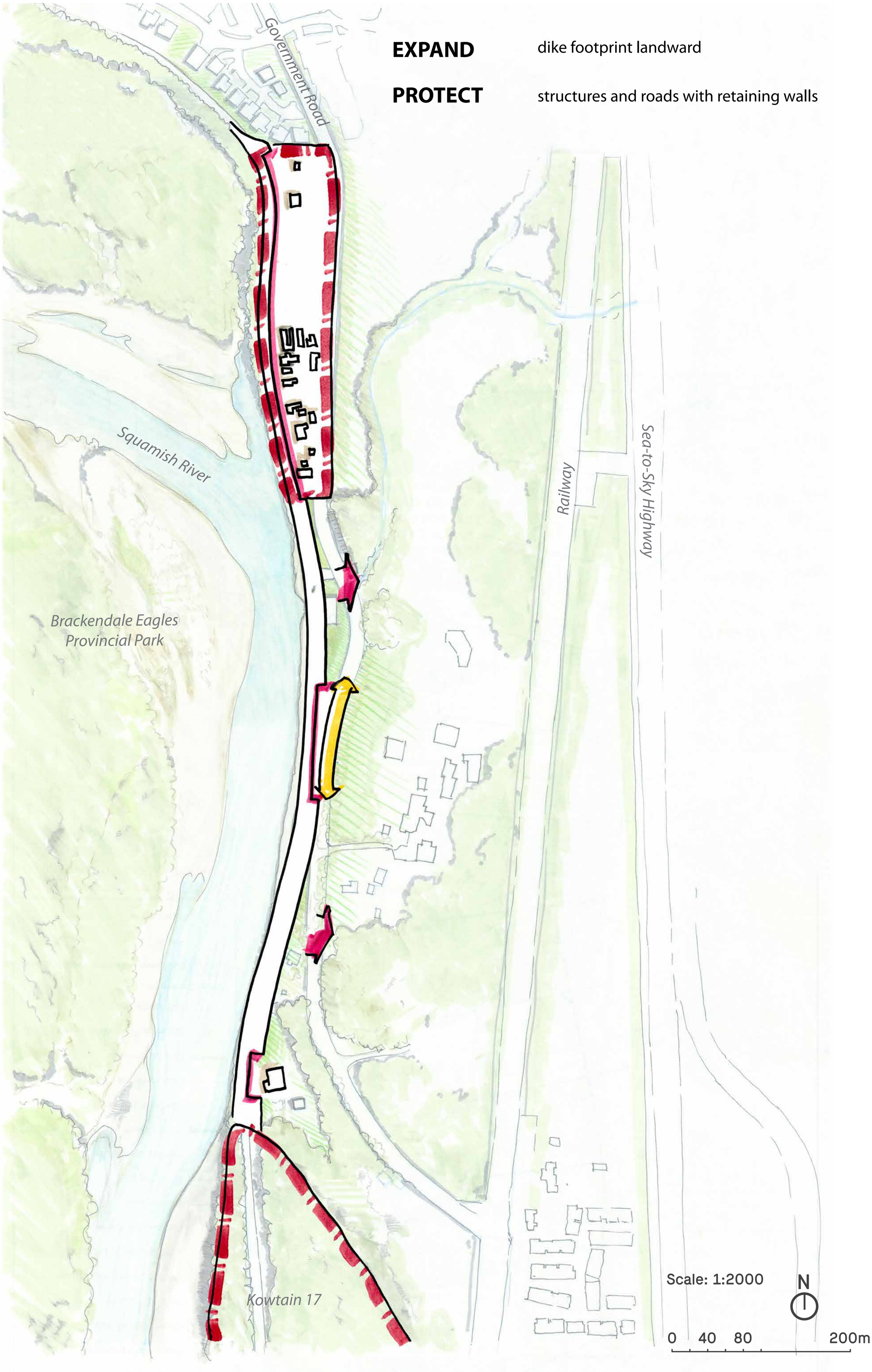
Appendix E

Initial High-level Concept Visualizations

1 Minimize Dike Fill

EXPAND dike footprint landward

PROTECT structures and roads with retaining walls



SQUAMISH

HAPA

1 Minimize Dike Fill

Raise dike on existing alignment by expanding on the land-side

Seepage control within dike

Use retaining walls to limit impact to Seaichem structures on land-side slope

Reserve elevation is at nation discretion

No change to Government Road

Retaining wall may be required to avoid impact to Government Road

Retaining wall may be required to avoid impact to residence

Government Road

STUDY LIMIT

Seaichem 16

Squamish River

Brackendale Eagles Provincial Park

Railway

Sea-to-Sky Highway

Kowtain 17

STUDY LIMIT

Scale: 1:2000

N

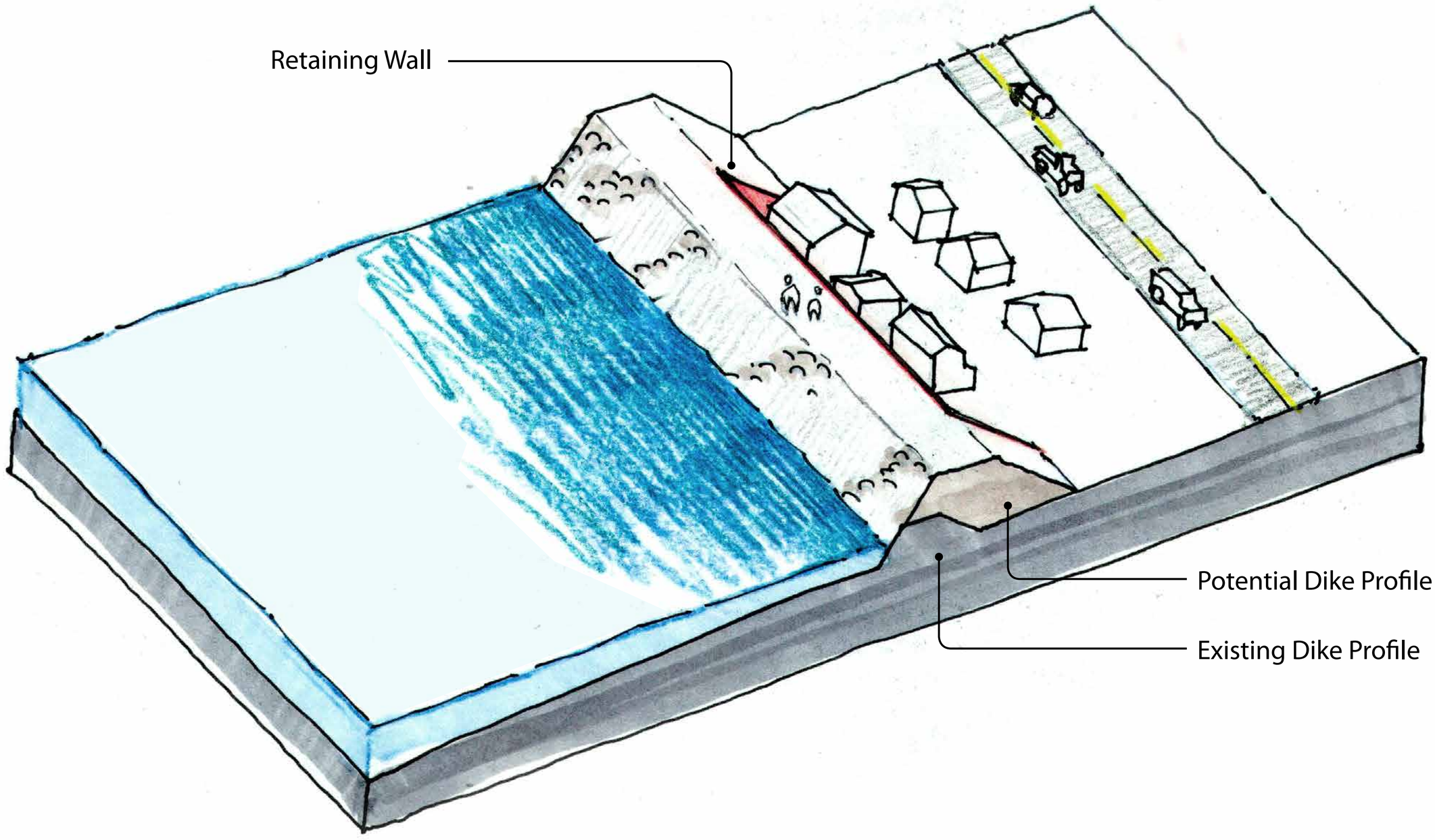
0 40 80 200m

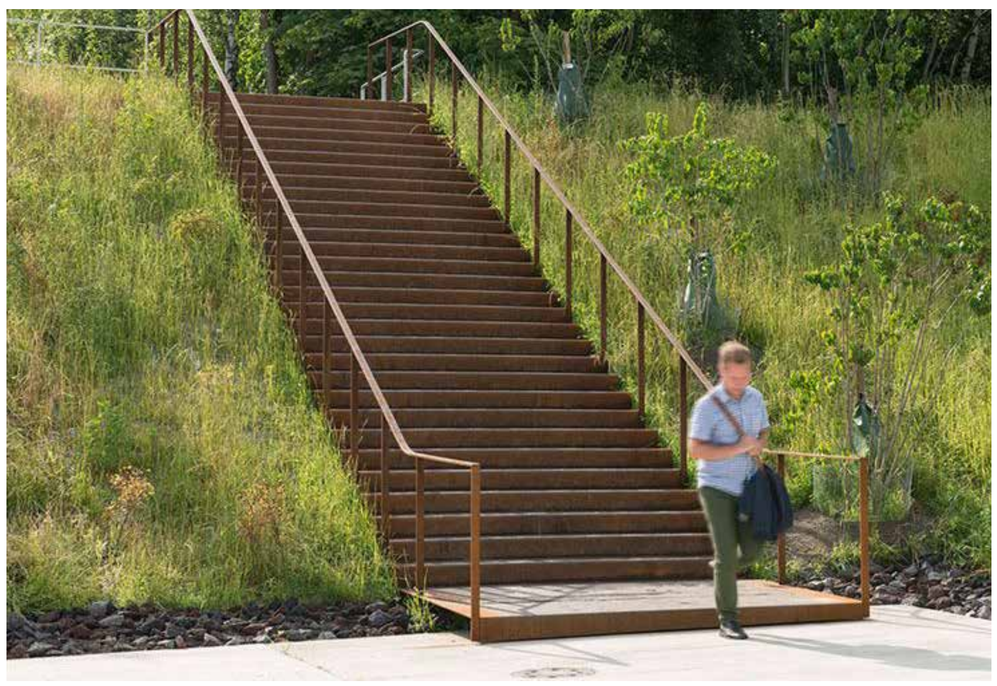
SQUAMISH

HAPA

1 Minimize Dike Fill

Upgraded dike negatively impacts existing structures





Steeper access to top of dike

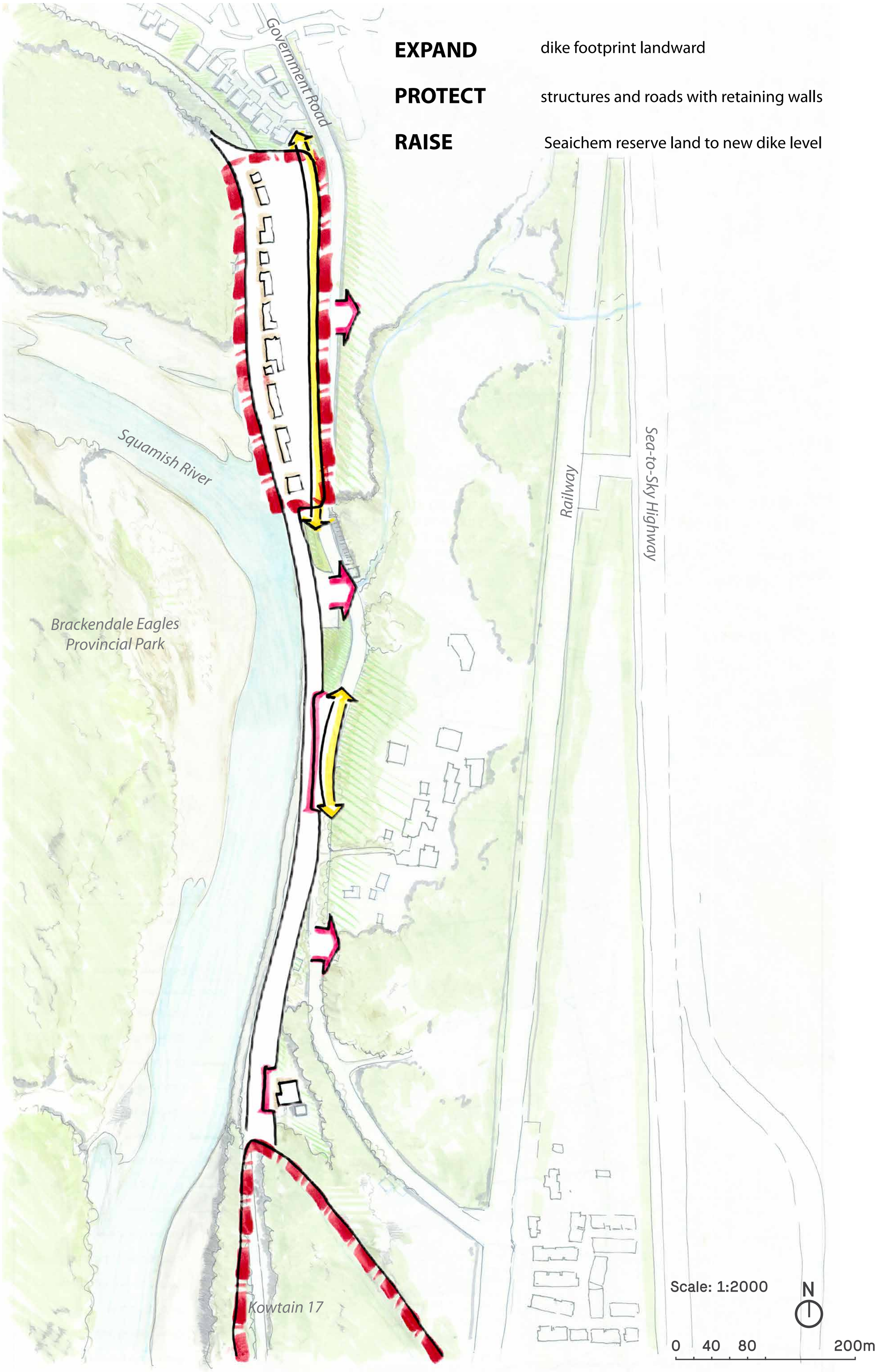
Retaining wall

2 Raise Seaichem Reserve

EXPAND dike footprint landward

PROTECT structures and roads with retaining walls

RAISE Seaichem reserve land to new dike level



SQUAMISH

HAPA

2 Raise Seaichem Reserve

Raise Seaichem land to dike elevation or near to dike elevation

Raise Seaichem land to, or near, dike elevation

Raise Government to, or near, dike elevation along its existing alignment

Road slopes down from reserve elevation to its existing elevation

Retaining wall may be required to avoid impact to Government Road

Retaining wall may be required to avoid impact to residence

Government Road

STUDY LIMIT

Seaichem 16

Squamish River

Brackendale Eagles Provincial Park

Railway

Sea-to-Sky Highway

STUDY LIMIT

Kowtain 17

Scale: 1:2000

N

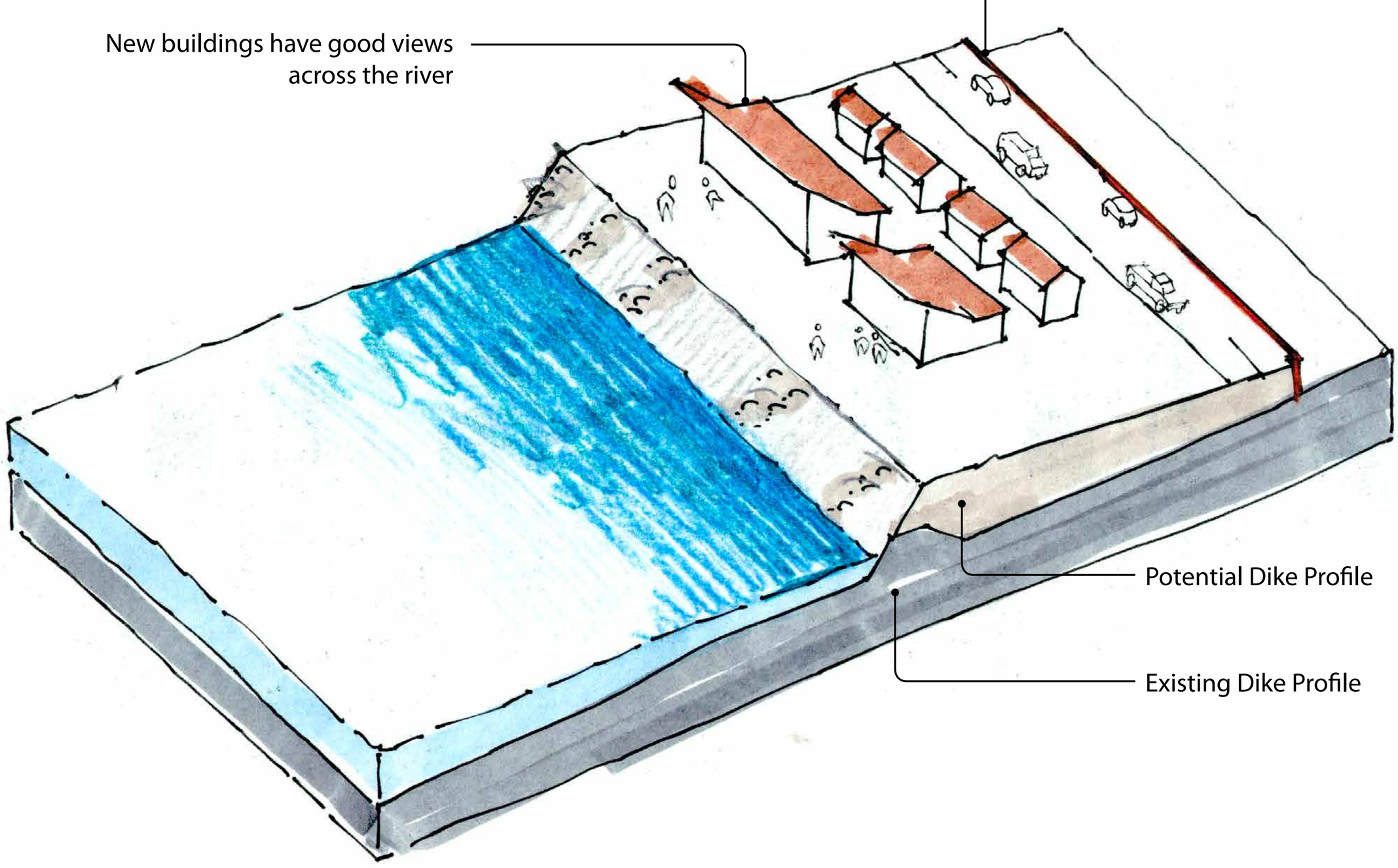
0 40 80 200m

SQUAMISH

HAPA

2 Raise Seaichem Reserve

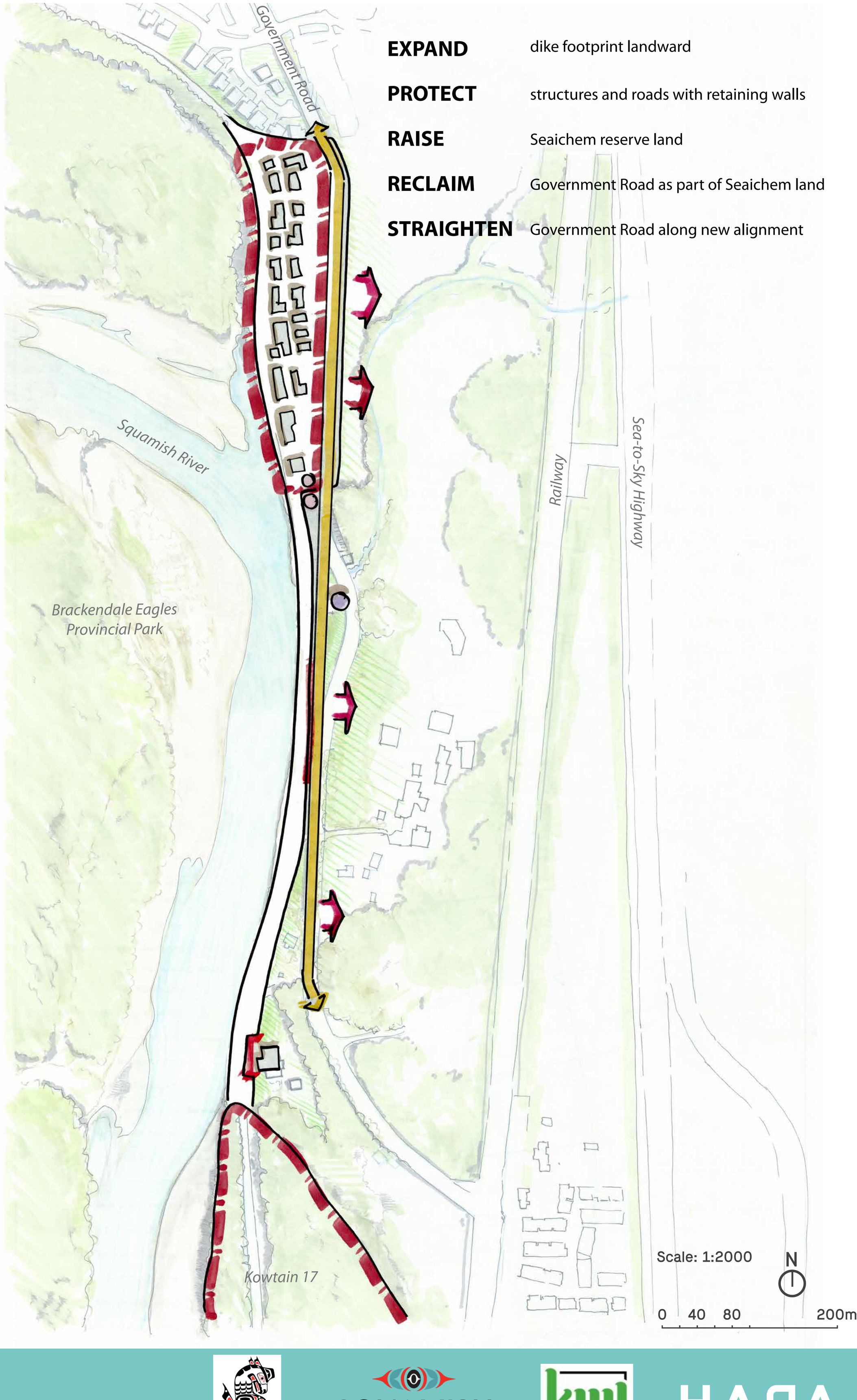
Land elevated to dike level offers a good vantage for future development



Raise land

New development with higher FCL

3 Straighten Government Road



EXPAND dike footprint landward

PROTECT structures and roads with retaining walls

RAISE Seaichem reserve land

RECLAIM Government Road as part of Seaichem land

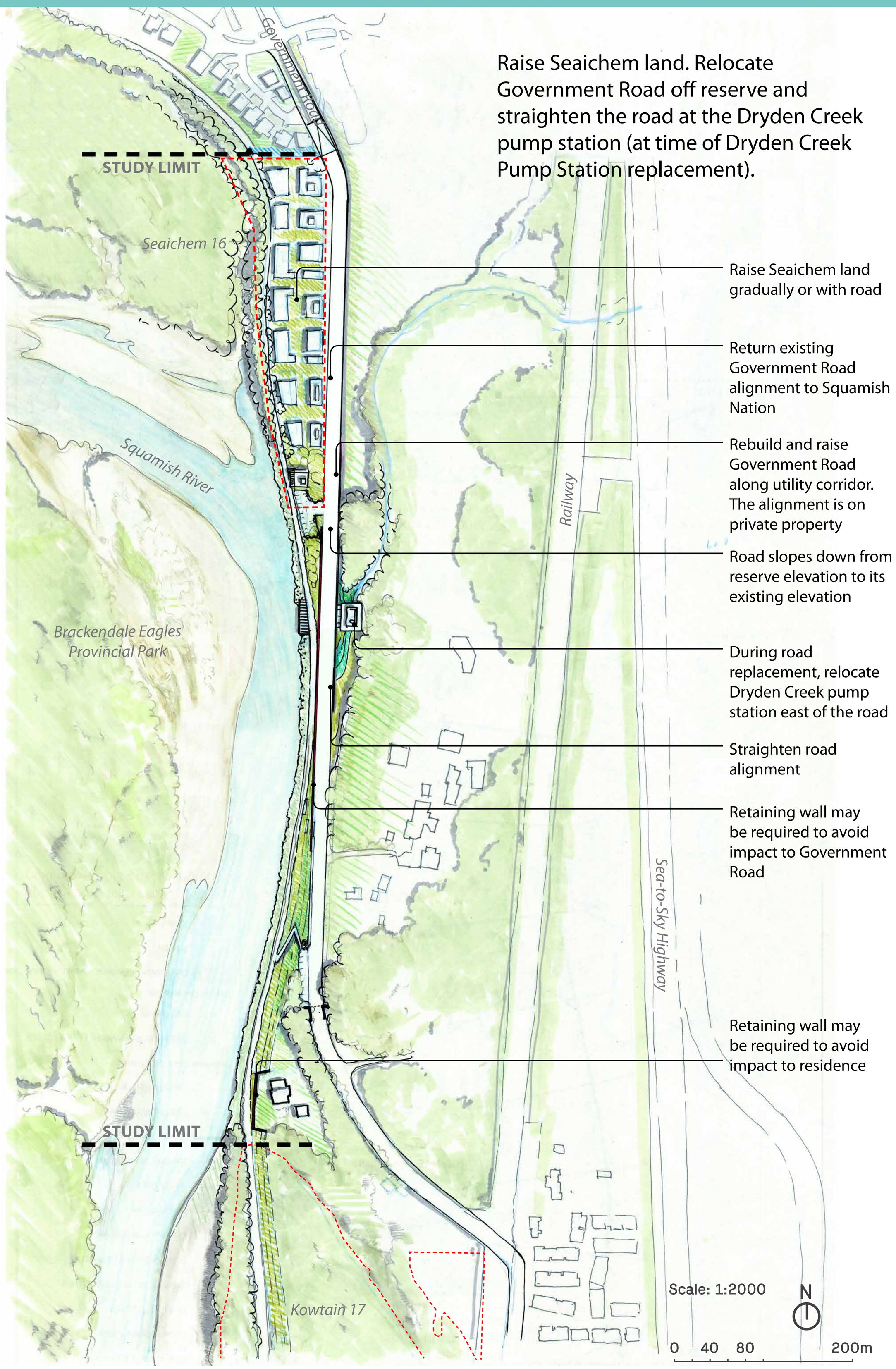
STRAIGHTEN Government Road along new alignment

SQUAMISH

HAPA

3 Straighten Government Road

Raise Seaichem land. Relocate Government Road off reserve and straighten the road at the Dryden Creek pump station (at time of Dryden Creek Pump Station replacement).

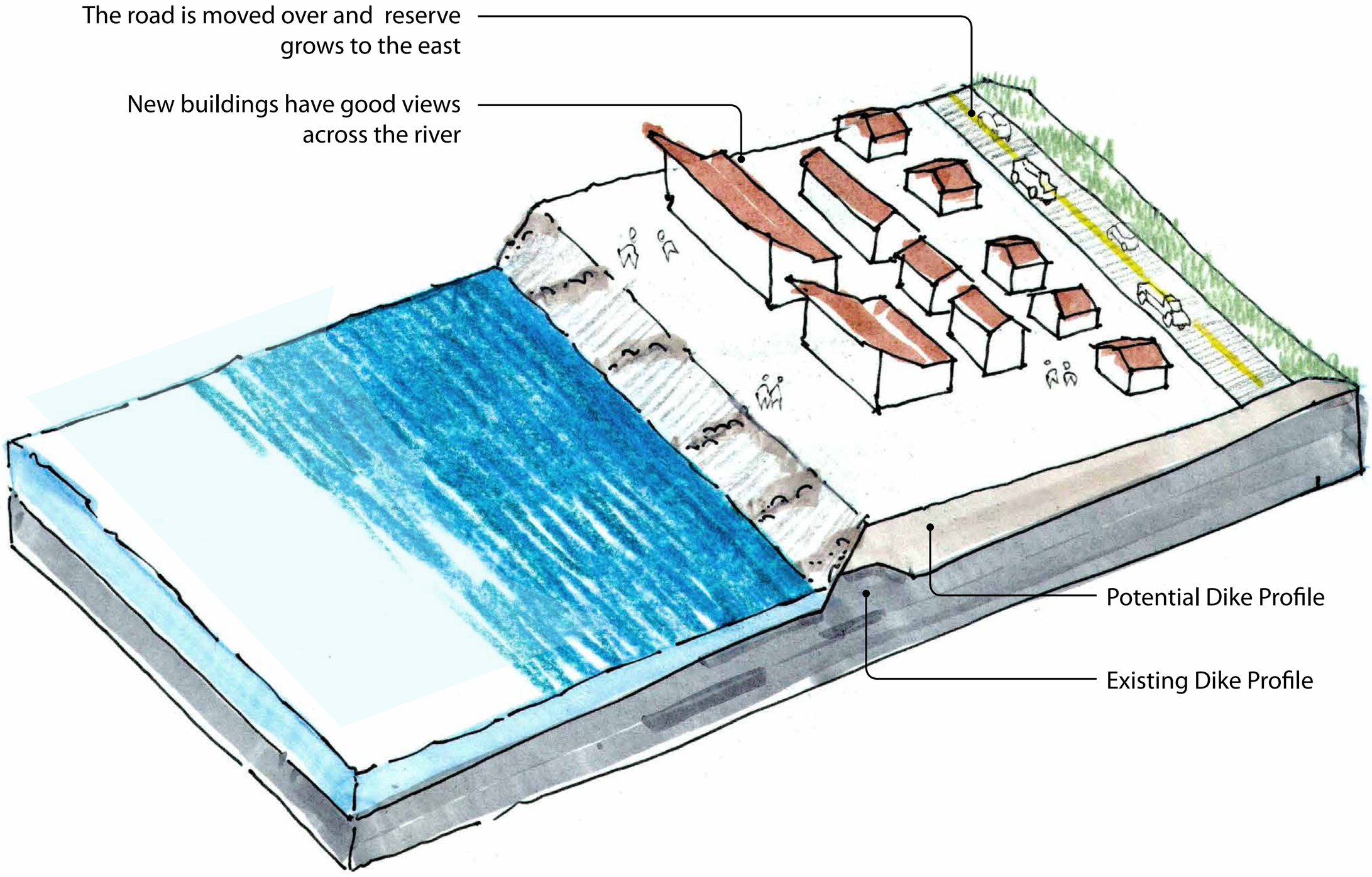


SQUAMISH

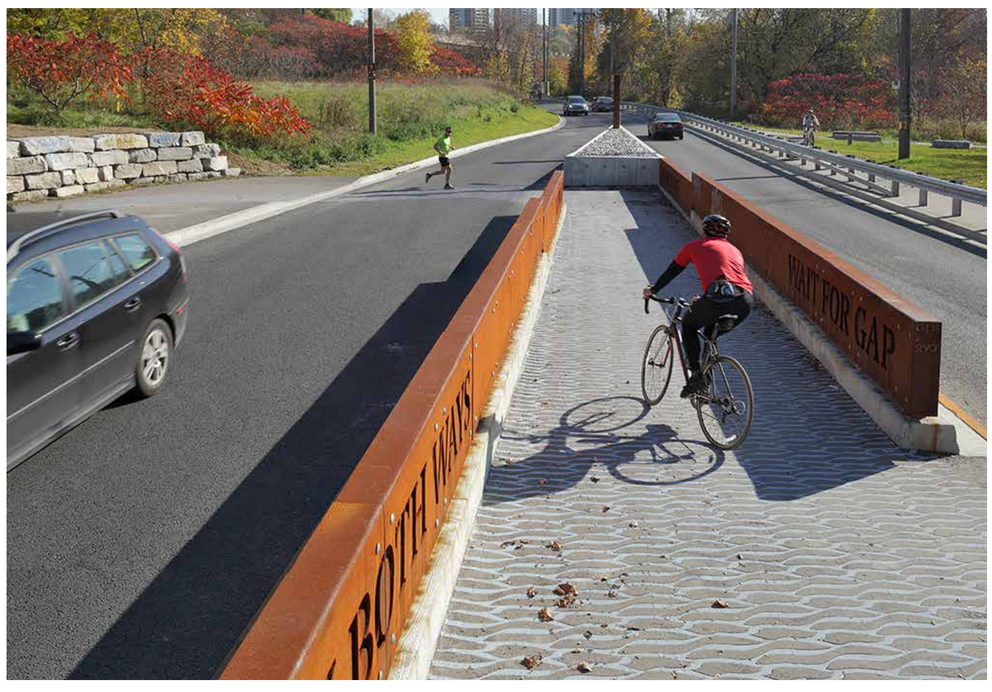
HAPA

3 Straighten Government Road

Government Road is moved off reserve land.

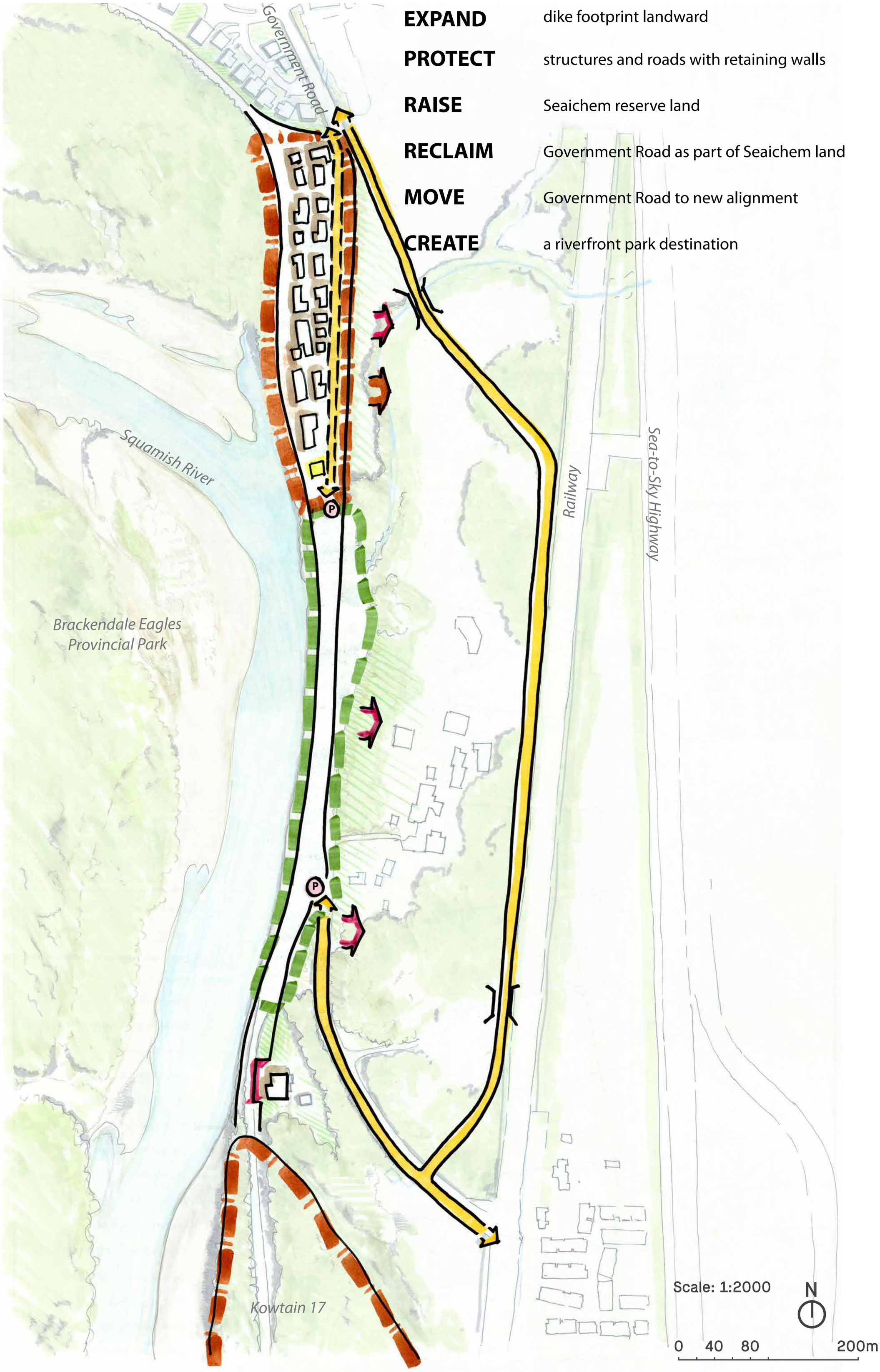


Pump station with view access



Multi-modal road potential

4 Relocate Government Road



EXPAND dike footprint landward

PROTECT structures and roads with retaining walls

RAISE Seaichem reserve land

RECLAIM Government Road as part of Seaichem land

MOVE Government Road to new alignment

CREATE a riverfront park destination

SQUAMISH

HAPA

4 Relocate Government Road

Relocate Government Road to align with the rail corridor and use the old road alignment to create a waterfront park. Create a dedicated entrance to both the park and the

Raise Seaichem land to, or near, dike elevation

New bridge or culvert required

Government Road alignment becomes a private entry road to Squamish Nation.

Waterfront dike park expansion

New access to private property

Relocate road alongside railway corridor

Move eagle viewing parking area to District owned lot

New bridge or culvert required

Dedicated park access road

Retaining wall may be required to avoid impact to residence

Government Road

STUDY LIMIT

Seaichem 16

Squamish River

Brackendale Eagles Provincial Park

Railway

Sea-to-Sky Highway

STUDY LIMIT

Kowtain 17

Scale: 1:2000

N

0 40 80 200m

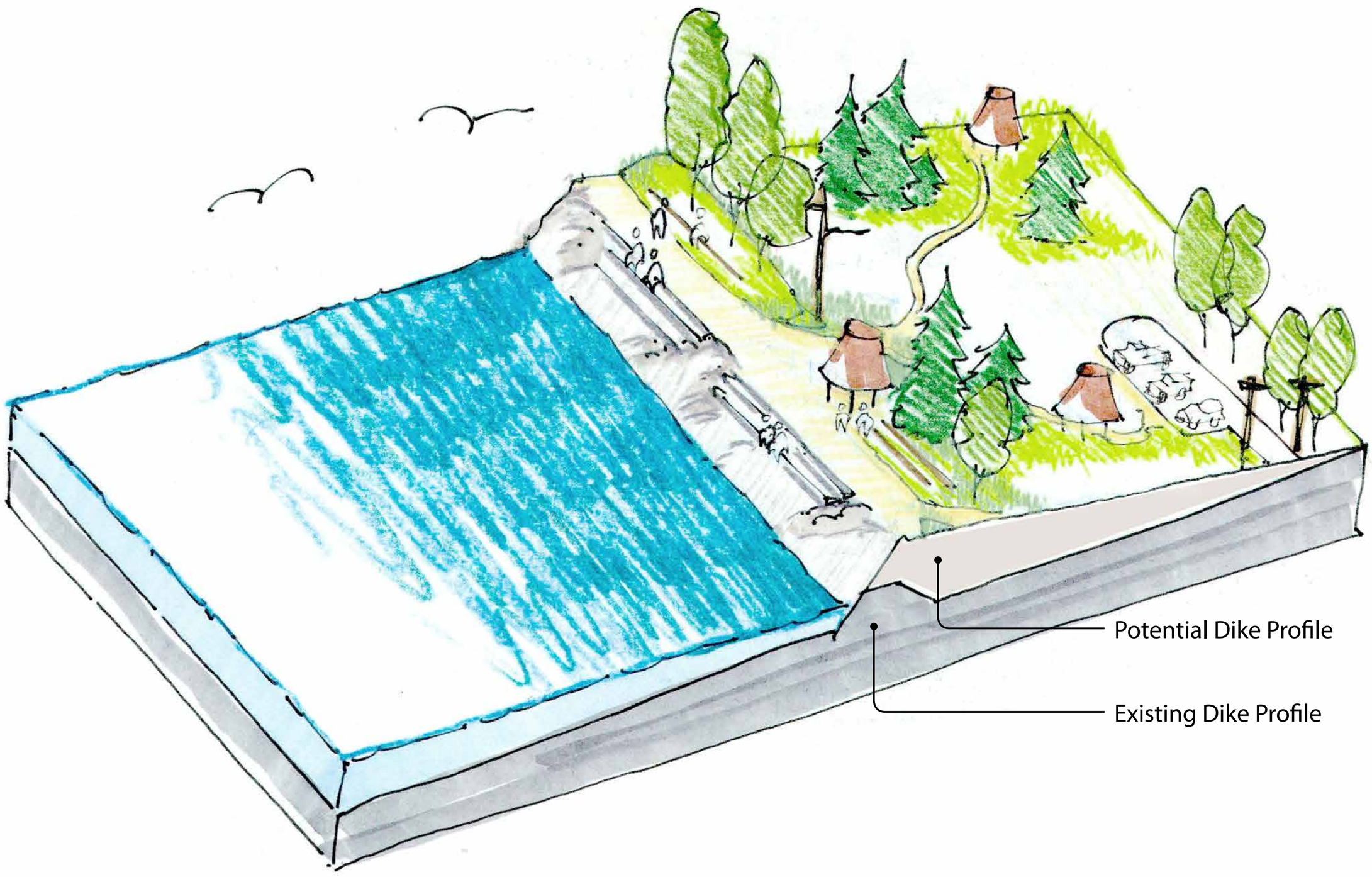
SQUAMISH

kwl

HAPA

4 Relocate Government Road

A new waterfront park becomes a major destination



Expanded park and viewing opportunities

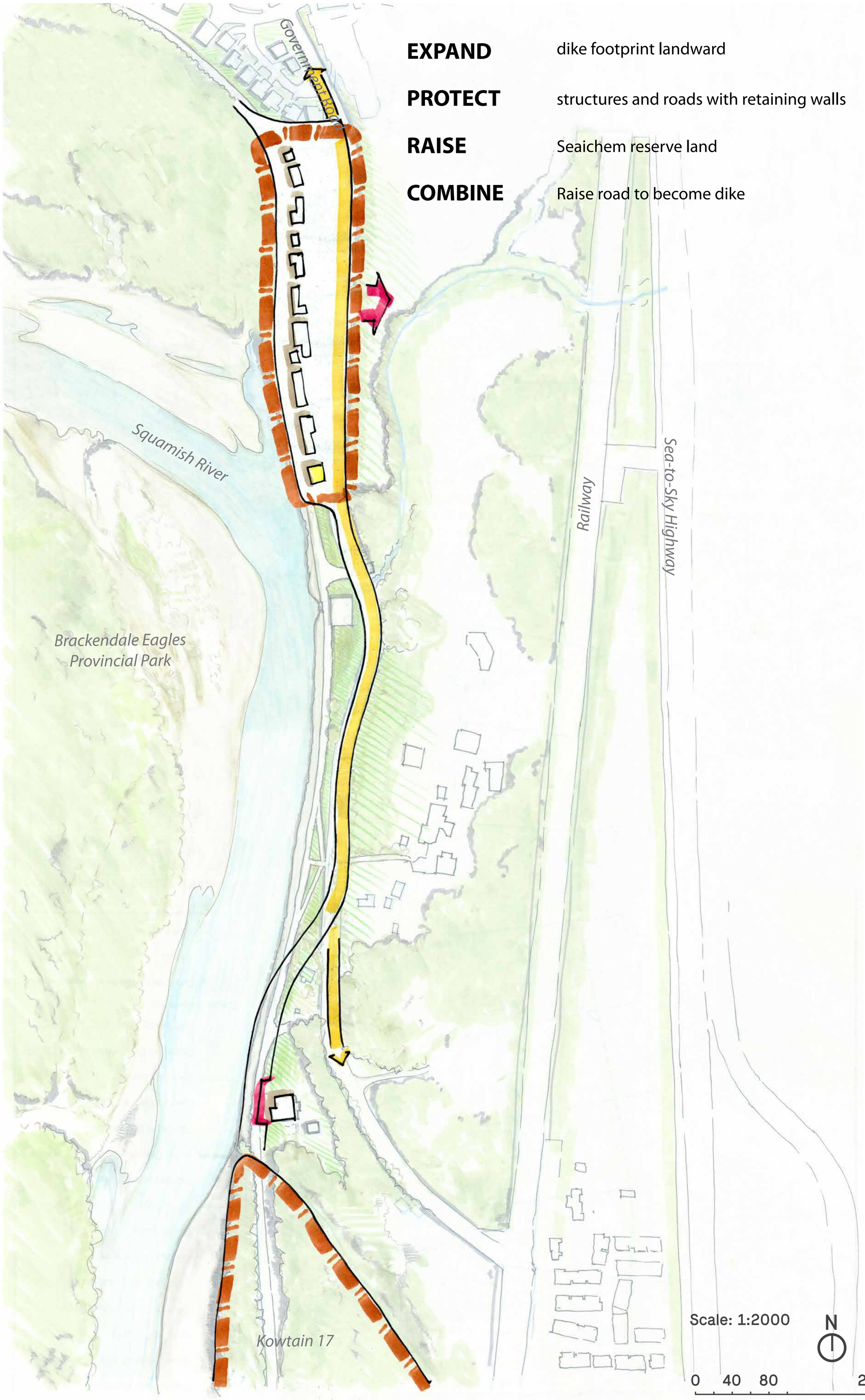
Floodable park areas

SQUAMISH

kwl

HAPA

5 Raise Government Road



EXPAND dike footprint landward

PROTECT structures and roads with retaining walls

RAISE Seaichem reserve land

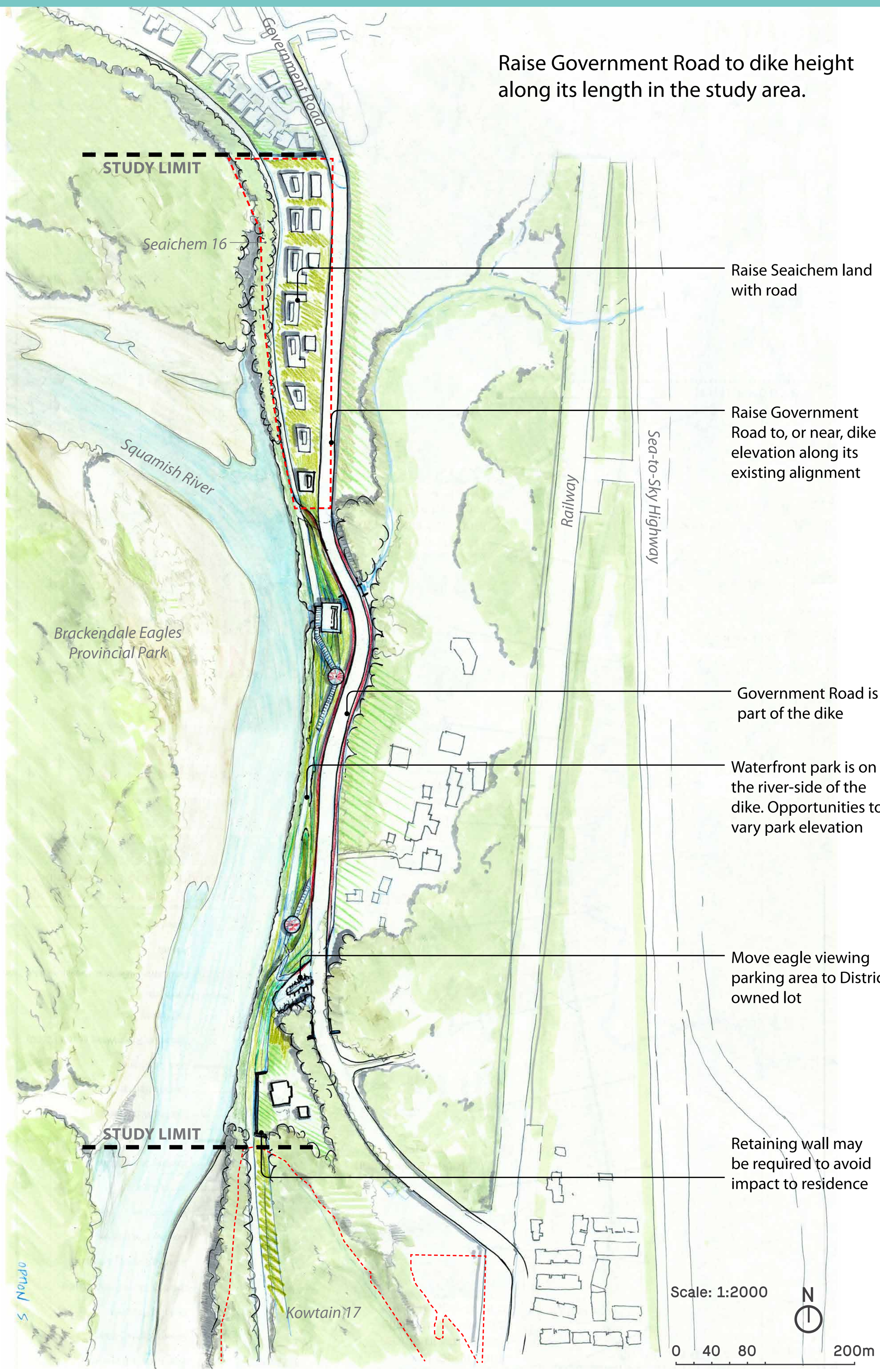
COMBINE Raise road to become dike

SQUAMISH

HAPA

5 Raise Government Road

Raise Government Road to dike height along its length in the study area.



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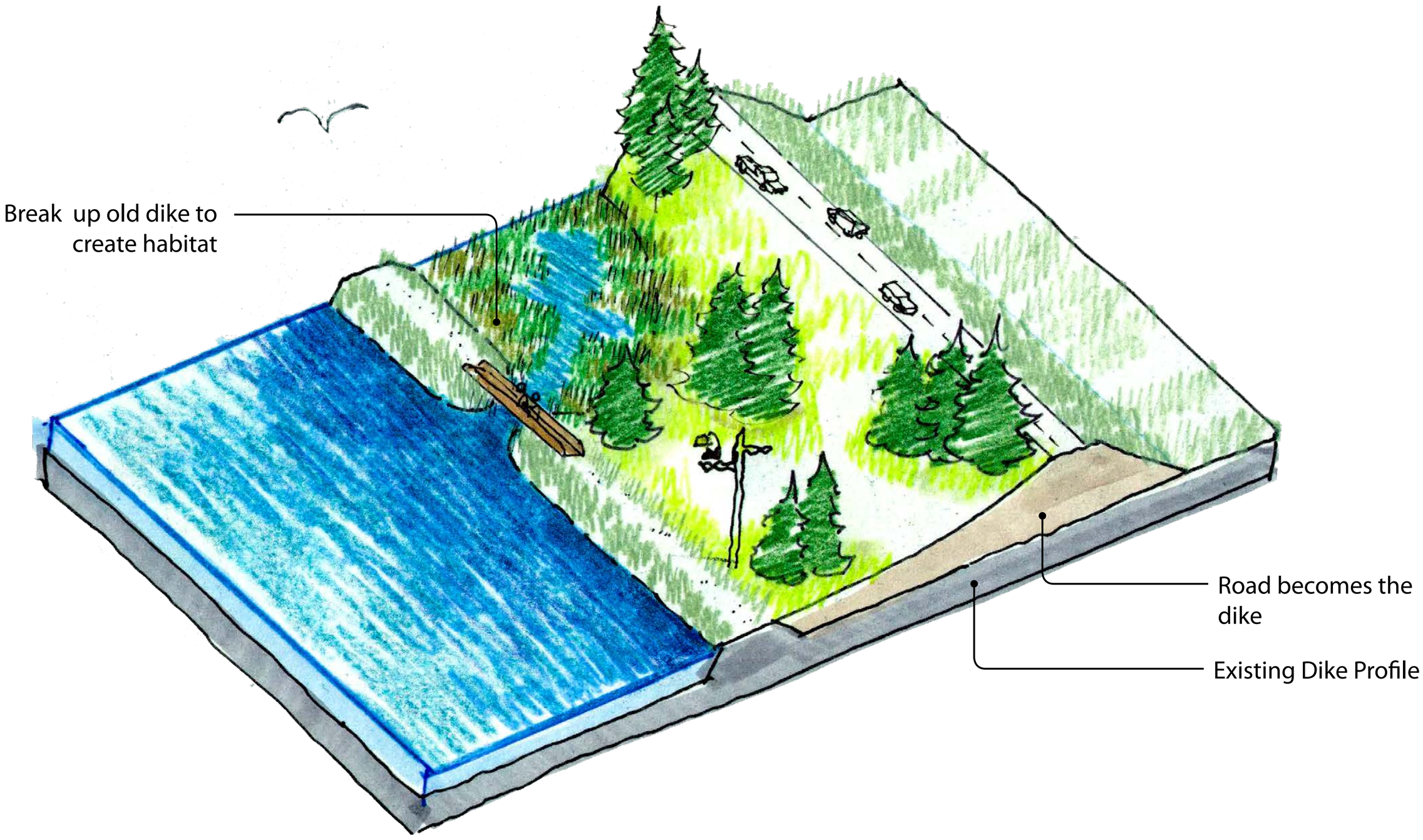
5 Raise Government Road

The old dike can be repurposed for habitat and recreational uses



Dike on top of road

Floodable park areas

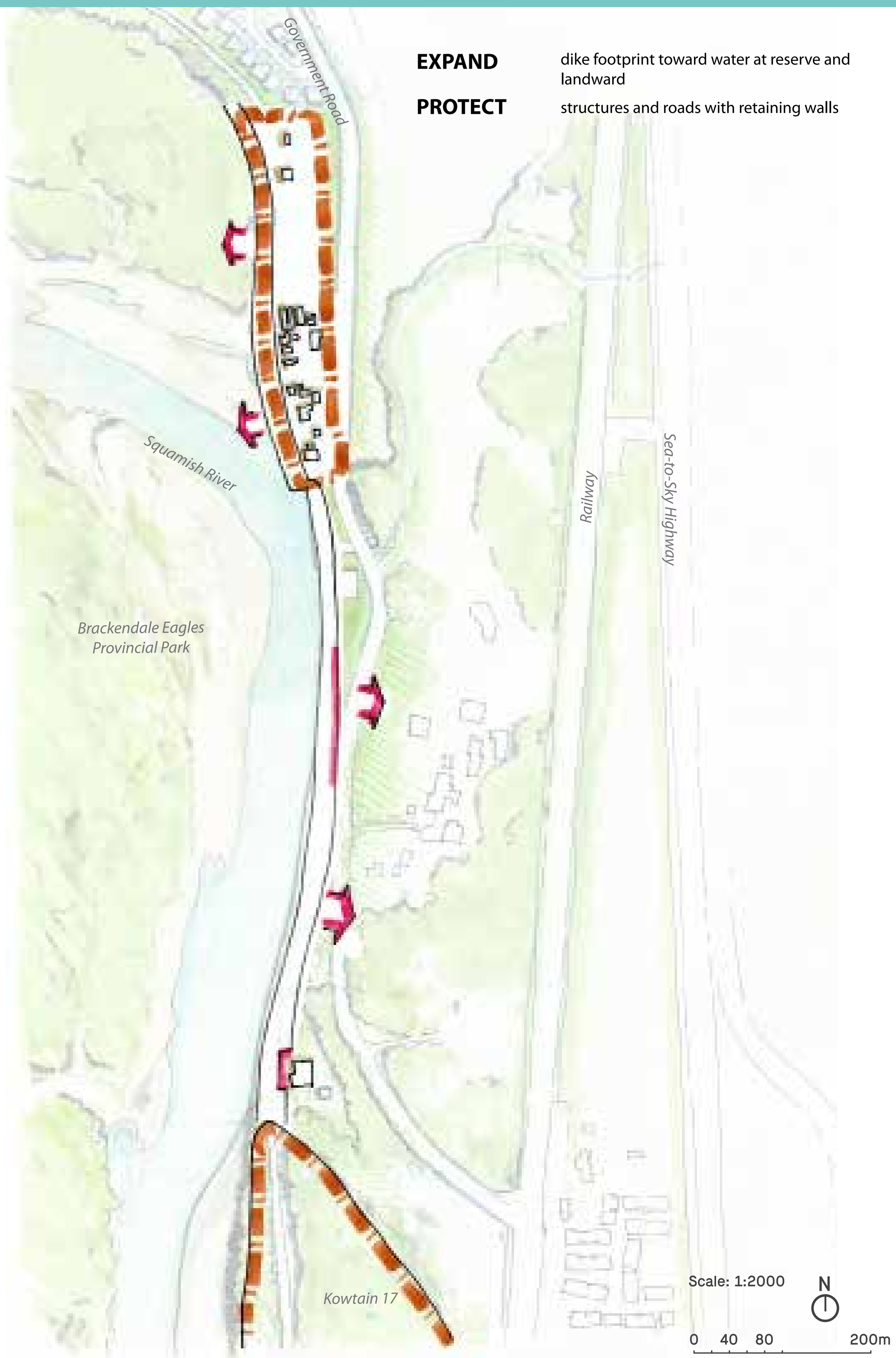
SQUAMISH

HAPA

6 Reclaim The Slough

EXPAND dike footprint toward water at reserve and landward

PROTECT structures and roads with retaining walls



SQUAMISH

HAPA

6 Reclaim The Slough

Raise the dike by expanding into the slough adjacent to the Seaichem reserve.

Elevation of reserve land remains unchanged or raised at nation's discretion

Extend dike towards river side with opportunities for habitat enhancement

Government Road remains at existing elevation

Retaining wall may be required to avoid impact to Government Road

Retaining wall may be required to avoid impact to residence

Government Road

STUDY LIMIT

Seaichem 16

Squamish River

Brackendale Eagles Provincial Park

Railway

Sea-to-Sky Highway

STUDY LIMIT

Kowtain 17

Scale: 1:2000

N

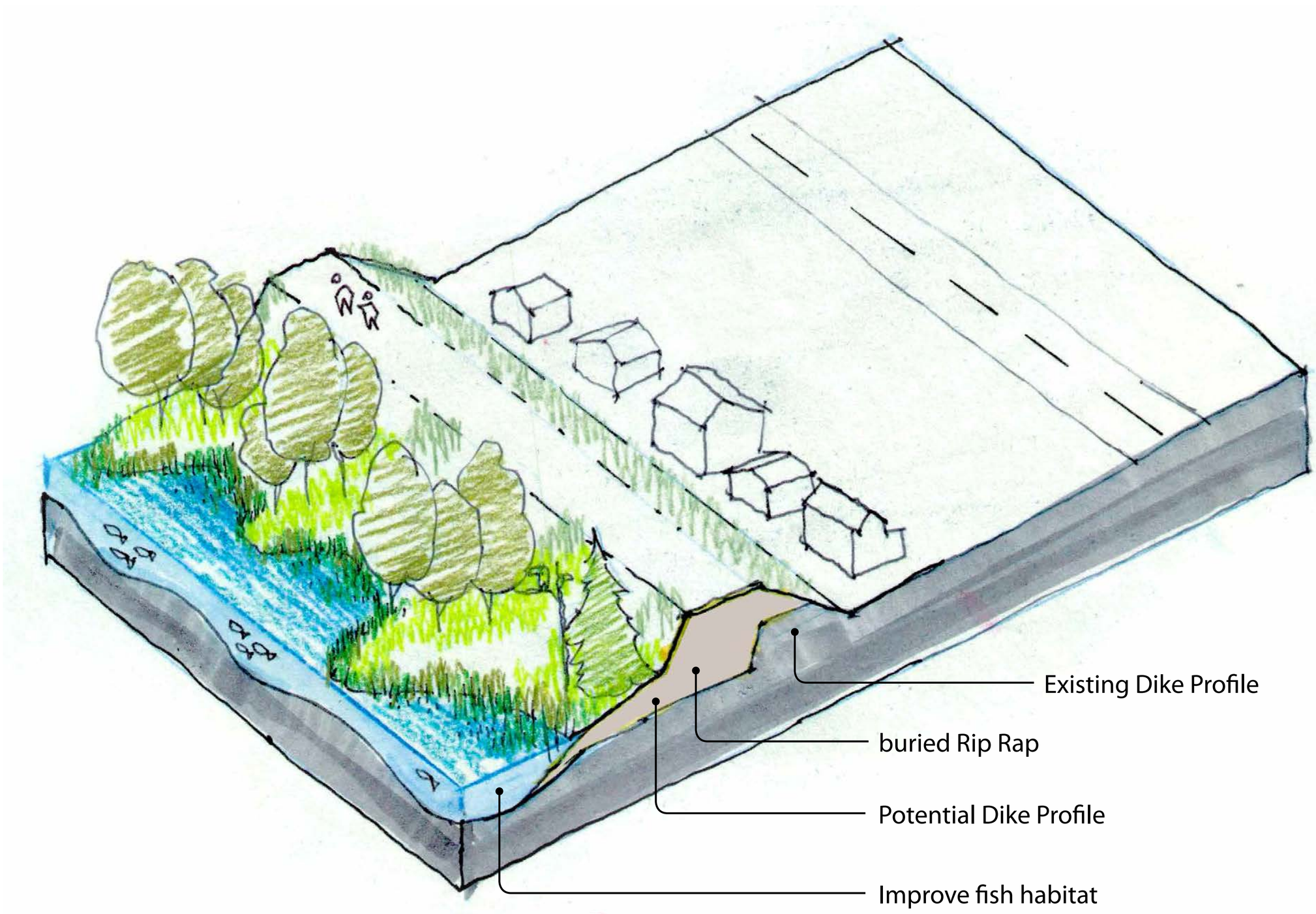
0 40 80 200m

SQUAMISH

HAPA

6 Reclaim The Slough

Dike edge varies on the water side to create habitat and recreational opportunities on water side of dike.



Move dike towards channel / water side

Opportunity for new viewing or interpretive shelters

SQUAMISH

kwl

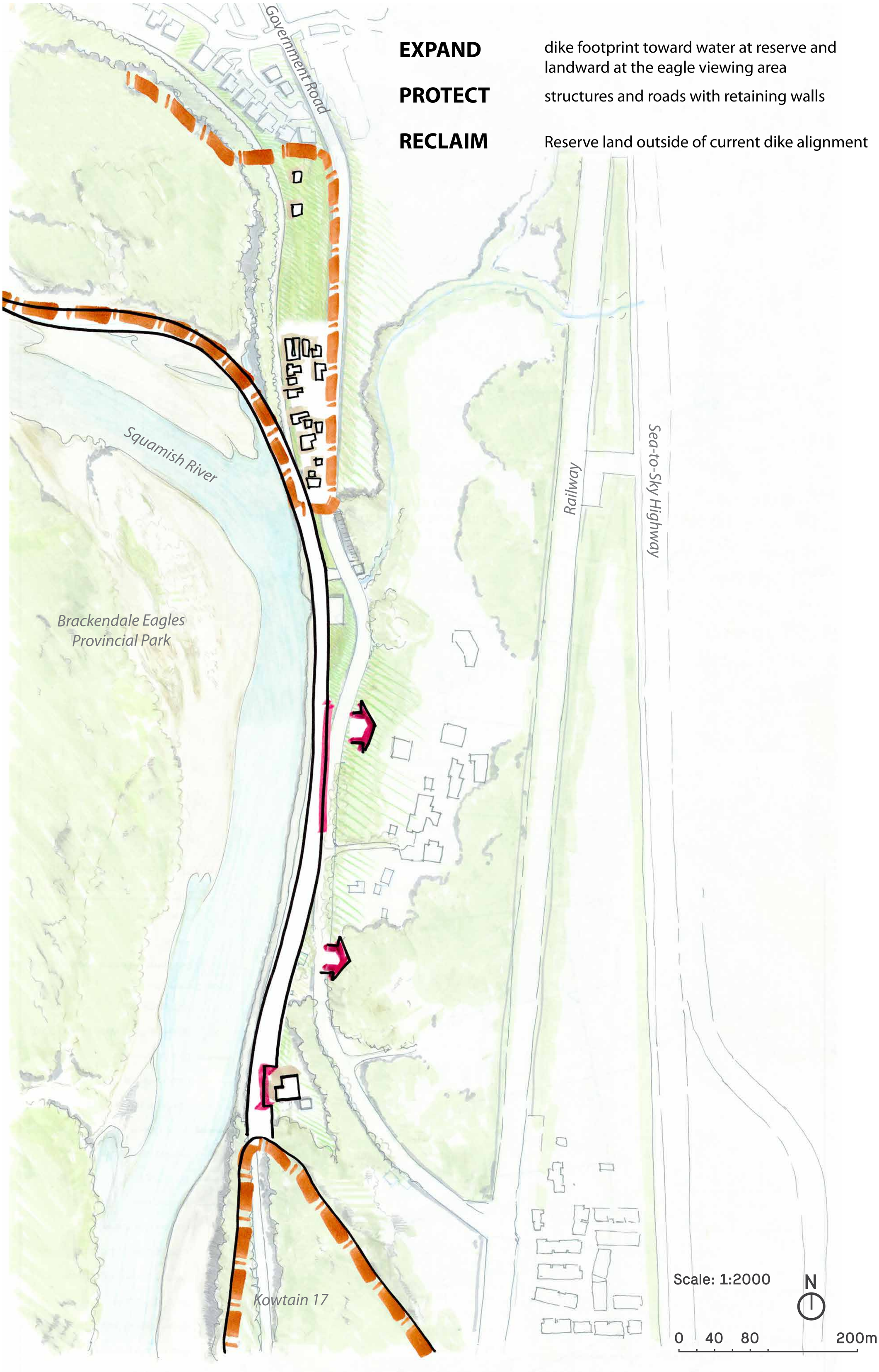
HAPA

7 Restore Reserve Land

EXPAND dike footprint toward water at reserve and landward at the eagle viewing area

PROTECT structures and roads with retaining walls

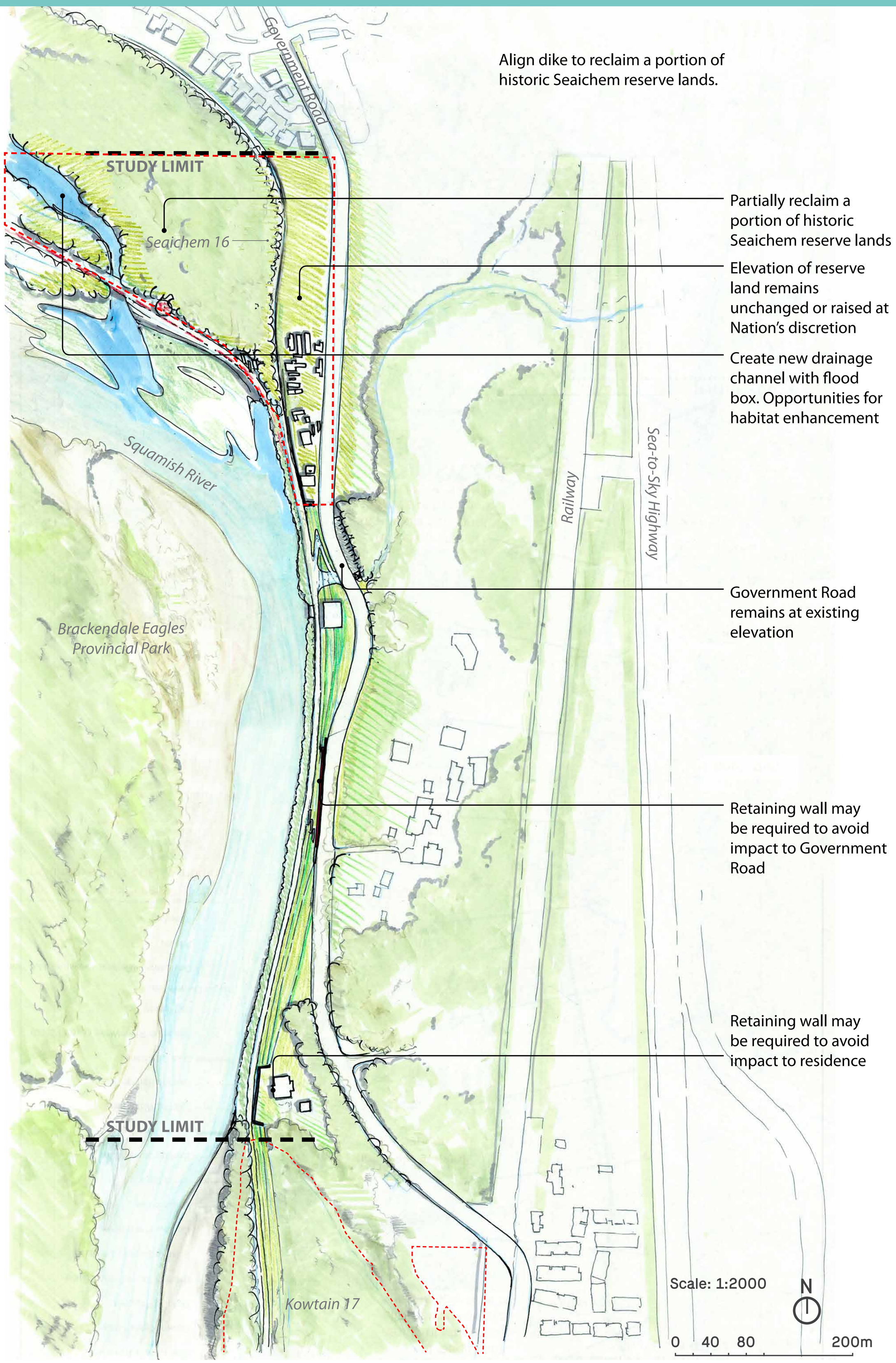
RECLAIM Reserve land outside of current dike alignment



SQUAMISH

HAPA

7 Restore Reserve Land



Align dike to reclaim a portion of historic Seaichem reserve lands.

Partially reclaim a portion of historic Seaichem reserve lands

Elevation of reserve land remains unchanged or raised at Nation's discretion

Create new drainage channel with flood box. Opportunities for habitat enhancement

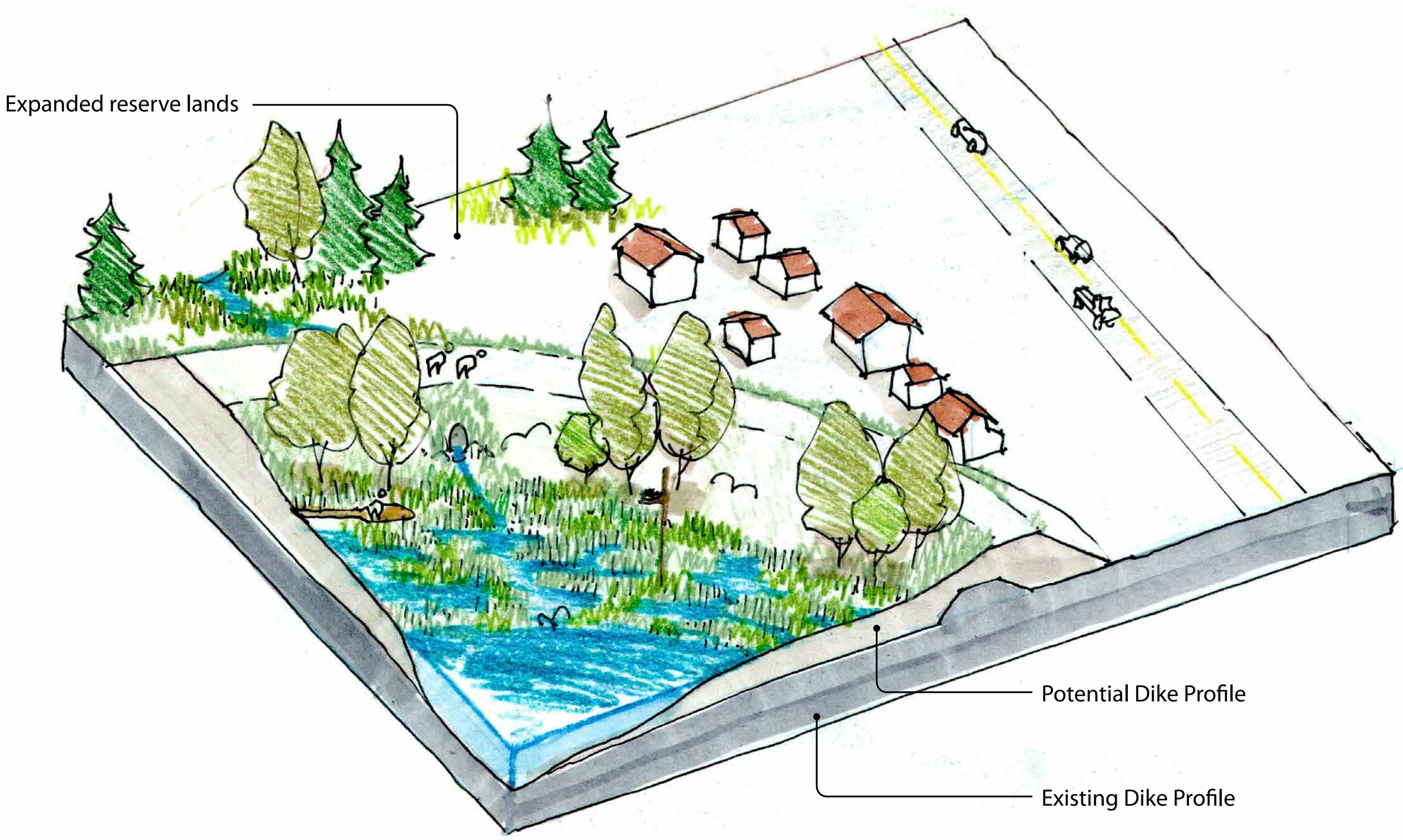
Government Road remains at existing elevation

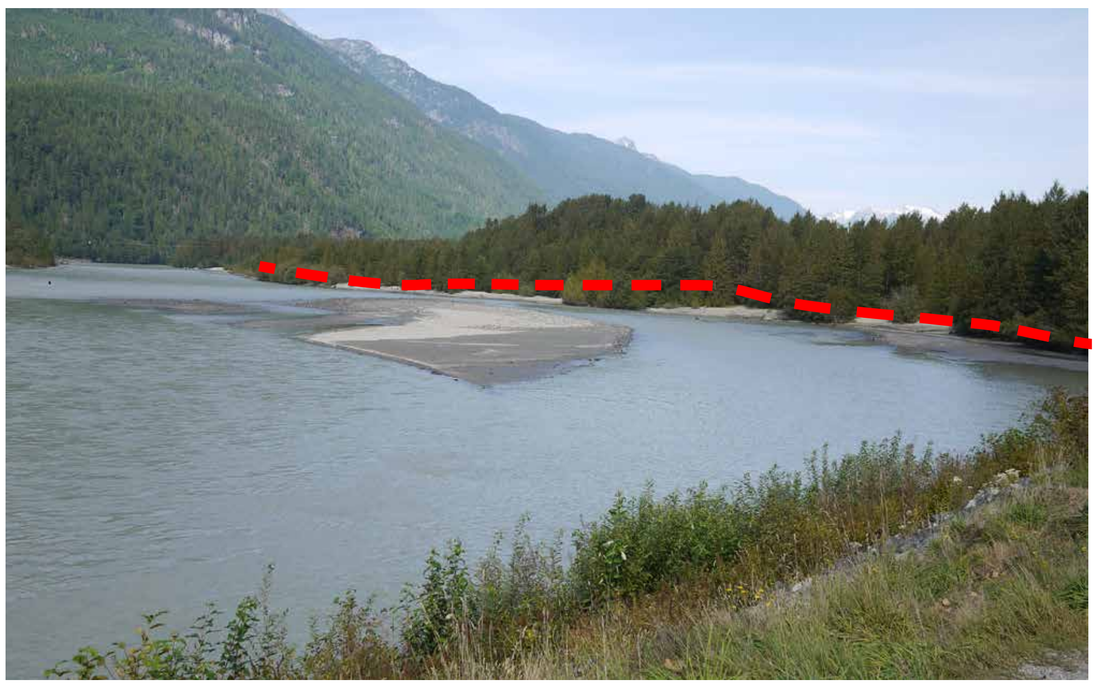
Retaining wall may be required to avoid impact to Government Road

Retaining wall may be required to avoid impact to residence

7 Restore Reserve Land

Dike edge varies on the water side to create habitat and recreational opportunities

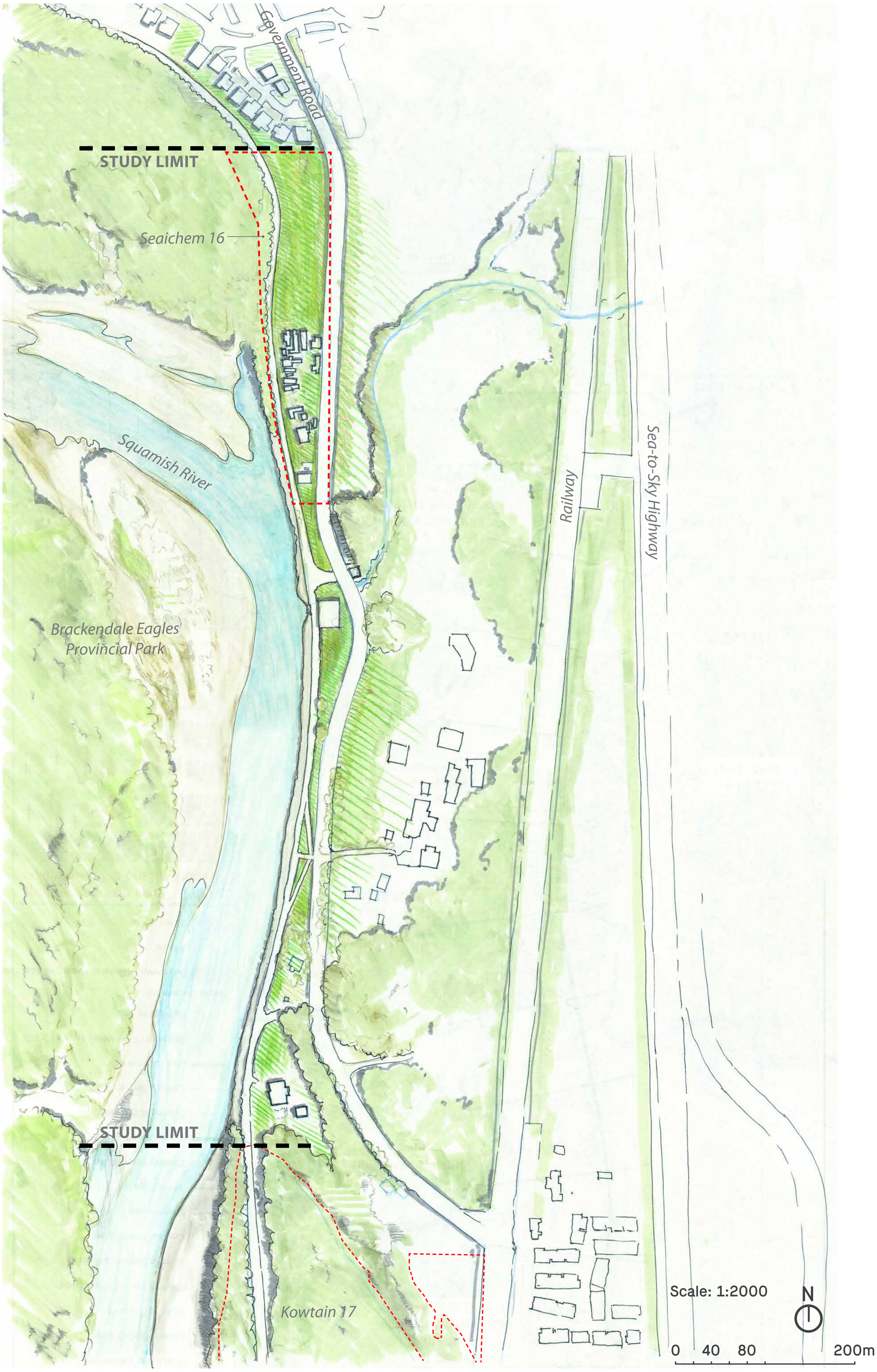




Reclaim land with dike expansion

Opportunity for nature viewing and first nations interpretative experience

EAGLE VIEWING AREA / SEAICHEM RESERVE MASTER PAN



KERR WOOD LEIDAL
consulting engineers

Appendix F

Geotechnical Analysis and Design Input Report (Thurber)

THURBER ENGINEERING LTD.

May 29, 2020 File: 26619

Kerr Wood Leidal Associates
200 - 4185A Still Creek Drive
Burnaby, BC
V5C 6G9

Attention: Shona Robinson, EIT

EAGLE VIEWING AREA/SIYICH'EM RESERVE DIKE MASTER PLAN
CONTRACT NO. 2019-021
GEOTECHNICAL ENGINEERING ASSESSMENT

Dear Shona:

As requested, Thurber Engineering Ltd. (Thurber) has carried out a geotechnical investigation for the above project. This report presents the results of the investigation and provides a geotechnical interpretation of the soils encountered and an assessment of conceptual dike design issues.

It is a condition of this proposal that Thurber's performance of its professional services will be subject to the attached Statement of Limitations and Conditions.

1. PROJECT UNDERSTANDING

The District of Squamish (the District) has retained Kerr Wood Leidal to prepare a dike master plan for the Eagle Viewing Area/Siyich'em Reserve dike on the Squamish River. The section of dike is about 1.1 km long and extends from the north end of Kowtain I.R. No. 15 to the north end of Siyich'em I.R. 16. The District's Integrated Flood Hazard Management Plan, which was completed in October 2017, identified that this section of dike has a high hazard. The existing dike does not meet the Ministry of Forests, Lands, Natural Resource Operations and Rural Development's (MFLNRORD's) standards. Issues that have been identified include:

- the dike crest is too low (inadequate freeboard);
- past observations of seepage, piping and sand boils;
- limitations of the dike right-of-way (narrow);
- existing infrastructure in and on the dike (e.g. buildings).

Thurber's scope of work on this project was to provide geotechnical design input for conceptual dike upgrade options that meet or exceed MFLNRORD's requirements for dike design. The conceptual input in this report is based on the conditions encountered during the geotechnical investigation at each dike section. Although the conditions encountered in the investigation were, in our opinion, typical for the area, the subsurface conditions will be different at other dike sections within the study reach. Accordingly, detailed design of any future dike upgrade will require an appropriately planned geotechnical investigation.

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2. GEOTECHNICAL INVESTIGATION

2.1 Program of Work

The field investigation consisted of two test holes (TH19-1 and TH19-2). TH19-1 was located towards the north end of the dike alignment in the Siyich'em Reach and TH19-2 was located at the south end of the alignment in the Eagle Viewing Area Reach. A sonic test hole and a Becker penetration test (BPT) were advanced to depths of nominally 21 m at each test hole location. The test hole location plan and test hole logs are included in Appendix A.

The sonic test holes were drilled using a Terra Sonic track-mounted drill rig operated by Omega Environmental Drilling Ltd on August 29, 2019. The BPT was completed using a truck-mounted rig operated by Foundex Explorations Ltd. on September 7, 2019.

The sonic drilling method provides continuous sample recovery and was used to evaluate the soil profile and obtain representative disturbed soil samples. A downhole seismic test (DST) was carried out in a casing installed in the sonic test hole at TH 19-2 to measure the small-strain shear modulus of the soil profile. BPT blow counts were recorded at continuous 15 cm intervals for the full depth of the tests to assess the in-situ relative density.

The soil conditions encountered in the test holes were logged in the field by an experienced geotechnical engineer and representative disturbed samples were collected for routine moisture content testing and visual classification in our laboratory. Fines content analyses (% passing 75 µm sieve) and Atterberg limit testing were carried out on select representative samples.

All test holes were located on dikes or within the dike right-of-way and were fully backfilled with bentonite in general accordance with B.C. groundwater protection regulations and MFLNRO requirements.

2.2 Results of the Investigation

The results of the investigation and laboratory testing are summarized on the attached test hole logs in Appendix A. The logs provide a complete, detailed description of the conditions encountered and should be used in preference to the generalized descriptions given below.

Both test holes were advanced from the crest of the dike through the dike fill. At TH 19-1, the dike fill comprised about 3.8 m of compact to very dense silty sand and gravel to gravelly sand, which was underlain by a 0.5 m thick layer of soft silt. Below the silt there was loose to compact sand and gravel with varying amounts of silt and cobbles extending to a depth of about 15.0 m. Below this, loose to compact sand was encountered to the maximum depth investigated.

At TH 19-2, the dike fill generally comprised about 5.8 m of compact to dense sand and gravel with some cobbles. Underlying the dike fill there was compact to dense sand and gravel with varying amounts of silt and cobbles extending to a depth of about 15 m. Below this, loose to compact sand was encountered to the maximum depth investigated.

Groundwater levels were estimated to be at about El. 5 m (CGVD 1928) at the time of the investigation and can be expected to vary with rainfall, drainage, infiltration and water levels in the Squamish River.

3. CONCEPTUAL DIKE DESIGN INPUT

Design and construction of the dikes must conform to requirements of the MFLNRORD to obtain approval under the Dike Management Act. As required by the MFLNRORD, dike design must consider:

- Non-seismic stability (under flood conditions);
- Seepage (i.e. piping/sand boils and landside heave);
- Settlement/subsidence (e.g. loss of freeboard);
- Seismic stability/performance (not under flood conditions).

The input provided below provides options for development of conceptual designs that meet or exceeds MFLNRORD's requirements.

Our input is based on three dike sections provided by KWL (attached): Sta 0+300 (Reach 1), Sta 0+600 (Reach 2), and the dike along Eagle Run Drive.

The conceptual dike upgrades have considered that the dike will have a standard dike section with 3H:1V and 2H:1V landside and waterside slopes, respectively and a 6 m wide dike crests, with the following modifications (Options):

Option 1 – Landside retaining wall
Option 2 – Dike widening/land raising
Option 3 – Dike realignment

The landside retaining wall (Option 1) assumes that the wall will be a sheet pile wall that may also function as a seepage cut-off. This option has a 6 m wide dike crest between the wall and the waterside crest of the dike. The dike widening (Option 2) considers landside dike widening to provide a 25.75 m wide crest and a 10H:1V landside slope. The realigned dike upgrades (Option 3) are based on a realigned dike with a standard dike section.

Input for provision of a seepage berm as discussed below does not include an assessment of the effect of the berm on non-seismic or seismic stability of the dike or on seepage volumes. The intent of the berm is to be a supplemental feature that is intended to control seepage exit gradients (i.e piping and boils).

As requested, the analysis of the two dike options along Eagle Run Drive was limited to a seismic assessment.

The following table provides a description of our analyses as it relates to KWL's Dike Master Plan.

KWL Dike Master Plan	Thurber Report
Siyich'em Reach, Option A	Sta 300, Option 1
Siyich'em Reach, Option B	Sta 300, Option 2
Siyich'em Reach, Option C	Sta 300, Option 3
	Eagle Run Drive, Option 3
Eagle Run Drive Reach	Eagle Run Drive, Existing
Eagle Viewing Area Reach (Wall)	Sta 600, Option 1

3.1 Non-Seismic Stability

The non-seismic stability of the conceptual upgrade options was assessed using the software program SLOPE/W published by GEOSLOPE and the finite element software program Plaxis 2D. This included stability analyses of the conceptual dike options under sustained and rapid drawdown flood conditions and under static non-flood conditions. The analyses considered stability of the landside dike slopes (and walls) under sustained (i.e. steady-state) design flood levels and stability of the waterside dike slopes under rapid drawdown conditions. Both landside and waterside stability were assessed for static non-flood conditions.

US Army Corps of Engineers' document "Design and Construction of Levees" (EM 1110-2-1913) recommends using a design factor of safety (FS) of 1.4 for under steady-state seepage conditions and 1.0 to 1.2 under rapid drawdown. A FS of 1.5 is typically considered to be an acceptable static FS for slopes under static, non-flood conditions.

3.1.1 Landside Wall Option

The SLOPE/W slope stability analysis indicated that the landside wall option would have acceptable factors of safety for the waterside of the dike under static and rapid drawdown conditions.

We assessed the potential for using a steel sheet pile wall to control seepage and retain the upgraded dike using the finite element software program Plaxis 2D. The analysis indicated that for stability under flood and static conditions, the sheet pile would need to have an embedment equal to 5 times the exposed wall height at both Sta. 0+300 and Sta. 0+600. Our analysis used an AZ-13 sheet pile (i.e. an AZ sheet pile with a section modulus of 1300 cm^3/m). Based on the soil types and BPT blow count, a heavier section, such as an AZ-19, may be required for installation.

3.1.2 Landside Widening and Relocation Options

The SLOPE/W analysis indicated these options have acceptable factors of safety under sustained and rapid drawdown flood conditions and under static non-flood conditions at both dike sections.

The results from the non-seismic Slope/W stability analyses are attached in Appendix B.

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3.2 Seepage

We understand that seepage is a concern with this dike. During floods there are high seepage volumes through the dike and problems with formation of sand boils on the landside of the dike. We assessed the effect of the upgrade options on seepage volumes relative to seepage volumes for the existing dike. Seepage was assessed using a Plaxis 2D finite element model based on the subsurface profiles encountered. Because the soil profiles encountered were similar at both test holes, the seepage recommendations provided below are applicable to both dike sections.

3.2.1 Retaining/Seepage Cut-off Wall

The analysis indicated that an 8 m deep seepage cut-off (i.e. 8 m below crest elevation, extending to about El. 4.0 m to 5.0 m) would be required to provide an upgraded dike section that allows nominally the same amount of seepage as the existing dike. We note that most of the seepage was through the sand and gravel that was encountered to a depth of about 15 m. Only a nominal amount of seepage occurs through the sand.

If the cut-off wall were extended through the sand and gravel into the underlying sand encountered at a depth of about 15 m below the dike crest, seepage volumes might be significantly less than they are for the existing dike. This would require a nominally 16 m deep wall. We note that incomplete cut-offs that partially penetrate the sand and gravel layer are less effective per metre depth of wall than a completely penetrating cut-off.

Cut-off		Relative Seepage Volumes	
Depth (m)	% of total depth	% reduction	% of existing
0	0	0	130
4	25	10	120
8	50	30	90
12	75	50	60
16	100	98	2

3.2.2 Seepage for Landside Widened Dike

This analysis indicated that this configuration would reduce seepage volumes by two-thirds when compared to the seepage volumes for the exiting dike.

3.2.3 Seepage Cut-off with Dike Relocation

The analysis indicated that the seepage volumes for this configuration would be about the same as the combined retaining/seepage cut-off wall option described above. The results of this analysis are provided in the table below.

Cut-off		Relative Seepage Volumes	
Depth (m)	% of total depth	% reduction	% of existing
0	0	0	95
4	25	5	90
8	50	25	70
12	75	45	50
16	100	97	3

3.2.4 Landside Seepage Berm

Where needed, additional seepage controlled could also be provided with a landside toe berm. In our July 11, 2011 memo “Squamish River Dikes – Eagle Viewing Area – Seepage Assessment” we suggested using a 15 m wide by 1.5 m thick seepage toe berm. Appropriate design of landside seepage berm would need to be done on a site-specific basis. We do not consider the seepage berm to be equivalent to landside dike raising regarding seismic performance.

3.3 Settlement

The subsurface conditions encountered during the geotechnical investigation indicate that dike settlement is probably not a significant concern for any of the dike configurations considered. We estimate that consolidation settlement of the 0.5 m thick silt layer encountered in TH19-1 would be less than 25 mm after raising the dike crest. Silt was not encountered in TH19-2.

3.4 Seismic Assessment

The assessment of the seismic performance of the dike sections followed the MFLNRORD’s 2014 Seismic Design Guidelines for Dikes (2014 Seismic Guidelines). The 2014 Seismic Guidelines recommend designing high consequence dikes to control seismic deformations within prescribed limits. The seismic deformation limits vary depending on the earthquake return period as shown in the table below.

Earthquake Return Period (years)	**Maximum Allowable Displacement (mm)**	
	Vertical	**Horizontal**
1 in 100	<30	<30
1 in 475	150	300
1 in 2,475	500	900

The relevant geotechnical seismic hazard for dikes is the occurrence of large seismic displacements that could cause damage and reduce the level of flood protection. Large deformations could result in formation of preferential flow paths through the dike that could lead

to piping, decreased dike stability (including under flood, rapid drawdown and static conditions) and loss of flood protection due to lowering of the dike crest elevation.

Thurber's experience with seismic design and assessment of dikes has been that the degree of seismic deformations largely depends on if liquefaction of the foundation soils occurs. Typically, if significant liquefaction is predicted to occur, the performance criteria of the 2014 Seismic Guidelines will not be met. If liquefaction is predicted not to occur, deformations tend to be small (i.e. less than 1 m) and if it does occur, deformations can be much larger (i.e. greater than 1 m). There does not tend to be a gradual increase in displacement with increasing seismic hazard (i.e. stronger earthquakes), rather there is a large increase when the earthquake exceeds a threshold level that initiates liquefaction. Accordingly, liquefaction is typically the most significant contributor to the seismic vulnerability for most dikes. Based on the results of the liquefaction analysis described below, we expect that large displacements exceeding the performance criteria of the 2014 Seismic Guidelines will typically initiate at about the 1 in 475-year return period seismic hazard.

Liquefaction results in the loss of strength and stiffness of granular soil. Seismic deformation of dikes will depend on factors including the earthquake intensity, extent of liquefaction, the dike configuration and the site topography and bathymetry. In general, larger deformations can be expected where:

- dikes are close to a slope (such as a riverbank),
- there are steeper slopes (including the dikes slopes and riverbank slopes),
- dikes are higher,
- more liquefiable soil is present.

Setback dikes, short dikes and dikes on non-liquefiable subgrades (i.e. clay-like soils and sufficiently dense granular soils) can be expected to have smaller seismic deformations under a given seismic hazard.

This seismic assessment was ultimately used to estimate the level of ground improvement that could be required to meet the displacement limits in the above table.

3.4.1 Assessment Methodology

The seismic assessment included selecting earthquake time-histories, site-specific response analyses (SSRAs), liquefaction triggering assessments and Newmark deformation analyses. The liquefaction triggering assessments and Newmark deformation analyses used the results from the SSRAs and the data from the BPTs.

The analyses used earthquake time-histories that were developed for the George Massey Tunnel replacement project. The earthquake time-histories were scaled to the seismic hazard for the site determined from Natural Resources Canada's on-line seismic hazard calculator. The analyses were carried out for the crustal, inslab, and interface (i.e. Cascadia subduction event) scenario earthquakes. Three earthquake time histories for each scenario earthquake were developed for each of the 1 in 100, 475 and 2,475-year return period seismic hazards.

We carried out 1-dimensional SSRAs using each of the time-histories that were developed as described above. The SSRAs were carried out using the software program DEEPSOIL published by the University of Illinois. The results of the SSRAs were used in both the liquefaction assessment and Newmark deformation analysis. The SSRAs used shear wave velocities from the DST data to estimate the site-specific seismic accelerations and seismically induced shear stresses and strains.

Liquefaction assessments using empirical methods were carried out to assess the degree of liquefaction and to provide estimates of reconsolidation settlement. The liquefaction assessments were carried out for flat ground (i.e. 1D) conditions for each of the three design earthquake levels and earthquake scenario types using the software program LiqSV published by Geologismiki. These assessments followed the methods described by Idriss and Boulanger (2008 and 2014) to evaluate the resistance to liquefaction (i.e. the cyclic resistance ratio (CRR)). The shear stress triggering liquefaction (i.e. the cyclic stress ratio (CSR)) was calculated by averaging the maximum stress ratio profiles from the SSRAs for each scenario earthquake (e.g. the CSR for the 1 in 100-year crustal earthquake was calculated using the average of the maximum stress ratio profiles from the three crustal time-histories).

The deformation analyses were carried out using a combination of limit-equilibrium slope stability and Newmark deformation analyses. The slope stability analyses used the software program Slope/W and evaluated the potential for flow slides, assessed stability under the critical Newmark yield acceleration and estimated the required level of ground improvement to meet the 2014 Seismic Guidelines. The critical Newmark yield accelerations were determined by carrying out a Newmark displacement analyses on the earthquake time-histories output from the SSRAs.

3.4.2 Assessment Results

The results of the liquefaction triggering analyses are presented on the plots generated by LiqSV in Appendix C. These plots show layers where liquefaction is anticipated (i.e. where the CSR is greater than the CRR and the factor of safety is less than one against liquefaction) and also provide estimates of post-liquefaction reconsolidation settlement.

The table below includes descriptions of the extent of liquefaction and corresponding Liquefaction Indices and shear strengths per the 2014 Seismic Guidelines.

Extent of Liquefaction	**Liquefaction Index**	**Shear Strength**
No liquefaction	Insignificant (L0)	N/A
Complete liquefaction not expected	Mild (L1)	80% of drained
Liquefaction occurs in zones of limited thickness	Moderate (L2)	Residual
Complete liquefaction	High (L3)	Residual

The liquefaction triggering assessment shows that liquefaction is not anticipated under all of the scenario earthquakes for the 1 in 100-year return period seismic hazard for both of the dike sections analysed. This corresponds to “No liquefaction (L0)” per the 2014 Seismic Guidelines.

At Sta. 0+300, liquefaction is anticipated under the 1 in 475 and 2475-year return period seismic hazards below a depth of about 8 m. Per the 2014 Seismic guidelines, we have inferred the Liquefaction Indexes for these seismic hazards to be “Moderate (L2)” and “High (L3)”, respectively.

At Sta. 0+600 liquefaction is anticipated for the 2475-year return period seismic hazard between depths of about 7 m to 9 m below a depth of about 14.5 m. Per the 2014 Seismic guidelines, we have inferred the Liquefaction Indexes for this seismic hazard to be “High (L3)”. Liquefaction appears to initiate at about the 1 in 475-year return period, accordingly we have assessed it to be Insignificant (L0) to mild (L1) for this seismic hazard at Sta. 0+600.

The post-liquefaction reconsolidation settlement estimates calculated using data from LiqSV are presented in the table below. For the 1 in 100-year return period seismic hazard, reconsolidation settlements are anticipated to be negligible.

Dike Section	Reconsolidation Settlement (mm)		
	EQ Return Period		
	1 in 100	1 in 475	1 in 2475
19-01	<10	140	190
19-02	<10	60	120

The time-histories from the SSRAs were used to calculate the Newmark yield accelerations for each of the each of the 1 in 100, 475 and 2,475-year return period seismic hazards. The Newmark analysis indicated that the yield acceleration corresponding to the 2014 Seismic Guidelines’ deformation limit for the 1 in 100 and 475-year return period seismic hazards was 0.14g and 0.19g for the 1 in 2,475-year return period earthquake. Accordingly, the critical yield acceleration of 0.19 g was used in the seismic slope stability modelling and assessment of conceptual ground improvement requirements.

The table below summarises the seismic performance of the two dike sections without ground improvement. Without ground improvement flow slides are anticipated to result in very large displacements. Where displacements were noted to be excessive, the Newmark displacements were predicted to exceed the performance requirements of the 2014 Seismic Guidelines and could be in the order of 1 m to 5 m. Ground improvement would be required to prevent flow slides and control excessive displacements. Where the seismic performance is “OK”, the dike is expected o meet the performance criteria for all the design seismic hazards. Where it is “Flow Slide” or “Excessive Displacement”, the seismic performance of the dike is anticipated to meet the performance criteria for only the 1 in 100-year seismic hazards.

Dike Location		Seismic Performance
Location	Option	
Sta. 300 - Waterside	1 - Wall	Flowslide
	2 - Widened	Flowslide
	3 - Realigned	Flowslide
Sta. 300 - Landside	1 - Wall	OK
	2 - Widened	OK
	3 - Realigned	Flowslide
Sta. 600 - Waterside	1 - Wall	Flowslide
Sta. 600 - Landside	1 - Wall	OK
Eagle Run - Waterside	Existing	Excessive Disp.
	3 - Realigned	Excessive Disp.
Eagle Run - Landside	Existing	OK
	3 - Realigned	OK

The output from the seismic stability analysis is provided in Appendix D. Figures 1 to 12 show the factors of safety with liquefied ground conditions without ground improvement. The figures that don't include the yield acceleration of 0.19g and have a factor of safety of less than one are indicative of flow slides. Figures that include the yield acceleration and have a factor of safety of less than one indicate excessive Newmark displacements.

Figures 13 to 20 in Appendix D show the estimated zones of ground improvement required to meet the performance requirements of the 2014 Seismic Guidelines. A summary of the required zones of ground improvement the dike sections for the upgrade options is provided in Table 1 at the end of the appendix. Typically, the zones of ground improvement are most effective when centred under the toe of the dike slopes.

Based on the conditions encountered, cutter soil mixing (CSM) could be the most suitable method of ground improvement. For costing purposes, we suggest that the level of CSM required within the ground improvement zones could cost in the range of $35 to $50 per cubic meter on a treated volume basis. This cost assumes that a replacement ratio of 10% to 15% would be acceptable.

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4. CLOSURE

We trust that this information is sufficient for your needs. Should you require clarification of any item or additional information, please contact us at your convenience.

Yours truly,
Thurber Engineering Ltd.
David Regehr, P.Eng.
Review Principal

Steven Coulter, P.Eng.
Project Engineer

Attachments:

Statement of Limitations and Conditions (1 page)
Dike Sections Sta. 0+300, Sta. 0+600 and Eagle Run (5 pages)
Appendix A – Geotechnical Investigation (8 pages)
Appendix B – Non-seismic Stability Slope/W Output (16 pages)
Appendix C – Liquefaction Assessment LiqSV Output (18 pages)
Appendix D – Seismic Stability Slope/w Output (21 pages)

THURBER

STATEMENT OF LIMITATIONS AND CONDITIONS

1. STANDARD OF CARE

This Report has been prepared in accordance with generally accepted engineering or environmental consulting practices in the applicable jurisdiction. No other warranty, expressed or implied, is intended or made.

2. COMPLETE REPORT

All documents, records, data and files, whether electronic or otherwise, generated as part of this assignment are a part of the Report, which is of a summary nature and is not intended to stand alone without reference to the instructions given to Thurber by the Client, communications between Thurber and the Client, and any other reports, proposals or documents prepared by Thurber for the Client relative to the specific site described herein, all of which together constitute the Report.

IN ORDER TO PROPERLY UNDERSTAND THE SUGGESTIONS, RECOMMENDATIONS AND OPINIONS EXPRESSED HEREIN, REFERENCE MUST BE MADE TO THE WHOLE OF THE REPORT. THURBER IS NOT RESPONSIBLE FOR USE BY ANY PARTY OF PORTIONS OF THE REPORT WITHOUT REFERENCE TO THE WHOLE REPORT.

3. BASIS OF REPORT

The Report has been prepared for the specific site, development, design objectives and purposes that were described to Thurber by the Client. The applicability and reliability of any of the findings, recommendations, suggestions, or opinions expressed in the Report, subject to the limitations provided herein, are only valid to the extent that the Report expressly addresses proposed development, design objectives and purposes, and then only to the extent that there has been no material alteration to or variation from any of the said descriptions provided to Thurber, unless Thurber is specifically requested by the Client to review and revise the Report in light of such alteration or variation.

4. USE OF THE REPORT

The information and opinions expressed in the Report, or any document forming part of the Report, are for the sole benefit of the Client. NO OTHER PARTY MAY USE OR RELY UPON THE REPORT OR ANY PORTION THEREOF WITHOUT THURBER'S WRITTEN CONSENT AND SUCH USE SHALL BE ON SUCH TERMS AND CONDITIONS AS THURBER MAY EXPRESSLY APPROVE. Ownership in and copyright for the contents of the Report belong to Thurber. Any use which a third party makes of the Report, is the sole responsibility of such third party. Thurber accepts no responsibility whatsoever for damages suffered by any third party resulting from use of the Report without Thurber's express written permission.

5. INTERPRETATION OF THE REPORT

a) Nature and Exactness of Soil and Contaminant Description: Classification and identification of soils, rocks, geological units, contaminant materials and quantities have been based on investigations performed in accordance with the standards set out in Paragraph 1. Classification and identification of these factors are judgmental in nature. Comprehensive sampling and testing programs implemented with the appropriate equipment by experienced personnel may fail to locate some conditions. All investigations utilizing the standards of Paragraph 1 will involve an inherent risk that some conditions will not be detected and all documents or records summarizing such investigations will be based on assumptions of what exists between the actual points sampled. Actual conditions may vary significantly between the points investigated and the Client and all other persons making use of such documents or records with our express written consent should be aware of this risk and the Report is delivered subject to the express condition that such risk is accepted by the Client and such other persons. Some conditions are subject to change over time and those making use of the Report should be aware of this possibility and understand that the Report only presents the conditions at the sampled points at the time of sampling. If special concerns exist, or the Client has special considerations or requirements, the Client should disclose them so that additional or special investigations may be undertaken which would not otherwise be within the scope of investigations made for the purposes of the Report.

b) Reliance on Provided Information: The evaluation and conclusions contained in the Report have been prepared on the basis of conditions in evidence at the time of site inspections and on the basis of information provided to Thurber. Thurber has relied in good faith upon representations, information and instructions provided by the Client and others concerning the site. Accordingly, Thurber does not accept responsibility for any deficiency, misstatement or inaccuracy contained in the Report as a result of misstatements, omissions, misrepresentations, or fraudulent acts of the Client or other persons providing information relied on by Thurber. Thurber is entitled to rely on such representations, information and instructions and is not required to carry out investigations to determine the truth or accuracy of such representations, information and instructions.

c) Design Services: The Report may form part of design and construction documents for information purposes even though it may have been issued prior to final design being completed. Thurber should be retained to review final design, project plans and related documents prior to construction to confirm that they are consistent with the intent of the Report. Any differences that may exist between the Report's recommendations and the final design detailed in the contract documents should be reported to Thurber immediately so that Thurber can address potential conflicts.

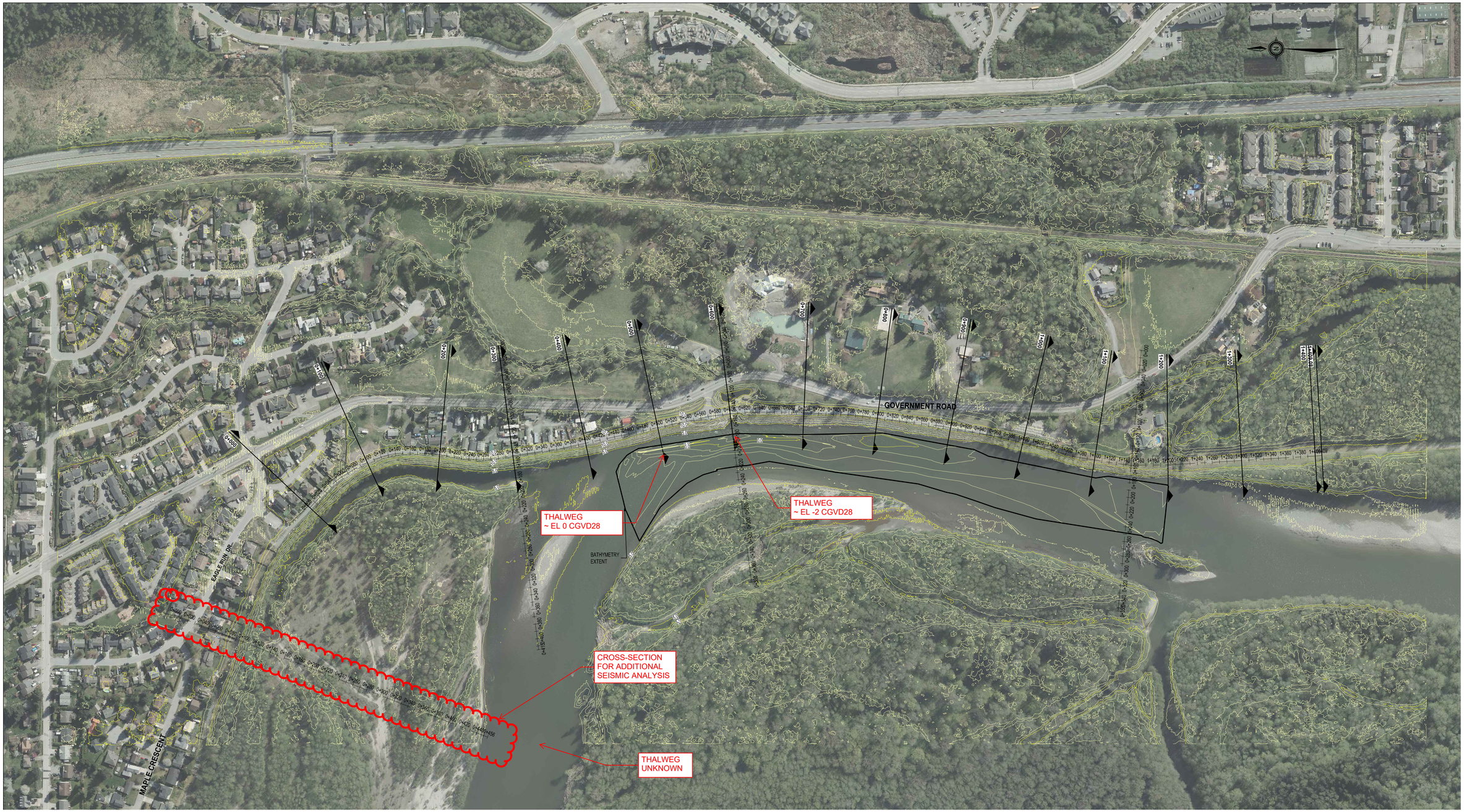
d) Construction Services: During construction Thurber should be retained to provide field reviews. Field reviews consist of performing sufficient and timely observations of encountered conditions in order to confirm and document that the site conditions do not materially differ from those interpreted conditions considered in the preparation of the report. Adequate field reviews are necessary for Thurber to provide letters of assurance, in accordance with the requirements of many regulatory authorities.

6. RELEASE OF POLLUTANTS OR HAZARDOUS SUBSTANCES

Geotechnical engineering and environmental consulting projects often have the potential to encounter pollutants or hazardous substances and the potential to cause the escape, release or dispersal of those substances. Thurber shall have no liability to the Client under any circumstances, for the escape, release or dispersal of pollutants or hazardous substances, unless such pollutants or hazardous substances have been specifically and accurately identified to Thurber by the Client prior to the commencement of Thurber's professional services.

7. INDEPENDENT JUDGEMENTS OF CLIENT

The information, interpretations and conclusions in the Report are based on Thurber's interpretation of conditions revealed through limited investigation conducted within a defined scope of services. Thurber does not accept responsibility for independent conclusions, interpretations, interpolations and/or decisions of the Client, or others who may come into possession of the Report, or any part thereof, which may be based on information contained in the Report. This restriction of liability includes but is not limited to decisions made to develop, purchase or sell land.



PLAN
Scale 1:2500

NOTE:

2016 IMAGERY SHOWN.

2013 CONTOURS SHOWN OUTSIDE OF BATHYMETRY EXTENT.

KERR WOOD LEIDAL
consulting engineers

0 10 (1:1,000) 50m

Info:

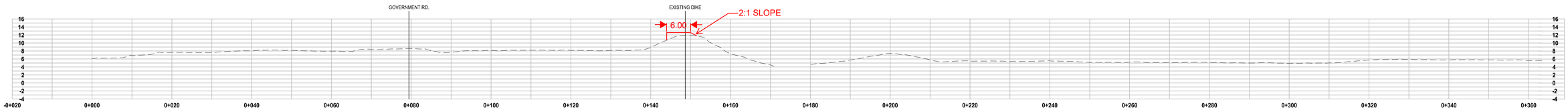
Seal:

Rev	Date	Des	Dwn	Chk	Description
A					

Rev	Date	Des	Dwn	Chk	Description

District of Squamish
Squamish River Dike Master Plan
Eagle Viewing/Seaichem Plan

Project No.	463.341	Drawing No.	Rev.
Group	#####		

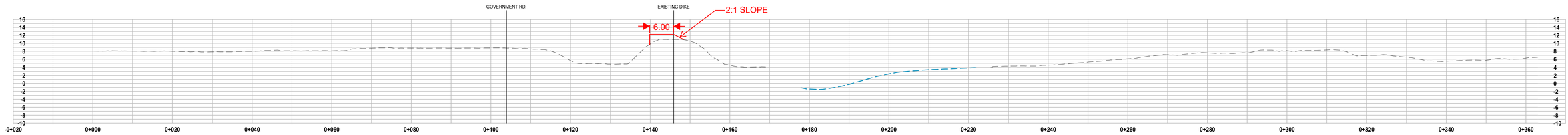


PROFILE AT STATION 0+300

Scale 1:500

OPTION 1

12.1 + 0.6 m = 12.7 m DIKE CREST ELEVATION



PROFILE AT STATION 0+600

Scale 1:500

OPTIONS 1, 2 & 7

11.6 + 0.6 m = 12.2 m DIKE CREST ELEVATION

NOTE: SECTION DERIVED FROM 2013 LIDAR.

KERR WOOD LEIDAL
consulting engineers

0 5 (1:500) 25m

Info:

Seal:

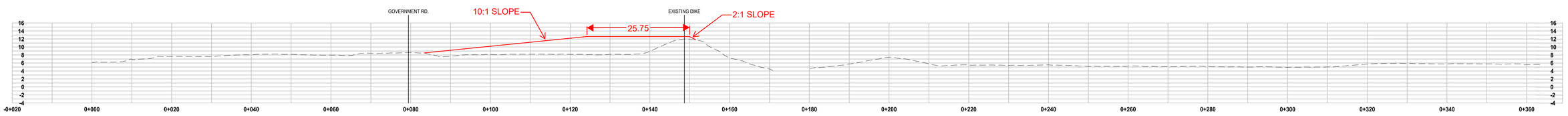
Rev	Date	Des	Dwn	Chk	Description
A					

Rev	Date	Des	Dwn	Chk	Description

District of Squamish
Squamish River Dike Master Plan

Eagle Viewing/Seaichem
Profiles at Station 0+300 and 0+600

Project No.	Drawing No.	Rev.
463.341		
Group #####		

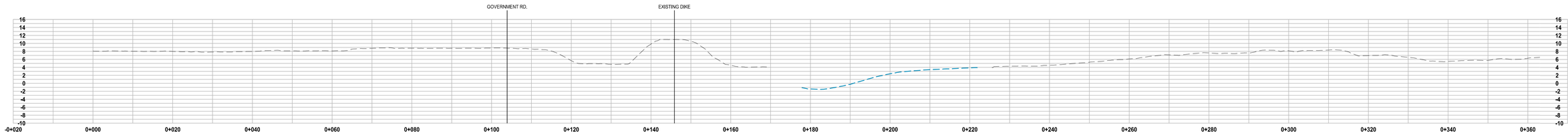


PROFILE AT STATION 0+300

Scale 1:500

OPTION 2

12.1 + 0.6 m = 12.7 m DIKE CREST ELEVATION



PROFILE AT STATION 0+600

Scale 1:500

NOTE: SECTION DERIVED FROM 2013 LIDAR.

KERR WOOD LEIDAL
consulting engineers

0 5 (1:500) 25m

Info:

Seal:

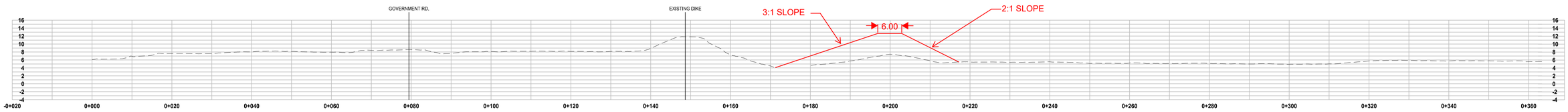
Rev	Date	Des	Dwn	Chk	Description
A					

Rev	Date	Des	Dwn	Chk	Description

District of Squamish
Squamish River Dike Master Plan

Eagle Viewing/Seaichem
Profiles at Station 0+300 and 0+600

Project No. 463.341
Group #####
Drawing No.
Rev.

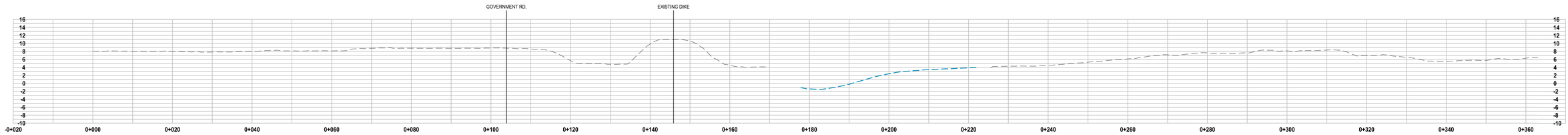


PROFILE AT STATION 0+300

Scale 1:500

OPTION 7

12.1 + 0.6 m = 12.7 m DIKE CREST ELEVATION



PROFILE AT STATION 0+600

Scale 1:500

NOTE: SECTION DERIVED FROM 2013 LIDAR.

KERR WOOD LEIDAL
consulting engineers

0 5 (1:500) 25m

Info:

Seal:

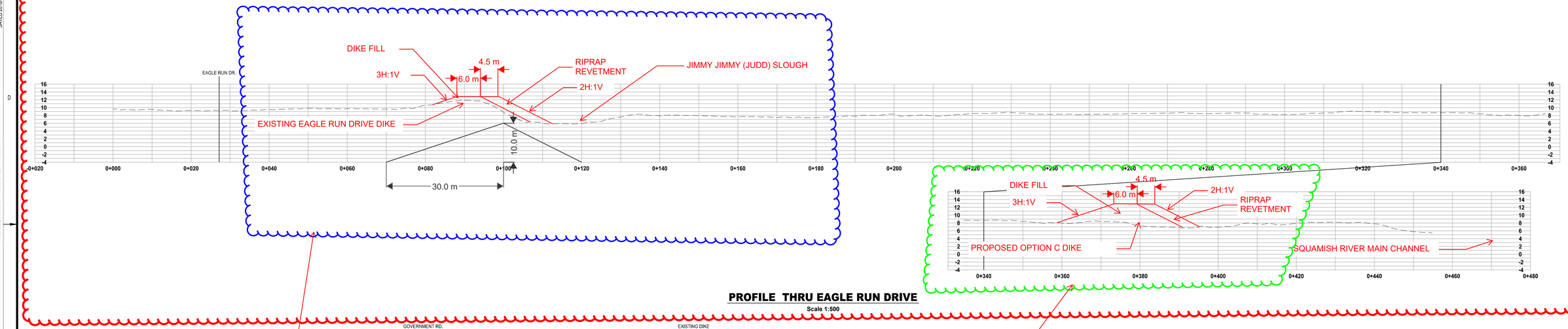
Rev	Date	Des	Dwn	Chk	Description
A					

Rev	Date	Des	Dwn	Chk	Description

District of Squamish
Squamish River Dike Master Plan

Eagle Viewing/Seaichem
Profiles at Station 0+300 and 0+600

Project No.	463.341	Drawing No.	Rev.
Group	#####		



PROFILE THRU EAGLE RUN DRIVE

Scale 1:500

ANALYSIS QUESTIONS FOR EAGLE RUN DRIVE DIKE:

1. WHAT IS THE SEISMIC PERFORMANCE OF THE EXISTING DIKE (WITHOUT ANY IMPROVEMENTS TO CREST ELEVATION OR GROUND IMPROVEMENT). WE ARE ASKING THIS QUESTION TO KNOW WHETHER THE EXISTING DIKE COULD ACT AS A SECONDARY DIKE THAT WOULD PROVIDE POST-EARTHQUAKE FLOOD PROTECTION TO THE OPTION C DIKE. IF POSSIBLE, PLEASE ESTIMATE A POST-EARTHQUAKE CREST ELEVATION.

2. WHAT IS THE SEISMIC PERFORMANCE FOR A PROPOSED DIKE CREST RAISE ON THIS ALIGNMENT? WOULD IT REQUIRE GROUND IMPROVEMENT TO MEET THE GUIDELINES? IF YES, WHAT WOULD THAT INVOLVE?

ANALYSIS QUESTIONS FOR PROPOSED OPTION C DIKE:

1. WHAT IS THE SEISMIC PERFORMANCE FOR THI DIKE? WOULD IT REQUIRE GROUND IMPROVEMENT TO MEET THE GUIDELINES? IF YES, WHAT WOULD THAT INVOLVE?

NOTE: SECTION DERIVED FROM 2013 LIDAR.

KERR WOOD LEIDAL
consulting engineers

0 .5 (1:500) 25m

Info:

Seal:

Rev	Date	Des	Dwn	Chk	Description
A					

Rev	Date	Des	Dwn	Chk	Description

District of Squamish
Squamish River Dike Master Plan

Eagle Viewing/Seaichem Profiles

Project No. 463.341
Drawing No.
Rev.
Group #####

SAVED 2016/05/17, 2:36 AM
Paper Size = ANSI D
A1 Full Size, this border measures 520 mm x 800 mm
millimeters
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THURBER

APPENDIX A

Plotted: November 26, 2019

LEGEND:

TEST HOLE

NOTES:
1. BASE PLAN TAKEN FROM GOOGLE EARTH.
2. TEST HOLE LOCATIONS ARE APPROXIMATE.

THURBER ENGINEERING LTD.

CLIENT: KERR WOOD LEIDAL ASSOCIATES

TEST HOLE LOCATION PLAN

EAGLE VIEWING AREA / SEAICHEM RESERVE
DIKE MASTER PLAN
SQUAMISH, B.C.

DESIGNED	DRAWN	APPROVED
ANR	MOM	

DATE	SCALE
26/11/19	1:2000

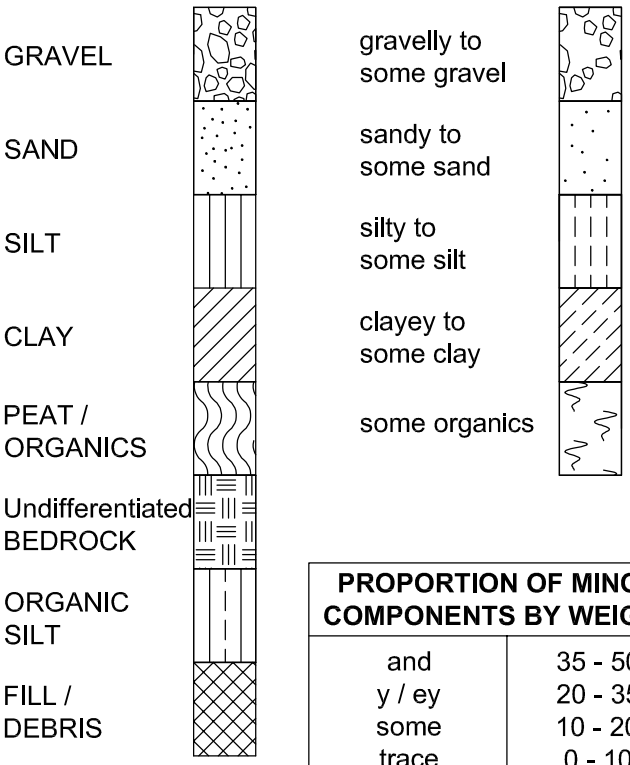
PROJECT No.	DWG. No.	REV.
26619	1	0

S:\Data\BST Projects\26xxx\26619\06_Drafting\03_Working\26619.dwg

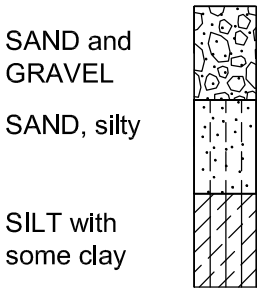
CANCEL PRINTS BEARING EARLIER NUMBER

SYMBOLS AND TERMS
FOR SOIL DESCRIPTION AND TEST HOLE LOGS

BASIC SOIL SYMBOLS



SYMBOL VARIATIONS - EXAMPLES[1]



DENSITY OF GRANULAR SOILS	
Description	SPT N[5] [6]
Very Loose	0 - 4
Loose	4 - 10
Compact	10 - 30
Dense	30 - 50
Very Dense	> 50

PROPORTION OF MINOR COMPONENTS BY WEIGHT[2]	
and	35 - 50%
y / ey	20 - 35%
some	10 - 20%
trace	0 - 10%

CONSISTENCY OF COHESIVE SOILS	
Description	Undrained Shear Strength (kPa)[6]
Very Soft	< 12
Soft	12 - 25
Firm	25 - 50
Stiff	50 - 100
Very Stiff	100 - 200
Hard	> 200

PENETRATION TESTS	
Dynamic Cone Penetration	
Standard Penetration	
Becker Closed Casing	
Becker Open Casing	
Bounce Chamber Pressure	

CLASSIFICATION BY PARTICLE SIZE				
		Size Range[6]		
			U.S. Standard Sieve Size	
Name		(mm)[3]	Retained	Passing
Boulders		> 200	8 inch	-
Cobbles		75 - 200	3 inch	8 inch
Gravel:	coarse	19 - 75	0.75 inch	3 inch
	fine	5 - 19	No. 4	0.75 inch
Sand:	coarse	2 - 5	No. 10	No. 4
	medium	0.4 - 2	No. 40	No. 10
	fine	0.075 - 0.4	No. 200	No. 40
Fines (Silt or Clay)[4]		< 0.075	-	No. 200

(1) Only selected examples of the possible variations or combinations of the basic symbols are illustrated.
(2) Example: SAND, silty, trace of gravel = sand with 20 to 35% silt and up to 10% gravel, by dry weight. Percentages of secondary materials are estimates based on visual and tactile assessment of samples.
(3) Approximate metric conversion.
(4) Fines are classified as silt or clay on the basis of Atterberg limits.
(5) SPT N values on test hole logs are uncorrected field values.
(6) Reference Canadian Foundation Engineering Manual 4th Edition, 2006.

THURBER

Sheet 1 of 3

LOG OF TEST HOLE

TEST HOLE NO. 19-1

LOCATION: See Dwg. 26619-1
N 5511464, E 489752 (Est.)

TOP OF HOLE ELEV:

METHOD: Sonic

DRILLING CO.: Omega Environmental Drilling Ltd.

INSPECTOR: ANR

THURBER

CLIENT: Kerr Wood Leidal Associates

PROJECT: Eagle Viewing Area / Seaichem Reserve - Dike Master Plan

DATE: August 29, 2019

FILE NO.: 26619

REVIEWED BY:

PENETRATION (blows/300 mm) | WATER CONTENT (%): ○ Disturbed ● Undisturbed | WATER LEVEL: Plastic Limit — Liquid Limit | SAMPLES: Disturbed, Undisturbed, No Recovery | UNDRAINED SHEAR STRENGTH (kPa): ◆ Peak ◇ Residual ◆ Remolded | GRAIN SIZE (%): ▲ Passing #200 sieve △ Passing #4 sieve | SOIL HEADSPACE READING (ppm): GASTECH reading, PID reading

DEPTH (m)	COMMENTS		SOILS DESCRIPTION
0	Run 1: 0 to 2.7 m depth Recovery= 89%		Grey-brown, silty SAND and GRAVEL with some to a traces of cobbles.
1		SW/GW	
2		SP-SM	
3	Run 2: 2.7 to 5.8 m depth Recovery= 55%	SP	Grey, gravelly SAND with some to a trace of cobbles and a trace of silt.
4		ML	Brown, moist SILT with some sand and traces of clay and gravel.
		SP-SM	Brown, moist SAND with a trace of silt.
5			
6	Run 3: 5.8 to 8.8 m depth Recovery= 80%		Brown, sandy GRAVEL with some cobbles and a trace of silt.
	106		
7		GW-GM	
8		GP	
9	Run 4: 8.8 to 11.9 m depth Recovery= 20%		- some fresh wood fragments at 8.7 m depth
10			

LOG OF TEST HOLE (COORD EST) 26619.GPJ THURBER_MOM.GDT 17/10/19- THURBER MOM.GLB

LOG OF TEST HOLE

TEST HOLE NO. **19-1**

LOCATION: See Dwg. 26619-1
N 5511464, E 489752 (Est.)

TOP OF HOLE ELEV:

METHOD: Sonic

DRILLING CO.: Omega Environmental Drilling Ltd.

INSPECTOR: ANR

THURBER

CLIENT: Kerr Wood Leidal Associates

PROJECT: Eagle Viewing Area / Seaichem Reserve - Dike Master Plan

DATE: August 29, 2019

FILE NO.: 26619

REVIEWED BY:

PENETRATION (blows/300 mm) | WATER CONTENT (%): ○ Disturbed ● Undisturbed | WATER LEVEL: Plastic Limit — Liquid Limit | SAMPLES: ◧ Disturbed ■ Undisturbed ⊠ No Recovery | UNDRAINED SHEAR STRENGTH (kPa): ◆ Peak ◇ Residual ◆ Remolded | GRAIN SIZE (%): ▲ Passing #200 sieve △ Passing #4 sieve | SOIL HEADSPACE READING (ppm): ■ GASTECH reading ⊠ PID reading

DEPTH (m) | 10 20 30 40 50 60 70 80 90 100 | **COMMENTS** | SOILS DESCRIPTION

10 — Brown, sandy GRAVEL with some cobbles and a trace of silt.

11

SP/GP

12 — Grey, cobbly GRAVEL with some sand and a trace of silt.

Run 5:
11.9 to 14.9 m depth
Recovery= 40%

13

14

GP

15 — Brown SAND with traces of gravel, cobbles and silt.

Run 6:
14.9 to 18.0 m depth
Recovery= 100%

SP

16

GP

17 — Brown COBBLES with some gravel and sand and a trace of silt.

Brown SAND with a trace to some silt and a trace of gravel.

SP

18

Run 7:
18.0 to 21.0 m depth
Recovery= 100%

SM

19

20

Sheet 3 of 3

LOG OF TEST HOLE

TEST HOLE NO. 19-1

LOCATION: See Dwg. 26619-1
N 5511464, E 489752 (Est.)

TOP OF HOLE ELEV:

METHOD: Sonic

DRILLING CO.: Omega Environmental Drilling Ltd.

INSPECTOR: ANR

THURBER

CLIENT: Kerr Wood Leidal Associates

PROJECT: Eagle Viewing Area / Seaichem Reserve - Dike Master Plan

DATE: August 29, 2019

FILE NO.: 26619

REVIEWED BY:

PENETRATION (blows/300 mm) | WATER CONTENT (%): ○ Disturbed ● Undisturbed | WATER LEVEL: Plastic Limit — Liquid Limit | SAMPLES: Disturbed, Undisturbed, No Recovery | UNDRAINED SHEAR STRENGTH (kPa): ◆ Peak ◇ Residual ◆ Remolded | GRAIN SIZE (%): ▲ Passing #200 sieve △ Passing #4 sieve | SOIL HEADSPACE READING (ppm): GASTECH reading, PID reading

10 20 30 40 50 60 70 80 90 100

COMMENTS

DEPTH (m)	SOILS DESCRIPTION
20	Brown SAND with a trace to some silt and a trace of gravel.
21	ML/SM
	End of hole at required depth. Water level undetermined due to sonic drilling method.
22	
23	
24	
25	
26	
27	
28	
29	
30	

LOG OF TEST HOLE (COORD EST) 26619.GPJ THURBER_MOM.GDT 17/10/19- THURBER MOM.GLB

Sheet 1 of 3

LOG OF TEST HOLE

TEST HOLE NO. 19-2

LOCATION: See Dwg. 26619-1
N 5511029, E 489813 (Est.)

TOP OF HOLE ELEV:

METHOD: Sonic

DRILLING CO.: Omega Environmental Drilling Ltd.

INSPECTOR: ANR

THURBER

CLIENT: Kerr Wood Leidal Associates

PROJECT: Eagle Viewing Area / Seaichem Reserve - Dike Master Plan

DATE: August 29, 2019

FILE NO.: 26619

REVIEWED BY:

PENETRATION (blows/300 mm) | WATER CONTENT (%): ○ Disturbed ● Undisturbed | WATER LEVEL: Plastic Limit — Liquid Limit | SAMPLES: Disturbed, Undisturbed, No Recovery | UNDRAINED SHEAR STRENGTH (kPa): ◆ Peak ◇ Residual ◆ Remolded | GRAIN SIZE (%): ▲ Passing #200 sieve △ Passing #4 sieve | SOIL HEADSPACE READING (ppm): GASTECH reading, PID reading

DEPTH (m) | 10 20 30 40 50 60 70 80 90 100 | COMMENTS | SOILS DESCRIPTION

0 — Brown, sandy GRAVEL with some cobbles and silt.

Run 1:
0 to 2.7 m depth
Recovery= 100%

GP-GM

1 — Brown, gravelly SAND with some silt.

SM

2

104

Run 2:
2.7 to 5.8 m depth
Recovery= 70%

168

3 — Brown, cobbly SAND and GRAVEL with a trace of silt.

SW-SM/GW-GM

4

124

5

SW-SM/GW-GM

6 — Grey, cobbly, sandy GRAVEL.

Run 3:
5.8 to 8.8 m depth
Recovery= 30%
Poor recovery between 5.8 and 8.8 m depth

7

GP/GW

8

9

Run 4:
8.8 to 11.9 m depth
Recovery= 65%

10 — Grey, silty GRAVEL with some sand.

GM

DEPTH (m)

LOG OF TEST HOLE (COORD EST) 26619.GPJ THURBER_MOM.GDT 17/10/19- THURBER MOM.GLB

LOG OF TEST HOLE

TEST HOLE NO. **19-2**

LOCATION: See Dwg. 26619-1
N 5511029, E 489813 (Est.)

TOP OF HOLE ELEV:

METHOD: Sonic

DRILLING CO.: Omega Environmental Drilling Ltd.

INSPECTOR: ANR

THURBER

CLIENT: Kerr Wood Leidal Associates

PROJECT: Eagle Viewing Area / Seaichem Reserve - Dike Master Plan

DATE: August 29, 2019

FILE NO.: 26619

REVIEWED BY:

PENETRATION (blows/300 mm) | WATER CONTENT (%): ○ Disturbed ● Undisturbed | WATER LEVEL: Plastic Limit — Liquid Limit | SAMPLES: ◧ Disturbed ■ Undisturbed ☒ No Recovery | UNDRAINED SHEAR STRENGTH (kPa): ◆ Peak ◇ Residual ◆ Remolded | GRAIN SIZE (%): ▲ Passing #200 sieve △ Passing #4 sieve | SOIL HEADSPACE READING (ppm): ■ GASTECH reading ⊠ PID reading

DEPTH (m) | 10 20 30 40 50 60 70 80 90 100 | **COMMENTS** | SOILS DESCRIPTION | DEPTH (m)

10 — Grey SAND and GRAVEL with some cobbles to cobbly and a trace of silt.

11

SW/GW

12 — Run 5:
11.9 to 14.9 m depth
Recovery= 50%

13

14

GW

15 — Run 6:
14.9 to 18.0 m depth
Recovery= 40%

Grey SAND with traces of silt and gravel.

16

17

SP

18 — Run 7:
18.0 to 21.0 m depth
Recovery= 90%

SP

19

- some silt to silty below 19.5 m depth

ML/SM

20

LOG OF TEST HOLE (COORD EST) 26619.GPJ THURBER_MOM.GDT 17/10/19- THURBER MOM.GLB

Sheet 3 of 3

LOG OF TEST HOLE

TEST HOLE NO. 19-2

LOCATION: See Dwg. 26619-1
N 5511029, E 489813 (Est.)

TOP OF HOLE ELEV:

METHOD: Sonic

DRILLING CO.: Omega Environmental Drilling Ltd.

INSPECTOR: ANR

THURBER

CLIENT: Kerr Wood Leidal Associates

PROJECT: Eagle Viewing Area / Seaichem Reserve - Dike Master Plan

DATE: August 29, 2019

FILE NO.: 26619

REVIEWED BY:

PENETRATION (blows/300 mm) | WATER CONTENT (%) ○ Disturbed ● Undisturbed | WATER LEVEL Plastic Limit — Liquid Limit | SAMPLES ◧ Disturbed ■ Undisturbed ☒ No Recovery | UNDRAINED SHEAR STRENGTH (kPa) ◆ Peak ◇ Residual ◆ Remolded | GRAIN SIZE (%) ▲ Passing #200 sieve △ Passing #4 sieve | SOIL HEADSPACE READING (ppm) ■ GASTECH reading ⊠ PID reading

10 20 30 40 50 60 70 80 90 100

DEPTH (m)	COMMENTS	SOILS DESCRIPTION
20		Grey SAND with traces of silt and gravel.
21		End of hole at required depth. Water level undetermined due to sonic drilling method.
22		
23		
24		
25		
26		
27		
28		
29		
30		

LOG OF TEST HOLE (COORD EST) 26619.GPJ THURBER_MOM.GDT 17/10/19- THURBER MOM.GLB

THURBER

APPENDIX B

Figure 1: 0+300_1_Wall_LTR_Static

Name: Existing Dike Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 35 °
Name: New Dike Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 35 °
Name: Sand and Gravel Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 35 °
Name: Sand Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 32 °
Name: Silt Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 30 kPa Phi: 28 °
Name: Rip Rap Model: Mohr-Coulomb Unit Weight: 20 kN/m³ Cohesion: 0 kPa Phi: 50 °

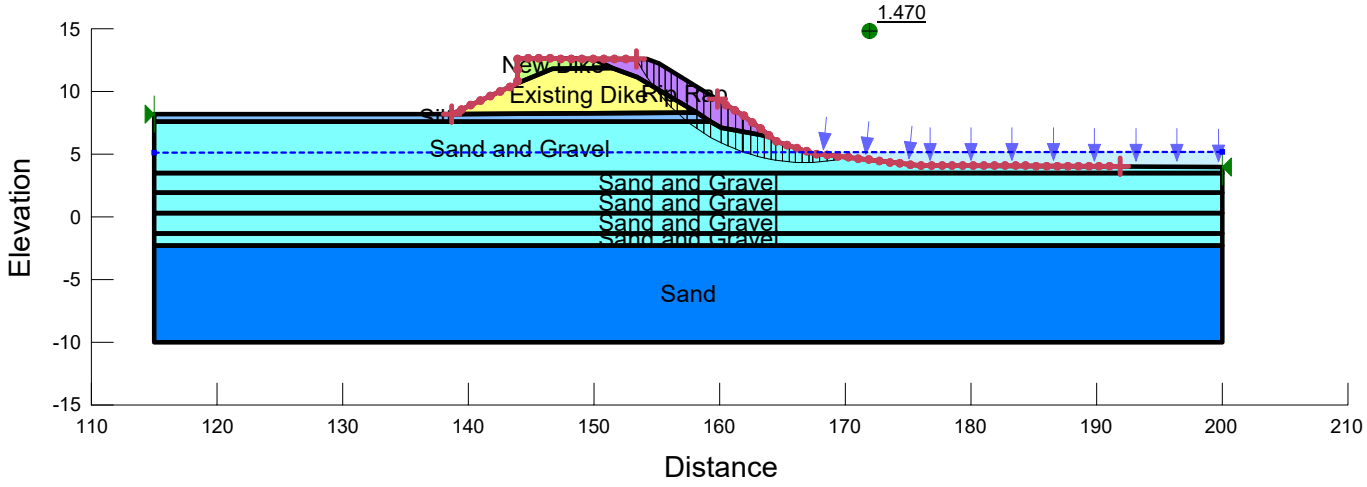


Figure 2: 0+300_1_Wall_RTL_Static

Name: Existing Dike Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 35 °
Name: New Dike Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 35 °
Name: Sand and Gravel Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 35 °
Name: Sand Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 32 °
Name: Silt Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 30 kPa Phi: 28 °
Name: Rip Rap Model: Mohr-Coulomb Unit Weight: 20 kN/m³ Cohesion: 0 kPa Phi: 50 °

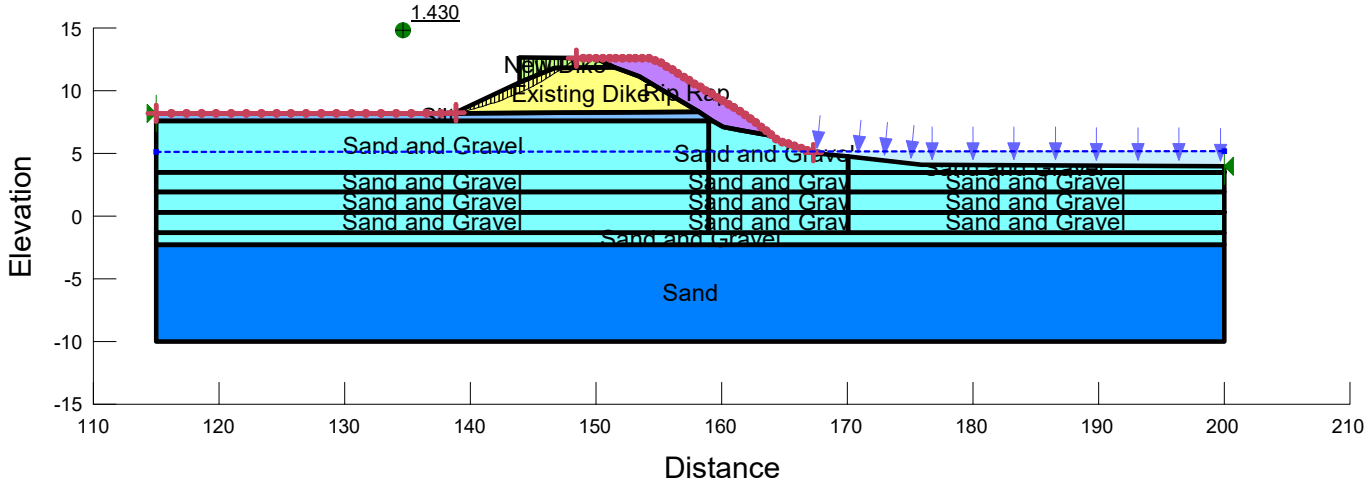


Figure 3: 0+300_2_Wide_LTR_Static

Name: Existing Dike Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 35 °
Name: New Dike Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 35 °
Name: Sand and Gravel Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 35 °
Name: Sand Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 32 °
Name: Silt Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 30 kPa Phi: 28 °
Name: Rip Rap Model: Mohr-Coulomb Unit Weight: 20 kN/m³ Cohesion: 0 kPa Phi: 50 °

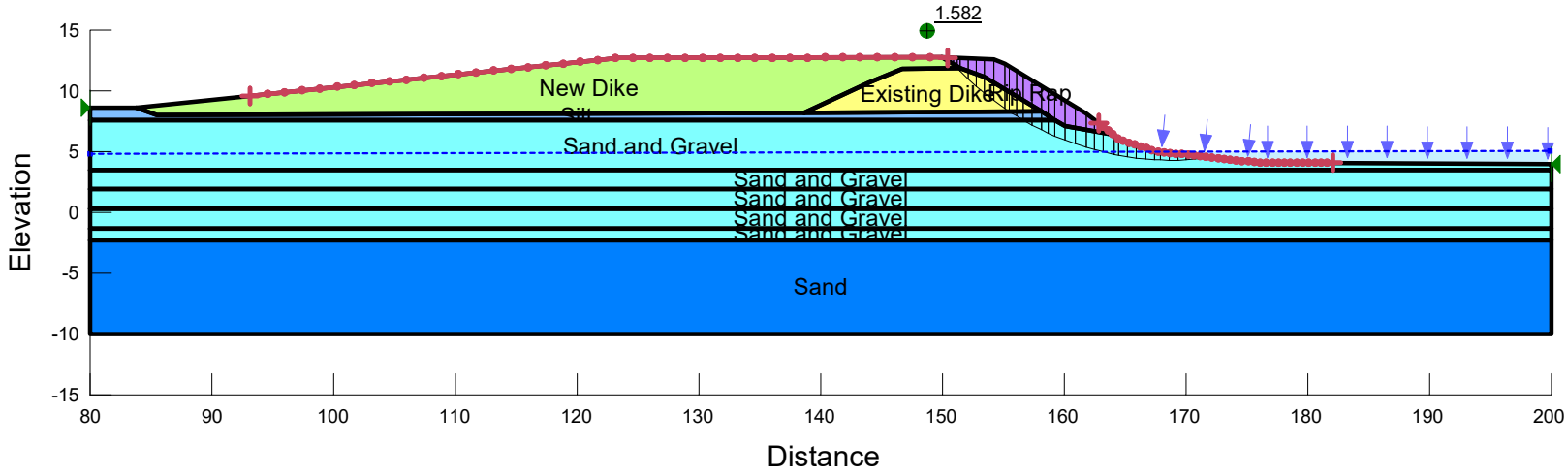


Figure 4: 0+300_2_Wide_RTL_Static

Name: Existing Dike Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 35 °
Name: New Dike Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 35 °
Name: Sand and Gravel Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 35 °
Name: Sand Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 32 °
Name: Silt Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 30 kPa Phi: 28 °
Name: Rip Rap Model: Mohr-Coulomb Unit Weight: 20 kN/m³ Cohesion: 0 kPa Phi: 50 °

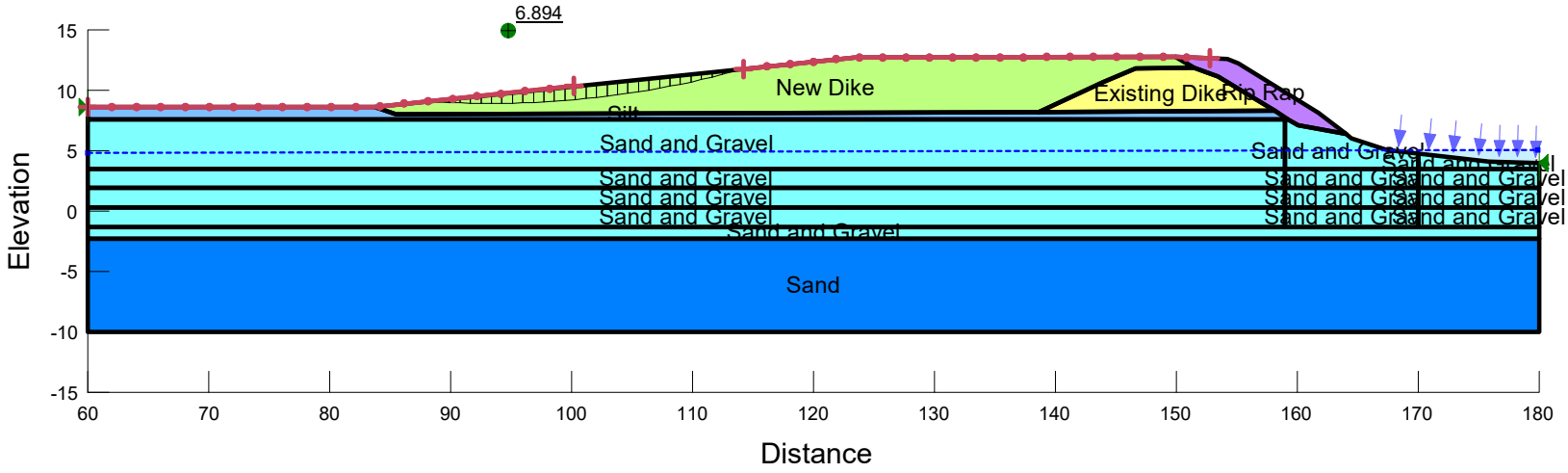


Figure 5: 0+300_7_Realign_LTR_Static

Name: Existing Dike Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 35 °
Name: New Dike Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 35 °
Name: Sand and Gravel Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 35 °
Name: Sand Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 32 °
Name: Silt Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 30 kPa Phi: 28 °
Name: Rip Rap Model: Mohr-Coulomb Unit Weight: 20 kN/m³ Cohesion: 0 kPa Phi: 50 °

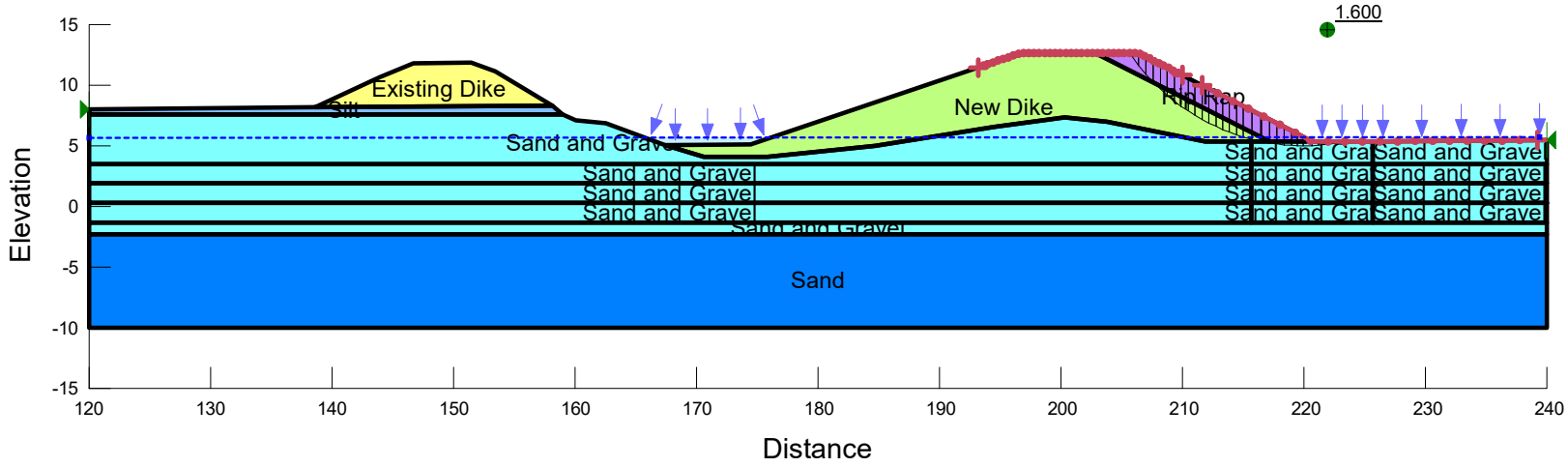


Figure 6: 0+300_7_Realign_RTL_Static

Name: Existing Dike Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 35 °
Name: New Dike Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 35 °
Name: Sand and Gravel Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 35 °
Name: Sand Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 32 °
Name: Silt Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 30 kPa Phi: 28 °
Name: Rip Rap Model: Mohr-Coulomb Unit Weight: 20 kN/m³ Cohesion: 0 kPa Phi: 50 °

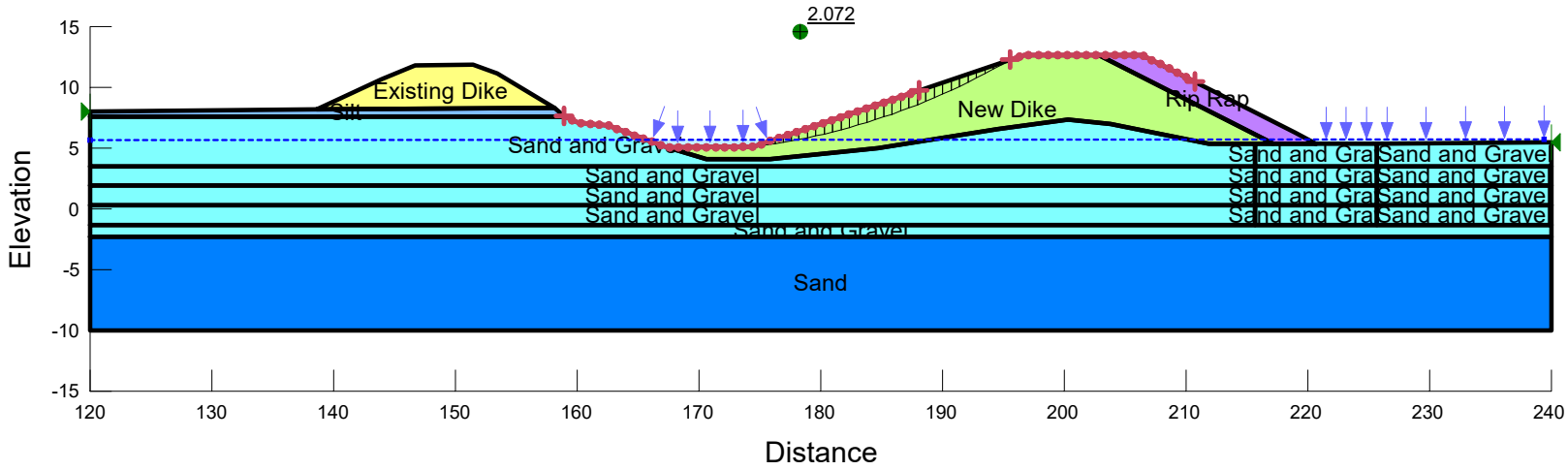


Figure 7: 0+300_1_Wall_RTL_Flood

Name: Existing Dike Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 35 °
Name: New Dike Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 35 °
Name: Sand and Gravel Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 35 °
Name: Sand Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 32 °
Name: Silt Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 30 kPa Phi: 28 °
Name: Rip Rap Model: Mohr-Coulomb Unit Weight: 20 kN/m³ Cohesion: 0 kPa Phi: 50 °

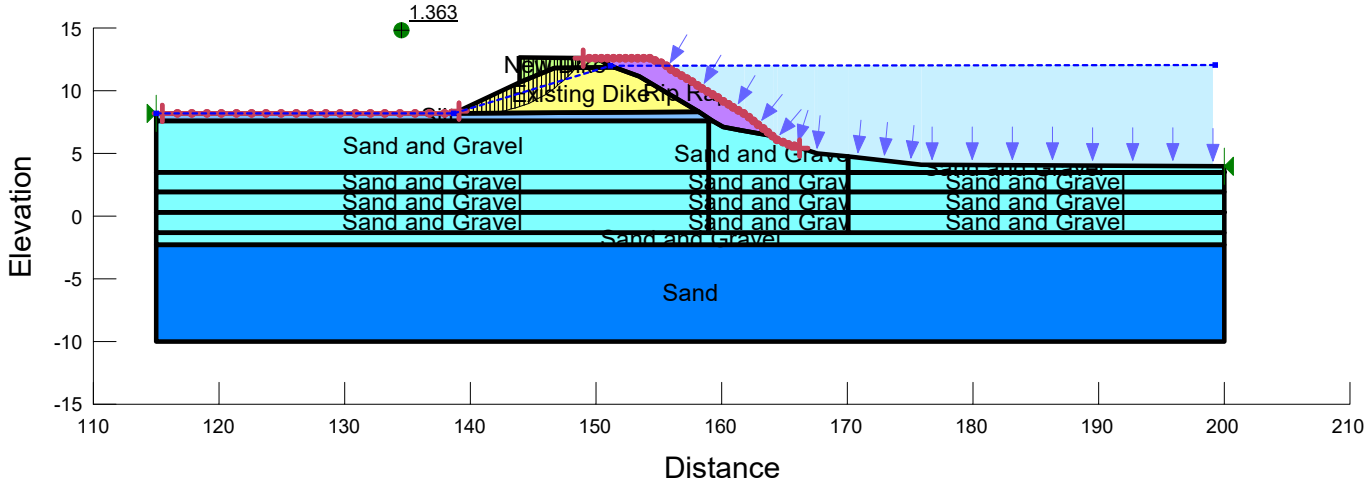


Figure 8: 0+300_2_Wide_RTL_Flood

Name: Existing Dike Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 35 °
Name: New Dike Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 35 °
Name: Sand and Gravel Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 35 °
Name: Sand Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 32 °
Name: Silt Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 30 kPa Phi: 28 °
Name: Rip Rap Model: Mohr-Coulomb Unit Weight: 20 kN/m³ Cohesion: 0 kPa Phi: 50 °

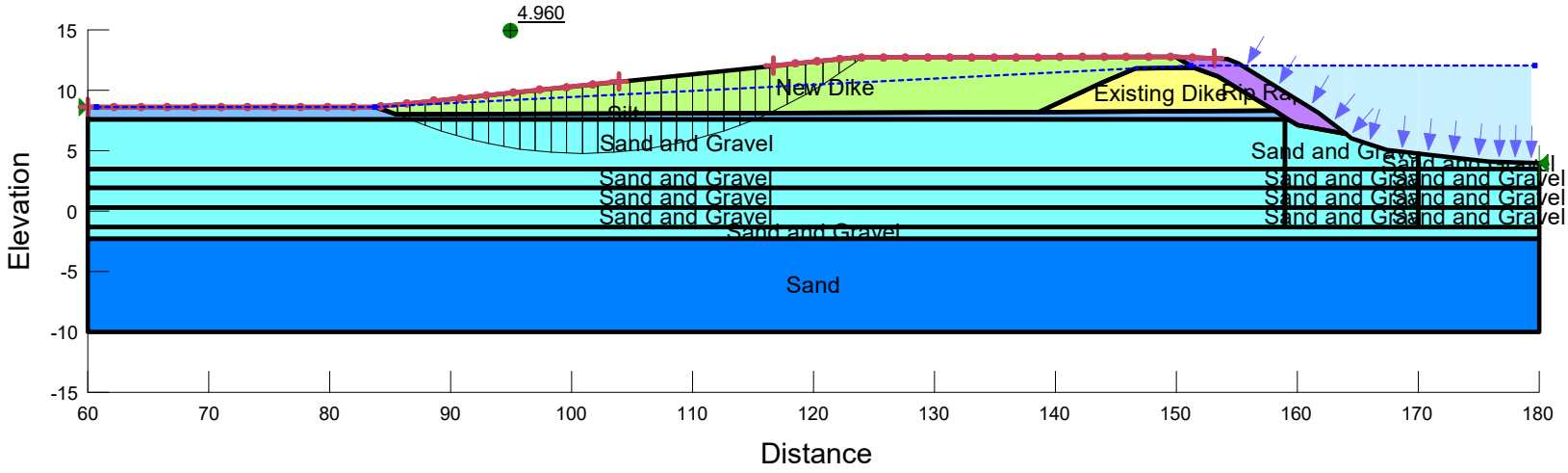


Figure 9: 0+300_7_Realign_RTL_Flood

Name: Existing Dike Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 35 °
Name: New Dike Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 35 °
Name: Sand and Gravel Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 35 °
Name: Sand Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 32 °
Name: Silt Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 30 kPa Phi: 28 °
Name: Rip Rap Model: Mohr-Coulomb Unit Weight: 20 kN/m³ Cohesion: 0 kPa Phi: 50 °

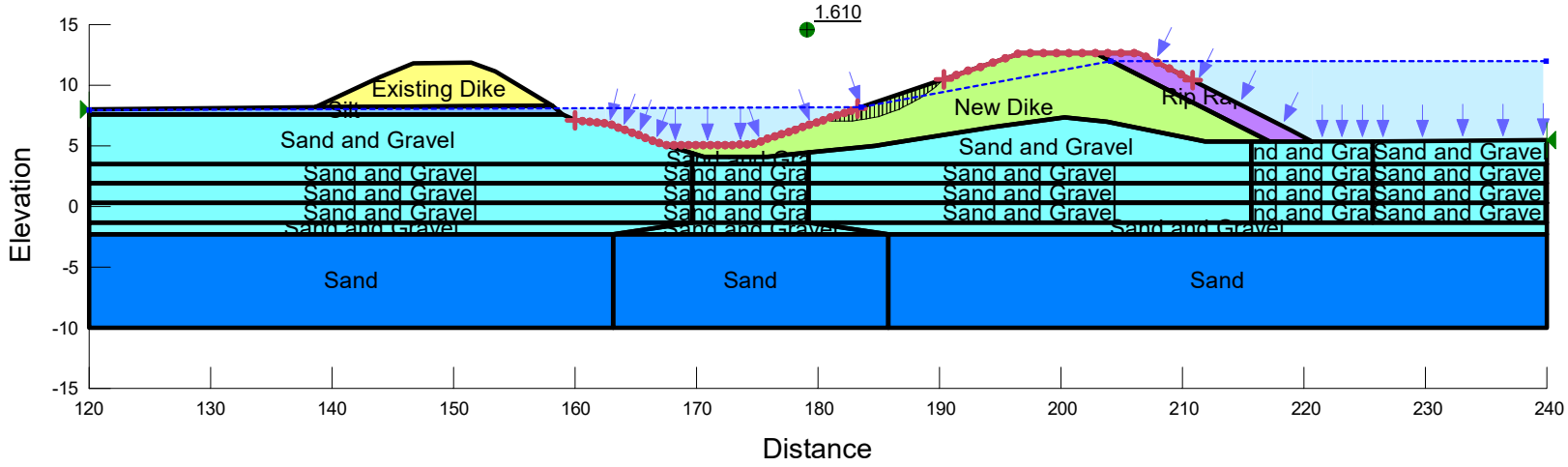


Figure 10: 0+300_1_Wall_LTR_Drawdown

Name: Existing Dike Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 35 °
Name: New Dike Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 35 °
Name: Sand and Gravel Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 35 °
Name: Sand Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 32 °
Name: Silt Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 30 kPa Phi: 28 °
Name: Rip Rap Model: Mohr-Coulomb Unit Weight: 20 kN/m³ Cohesion: 0 kPa Phi: 50 °

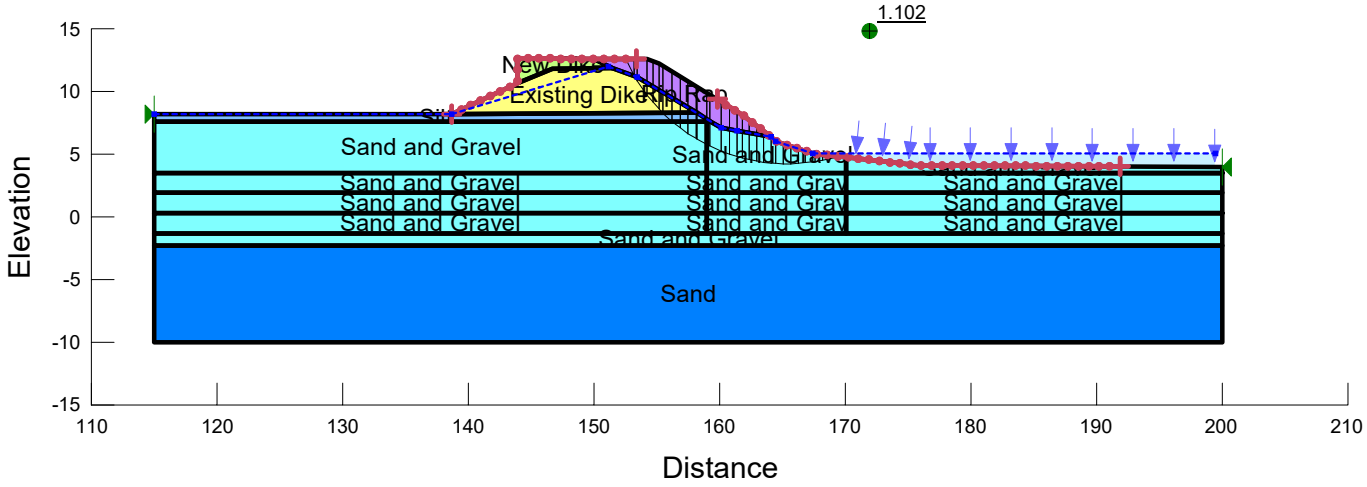


Figure 11: 0+300_2_Wide_LTR_Drawdown

Name: Existing Dike Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 35 °
Name: New Dike Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 35 °
Name: Sand and Gravel Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 35 °
Name: Sand Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 32 °
Name: Silt Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 30 kPa Phi: 28 °
Name: Rip Rap Model: Mohr-Coulomb Unit Weight: 20 kN/m³ Cohesion: 0 kPa Phi: 50 °

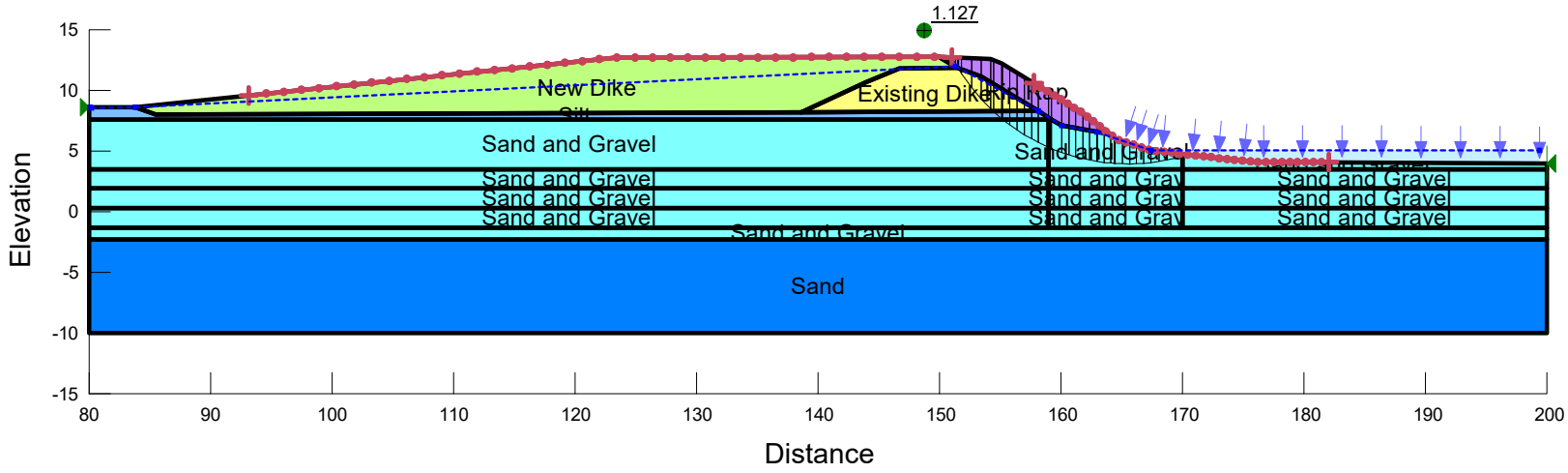


Figure 12: 0+300_7_Realign_LTR_Drawdown

Name: Existing Dike Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 35 °
Name: New Dike Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 35 °
Name: Sand and Gravel Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 35 °
Name: Sand Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 32 °
Name: Silt Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 30 kPa Phi: 28 °
Name: Rip Rap Model: Mohr-Coulomb Unit Weight: 20 kN/m³ Cohesion: 0 kPa Phi: 50 °

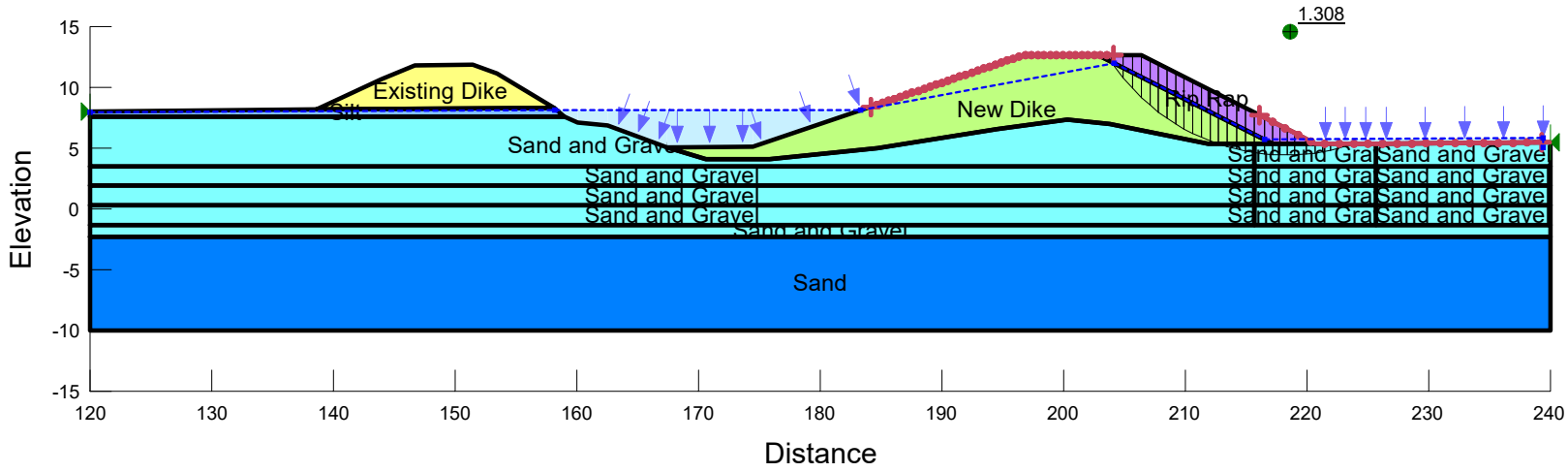


Figure 13: 0+600_1_Wall_LTR_Static

Name: Existing Dike Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 35 °
Name: New Dike Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 35 °
Name: Sand and Gravel Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 35 °
Name: Sand Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 32 °
Name: Rip Rap Model: Mohr-Coulomb Unit Weight: 20 kN/m³ Cohesion: 0 kPa Phi: 50 °

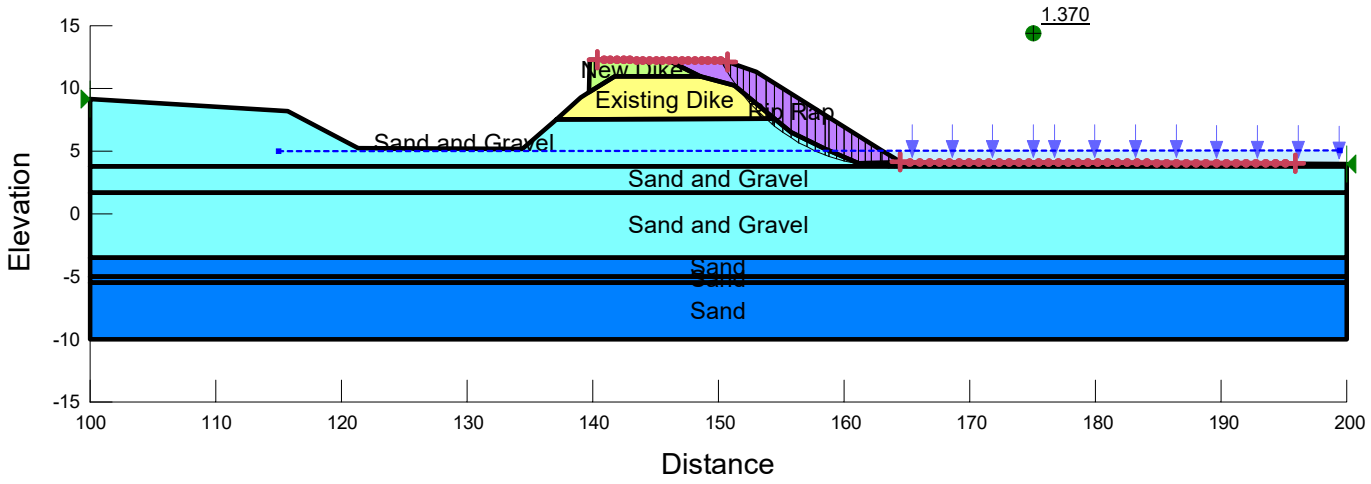


Figure 14: 0+600_1_Wall_RTL_Static

Name: Existing Dike Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 35 °
Name: New Dike Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 35 °
Name: Sand and Gravel Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 35 °
Name: Sand Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 32 °
Name: Rip Rap Model: Mohr-Coulomb Unit Weight: 20 kN/m³ Cohesion: 0 kPa Phi: 50 °

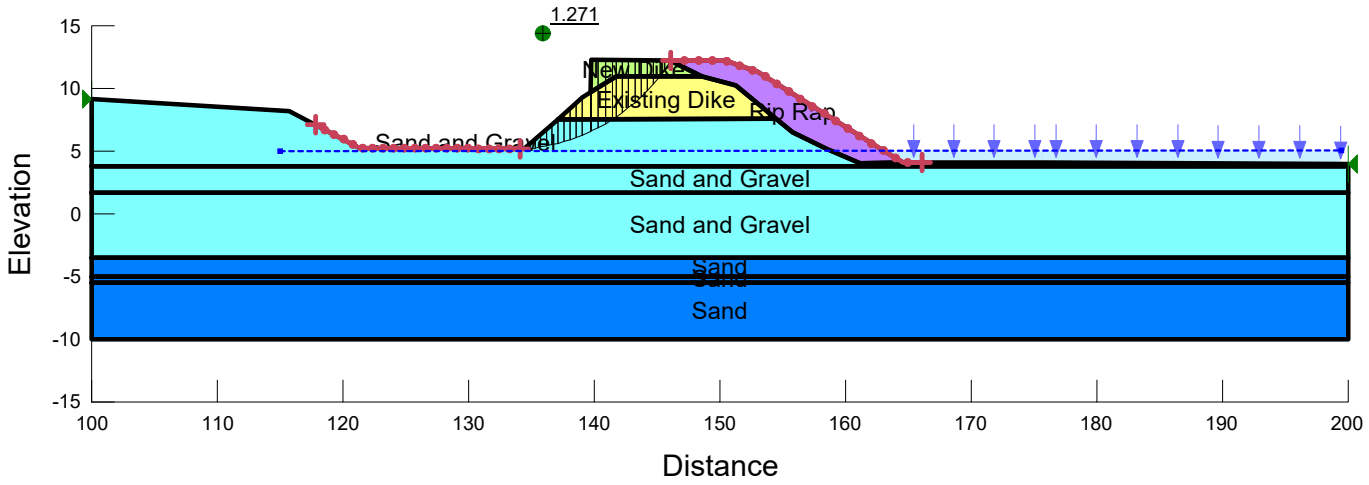


Figure 15: 0+600_1_Wall_RTL_Flood

Name: Existing Dike Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 35 °
Name: New Dike Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 35 °
Name: Sand and Gravel Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 35 °
Name: Sand Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 32 °
Name: Rip Rap Model: Mohr-Coulomb Unit Weight: 20 kN/m³ Cohesion: 0 kPa Phi: 50 °

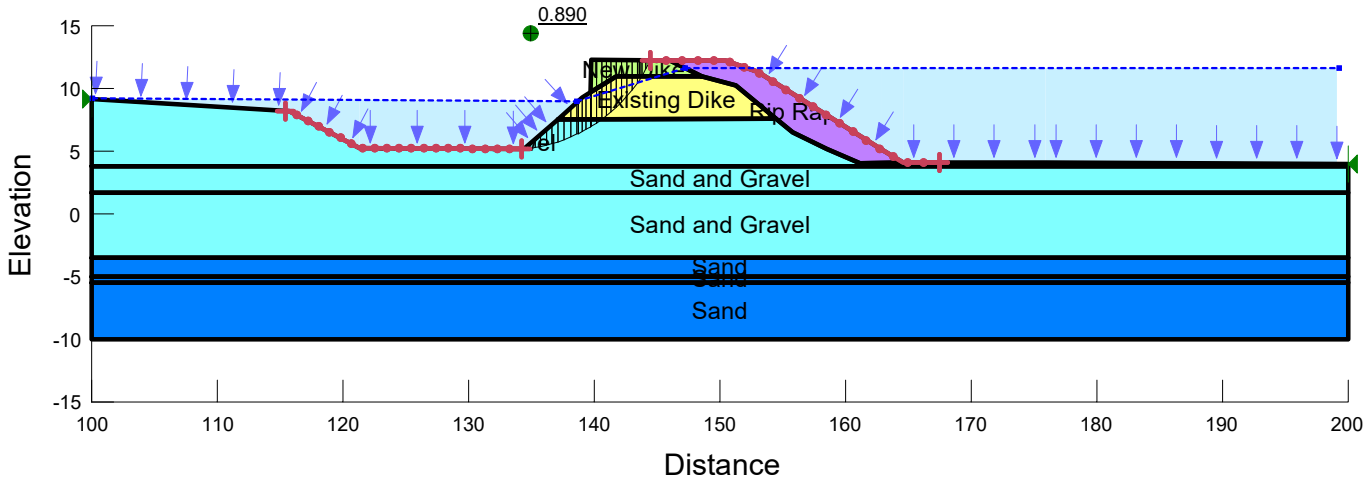
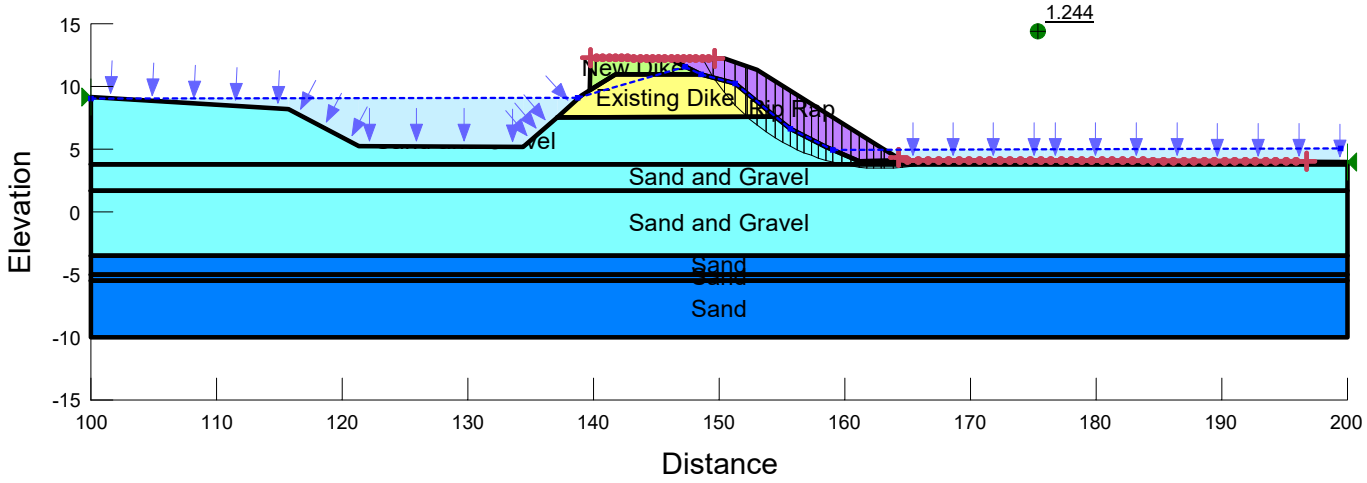


Figure 16: 0+600_1_Wall_LTR_Drawdown

Name: Existing Dike Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 35 °
Name: New Dike Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 35 °
Name: Sand and Gravel Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 35 °
Name: Sand Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 32 °
Name: Rip Rap Model: Mohr-Coulomb Unit Weight: 20 kN/m³ Cohesion: 0 kPa Phi: 50 °



THURBER

APPENDIX C

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SPT BASED LIQUEFACTION ANALYSIS REPORT

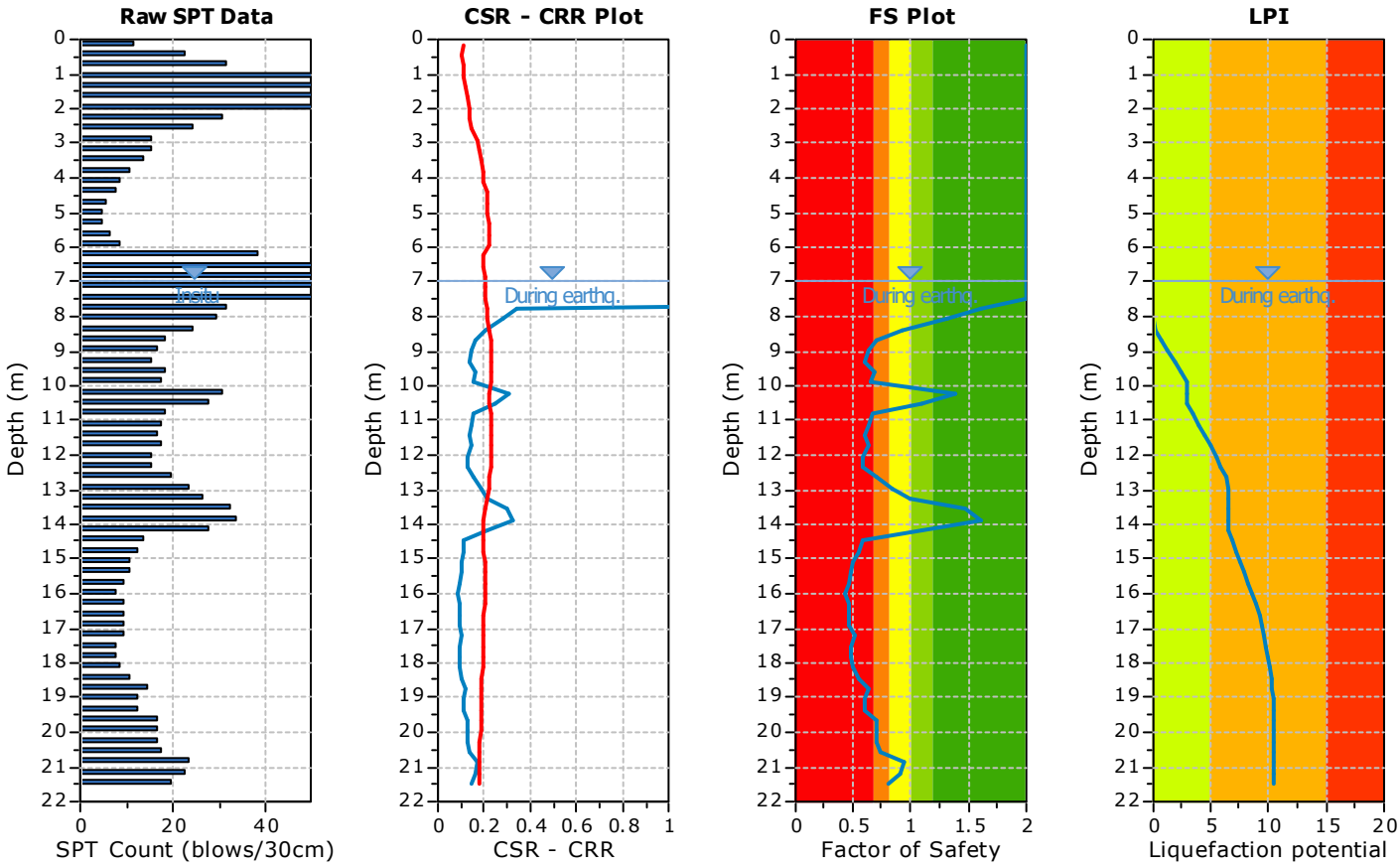
Project title : Eagle Viewing Area/Seaichem Dike

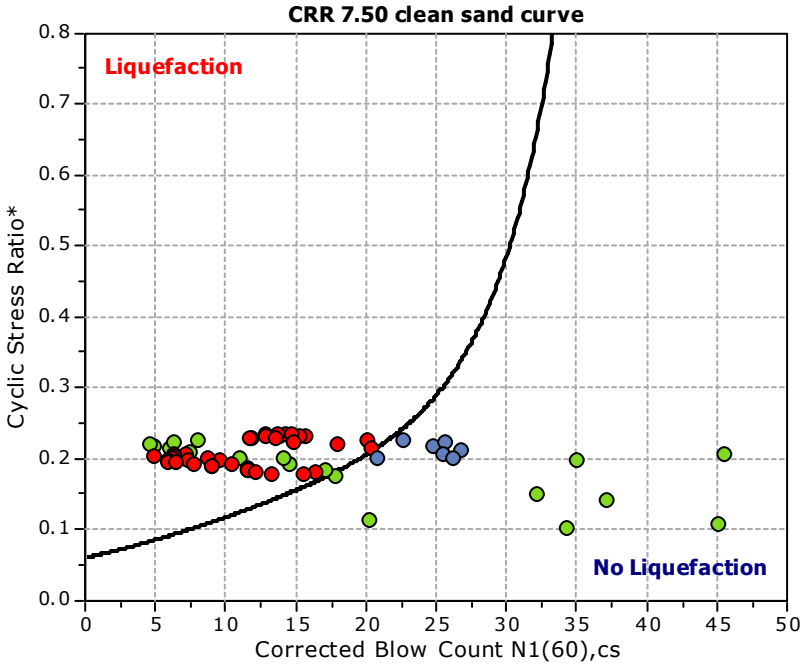
SPT Name: A2475 Crustal

Location : Squamish, BC TH19-1

:: Input parameters and analysis properties ::

Analysis method:	Boulanger & Idriss, 2014	G.W.T. (in-situ):	7.00 m
Fines correction method:	Boulanger & Idriss, 2014	G.W.T. (earthq.):	7.00 m
Sampling method:	Standard Sampler	Earthquake magnitude M_w:	7.00
Borehole diameter:	65mm to 115mm	Peak ground acceleration:	Custom
Rod length:	1.50 m	Eq. external load:	0.00 kPa
Hammer energy ratio:	1.00		





F.S. color scheme

- Almost certain it will liquefy
- Very likely to liquefy
- Liquefaction and no liq. are equally likely
- Unlike to liquefy
- Almost certain it will not liquefy

LPI color scheme

- Very high risk
- High risk
- Low risk

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SPT BASED LIQUEFACTION ANALYSIS REPORT

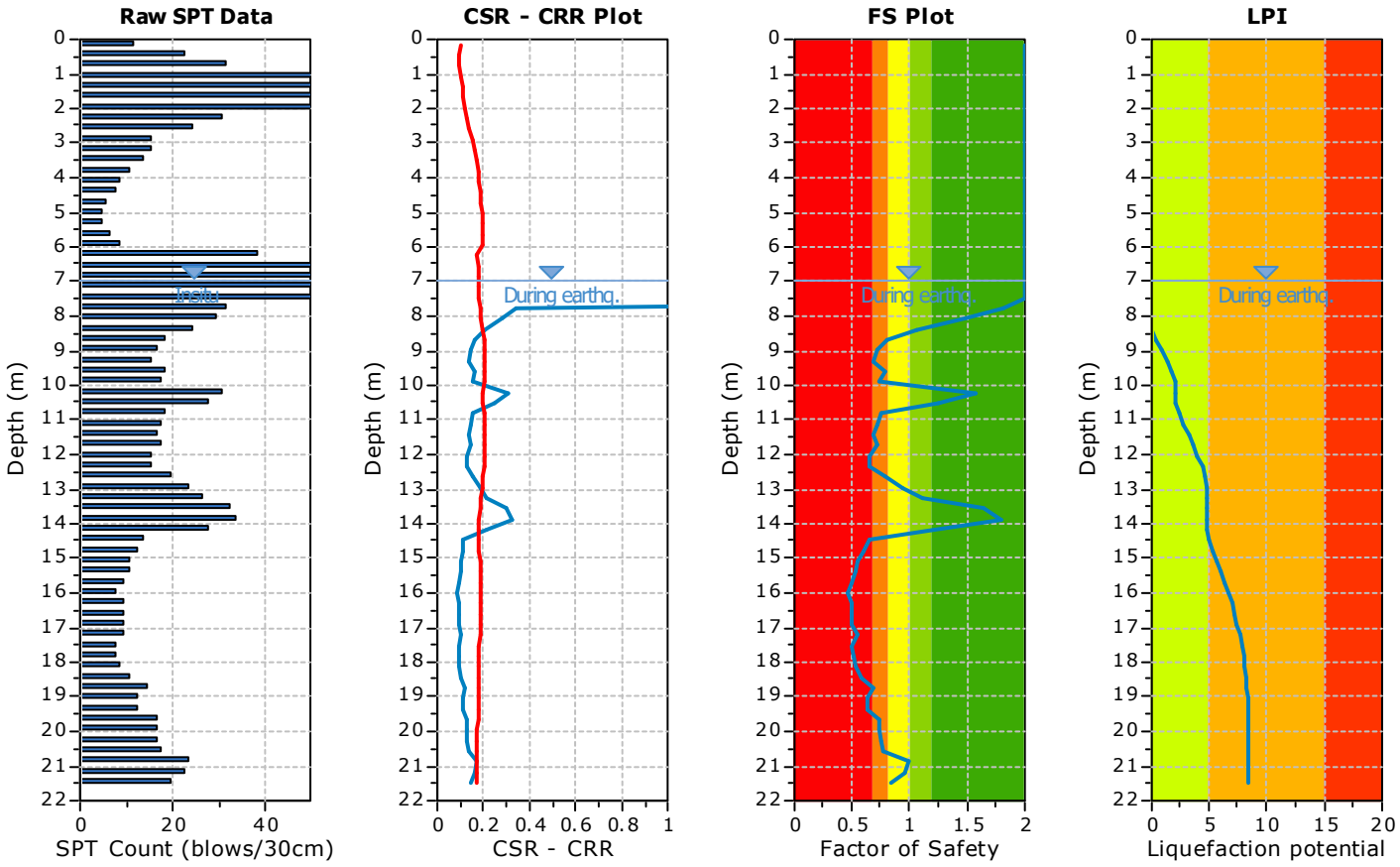
Project title : Eagle Viewing Area/Seaichem Dike

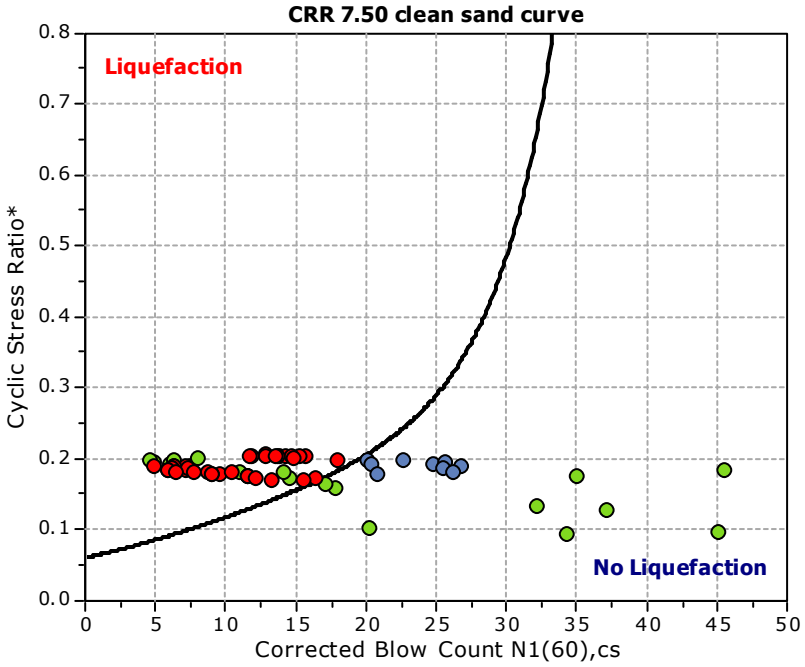
SPT Name: D2475 Inslab

Location : Squamish, BC TH19-1

:: Input parameters and analysis properties ::

Analysis method:	Boulanger & Idriss, 2014	G.W.T. (in-situ):	7.00 m
Fines correction method:	Boulanger & Idriss, 2014	G.W.T. (earthq.):	7.00 m
Sampling method:	Standard Sampler	Earthquake magnitude M_w:	7.00
Borehole diameter:	65mm to 115mm	Peak ground acceleration:	Custom
Rod length:	1.50 m	Eq. external load:	0.00 kPa
Hammer energy ratio:	1.00		





F.S. color scheme

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- Liquefaction and no liq. are equally likely
- Unlike to liquefy
- Almost certain it will not liquefy

LPI color scheme

- Very high risk
- High risk
- Low risk

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SPT BASED LIQUEFACTION ANALYSIS REPORT

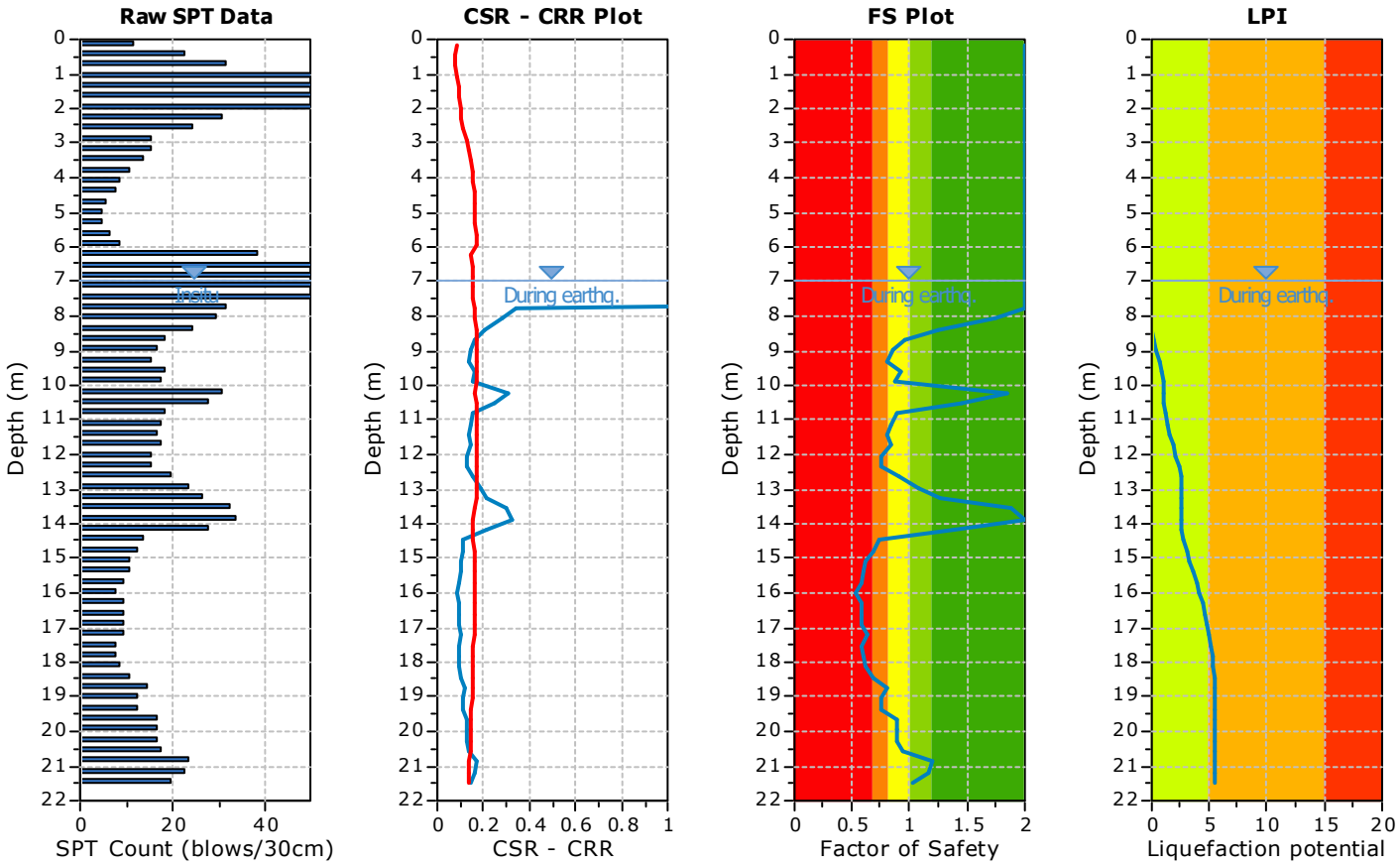
Project title : Eagle Viewing Area/Seaichem Dike

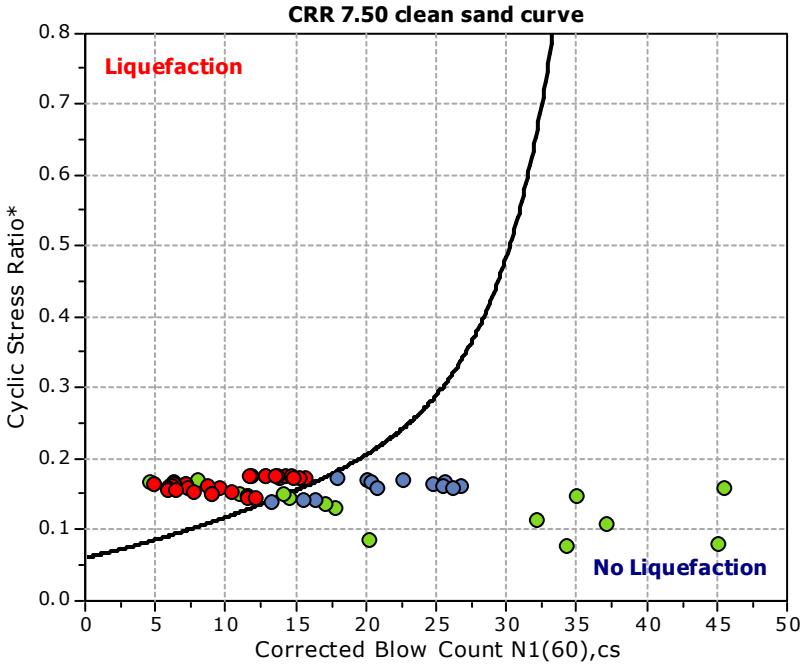
SPT Name: G2475 Subduction

Location : Squamish, BC TH19-1

:: Input parameters and analysis properties ::

Analysis method:	Boulanger & Idriss, 2014	G.W.T. (in-situ):	7.00 m
Fines correction method:	Boulanger & Idriss, 2014	G.W.T. (earthq.):	7.00 m
Sampling method:	Standard Sampler	Earthquake magnitude M_w:	7.00
Borehole diameter:	65mm to 115mm	Peak ground acceleration:	Custom
Rod length:	1.50 m	Eq. external load:	0.00 kPa
Hammer energy ratio:	1.00		





F.S. color scheme

- Almost certain it will liquefy
- Very likely to liquefy
- Liquefaction and no liq. are equally likely
- Unlike to liquefy
- Almost certain it will not liquefy

LPI color scheme

- Very high risk
- High risk
- Low risk

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SPT BASED LIQUEFACTION ANALYSIS REPORT

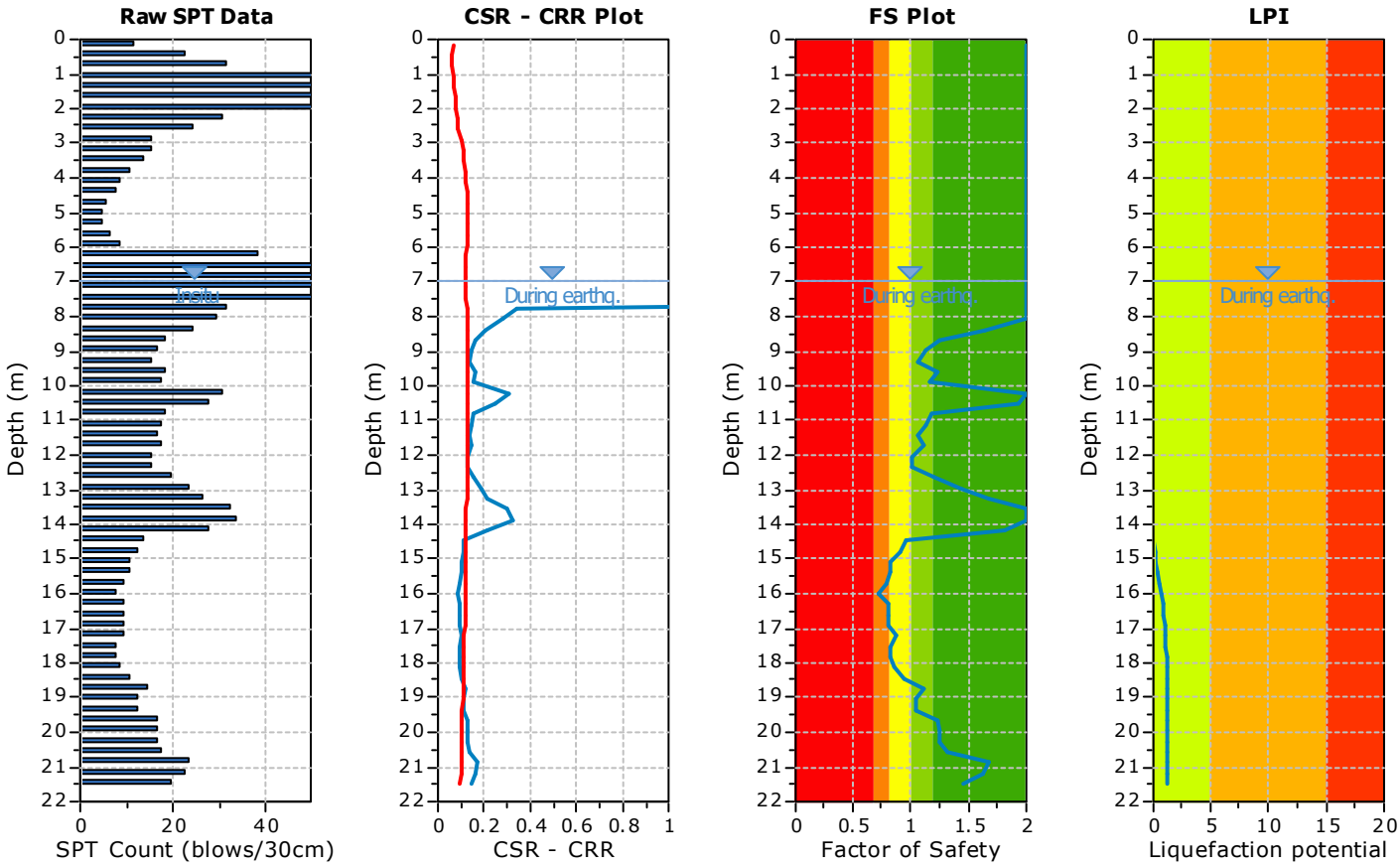
Project title : Eagle Viewing Area/Seaichem Dike

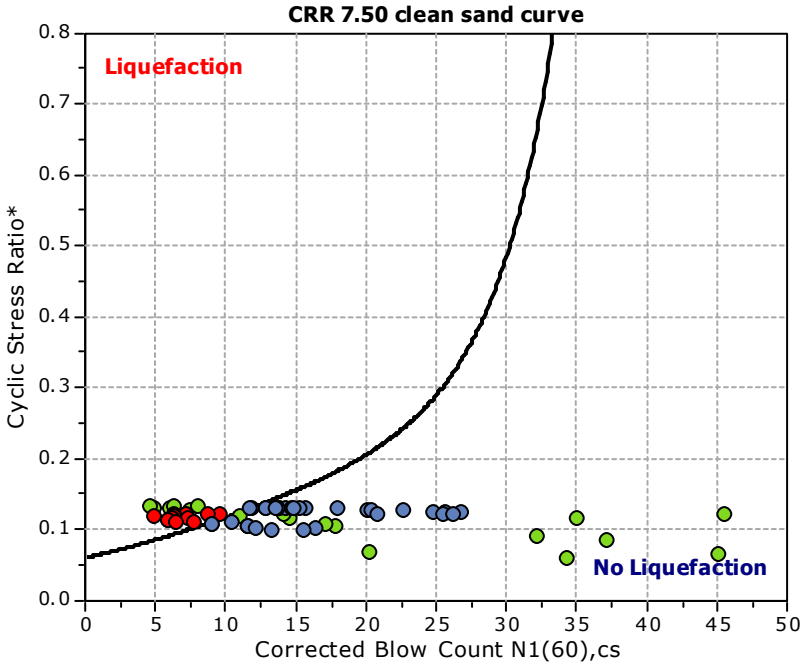
SPT Name: A475 Crustal

Location : Squamish, BC TH19-1

:: Input parameters and analysis properties ::

Analysis method:	Boulanger & Idriss, 2014	G.W.T. (in-situ):	7.00 m
Fines correction method:	Boulanger & Idriss, 2014	G.W.T. (earthq.):	7.00 m
Sampling method:	Standard Sampler	Earthquake magnitude M_w:	7.00
Borehole diameter:	65mm to 115mm	Peak ground acceleration:	Custom
Rod length:	1.50 m	Eq. external load:	0.00 kPa
Hammer energy ratio:	1.00		





F.S. color scheme

- Almost certain it will liquefy
- Very likely to liquefy
- Liquefaction and no liq. are equally likely
- Unlike to liquefy
- Almost certain it will not liquefy

LPI color scheme

- Very high risk
- High risk
- Low risk

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SPT BASED LIQUEFACTION ANALYSIS REPORT

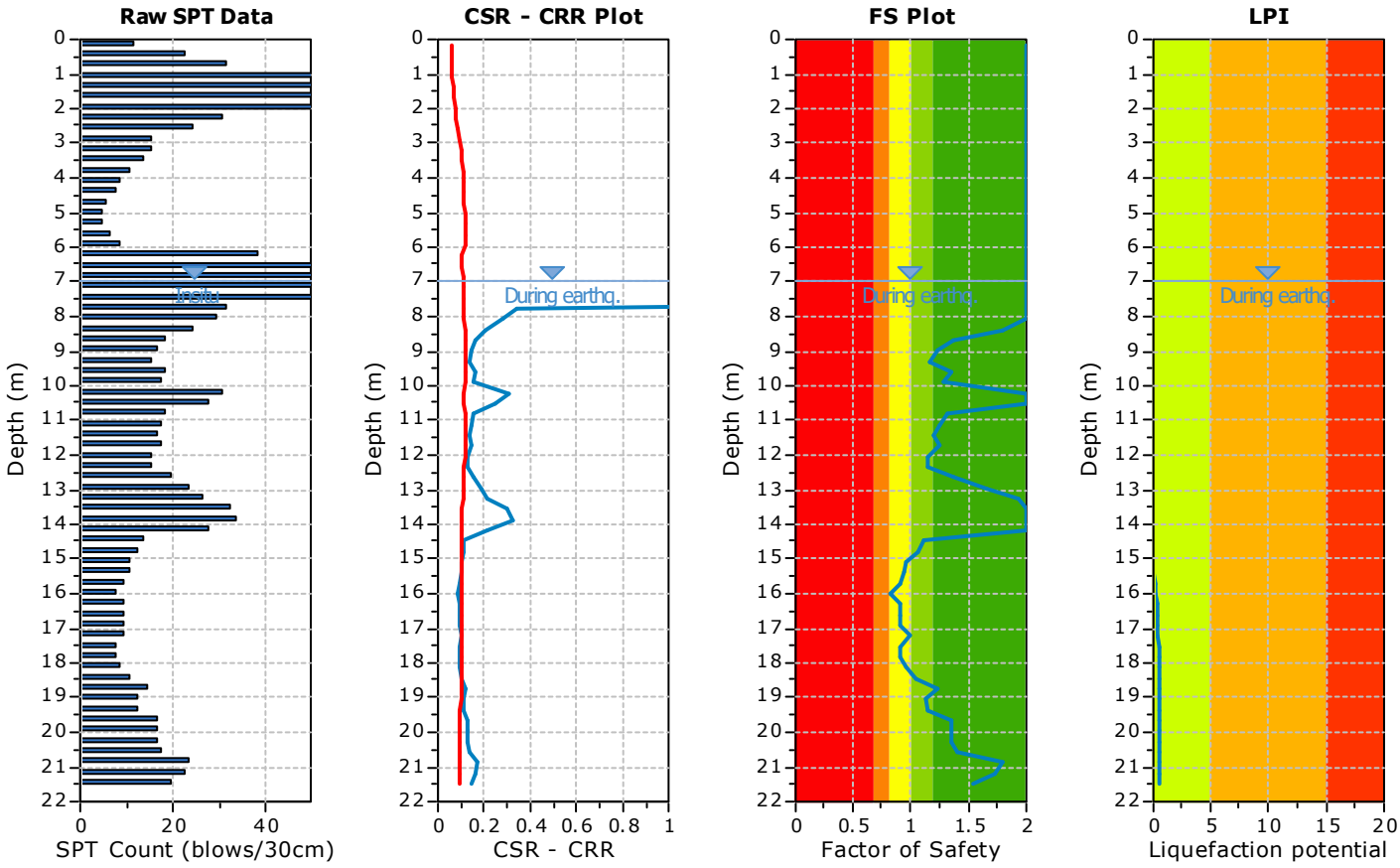
Project title : Eagle Viewing Area/Seaichem Dike

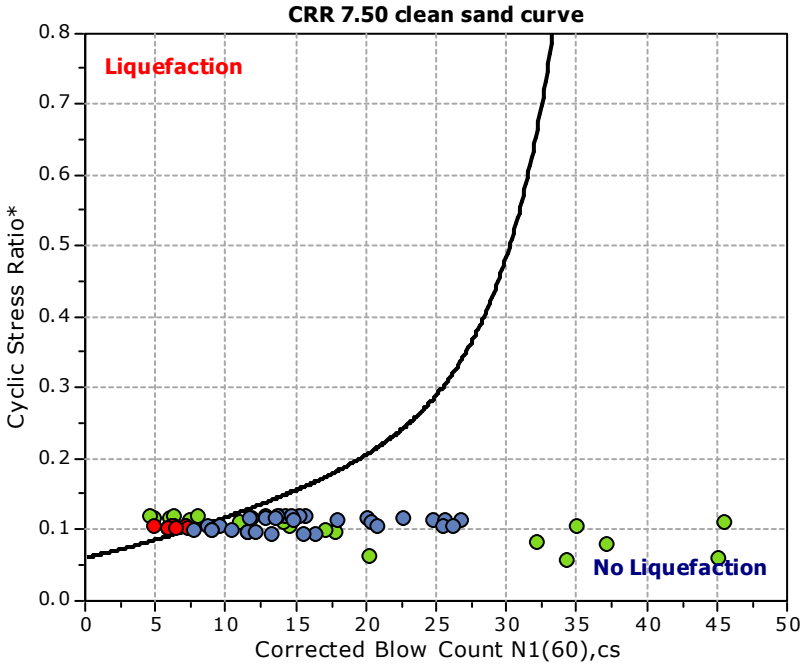
SPT Name: D475 Inslab

Location : Squamish, BC TH19-1

:: Input parameters and analysis properties ::

Analysis method:	Boulanger & Idriss, 2014	G.W.T. (in-situ):	7.00 m
Fines correction method:	Boulanger & Idriss, 2014	G.W.T. (earthq.):	7.00 m
Sampling method:	Standard Sampler	Earthquake magnitude M_w:	7.00
Borehole diameter:	65mm to 115mm	Peak ground acceleration:	Custom
Rod length:	1.50 m	Eq. external load:	0.00 kPa
Hammer energy ratio:	1.00		





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LPI color scheme

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- High risk
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SPT BASED LIQUEFACTION ANALYSIS REPORT

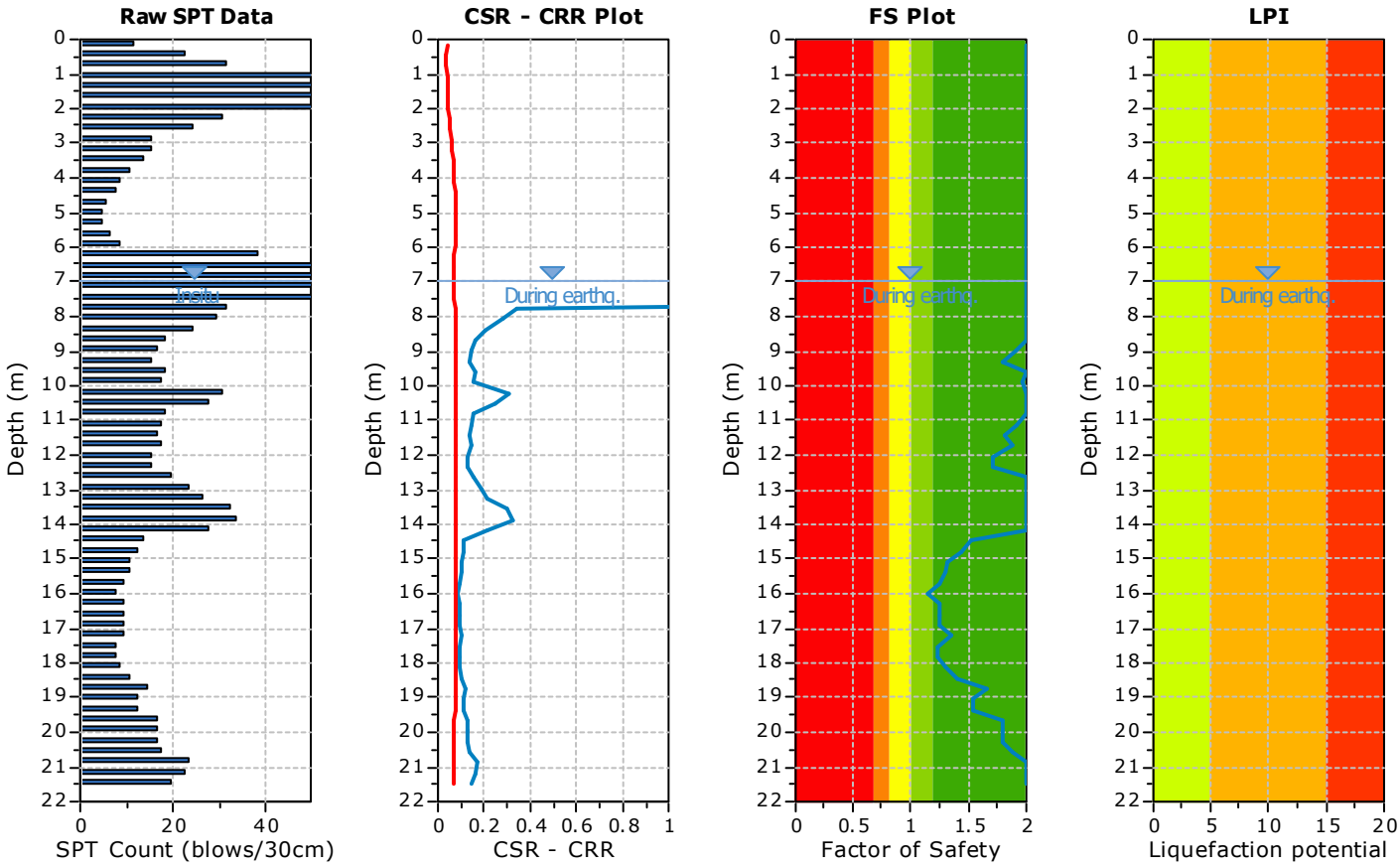
Project title : Eagle Viewing Area/Seaichem Dike

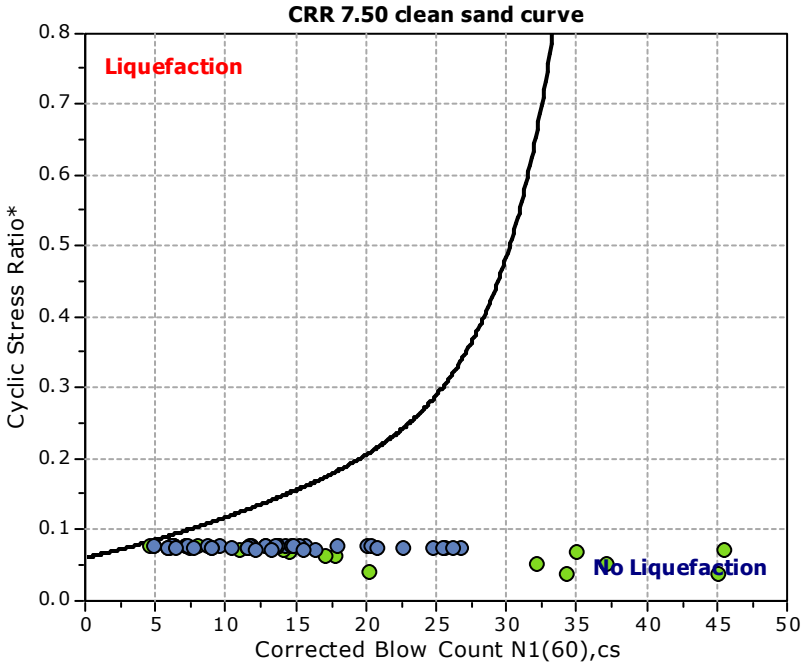
SPT Name: G475 Subduction

Location : Squamish, BC TH19-1

:: Input parameters and analysis properties ::

Analysis method:	Boulanger & Idriss, 2014	G.W.T. (in-situ):	7.00 m
Fines correction method:	Boulanger & Idriss, 2014	G.W.T. (earthq.):	7.00 m
Sampling method:	Standard Sampler	Earthquake magnitude M_w:	7.00
Borehole diameter:	65mm to 115mm	Peak ground acceleration:	Custom
Rod length:	1.50 m	Eq. external load:	0.00 kPa
Hammer energy ratio:	1.00		





F.S. color scheme

- Almost certain it will liquefy
- Very likely to liquefy
- Liquefaction and no liq. are equally likely
- Unlike to liquefy
- Almost certain it will not liquefy

LPI color scheme

- Very high risk
- High risk
- Low risk

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SPT BASED LIQUEFACTION ANALYSIS REPORT

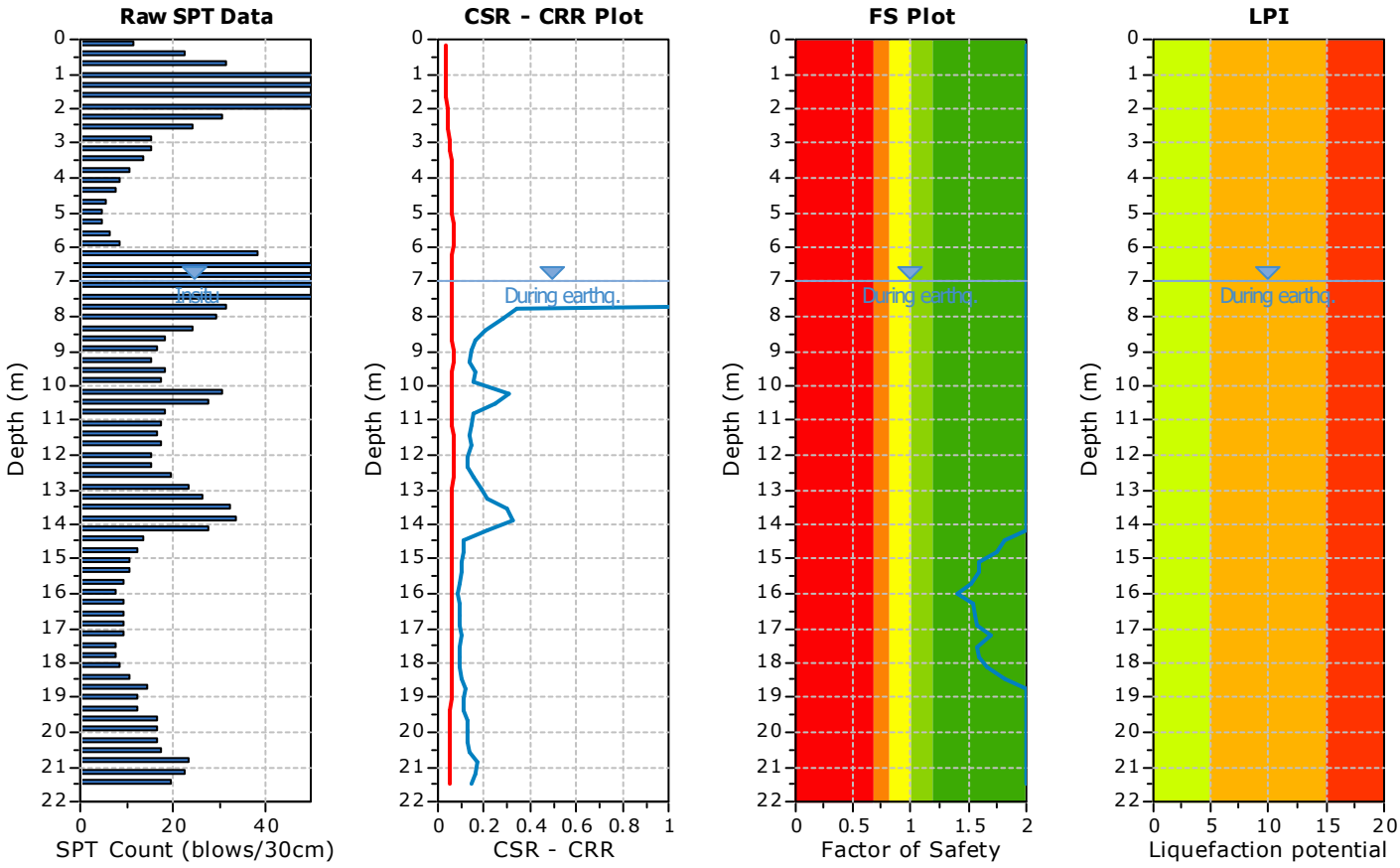
Project title : Eagle Viewing Area/Seaichem Dike

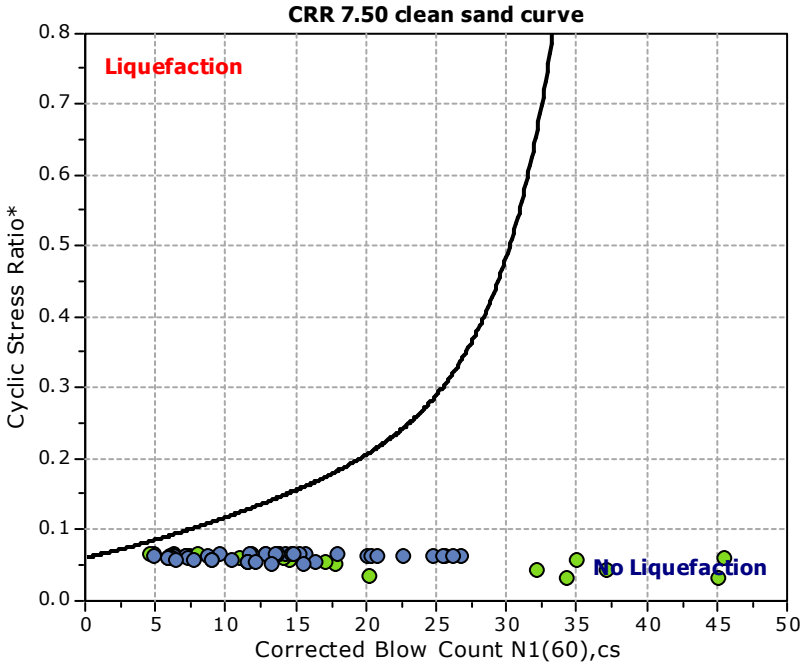
SPT Name: A100 Crustal

Location : Squamish, BC TH19-1

:: Input parameters and analysis properties ::

Analysis method:	Boulanger & Idriss, 2014	G.W.T. (in-situ):	7.00 m
Fines correction method:	Boulanger & Idriss, 2014	G.W.T. (earthq.):	7.00 m
Sampling method:	Standard Sampler	Earthquake magnitude M_w:	7.00
Borehole diameter:	65mm to 115mm	Peak ground acceleration:	Custom
Rod length:	1.50 m	Eq. external load:	0.00 kPa
Hammer energy ratio:	1.00		





F.S. color scheme

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LPI color scheme

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SPT BASED LIQUEFACTION ANALYSIS REPORT

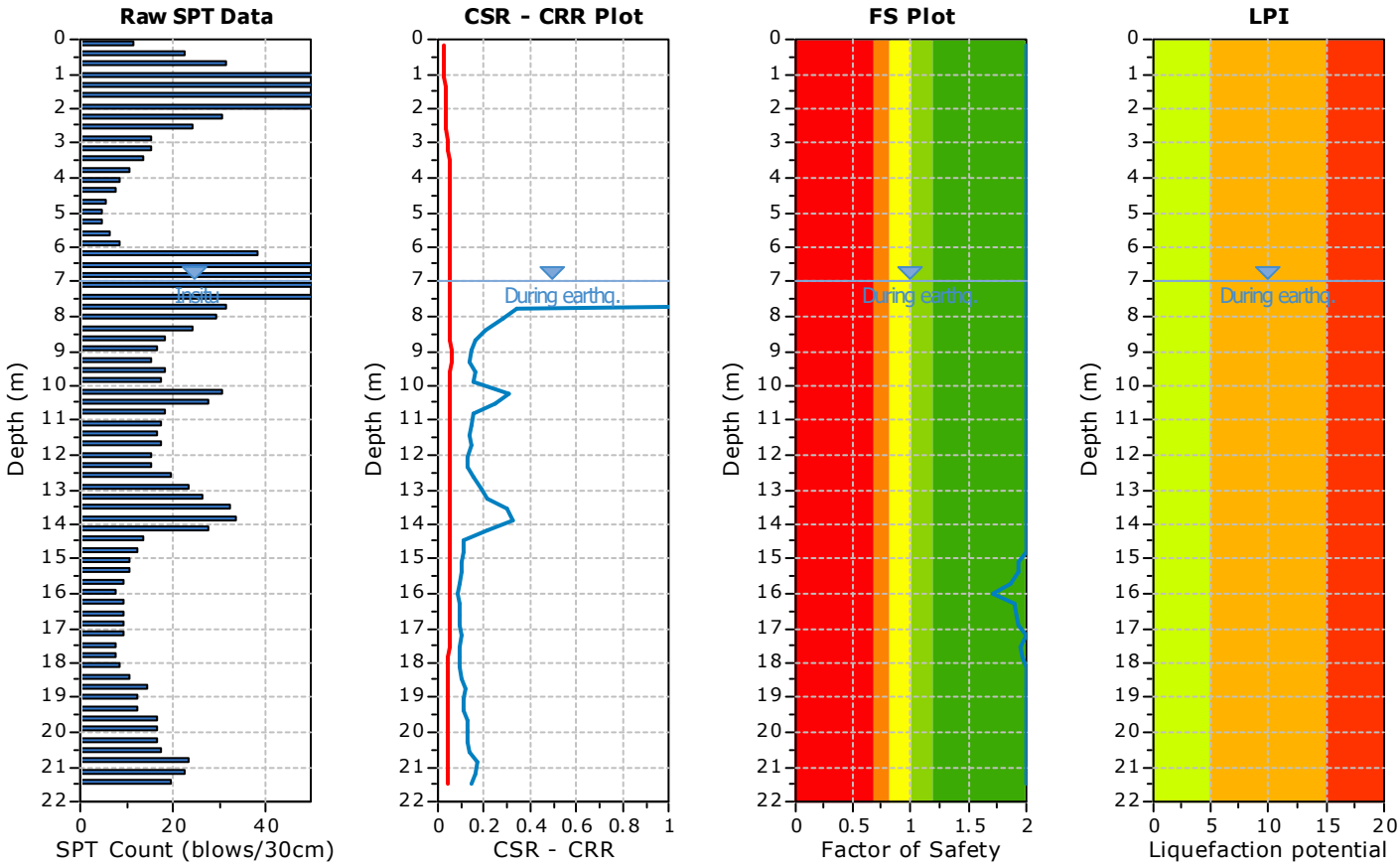
Project title : Eagle Viewing Area/Seaichem Dike

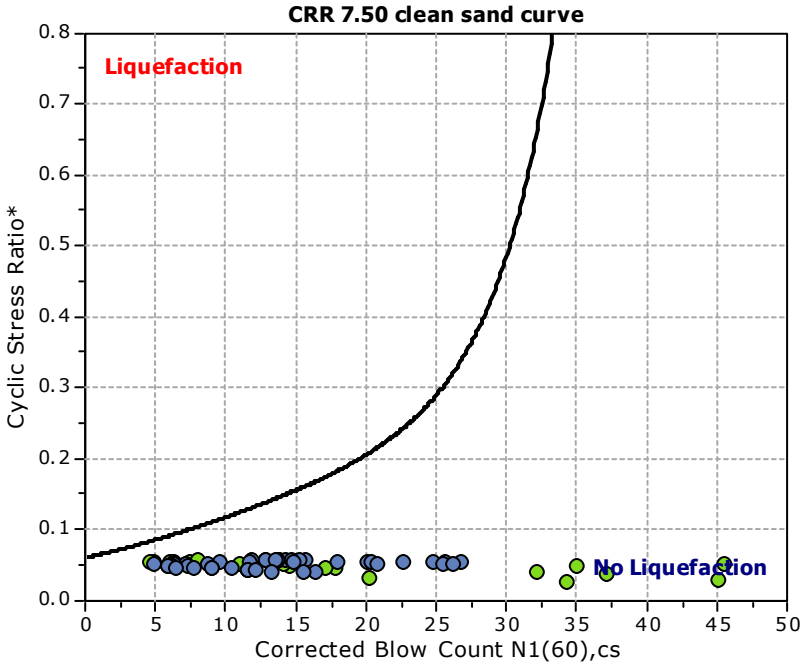
SPT Name: D100 Inslab

Location : Squamish, BC TH19-1

:: Input parameters and analysis properties ::

Analysis method:	Boulanger & Idriss, 2014	G.W.T. (in-situ):	7.00 m
Fines correction method:	Boulanger & Idriss, 2014	G.W.T. (earthq.):	7.00 m
Sampling method:	Standard Sampler	Earthquake magnitude M_w:	7.00
Borehole diameter:	65mm to 115mm	Peak ground acceleration:	Custom
Rod length:	1.50 m	Eq. external load:	0.00 kPa
Hammer energy ratio:	1.00		





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LPI color scheme

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SPT BASED LIQUEFACTION ANALYSIS REPORT

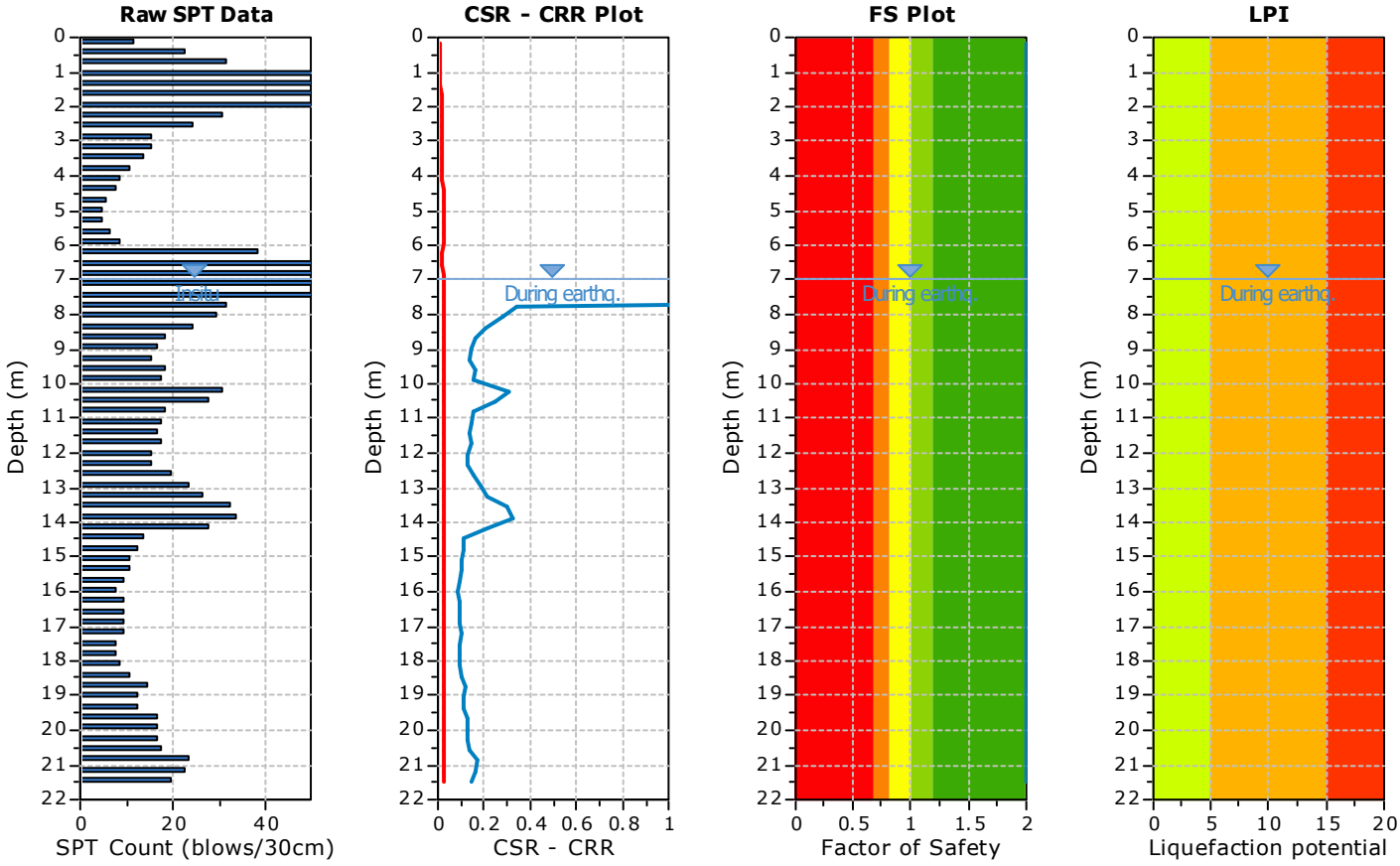
Project title : Eagle Viewing Area/Seaichem Dike

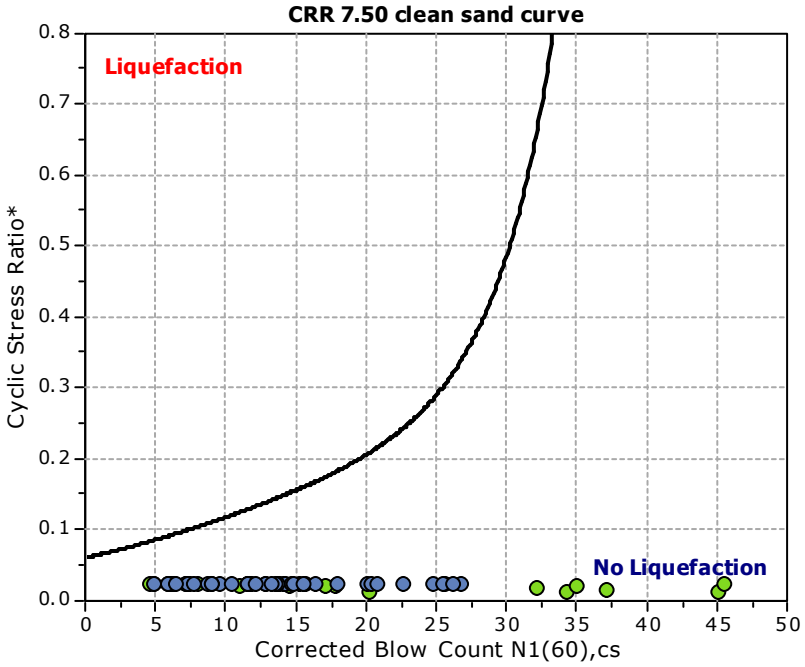
SPT Name: G100 Subduction

Location : Squamish, BC TH19-1

:: Input parameters and analysis properties ::

Analysis method:	Boulanger & Idriss, 2014	G.W.T. (in-situ):	7.00 m
Fines correction method:	Boulanger & Idriss, 2014	G.W.T. (earthq.):	7.00 m
Sampling method:	Standard Sampler	Earthquake magnitude M_w:	7.00
Borehole diameter:	65mm to 115mm	Peak ground acceleration:	Custom
Rod length:	1.50 m	Eq. external load:	0.00 kPa
Hammer energy ratio:	1.00		





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LPI color scheme

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- High risk
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SPT BASED LIQUEFACTION ANALYSIS REPORT

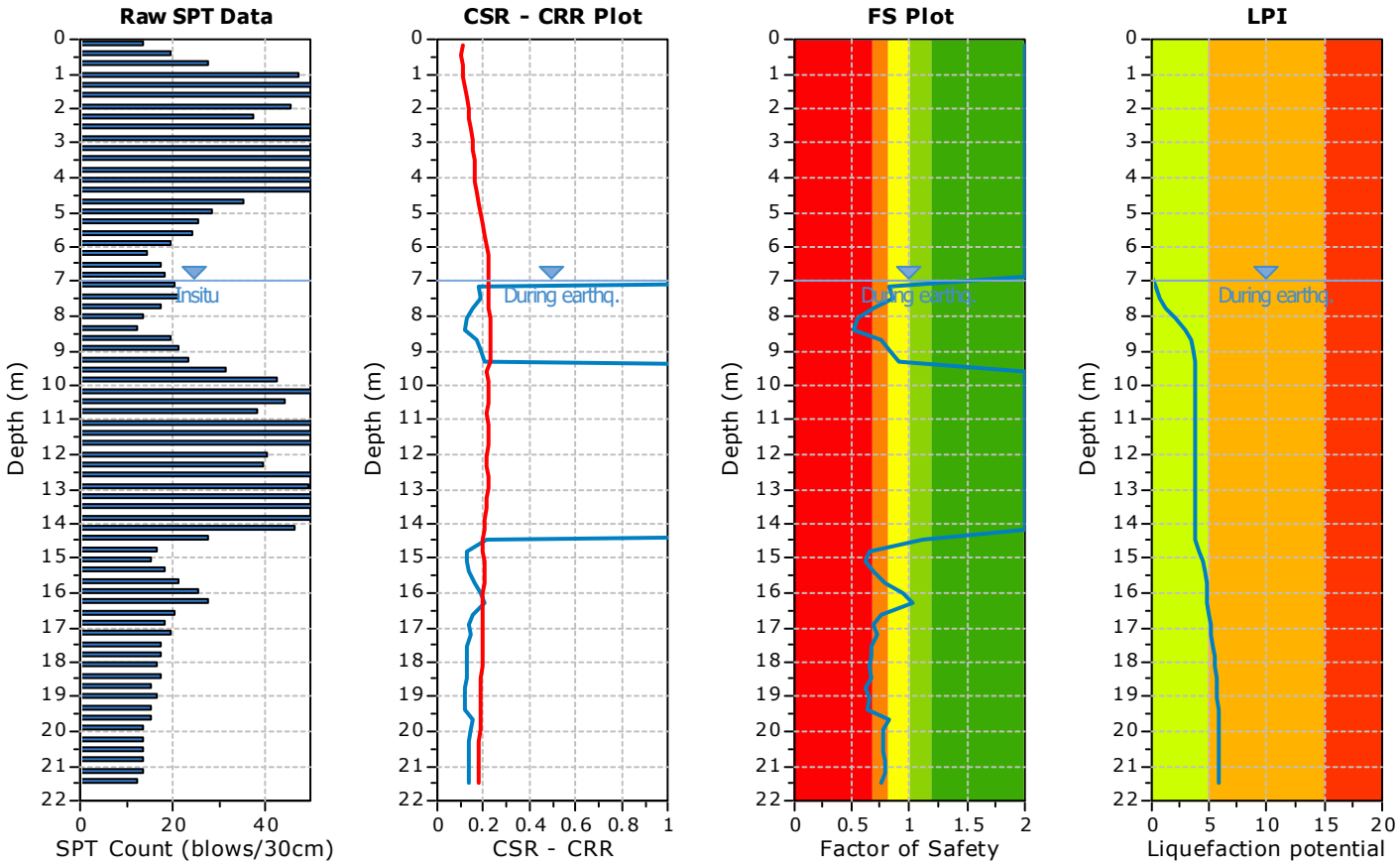
Project title : Eagle Viewing Area/Seaichem Dike

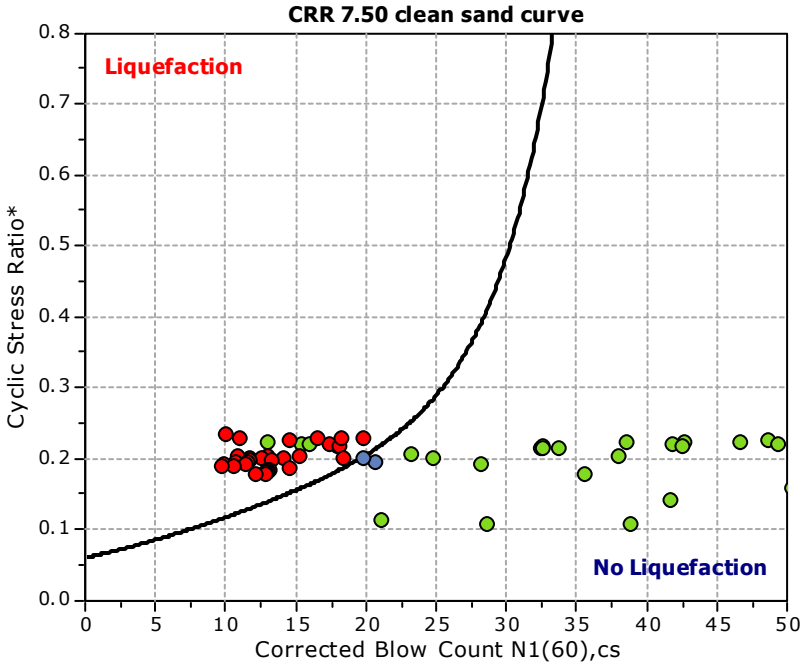
SPT Name: A2475 Crustal

Location : Squamish, BC TH19-2

:: Input parameters and analysis properties ::

Analysis method:	Boulanger & Idriss, 2014	G.W.T. (in-situ):	7.00 m
Fines correction method:	Boulanger & Idriss, 2014	G.W.T. (earthq.):	7.00 m
Sampling method:	Standard Sampler	Earthquake magnitude M_w:	7.00
Borehole diameter:	65mm to 115mm	Peak ground acceleration:	Custom
Rod length:	1.50 m	Eq. external load:	0.00 kPa
Hammer energy ratio:	1.00		





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LPI color scheme

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- High risk
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SPT BASED LIQUEFACTION ANALYSIS REPORT

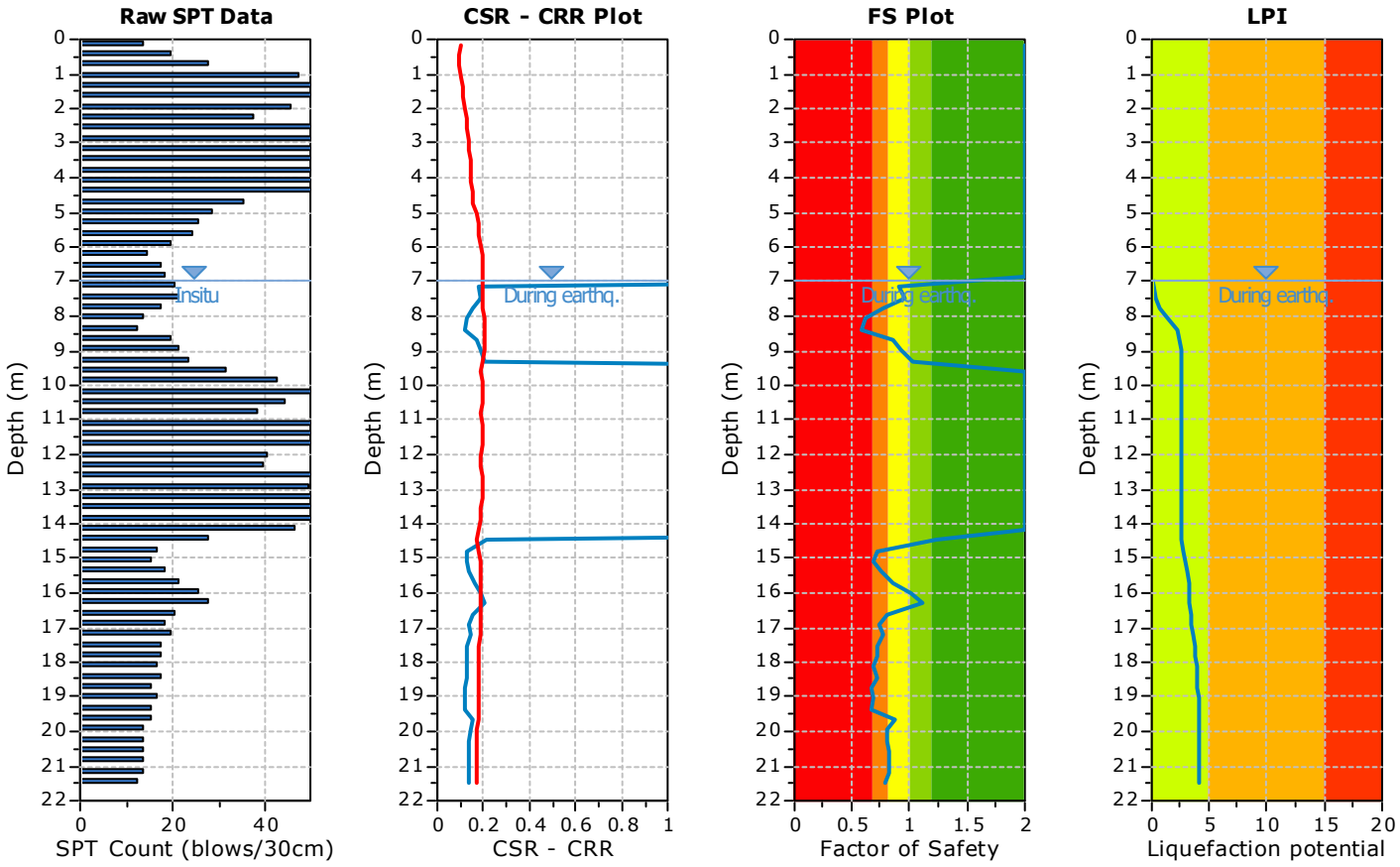
Project title : Eagle Viewing Area/Seaichem Dike

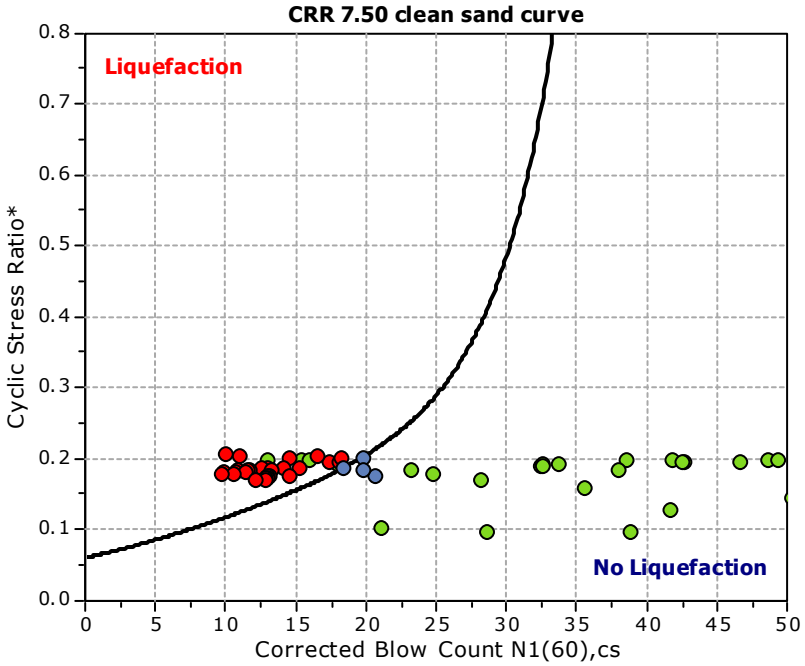
SPT Name: D2475 Inslab

Location : Squamish, BC TH19-2

:: Input parameters and analysis properties ::

Analysis method:	Boulanger & Idriss, 2014	G.W.T. (in-situ):	7.00 m
Fines correction method:	Boulanger & Idriss, 2014	G.W.T. (earthq.):	7.00 m
Sampling method:	Standard Sampler	Earthquake magnitude M_w:	7.00
Borehole diameter:	65mm to 115mm	Peak ground acceleration:	Custom
Rod length:	1.50 m	Eq. external load:	0.00 kPa
Hammer energy ratio:	1.00		





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SPT BASED LIQUEFACTION ANALYSIS REPORT

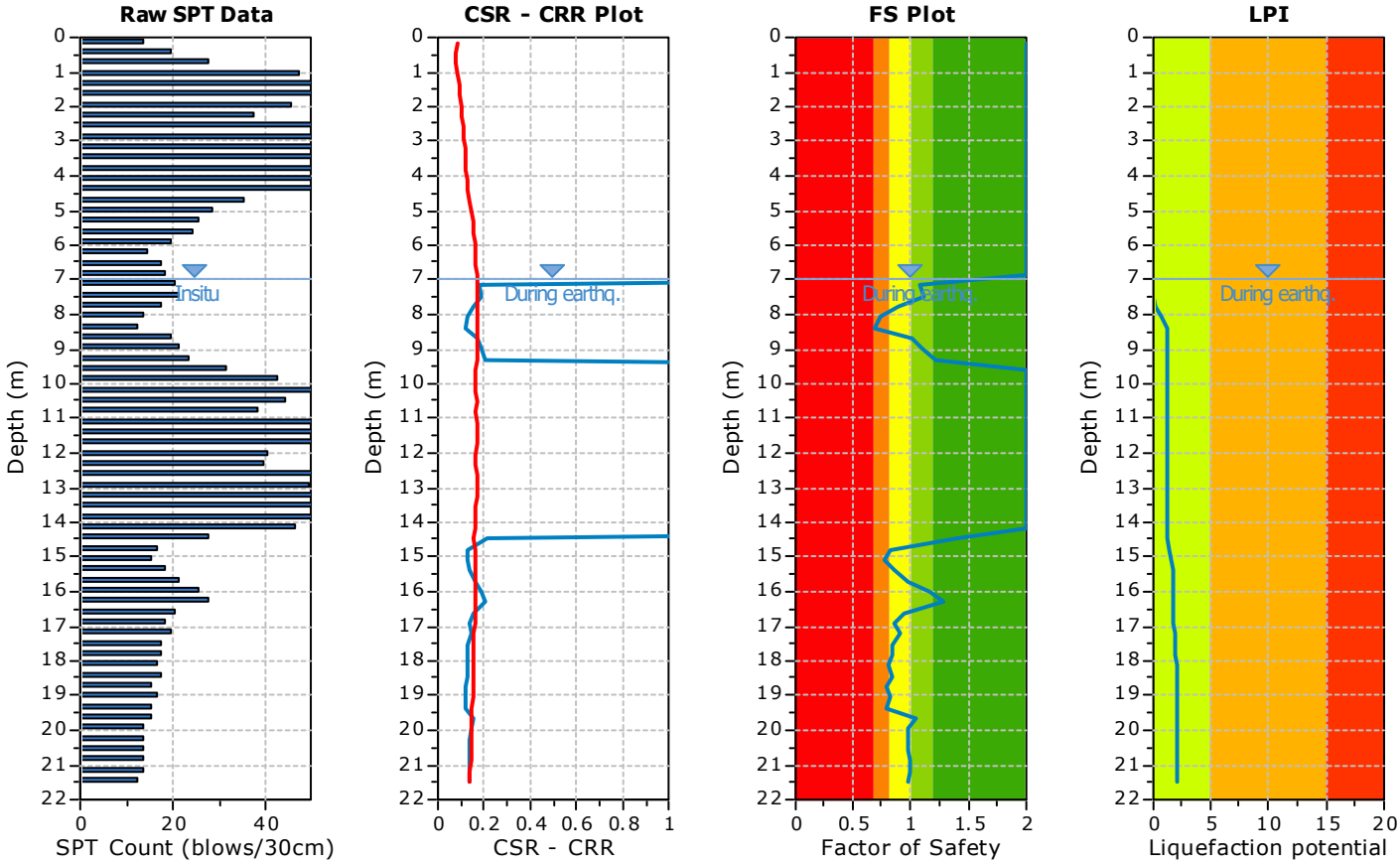
Project title : Eagle Viewing Area/Seaichem Dike

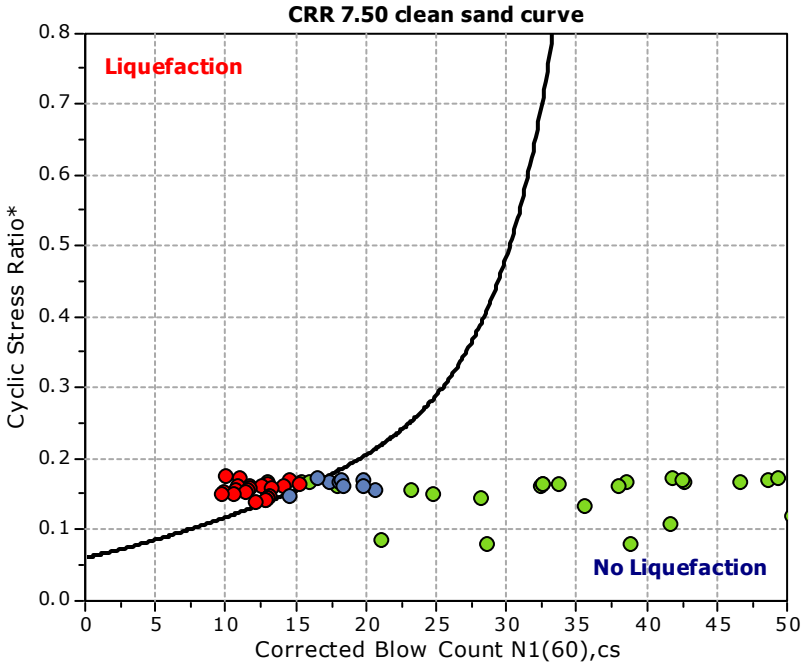
SPT Name: G2475 Subduction

Location : Squamish, BC TH19-2

:: Input parameters and analysis properties ::

Analysis method:	Boulanger & Idriss, 2014	G.W.T. (in-situ):	7.00 m
Fines correction method:	Boulanger & Idriss, 2014	G.W.T. (earthq.):	7.00 m
Sampling method:	Standard Sampler	Earthquake magnitude M_w:	7.00
Borehole diameter:	65mm to 115mm	Peak ground acceleration:	Custom
Rod length:	1.50 m	Eq. external load:	0.00 kPa
Hammer energy ratio:	1.00		





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- High risk
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SPT BASED LIQUEFACTION ANALYSIS REPORT

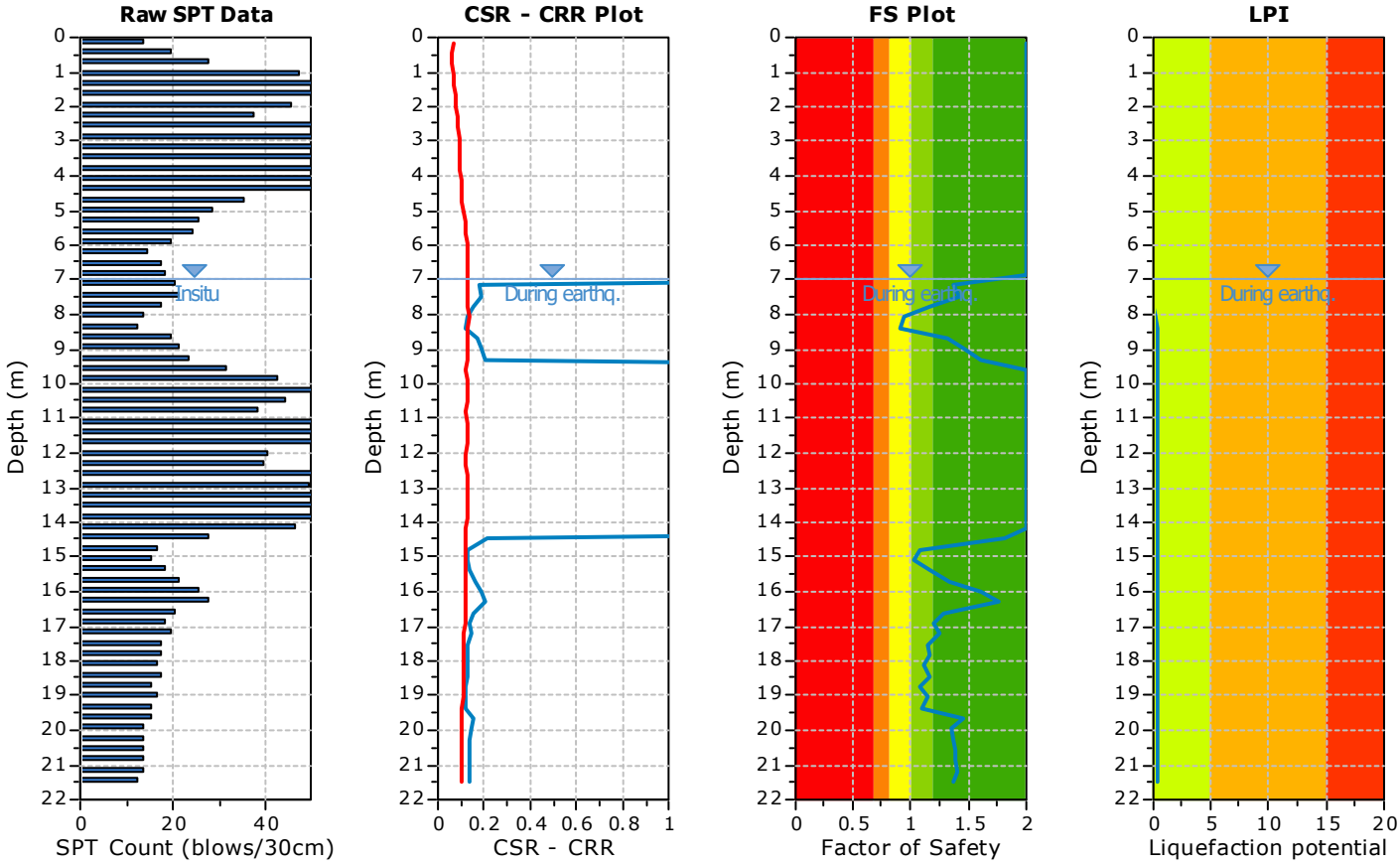
Project title : Eagle Viewing Area/Seaichem Dike

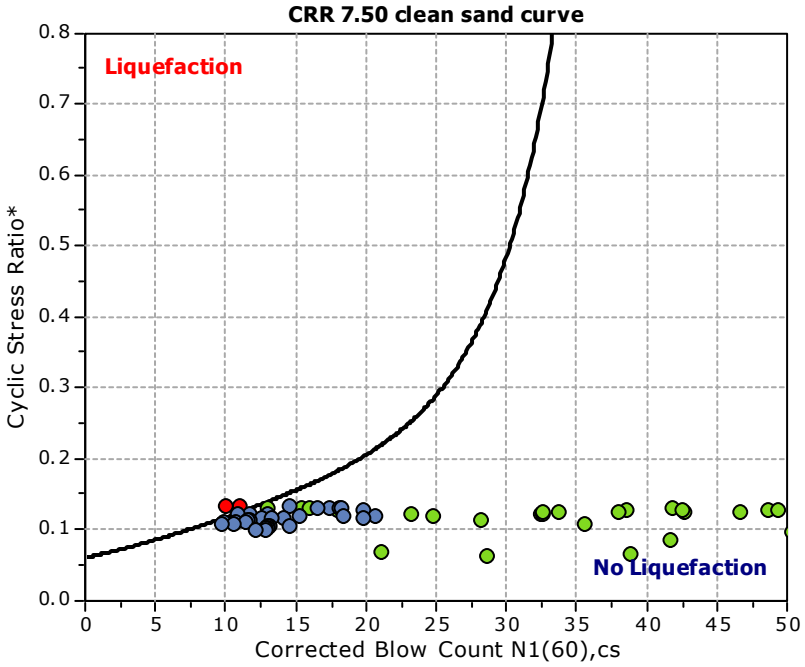
SPT Name: A475 Crustal

Location : Squamish, BC TH19-2

:: Input parameters and analysis properties ::

Analysis method:	Boulanger & Idriss, 2014	G.W.T. (in-situ):	7.00 m
Fines correction method:	Boulanger & Idriss, 2014	G.W.T. (earthq.):	7.00 m
Sampling method:	Standard Sampler	Earthquake magnitude M_w:	7.00
Borehole diameter:	65mm to 115mm	Peak ground acceleration:	Custom
Rod length:	1.50 m	Eq. external load:	0.00 kPa
Hammer energy ratio:	1.00		





F.S. color scheme

- Almost certain it will liquefy
- Very likely to liquefy
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- Almost certain it will not liquefy

LPI color scheme

- Very high risk
- High risk
- Low risk

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SPT BASED LIQUEFACTION ANALYSIS REPORT

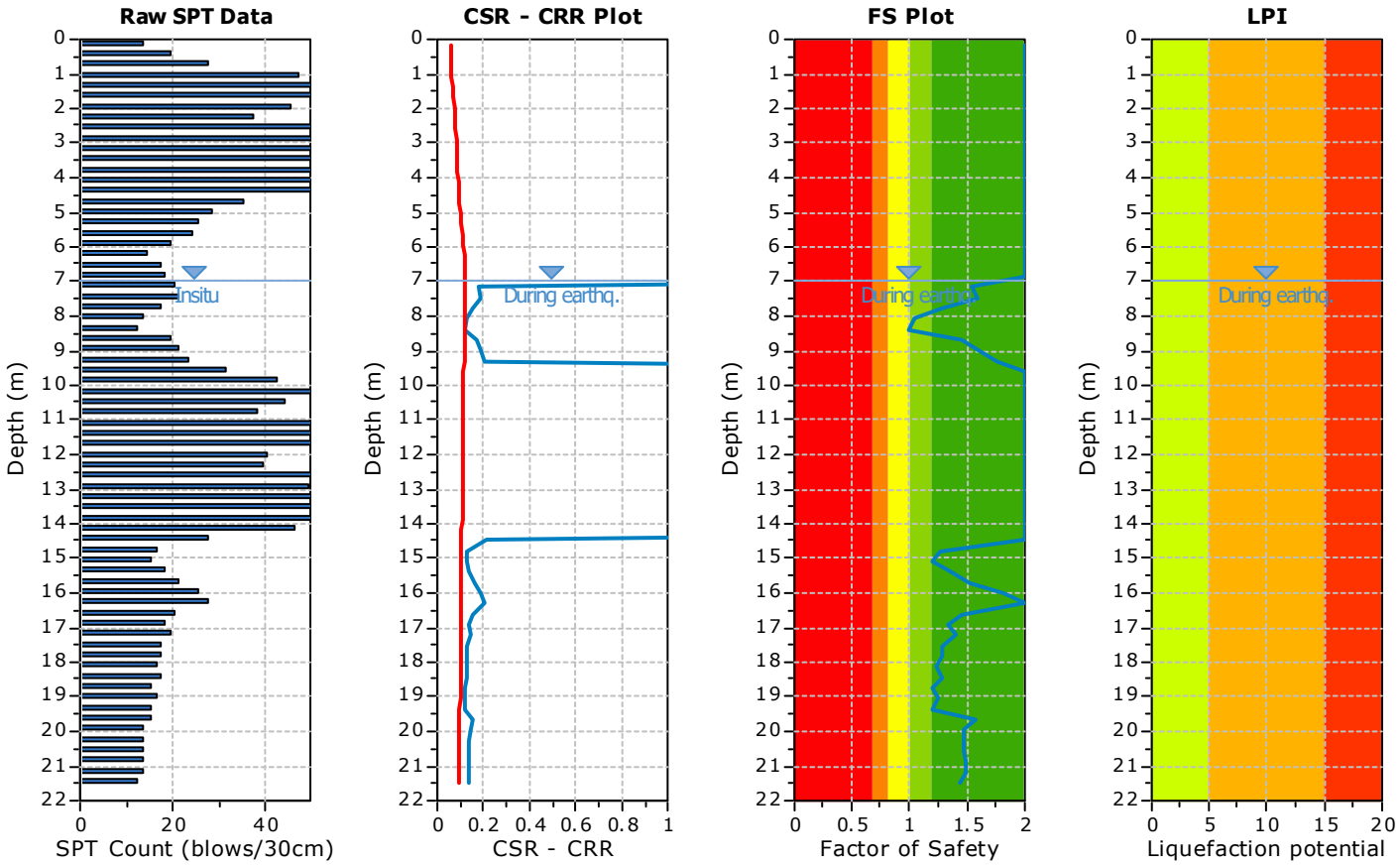
Project title : Eagle Viewing Area/Seaichem Dike

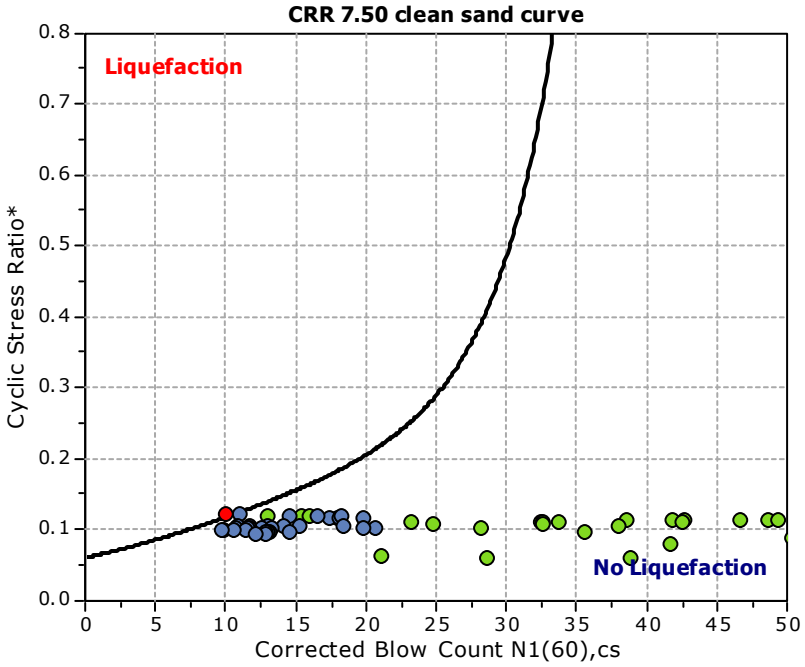
SPT Name: D475 Inslab

Location : Squamish, BC TH19-2

:: Input parameters and analysis properties ::

Analysis method:	Boulanger & Idriss, 2014	G.W.T. (in-situ):	7.00 m
Fines correction method:	Boulanger & Idriss, 2014	G.W.T. (earthq.):	7.00 m
Sampling method:	Standard Sampler	Earthquake magnitude M_w:	7.00
Borehole diameter:	65mm to 115mm	Peak ground acceleration:	Custom
Rod length:	1.50 m	Eq. external load:	0.00 kPa
Hammer energy ratio:	1.00		





F.S. color scheme

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LPI color scheme

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SPT BASED LIQUEFACTION ANALYSIS REPORT

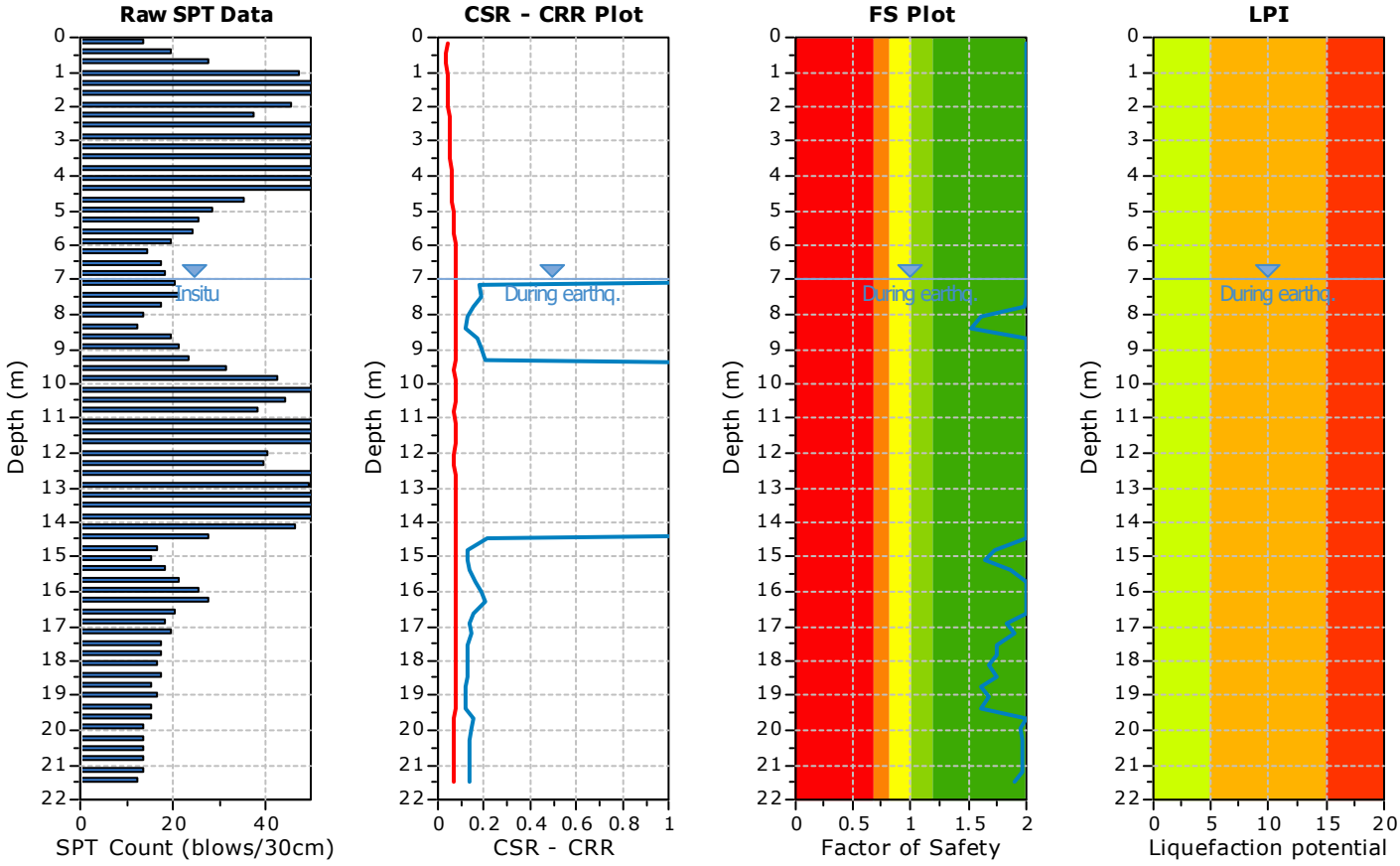
Project title : Eagle Viewing Area/Seaichem Dike

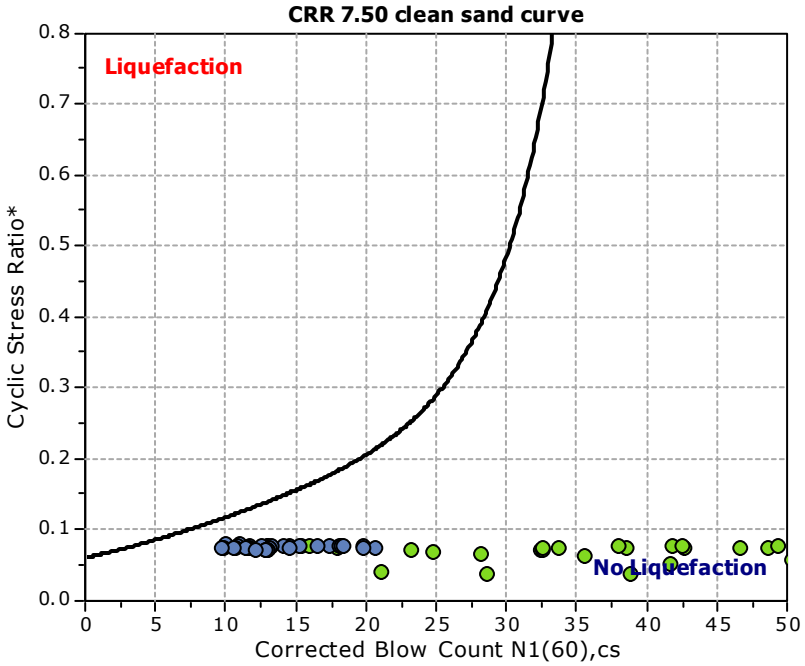
SPT Name: G475 Subduction

Location : Squamish, BC TH19-2

:: Input parameters and analysis properties ::

Analysis method:	Boulanger & Idriss, 2014	G.W.T. (in-situ):	7.00 m
Fines correction method:	Boulanger & Idriss, 2014	G.W.T. (earthq.):	7.00 m
Sampling method:	Standard Sampler	Earthquake magnitude M_w:	7.00
Borehole diameter:	65mm to 115mm	Peak ground acceleration:	Custom
Rod length:	1.50 m	Eq. external load:	0.00 kPa
Hammer energy ratio:	1.00		





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SPT BASED LIQUEFACTION ANALYSIS REPORT

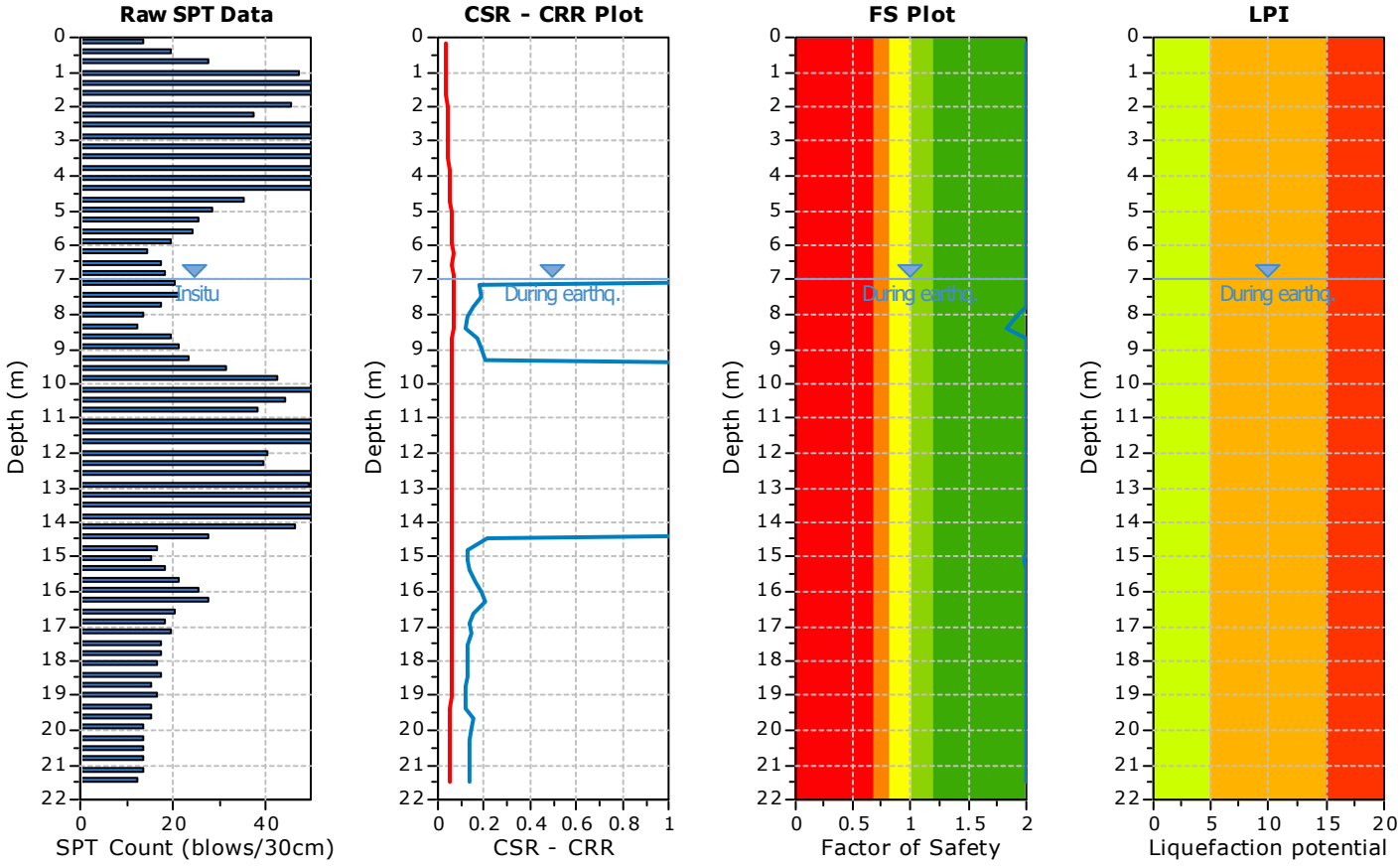
Project title : Eagle Viewing Area/Seaichem Dike

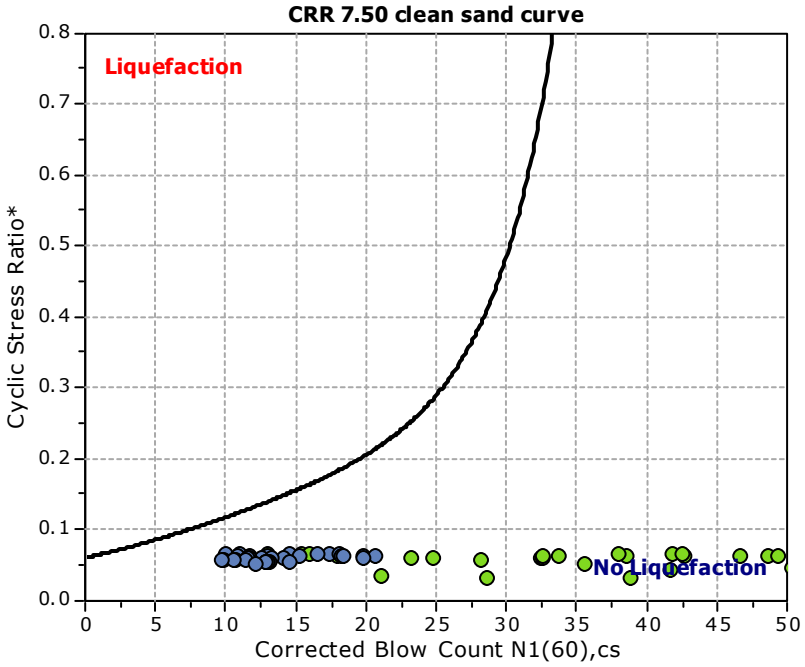
SPT Name: A100 Crustal

Location : Squamish, BC TH19-2

:: Input parameters and analysis properties ::

Analysis method:	Boulanger & Idriss, 2014	G.W.T. (in-situ):	7.00 m
Fines correction method:	Boulanger & Idriss, 2014	G.W.T. (earthq.):	7.00 m
Sampling method:	Standard Sampler	Earthquake magnitude M_w:	7.00
Borehole diameter:	65mm to 115mm	Peak ground acceleration:	Custom
Rod length:	1.50 m	Eq. external load:	0.00 kPa
Hammer energy ratio:	1.00		





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LPI color scheme

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- High risk
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SPT BASED LIQUEFACTION ANALYSIS REPORT

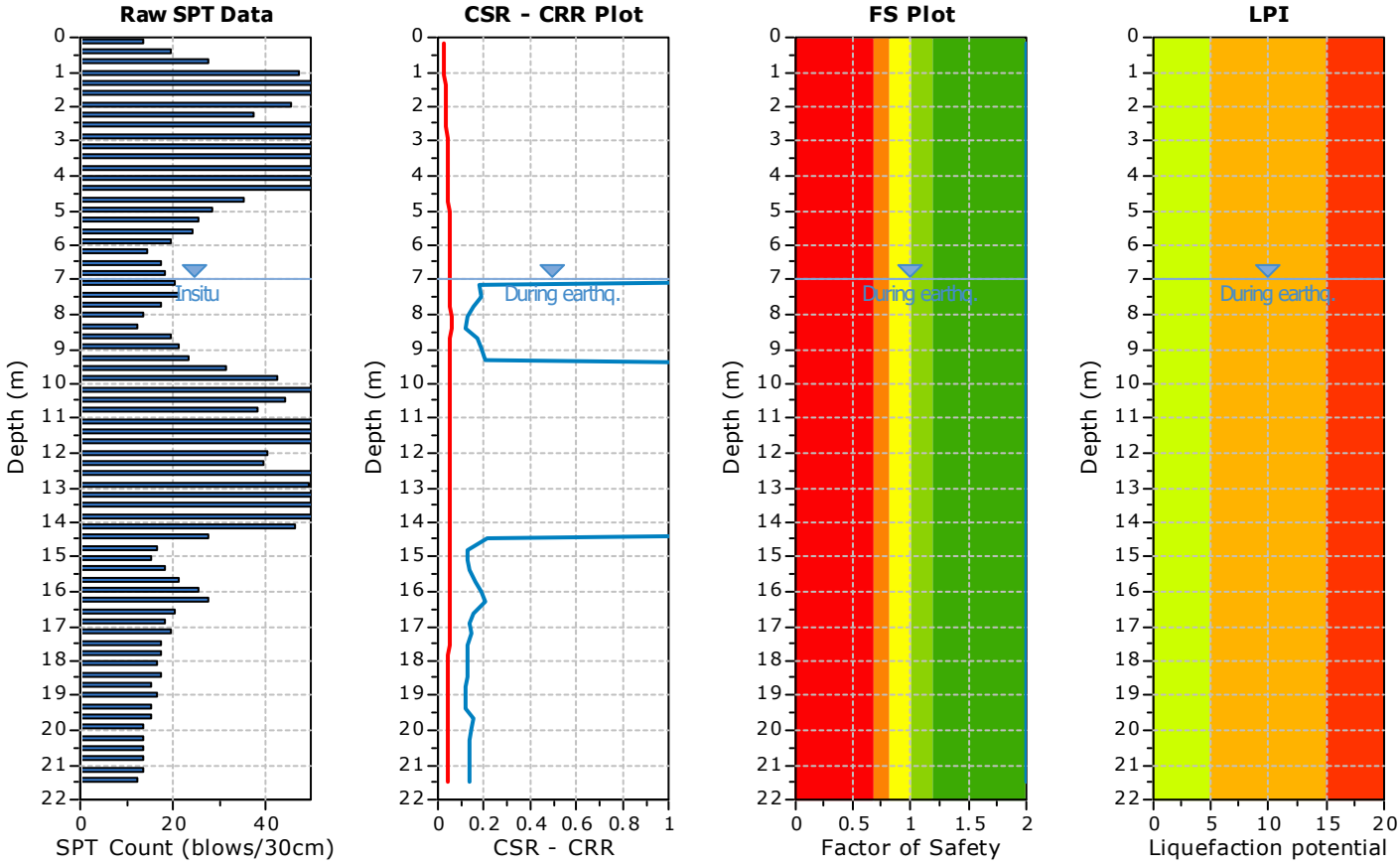
Project title : Eagle Viewing Area/Seaichem Dike

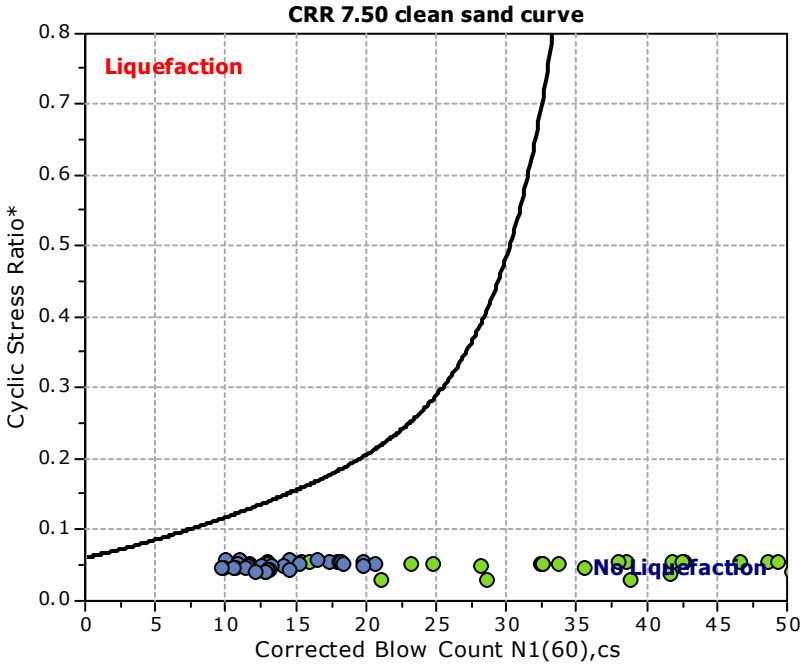
SPT Name: D100 Inslab

Location : Squamish, BC TH19-2

:: Input parameters and analysis properties ::

Analysis method:	Boulanger & Idriss, 2014	G.W.T. (in-situ):	7.00 m
Fines correction method:	Boulanger & Idriss, 2014	G.W.T. (earthq.):	7.00 m
Sampling method:	Standard Sampler	Earthquake magnitude M_w:	7.00
Borehole diameter:	65mm to 115mm	Peak ground acceleration:	Custom
Rod length:	1.50 m	Eq. external load:	0.00 kPa
Hammer energy ratio:	1.00		





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SPT BASED LIQUEFACTION ANALYSIS REPORT

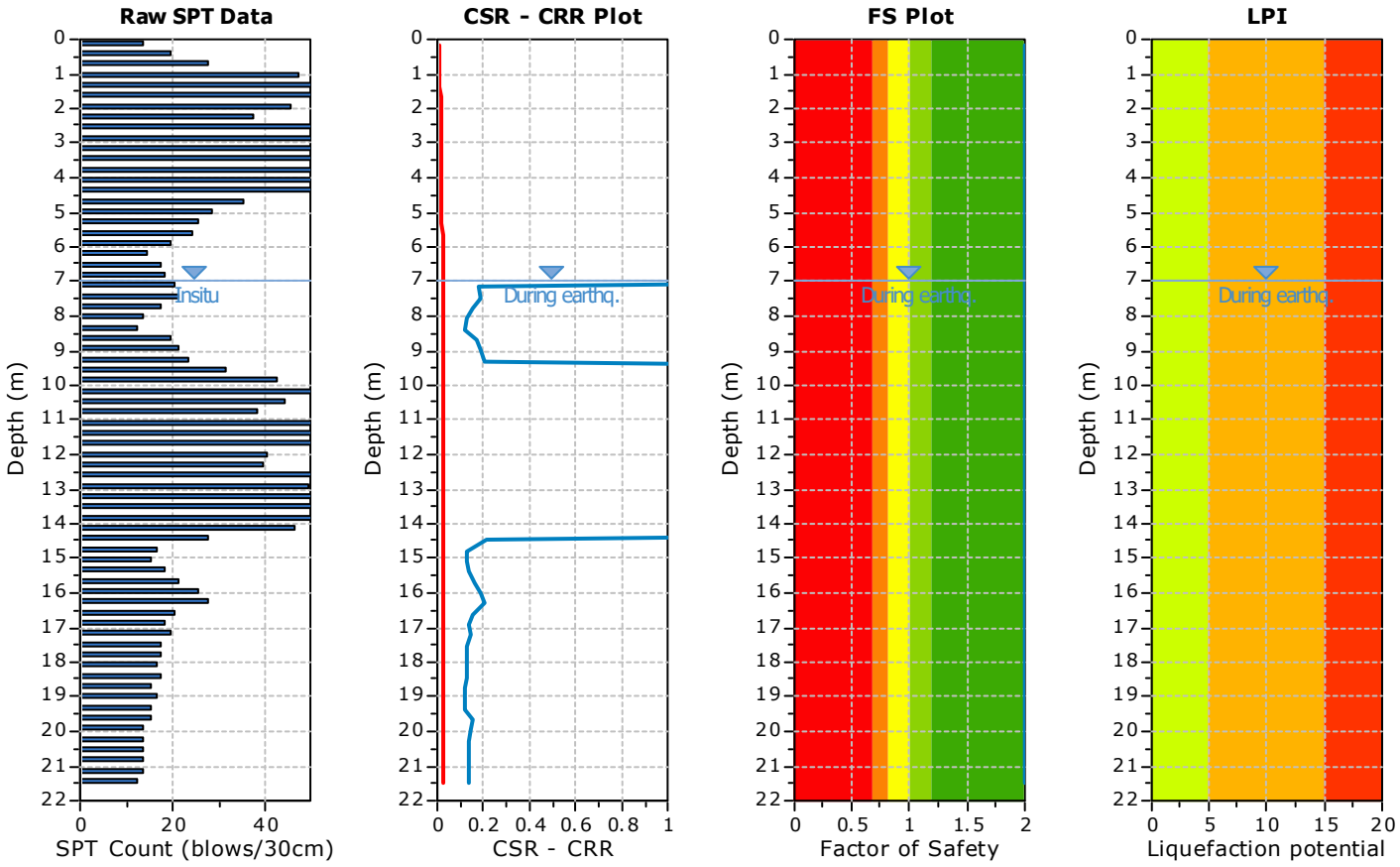
Project title : Eagle Viewing Area/Seaichem Dike

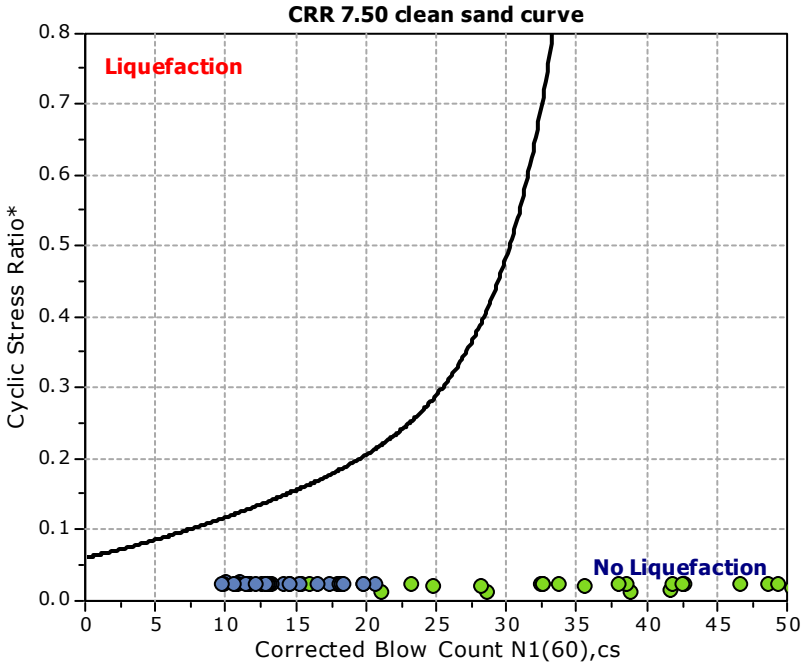
SPT Name: G100 Subduction

Location : Squamish, BC TH19-2

:: Input parameters and analysis properties ::

Analysis method:	Boulanger & Idriss, 2014	G.W.T. (in-situ):	7.00 m
Fines correction method:	Boulanger & Idriss, 2014	G.W.T. (earthq.):	7.00 m
Sampling method:	Standard Sampler	Earthquake magnitude M_w:	7.00
Borehole diameter:	65mm to 115mm	Peak ground acceleration:	Custom
Rod length:	1.50 m	Eq. external load:	0.00 kPa
Hammer energy ratio:	1.00		





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LPI color scheme

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THURBER

APPENDIX D

Figure 1: 0+300_1_Wall_LTR_Liquefied

Name: Existing Dike Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 35 °
Name: New Dike Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 35 °
Name: Sand and Gravel Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 35 °
Name: Sand Liquefied Model: S=f(overburden) Unit Weight: 19 kN/m³
Name: Silt Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 30 kPa Phi: 28 °
Name: Rip Rap Model: Mohr-Coulomb Unit Weight: 20 kN/m³ Cohesion: 0 kPa Phi: 50 °

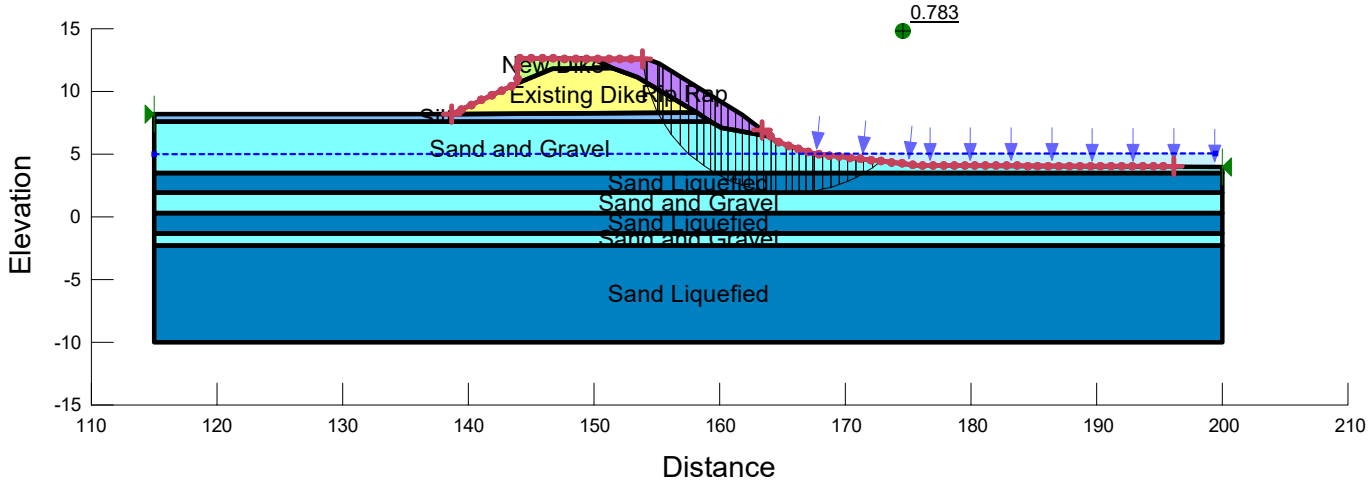

Figure 2: 0+300_1_Wall_RTL_Liquefied Horz Seismic Load: 0.19

Name: Existing Dike Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 35 °
Name: New Dike Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 35 °
Name: Sand and Gravel Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 35 °
Name: Sand Liquefied Model: S=f(overburden) Unit Weight: 19 kN/m³
Name: Silt Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 30 kPa Phi: 28 °
Name: Rip Rap Model: Mohr-Coulomb Unit Weight: 20 kN/m³ Cohesion: 0 kPa Phi: 50 °

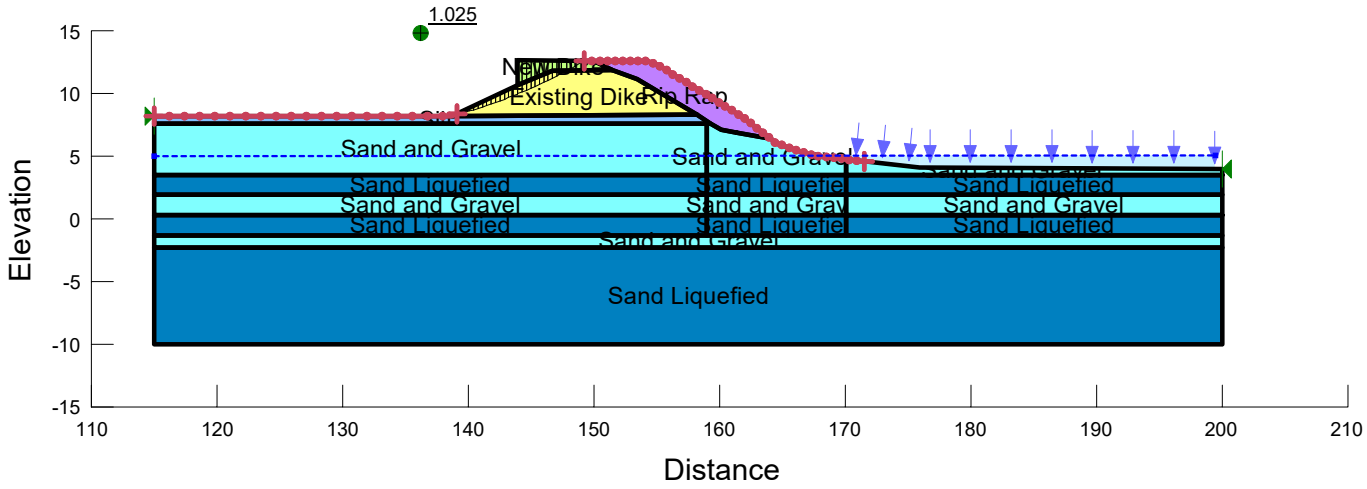

Figure 3: 0+300_2_Wide_LTR_Liquefied

Name: Existing Dike Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 35 °
Name: New Dike Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 35 °
Name: Sand and Gravel Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 35 °
Name: Sand Liquefied Model: S=f(overburden) Unit Weight: 19 kN/m³
Name: Silt Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 30 kPa Phi: 28 °
Name: Rip Rap Model: Mohr-Coulomb Unit Weight: 20 kN/m³ Cohesion: 0 kPa Phi: 50 °

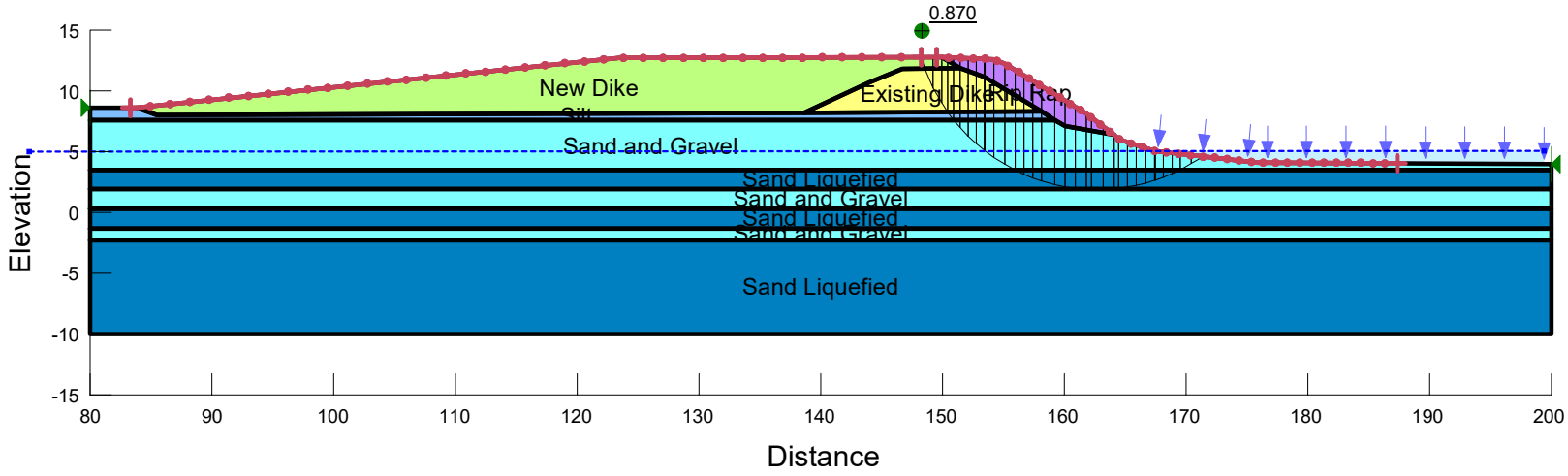

Figure 4: 0+300_2_Wide_RTL_Liquefied Horz Seismic Load: 0.19

Name: Existing Dike Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 35 °
Name: New Dike Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 35 °
Name: Sand and Gravel Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 35 °
Name: Sand Liquefied Model: S=f(overburden) Unit Weight: 19 kN/m³
Name: Silt Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 30 kPa Phi: 28 °
Name: Rip Rap Model: Mohr-Coulomb Unit Weight: 20 kN/m³ Cohesion: 0 kPa Phi: 50 °

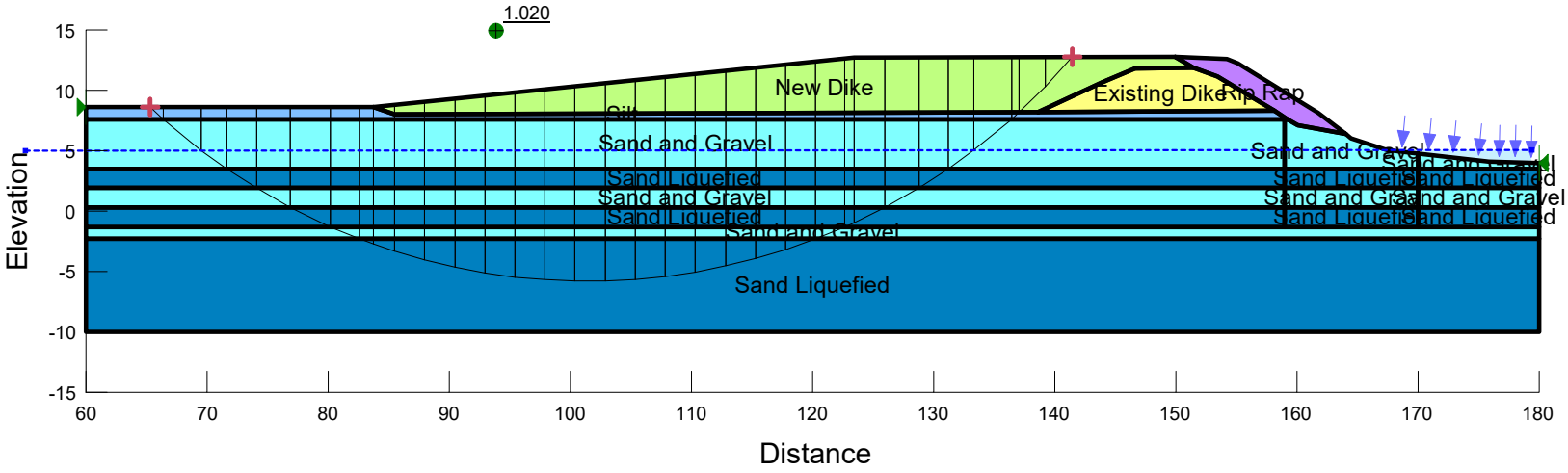

Figure 5: 0+300_3_Realign_LTR_Liquefied

Name: Existing Dike Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 35 °
Name: New Dike Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 35 °
Name: Sand and Gravel Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 35 °
Name: Sand Liquefied Model: S=f(overburden) Unit Weight: 19 kN/m³
Name: Silt Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 30 kPa Phi: 28 °
Name: Rip Rap Model: Mohr-Coulomb Unit Weight: 20 kN/m³ Cohesion: 0 kPa Phi: 50 °

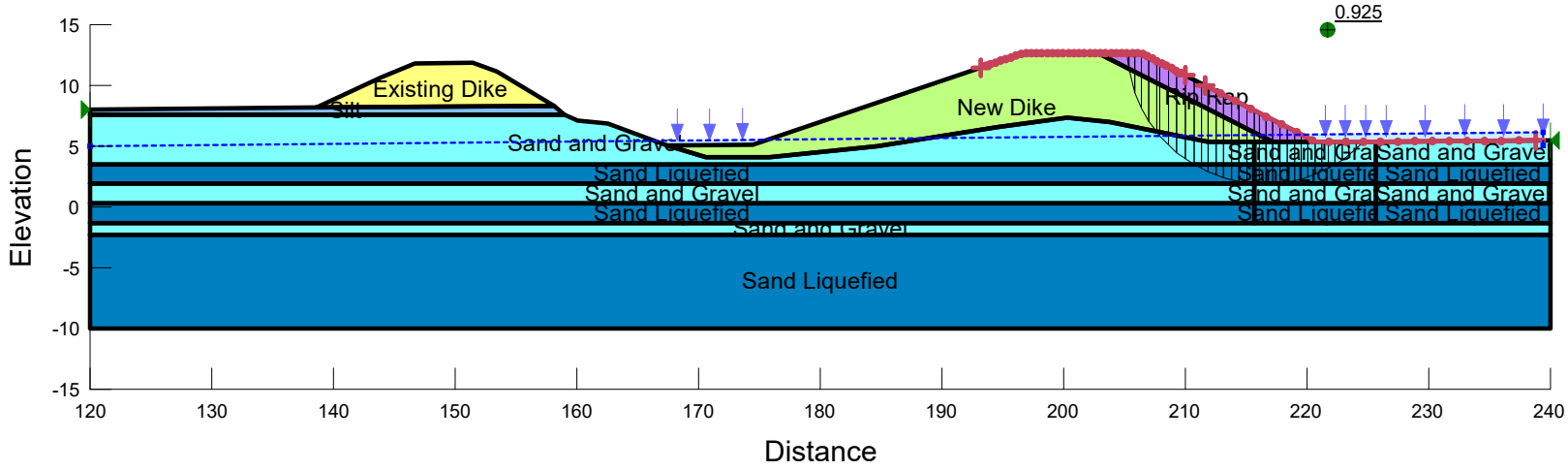

Figure 6: 0+300_3_Realign_RTL_Liquefied

Name: Existing Dike Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 35 °
Name: New Dike Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 35 °
Name: Sand and Gravel Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 35 °
Name: Sand Liquefied Model: S=f(overburden) Unit Weight: 19 kN/m³
Name: Silt Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 30 kPa Phi: 28 °
Name: Rip Rap Model: Mohr-Coulomb Unit Weight: 20 kN/m³ Cohesion: 0 kPa Phi: 50 °

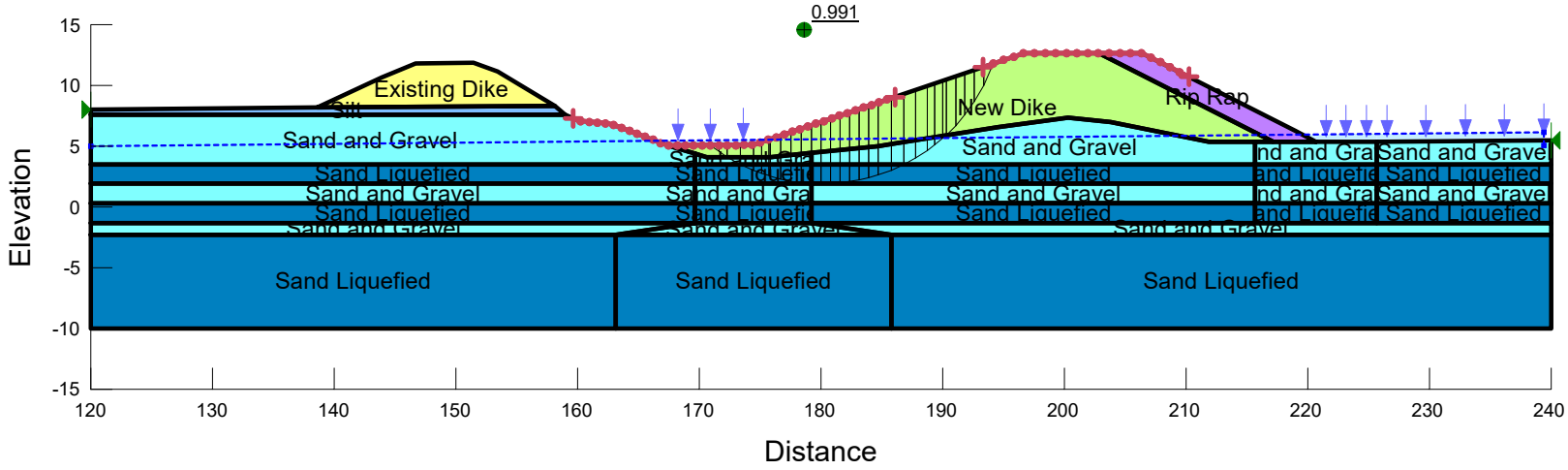

Figure 7: Eagle Run_Existing_LTR_Liquefied Horz Seismic Load: 0.19

Name: Existing Dike Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 35 °
Name: New Dike Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 35 °
Name: Sand and Gravel Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 35 °
Name: Sand Liquefied Model: S=f(overburden) Unit Weight: 19 kN/m³
Name: Silt Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 30 kPa Phi: 28 °
Name: Rip Rap Model: Mohr-Coulomb Unit Weight: 20 kN/m³ Cohesion: 0 kPa Phi: 50 °

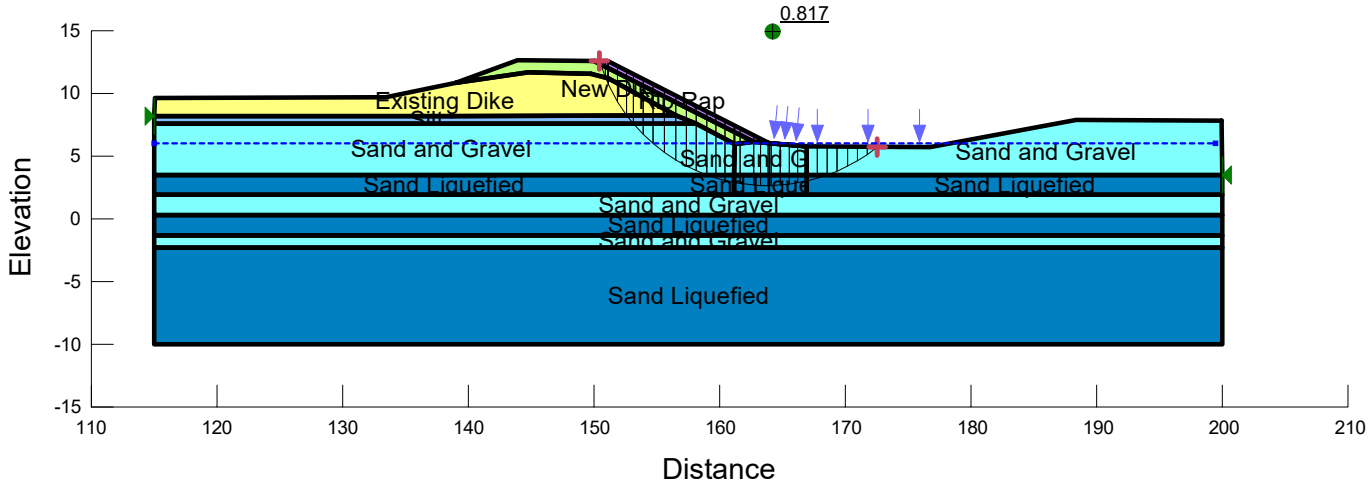

Figure 8: Eagle Run_Existing_RTL_Liquefied Horz Seismic Load: 0.19

Name: Existing Dike Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 35 °
Name: New Dike Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 35 °
Name: Sand and Gravel Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 35 °
Name: Sand Liquefied Model: S=f(overburden) Unit Weight: 19 kN/m³
Name: Silt Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 30 kPa Phi: 28 °
Name: Rip Rap Model: Mohr-Coulomb Unit Weight: 20 kN/m³ Cohesion: 0 kPa Phi: 50 °

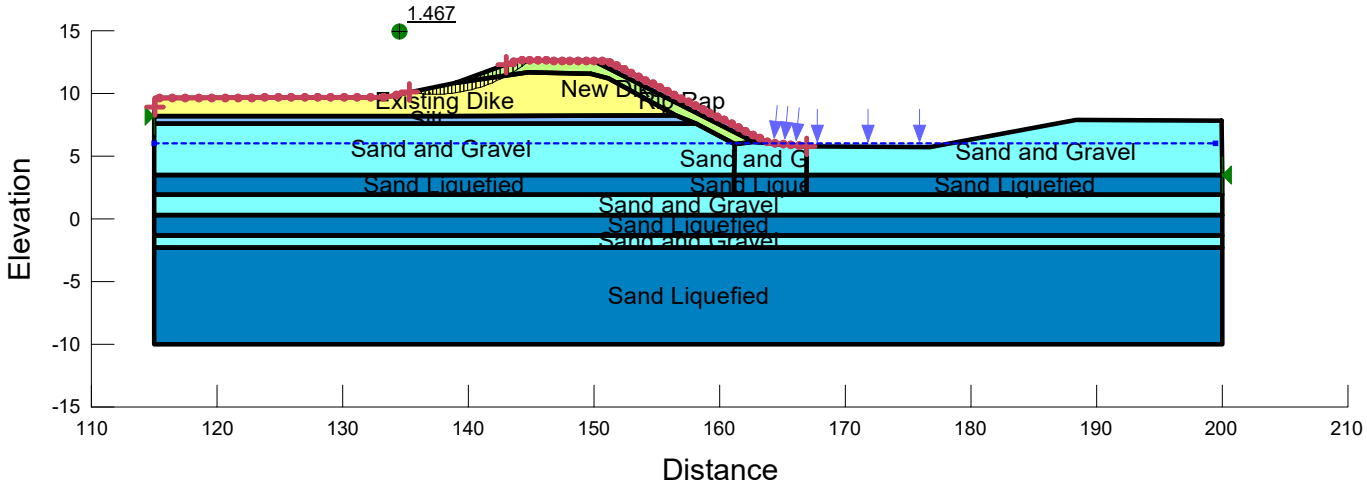

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Figure 9: Eagle Run 1_Realign_LTR_Liquefied Horz Seismic Load: 0.19

Name: New Dike Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 35 °
Name: Sand and Gravel Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 35 °
Name: Sand Liquefied Model: S=f(overburden) Unit Weight: 19 kN/m³
Name: Silt Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 30 kPa Phi: 28 °
Name: Rip Rap Model: Mohr-Coulomb Unit Weight: 20 kN/m³ Cohesion: 0 kPa Phi: 50 °

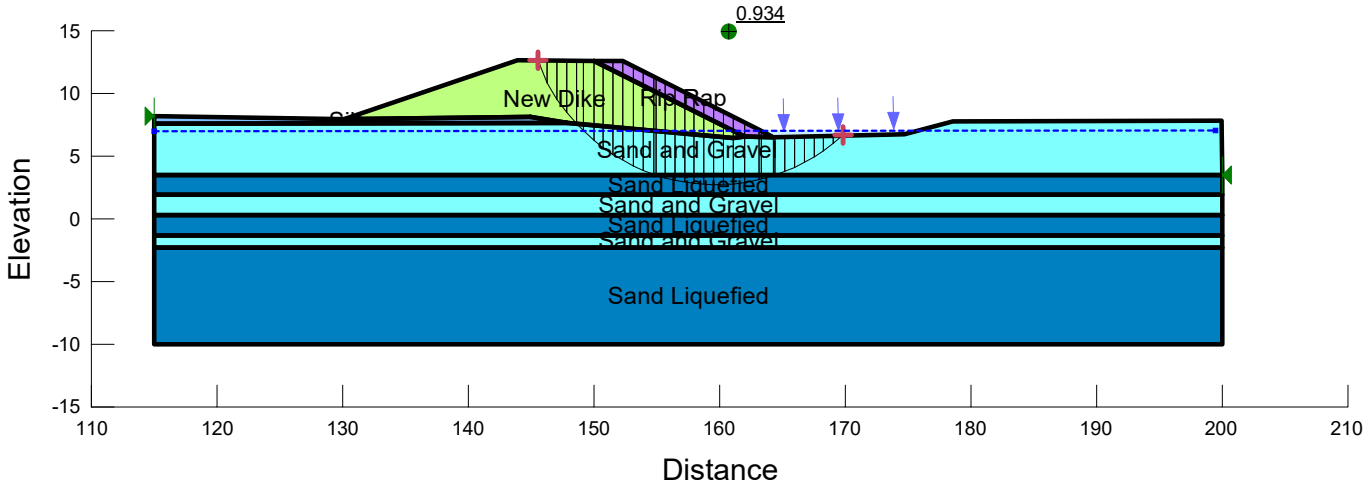

Figure 10: Eagle Run 1_Realign_RTL_Liquefied Horz Seismic Load: 0.19

Name: New Dike Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 35 °
Name: Sand and Gravel Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 35 °
Name: Sand Liquefied Model: S=f(overburden) Unit Weight: 19 kN/m³
Name: Silt Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 30 kPa Phi: 28 °
Name: Rip Rap Model: Mohr-Coulomb Unit Weight: 20 kN/m³ Cohesion: 0 kPa Phi: 50 °

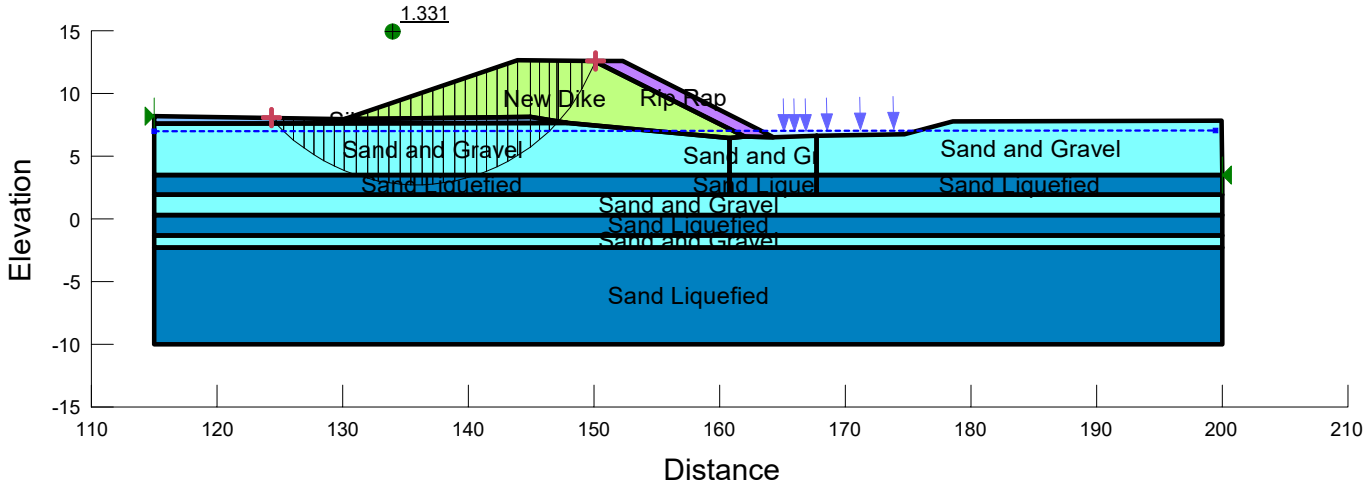

Figure 11: 0+600_1_Wall_LTR_Liquefied

Name: Existing Dike Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 35 °
Name: New Dike Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 35 °
Name: Sand and Gravel Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 35 °
Name: Sand Liquefied Model: S=f(overburden) Unit Weight: 19 kN/m³
Name: Rip Rap Model: Mohr-Coulomb Unit Weight: 20 kN/m³ Cohesion: 0 kPa Phi: 50 °

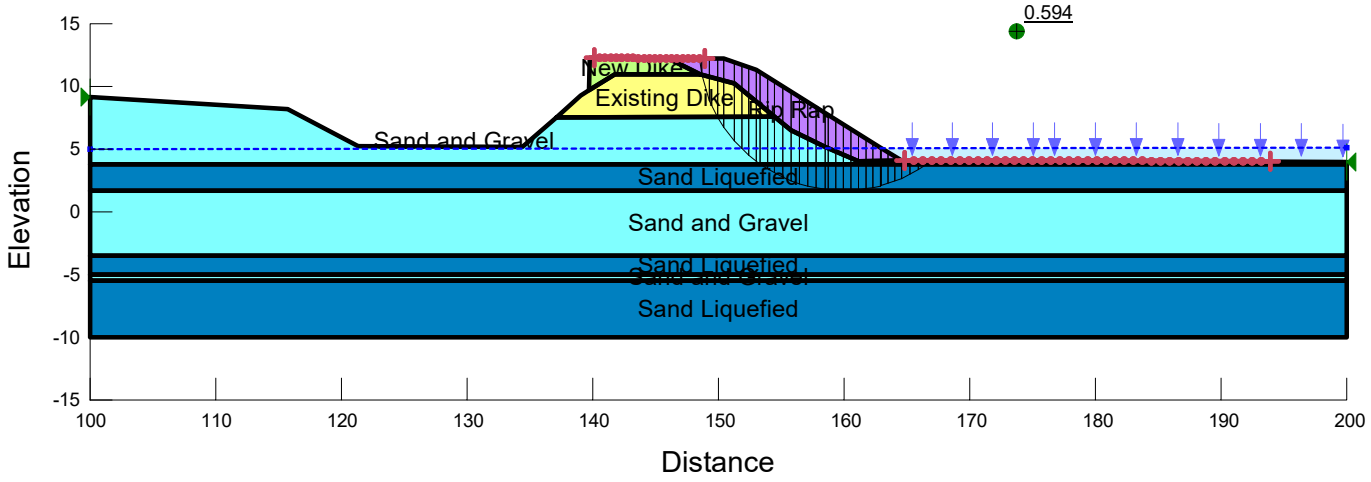

Figure 12: 0+600_1_Wall_RTL_Liquefied

Name: Existing Dike Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 35 °
Name: New Dike Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 35 °
Name: Sand and Gravel Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 35 °
Name: Sand Liquefied Model: S=f(overburden) Unit Weight: 19 kN/m³
Name: Rip Rap Model: Mohr-Coulomb Unit Weight: 20 kN/m³ Cohesion: 0 kPa Phi: 50 °

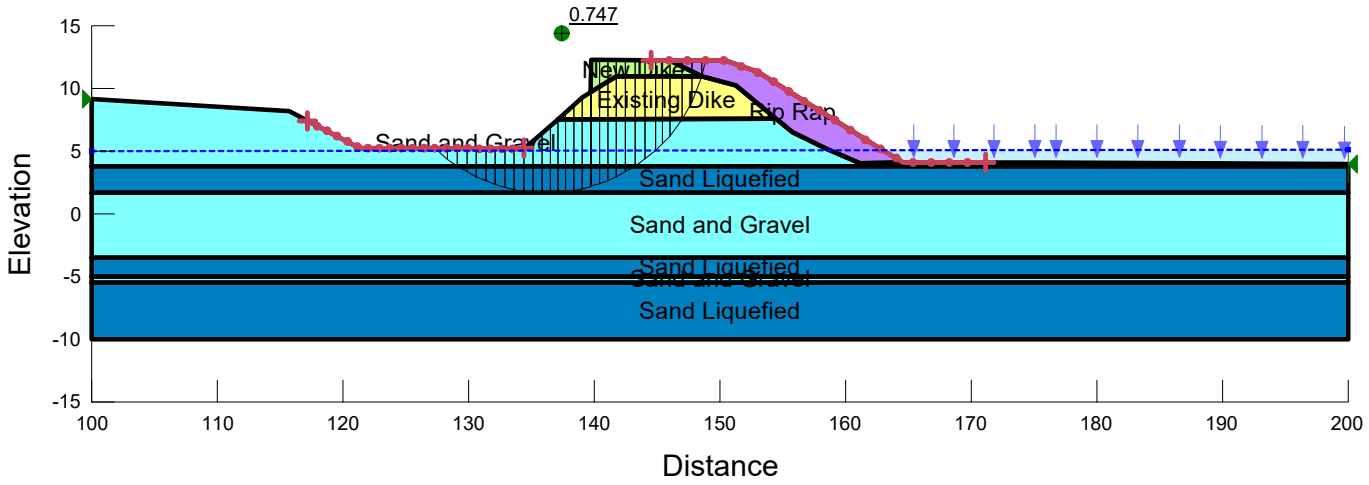

Figure 13: 0+300_1_Wall_LTR_Liquefied GI Horz Seismic Load: 0.19

Name: Existing Dike Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 35 °
Name: New Dike Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 35 °
Name: Sand and Gravel Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 35 °
Name: Sand Liquefied Model: S=f(overburden) Unit Weight: 19 kN/m³
Name: Silt Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 30 kPa Phi: 28 °
Name: Rip Rap Model: Mohr-Coulomb Unit Weight: 20 kN/m³ Cohesion: 0 kPa Phi: 50 °
Name: Densified Ground Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 35 °

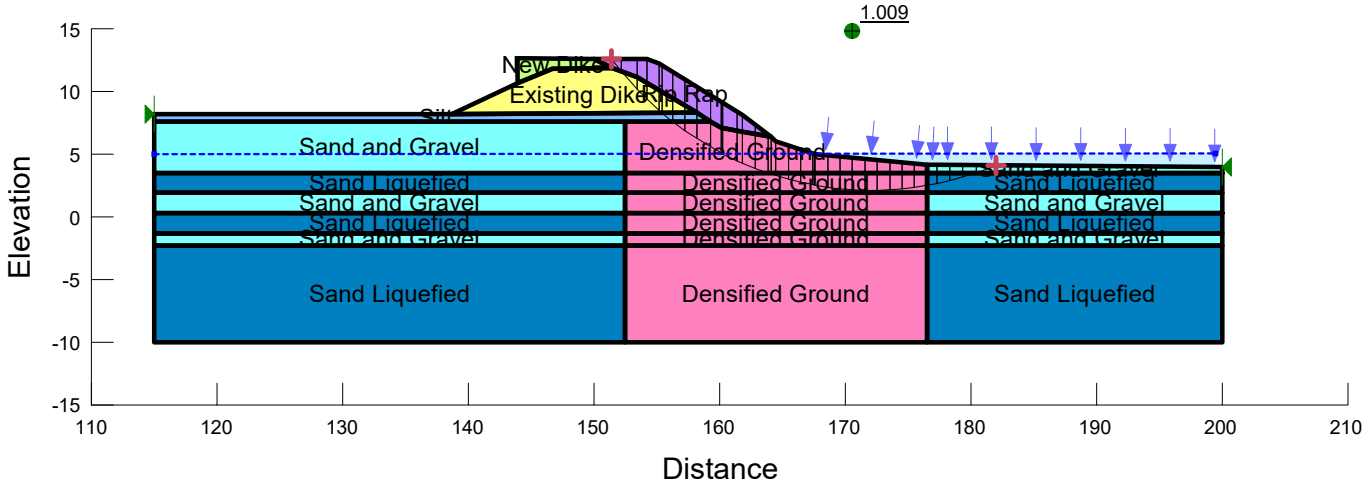

Figure 14: 0+300_2_Wide_LTR_Liquefied GI Horz Seismic Load: 0.19

Name: Existing Dike Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 35 °
Name: New Dike Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 35 °
Name: Sand and Gravel Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 35 °
Name: Sand Liquefied Model: S=f(overburden) Unit Weight: 19 kN/m³
Name: Silt Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 30 kPa Phi: 28 °
Name: Rip Rap Model: Mohr-Coulomb Unit Weight: 20 kN/m³ Cohesion: 0 kPa Phi: 50 °
Name: Densified Ground Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 35 °

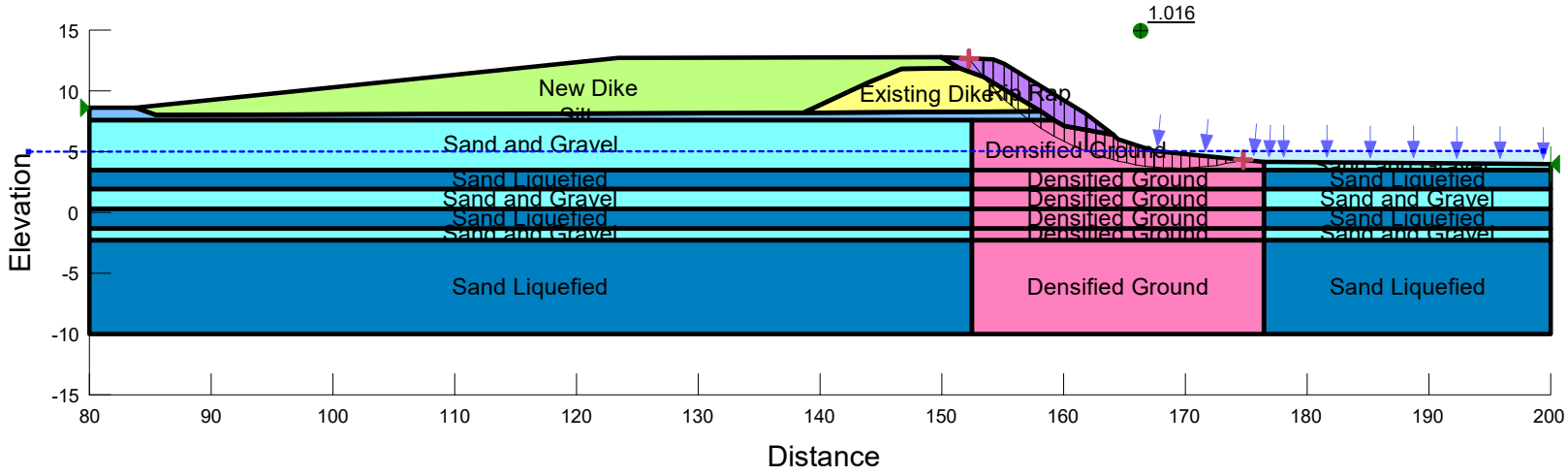

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Figure 15: 0+300_3_Realign_LTR_Liquefied GI Horz Seismic Load: 0.19

Name: Existing Dike Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 35 °
Name: New Dike Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 35 °
Name: Sand and Gravel Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 35 °
Name: Sand Liquefied Model: S=f(overburden) Unit Weight: 19 kN/m³
Name: Silt Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 30 kPa Phi: 28 °
Name: Rip Rap Model: Mohr-Coulomb Unit Weight: 20 kN/m³ Cohesion: 0 kPa Phi: 50 °
Name: Densified Ground Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 35 °

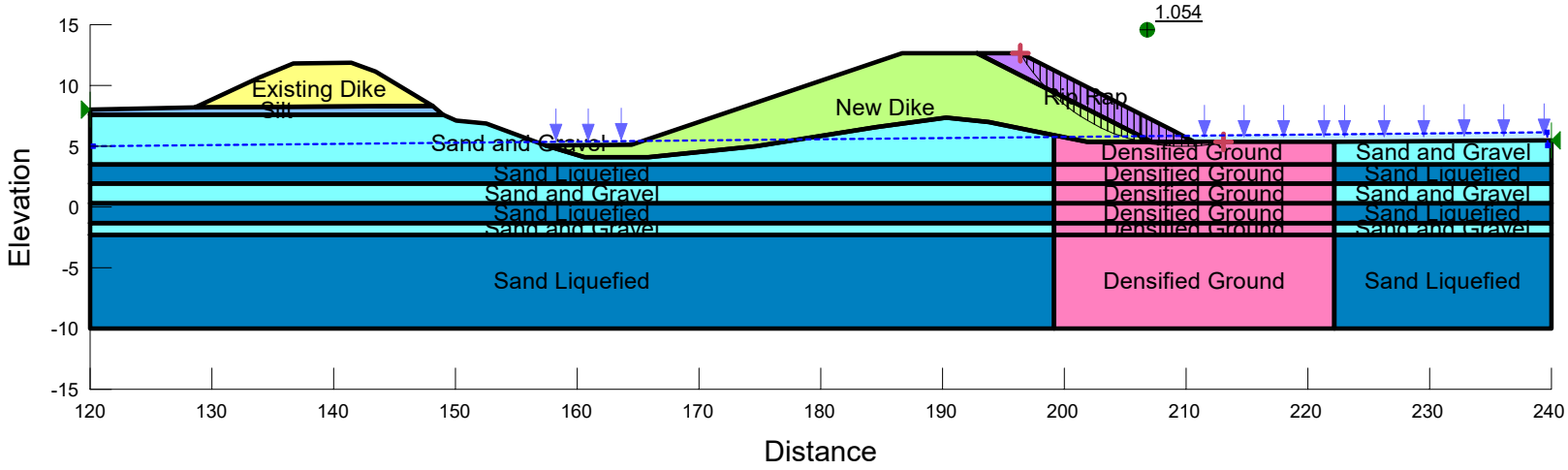

Figure 16: 0+300_3_Realign_RTL_Liquefied GI Horz Seismic Load: 0.19

Name: Existing Dike Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 35 °
Name: New Dike Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 35 °
Name: Sand and Gravel Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 35 °
Name: Sand Liquefied Model: S=f(overburden) Unit Weight: 19 kN/m³
Name: Silt Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 30 kPa Phi: 28 °
Name: Rip Rap Model: Mohr-Coulomb Unit Weight: 20 kN/m³ Cohesion: 0 kPa Phi: 50 °
Name: Densified Ground Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 35 °

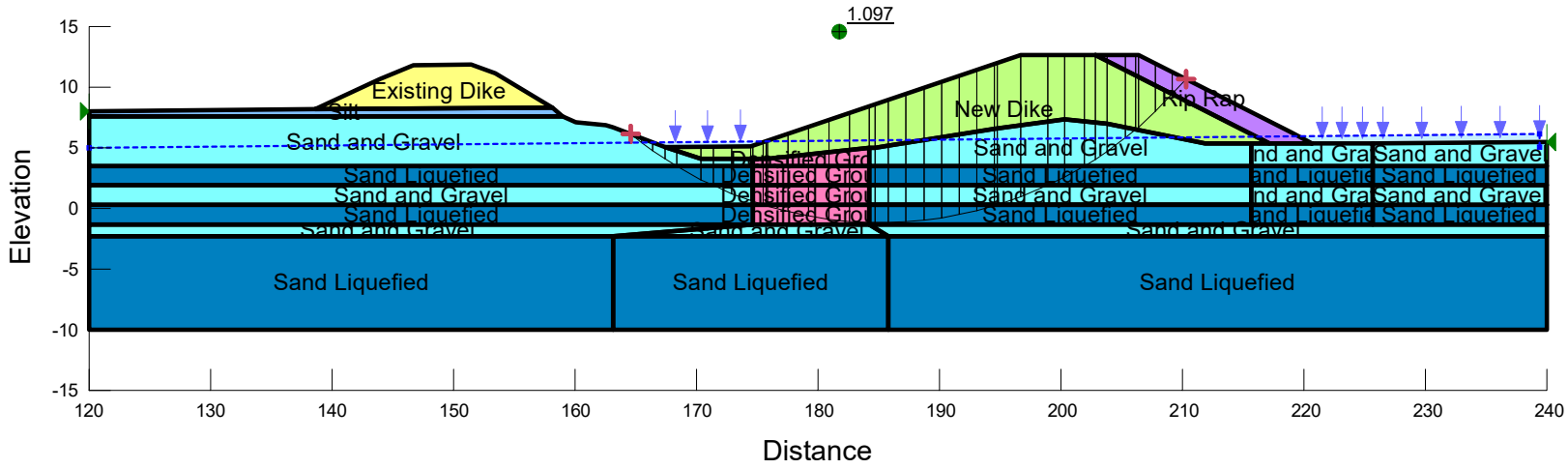

Figure 17: Eagle Run_Existing_LTR_Liquefied GI Horz Seismic Load: 0.19

Name: Existing Dike Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 35 °
Name: New Dike Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 35 °
Name: Sand and Gravel Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 35 °
Name: Sand Liquefied Model: S=f(overburden) Unit Weight: 19 kN/m³
Name: Silt Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 30 kPa Phi: 28 °
Name: Rip Rap Model: Mohr-Coulomb Unit Weight: 20 kN/m³ Cohesion: 0 kPa Phi: 50 °
Name: Densified Ground Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 35 °

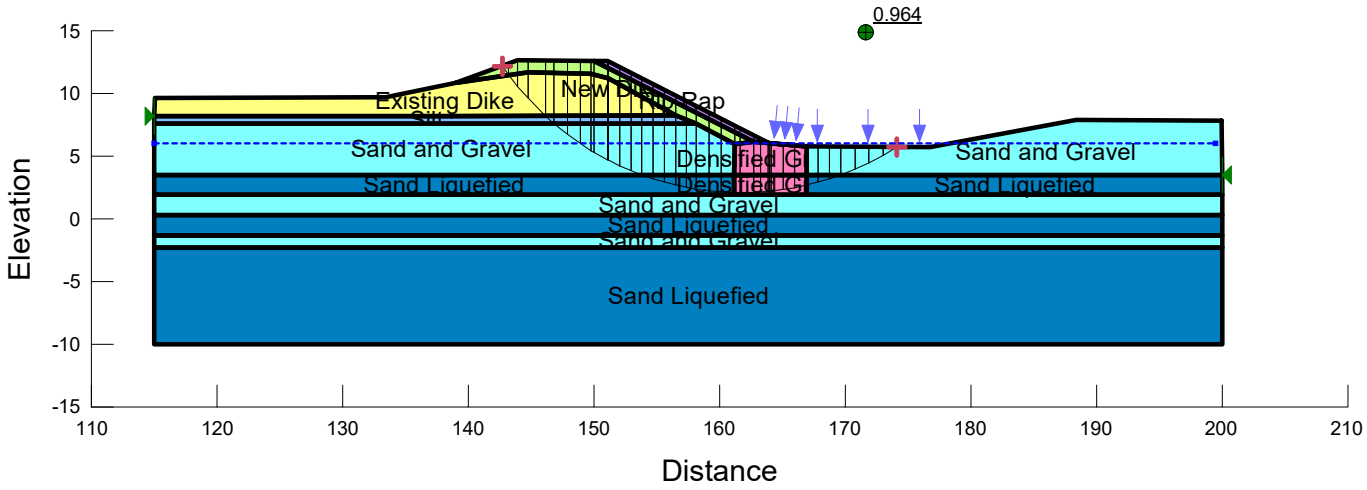

Figure 18: Eagle Run 1_Realign_LTR_Liquefied GI Horz Seismic Load: 0.19

Name: New Dike Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 35 °
Name: Sand and Gravel Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 35 °
Name: Sand Liquefied Model: S=f(overburden) Unit Weight: 19 kN/m³
Name: Silt Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 30 kPa Phi: 28 °
Name: Rip Rap Model: Mohr-Coulomb Unit Weight: 20 kN/m³ Cohesion: 0 kPa Phi: 50 °
Name: Densified Ground Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 35 °

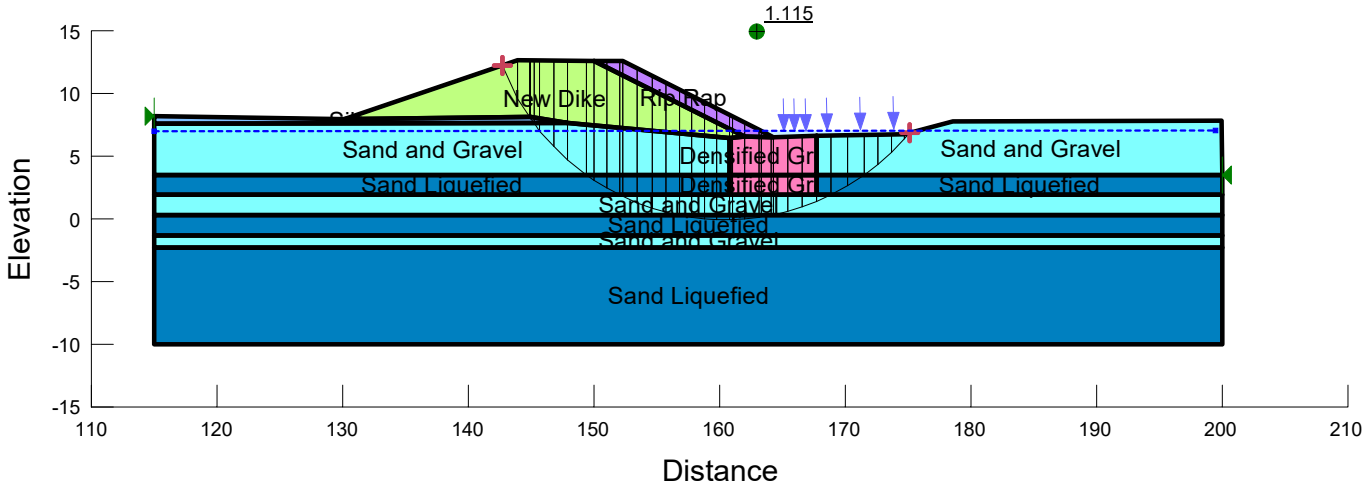

Figure 19: 0+600_1_Wall_LTR_Liquefied GI Horz Seismic Load: 0.19

Name: Existing Dike Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 35 °
Name: New Dike Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 35 °
Name: Sand and Gravel Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 35 °
Name: Sand Liquefied Model: S=f(overburden) Unit Weight: 19 kN/m³
Name: Rip Rap Model: Mohr-Coulomb Unit Weight: 20 kN/m³ Cohesion: 0 kPa Phi: 50 °
Name: Densified Ground Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 40 °

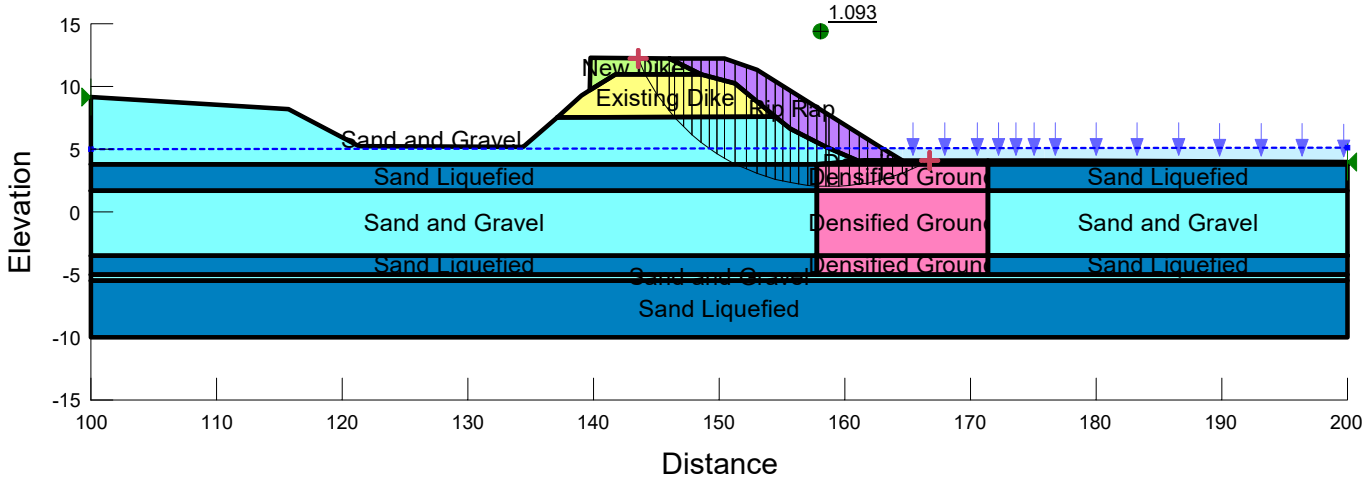

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Figure 20: 0+600_1_Wall_RTL_Liquefied GI Horz Seismic Load: 0.19

Name: Existing Dike Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 35 °
Name: New Dike Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 35 °
Name: Sand and Gravel Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 35 °
Name: Sand Liquefied Model: S=f(overburden) Unit Weight: 19 kN/m³
Name: Rip Rap Model: Mohr-Coulomb Unit Weight: 20 kN/m³ Cohesion: 0 kPa Phi: 50 °
Name: Densified Ground Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 40 °

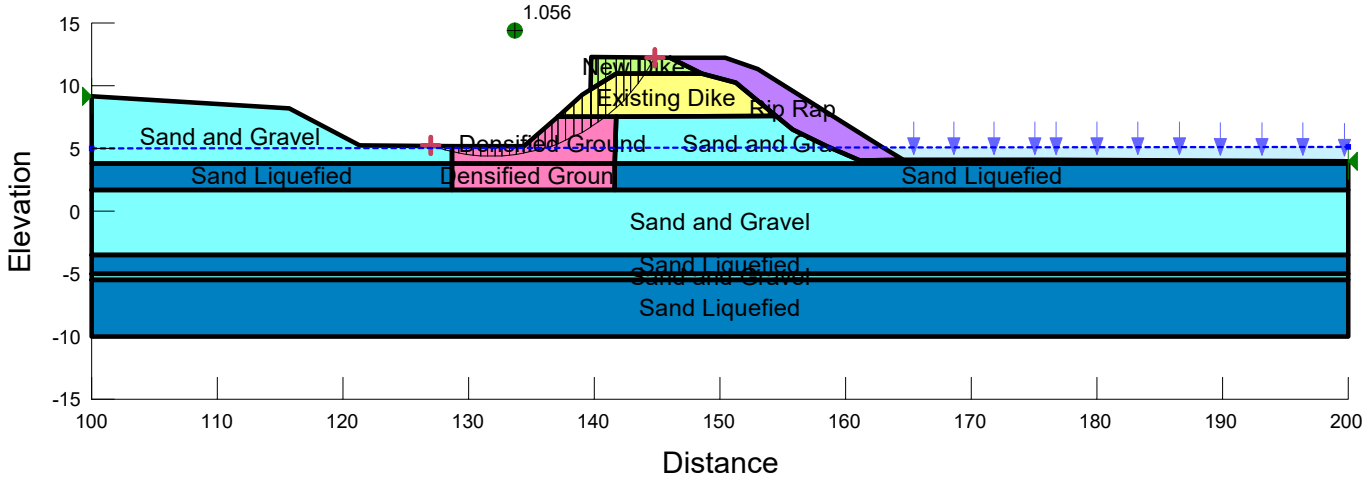

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Table 1. Conceptual Zone of Ground Improvement

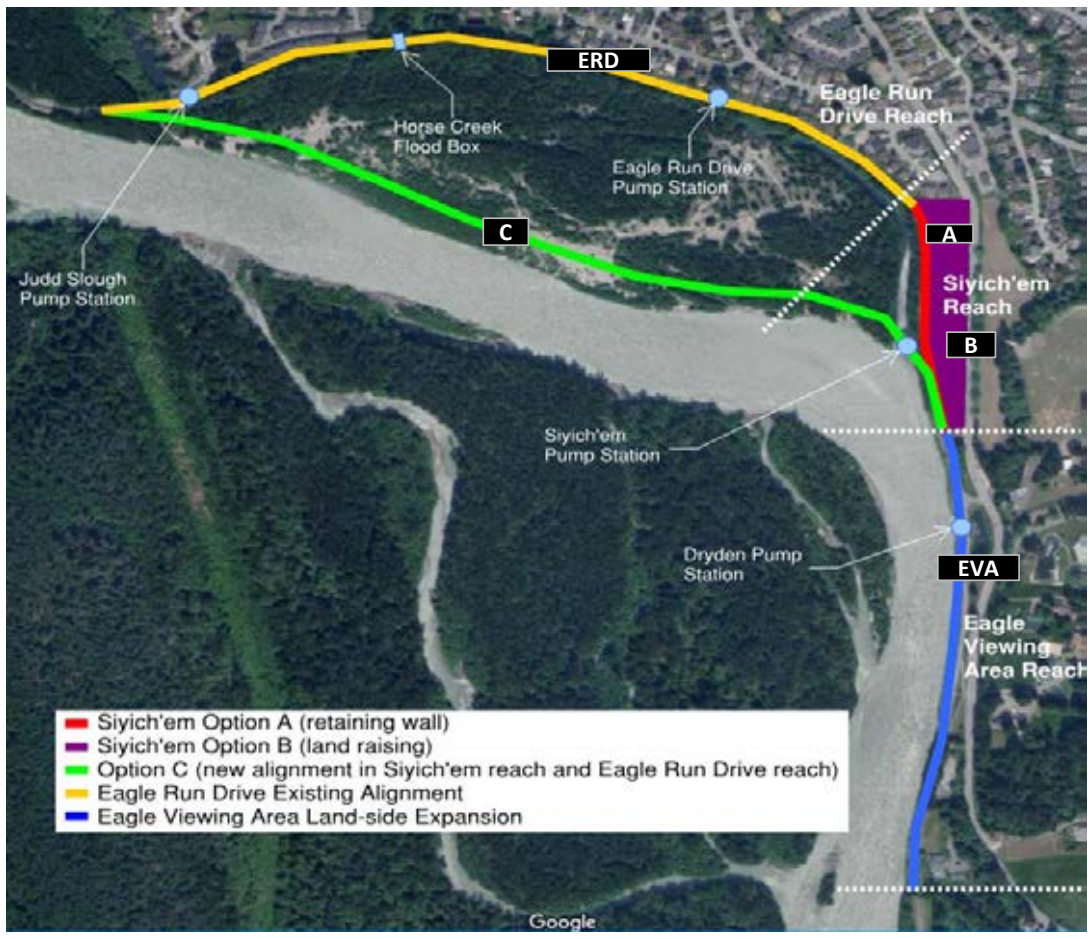
Dike Location		Ground Improvement Zone			
Location	Option	Width (m)	Depth (m)	Bottom El. (m)	Volume (m^3/m)
Sta. 300 - Waterside	1 - Wall	24	18	-10	430
	2 - Widened	24	18	-10	430
	3 - Realigned	24	16	-10	380
Sta. 300 - Landside	1 - Wall	-	-	-	-
	2 - Widened	-	-	-	-
	3 - Realigned	10	6.5	-1.5	65
Sta. 600 - Waterside	1 - Wall	14	9	1.5	130
	2 - Widened	14	9	1.5	130
Sta. 600 - Landside	1 - Wall	-	-	-	-
Eagle Run - Waterside	Existing	7	4.5	2	30
	3 - Realigned	7	4.5	2	30
Eagle Run - Landside	Existing	-	-	-	-
	3 - Realigned	-	-	-	-

KERR WOOD LEIDAL
consulting engineers

Appendix G

Class-D Construction Cost Estimates

Definition Sketch Showing Reaches and Options



Summary of All Class-D Cost Estimates

Major Items	Dike Reach / Option				
	Option A	Option B	Option C	Eagle Run Drive Dike Existing Alignment (ERD)	Eagle Viewing Area Land-side Expansion (EVA)
Length	485 m	485 m	1560 m	1340 m	665 m
General	$ 1,259,200	$ 1,450,200	$ 3,417,600	$ 2,286,400	$ 1,793,600
Site Preparation	$ 85,935	$ 485,798	$ 1,397,630	$ 356,192	$ 167,643
Ground Improvement for Seismic Performance	$ 10,427,500	$ 10,427,500	$ 8,814,000	$ 2,010,000	$ 4,322,500
Dike Construction	$ 7,367,658	$ 8,205,087	$ 24,586,045	$ 12,198,111	$ 9,853,744
Utilities	$ -	$ 1,300,000	$ 8,600,000	$ 8,200,000	$ 12,600,000
Restoration, Finishes, and Amenities	$ 510,000	$ 2,736,000	$ 600,000	$ 500,000	$ 57,500
Habitat Compensation Allowance	$ 982,515	$ 1,230,229	$ 4,741,528	$ 1,277,535	$ 1,439,749
Professional Services and Construction Contingency	$ 6,877,602	$ 8,611,605	$ 21,636,874	$ 11,497,816	$ 10,078,245
Total Construction Cost (All Components)	**$ 27,511,000**	**$ 34,447,000**	**$ 73,794,000**	**$ 38,327,000**	**$ 40,313,000**
Total Construction Cost EXCLUDING Ground Improvement for Seismic Performance (all options) and Dryden Creek Pump Station (Eagle Viewing Area only)	**$ 12,330,000**	**$ 19,264,000**	**$ 59,586,000**	**$ 35,190,000**	**$ 15,674,000**

Full Length Comparison - Fishermen's Park to Kowtain - All Construction Components

Components	Option A + ERD + EVA	Option B + ERD + EVA	Option C + EVA
Length	2.5 km		2.2 km
Option A, B, or C cost	$ 28 M	$ 34 M	$ 74 M
ADD Eagle Run Drive Existing Alignment to Options A and B	$ 38 M		-
ADD Eagle Viewing Area Land-side Expansion Option all options	$ 40 M		
Total for Comparison ($ million)	$ 106 M	$ 113 M	$ 114 M

Full Length Comparison - Fishermen's Park to Kowtain - EXCLUDING Ground Improvement for Seismic Performance and Dryden Creek Pump Station

Components	Option A + ERD + EVA	Option B + ERD + EVA	Option C + EVA
Length	2.5 km		2.2 km
Option A, B, or C cost	$ 12 M	$ 19 M	$ 60 M
ADD Eagle Run Drive Existing Alignment to Options A and B	$ 35 M		-
ADD Eagle Viewing Area Land-side Expansion Option all options	$ 16 M		
Total for Comparison ($ million)	$ 63 M	$ 70 M	$ 75 M

Class-D construction cost estimate for Option A (retaining wall) in the Siyich'em reach (approx. total length: 485 m)

Item	Description	Unit	Quantity	Unit Rate	TOTAL PRICE $	Comment
1	**General**					
1.01	Mobilization and demobilization	LS	1	$ 189,000	$ 189,000	1% of total cost.
1.02	General conditions, bonding and insurance	LS	1	$ 567,000	$ 567,000	3% of total cost.
1.03	Water management and isolation for bank protection works	m	485	$ 800	$ 388,000	
1.04	Traffic management	week	24	$ 4,800	$ 115,200	4-person crew for 6 months.
				SUBTOTAL FOR TASK	**$ 1,259,200**	
2	**Site Preparation**					
2.01	Tree Clearing	m^2	5,250	$ 7	$ 36,938	
2.02	Grubbing, Clearing & Stripping	m^2	4,359	$ 11	$ 48,997	
				SUBTOTAL FOR TASK	**$ 85,935**	
3	**Ground Improvement for Seismic Performance**					
3.01	Ground improvement via soil mixing zone along water-side edge of dike footprint	m^3	208,550	$ 50	$ 10,427,500	1 ground improvement zone (24 m wide and 18 m deep) running aling dike crest / water-side slope. Challenging conditions given adjacent river channel.
				SUBTOTAL FOR TASK	**$ 10,427,500**	
4	**Dike Construction**					
4.01	Supply and install steel sheetpile seepage cutoff wall & retaining wall	m^2	8320	$ 550	$ 4,576,000	16 m tall sheetpile wall provides dike stability, reduces seepage volumes, and serves as a retaining wall.
4.02	Supply, place, and compact dike fill	m^3	7459	$ 50	$ 372,965	
4.03	Allowance for riprap revetment buried toe	m	485	$ 3,088	$ 1,497,438	
4.04	Supply and place riprap onto existing riprap slope along Jimmy Jimmy (Judd) Slough	m^3	4,811	$ 65	$ 312,697	1 m thick class 250 Kg riprap placed onto existing riprap. Lower unit rate for riprap along more sheltered Jimmy Jummy (Judd) Slough area. Challenging conditions given minimal space for construction access.
4.05	Supply and place riprap onto existing riprap slope south of Jimmy Jimmy (Judd) Slough outlet	m^3	5,334	$ 85	$ 453,358	1 m thick class 1000 kg riprap placed onto existing riprap. Higher unit rate for riprap along more exposed area south of Jimmy Jimmy (Judd) Slough outlet. Challenging conditions given minimal space for construction access.
4.06	Supply, place, and compact granular base for dike crest surface	m^2	2,910	$ 20	$ 58,200	
4.07	Supply and install safety railing for land-side edge of dike crest (above retaining wall)	m	485	$ 200	$ 97,000	Railing required above retaining wall.
				SUBTOTAL FOR TASK	**$ 7,367,658**	
5	**Utilities**					
	[none in Siyichem reach Option A]				$ -	
				SUBTOTAL FOR TASK	**$ -**	
6	**Restoration, Finishes, & Amenities**					
6.01	Allowance to replace existing structure attached to dike (Watershed Grill)	LS	1	$ 500,000	$ 500,000	
6.02	Allowance for landscape restoration on Siyich'em reserve along retaining wall bottom	LS	1	$ 10,000	$ 10,000	No finishes or landscaping on dike because it is not a public path through Siyich'em reserve.
				SUBTOTAL FOR TASK	**$ 510,000**	
	CONSTRUCTION COST SUBTOTAL				**$ 19,650,293**	
	ALLOWANCES & CONTINGENCIES					
	Professional services & construction administration	5%			$ 982,515	
	Habitat impact compensation	5%			$ 982,515	Lower end of compensation allowance given limited impacts during construction
	Contingencies	30%			$ 5,895,088	Lower end of contingency range given that this option would be more conventional
				TOTAL AMOUNT (excl. GST, Rounded)	**$ 27,511,000**	

Note: Estimates have been prepared with little or no site information and as such indicates the approximate magnitude of the cost of the capital tasks, for project planning purposes only. The estimate has been derived from unit costs for similar projects.

Class-D construction cost estimate for Option B (land raising) in the Siyich'em reach (approx. total length: 485 m)

Item	Description	Unit	Estimated Quantity	Unit Rate	TOTAL PRICE $	Comment
1	**General**					
1.01	Mobilization and demobilization	LS	1	$ 237,000	$ 237,000	1% of total cost.
1.02	General conditions, bonding and insurance	LS	1	$ 710,000	$ 710,000	3% of total cost.
1.03	Water management and isolation for bank protection works	m	485	$ 800	$ 388,000	
1.04	Traffic management	week	24	$ 4,800	$ 115,200	4-person crew for 6 months.
				SUBTOTAL FOR TASK	**$ 1,450,200**	
2	**Site Preparation**					
2.01	Tree Clearing	m^2	5,950	$ 7	$ 41,863	
2.02	Grubbing, Clearing & Stripping	m^2	25,706	$ 11	$ 288,935	
2.03	Allowance to remove existing structures on Siyich'em reserve	allow	1	$ 150,000	$ 150,000	
2.04	Allowance to remove existing buried utilities on Siyich'em reserve (water, sewer, septic)	allow	1	$ 5,000	$ 5,000	
				SUBTOTAL FOR TASK	**$ 485,798**	
3	**Ground Improvement for Seismic Performance**					
3.01	Ground improvement via soil mixing zone along water-side edge of dike footprint	m^3	208,550	$ 50	$ 10,427,500	1 ground improvement zone (24 m wide and 18 m deep) running aling dike crest / water-side slope. Challenging conditions given adjacent river channel.
				SUBTOTAL FOR TASK	**$ 10,427,500**	
4	**Dike Construction**					
4.01	Supply, place, and compact dike fill (includes land raising on reserve)	m^3	76,472	$ 50	$ 3,823,595	
4.02	Construct short height retaining wall for grade separeation at Government Road (0+280 to 0+480)	m^2	400	$ 400	$ 160,000	
4.03	Supply and install 16 m deep steel sheetpile seepage cutoff wall (south end 0+480 to 0+555)	m^2	1200	$ 500	$ 600,000	Sheetpile only required at the south end of reach where there is limited room for land raising. 16 m tall sheetpile wall provides dike stability, reduces seepage volumes, and serves as a retaining wall.
4.04	Allowance for riprap revetment buried toe	m	485	$ 3,088	$ 1,497,438	
4.05	Supply and place riprap onto existing riprap slope along Jimmy Jimmy (Judd) Slough	m^3	4,811	$ 65	$ 312,697	1 m thick class 250 Kg riprap placed onto existing riprap. Lower unit rate for riprap along more sheltered Jimmy Jummy (Judd) Slough area. Challenging conditions given minimal space for construction access.
4.06	Supply and place riprap onto existing riprap slope south of Jimmy Jimmy (Judd) Slough outlet	m^3	5,334	$ 85	$ 453,358	1 m thick class 1000 kg riprap placed onto existing riprap. Higher unit rate for riprap along more exposed area south of Jimmy Jimmy (Judd) Slough outlet. Challenging conditions given minimal space for construction access.
4.07	Supply, place, and compact granular base for dike crest surface	m^2	67,900	$ 20	$ 1,358,000	
				SUBTOTAL FOR TASK	**$ 8,205,087**	
5	**Utilities**					
5.01	Allowance for new utility servicing (water, sewer, sanitary), access road, and landscaping on Siyich'em reserve	LS	1	$ 1,300,000	$ 1,300,000	
				SUBTOTAL FOR TASK	**$ 1,300,000**	
6	**Restoration, Finishes, & Amenities**					
6.01	Allowance to replace existing structure attached to dike (Watershed Grill)	LS	1	$ 500,000	$ 500,000	
6.02	Allowance to replace single family homes on Siyich'em reserve	each	1	$ 200,000	$ 200,000	
6.03	Allowance to replace mobile homes on Siyich'em reserve	each	11	$ 100,000	$ 1,100,000	
6.04	Allowance for 8-month residential displacement compensation on Siyich'em reserve (per household)	each	12	$ 78,000	$ 936,000	Does not include an compensation allowance for loss of income or business revenue.
				SUBTOTAL FOR TASK	**$ 2,736,000**	
	CONSTRUCTION COST SUBTOTAL				**$ 24,604,585**	
	ALLOWANCES & CONTINGENCIES					
	Professional services & construction administration	5%			$ 1,230,229	
	Habitat impact compensation	5%			$ 1,230,229	Lower end of compensation allowance given limited impacts during construction
	Contingencies	30%			$ 7,381,376	Lower end of contingency range given that this option would be more conventional
				TOTAL AMOUNT (excl. GST, Rounded)	**$ 34,446,000**	

Note: Estimates have been prepared with little or no site information and as such indicates the approximate magnitude of the cost of the capital tasks, for project planning purposes only. The estimate has been derived from unit costs for similar projects.

Class-D construction cost estimate for Option C (new dike alignment) in the Siyich'em reach and extending to Fishermans Park (approx. total length: 1560 m)

Item	Description	Unit	Estimated Quantity	Unit Rate	TOTAL PRICE $	Comment
1	**General**					
1.01	Mobilization and demobilization	LS	1	$ 456,000	$ 456,000	1% of total cost.
1.02	General conditions, bonding and insurance	LS	1	$ 1,368,000	$ 1,368,000	3% of total cost.
1.03	Water management and isolation for bank protection works	m	1560	$ 800	$ 1,248,000	
1.04	Traffic management	week	72	$ 4,800	$ 345,600	4-person crew for 18 months.
				SUBTOTAL FOR TASK	**$ 3,417,600**	
2	**Site Preparation**					
2.01	Tree Clearing	m^2	64,250	$ 7	$ 452,051	
2.02	Grubbing, Clearing & Stripping	m^2	73,290	$ 11	$ 823,780	
2.03	Allowance for temporary access works	LS	1	$ 75,000	$ 75,000	Allowance includes a construction access road along land-side toe of dike (toe berm corridor), laydown and truck turn-around areas, and a construciton access bridge over Jimmy Jimmy (Judd) Slough.
2.04	Supply, place, and compact ganular sub-base for land-side construction access road	m^3	2,340	$ 20	$ 46,800	
				SUBTOTAL FOR TASK	**$ 1,397,630**	
3	**Ground Improvement for Seismic Performance**					
3.01	Ground improvement via soil mixing zone	m^3	176,280	$ 50	$ 8,814,000	2 ground improvement zones (water-side 24 m wide and 16 m deep, and land-side 10 m wide and 6.5 m deep) running aling dike crest / slope for southern 300 m. Challenging conditions given adjacent river channel. 1 ground improvement zone (water-side 7 m wide and 4.5 m deep) running along the dike crest / slope for the northern/western 1200 m.
				SUBTOTAL FOR TASK	**$ 8,814,000**	
4	**Dike Construction**					
4.01	Supply, place, and compact dike fill (includes toe berm for seepage control)	m^3	228,482	$ 50	$ 11,424,098	Includes a land-side toe berm extending 15 m from toe of 3H:1V land-side dike slope. Land-side toe berm selected over internal deep sheetpile seepage cutoff wall to reduce cost. Footprint of land-side toe berm would need to be coordinated with land use plans for the land recapture concept linked with this option.
4.02	Allowance for additional fill for turnouts and access ramps	LS	1	$ 150,000	$ 150,000	3 turnouts and 1 access ramp
4.03	Supply and install 16 m deep steel sheetpile seepage cutoff wall (southern 150 m of reach)	m^2	3360	$ 550	$ 1,848,000	Sheetpile only required at the south end of reach where there is limited room for a land-side toe berm for seepage control. 16 m tall sheetpile wall provides dike stability, reduces seepage volumes, and serves as a retaining wall.
4.04	Allowance for riprap revetment buried toe along Siyich'em reach	m	300	$ 3,088	$ 926,250	
4.05	Allowance for riprap revetment buried toe along Eagle Run Drive reach	m	1,260	$ 3,800	$ 4,788,000	
4.06	Supply and place granular filter layer onto river-side slope	m^3	11,569	$ 70	$ 809,859	0.5 m thick granular filter layer.
4.07	Supply and place riprap layer onto granular filter layer	m^3	46,278	$ 85	$ 3,933,601	2 m thick Class 1000 kg riprap layer.
4.08	Supply, place, and compact granular base for dike crest surface	m^2	9,360	$ 20	$ 187,200	
4.09	Supply and install safety railing for land-side edge of dike crest (above retaining wall only southern 150 m)	m	210	$ 200	$ 42,000	
4.10	Supply and place topsoil for land-side slope and toe berm	m^2	39,753	$ 10	$ 397,530	
4.11	Supply and apply hydroseeding for land-side slope and toe berm	m^2	39,753	$ 2	$ 79,506	
				SUBTOTAL FOR TASK	**$ 24,586,045**	
5	**Utilities**					
5.01	Allowance for new fish-friendly pump station and floodbox at Jimmy Jimmy (Judd) Slough outlet and decomission pump stations on Eagle Run Drive dike	LS	1	$ 8,600,000	$ 8,600,000	Note: high level of uncertainty due to lack of hydrologic analysis to support design criteria and cost estimate.
				SUBTOTAL FOR TASK	**$ 8,600,000**	
6	**Restoration, Finishes, & Amenities**					
6.01	Allowance to replace existing structure attached to dike (Watershed Grill)	LS	1	$ 500,000	$ 500,000	
6.02	Water access ramps for Squamish Nation	LS	1	$ 100,000	$ 100,000	
				SUBTOTAL FOR TASK	**$ 600,000**	
	CONSTRUCTION COST SUBTOTAL				**$ 47,415,275**	
	ALLOWANCES & CONTINGENCIES					
	Allowance for additional dike upgrading upstream due increased flood levels	LS	1	$ 300,000	$ 300,000	
	Professional services & construction administration	5%			$ 2,370,764	
	Habitat impact compensation	10%			$ 4,741,528	Upper end of compensation allowance given potential long-term impacts
	Contingencies	40%			$ 18,966,110	Higher end of contingency range given that this option would involve more challenging construction conditions related to the vicinity of the Squamish River.
				TOTAL AMOUNT (excl. GST, Rounded)	**$ 73,794,000**	

Note: Estimates have been prepared with little or no site information and as such indicates the approximate magnitude of the cost of the capital tasks, for project planning purposes only. The estimate has been derived from unit costs for similar projects.

Class-D construction cost estimate for upgrading the existing dike along Eagle Run Drive, between Siyich'em reserve and Fishermans Park (approx. total length: 1340 m)

Item	Description	Unit	Estimated Quantity	Unit Rate	TOTAL PRICE $	Comment
1	**General**					
1.01	Mobilization and demobilization	LS	1	$ 246,000	$ 246,000	1% of total cost.
1.02	General conditions, bonding and insurance	LS	1	$ 738,000	$ 738,000	3% of total cost.
1.03	Water management and isolation for bank protection works	m	1340	$ 800	$ 1,072,000	
1.04	Traffic management	week	48	$ 4,800	$ 230,400	4-person crew for 12 months.
				SUBTOTAL FOR TASK	**$ 2,286,400**	
2	**Site Preparation**					
2.01	Tree clearing	m^2	33,500	$ 7	$ 235,700	
2.02	Grubbing, clearing & stripping	m^2	10,720	$ 11	$ 120,493	
				SUBTOTAL FOR TASK	**$ 356,192**	
2	**Ground Improvement For Seismic Performance**					
2.01	Ground improvement via soil mixing zone along water-side edge of dike footprint	m^3	40,200	$ 50	$ 2,010,000	1 ground improvement zone (water-side 7 m wide and 4.5 m deep) running along the dike crest / slope. Challenging conditions given adjacent river channel.
				SUBTOTAL FOR TASK	**$ 2,010,000**	
3	**Dike Construction**					
3.01	Supply and install 16 m deep steel sheetpile seepage cutoff wall	m^2	13450	$ 500	$ 6,725,000	Sheetpile provides dike stability, reduces seepage volumes, and serves as a retaining wall.
3.02	Supply, place, and compact dike fill	m^3	22,471	$ 50	$ 1,123,538	
3.03	Allowance for additional fill for turnouts and access ramps	LS	1	$ 150,000	$ 150,000	3 turnouts and 1 access ramp.
3.03	Supply and place riprap revetment buried toe	m	1,340	$ 1,853	$ 2,482,350	
3.04	Supply and place riprap onto existing riprap slope along Jimmy Jimmy (Judd) Slough	m^3	19,822	$ 65	$ 1,288,422	Lower unit rate for riprap along more sheltered Jimmy Jummy (Judd) Slough area.
3.05	Supply, place, and compact granular base for dike crest surface	m^2	8,040	$ 20	$ 160,800	
3.06	Supply and install safety railing for land-side edge of dike crest (above retaining wall)	m	1,340	$ 200	$ 268,000	Railing required above retaining wall.
				SUBTOTAL FOR TASK	**$ 12,198,111**	
4	**Utilities**					
4.01	Allownace to replace existing floodbox at Horse Creek with a fish-friendly flo	LS	1	$ 700,000	$ 700,000	Note: high level of uncertainty due to lack of hydrologic analysis to support design criteria and cost estimate.
4.02	Allownace to replace existing Eagle Run pump station and floodbox	LS	1	$ 1,500,000	$ 1,500,000	
4.03	Allowance to replace Judd Slough (Fishermen's Park) pump station and floodbox (fish-friendly)	LS	1	$ 6,000,000	$ 6,000,000	
				SUBTOTAL FOR TASK	**$ 8,200,000**	
5	**Restoration, Finishes, & Amenities**					
5.01	Allowance for landscape restoration, landscaping, and trail furniture	LS	1	$ 500,000	$ 500,000	High coss anticipated due to adjacent private property landscape restoration requirements.
				SUBTOTAL FOR TASK	**$ 500,000**	
	CONSTRUCTION COST SUBTOTAL				**$ 25,550,703**	
	ALLOWANCES & CONTINGENCIES					
	Professional services & construction administration	5%			$ 1,277,535	
	Habitat impact compensation	5%			$ 1,277,535	Lower end of compensation allowance given limited impacts during construction
	Contingencies	40%			$ 10,220,281	Higher end of contingency range given that this option would involve more challenging conditions than Options A and B due to space limitations
	TOTAL AMOUNT (excl. GST, Rounded)				**$ 38,326,000**	

Note: Estimates have been prepared with little or no site information and as such indicates the approximate magnitude of the cost of the capital tasks, for project planning purposes only. The estimate has been derived from unit costs for similar projects.

Class-D construction cost estimate for upgrading the existing dike in the Eagle Viewing Area by raising it and expanding it towards the land-side (east) (approx. total length: 665 m)

Item	Description	Unit	Estimated Quantity	Unit Rate	TOTAL PRICE $	Comment
1	**General**					
1.01	Mobilization and demobilization	LS	1	$ 277,000	$ 277,000	1% of total cost.
1.02	General conditions, bonding and insurance	LS	1	$ 831,000	$ 831,000	3% of total cost.
1.03	Water management and isolation for bank protection works	m	665	$ 800	$ 532,000	
1.04	Traffic management	week	32	$ 4,800	$ 153,600	4-person crew for 12 months.
				SUBTOTAL FOR TASK	**$ 1,793,600**	
2	**Site Preparation**					
2.01	Tree Clearing	m^2	5,920	$ 7	$ 41,652	
2.02	Grubbing, Clearing & Stripping	m^2	10,542	$ 11	$ 118,491	
2.03	Remove and stockpile existing structures and furniture on the dike	LS	1	$ 7,500	$ 7,500	
				SUBTOTAL FOR TASK	**$ 167,643**	
3	**Ground Improvement for Seismic Performance**					
3.01	Ground improvement via soil mixing zone dike footprint	m^3	86,450	$ 50	$ 4,322,500	1 ground improvement zone (water-side 14 m wide and 9 m deep) running along the dike crest / slope. Challenging conditions given adjacent river channel.
				SUBTOTAL FOR TASK	**$ 4,322,500**	
4	**Dike Construction**					
4.01	Supply, place, and compact dike fill (includes toe berm for seepage control where space is available)	m^3	23,885	$ 50	$ 1,194,263	
4.02	Allowance for additional fill for turnouts and access ramps	LS	1	$ 100,000	$ 100,000	
4.03	Supply and install steel sheetpile seepage cutoff wall & retaining wall (limited to areas where there is no room for a land-side toe berm)	m^2	9,120	$ 500	$ 4,560,000	16 m tall sheetpile wall required for ~500 m of length where there is not sufficient room for land-side toe berm for seepage control / stability.
4.04	Supply and install short-height retaining walls at transition points between land-side toe berm sections and retaining wall dike sections	m^2	188	$ 400	$ 75,000	
4.05	Allowance for riprap revetment buried toe along Siyich'em reach	m	665	$ 4,275	$ 2,842,875	
4.06	Supply and place riprap onto existing riprap slope	m^3	12,330	$ 65	$ 801,443	1 m thick class 250 kg riprap placed onto existing riprap. Lower unit rate for riprap as the length less exposed to impinging river than Siyich'em reach. Challenging conditions given minimal space for construction access.
4.07	Supply, place, and compact granular base for dike crest surface	m^2	3,990	$ 20	$ 79,800	
4.08	Supply and install safety railing for land-side edge of dike crest (above retaining wall)	m	340	$ 200	$ 68,000	Railing required above retaining wall.
4.09	Supply and place topsoil for land-side slope and toe berm	m^2	11,030	$ 10	$ 110,302	
4.10	Supply and apply hydroseeding for land-side slope and toe berm	m^2	11,030	$ 2	$ 22,060	
				SUBTOTAL FOR TASK	**$ 9,853,744**	
5	**Utilities**					
5.01	Allowance for new fish-friendly Dryden Creek pump station and floodbox	LS	1	$ 12,600,000	$ 12,600,000	Note: high level of uncertainty due to lack of hydrologic analysis to support design criteria and cost estimate.
				SUBTOTAL FOR TASK	**$ 12,600,000**	
5	**Restoration, Finishes, & Amenities**					
5.01	Allowance for re-installing Eagle Watch program facilities	LS	1	$ 7,500	$ 7,500	
5.02	Allowance for bare-minimum landscaping	LS	1	$ 50,000	$ 50,000	
				SUBTOTAL FOR TASK	**$ 57,500**	
	CONSTRUCTION COST SUBTOTAL				**$ 28,794,987**	
	ALLOWANCES & CONTINGENCIES					
	Professional services & construction administration	5%			$ 1,439,749	
	Habitat impact compensation	5%			$ 1,439,749	
	Contingencies	30%			$ 8,638,496	
				TOTAL AMOUNT (excl. GST)	**$ 40,313,000**	

Note: Estimates have been prepared with little or no site information and as such indicates the approximate magnitude of the cost of the capital tasks, for project planning purposes only. The estimate has been derived from unit costs for similar projects.

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Appendix H

Engagement Materials and Results Summary

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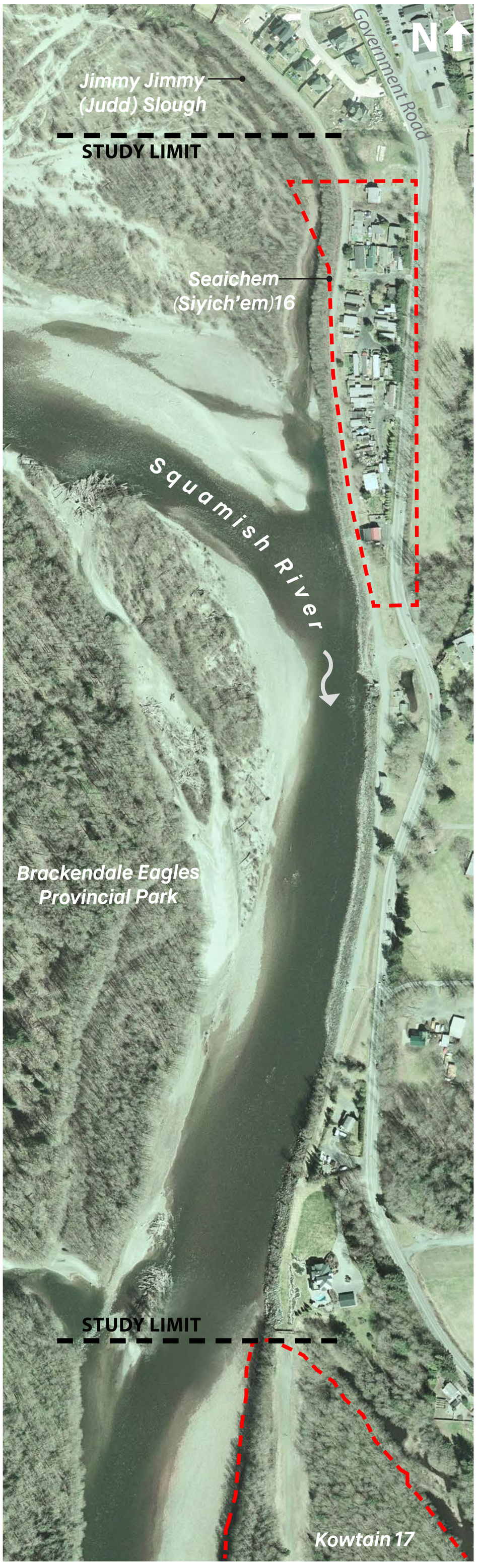
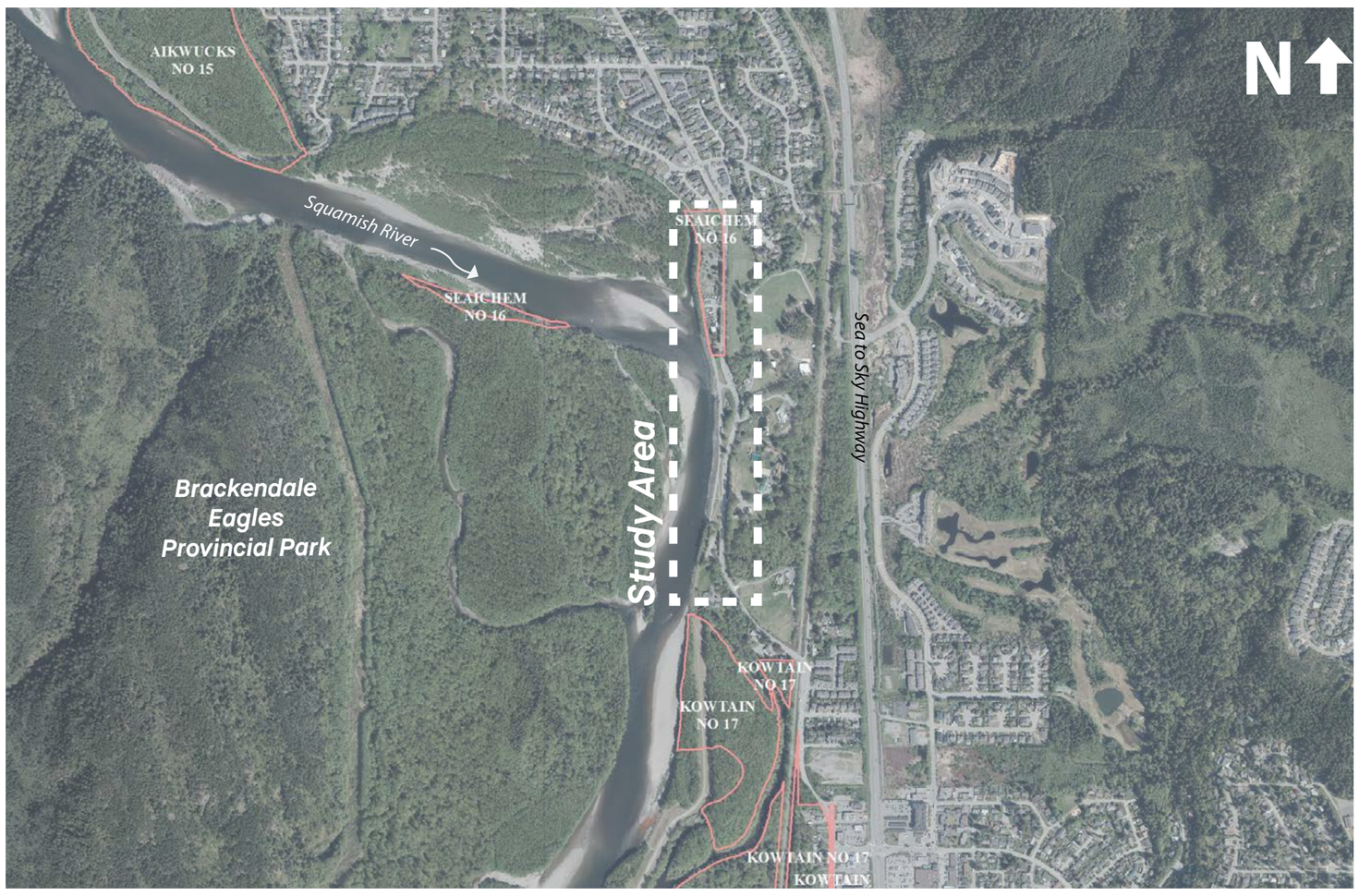
December 2019 Open House Boards

SIYICH'EM RESERVE AND EAGLE VIEWING AREA
PROJECT OVERVIEW

AERIAL OF STUDY AREA



AERIAL OF STUDY AREA WITH CONTEXT



PROJECT OVERVIEW

The project focuses on the area of the Squamish River dike between the northern end of Siyích'em I.R. No. 16 and the northern end of Kowtain I.R. No. 17.

This project assesses options for upgrading the dike protecting Brackendale and the rest of Squamish in accordance with the recently completed Squamish Integrated Flood Hazard Management Plan (IFHMP). The project also considers non-flood protection challenges and opportunities of the area.

The project will consider possible dike alignments and other flood protection options for the area. The aim is to develop a plan which accommodates a number of considerations, including:

- shared jurisdiction between the District and Nation;
- infrastructure on, through, and next to the dike;
- encroaching development;
- private property challenges;
- impinging river flows and debris impact;
- sensitive environmental habitat areas; and
- tourism and recreational use.

This project does not involve implementation, i.e. no dike construction. A future project or projects will implement the plan and will provide further opportunities for input. The master plan project is funded by the federal and provincial government.

SIYICH'EM RESERVE

EAGLE WATCHING

HABITAT

GOVERNMENT ROAD

PATH ALONG DIKE

PUMP STATION

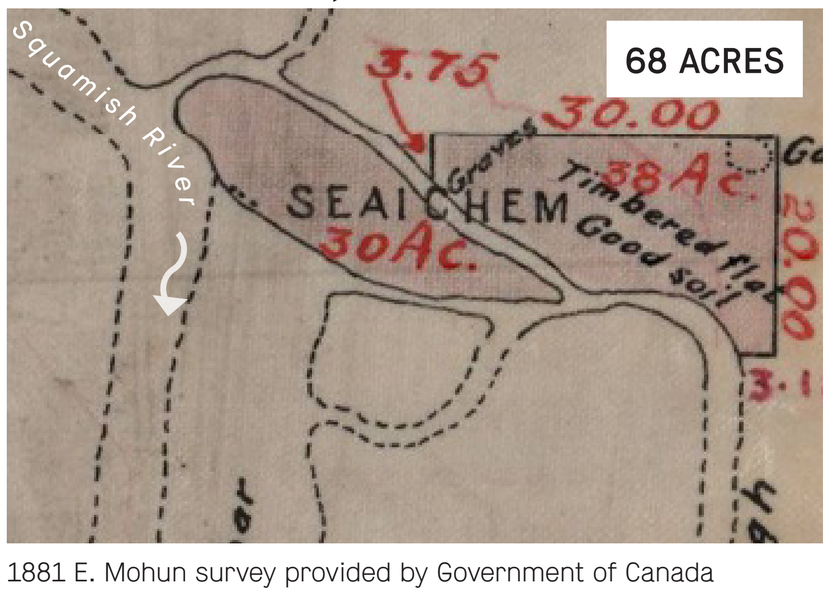
SIYICH'EM RESERVE AND EAGLE VIEWING AREA
RESERVE LAND HISTORY

SIYICH'EM RESERVE LOSS OF LAND

A Government of Canada survey map of the Siyich'em reserve dated 1881 shows that the reserve comprises an island in the river and a mainland parcel on the west side of Government Road. The 1881 survey shows a total area of 68 acres (30 acres on the island and 38 acres on the mainland parcel). The 1881 survey also shows the main Squamish River channel located to the west of the island parcel.

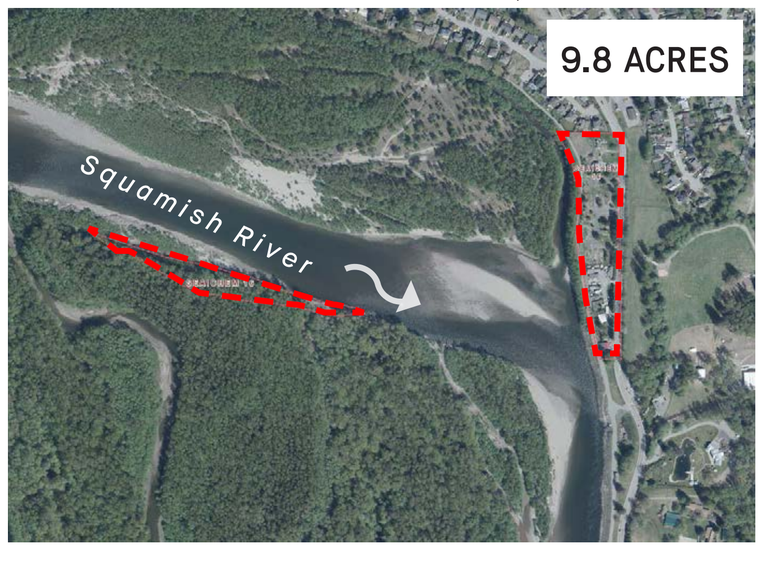
The current Government of Canada mapping of the Siyich'em reserve defines a much smaller area (only 9.8 acres) as the Siyich'em reserve, comprising a 6.6 acre remnant of the mainland parcel and a 3.2 acre remnant of the original island parcel. There are many factors that may have contributed to the physical and mapped loss of land on Siyich'em reserve, including historical diking and river engineering decisions and works, logging practices and logjams, river erosion and alignment change.

SIYICH'EM RESERVE, 1881



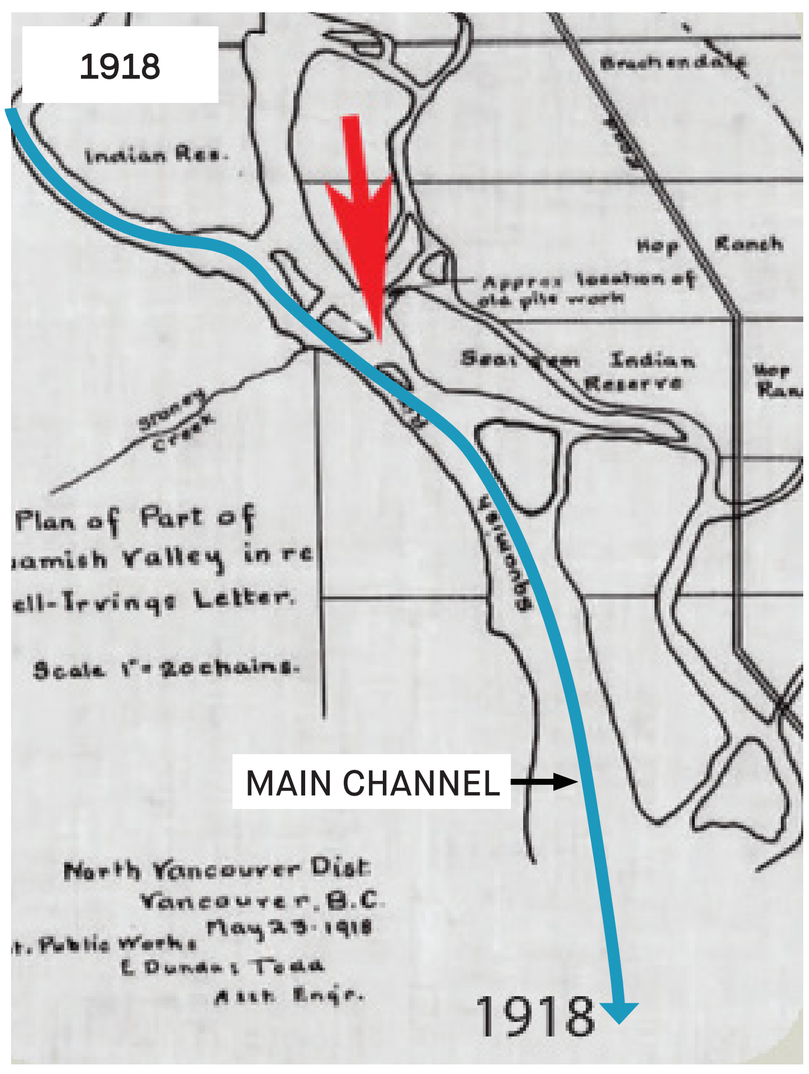
1881 E. Mohun survey provided by Government of Canada

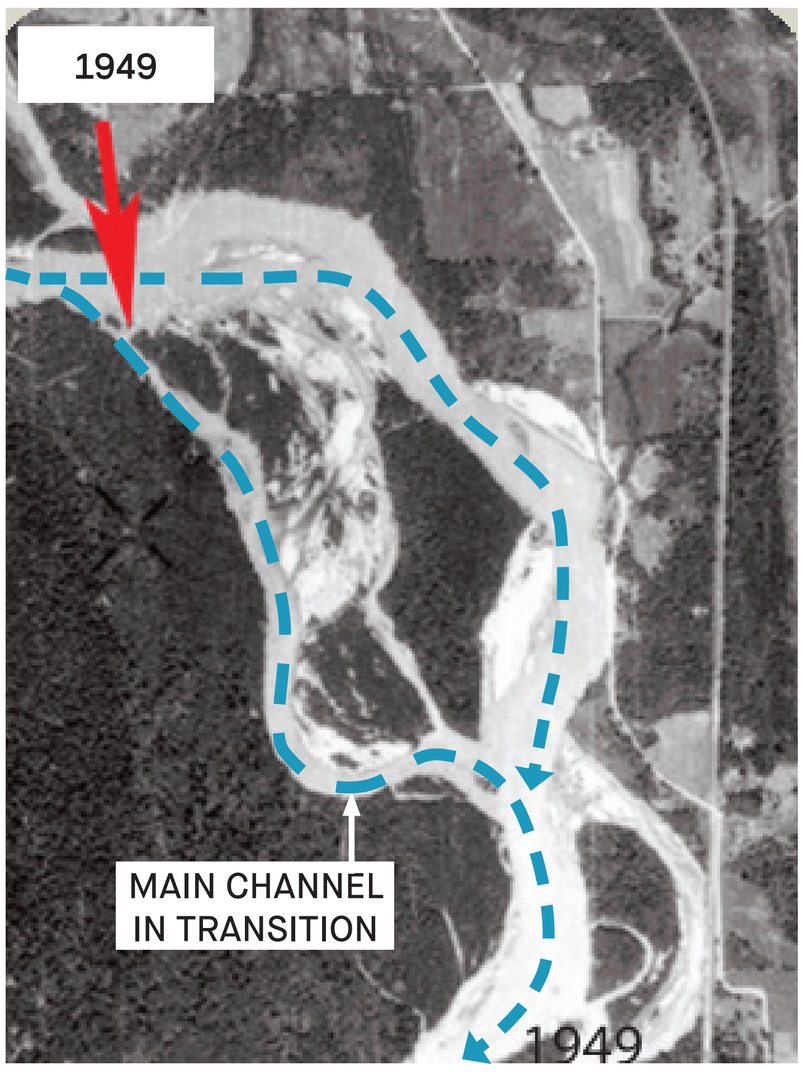
SIYICH'EM RESERVE BOUNDARY, TODAY



RIVER EROSION AND CHANNEL MIGRATION

This panel of historical airphotos shows changes in the Squamish River main channel alignment since the 1900's. The red arrow on each photo is a reference that points to the same approximate location in all three photos. Comparing the 1918 photo (bottom left) to the 2008 photo (bottom right), we can see that the main river channel was located on the west (left) side of the red arrow in 1918 and is now located on the east (right) side of the red arrow. The main channel in 1918 is now a side channel that can be seen on the 2008 photo.





CURRENT CONDITIONS

Homes and structures on the Siyich'em reserve are located immediately adjacent to and below the existing dike.

Forested floodplain areas provide riparian habitat and potential eagle nesting trees.

The south end of the Siyich'em reserve. The Watershed Grill patio is attached to the existing dike crest.

SIYICH'EM RESERVE AND EAGLE VIEWING AREA
HISTORY OF FLOODS AND FLOOD PROTECTION NEEDS

MAJOR FLOODS IN STUDY AREA

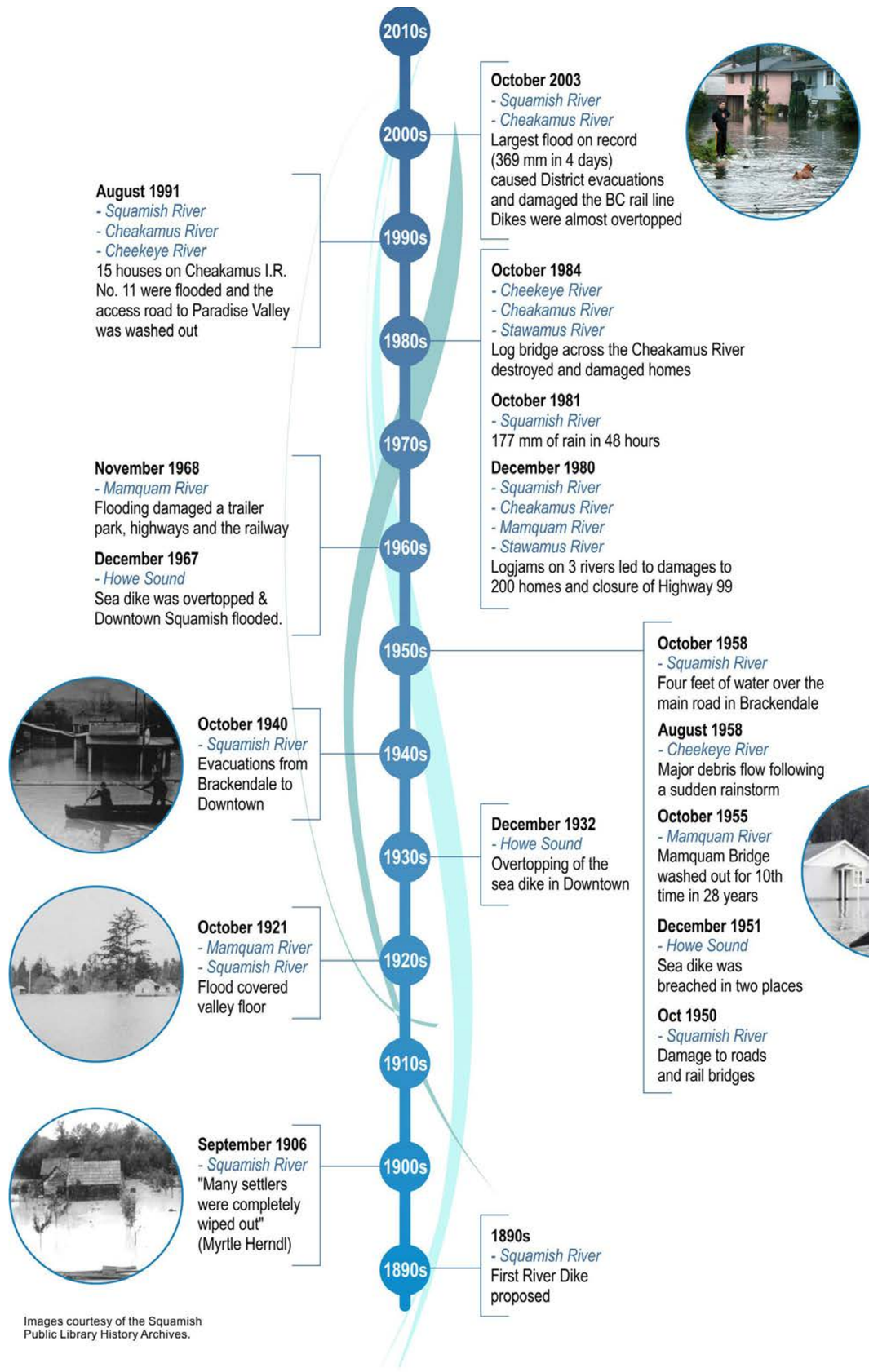
The Squamish valley has a long unrecorded and recorded history of flooding from different rivers and also from Howe Sound. The recent history of floods timeline (right) was created as part of the recent Squamish Integrated Flood Hazard Management Plan (IFHMP) project and shows some of the most notable recorded flood events.

The Siyich'em and Brackendale communities have lived through many Squamish River floods. The photos below recall two of the more notable floods; a major flood in the 1930s and the October 2003 flood, which is the largest Squamish River flood since measurements were formally recorded.

LEVEL OF PROTECTION

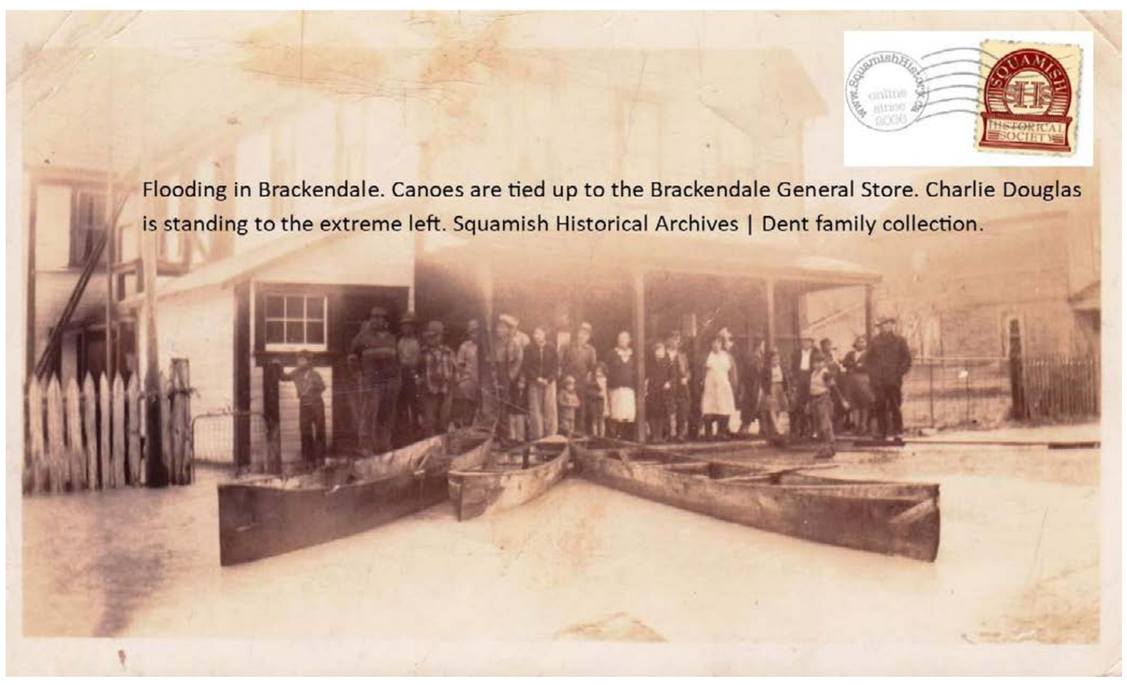
The IFHMP recommends a '500-year return period' level of protection for Squamish River dikes. A 500-year return period flood can happen in any year, but it has a very low probability (0.2% per year).

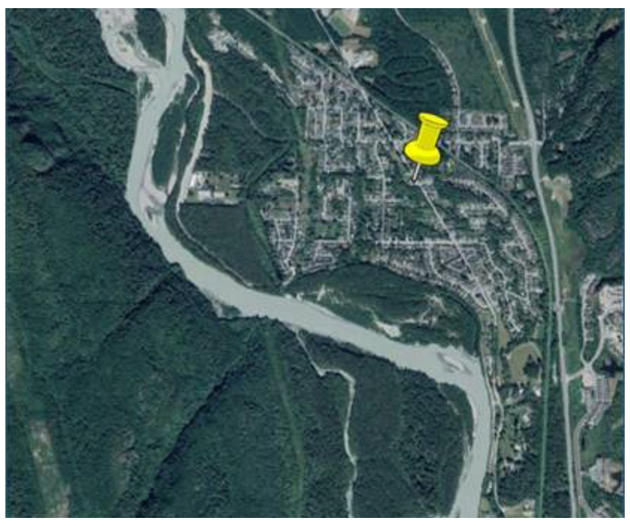
RECENT HISTORY OF FLOODS IN SQUAMISH



Images courtesy of the Squamish Public Library History Archives.

1930s BRACKENDALE GENERAL STORE

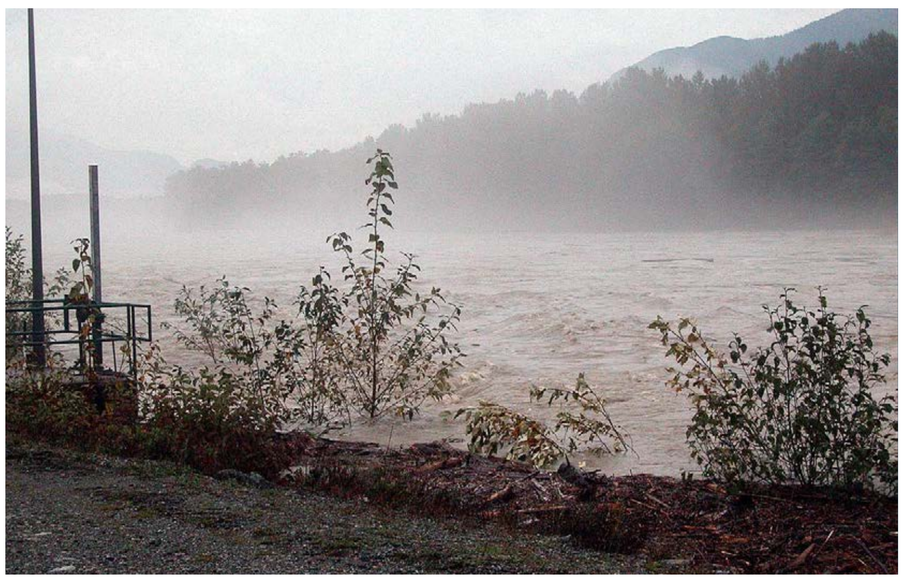




(Above) Canoes tied up at the Brackendale General Store during a major flood in the 1930s. Photo provided by the Squamish Historical Society.

(Left) Brackendale General Store is located approximately 0.5 miles (850 metres) from the current Squamish River Channel.

2003 FLOOD



Floodwaters lapping at the Squamish River dike at Dyrden Creek pump station within the study area during the October 2003 flood. Records indicate that the river level reached within 0.3 m (1 foot) of the dike crest. Major seepage* and piping* (sand boil) issues were observed raising concerns about dike stability – fortunately, the dike did not breach and floodwaters receded.

SEEPAGE FLOODING IN SIYICH'EM DURING OCTOBER 2003 FLOOD

Seepage* through the dike caused ponding and shallow flooding in Siyich'em reserve during the October 2003 flood. Seepage flooding is experienced regularly on the Siyich'em reserve during large Squamish River floods.

* **Seepage**: The flow of water through the dike.

* **Piping:** The loss of fine sediments through the dike resulting in the formation of a pipe gap.

SIYICH'EM RESERVE AND EAGLE VIEWING AREA
DIKE MASTER PLAN PROCESS

WHAT IS A DIKE MASTER PLAN?

The dike master plan will be a document that expresses the preferred vision and concept for upgrading flood protection within the study area while acknowledging and addressing non-flood protection related issues that are related to the study area. The master plan will guide future detailed design and construction projects that will implement the plan. The master plan development is led by a project steering committee comprising District, Nation, and Government of Canada representatives, supported by a consulting team of engineers, biologists, and landscape architects. The project timeline is presented below. The project timeline is governed by the funding grant deadline of Spring 2020. Engagement with the Squamish Nation and community stakeholders is an important component of the project and is also described below.

PROJECT TIMELINE

NATION AND DISTRICT COMMON INTERESTS FOR OPTIONS DEVELOPMENT

The project steering committee developed the following 7 common interests to guide the identification, development, and evaluation of flood protection options. These interests span flood protection, land tenure, environmental, social/cultural, recreational and financial factors.

- ADDRESS FLOOD RISK AND PUBLIC SAFETY
- RECAPTURE SQUAMISH NATION LAND AND ENABLE BENEFICIAL USE
- OPTIMIZE PROJECT COSTS
- MINIMIZE IMPACTS TO THE ENVIRONMENT
- ADDRESS IMMEDIATE FLOOD RISK, WHILE ENABLING LONG TERM APPROACHES
- ACKNOWLEDGE AND REFLECT SITE HISTORY AND CULTURE IN DESIGN AND IMPLEMENTATION
- ENABLE FUTURE COLLABORATION ON RESOLVING DIKE/PATH ACCESS ISSUES

HOW AND WHEN CAN I PARTICIPATE?

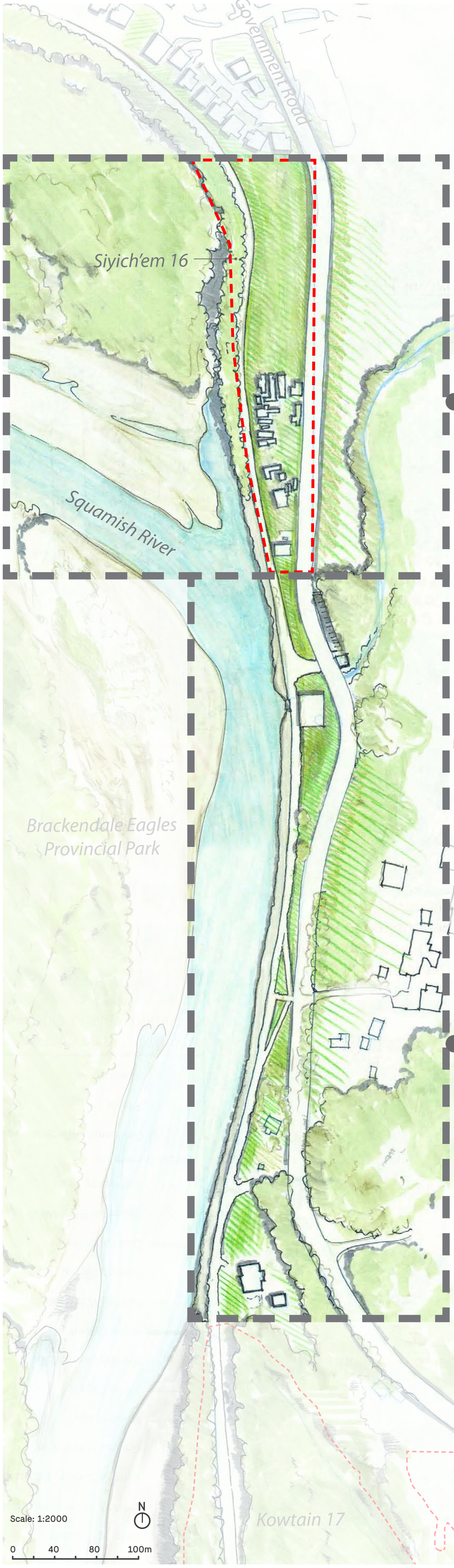
Stakeholder participation is important to the success of the project, and input is sought for the following tasks:

- Gathering values and concerns related to the site;
- Review of options shortlisted by the District and Nation now; and
- Review of the draft master plan.

THE ENGAGEMENT PROCESS INCLUDES THE FOLLOWING FORMATS / VALUES:

- Online survey on values and concerns related to the site (on-going);
- Targeted stakeholder workshops to gather feedback on shortlisted options (complete);
- Public open house and online survey to gather feedback on shortlisted options (December 5, 2019);
- Targeted workshops to gather feedback on the draft master plan (Spring 2020); and
- Public open house and online survey to gather feedback on the draft master plan (Spring 2020).

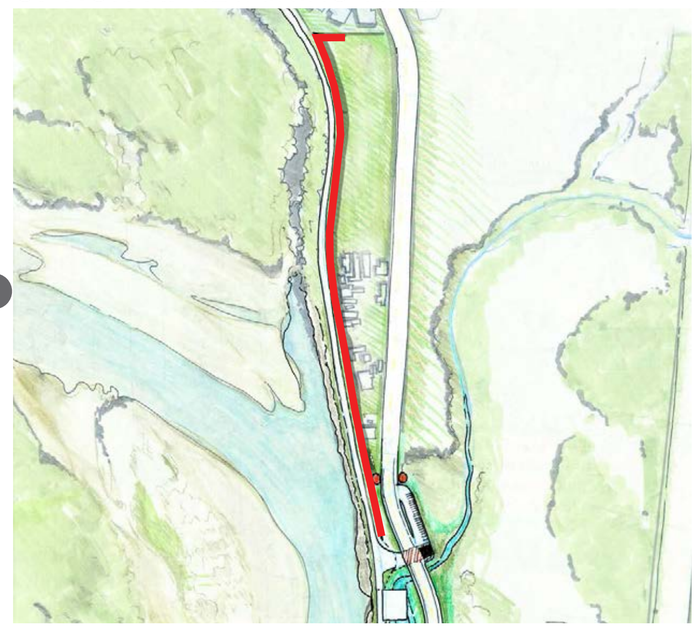
SIYICH'EM RESERVE AND EAGLE VIEWING AREA
REACH BOUNDARIES AND SHORTLISTED OPTIONS



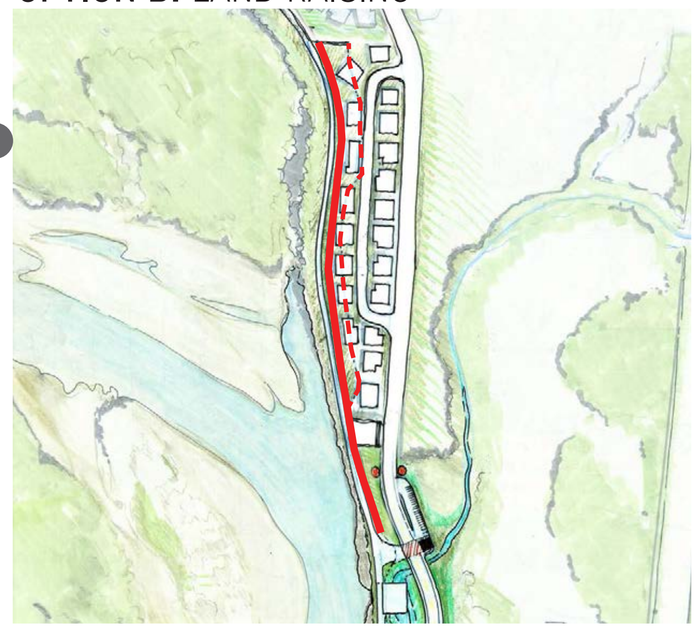
REACH 1: SIYICH'EM RESERVE

3 OPTIONS

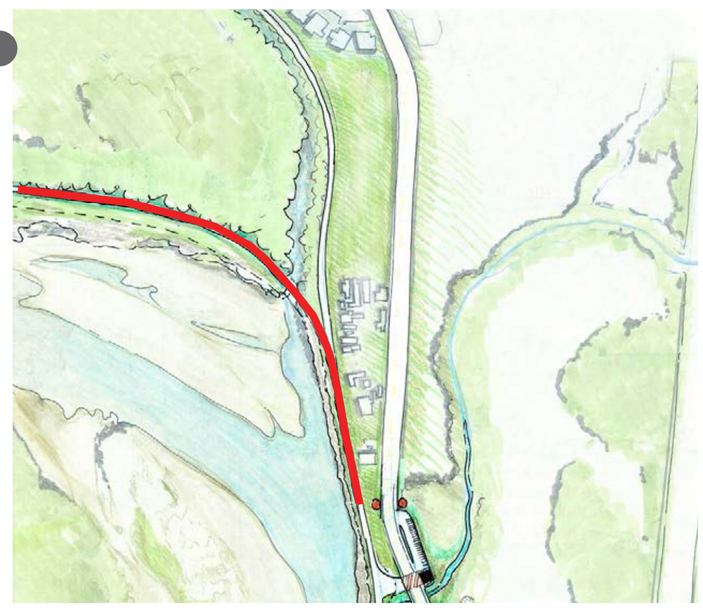
OPTION A: RETAINING WALL



OPTION B: LAND RAISING



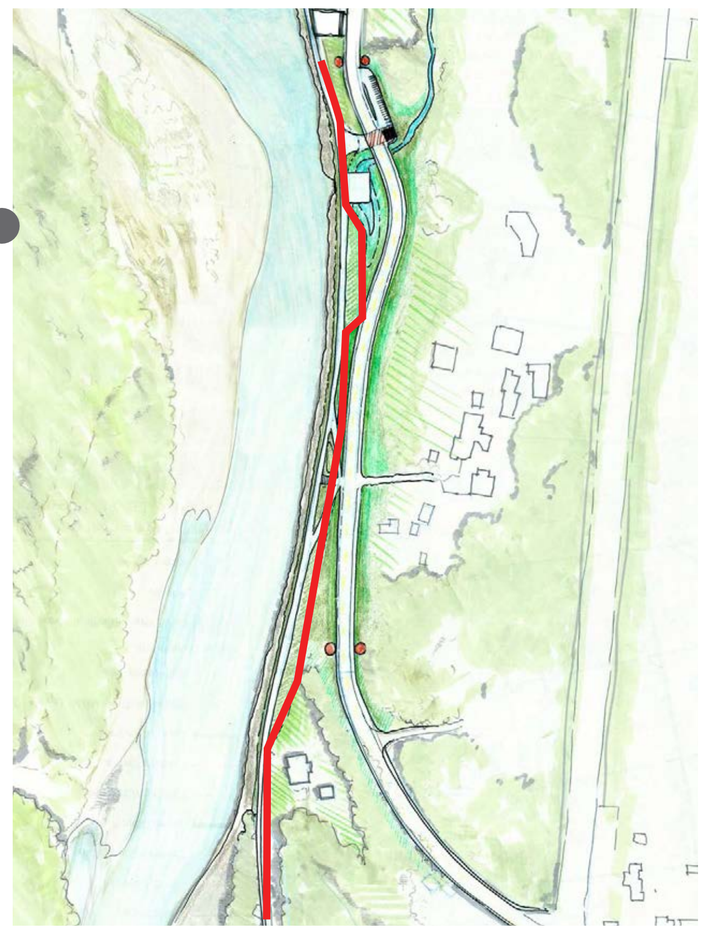
OPTION C: NEW DIKE AND LAND RECAPTURE



REACH 2: EAGLE VIEWING AREA

1 OPTION

LAND-SIDE RAISE



REACH 1: SIYICH'EM RESERVE
OPTION A: RETAINING WALL

DESCRIPTION:

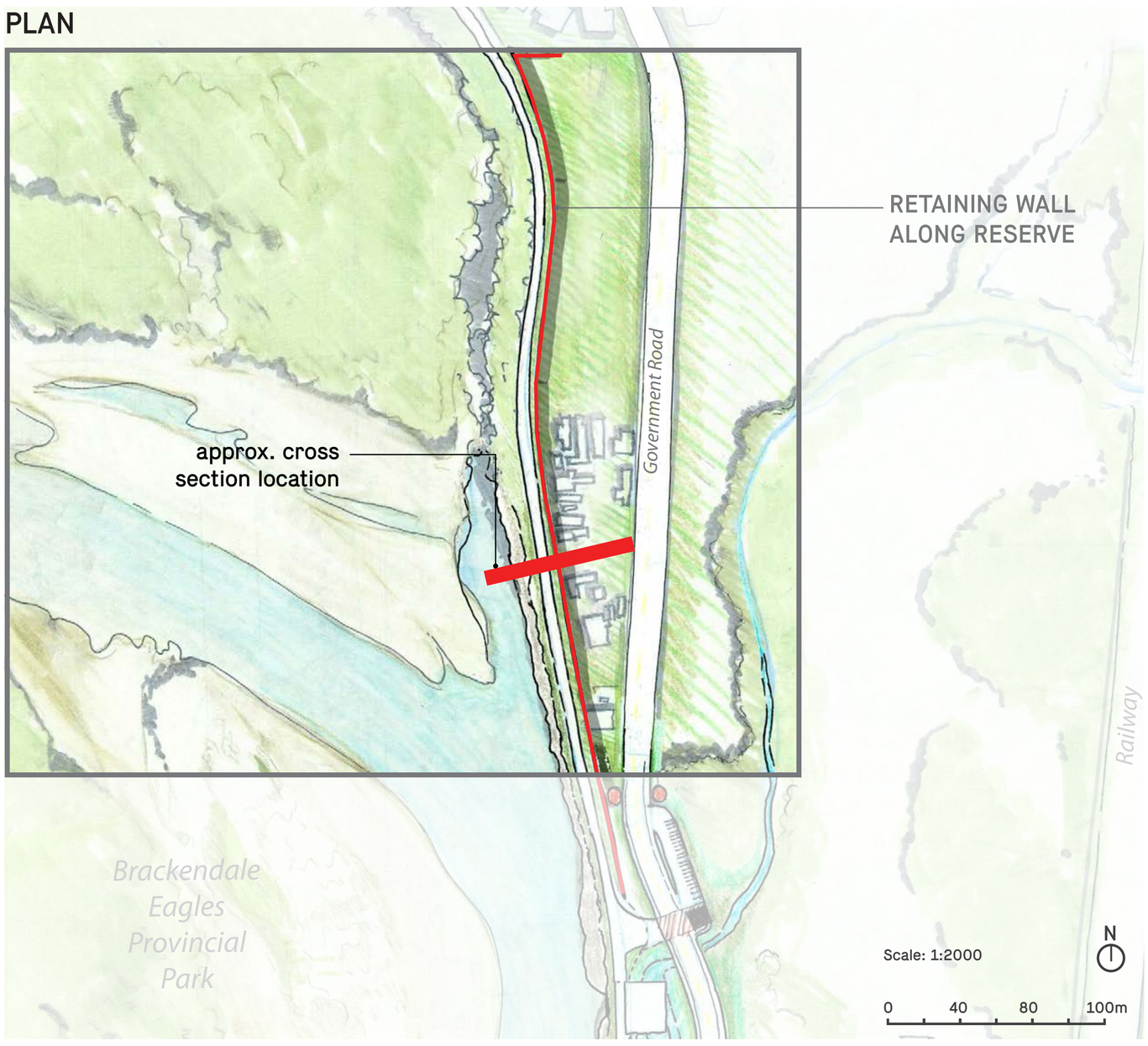
This option involves raising the existing dike crest by approximately 1.5m while limiting the dike footprint to the existing footprint by using retaining walls to contain the raised dike. The total retaining wall height will be 5m or more, and the wall would disrupt views for existing structures on the reserve. This approach aims to prevent any further dike encroachment onto Siyich'em land, however the Watershed Grill structure attached to the existing dike would need to be removed.

A deep cutoff wall would be incorporated into the dike for seepage control, but it may not be fully effective at reducing seasonal seepage volumes through the reserve given the low-lying elevation of the reserve.

Existing riprap bank protection may need to be upgraded which could involve limited work in the Squamish River to provide adequate protection against river scour. Ground improvement measures may be required to improve seismic performance of the proposed dike upgrade.

Land tenure for dike maintenance (e.g. a right-of-way) does not currently exist and the preferred right-of-way width including extending 7.5m from the dike toe would not be possible given the location of existing structures on Siyich'em.

PLAN

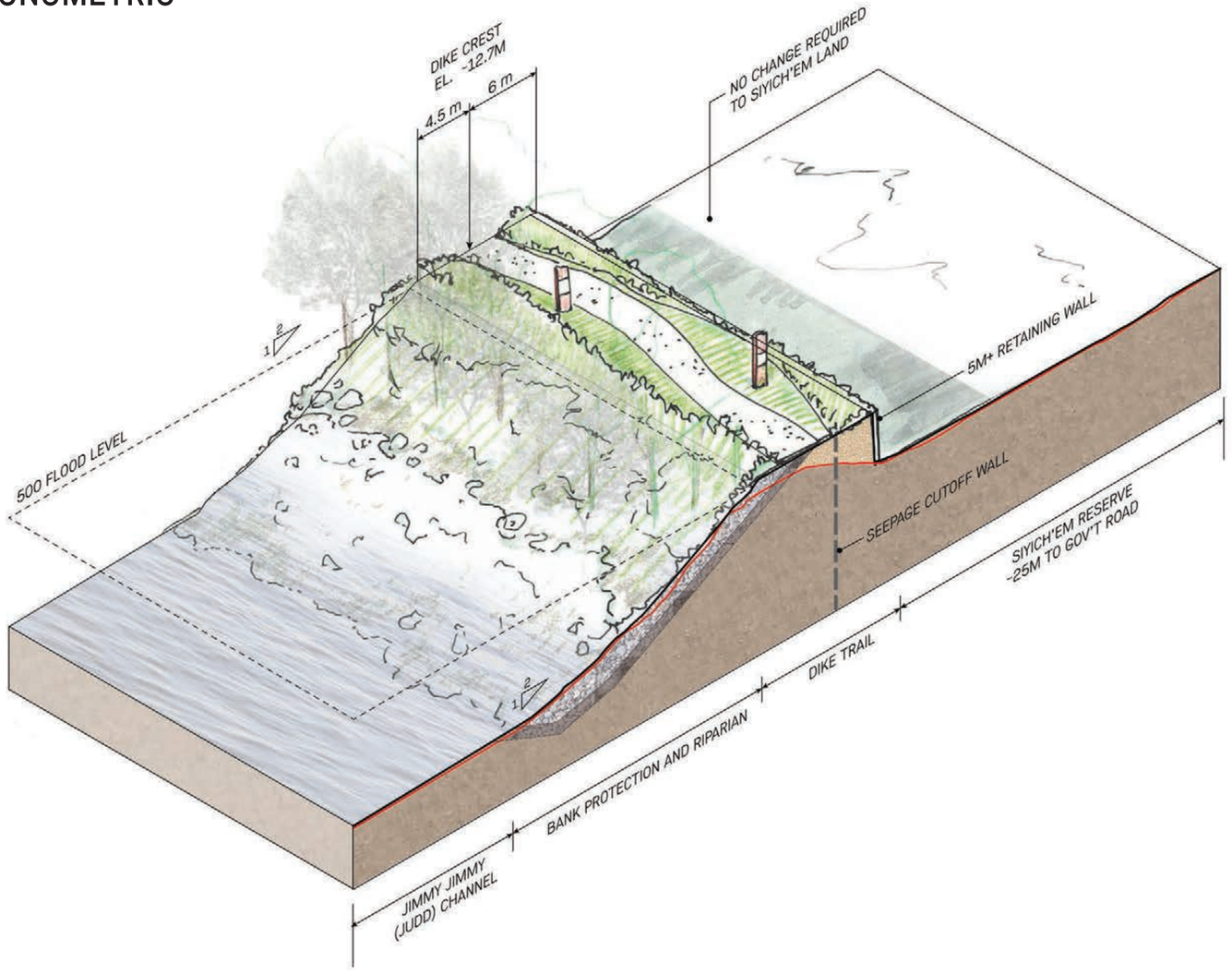


PRECEDENTS

APPROX. 5M+ HIGH RETAINING WALL

RETAINING WALL ADJACENT TO HOMES

AXONOMETRIC



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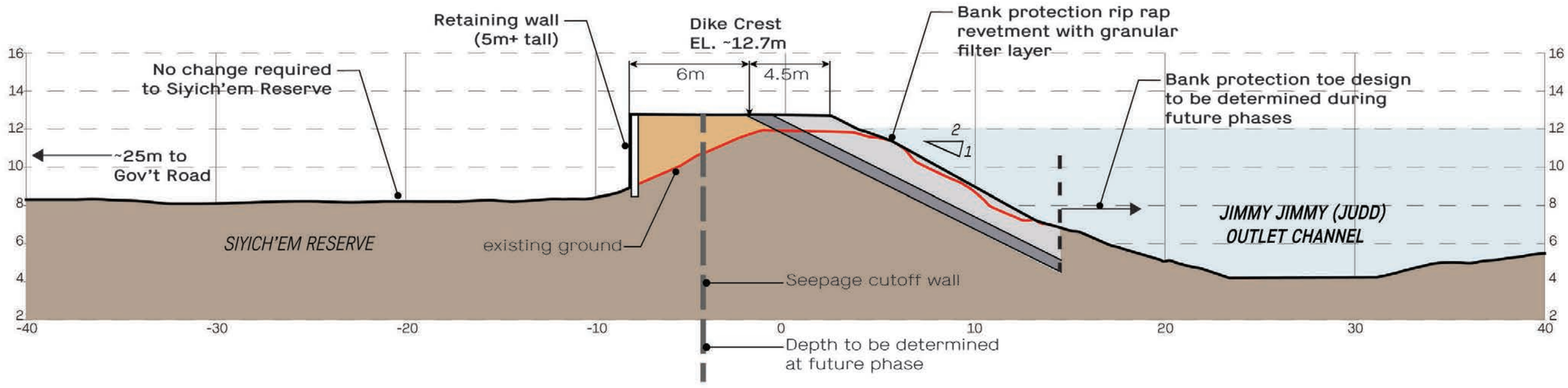


REACH 1: SIYICH'EM RESERVE
OPTION B: LAND RAISING

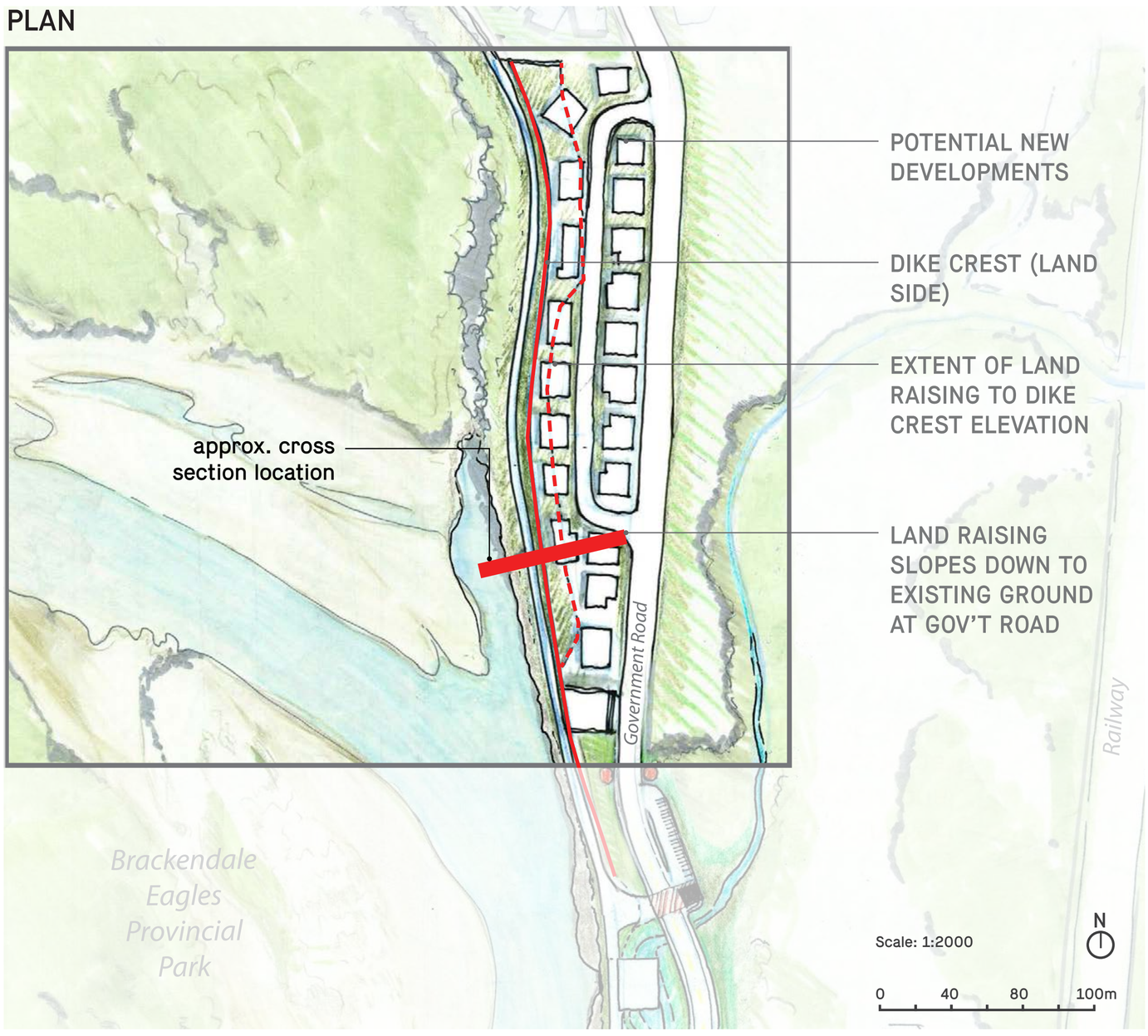
DESCRIPTION:

This option involves raising Siyich'em land up to the proposed dike crest elevation (approximately 1.5m above the current dike crest). This approach would require removal and replacement of the existing structures and services on the reserve but would benefit the reserve as the replacement structures (and future development) would be significantly more protected from seasonal seepage issues and afforded a better vantage over the river. The raised land would slope down to meet Government Road with the potential use of short height (~1 m) retaining walls.

The land raising would negate the need for a deep cutoff wall within the dike for seepage control. Existing riprap bank protection may need to be upgraded which could involve limited work in Squamish River to provide an adequate protection against river scour. Ground improvement measures may be required to improve seismic performance of proposed dike upgrade.

Land tenure for dike maintenance (e.g. a right-of-way) does not currently exist. Under this approach, the regulated dike would be a 6 m wide portion of the raised land along the river bank(plus the riprap bank protection). The conventional right-of-way extending 7.5m from the dike toe could be negated given the area of raised land acting as part of the dike.

PLAN

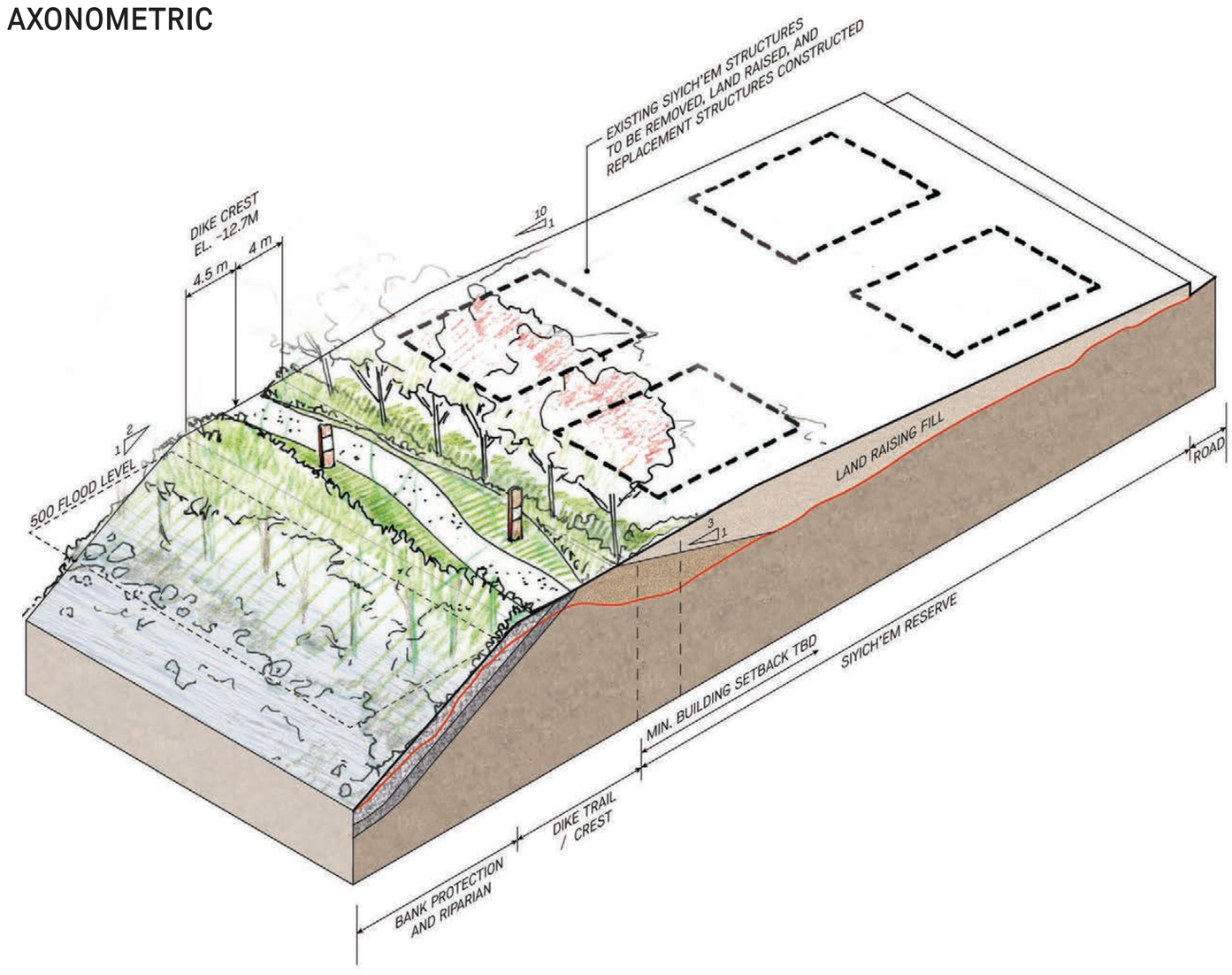


PRECEDENTS

HOMES WITH RETAINING WALLS TO MANAGE GRADES

TERRACED/ BUILDING ON SLOPE

AXONOMETRIC



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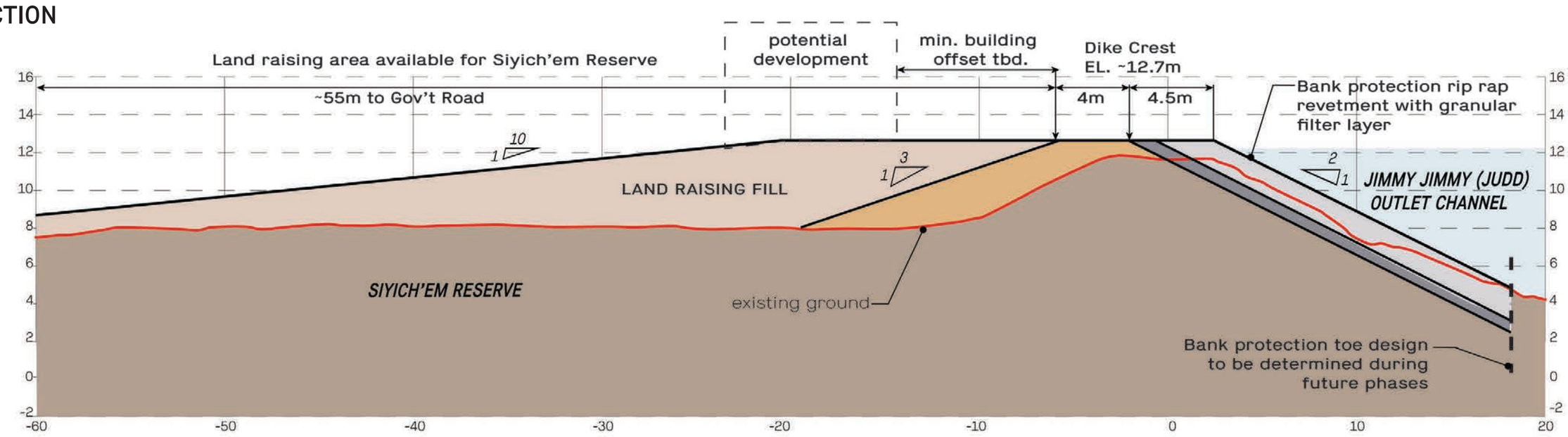


REACH 1: SIYICH'EM RESERVE
OPTION C: NEW DIKE AND LAND RECAPTURE

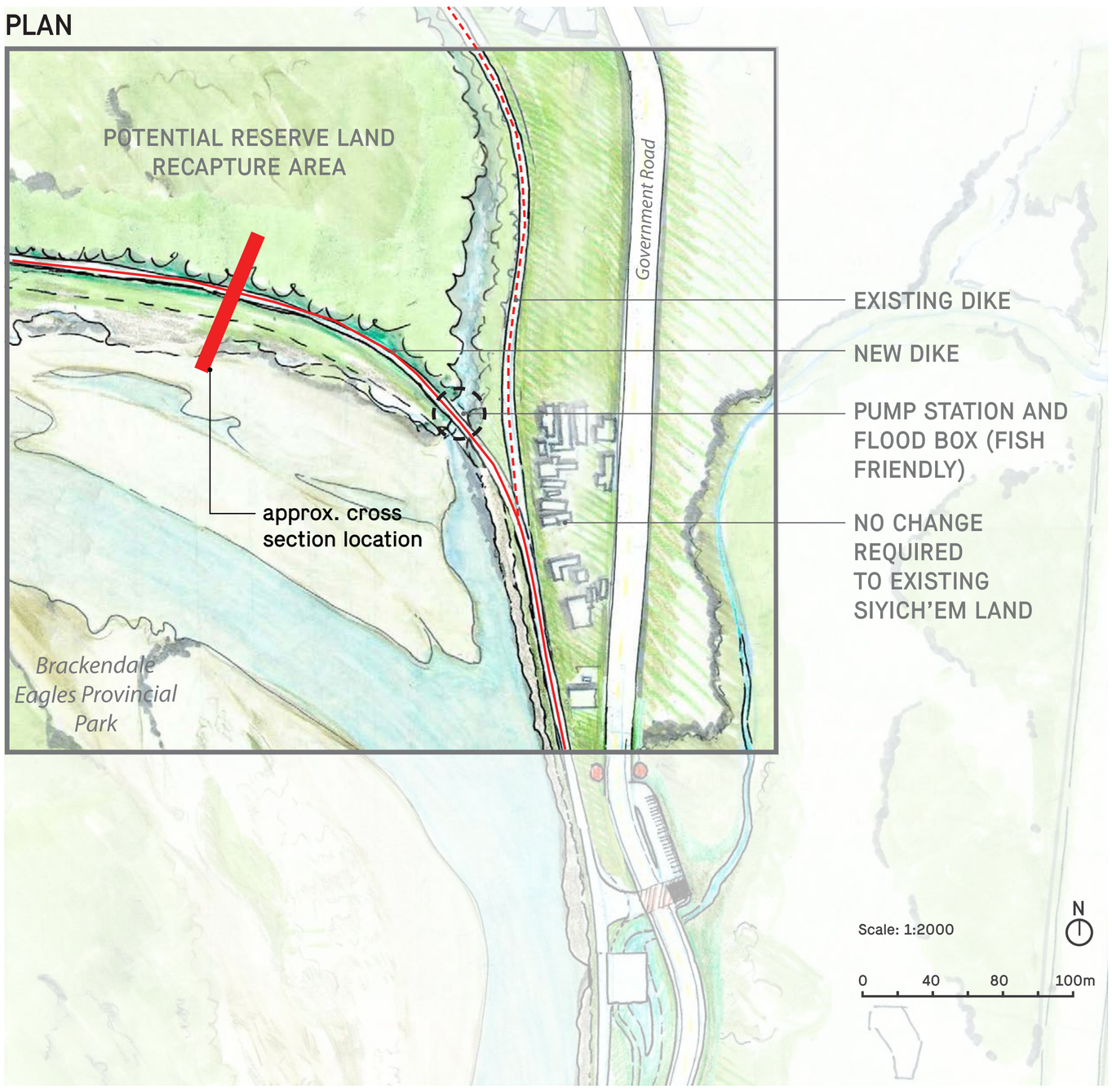
DESCRIPTION:

This option involves constructing a dike on a new alignment heading north-west from Siyich'em reserve along and setback from the active Squamish River bank and connecting to the existing dike at Fisherman's Park. This approach would enable the recapture and beneficial use of lost reserve lands for the Squamish Nation. It may also be possible to use the general approach of a new dike alignment to further reduce flood risk by providing additional internal floodway capacity (where floodwaters could safely be conveyed following an upstream dike breach). However, additional technical work would be required to study this and it may require significant modifications to the concept presented here.

The new dike alignment would partially disconnect a large, forested gravel bar island from the Squamish River. Partial connection could be maintained via a fish-friendly pump station at the outlet of Jimmy Jimmy (Judd) Slough. The dike alignment would be set back from the active river channel by 30m or more, except for the connection points at Fisherman's Park and at the existing dike near the south edge of Siyich'em reserve. The potential impact on flood levels should be investigated for potential transfer of risk and/or additional dike upgrading requirements upstream.

The dike alignment would replace the existing Squamish River dike located along Eagle Run Drive and the cost of future upgrades for the Eagle Run Drive dike should be discounted from the cost of the proposed dike alignment.

PLAN



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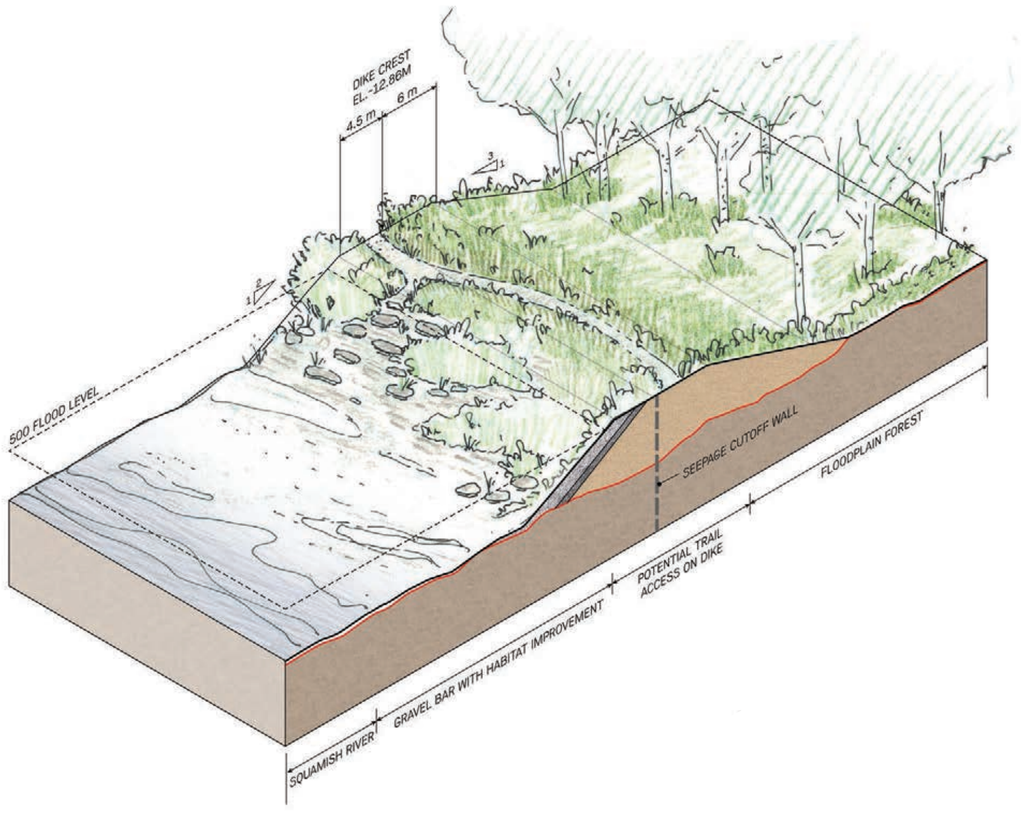
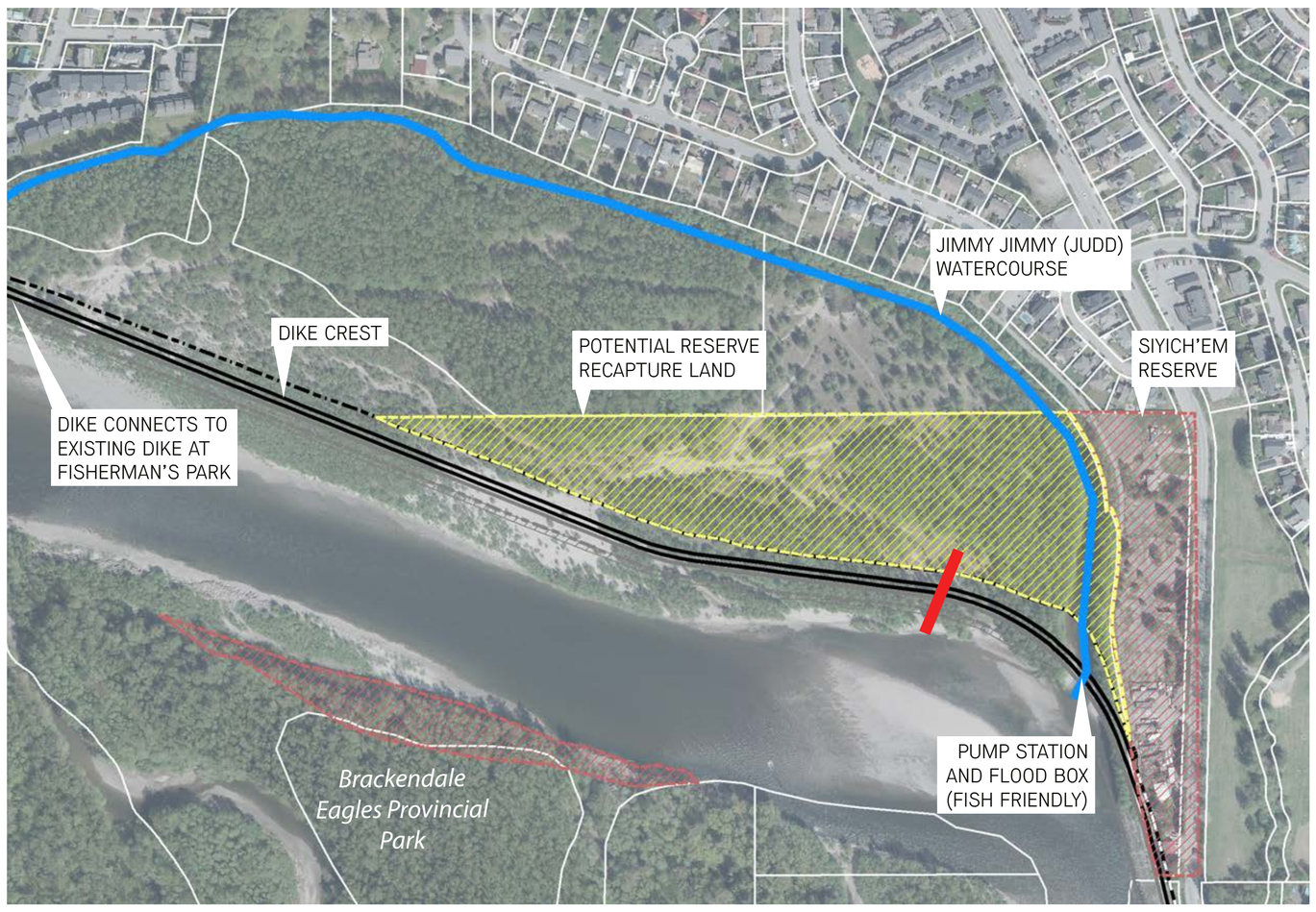


PLAN SHOWING EXTENT OF LAND RECAPTURE AND NEW DIKE



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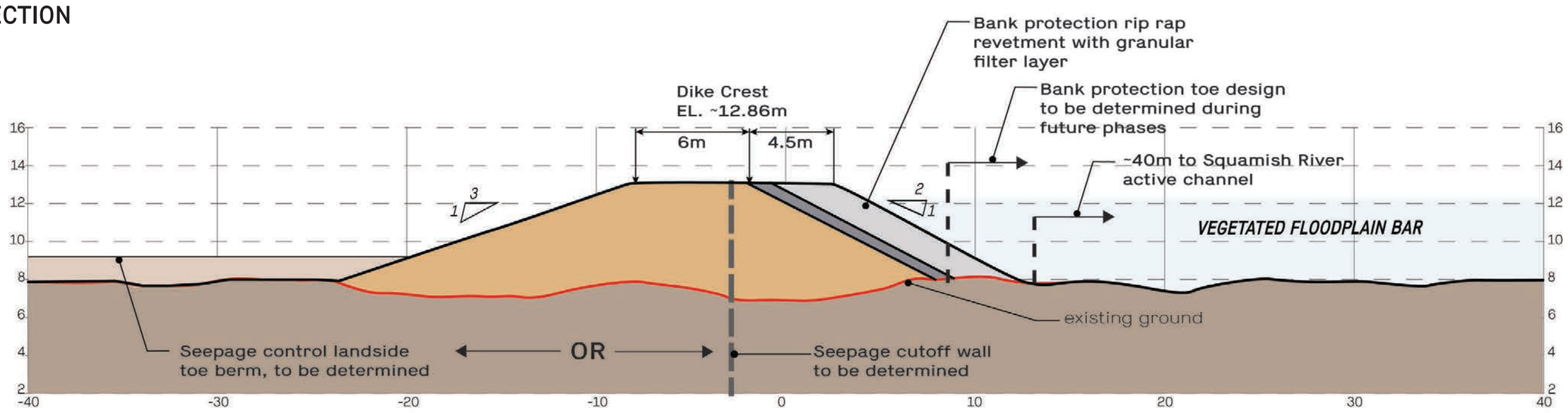


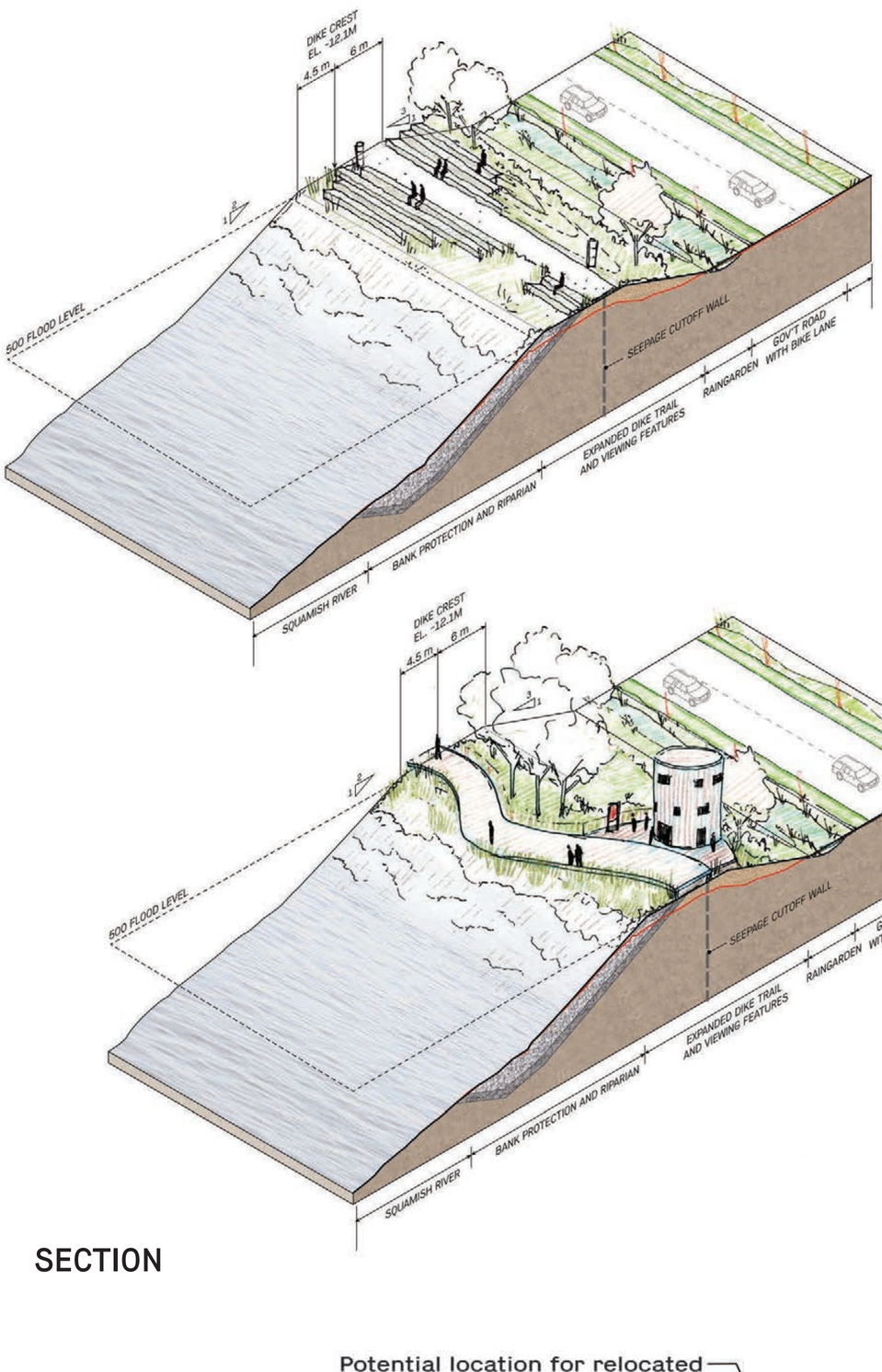
REACH 2: EAGLE VIEWING AREA
LAND-SIDE RAISE

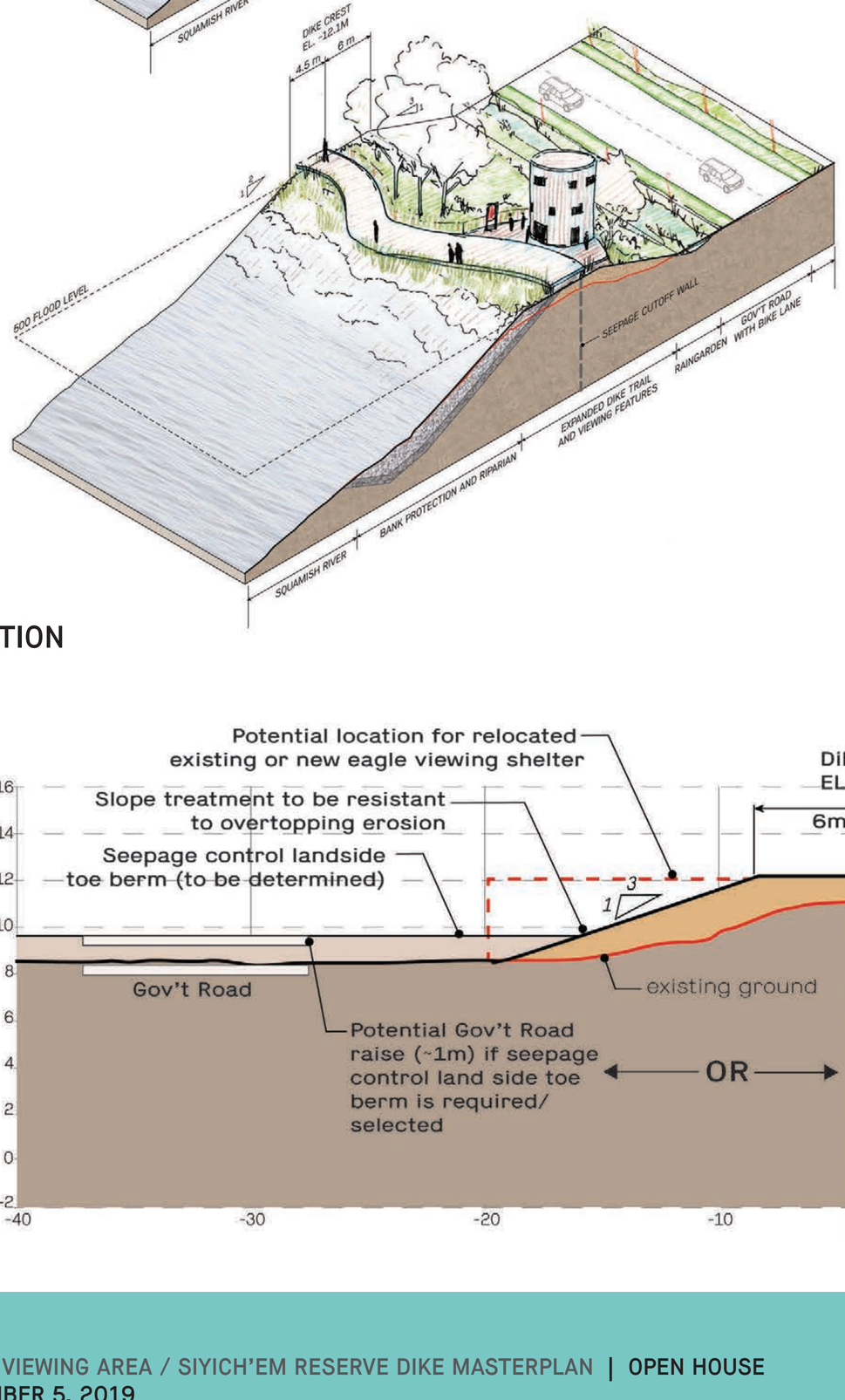
DESCRIPTION:

This option involves raising the existing dike crest by approximately 1.5 m between Dryden Creek pump station and the north boundary of Kowtain I.R. 17.

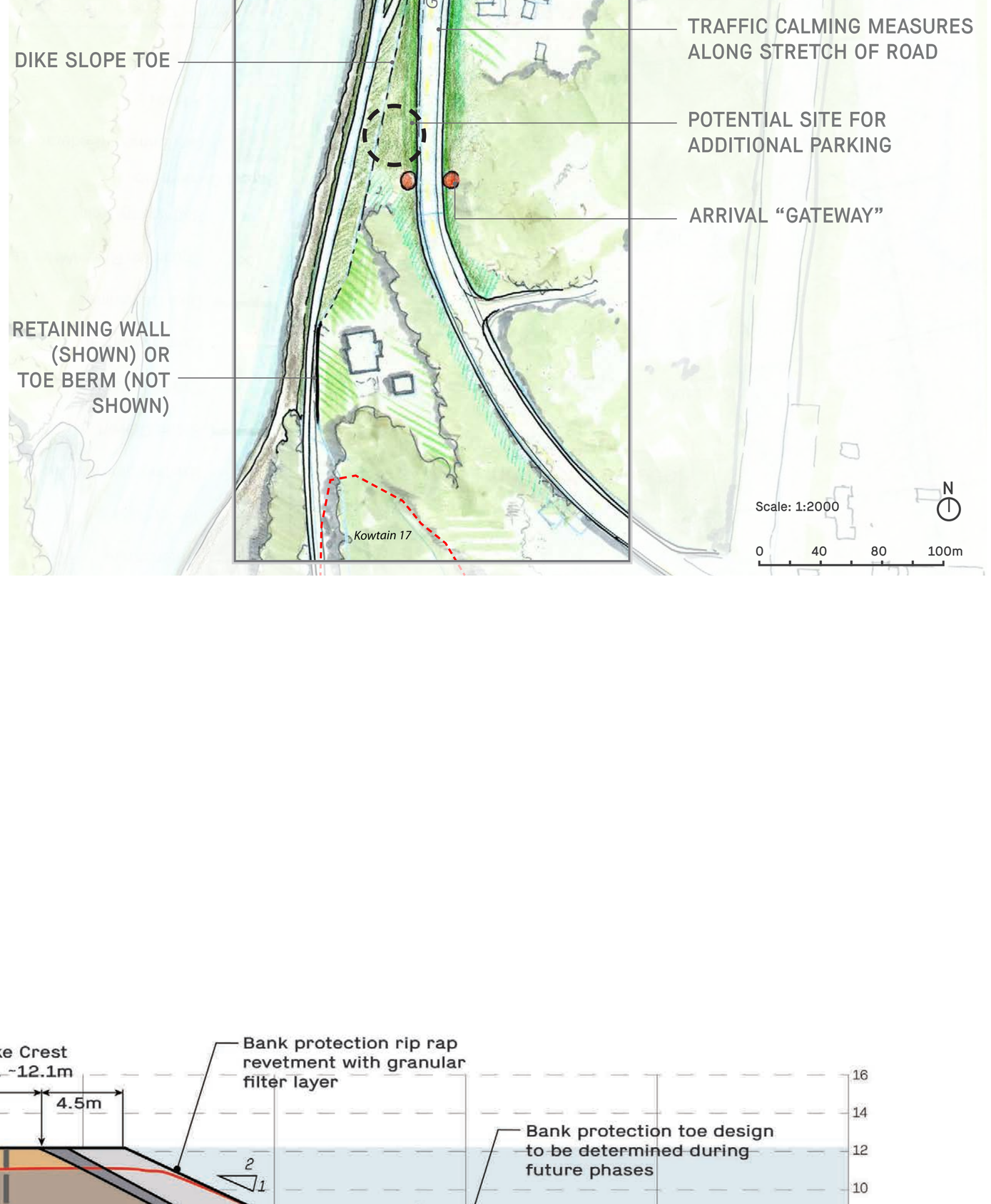
In general, the dike footprint would be expanded towards the land (east) with a vegetated slope at a gradient of 3 horizontal to 1 vertical. Retaining walls would be used to limit the footprint in areas with limited space due to existing infrastructure and/or structures. Existing riprap bank protection may need to be upgraded which could involve limited work in the Squamish River to provide adequate protection against river scour. Seepage control would be provided using either an internal, deep seepage cut-off wall or a land-side toe berm (approximately 15 m wide, 1.5 m thick). If a toe berm is selected, it may conflict with Government Road which could be addressed by localized raising of Government Road. Ground improvement measures may be required to improve seismic performance of the proposed dike upgrade.

Existing eagle viewing facilities (shelter, interpretative signage, etc.) and benches would be removed and replaced/ upgraded. Dike upgrades at Dryden Creek pump station may trigger pump station upgrades.





PLAN



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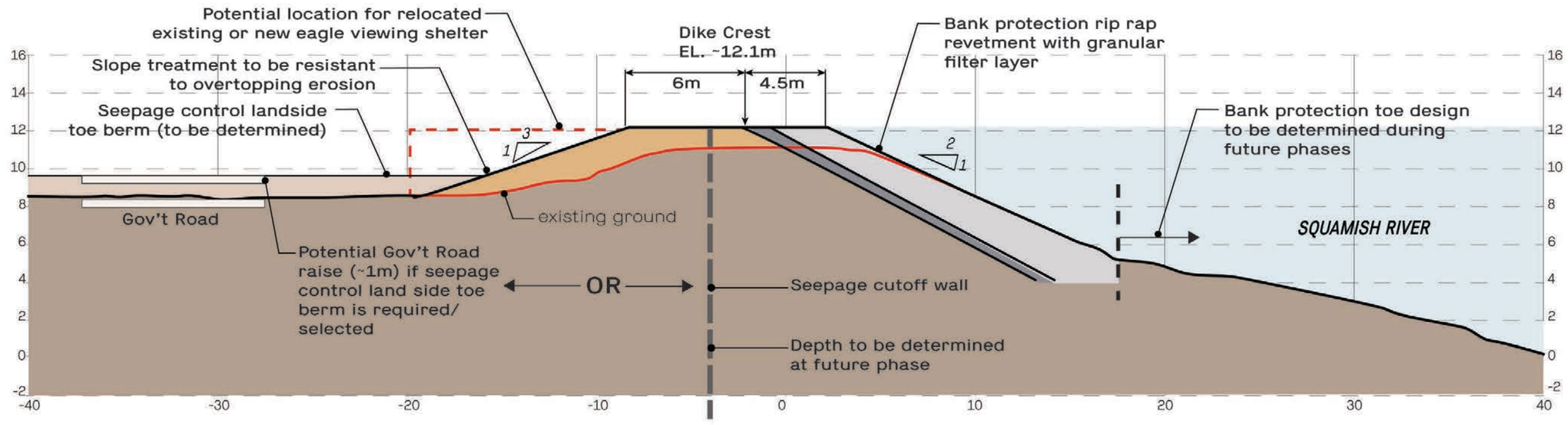


REACH 2: EAGLE VIEWING AREA
PUBLIC AMENITY CONCEPTS

CURRENT CONDITIONS

PARKING LOT

DRYDEN CREEK PUMP STATION

PORTABLE TOILETS

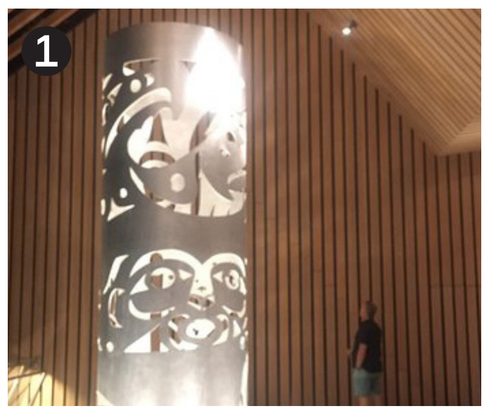
EAGLE WATCH PROGRAM

DIKE TRAIL WITH BENCHES

ARRIVAL AND WAYFINDING

GATEWAY

LOCAL ART

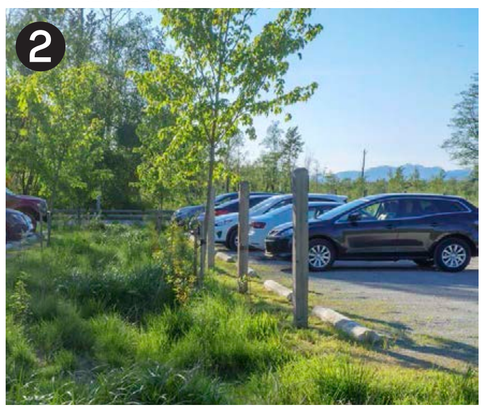


Rick Harry

TRAIL WAYFINDING

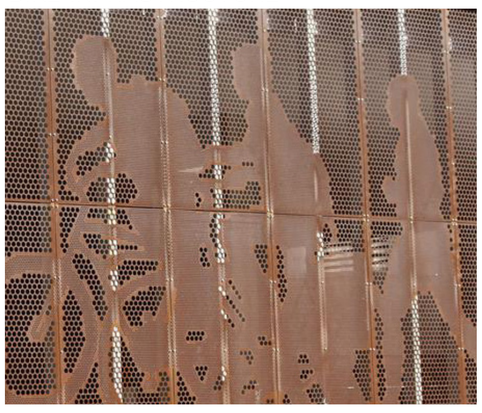
VISITOR FACILITIES

FORMALIZED/ EXPANDED PARKING



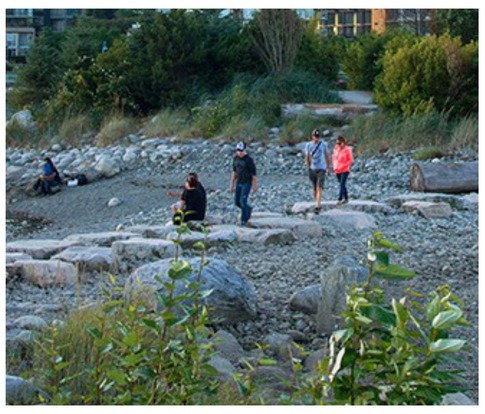
PERMANENT WASHROOMS

BIKE INFRASTRUCTURE



RECREATION AND EDUCATION

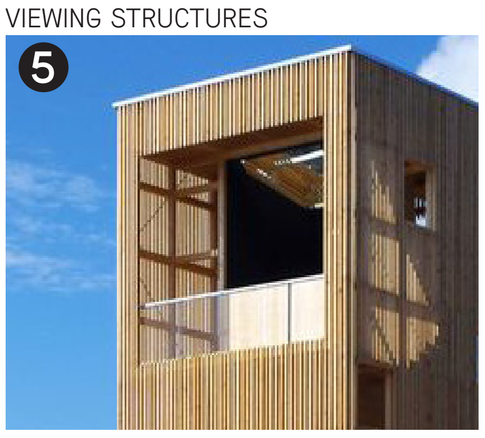
OUTDOOR CLASSROOM



SOCIAL SEATING

COMBINE PUMP STATION UPGRADE WITH VIEWING STRUCTURE

VIEWING STRUCTURES



INTERPRETIVE SHELTER

ACCESS THE WATER

PLANTING AND HABITAT IMPROVEMENTS

WETLAND HABITAT

ENHANCED NATIVE PLANTING

BOARDWALK OVER PLANTING

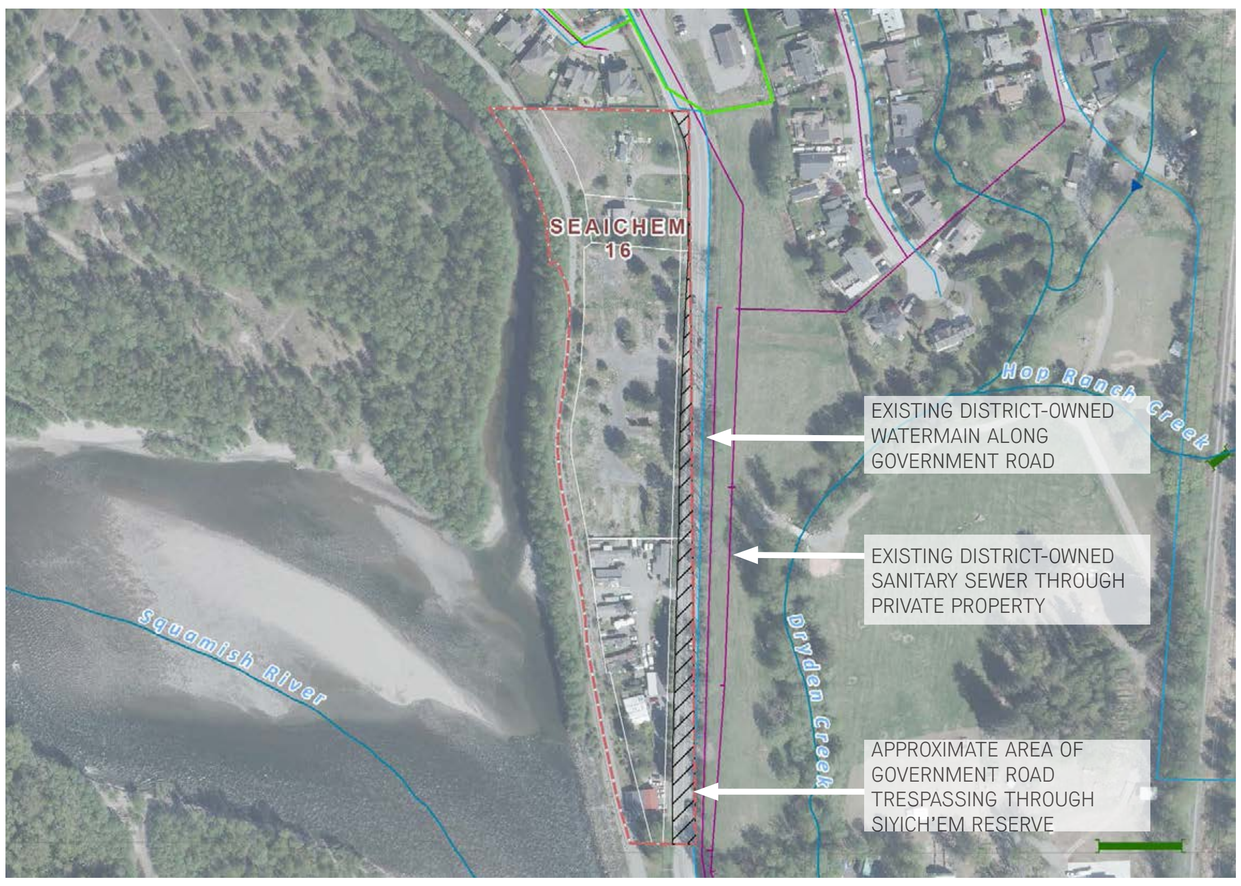
SIYICH'EM RESERVE AND EAGLE VIEWING AREA
OTHER CONCEPTS (NOT DIRECTLY RELATED TO FLOOD PROTECTION)

OTHER CONCEPTS

The dike master plan focuses on options to address immediate structural flood protection needs, i.e. diking to keep floodwaters out. However, the steering committee acknowledges, through the expression of the common interests presented on an earlier board, that there are other issues (not directly related to flood protection) that could be addressed as part of the master plan. Some of these issues are proposed to be addressed directly through the shortlisted diking options. Two additional concepts (not directly related to flood protection) have also been identified to be acknowledged and incorporated into the master plan.

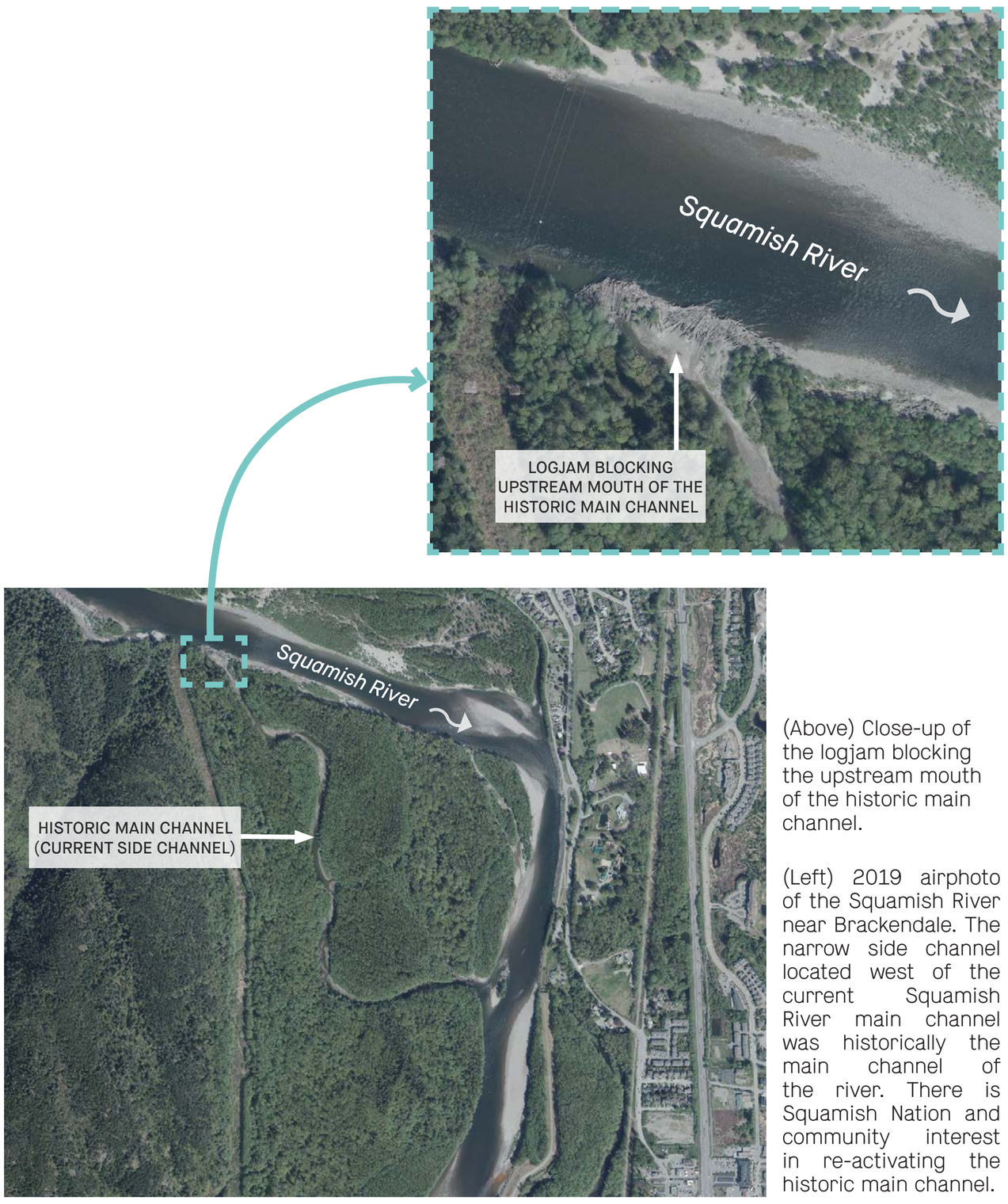
RELOCATING GOVERNMENT ROAD OFF OF SIYICH'EM

Government Road runs through the Siyich'em reserve without legal land tenure. The District and Nation are interested in exploring realigning a portion of Government Road to eliminate the historic trespass. Technical work is underway to develop a conceptual realignment and estimate the associated construction costs. To re-align the road off of the reserve, the road would have to go through a portion of the private properties located along the west side of Government Road. Incidentally, there is already a District-owned sanitary sewer pipe located east of the road through private property. The master plan project does involve detailed design of the realignment and the District would engage directly with the private property owners prior to advancing the work.



RE-ACTIVATE HISTORIC RIVER CHANNEL

The steering committee and consultant team have heard clearly from Squamish Nation members and community members that there is interest in re-activating the historic main channel of the Squamish River (indicated on the airphoto below – left) to relocate the main channel away from the existing dike to the historic main channel. The interest in this concept is primarily based on the desire to recapture historic reserve land and to reduce river erosion hazards which threaten the existing dike. This concept by itself would not directly address immediate flood risk as relocating the river would not necessarily lower water levels and a dike upgrade would still be required. Additionally, this concept would involve large river engineering works to re-activate the historic main channel and would likely require on-going maintenance to encourage the development of the historic main channel. This concept requires extensive technical and environmental studies to advance before a decision can be made about it; these are not possible within the limited schedule of the dike master plan dictated by the provincial and federal funding grant. Accordingly, the dike master plan is being developed in a way that diking options will be generally compatible with a potential future river re-alignment project, if such a project is advanced and approved. This is reflected in one of the District and Nation common interests presented on an earlier board: "Address immediate flood risk, while enabling long-term approaches".



(Above) Close-up of the logjam blocking the upstream mouth of the historic main channel.

(Left) 2019 airphoto of the Squamish River near Brackendale. The narrow side channel located west of the current Squamish River main channel was historically the main channel of the river. There is Squamish Nation and community interest in re-activating the historic main channel.

SIYICH'EM RESERVE AND EAGLE VIEWING AREA
SHARE YOUR COMMENTS VIA STICKY NOTES

Your input is valued and will be used to inform the steering committee in its review, refinement, and evaluation of the shortlisted diking options and the overall plan development. Please write down your comments on the provided sticky notes and place them on the board under the following categories: general comments, Siyich'em reach comments, and eagle viewing area comments.

In addition, we invite you to provide additional input through an online survey which can be accessed at: **https://www.surveymonkey.com/r/siyichem_publicsurvey2** or via the QR code.

Paper copies are also available from the project representatives at the open house.

GENERAL COMMENTS

SIYICH'EM REACH COMMENTS

EAGLE VIEWING AREA REACH COMMENTS

KERR WOOD LEIDAL
consulting engineers

November 2019 Community Groups Meeting Notes

KERR WOOD LEIDAL
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Greater Vancouver
200 - 4185A Still Creek Drive
Burnaby, BC V5C 6G9
T 604 294 2088
F 604 294 2090

Meeting Agenda

Meeting Date & Time: Nov. 19, 2019 – 9 am to 11 am

Location: District of Squamish Municipal Hall

Re: **Eagle Viewing Area / Siyich'em Reserve Dike Master Plan**
Shortlisted Options Targeted Stakeholder Meeting with Community Groups
Our File 463.341

Attendees: David Roulston (District of Squamish)
Paul Wick, Austin Chandler (Squamish Nation)
Amir Taleghani (Kerr Wood Leidal)

Community Group Representatives:

- Squamish Historical Society
- Tourism Squamish
- Squamish Chamber of Business
- Squamish Environment Society EagleWatch Program
- Squamish River Watershed Society
- Squamish Trails
- School District 48
- Local Qualified Professionals

Item	Topic	Duration
1.	**Introductory remarks by District & Nation representatives** • Welcome attendees and high-level study area and project introduction	5 minutes
2.	**Roundtable introductions** • Please introduce yourself and briefly describe your connection to the study area	10 minutes
3.	**Presentation part 1 – background information and study area** Presentation outline: o Squamish River flood hazard and recent integrated flood hazard management plan o Study area introduction and history ▪ Siyich'em reserve land loss o Study area existing conditions ▪ Land use ▪ Flood protection features and deficiencies ▪ Environmental habitat o Dike master planning process, schedule, and engagement opportunities	15 minutes

Item	Topic	Duration
4.	**Comments & questions on presentation part 1** • Opportunity for attendees to provide additional background information o Questions that cannot be answered on the spot will be noted o Ideas 'parking lot' for out of scope comments / questions	15 minutes
	Refreshment Break	15 minutes
5.	**Presentation part 2 - shortlisted dike options** Presentation outline: o District and Nation values for developing dike options o Options development process o Present and describe shortlisted dike options ▪ Plan view and typical cross-section ▪ Feasibility considerations and impacts o Discuss other potential features o Confirm decision process, schedule, and next steps	25 minutes
6.	**Questions & answers on background presentation** • Open floor Q&A. o Questions that cannot be answered on the spot will be noted. o Ideas 'parking lot' for out of scope comments / questions.	15 minutes
7.	**Targeted questions for input on shortlisted options** • Gather input on the following questions for each option: o Overall, do you support this option? o What changes would you suggest to this option? • What other features (non-flood protection) would you like to see considered? o E.g. public amenity features (only for the eagle viewing area).	15 minutes
8.	**Adjourn / meeting feedback forms** • Provide feedback forms and collect after 5 minutes (or offer to collect via e-mail)	5 minutes

Prepared by: Amir Taleghani, M.Eng., P.Eng., Project Engineer, Kerr Wood Leidal

KERR WOOD LEIDAL
consulting engineers

Email Record

From:	David Roulston <Droulston@squamish.ca>
Sent:	November 19, 2019 3:30 PM
To:	Amir Taleghani <ATaleghani@kwl.ca>; Chris Wyckham <cwyckham@squamish.ca>; Austin Chandler <achandler@squamish.net>; Paul Wick <Paul_wick@squamish.net>
Cc:	Erica Ellis <EEllis@kwl.ca>
Subject:	Community Group Workshop - Draft Meeting Notes

Hi All,

Please see my draft meeting notes below:

Attendees: Amir Taleghani (KWL), David Roulston(DoS), Chris Wyckham (DoS), Carl Halvorson, Mohamed Azim (SD48), Steve Fofonoff (SFA Engineering), Austin Chandler (SN), Paul Wick (SN), Sharon Hansen (Squamish Historical Society), Betty Adamson (Squamish Historical Society)

Notes:

AT - presented on Background Information MA - offered that the School District would be willing to provide letters of support for grant applications.

<u>Reach 1 – Siyich'em Reserve</u>

AT - presented on short-listed options for upgrading the dike.
MA – costing information is very important for tax payers and stakeholders to provide comments on design options
CH – inquired whether seepage cutoff wall could double up as retaining wall for Option 1 (retaining wall)
AT – yes it is possible and may be lower cost
CH – for Option 2 (land raising on Siyich'em) is it possible to do a partial raise rather than raise the entire land up to the crest of the dike
AT – responded that it is possible but it was proposed to raise to height of dike for safety of future structures on reserve land
General group comments on Option 3 (new dike alignment)
- Concerns about loss of fishing beach due to dike construction or river morphology. Would channel be scoured deeper due to new dike alignment? Would beach be scoured away due to channelizing river?
    - o This requires further investigation
- There has been discussion about using the island as an off-leash dog park
- The island is regularly flooded to waist deep as evidenced by fish remains and debris being left in trees. What impacts would there be on flood levels due to the new dike alignment?
    - o Requires further investigation to be undertaken as part of this project.
- Wouldn't the Judd Slough Pump Station need to be relocated to the downstream end of Jimmy Jimmy (Judd) Slough?

o Likely yes

- There may be environmental/eagle benefits to the new dike alignment by avoiding scouring out fish remains during high water events. Water would be calmer in Jimmy Jimmy (Judd) Slough.
- What are the environmental impacts of the new dike alignment?
    o To be reviewed in further detail.

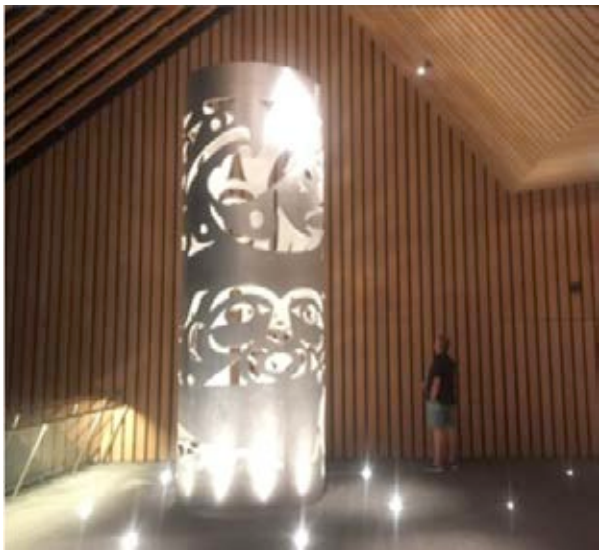
Reach 2 – Eagle Viewing Area

General comment that the view tower does not seem to provide much benefit vs. viewing at dike level
CH – existing Eagle Viewing infrastucture works and suggested removing during construction and re-using the same infrastructure. Saves money and it works.
CH- area needs to be handicap accessible
SF – making the area an attraction will exacerbate parking. Is parking being looked at?
- Yes
- Suggested to include significant bicycle infrastructure (racks) to promote active transportation to the area. CH noted that there is a large, flat area south of the Dryden Creek forebay that may be possible parking area.

MA – would like to see additional seating incorporated CH – would like to see the area made a community gathering place.
BA – would like to incorporate signage/pictures of local history. Some ideas included a picture of the Judd family on the bank of the Squamish River or a picture of the former suspension bridge across the river.
- Other ideas included: Squamish Nation oral history story of 'The Flood' & history of flooding and dikes in Squamish

MA – would like to see proper washroom facilities in the area
MA- school groups take field trips to the area. Should consider Bus Parking, educational materials (signage), additional seating, safety signage (i.e warnings about getting too close to river), barricades at appropriate points.
CH – would like to see a proper ramp down to the river's edge for people to 'put in' canoes, kayaks, SUPs, etc.
Area is used for net fishing currently immediately downstream of Dryden Creek There was general group consensus that arrival gateways were a good idea. Suggestion for local culture/art installations at gateways. Suggestions included something like Xwalacktun/Rick Harry's installations at Audain Art Museum or Ambleside (see below)
SF – traffic safety is an issue – should consider traffic calming and improved lighting
BA – concerned about loss of walnut trees on east side of Government Road due to re-aligning Government Road offreserve. They should be preserved wherever possible.
MA – the project has massive potential to transform Squamish's riverfront and would like to see the project approached as such.

Meeting adjourned.



Please add or revise as you see fit.

Thanks David

David Roulston, P.Eng | Manager of Municipal Infrastructure
District of Squamish | Hardwired for Adventure
604.815.4952 | droulston@squamish.ca | www.squamish.ca

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KERR WOOD LEIDAL
consulting engineers

November 2019 Siyich'em Residents / Families Meeting Notes

KERR WOOD LEIDAL
consulting engineers

Greater Vancouver
200 - 4185A Still Creek Drive
Burnaby, BC V5C 6G9
T 604 294 2088
F 604 294 2090

Meeting Agenda

Meeting Date & Time: Nov. 20, 2019 – 6 pm to 8 pm

Location: Squamish Nation Totem Hall, Stawamus Room

Re: **Eagle Viewing Area / Siyich'em Reserve Dike Master Plan**
Shortlisted Options Targeted Stakeholder Meeting with Siyich'em Residents
Our File 463.341

Attendees: David Roulston (District of Squamish)
Paul Wick, Austin Chandler (Squamish Nation)
Amir Taleghani (Kerr Wood Leidal)

Siyich'em Residents Representatives:
- Williams Family
- Billy Family

Item	Topic	Duration
1.	**Introductory remarks by District & Nation representatives** • Welcome attendees and high-level study area and project introduction	5 minutes
2.	**Roundtable introductions** • Please introduce yourself and briefly describe your connection to the study area	10 minutes
3.	**Presentation part 1 – background information and study area** Presentation outline: o Squamish River flood hazard and recent integrated flood hazard management plan o Study area introduction and history ▪ Siyich'em reserve land loss o Study area existing conditions ▪ Land use ▪ Flood protection features and deficiencies ▪ Environmental habitat o Dike master planning process, schedule, and engagement opportunities	15 minutes
4.	**Comments & questions on presentation part 1** • Opportunity for attendees to provide additional background information o Questions that cannot be answered on the spot will be noted o Ideas 'parking lot' for out of scope comments / questions	15 minutes
	Refreshment Break	15 minutes

Item	Topic	Duration
5.	**Presentation part 2 - shortlisted dike options** Presentation outline: o District and Nation values for developing dike options o Options development process o Present and describe shortlisted dike options ▪ Plan view and typical cross-section ▪ Feasibility considerations and impacts o Discuss other potential features o Confirm decision process, schedule, and next steps	25 minutes
6.	**Questions & answers on background presentation** • Open floor Q&A o Questions that cannot be answered on the spot will be noted o Ideas 'parking lot' for out of scope comments / questions	15 minutes
7.	**Targeted questions for input on shortlisted options** • Gather input on the following questions for each option: o Overall, do you support this option? o What changes would you suggest to this option? • What other features (non-flood protection) would you like to see considered? o E.g. public amenity features (only for the eagle viewing area)	15 minutes
8.	**Adjourn / meeting feedback forms** • Provide feedback forms and collect after 5 minutes (or offer to collect via e-mail)	5 minutes

Prepared by: Amir Taleghani, M.Eng., P.Eng., Project Engineer, Kerr Wood Leidal

KERR WOOD LEIDAL
consulting engineers

Email Record

From: David Roulston
Sent: November 21, 2019 4:33 PM
To: Amir Taleghani; Paul Wick; Austin Chandler
Cc: Chris Wyckham
Subject: Williams/Billy Family Meeting Notes

Hi All,

I took the following notes from last night's meeting. Please provide any additions/revisions as you see fit.

Amir provided presentation per his previously attached Powerpoint.

Comments from Williams/Billy family attendees:
- Would like a member of their family on the Steering Committee given they are land owners
- Williams/Billy families should not be considered 'Stakeholders'
- Would like SN/DoS elected officials at the meeting
- Desire to see river diverted back to old main channel on west side of valley
- Dike upgrades that don't recapture lost reserve land are considered 'Band-Aids'
- Provided history of Williams family amalgamation with Squamish Nation
- Question regarding who would own land if lost reserve land was recaptured. Would it become general Reserve land or CP land?
    - o The answer may be influenced by the original CP extents
- Government Road is trespassing on CP/Reserve land. Would like compensation for historic trespass of dike & road as a reconciliation measure.
- Billy family indicated a desire to be compensated equally.
- Would raising dike mean widening?
    - o Not necessarily. It could be raised in place through the use of a retaining wall.
- Tree stumps and organics have been found in the dike when installing the totem pole near Watershed Grill o DoS aware of poor construction materials in the dike
- For land raising option, would land need to be raised to the height of the dike?
    - o Not necessarily, however it has benefits, including improved site safety.
- Williams family would like a copy of the Powerpoint presentation, will meet internally and discuss and then would like follow up meeting with project team
- Does Audoban Society still own lands on west side of river (old channel)
    - o Post meeting note: No, it all appears to be Crown land/Provincial Park. They would need to be engaged if we pursued active river diversion measures.
- Concern raised for eagles. Member of Billy family mentioned a desire to close the dike during high eagle season. Would like construction to avoid impacts to eagles.
- Member of Williams family may provide sketch of historical use of reserve land.
- Members of Williams/Billy family are artists and would like an opportunity to be involved in future public art installations if public gateways are included.
- Question about where Government Road would go if relocated off reserve

o Just east of existing reserve on private land currently used for agriculture.
- Concerns raised about losing row of walnut trees if road is realigned.
o Noted. Would need to look at this in detailed design.

Please let me know if you have any revisions.

Thanks David

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November 2019 Private Land Owners Meeting Notes

KERR WOOD LEIDAL
consulting engineers

Greater Vancouver
200 - 4185A Still Creek Drive
Burnaby, BC V5C 6G9
T 604 294 2088
F 604 294 2090

Meeting Agenda

Meeting Date & Time: Nov. 21, 2019 – 6 pm to 8 pm

Location: District of Squamish Hall, Council Chambers

Re: **Eagle Viewing Area / Siyich'em Reserve Dike Master Plan**
Shortlisted Options Targeted Stakeholder Meeting with Landowners
Our File 463.341

Attendees: David Roulston (District of Squamish)
Paul Wick, Austin Chandler (Squamish Nation)
Amir Taleghani (Kerr Wood Leidal)

Landowners Representatives:
- Local residential property owners
- Easter Seals BC
- Watershed Grill (tenant)

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Prepared by: Amir Taleghani, M.Eng., P.Eng., Project Engineer, Kerr Wood Leidal

KERR WOOD LEIDAL
consulting engineers

Email Record

From: David Roulston
Sent: November 25, 2019 11:21 AM
To: Paul Wick; Amir Taleghani
Cc: Erica Ellis; Austin Chandler; Chris Wyckham
Subject: Eagle Viewing Area/Siyich'em DMP - Landowners/Residents/Businesses - Meeting Notes

Hi All,

Below are meeting notes from Thursday evening's meeting. Please let me know of any revisions.

Attendees:
Project Team: Paul Wick, Amir Taleghani, David Roulston
Land owners, Residents, Businesses:
Gordie & Sandy Buck (residents of Siyich'em Trailer Park)
Brandy Willmot (Watershed Grill Owner)
Chad Grixti (representing Brad Brown, resident of Siyichem Trailer Park)
Lisa Beck & Bruce Kirk (Easter Seals)
Ingrid McDougall (Hop Creek Farms)
Teresa & Mike Hughesman (41030 Government Rd)

AT provided background presentation and presentation on short-listed options
MH – focus should be on public safety and improving the dike first and improvements to the Eagle Viewing Area as a secondary matter
IM – they have an active farming operation including livestock (pigs, sheep, etc). A flood would cause significant disruption and emergency response for them to transport livestock.
GB – Why are trees allowed to grow in the dike – it's a risk.
- DR – we agree. DoS is working on addressing vegetation management section by section. There are challenges that prevent us from removing trees in some cases including riparian areas regulations and lack of land tenure.

MH - would like to move the river to the west side of the valley
- AT - We are looking at that as part of this project, but it does not reduce the need to improve the dike in the project area which is the main focus of this project.

MH – (in response to new dike alignment option) – does this place greater pressure/force on the dike?
- AT - Good question. Will be running model to evaluate impacts of new dike alignment. BW – When will dike upgrades be taking place?
- DR - It is dependent on funding. This project is the 3 rd highest priority of our large diking projects. We are targeting a 3-5 year timeframe.

LB – Mentioned that there is an eagle nest on Easter Seals lot
MH – Raised concern about making the area into a park. Has concerns about liveability if the area becomes busier. Need to ensure there are facilities to accommodate tourists if we will be drawing more people to the area.

Group – Parking is a disaster. Issues are: 1) commuters park in the gravel parking area utilizing spots for tourists, 2) parking lot area and shoulder are not properly maintained, 3) people are parking on private property and/or blocking access to private property, 4) parking on shoulder is a safety issue. There needs to be sufficient parking for Watershed Grill/Eagle Viewing Area and for it to avoid disruption to residents. Ideas included:

- Expand northern parking area
- Pave/paint parking area for more efficient parking
- Traffic calming with curb bump outs/formal parking bays
- Provide flashing pedestrian beacon for improved road crossing safety
- Provide shuttles to the area
- Provide designated bus parking
- Have limited time parking or pay parking to prevent long-term parking
- Complete traffic needs study

MH – the current no-post barriers are not well placed and are causing issues
Group - Amenities discussion. Feedback included:

- Ensure accessibility for all (ramps)
- Idea: have totem poles/lighting on dike
- Amazing wildlife in area – bears, seals, elk, eagles.
- Don't build area up too much.
- Keep the landscaping 'organic' and authentic to the area. Use natural materials.
- Maintain rural nature rather than urban design features.
- Use local artists

Post Meeting Note: Easter Seals mentioned the possibility of creating a pay parking site on their lot. They already have a cleared gravel area suitable for providing parking. They are open to further discussion.

Thanks,
David

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KERR WOOD LEIDAL
consulting engineers

Online Survey #1 Analysis

Analysis of Online Survey #1 Results

Breakdown of respondents (128)

- 1 Siyich'em I.R. No. 16 resident
- 6 Squamish Nation Member
- 23 District Residents within the study area
- 93 District Residents outside the study area
- 5 Owner or Employee of a Business inside the study area
- 4 (None of the above) (Visitor)

- Based on responses from all the respondents, the top three most important interests in the development of options are; Environmental Habitat including fish and bird), Government Road safety for vehicles, cyclists, and pedestrians, and trail systems and connectivity to other trials
- Based on responses from the 23 district residents in the study area, the top three most important interests in the development of options are; Environmental Habitat including fish and bird, Government Road safety for vehicles, cycles, and pedestrians, and Construction Impacts on Residents.
- Based on responses from the 93 district residents outside the study area, the top three most important interests in the development of options are; Environmental Habitat including fish and bird), Government Road safety for vehicles, cyclists, and pedestrians, and trail systems and connectivity to other trials
- Based on responses in the open-ended questions from all respondents (128), the top three most important features are; upgraded park facilities, Connectivity from the North and South side of the dike, and increased parking. (See graph below).
- Respondents (6) that are members of the Squamish Nation responded in the open-ended questions that they were most concerned about ensuring habitat protection, safer traffic control (crosswalks, sidewalks), and fear of how tourism will impact the local residential area.
- Respondents (23) that are district residents within the study area responded in the open-ended questions that they were most concerned about dike maintenance, trail connectivity, impact to residents, and protection of natural habitat.
- 92% (118) of the respondents indicate that they have used Government Road and the eagle viewing dike/path. 75% (96) of the respondents indicated that they have visited a local business (Watershed Grill, Coffee Shop) and 62% (79) of the respondents indicated that they use the Squamish River water side for activities such as fishing or rafting.
- 80% (103) of respondents indicated that they drive on Government Rd. Of those respondents 69% (71) indicate that they also walk or cycle on Government Rd.
- 17 (13.5%) Strongly Agree and 64 (50.8%) of respondents Somewhat Agree that enough information was provided to enable respondents to share input on the questions in this survey.

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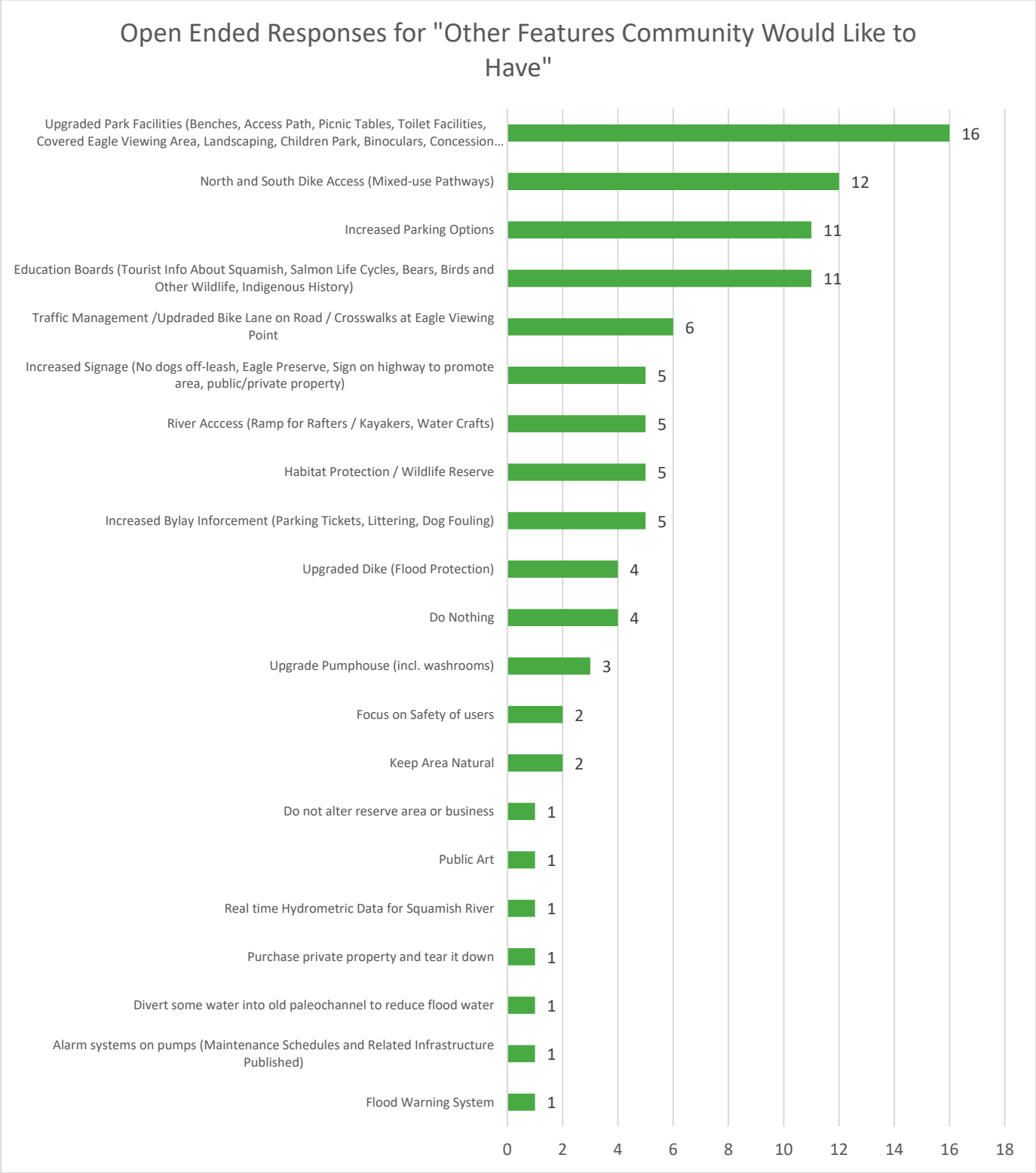
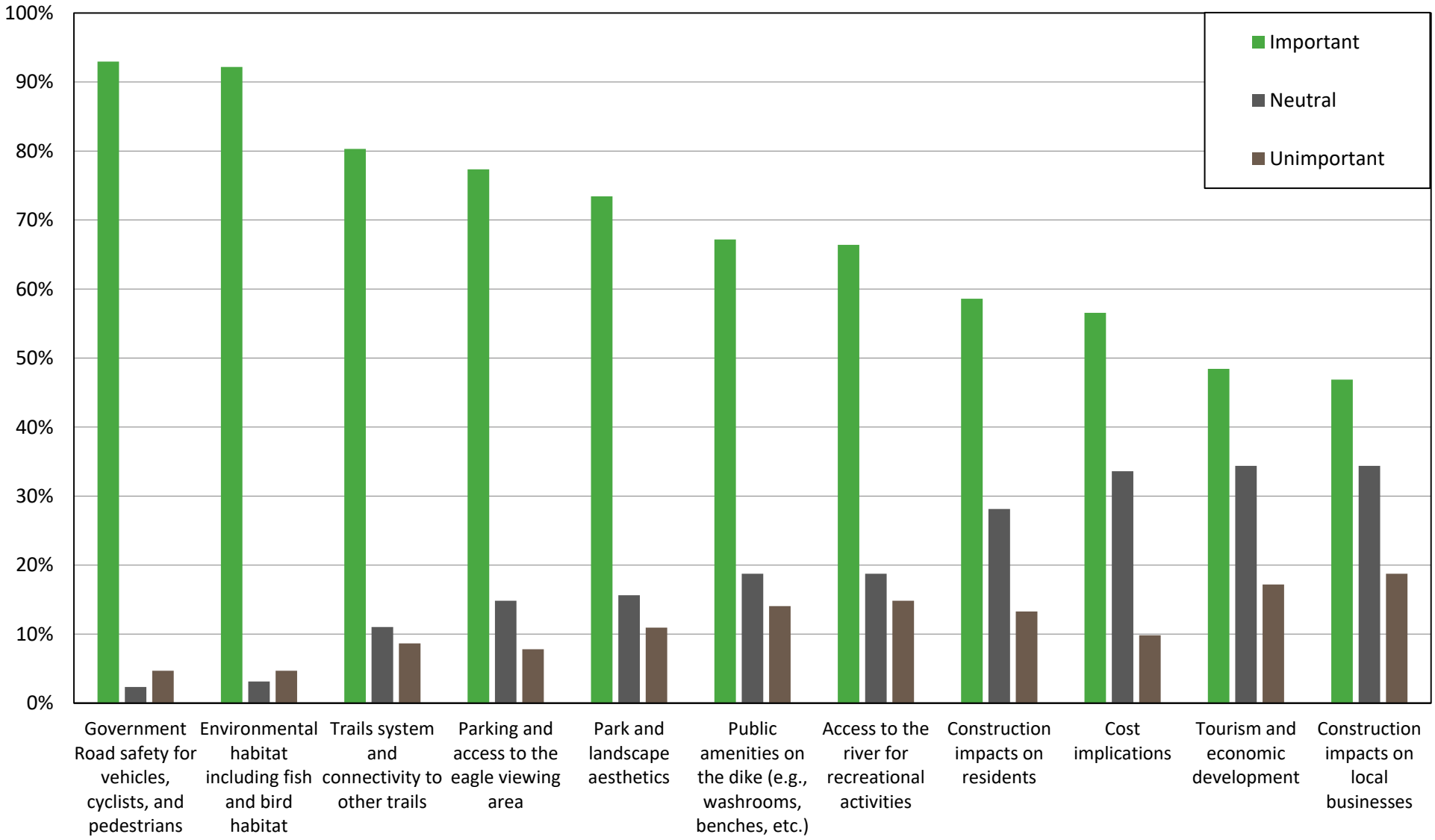
Graphics


Open Ended Responses for "Other Features Community Would Like to Have"
Upgraded Park Facilities (Benches, Access Path, Picnic Tables, Toilet Facilities, Covered Eagle Viewing Area, Landscaping, Children Park, Binoculars, Concession...
16
North and South Dike Access (Mixed-use Pathways)
12
Increased Parking Options
11
Education Boards (Tourist Info About Squamish, Salmon Life Cycles, Bears, Birds and Other Wildlife, Indigenous History)
11
Traffic Management /Updraded Bike Lane on Road / Crosswalks at Eagle Viewing Point
6
Increased Signage (No dogs off-leash, Eagle Preserve, Sign on highway to promote area, public/private property)
5
River Acccess (Ramp for Rafters / Kayakers, Water Crafts)
5
Habitat Protection / Wildlife Reserve
5
Increased Bylay Inforcement (Parking Tickets, Littering, Dog Fouling)
5
Upgraded Dike (Flood Protection)
4
Do Nothing
4
Upgrade Pumphouse (incl. washrooms)
3
Focus on Safety of users
2
Keep Area Natural
2
Do not alter reserve area or business
1
Public Art
1
Real time Hydrometric Data for Squamish River
1
Purchase private property and tear it down
1
Divert some water into old paleochannel to reduce flood water
1
Alarm systems on pumps (Maintenance Schedules and Related Infrastructure Published)
1
Flood Warning System
1
0
2
4
6
8
10
12
14
16
18

How important are the following interests to you in the development of options for flood protection upgrading in the study area?



Squamish Survey

Sḵwx̱wú7mesh Úxwumixw
Squamish Nation

SQUAMISH
HARDWIRED for ADVENTURE

Between Summer 2019 and Spring 2020, the District of Squamish and Squamish Nation are developing a master plan for the Squamish River dike in the Siy̓Ích'em Reserve and Eagle Viewing Area, along Government Road.

This survey provides an initial opportunity for stakeholders to voice their values and interests associated with the project site.

1. Please tell us about yourself (Select all that apply)

☐ Siy̓Ích'em I.R. No. 16 resident

☐ Squamish Nation member

☐ District resident within the study area (see attached map)

☐ District resident outside of the study area (see attached map)

☐ Owner or employee of a business within the study area (see attached map)

☐ None of the above (e.g.-visitor to the study area (see attached map))

2. What is your age?

☐ < 15 years

☐ 15-24 years

☐ 25-44 years

☐ 45-64 years

☐ > 65 years

3. Please describe the frequency of your visits for each location below, and the activities you participate in while there.

☐ Squamish River waterside ___ times/month, to participate in (e.g., rafting, fishing) _____

☐ Eagle viewing dike/path ___ times/month, to participate in (e.g., dog walking) _____

☐ Local businesses on/near dike ___ times/month, to participate in (e.g., dining)_____

☐ Government Road ___ times/month, to participate in (e.g., driving, cycling) _____

☐ Other ___ times/month, to participate in _____

4. How important are the following interests to you in the development of options for flood protection upgrading in the study area? (Check one column for each row)

Interest	Very Unimportant	Unimportant	Neutral	Important	Very Important
Park and landscape aesthetics					
Public amenities on the dike (e.g. washrooms, benches, etc.)					
Parking and access to the eagle viewing area					
Trail system and connectivity to other trails					
Access to the river for recreational activities					
Government Road safety for vehicles, cyclists, and pedestrians					
Environmental habitat, including fish and bird habitat					
Cost implications					
Tourism and economic development					
Construction impacts on local businesses					
Construction impacts on residents					
Other:					
Other:					

a) What other features would you like to see as part of flood protection along the Eagle Run/ Siy̓Ích'em reach?

5. **Do you have additional comments, questions, or concerns to share?**

6. **Was enough information provided (e.g. via the survey and project website) to enable you to share your input on the questions in this survey?** (Please select one)

   a) Strongly Agree
   b) Somewhat Agree
   c) Unsure/Neutral
   d) Somewhat Disagree
   e) Strongly Disagree

7. **Are you interested in being notified as additional information becomes available? Y / N**

   If yes, please provide your e-mail address:

8. **Do you require a project team member to contact you to discuss your comments further? Y / N**

THANK YOU FOR YOUR INPUT!

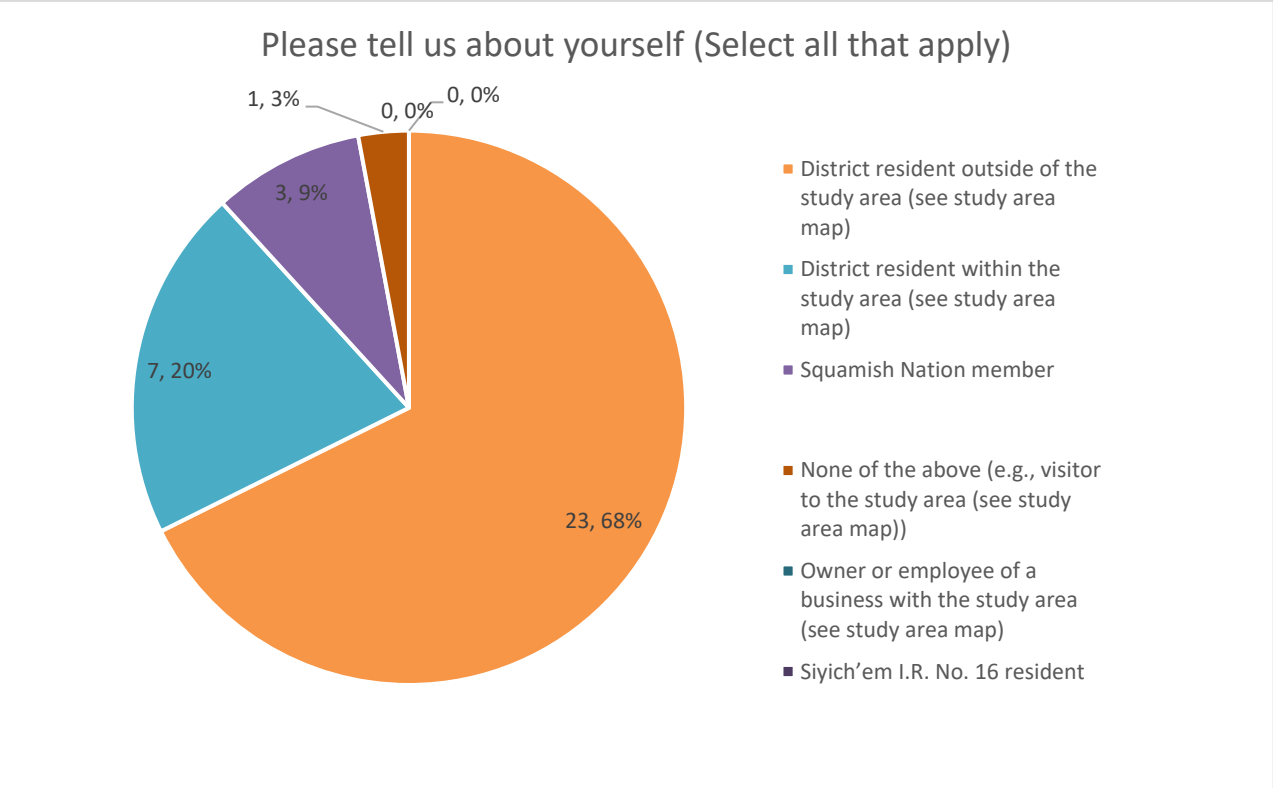
KERR WOOD LEIDAL
consulting engineers

Online Survey #2 Analysis

Analysis of Online Survey #2 Results

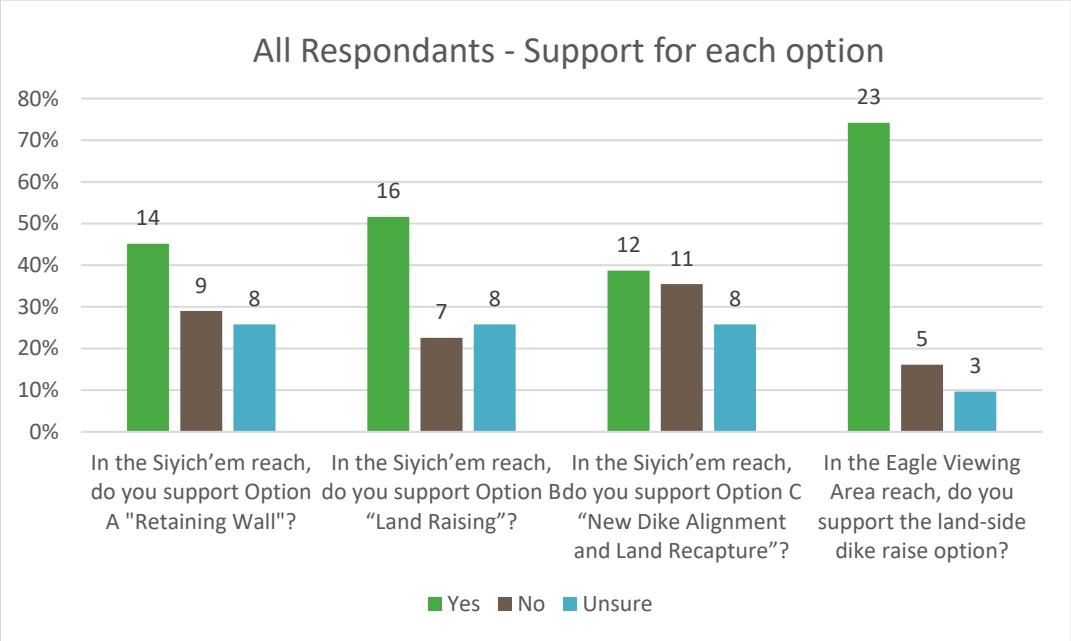
Breakdown of respondents (31)

- 20 District Residents outside the study area
- 7 District Residents within the study area
- 3 Squamish Nation Member
- 1 (None of the above) (Visitor)
- 0 Siyich'em I.R. No. 16 resident
- 0 Owner or Employee of a Business inside the study area

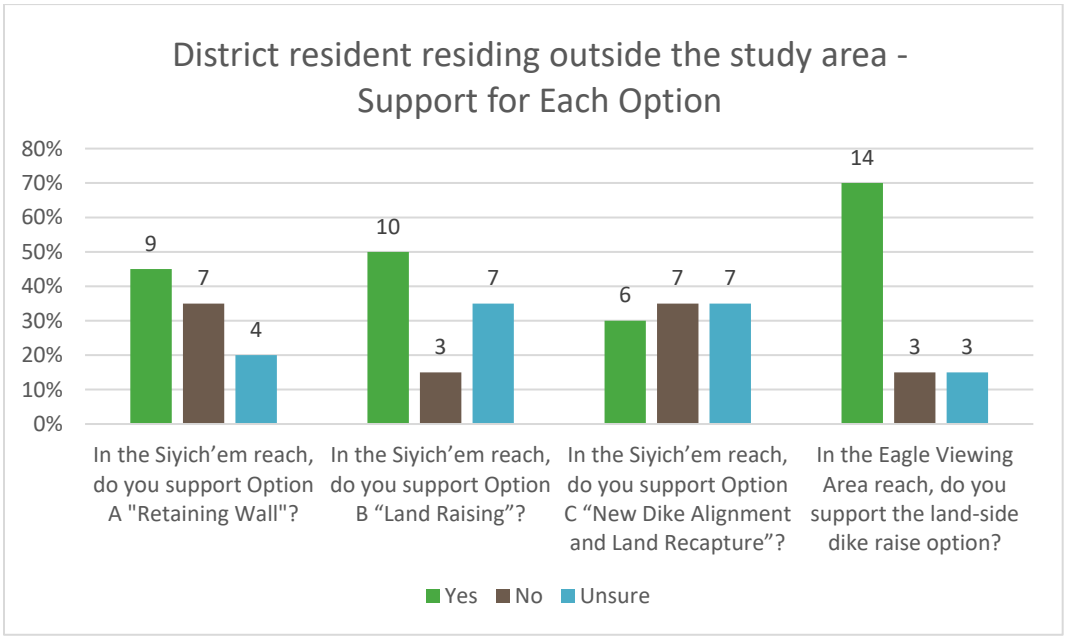


Questions 3-6: Questions related to support for the three different options A, B, C and support for the land side dike raise in the eagle viewing reach.

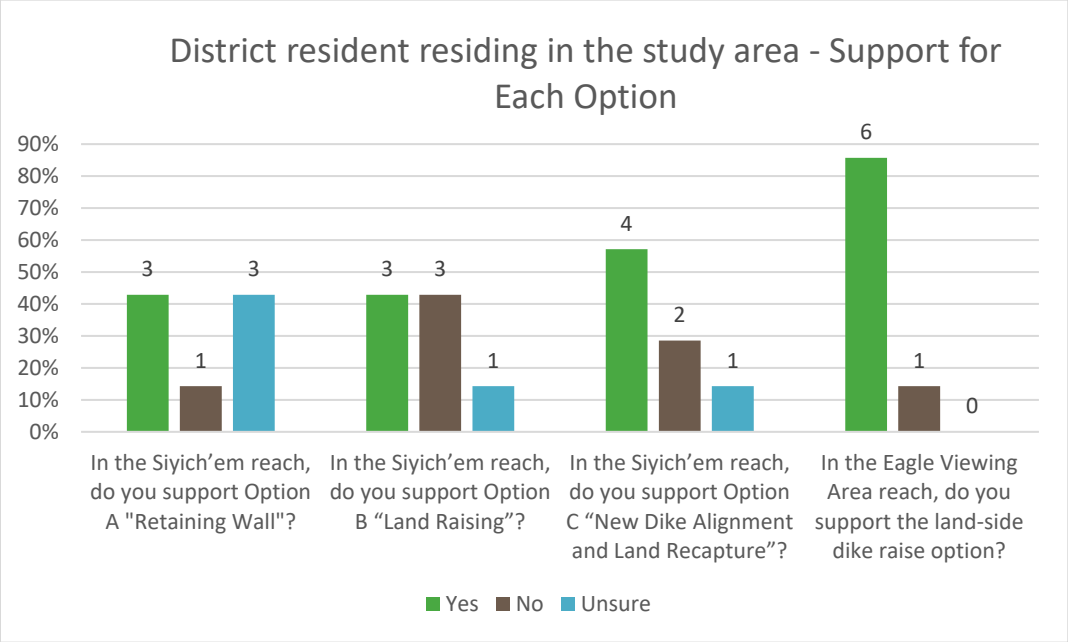
- Based on all responses, Option B “Land Raising” has the most support with 52% of respondents replying yes. (See chart below)



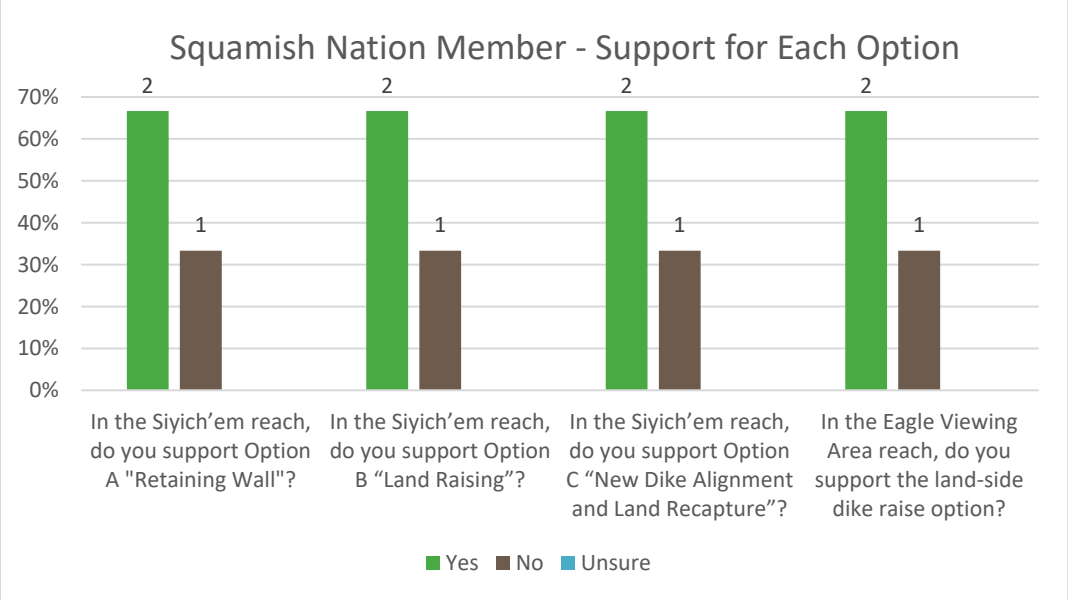
- Based on responses from district residents residing outside the study area, Option B “Land Raising” has the most support with 50% of respondents replying yes. (See chart below)



- Based on responses from district residents residing in the study area, Option C “New Dike Alignment and Land Recapture” has the most support with 57% of respondents replying yes. (See chart below)

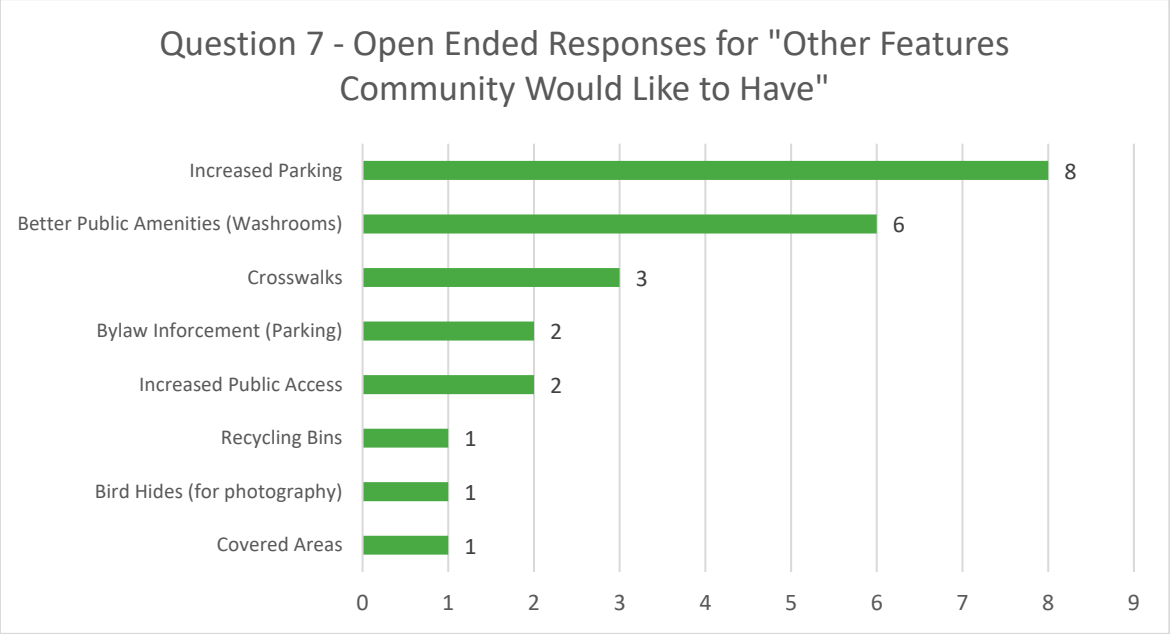


- Based on responses from Squamish Nation Members, each option has the same amount of responses. (See chart below)



Question 7. What other features (not directly related to flood protection) would you like to see considered and/or added in the eagle viewing area? (e.g. public amenities)?

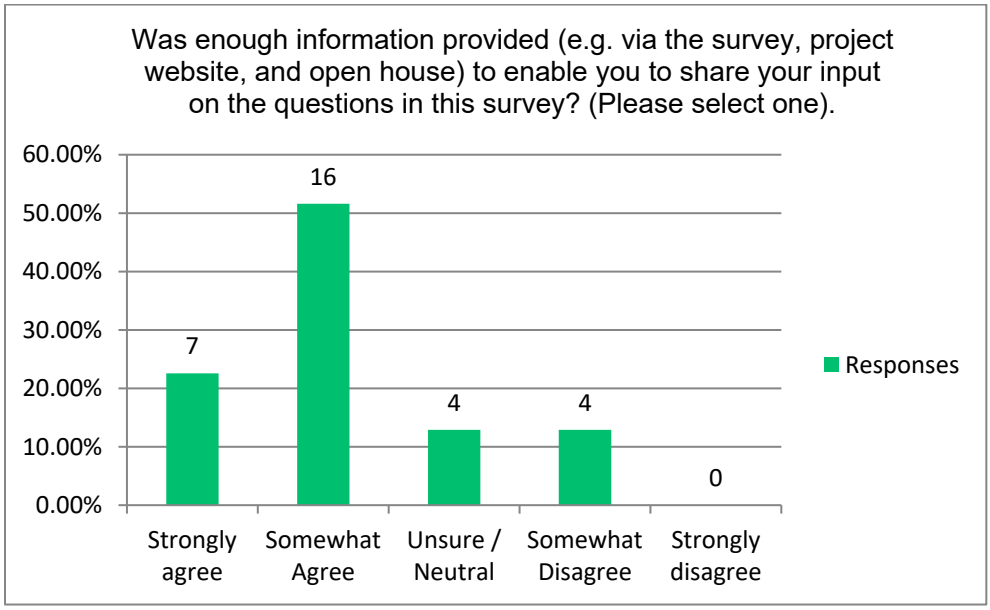
Based on written responses from all respondents (31), the top three most important features are; increased parking, better public amenities such as washrooms, and introducing crosswalks.



Question 8. Do you have additional comments, questions, or concerns to share?

- *"It appears Salmon and Eagles are being considered, but have the impacts on bears, elk, coyote, wolves, cougars etc been considered with option 3? Elk frequently spending time on the Northern shore of the river along Judd Beach, as do bears and I can only imagine other animals. What happens to them when yet another area of habitat is removed from their range?"*
- *"Keep up the good work and be bold. This is the future and it's worth it."*
- *"We need to support all efforts to maintain the salmonella n runs. Without them, eagle watching will be a fruitless activity. Also, maintain the Grill if at all possible."*

Question 9. Was enough information provided (e.g. via the survey, project website, and open house) to enable you to share your input on the questions in this survey? (Please select one).



Eagle Viewing Area / Si’Ích’em Dike Master Plan

Public Survey #2

Eagle Viewing Area / Siy̓Ích'em Dike Master Plan

Public Survey #2

Between Summer 2019 and Spring 2020, the District of Squamish and Squamish Nation are developing a master plan for the Squamish River dike in the Siy̓Ích'em Reserve and Eagle Viewing Area, along Government Road.

More information about the project including background information, process, and schedule is available on the project website: https://squamish.ca/yourgovernment/projects-and-initiatives/eaglesiyichemdike/

This survey follows survey #1 which asked stakeholders to identify their connection to the study area and voice their values and interests associated with the study area.

This survey provides an opportunity for stakeholders to delve deeper and provide feedback on the flood protection options shortlisted by the District and Nation, and to comment other features not directly related to flood protection (e.g. public amenities in the eagle viewing area).

Materials describing the shortlisted flood protection options (including presentations, boards, and handouts) are available on the project website, at meetings for targeted stakeholder groups, and at the project public open house (December 5th, 2019 6 pm to 8 pm at the Squamish Adventure Centre).

Please complete this survey online (link at the project website) or on paper and return it to project team members.

1. Please tell us about yourself (Select all that apply)

- ☐ Siy̓Ích'em I.R. No. 16 resident
- ☐ Squamish Nation member
- ☐ District resident within the study area (see attached map)
- ☐ District resident outside of the study area (see attached map)
- ☐ Owner or employee of a business within the study area (see attached map)
- ☐ None of the above (e.g.-visitor to the study area (see attached map))

2. What is your age?

- ☐ < 15 years
- ☐ 15-24 years
- ☐ 25-44 years
- ☐ 45-64 years
- ☐ > 65 years

Questions regarding shortlisted flood protection upgrading options in the Siy̓Ích'em reach:
(refer to project website or open house for materials)

3. Do you support the "Retaining Wall" option?

- ☐ Yes
- ☐ No
- ☐ Unsure

Comments and/or suggested changes:

---

4. Do you support the "Land Raising" option?

- ☐ Yes
- ☐ No
- ☐ Unsure

Comments and/or suggested changes:

---

5. Do you support the "New Dike Alignment and Land Recapture" option?

- ☐ Yes
- ☐ No
- ☐ Unsure

Comments and/or suggested changes:

Questions regarding shortlisted flood protection upgrading options in the eagle viewing reach:
(refer to project website or open house for materials)

6. **Do you support the preferred option for dike upgrading in the eagle viewing area? (raise existing dike crest and expand towards the land (east).**

   ☐ Yes

   ☐ No

   ☐ Unsure

   Comments and/or suggested changes:

   _____

   _____

7. **What other features (not directly related to flood protection) would you like to see considered and/or added in the eagle viewing area? (e.g. public amenities)**

   _____

   _____

Wrap-up Questions:

8. **Do you have additional comments, questions, or concerns to share?**

   _____

   _____

   _____

   _____

9. **Was enough information provided (e.g. via the survey, project website, and open house) to enable you to share your input on the questions in this survey?** (Please select one)

   ☐ Strongly Agree

   ☐ Somewhat Agree

   ☐ Unsure/Neutral

   ☐ Somewhat Disagree

   ☐ Strongly Disagree

10. **Are you interested in being notified as additional information becomes available?**

    ☐ Yes

☐ No

If yes, please provide your e-mail address:

_____

11. Do you require a project team member to contact you to discuss your comments further?

☐ Yes

☐ No

THANK YOU FOR YOUR INPUT!

KERR WOOD LEIDAL
consulting engineers

Fisheries and Oceans Canada Feedback Letter

Fisheries and Oceans Canada
Pêches et Océans Canada

Pacific Region
Suite 200 - 401 Burrard Street
Vancouver, BC
V6C 3S4

Région du Pacifique
Pièce 200 - 401 rue Burrard
Vancouver (C.-B.)
V6C 3S4

January 03, 2020

Your file *Votre référence*

Our file *Notre référence*
19-HPAC-00781

District of Squamish
P.O. Box 310
Squamish, BC
V8B 0A3

Attention: David Ralston
droulston@squamish.ca

Squamish Nation
P.O. Box 86131
North Vancouver, BC
V7L 4J5

Attention: Paul Wick
paul_wick@squamish.net

Subject: Eagle Viewing Area / Siyich'em Reserve Dike Master Plan – Additional information is required for the review of your request.

The Fish and Fish Habitat Protection Program (the Program) of Fisheries and Oceans Canada (DFO) received your proposal on December 4, 2019. We understand that you propose to:

- Upgrade approximately 1km length of dike at the Eagle Viewing Area / Siyich'em Reserve in Squamish, BC.
- Re-activate the former main channel of the river on the west side of the river which has been blocked by a large log jam by removal of the log jam.
- Replace an old, abandoned culvert at the north end of Jimmy Jimmy (Judd) Slough and install tide gates in order to re-water the Slough.

Your proposal is being reviewed to determine whether it is a work, undertaking or activity that is likely to result in:

- the death of fish by means other than fishing and the harmful alteration, disruption or destruction of fish habitat which are prohibited under subsections 34.4(1) and 35(1) of the *Fisheries Act*; and
- effects to listed aquatic species at risk, any part of their critical habitat or the residences of their individuals in a manner which is prohibited under sections 32, 33 and subsection 58(1) of the *Species at Risk Act*.

The aforementioned outcomes are prohibited unless authorized under their respective legislation and regulations.

The Program is in receipt of the following information:

- The email sent to the Program on December 4, 2019 and supporting documents regarding "Request for Review - Eagle Viewing Area / Siyich'em Reserve Dike Master Plan".

- The Request for Review Form completed by David Roulston dated 28/11/2019 and supporting documents.
- The Siyich'em Reserve and Eagle Viewing Area Project Overview / Eagle Viewing Area / Siyich'em Reserve Dike Masterplan | Open House dated December 5, 2019.

Based on the information provided, the Program is of the view that your proposal could potentially result in prohibited effects to fish and fish habitat. However, in order for the Program to continue and complete a review of your proposal and determine whether prohibited effects to fish and fish habitat are likely, the Program requests that a detailed description and engineered drawings be provided for your proposal.

The Program recognizes that a detailed description and engineered drawings for the proposal are not available as the designs are in the preliminary stages. The Program also understands that at this time the District of Squamish and Squamish Nation are seeking feedback from the Program on the dike options and other works described in the information provided. In this regard, please note the following:

a) Reach 1: Siyich'em Reserve - 3 Options
   - Option A - Retaining Wall
     Raising the dike crest and construction of a seepage cutoff wall and/or retaining wall on the land-side of the dike along its current alignment. Bank protection rip rap revetment is to be constructed on the river-side dike slope requiring riparian vegetation removal and in-water works.

     DFO Program Comments
     The bank protection rip rap revetment design for the river-side dike slope is to minimize the removal of riparian vegetation and minimize the disturbance to areas below the high water elevation.

   - Option B – Land Raising
     Raising the dike crest and raising the Siyich'em Reserve lands on the land side of the dike along its current alignment. Bank protection rip rap revetment is to be constructed on the river-side dike slope requiring riparian vegetation removal and in-water works

     DFO Program Comments
     The bank protection rip rap revetment design for the river-side dike slope is to minimize the removal of riparian vegetation and minimize the disturbance to areas below the high water elevation.

   - Option C – New Dike and Land Recapture
     Build the dike along a new alignment heading north-west from Siyich'em reserve along and setback from the active Squamish River bank and connecting to the existing dike at Fisherman's Park. The new dike alignment would partially disconnect a large, forested gravel bar island from the Squamish River. Partial

.../3

connection could be maintained via a fish-friendly pump station at the outlet of Jimmy Jimmy (Judd) Slough. The dike alignment would be set back from the active river channel by 30m or more, except for the connection points at Fisherman's Park and at the existing dike near the south edge of Siyich'em reserve.

DFO Program Comments

The Program will need further information in order to provide specific comments. In particular, it is not clear to what extent and how often the large forested gravel bar island to be separated from the Squamish River with a new dike inundates with Squamish River waters from high water events. Areas of the large forested gravel bar island frequently inundated by waters from the Squamish River could be considered by the Program to be fish habitat. Should areas of fish habitat be disconnected from the Squamish River by a new dike, the project should be redesigned to avoid or minimize impacts to fish habitat.

If the large forested gravel bar island is not considered by the Program to be fish habitat, the new dike alignment should be setback from the high water elevation of the Squamish River. It is understood from the information provided that the new dike is setback 30 metres from the Squamish River.

Further, Jimmy Jimmy (Judd) Slough is considered by the Program to be fish habitat especially given that salmon have access ot the Slough. If any new dike alignment crosses Jimmy Jimmy (Judd) Slough, the Program would need there to be a fish-friendly pump station at the location of the dike crossing of Jimmy Jimmy (Judd) Slough.

b) Reach 2: Eagle Viewing Area

- Preferred Option – Land-Side Raise

  This option involves raising the existing dike crest between Dryden Creek pump station and the north boundary of Kowtain I.R. 17. In general, the dike footprint would be expanded towards the land (east) with a vegetated slope at a gradient of 3 horizontal to 1 vertical. Retaining walls would be used to limit the footprint in areas with limited space due to existing infrastructure and/or structures. Bank protection rip rap revetment is to be constructed on the river-side dike slope requiring riparian vegetation removal and in-water works.

  DFO Program Comments

  The bank protection rip rap revetment design for the river-side dike slope is to minimize the removal of riparian vegetation and minimize the disturbance to areas below the high water elevation.

c) Log Jam Removal on West Side of River

In addition to the above Options, the Program understands that the District of Squamish and Squamish Nation are evaluating re-activating the former main channel of the river on the west side of the river which has been blocked by a large log jam. Works would entail removal of the log jam and potential further adaptive works, if and as necessary. The Program is generally supportive of the removal of the log jam

but further information on what adaptive works would be required in order for the Program to confirm this support. It should also be noted that if flows are directed into the former main channel by removal of the log jam, the channel should not contain isolated pools of water when flows recede in order to prevent fish stranding.

d) Tide Gates at North End of Jimmy Jimmy (Judd) Slough
The Program also understands that the District of Squamish and Squamish Nation are intending to replace an old, abandoned culvert at the north end of Jimmy Jimmy (Judd) Slough (49.77N, 123.17W) and install tide gates in order to re-water the slough as early as 2020. The intent is to open the gates during low water conditions to flush organics and fine sediment from the slough and improve fish habitat. The Program is generally supportive of this installation of tide gates. However, the District of Squamish should continue to discuss and receive advice from DFO's habitat restoration group for guidance to ensure that the tide gates are designed to improve fish habitat.

To reiterate, while the Program has provided comments above including requests for additional information, the Program also requires a detailed description including engineered drawings of the proposal for the dike Option selected, the removal of the log jam on the west side of the Squamish River, and the new tide gates at the north end of Jimmy Jimmy (Judd) Slough in order to determine whether prohibited effects to fish and fish habitat are likely and determine whether a *Fisheries Act* 34.4(2)(b) and/or 35(2)(b) Authorization is required. This required information should be submitted as part of the submissions of a new Request for Review Form to the Program for each of the proposals.

Should you have any questions or concerns about the design of your proposal and compliance with the *Fisheries Act* and the *Species at Risk Act* you are also encouraged to contact an environmental professional familiar with measures to avoid impacts to fish and fish habitat.

If you have any questions with the content of this letter, please contact me at our Vancouver office at 604-666-8027 or by email at brian.naito@dfo-mpo.gc.ca. Please refer to the file number referenced above when corresponding with the Program.

Yours sincerely,

Brian Naito

Brian Naito
Section Head – Lower Mainland
Fish and Fish Habitat Protection Program

KERR WOOD LEIDAL
consulting engineers

BC Inspector of Dikes Feedback E-mail

Amir Taleghani

From: Amir Taleghani
Sent: May 26, 2020 3:17 PM
To: Amir Taleghani
Subject: Request for Review - Eagle Viewing Area / Siyich'em Reserve Dike Master Plan

From: Yip, Queenie FLNR:EX [mailto:Queenie.Yip@gov.bc.ca]
Sent: December 27, 2019 4:37 PM
To: David Roulston <Droulston@squamish.ca>
Cc: Hahn, Mitchell FLNR:EX <Mitchell.Hahn@gov.bc.ca>; Erica Ellis (EEllis@kwl.ca) <EEllis@kwl.ca>; 'Amir Taleghani' <ATaleghani@kwl.ca>; Paul Wick <Paul_wick@squamish.net>; Austin Chandler <achandler@squamish.net>
Subject: RE: Request for Review - Eagle Viewing Area / Siyich'em Reserve Dike Master Plan

Hi David

I have reviewed the preliminary options presented. Since there are only preliminary concepts presented and no details included for the options, I cannot provide in-depth feedbacks. My initial feedbacks are summarized below for each shortlisted options.

Reach 1-Option A:

- Right-of-way should be established for maintenance work or future alternation
- The height of the retaining wall should be at least equal to or taller than the dike height with climate projection to 2100

Reach 1-Option B:

- Development is not allowed on the regulated portion of the dike. We are in the process of clarifying the concept of “regulated portion” of the dike. Basically, the regulated portion of the dike is counting from the point where the modelled seismic displacement is within the displacement limit as specified in the seismic guideline, plus the minimum dike slope reached the natural ground, plus 7.5 m for ROW. “The potential development” on the diagram from the attachment is still within the regulated portion of the dike.

Reach 1-Option C:

- There is a permeant partial disconnectivity. It maybe a repeating problem similar to the training berm in Squamish South
- The new alignment is closer to the braided river. It does not seems to be a good idea because there is very high potential riprap will be required for the entire section, which will incur high costs (riprap and future costs) and creates many regulatory hurdles.

Reach 2-Preferred Option:

- I would foresee WSA Section 11 approval and approval from Resource Management will be the bottleneck of this option

I have also requested some help from WSA Section 11 team to look at the plan using their lens. I will forward their feedbacks to you once they are finalized.

I’ll be away from the office until Jan 22. If you have any question, I’ll try to get back to you before Jan 27.

Queenie

From: David Roulston <Droulston@squamish.ca>
Sent: December 5, 2019 1:56 PM

To: Yip, Queenie FLNR:EX <Queenie.Yip@gov.bc.ca>
Cc: Hahn, Mitchell FLNR:EX <Mitchell.Hahn@gov.bc.ca>; Erica Ellis (EEllis@kwl.ca) <EEllis@kwl.ca>; 'Amir Taleghani' <ATaleghani@kwl.ca>; Paul Wick <Paul_wick@squamish.net>; Austin Chandler <achandler@squamish.net>
Subject: Request for Review - Eagle Viewing Area / Siyich'em Reserve Dike Master Plan

Hi Queenie,

The District of Squamish and Squamish Nation have received Federal/Provincial funding under the National Disaster Mitigation Program to complete a dike master plan for the Eagle Viewing Area / Siyich'em Reserve in Squamish, BC. We have engaged a multi-disciplinary team to assist in preparing the plan including KWL, Thurber and Hapa Collaborative. The intent of the plan is to determine the preferred dike upgrade strategy for the area which is approximately 1km in length.

At this stage, the project team has shortlisted options as shown in the attached and we are completing stakeholder/regulator (DFO, IOD, Crown land managers) engagement seeking feedback on dike upgrade options. Thurber has completed geotechnical investigation and are finalizing their analysis. I will provide their report when available.

Due to grant funding deadlines, the project team is intending to select a preferred option at a Steering Committee meeting on January 27. As such, we are seeking feedback prior to that date. We are not seeking approvals for any of the options, but rather any feedback you would like us to consider when selecting a preferred option (e.g regulatory hurdles, IOD thoughts/concerns, items to be addressed during detailed design, etc). To be clear, this is a planning project and we will be seeking to develop detailed design and construction as part of a future project.

Please confirm receipt of this email so I can be sure the large attachment has made it through successfully. If you have any questions or would like to discuss, please let me know. Please also let me know if you would prefer to discuss in a face to face meeting or via teleconference and I can coordinate.

Regards,
David

David Roulston, P.Eng | **Manager of Municipal Infrastructure**
District of Squamish | *Hardwired for Adventure*
604.815.4952 | droulston@squamish.ca | www.squamish.ca

SQUAMISH

I humbly acknowledge that I work within the traditional territory of the Squamish Nation, Sḵwx̱wú7mesh Úxwumixw.

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from your system. Please note that correspondence with any government body, including District of Squamish Council and Staff, can be subject to disclosure under the Freedom of Information and Protection of Privacy Act.

KERR WOOD LEIDAL
consulting engineers

BC Parks Feedback E-mail

Amir Taleghani

From: Amir Taleghani
Sent: May 26, 2020 3:20 PM
To: Amir Taleghani
Subject: FW: Eagle Viewing Area / Siyich'em Reserve Dike Master Plan

From: Kohlhardt, Regan P ENV:EX [mailto:Regan.Kohlhardt@gov.bc.ca]
Sent: November 29, 2019 3:25 PM
To: David Roulston <Droulston@squamish.ca>
Cc: Sarah McJannet <smcjannet@squamish.ca>; Whiteside, David ENV:EX <David.Whiteside@gov.bc.ca>
Subject: RE: Eagle Viewing Area / Siyich'em Reserve Dike Master Plan

Hi David,

I'm cc'ing David Whiteside, our new Area Supervisor for Squamish, so that he knows about the dike master plan project.

I had a quick chat with our Conservation Specialist about this. We would need more information about how restoration of the channel would affect hydrology. Depending on the effect, we'd need to assess values lost vs. values gained (specifically values related to fish). I'm curious if DFO has more specific information on expected impacts. Can you share their response with us?

In short, we're cautiously open to exploring the concept, so keep us updated as you get more information.

Thanks and hope to see you around town soon!
Regan

From: David Roulston <Droulston@squamish.ca>
Sent: November 26, 2019 3:11 PM
To: Kohlhardt, Regan P ENV:EX <Regan.Kohlhardt@gov.bc.ca>
Cc: Sarah McJannet <smcjannet@squamish.ca>
Subject: Eagle Viewing Area / Siyich'em Reserve Dike Master Plan

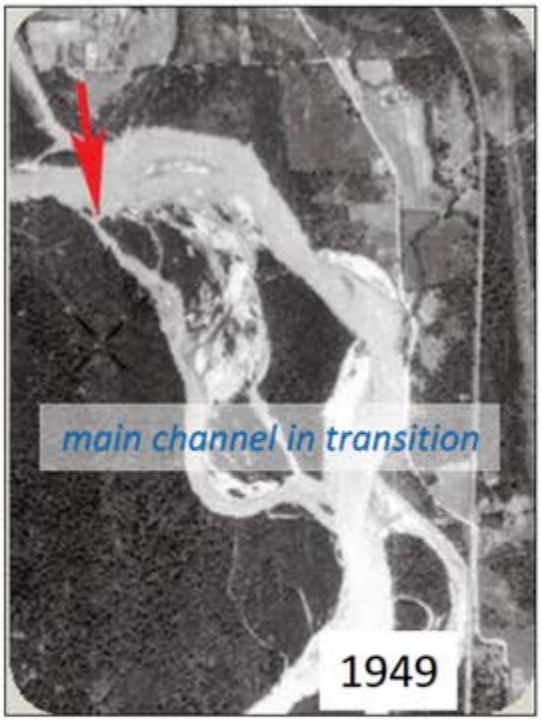
Hi Regan,

Nice to hear you are back in Squamish – welcome back!

I've been meaning to connect with you for awhile now on a dike master plan project that I'm working on. The District and Squamish Nation have received a grant to complete a Dike Master Plan for the Eagle Viewing Area and Seaichem (Siyich'em) Reserve. The goal of the project is to determine the preferred method for upgrading the dike over a 1km section (from the north end of Kowtain Reserve to the north end of Seaichem Reserve). I've attached a Powerpoint presentation from a recent Stakeholder Engagement Session for your background information.

Although it doesn't necessarily impact how we address the dike, through our engagement process we have consistently heard a desire from stakeholders and Squamish Nation to re-activate an old river channel which flowed along the west side of the valley through the Brackendale Eagles Provincial Park. This may alleviate some of the pressure being placed on the dike in high water conditions though that still needs to be determined. The arrow in the figure below is in the same spot and it shows how the river has migrated east over time.

There is a log jam currently blocking the inlet to the channel (see aerial photo below), . One concept has been to remove the log jam and see if that naturally restores the channel. We have no specific timeline or budget to complete this work imminently but I wanted to raise the issue and get BC Parks feedback on the concept to determine whether this is worth investing further effort. I also intend to discuss with DFO's Resource Restoration Unit to get their thoughts.



Time

Please let me know your thoughts. I'm also happy to chat if you'd prefer.

Thanks,
David

David Roulston, P.Eng | **Manager of Municipal Infrastructure**
District of Squamish | *Hardwired for Adventure*
604.815.4952 | droulston@squamish.ca | www.squamish.ca

SQUAMISH

I humbly acknowledge that I work within the traditional territory of the Squamish Nation, Sḵwx̱wú7mesh Úxwumixw.

Please consider the environment before printing this e-mail.

KERR WOOD LEIDAL
consulting engineers

September 2020 Siyich'em Residents / Families Meeting Notes

KERR WOOD LEIDAL
consulting engineers

Greater Vancouver
200 - 4185A Still Creek Drive
Burnaby, BC V5C 6G9
T 604 294 2088
F 604 294 2090

Meeting Minutes

Meeting Date: 2020-09-23 – 5:30 pm

Location: Virtual via Zoom

Re: **Eagle Viewing Area / Siyich'em Reserve Dike Master Plan**
Draft Master Plan Engagement Meeting with Siyich'em Families / Residents
Our File 0463.341-170

Attendees: Bob Sokol, Paul Wick, Austin Chandler, (Squamish Nation staff)
Amir Taleghani, Shona Robinson (KWL)
Siyich'em Families / Residents (names not recorded for privacy)

Distribution: To be included into dike master plan final report (appendices)

Introductions and Presentation

Squamish Nation and KWL staff were introduced.

Amir Taleghani of KWL provided a presentation on the draft dike master plan content. A PDF of the presentation is attached. The presentation portion of the meeting was recorded via ZOOM and the recording is saved on file by Squamish Nation and KWL.

Comments, Questions, Answers, and Discussion

Question *(Siyich'em family member / resident):* Agrees that the preferred concept alignment along the Siyich'em reserve (Option C) is where they want to go, in terms of being able to address historic problems with land tenure. Wondered how long Squamish Nation has been negotiating the Government Road trespass issue and resolution with the District of Squamish and residents. Why has no one from the Siych'em families / residents been included so far? Noted that there is a Certificate of Possession (CP) title on Siyich'em. Requested access to any documents. Requested to know who has been involved in negotiations to date.

> ***Answer*** *(Bob Sokol):* There has been no formal negotiation of the Government Road relocation concept. The relocation concept has been explored at a very preliminary technical level only and the draft master plan includes a potential alignment figure. Any future work or negotiations would include all impacted parties, including the Squamish Nation and CP holders. Squamish Nation and District of Squamish councillors are on the steering committee and the draft master plan has been conditionally endorsed by Squamish Council and the District of Squamish to date.

Question *(Siyich'em family member / resident):* Confirming that the existing Siyich'em reserve includes a narrow strip on the west side of the river. Noted that the Nation historically had long houses in this area. Asked whether there are going to be archeologists investigating along both sides of the river. How would this be funded?

> ***Answer*** *(Amir Taleghani):* Future archeological investigation work is listed in the draft master plan as part of the next steps to implement the plan. Agreed to specifically highlight consideration for west bank of

river in the archeology work. Funding has not been finalized, but it would be a collaborative effort among different levels of governments.

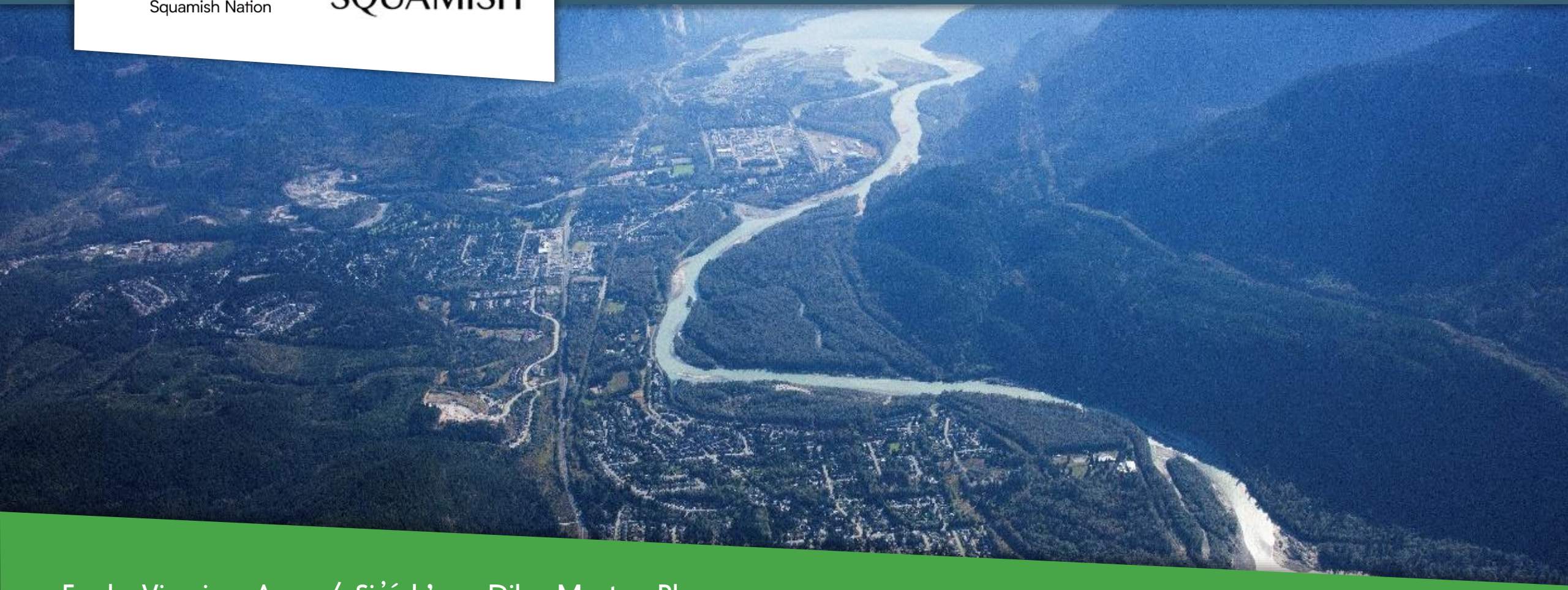
Question *(Siyich'em family member / resident):* Are we going to get documentation/notes of this meeting? Would like to be updated on what has happened since November 2019, feels that the family has not been fully informed about the process and next steps. Would like to know what the next steps are.

> ***Answer*** *(Bob Sokol, Amir Taleghani, Shona Robinson)*: We will include notes from this meeting in an appendix to the final report. The summary of any results of any meetings and changes since November 2019 are documented in the draft master plan. Agreed to continue to notify Siyich'em families / residents about project progress, including when the two councils (Squamish Nation and District of Squamish) will be considering the final master plan.

Enclosed: PDF copy of presentation from the meeting.

Sḵwx̱wú7mesh Úxwumixw
Squamish Nation

SQUAMISH



Eagle Viewing Area / Siy̓ích'em Dike Master Plan

Draft Dike Master Plan - Siy̓ích'em Residents Meeting

Presentation

September 23rd, 2020

Sḵwx̱wú7mesh Úxwumixw Squamish Nation

SQUAMISH

KERR WOOD LEIDAL consulting engineers

THURBER ENGINEERING LTD.

HAPA

Meeting Purpose & Agenda

Purpose: Inform residents of draft master plan content & get input on next steps

1. Introductions
2. Project Background
3. Dike Master Planning Process
4. **Selected Option – Overview**
5. Possible Next Steps
6. **Discussion**

Squamish River near Siyich'em.

Introductions & Project Personnel

Table 1-1: Project Steering Committee Members

Name	Organization
David Roulston	District of Squamish
Chris Wyckham	District of Squamish
Gary Buxton	District of Squamish
John French	District of Squamish
Armand Hurford	District of Squamish
Paul Wick	Squamish Nation
Bob Sokol	Squamish Nation
Austin Chandler	Squamish Nation
Michelle George	Squamish Nation
Joshua Joseph	Squamish Nation
Chris Lewis	Squamish Nation
Chief Richard (Dick) Williams	Squamish Nation
Peter Baker	Squamish Nation
Monica Jacobs	Squamish Nation
Brent Baron	Indigenous Services Canada

Table 1-2: Consultant Team Key Staff

Name	Organization	Role(s)
Erica Ellis	KWL	Lead Consultant Project Manager
Mike Currie	KWL	Technical Reviewer
David Roche	KWL	KWL Advisor to District
Jeff Derer	KWL	KWL Advisor to Nation
Amir Taleghani	KWL	Project Engineer
Shona Robinson	KWL	Junior Engineer
Heather Kingcott	KWL	Project Biologist
Patrick Burke	KWL	Project Biologist
Steve Coulter	Thurber	Thurber Project Manager/Geotechnical Engineer
Lukas Holy	Hapa	Hapa Project Manager/Landscape Designer
Allison Tweedie	Hapa	Landscape Designer

Background - Squamish River Flood Hazard

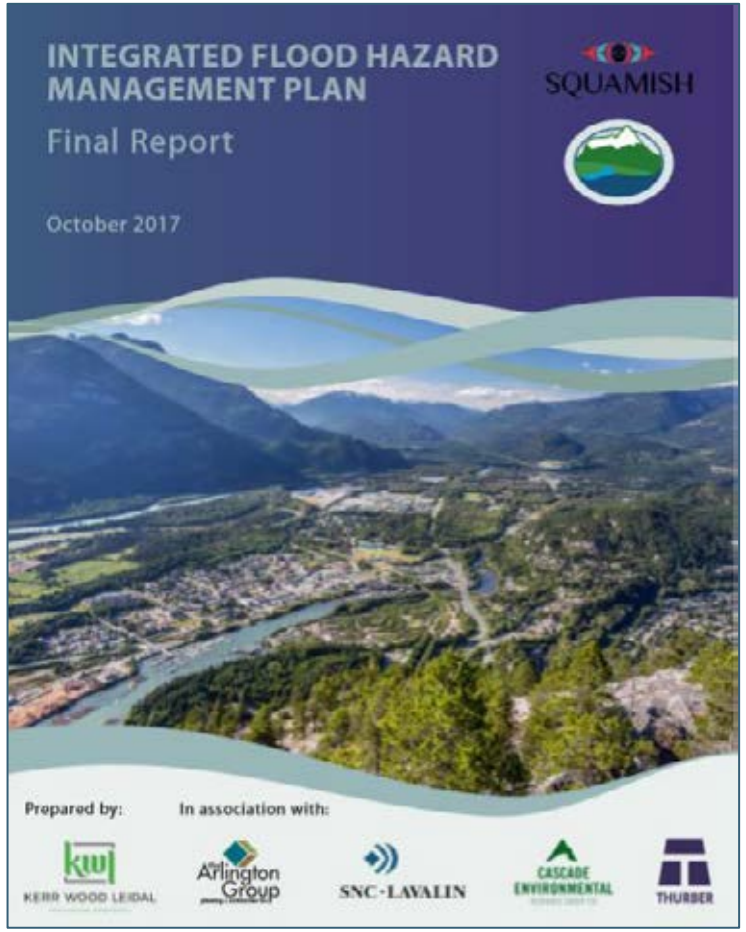
Squamish faces river, coastal, and dike breach hazards

District recently completed an Integrated Flood Hazard Management Plan (IFHMP).

A recent flood risk assessment has revealed that current flood risk to loss of life is unacceptable.

Potential dike breaches (including at the Eagle Viewing – Siyich'em area are major hazards).

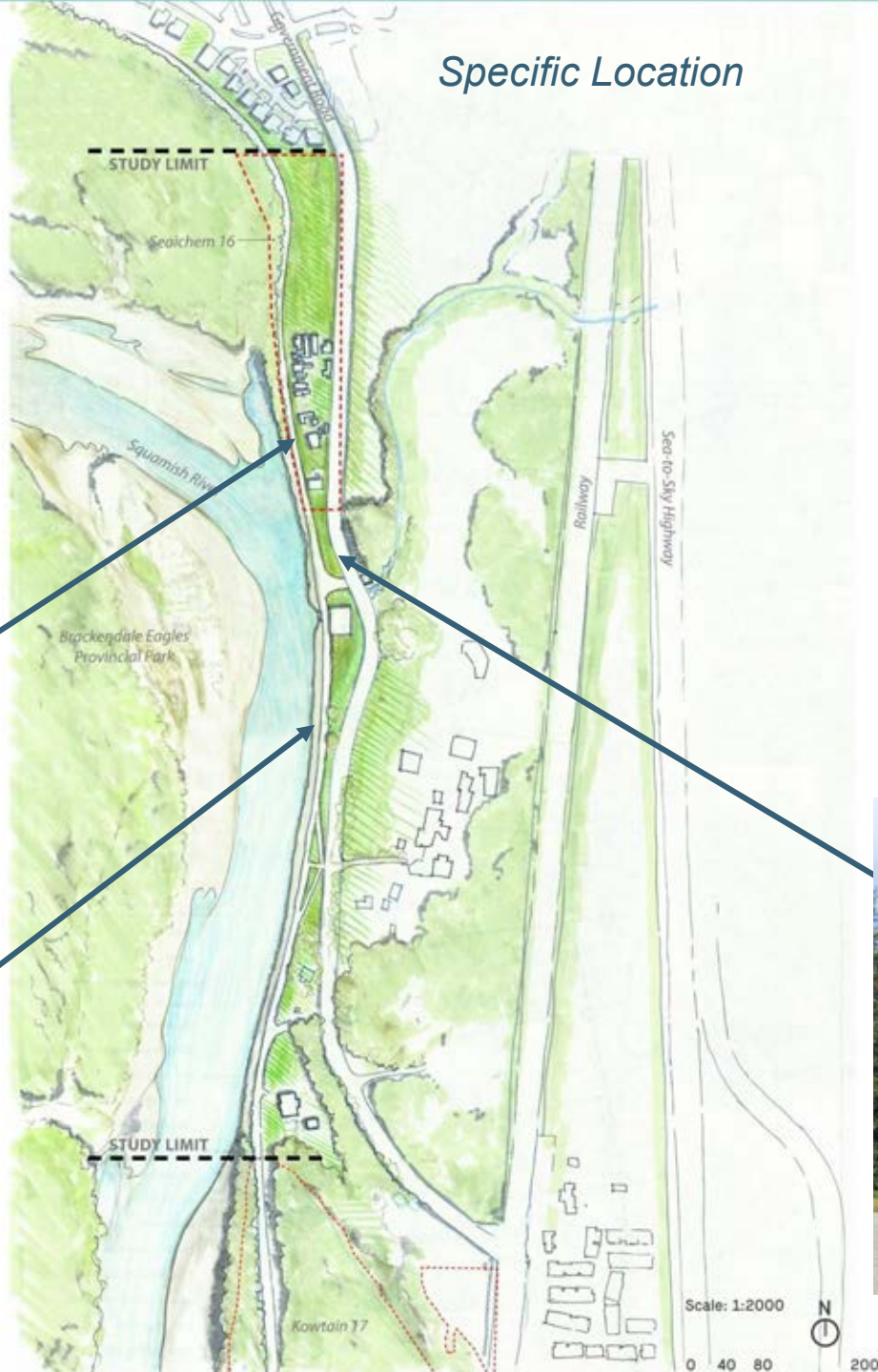
IFHMP recommended a dike master plan for the Eagle Viewing – Siyich'em area.



Original Study Area

Siyich'em 16 to
Kowtain 17

Specific Location



General Location (Google Earth)

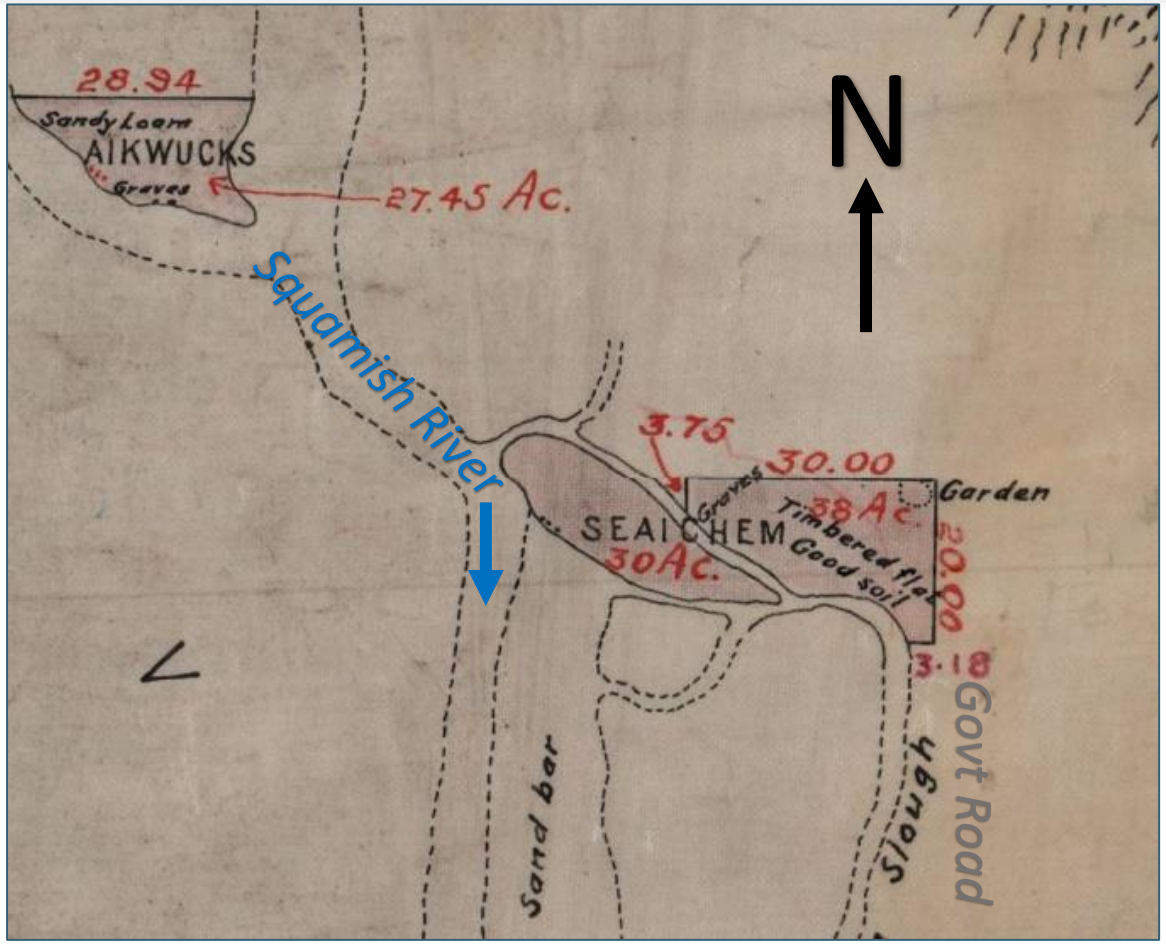
History - Siyich'em Reserve Land Loss

Original reserve size:

- 68 acres
  - 38 acres on main land
  - 30 acres bar/island in the river

Current:

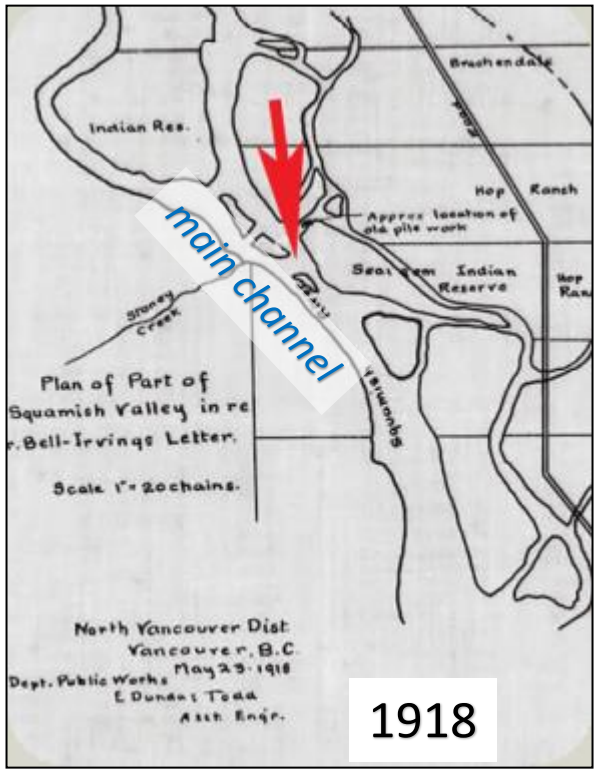
- 9.8 acres
  - 6.6 acres main reserve
  - 3.2 acres west of river

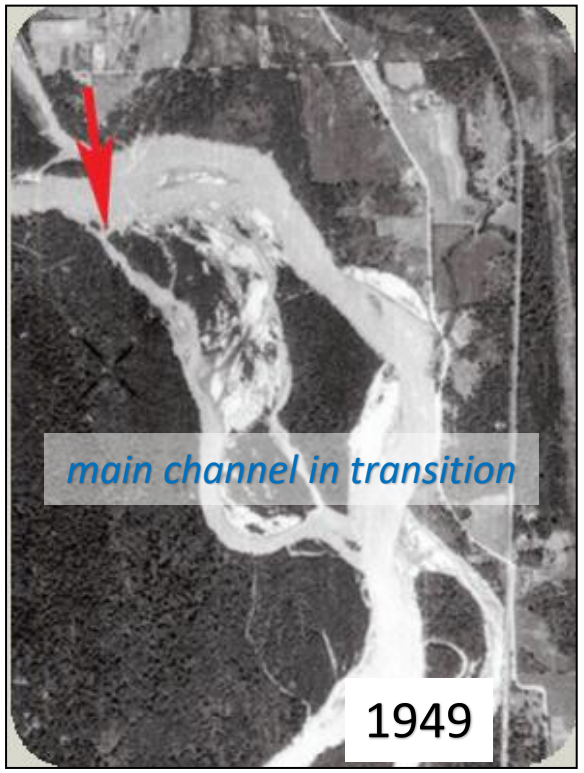


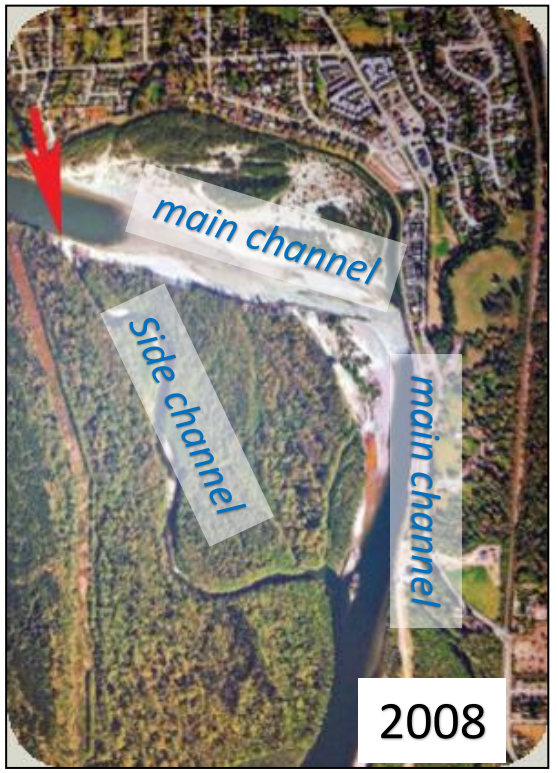
Portion of plan originally surveyed/drawn by E. Mohun, 1881

Source: Government of Canada

History - River Changes and Siyich'em Reserve Land Loss







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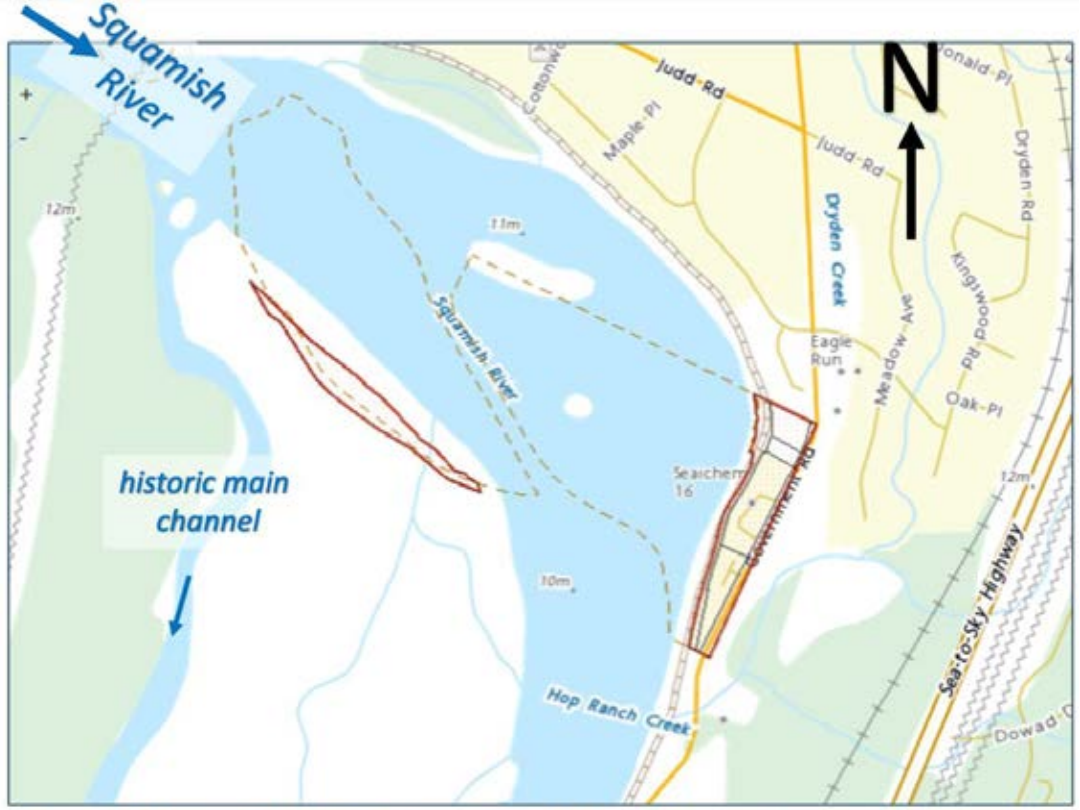
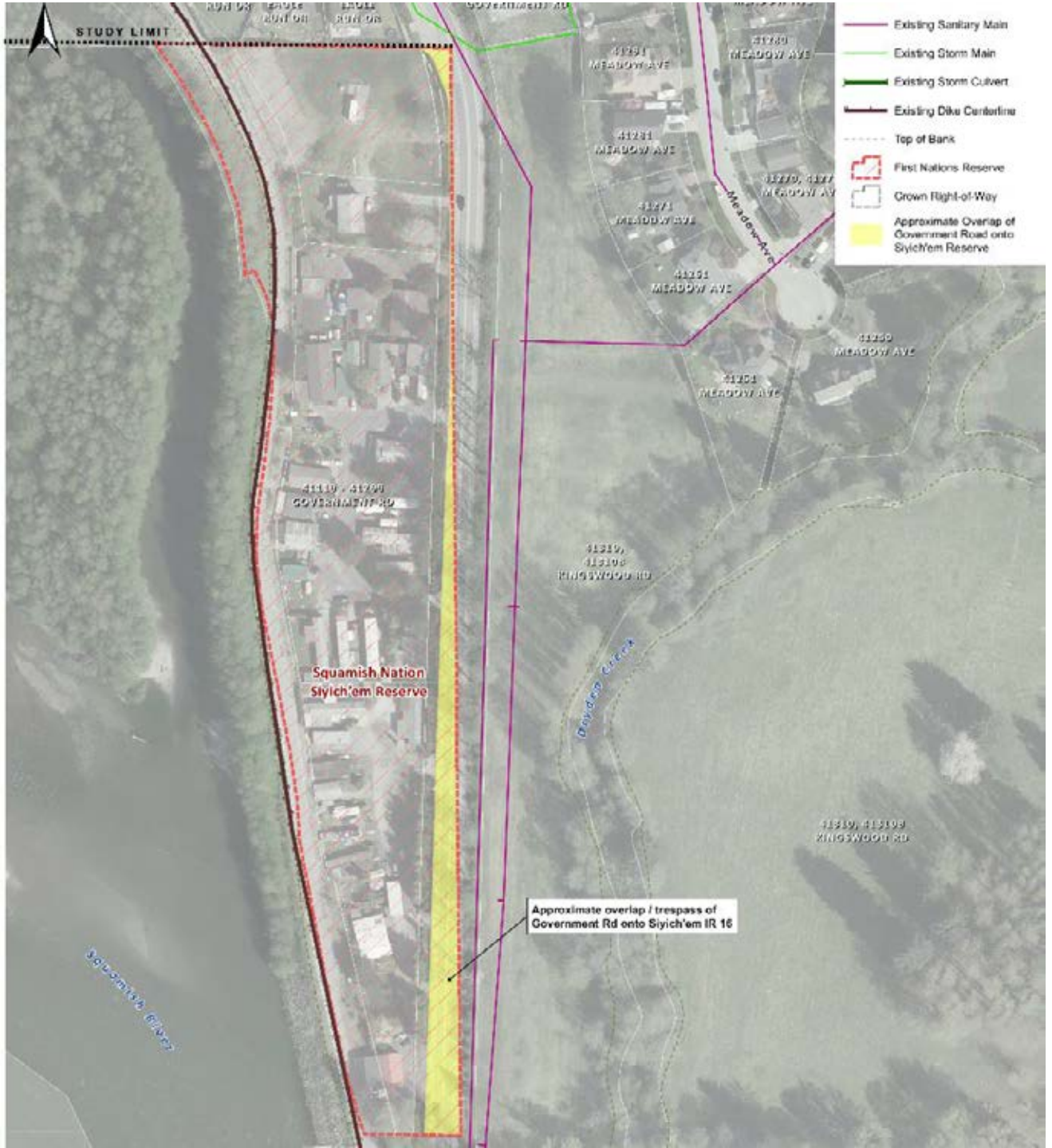
Time

Siyich'em Reserve Lands Today



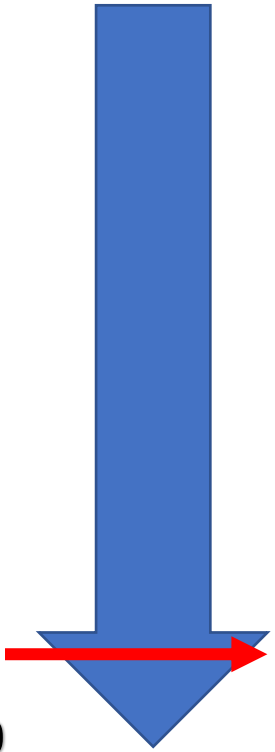
Canada Lands Survey System - CLSS Map Browser
Source: Government of Canada



- 9.8 acres
  - 6.6 acres main reserve
    - Includes Govt Road trespass
  - 3.2 acres west of river

Context – Master Plan Process & Schedule

August 2019

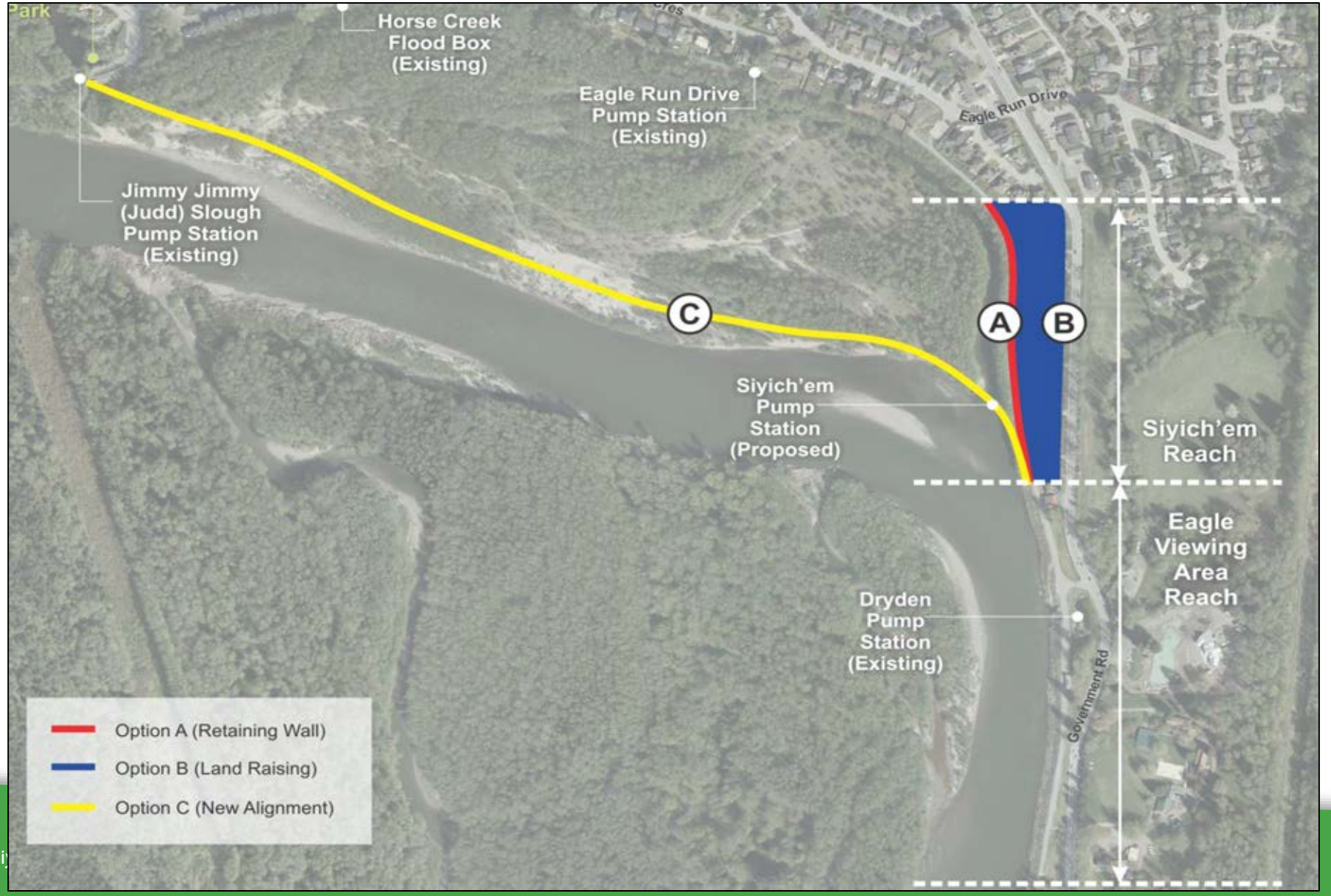


We are here

September 2020

- Project start-up & background information review ✓
- Launch project website ✓
- Identify common interests ✓
- Brainstorm potential flood protection options ✓
- Shortlist 3 flood protection options ✓
- Engagement on shortlisted options ✓
- Select the preferred flood protection option ✓
- Develop an implementation plan ✓
- Engagement on draft plan
- Finalize plan

3 Options in Siyich'em Assessed in Fall 2019 / Winter 2020



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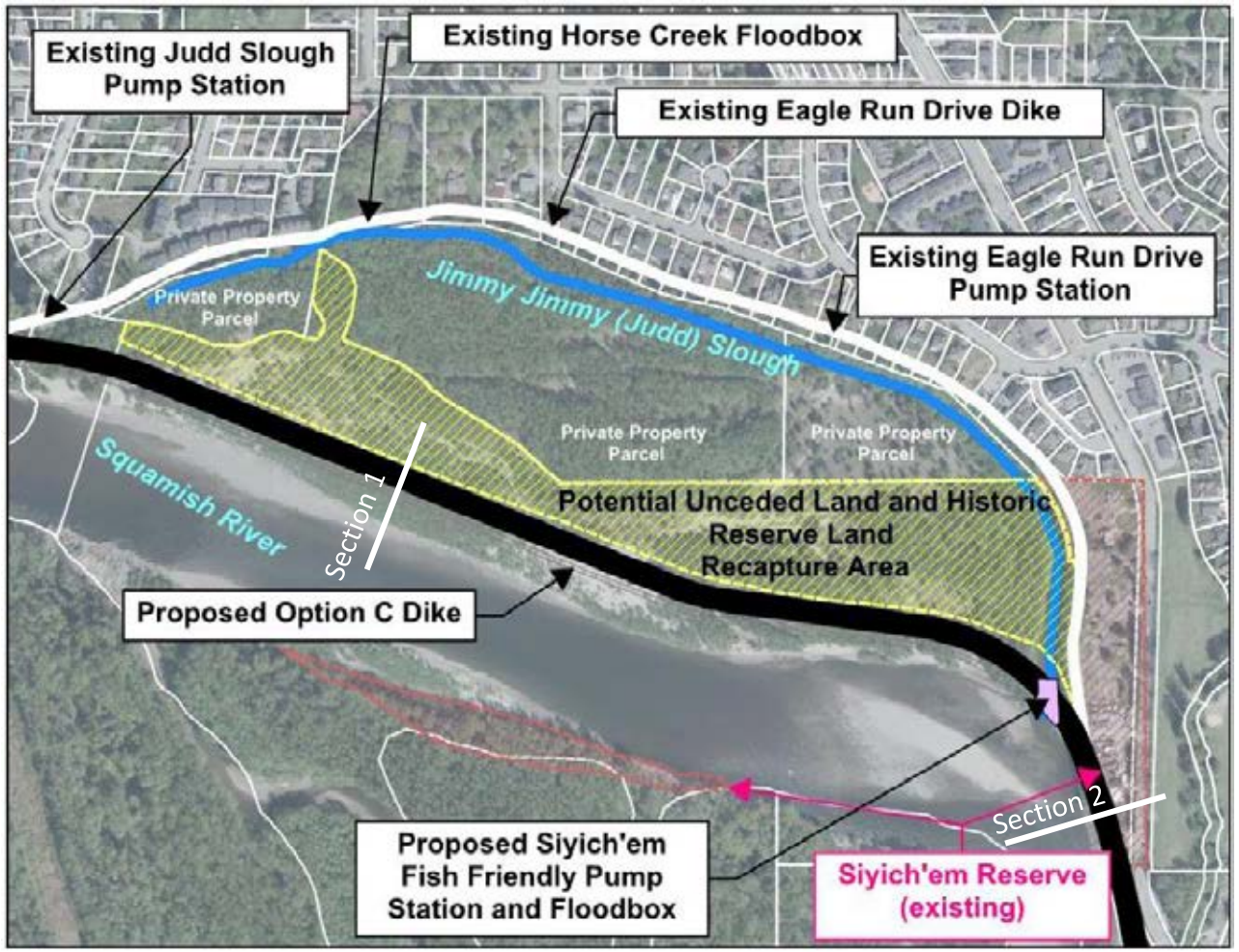
November 2019 Meeting with You

Some of the comments from the November 2019 meeting	Project team response
Dike upgrades that don't recapture lost reserve land are considered 'Band-Aids'	Selected option includes potential land recapture.
Who would own land if recaptured?	To be determined by Squamish Nation as a next step
Can river be diverted back to old main channel on west side of valley?	The selected option will allow for this in the future, but additional study is required as this project focused on diking.
Would like compensation for historic trespass of dike & road as a reconciliation measure.	Selected option includes road relocation off of reserve.
Can a family member be on the Steering Committee?	Squamish Nation councilors, staff, and Chief Dick Williams are on the committee. Opportunities for Siyich'em families to provide input include November 2019 meeting and September 2020 meeting.
Can SN/DoS elected officials attend the meeting?	Feedback from the meeting is taken to the steering committee which includes elected officials.

Selected Option – Overview & Expanded Study Area

Selected Option – Siyich'em Reserve Area



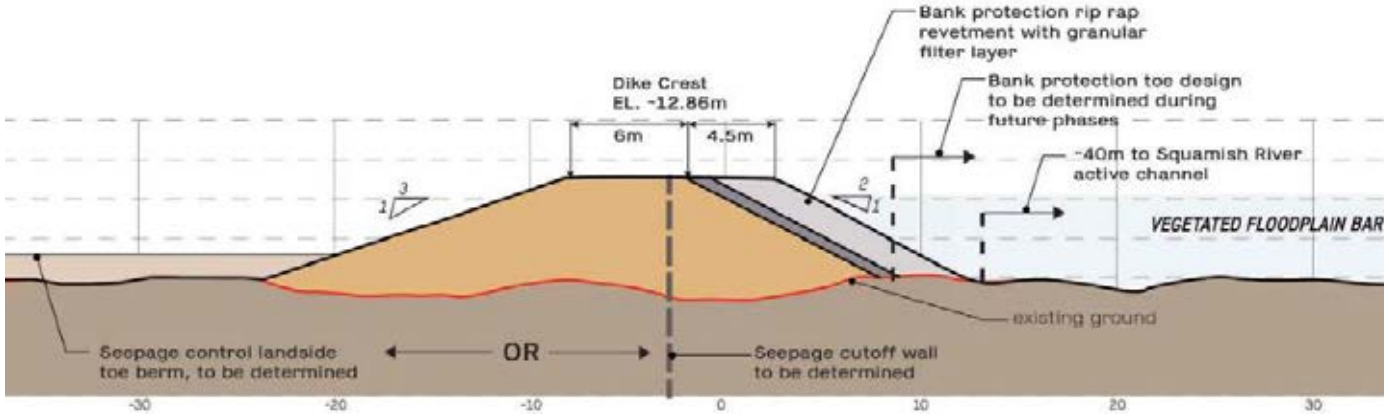
Potential land recapture / yellow polygon – 9.8 Ha

Current reserve size / red polygon – ~4 Ha

Historic reserve size – ~27 Ha

Selected Option – Potential Land Recapture Area

CROSS-SECTION



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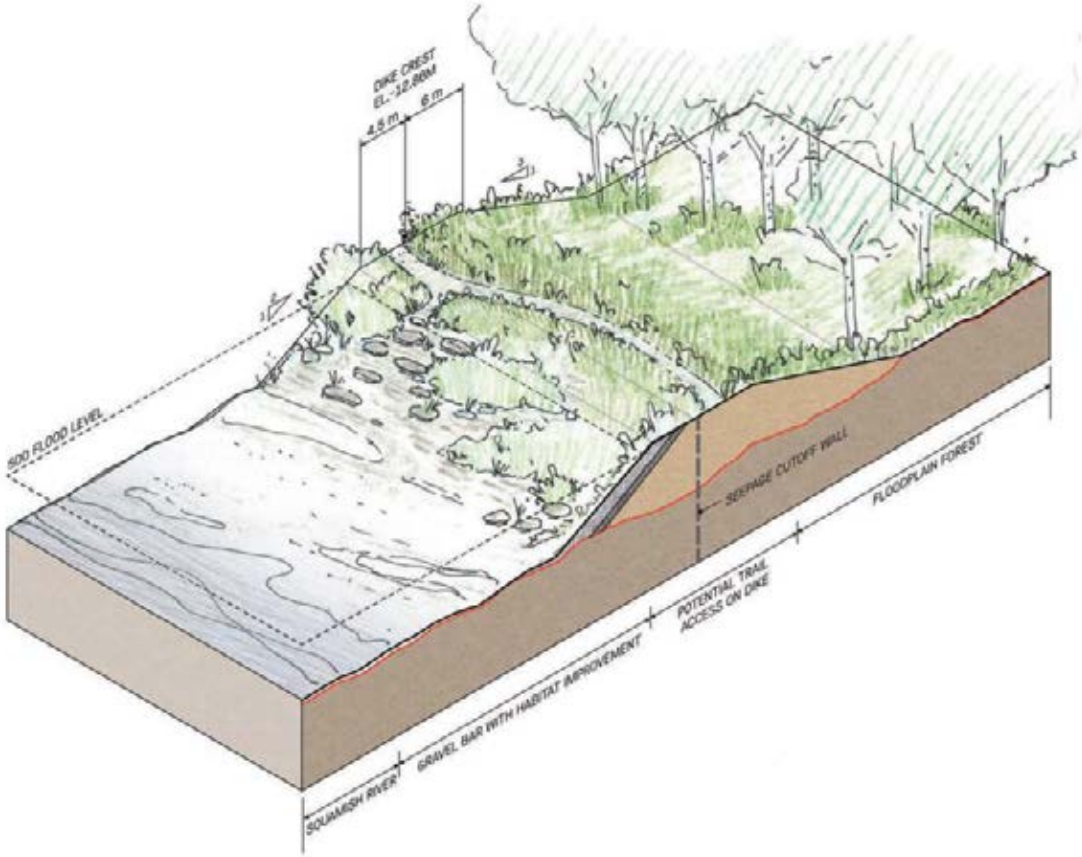

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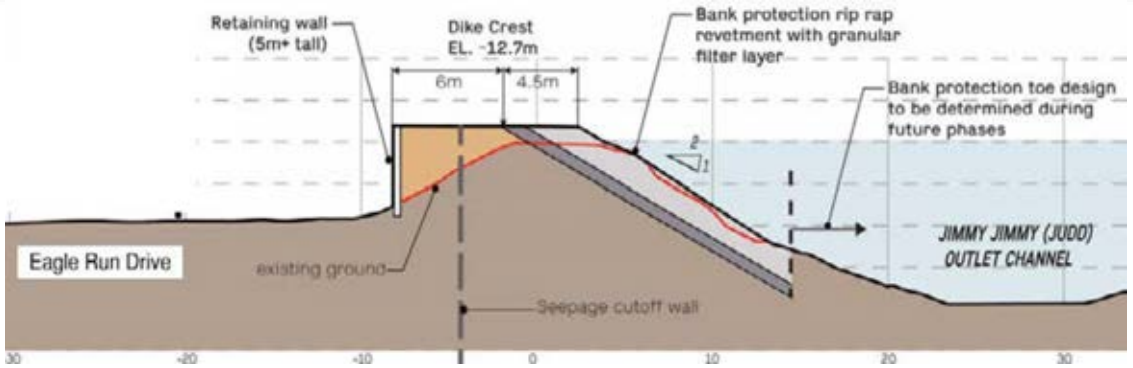
Selected Option – South End of Siyich'em Reserve



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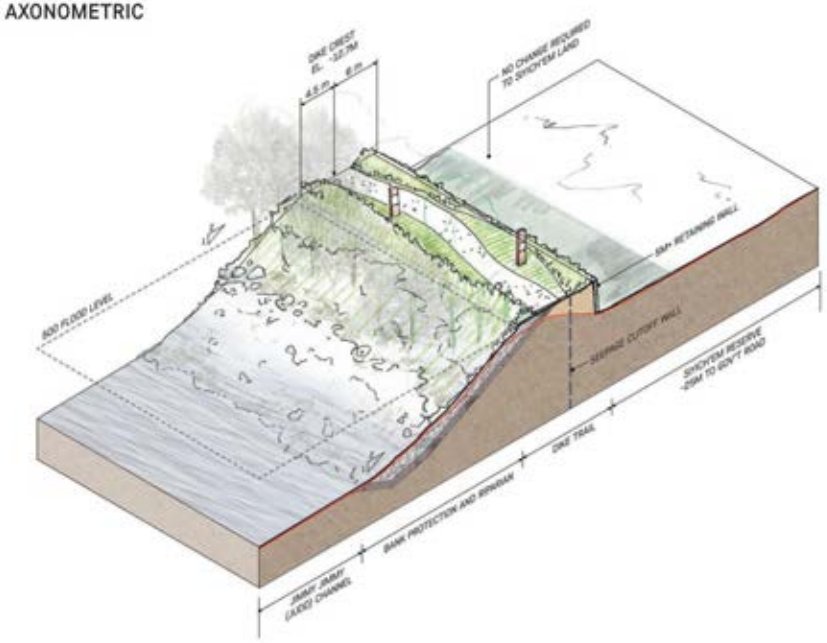
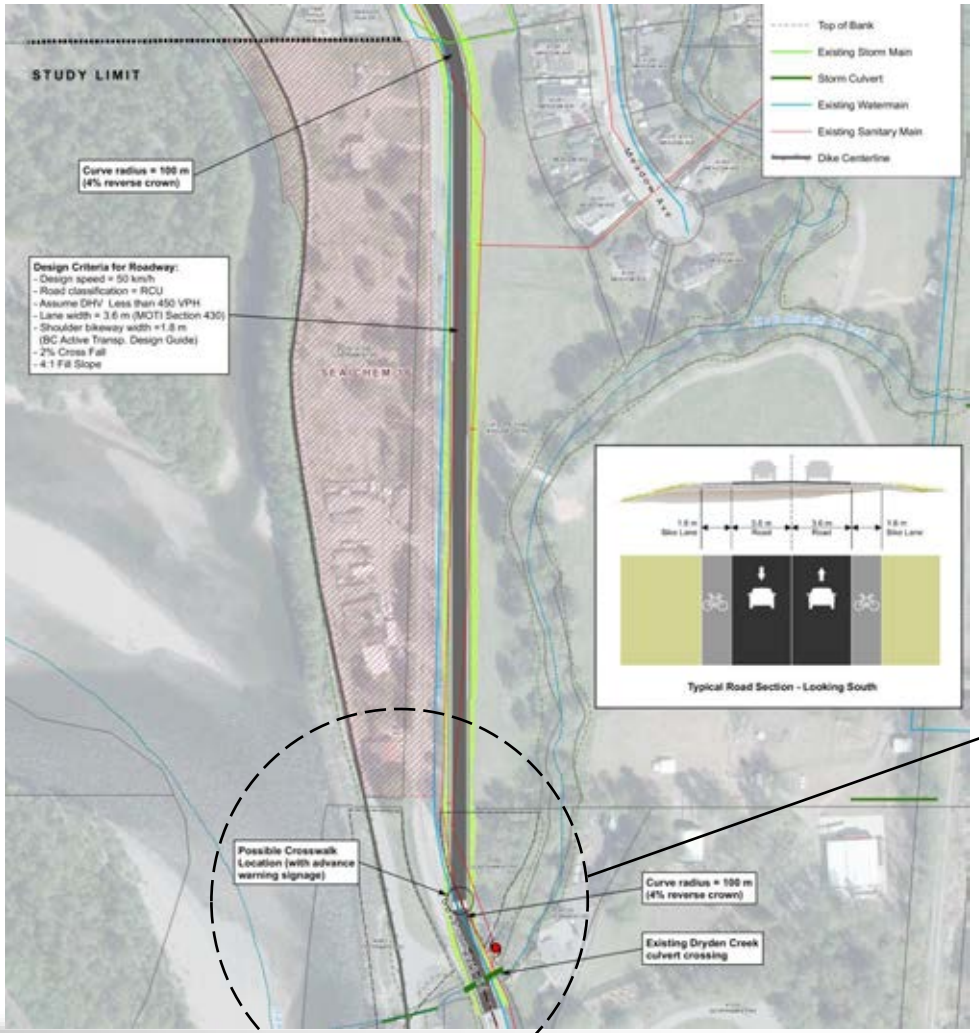
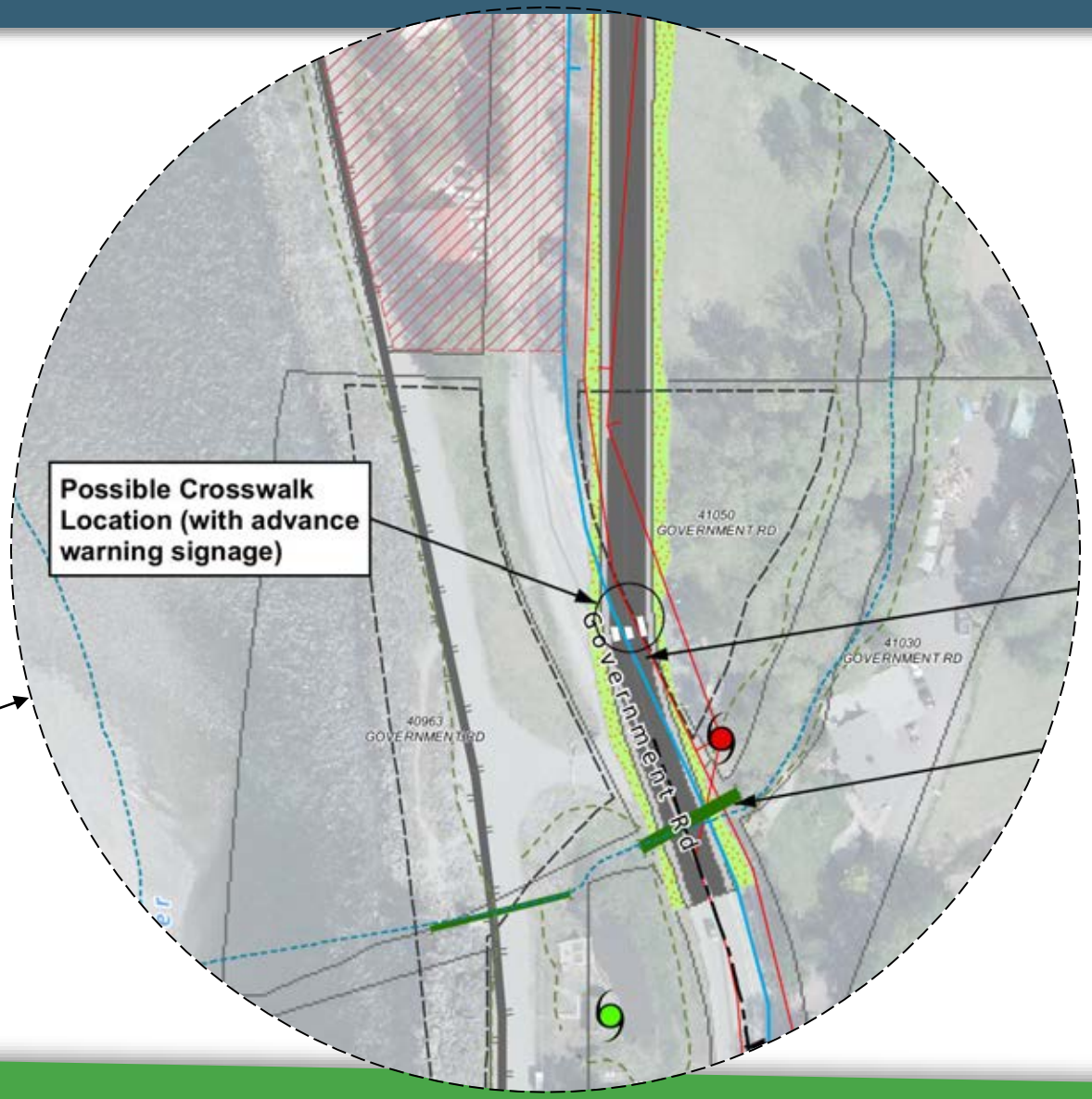


APPROX. 5M+ HIGH RETAINING WALL

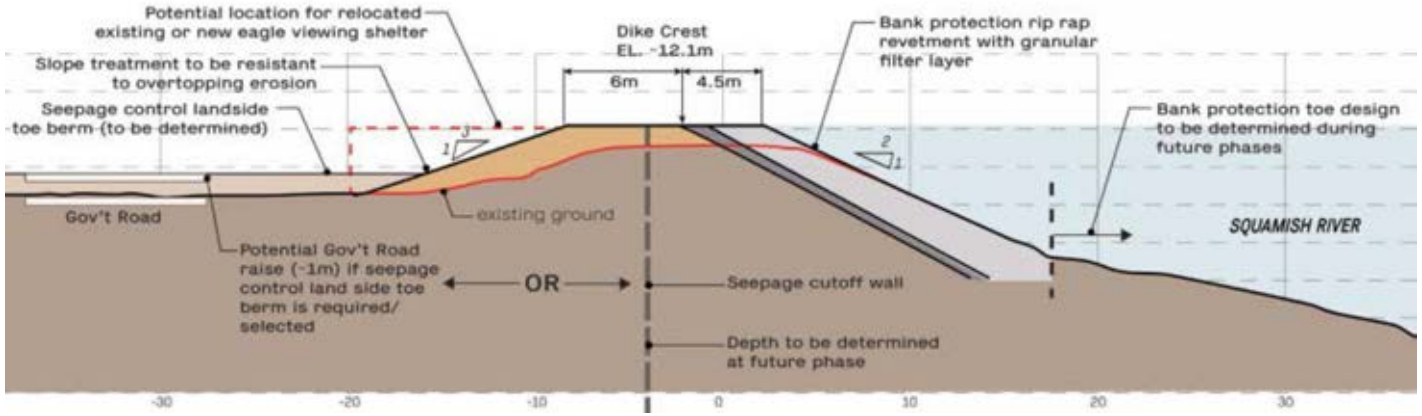
Selected Option – Government Road Relocation





Selected Option – Eagle Viewing Area (South of Siyich'em)

CROSS-SECTION



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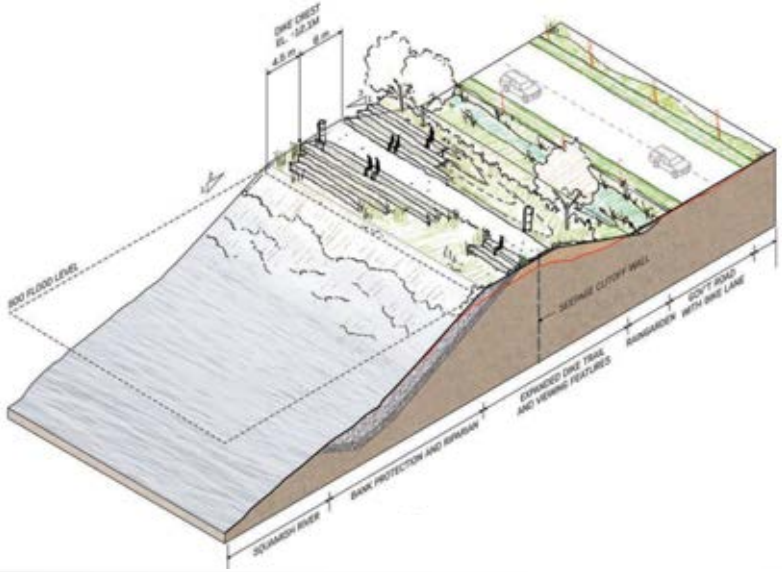
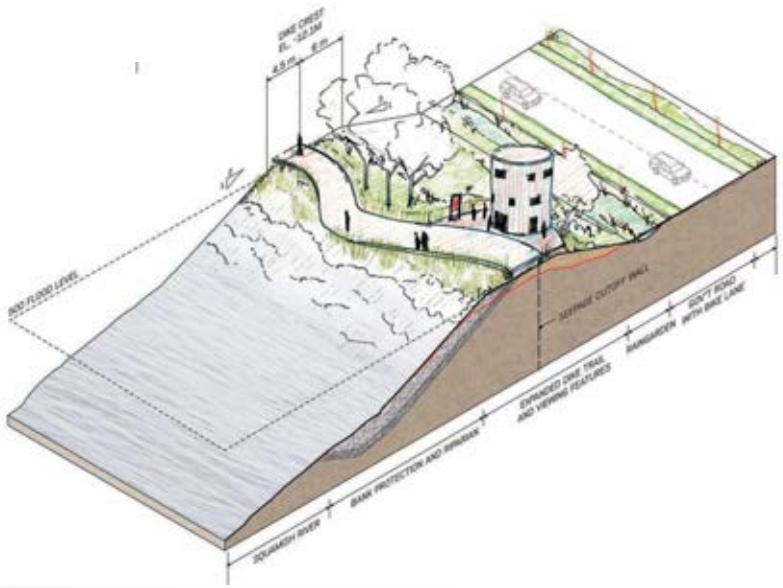
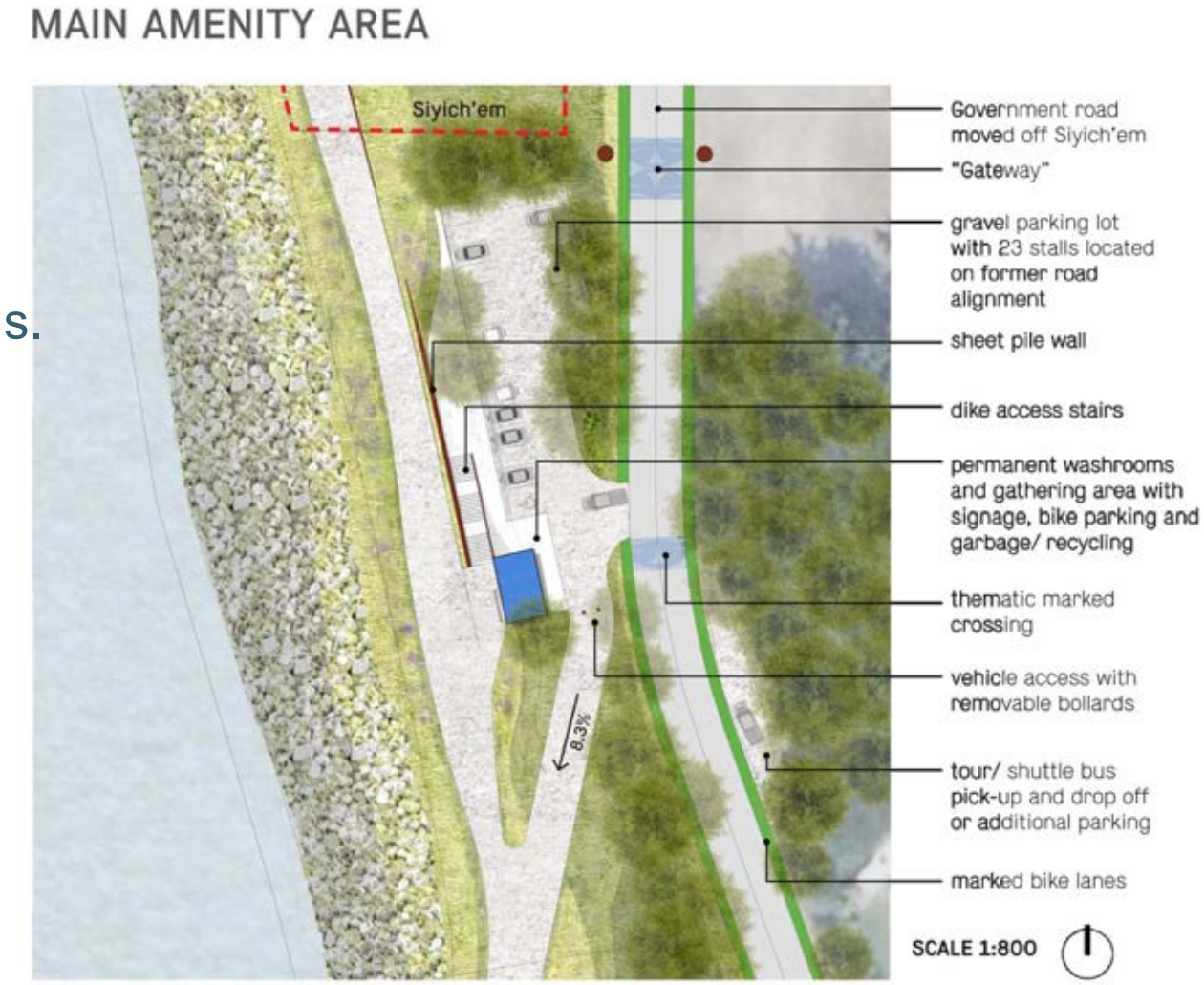




Selected Option – Eagle Viewing Area (South of Siyich'em)

Public Amenity Concepts:

- Gateways to eagle viewing area at each end.
- Trails (boardwalk) and social seating.
- Replace EagleWatch program shelter & boards.
- Viewing tower.
- Interpretive signage reflecting history (Siyich'em)
- Permanent washroom in parking lot.
- Additional parking lot south of existing ramps.
- Traffic calming and improved pedestrian road crossing.



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Possible Next Steps

Next steps required to advance the plan towards implementation include:

- Land tenure administrative processes;
- Additional analysis and feasibility assessments;
- Preliminary design and engagement;
- Regulatory engagement;
- Detailed design, engagement, and permitting; and
- Construction, operation, and maintenance.

What additional next steps should be included?

Squamish River near Siyich'em.

Comments & Questions

Feedback will be included in the final Dike Master Plan.

Squamish River dike looking north at eagle viewing shelter

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Online Survey #3 Analysis

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Squamish Nation

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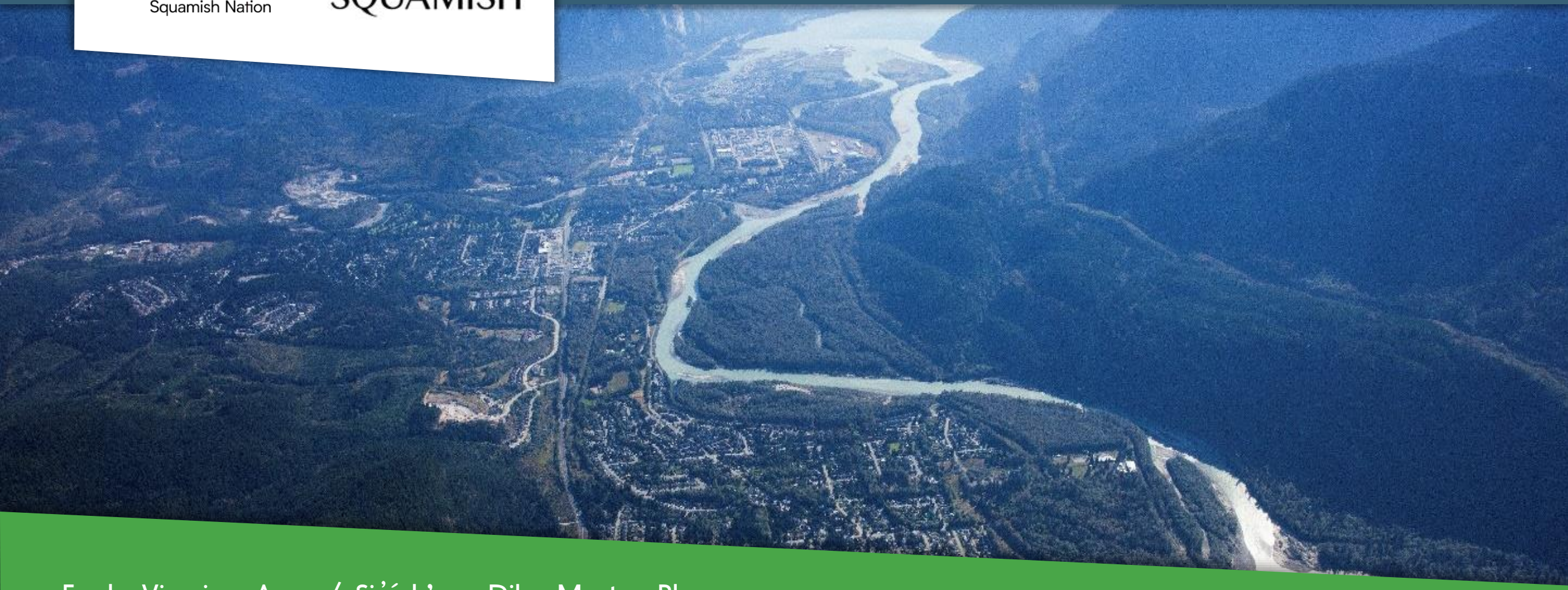

Eagle Viewing Area / Siy̓ích'em Dike Master Plan

Online Survey #3 – Summary of Results

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Online Survey #3

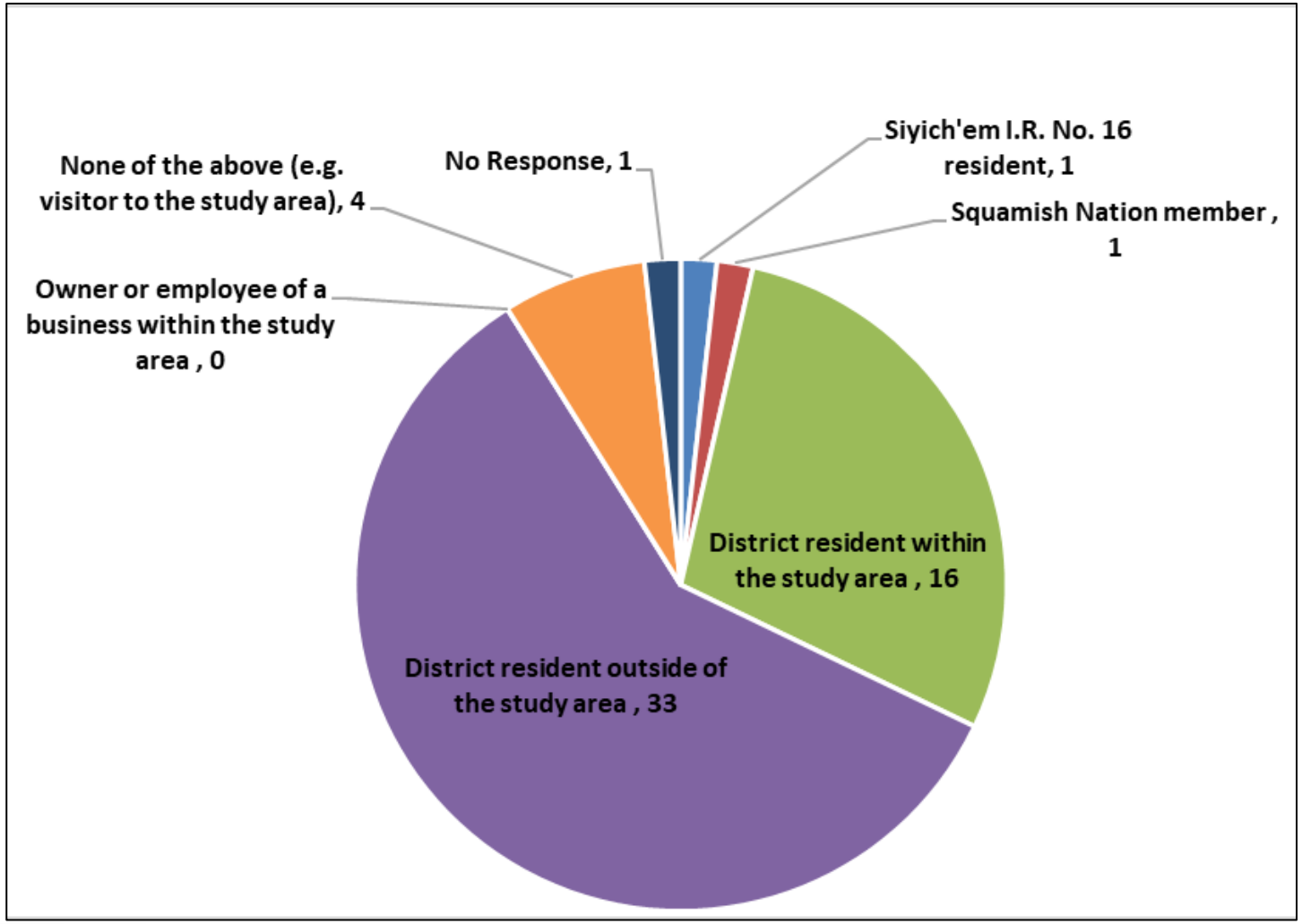
<u>Purpose:</u> Gather feedback on draft master plan including on selected dike upgrading concepts.

- Posted online from June 2020 to September 2020.
- Linked with project webpage hosted on District of Squamish website.
- Survey asked respondents to review the draft dike master plan including the selected dike upgrading options.
- 11 questions including open-ended feedback comment opportunities.
- A copy of the survey is provided at the end of this document.

Survey Results

Respondent Profiles

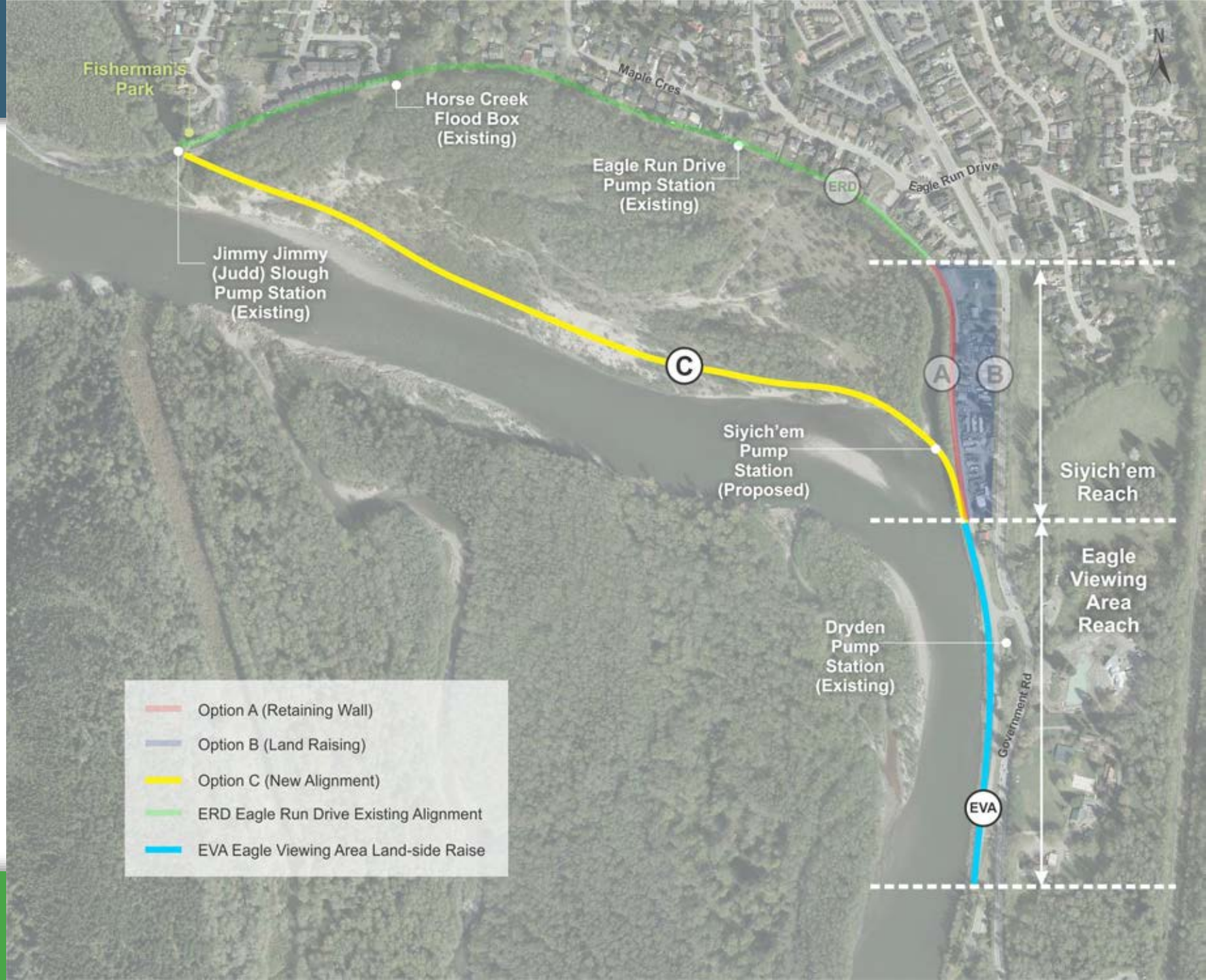
- 56 respondents.
- Mostly District of Squamish residents, including both study area residents and residents from elsewhere in the District
- Only 2 Squamish Nation resident or member respondents.
- Age of the majority of respondents was between 25 and 44 years.



Survey Results

The survey asked respondents whether they support the selected dike upgrading options:

- New alignment (C, yellow) between Siyich'em Reserve and Fisherman's park
- Existing alignment upgrade (EVA, blue) in the Eagle Viewing Area

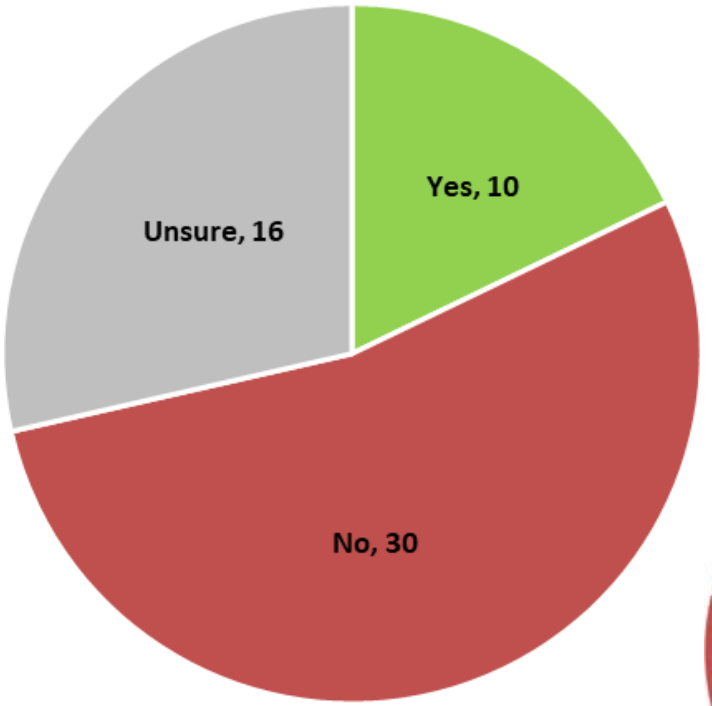


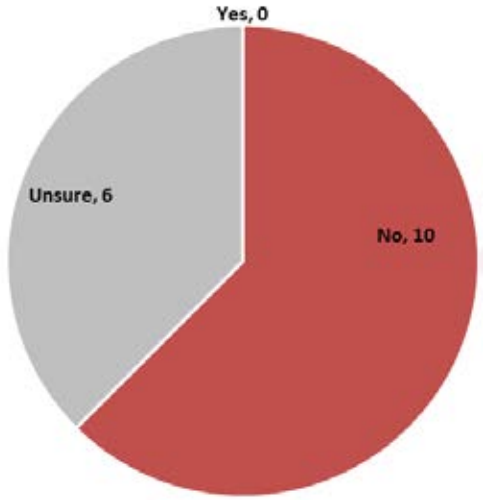
Survey Results

Support for New Dike Alignment (Siyich'em Reserve to Fisherman's Park)

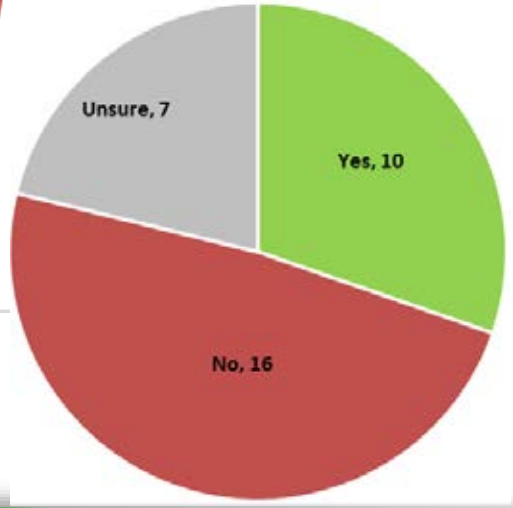
- Majority do not support the selected option (new dike alignment).
- More relative opposition from District residents from the study area.
- Concerns expressed in comments:
  - Habitat and ecosystem impacts.
  - Impacts to and loss of access to recreational areas (e.g. beach).
  - Enabling development of green/natural areas.
- Suggestions of compensating Squamish Nation land tenure issues through off-site land transfer or other approaches.

All respondents (56)





District residents in study area (16)



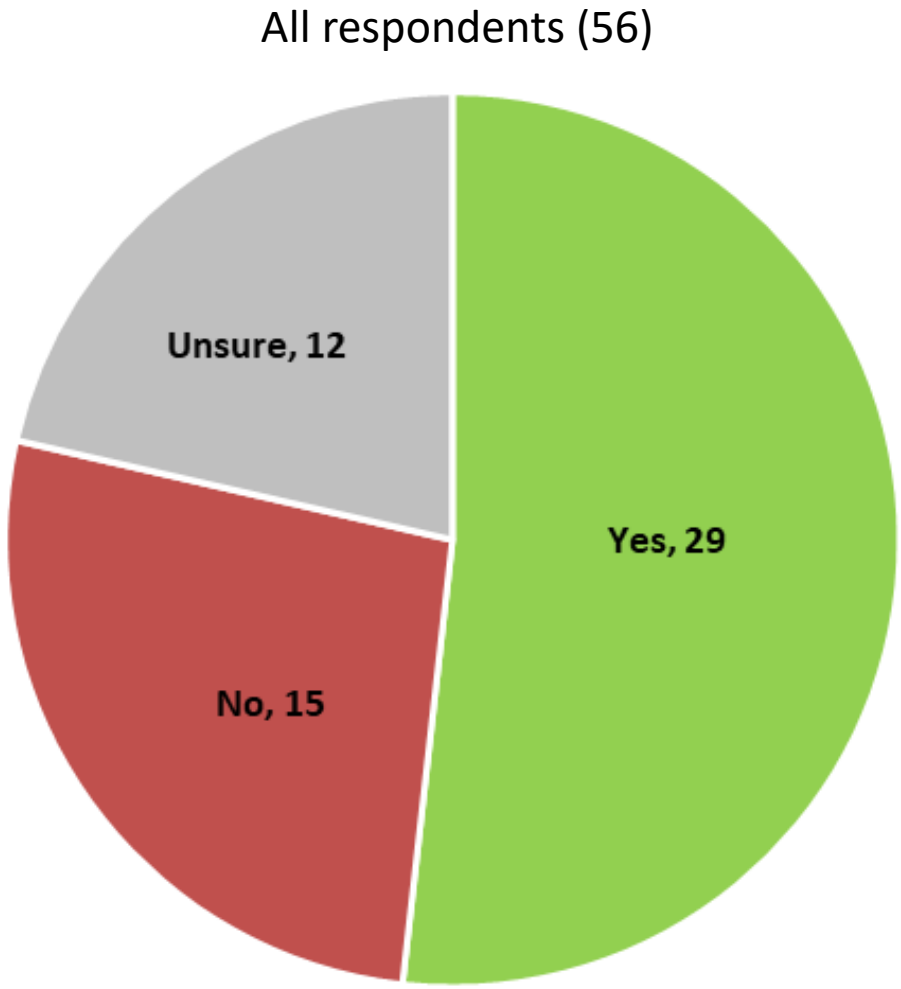
District residents outside of study area (33)

Survey Results

Support for Dike Upgrading on Existing Alignment in the Eagle Viewing Area

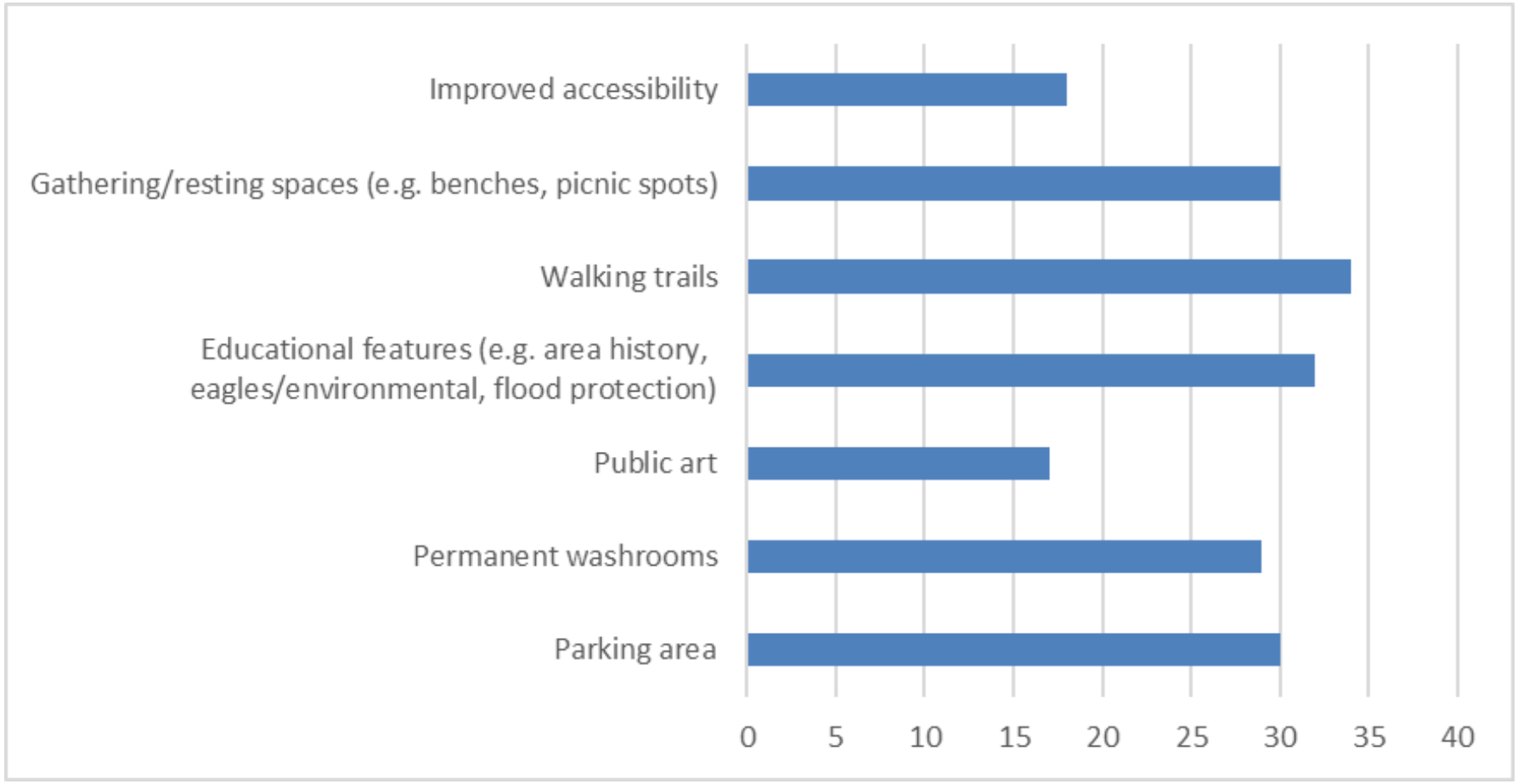
- Majority support the selected option (raise dike on existing alignment).

- Written comment themes:
  - Support maintaining existing alignment.
  - Concern for habitat and ecosystem impacts.
  - Support for maintaining the EagleWatch program infrastructure



Survey Results

Support for Pubic Amenity Improvements in the Eagle Viewing Area



Original Survey Attached

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Squamish Nation

SQUAMISH
HARDWIRED for ADVENTURE

Eagle Viewing Area / Siy̓Ích'em Dike Master Plan

Public Survey #3

Between Summer 2019 and Spring 2020, the District of Squamish and Squamish Nation developed a draft master plan for the Squamish River dike in the Siy̓Ích'em Reserve and Eagle Viewing Area, along Government Road.

More information about the project including background information, process, and schedule is available on the project website: https://squamish.ca/yourgovernment/projects-and-initiatives/eaglesiyichemdike/

This survey follows surveys #1 and #2. Survey #1 asked stakeholders to identify their connection to the study area and voice their values and interests associated with the study area. Survey #2 provided an opportunity for stakeholders to delve deeper and provide feedback on the flood protection options shortlisted by the District and Nation, and to comment other features not directly related to flood protection (e.g. public amenities in the eagle viewing area).

Information from the draft dike master plan is available on the project website. This draft dike master plan describes the master planning process with details related to the selected option. This includes cost estimates, high-level public amenities, and considerations for master plan implementation.

Please complete this survey online (link at the project website) or on paper and return it to project team members.

1. Please tell us about yourself (Select all that apply)

☐ Siy̓Ích'em I.R. No. 16 resident

☐ Squamish Nation member

☐ District resident within the study area (see attached map)

☐ District resident outside of the study area (see attached map)

☐ Owner or employee of a business within the study area (see attached map)

☐ None of the above (e.g.-visitor to the study area (see attached map))

2. What is your age?

☐ < 15 years

☐ 15-24 years

☐ 25-44 years

☐ 45-64 years

☐ > 65 years

3. Do you support the selected option for the Siyich'em reach (i.e. Option C – New Dike Alignment and Land Recapture)?

- ☐ Yes
- ☐ No
- ☐ Unsure

Comments and/or suggested changes:

4. **Do you support the preferred option for dike upgrading in the Eagle Viewing Area reach? (raise existing dike crest and expand towards the land (east).**

- ☐ Yes
- ☐ No
- ☐ Unsure

Comments and/or suggested changes:

5. **In general, what features of the draft plan do you support?**

6. **In general, what features of the draft plan are you concerned about?**

7. **What amenities would you like to see included in the Eagle Viewing Area reach?**

- ☐ Permanent washrooms
- ☐ Additional and expanded parking
- ☐ Ample seating opportunities that are flexible and social
- ☐ Educational features (e.g. area history, eagle watch, environmental, flood protection)
- ☐ Local Squamish Nation art

- ☐ Trail connectivity and wayfinding
- ☐ Planting improvements
- ☐ Improved accessibility

Comments and/or suggested changes:

_____

_____

Wrap-up Questions:

8. Do you have additional comments, questions, or concerns to share?

_____

_____

_____

_____

9. Was enough information provided (e.g. via the survey, project website, and draft dike master plan) to enable you to share your input on the questions in this survey? (Please select one)

- ☐ Strongly Agree
- ☐ Somewhat Agree
- ☐ Unsure/Neutral
- ☐ Somewhat Disagree
- ☐ Strongly Disagree

10. Are you interested in being notified as additional information becomes available?

- ☐ Yes
- ☐ No

If yes, please provide your e-mail address:

_____

11. Do you require a project team member to contact you to discuss your comments further?

- ☐ Yes
- ☐ No

THANK YOU FOR YOUR INPUT!

KERR WOOD LEIDAL
consulting engineers

Appendix I

District of Squamish Preferred Option Recommendation Council Report

REPORT TO:	Council	FOR:	COW
REPORT FROM:	Community Planning & Infrastructure		
PRESENTED:	February 11, 2020	FILE:	
SUBJECT:	Eagle Viewing Area / Siyich'em (Seaichem) Reserve Dike Master Plan		

Recommendation:

That Council approve the following resolutions:

THAT the District of Squamish endorse Option C: New Dike Alignment as the preferred dike upgrading option from the south end of Siyich'em Reserve to Aik'wucks Reserve; and,

THAT the project team complete further recommended work as described in the February 11, 2020 report to Council to further evaluate the feasibility and viability of Option C: New Dike Alignment prior to seeking adoption of the Eagle Viewing Area / Siyich'em Reserve Dike Master Plan.

1. Objective:

Staff are seeking Council endorsement of a new dike alignment from the Siyich'em Reserve to Aik'wucks Reserve and to complete further work to evaluate the option in greater detail. Staff are also seeking endorsement of the dike upgrading concept through the Eagle Viewing Area as described in this report.

2. Background:

The District adopted an Integrated Flood Hazard Management Plan in 2017 following a three-year process involving significant technical work and community engagement. Included in the recommendations of the plan is to complete a dike master plan for the Eagle Viewing Area / Siyich'em Reserve area. Flood levels were within 0.5m of the dike crest during the 2003 flood and there is significant seepage through the dike during high water events. This stretch of the Squamish River dike will be one of the most challenging areas to upgrade due to constraints including multiple different land owners, infrastructure conflicts, and significant dike deficiencies.

Council approved award of the consulting services contract on July 23, 2019 to Kerr Wood Leidal Associates Ltd. (KWL). The District of Squamish and Squamish Nation are project partners for this project.

This project is fully funded with a $270,000 grant received under the National Disaster Mitigation Program.

Work Completed to Date

Since Council approved award of this project in July 2019, Staff have been working closely with KWL and Squamish Nation. The following work has been undertaken to date:

- Prepared Project Charter and Stakeholder Engagement Plan.
- Formed a Steering Committee comprised of District Staff, Squamish Nation Staff and Councillors, and Indigenous Services Canada.
- Held an initial options development meeting with Steering Committee. A total of eight dike upgrading options for the area were developed.
- Completed geotechnical investigation and seismic stability analysis.
- Steering Committee shortlisted three options for the Siyich'em Reserve area. One option was selected for the Eagle Viewing Area where the design options are more constrained.
- Engaged community and stakeholders through multiple formats. Activities to date have included: creating and updating project website, posting public signage with project and contact information on the dike, two online surveys (162 responses), one presentation to Squamish Nation's Planning and Capital Projects Committee (PCPC) comprised of Staff and 6 Councillors, three workshops with community groups, local businesses/residents and Squamish Nation residents, one Public Open House and corresponding with regulators (DFO, Parks, MFLNRORD) on the three shortlisted options. Further activities are planned prior to completing the project.
- Completed technical analysis on the three shortlisted options near Siyich'em Reserve. Technical analyses included seismic stability analysis, river modeling and cost estimation for the purposes of informing a decision.

3. Project Information:

History and Context

It is important to understand the documented history of the Siyich'em Reserve and the Squamish River when evaluating dike upgrade options for the area.

- 1881 - the Siyich'em Reserve totaled 68 acres in size and was generally located east of the main river channel (see Page 2 of Attachment 1) although a branch of the river intersected the reserve (currently known as Jimmy Jimmy (Judd) Slough). This condition remained static until at least 1918.
- 1949 – an aerial photo shows that the river was in transition and the main channel of the river was in the process of migrating east resulting in erosion of a significant portion of the reserve. It is possible that erosion was caused or exacerbated by logging practices in the watershed and log jams blocking the west channel of the river.
- 1968 - as a result of ongoing erosion threatening developed lands (Reserve, Crown and private), the Province approved funding and undertook construction of riverbank protection along the current dike alignment including the portion through Siyich'em Reserve (see Attachment 2). (*Note: the Province was responsible for dike construction and maintenance until the 2000's at which point the responsibility was passed onto Local/Regional Governments*). The Province did not secure land tenure for dike

maintenance or upgrade purposes which means that any future dike improvements or maintenance on reserve land would require agreement by Indigenous Services Canada/Squamish Nation.

- 1976 – A Canada Lands Survey showed that the river had fully migrated to its present eastern alignment (see Attachment 3). As a result, the original 68 acres had been reduced down to the present 9.8 acres.
- 1982 – The Province undertook additional dike upgrades along the present alignment resulting in its current approximate form.
- 1982 to Present - significant land has accreted in the area of the historic reserve. The main river channel still intersects a large portion of the historic reserve.
- 2003 – The flood of record occurred bringing the river to within 0.5m of the dike crest. Significant seepage was witnessed through the dike, including on Siyich'em Reserve during this event.

Dike Upgrade Options – Siyich'em Reserve

Three main options have been shortlisted for evaluation through Siyich'em Reserve as follows (see Attachment 1 for illustrations):

Option A – Retaining Wall – this option entails building a retaining wall along the present landside of the dike to avoid further encroachment into the reserve. Additional dike fill would be placed from the retaining wall towards the river. It may also be necessary to construct a deep seepage cutoff wall which could potentially be combined with the retaining wall for cost efficiencies. It is likely that erosion protection would require upgrading in this area which would entail placing larger rip rap (large angular rock) and dike toe protection. Given this upgrade would occur along the existing dike alignment, it is presumed that the dike from the Siyich'em Reserve to the Judd Slough Pump Station would also be upgraded along the existing dike alignment.

Option B – Land Raising – this option entails raising the Siyich'em Reserve land up to the dike crest elevation. This would require removal and replacement of the existing structures and services on the reserve but would reduce seepage and enhance the safety of future structures. Given this upgrade would occur along the existing dike alignment, it is presumed that the dike from the Siyich'em Reserve to the Judd Slough Pump Station would also be upgraded along the existing dike alignment.

Option C – New Dike Alignment – this option entails constructing the dike on a new alignment heading north-west from Siyich'em Reserve, setback 30 metres from the active Squamish River bank, and connecting to the existing dike at Fisherman's Park. This approach would enable the recapture of lost reserve lands for the Squamish Nation. The new dike alignment would partially disconnect a large, forested gravel bar island from the Squamish River. Partial connection could be maintained via a fish-friendly pump station at the outlet of Jimmy Jimmy (Judd) Slough.

Dike Upgrade Options – Eagle Viewing Area

There is only one preferred option for upgrading the dike in the Eagle Viewing Area. This entails raising the dike and expanding the footprint towards the land (east) where there is sufficient space. Where there is limited space due to existing infrastructure (i.e. Dryden Creek Pump Station, Government Road), localized retaining walls would be used to prevent encroachment. Existing rip rap likely requires upgrades to provide protection against river erosion. Seepage would be addressed through either widening or a deep seepage cut-off wall. The cost estimate to upgrade the Eagle Viewing Area dike from the north end of Kowtain Reserve to the south end of Siyich'em Reserve is $16 million, excluding ground improvement for seismic performance and replacement or upgrade of the Dryden Creek Pump Station.

Other Items

Seismic Protection

Initial seismic analysis indicates that the dike does not meet Provincial seismic guidelines for dikes and would require ground improvement to meet the guidelines. Ground improvement for dikes can be cost prohibitive and some local governments have been successful in receiving permits for interim dike upgrades without ground improvement on the basis of completing risk assessments or making commitments to undertake seismic improvements in the future once the dike meets basic geometric standards. It is anticipated that the District would pursue this approach during the detailed design stage of the project. For the purposes of cost estimation, two separate estimates have been prepared for options with and without ground improvement. Cost estimates are presented in the Options Evaluation section below.

River Re-alignment

Through engagement with Squamish Nation and the community, there were many comments regarding restoring the historic river channel on the west side of the river (see Attachment 1 for details). This option hasn't been modeled, but one aspect would involve removing the large log jam currently blocking the inlet to the channel. Generally, all dike upgrading options would allow for this in the future if so desired. Key points include:

(1) Even if the main channel of the river was re-aligned, the current main channel would still be active in conveying water during a flood (and likely under normal flow conditions as well). Therefore, re-aligning the river would not alleviate the need to upgrade the dike.

(2) It is unknown what impact this would have on river morphology. It is likely that logs and debris would simply block the opening again. Maintaining a clear opening at the river channel inlet could therefore become a high maintenance item.

(3) It is unknown what environmental impacts would be from re-activating the channel. Currently the channel has slow moving water in it from seepage through the upstream log jam. This could provide valuable fish habitat that would be altered by re-activating the channel. There is potential that re-activating the channel could lead to erosion and scour in the channel and loss of fish habitat.

(4) This concept would require extensive technical and environmental studies to gain a greater understanding of how the channel is functioning as fish habitat and what adaptive works would be required to avoid negative fish habitat impacts.

Government Road Trespass

A portion of Government Road is in trespass through Siyich'em Reserve (see Attachment 1 for details). To re-align the road would require moving it east. This project is being evaluated in further detail to develop a conceptual realignment and estimate the associated costs.

Public Amenity Concepts

The project team developed several public amenity concepts for community engagement including:

- Installation of arrival gateways at either end of the Eagle Viewing Area
- Installation of local public art and trail wayfinding
- Adding eagle viewing structures
- Formalizing and expanding parking in the area
- Adding permanent washroom facilities
- Improving bike infrastructure (to alleviate traffic and promote active transportation)
- Adding seating
- Improving, or at minimum, maintaining the existing interpretive shelter
- Providing water access
- Public Access – while public access along the dike is outside the scope of the master plan, none of the presented options preclude future discussions on the matter.

These options will be further assessed and desirable elements will be incorporated into the final Dike Master Plan.

Options Evaluation

	Option A – Retaining Wall	**Option B – Land Raising**	**Option C – New Dike Alignment**
Correcting Historic Loss of Reserve Land	Poor	Poor	Significant opportunity
Reaching Agreement with Squamish Nation	Low – SN Staff have indicated SN Council unlikely to approve	Low – SN Staff have indicated SN Council unlikely to approve	Higher likelihood of receiving agreement
Cost* **	$47M	$54M	$60M

Grant Funding Opportunities	Low	Low	Good
Environmental Impacts & Permitting	Simplest	Simplest	Complex. There is risk of not receiving permits from DFO and MFLNRORD.
Hydrotechnical	Most feasible (less alteration of existing watercourses, no impact on flood level)	Most feasible (less alteration of existing watercourses, no impact on flood level)	Challenging (partially disconnects slough and gravel bar from river, modest increases in flood levels for up to 2km upstream)
Operations & Maintenance Requirements	Low (reduced erosion due to setback from main river channel)	Low (reduced erosion due to setback from main river channel)	High (greater rip-rap maintenance due to closer proximity of river to dike)
Dike Maintenance Act Permitting	Simple	Simple	Complex but not considered insurmountable.
Constructability	Challenging working in close proximity to homes on reserve and in Brackendale.	Challenging working in close proximity to homes on reserve and in Brackendale.	Most complex. New water crossing required to cross Jimmy Jimmy (Judd) Slough. Significantly greater fill volume required for new dike.
Phasing Potential	Greater potential to phase works since it is upgrading an existing dike and can be divided in sections.	Greater potential to phase works since it is upgrading an existing dike and can be divided in sections.	Less potential to phase work - new alignment must be fully constructed to be operational

*** Cost is for the dike from Siyich'em Reserve to Judd Slough Pump Station and excludes ground improvement. See Attachment 4 details.

Summary of Engagement

Squamish Nation Feedback

Through the extensive collaboration with Squamish Nation to date, several key messages have been clear. These are as follows:

- Squamish Nation have expressed that the Squamish River dike is located on reserve land without land tenure and that the dike alignment does not protect the historic reserve land.
- It has further been expressed that Government Road is also in trespass on Siyich'em Reserve and there is a desire to see it re-located off reserve.
- There has been interest expressed in re-instating the former main river channel on the west side of the river.
- Squamish Nation have expressed concerns that the dike construction from the 1960's to 1980's further trained the Squamish River along its current alignment due to dredging dike material from the river channel.
- Squamish Nation have expressed through the District's Integrated Flood Hazard Management Plan (IFHMP) and in this project that they are adopting a 'No Loss of Reserve' approach to dike construction in Squamish meaning that, at minimum, dike upgrades must not result in a loss of useable reserve land.
- Squamish Nation Staff have indicated that it is unlikely Options A or B would be approved by their Council due to historic dike construction concerns and historic loss of reserve land.

<u>Community/Stakeholders Feedback</u>

The project team heard the following feedback through the stakeholder engagement activities:

- There are concerns about habitat impacts and impacts to Fisherman's beach which is an active fishing site. There were some comments acknowledging the challenge of balancing reserve land recapture against habitat protection.
- There was no consistent preference of any particular option.
- Significant feedback was provided regarding lack of parking and transportation issues (poor sightlines, pedestrian/cycling/vehicle conflicts).

<u>Inspector of Dikes</u>

- Option A (retaining wall)
    - Indicated a desire for the District to acquire land tenure for the dike.
- Option B (land raising)
    - Future development on reserve should be set back from the 'regulated portion' of the dike
- Option C
    - Concerns regarding permanent partial disconnection of Fisherman's/Jimmy Jimmy (Judd) Slough from the river.
    - There would be high construction and maintenance costs for rip rap due to higher erosion potential with the dike closer to the river.

    - There would be regulatory hurdles with this option
- Feedback from the *Water Sustainability Act* team was requested but no feedback has been provided to date.

Fisheries and Oceans Canada (DFO)

DFO has reviewed the dike upgrade options as well as potential re-activation of the former main channel of the river on the west side of the river. Their review indicated that this project could result in prohibited effects to fish and fish habitat and that, in order to complete their review, a detailed description of the project and detailed drawings are required. Specific feedback on the three options is as follows:

Options A/B and Eagle Viewing Area – the design for river side rip rap improvements is to minimize the removal of riparian vegetation and minimize the disturbance to areas below the high water elevation.

Option C (new dike alignment) – DFO requires further information to provide specific comments including how often the gravel bar island is inundated by the river. Areas frequently inundated could be considered fish habitat. Should areas of fish habitat be disconnected from the Squamish River by a new dike, the project should be redesigned to avoid or minimize impacts to fish habitat. Further, Jimmy Jimmy (Judd) Slough is considered to be fish habitat and any new dike crossing Jimmy Jimmy (Judd) Slough would need there to be a fish-friendly pump station.

Log Jam Removal on West side of River – DFO is generally supportive but requires further information to determine what adaptive works would be required (e.g. to prevent fish stranding, erosion/scour, etc).

Summary

Option C presents significant benefits and opportunities including:

- Reconciling historic trespass of the dike on reserve land and recapturing the historic boundary of the reserve.
- Option C is positioned well for future grant funding opportunities and potentially securing funding from additional sources.
- Dike construction would be a greater distance from existing homes and businesses located behind the existing dike alignment resulting in a reduced construction impact on both reserve and private lands.

Technical challenges associated with Option C include:

- Highest cost.
- Risk of not receiving permits from DFO and/or MFLNRORD.
- Potential impacts to fish habitat due to partial disconnection of a natural area of the river corridor.
- Results in modest increases in flood levels upstream.

On balance, staff recommend pursuing Option C.

Recommendations

It is recommended to:

1. Select Option C (new dike alignment) as the preferred option from Siyich'em Reserve to Aik'wucks Reserve and to continue advancing the Dike Master Plan on that basis.
2. Complete further work to assess the feasibility of Option C as listed below. Note that it will not be possible to complete all listed work as part of this Dike Master Plan due to funding limitations and the grant deadline for project completion (end of May for final report).
    - Geotechnical - Complete geotechnical drilling investigation along the new dike alignment to evaluate seismic stability and other geotechnical considerations.
    - Stormwater - Complete stormwater study to determine size and function of the future pump station at slough outlet and any other required drainage modifications to facilitate this option.
    - Permitting - It will be required to advance the design to a point of having detailed drawings in order to gain greater certainty from regulators (DFO, MFLNRORD). It is recommended to advance the design in order to further engage with regulators to determine whether the project can receive permitting.
    - Land Tenure – It is recommended to engage in discussions with Squamish Nation's Rights and Title team to secure access rights for ongoing dike maintenance purposes.
3. Advance the Dike Master Plan using the preferred option for the Eagle Viewing Area (north end of Kowtain Reserve to South end of Siyich'em Reserve).
4. Complete further work to prepare a final draft Dike Master Plan including developing the preferred options in further detail, further evaluating the preferred options, refining cost estimates and completing community engagement.
5. Report back to Council prior to project completion to seek endorsement of the Dike Master Plan.

4. Implications:

a. Budget:

The master plan project is contained within the 2019-23 Financial Plan and is funded 100% by the National Disaster Mitigation Program grant.

The District and Squamish Nation will be evaluating all potential funding sources for future capital funding of the projects.

b. Organizational Impact:

This project is included in the work plan and will be managed by Engineering Department Staff.

c. Policy:

OCP 6.1a Strengthen relationships with First Nations through policies, processes and actions to advance and support Reconciliation in Squamish. (Note: There are many other relevant policies within Section 6 of the OCP.)

OCP 11.1a - Assess and manage the multiple natural hazards in Squamish to maintain these risks within levels acceptable to the public.

d. Bylaws:

N/A

5. Council Priority Areas

The Planet and Environment

Environmental protection/preservation is a key consideration in assessing dike upgrade options

The Economy and Local Jobs

Dike improvements in this area will enhance protection for a significant number of businesses and employment lands and enhance the resiliency of the local economy which would be significantly impacted by a major flood.

Neighbourhood Connectivity and Public Spaces

This project will significantly upgrade the Eagle Viewing Area, enhancing it as a public space.

6. Engagement:

The District is partnering and collaborating with Squamish Nation on this project. The goal of the project is to reach consensus on the preferred dike upgrading option with Squamish Nation upon the conclusion of this project.

The District of Squamish is engaging the community and stakeholders at the 'Involve' level of the IAP2 spectrum. Engagement activities have included a 2 online surveys, a Public Open House and workshops with community groups, local residents and business owners. The project team has also engaged with regulators including BC Provincial Parks, Fisheries and Oceans Canada (DFO) and the Ministry of Forests, Lands, Natural Resource Operations and Rural Development (MFLNRORD) which includes *Water Sustainability Act* regulators, Inspector of Dikes and land managers.

7. Next Implementation Steps:

With Council's endorsement, the project team will continue further work evaluating the preferred option and preparing the final Dike Master Plan, including final community engagement. Upon conclusion of the Dike Master Plan, Staff will begin seeking funding to advance the preferred option.

8. Attachments:

1. Open House Boards, December 5, 2019, Kerr Wood Leidal & Hapa Collaborative
2. Dike Construction Chronology, Ministry of Environment, 2007
3. Canada Lands Survey, 1976
4. Cost Estimates, Kerr Wood Leidal, 2020

9. Alternatives to Staff Recommendation:

THAT Council direct Staff to complete further work prior to endorsing a preferred Option for the Eagle Viewing / Siyich'em Reserve Dike Master plan.

10. Staff Review

Prepared By:

David Roulston, Manager of Municipal Infrastructure

Reviewed By:

Chris Wyckham, P.Eng, Director of Engineering

Jonas Velaniskis, Acting GM of Community Planning & Infrastructure

Robin Arthurs, General Manager Corporate Services

Rolland Russell, Acting Manager of Financial Planning

CAO Recommendation:

That the recommendation of the Community Planning and Infrastructure be approved.

Robin Arthurs A/CAO

KERR WOOD LEIDAL
consulting engineers

Appendix J

Preferred Option Refined Conceptual Design Figures

District of Squamish / Squamish Nation

Eagle Viewing Area / Siyich'em Dike Master Plan

KERR WOOD LEIDAL consulting engineers

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AYKWAKS

DISTRICT OF SQUAMISH

SIYICH'EM

SIYICH'EM

KOWTAIN

1

2

3

4

5

6

7

8

9

Dryden Creek

Hop Ranch Creek

Newport Creek

Thunderbird Creek

Meighan Creek

Legend

- First Nations Reserve
- Watercourse
- Proposed Pump Station or Upgrade

Concept Design Footprint Area

- Dike Land-Side Slope (3H:1V)
- Land-Side Toe Berm for Seepage Control (1.5 m Tall)
- Dike Crest (6 m Wide)
- Riprap Crest
- Dike Water-Side Riprap Slope (2H:1V)
- Buried Riprap Toe (Width TBD)

DRAFT

Project No. 463-341

Date May 2020

Scale 1:10,000 0 50 100 200 (m)

Preferred Dike Conceptual Design Alignment and Footprint

Overview

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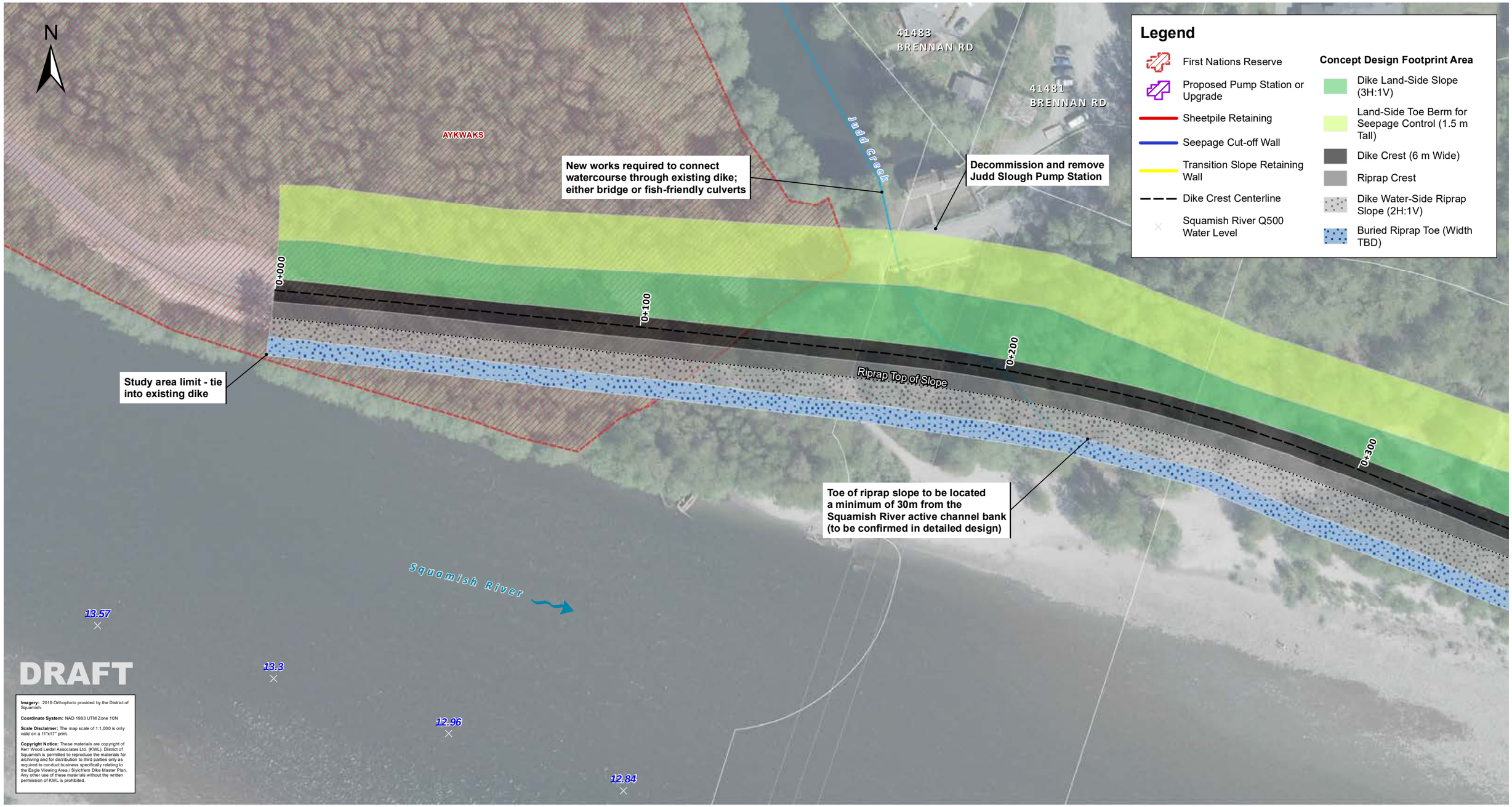
District of Squamish / Squamish Nation

Eagle Viewing Area / Siyich'em Dike Master Plan

KERR WOOD LEIDAL consulting engineers



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Imagery: 2019 Orthophoto provided by the District of Squamish.

Coordinate System: NAD 1983 UTM Zone 10N

Scale Disclaimer: The map scale of 1:1,000 is only valid on a 11"x17" print.

Project No. 463-341

Date May 2020

Scale 1:1,000 0 5 10 20 (m)

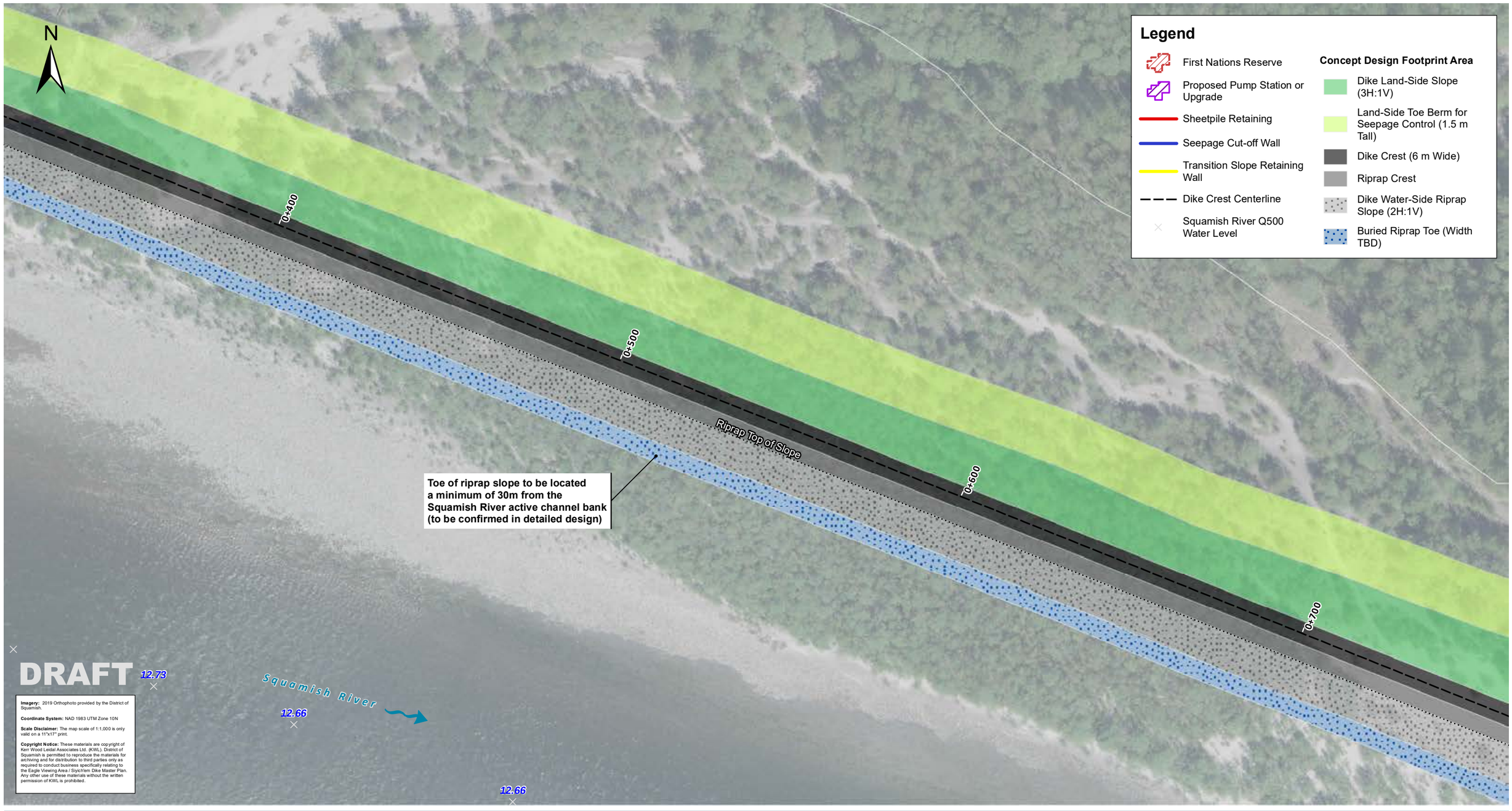
Preferred Dike Conceptual Design Alignment and Footprint

Figure 1

District of Squamish / Squamish Nation

Eagle Viewing Area / Siyich'em Dike Master Plan

KERR WOOD LEIDAL consulting engineers



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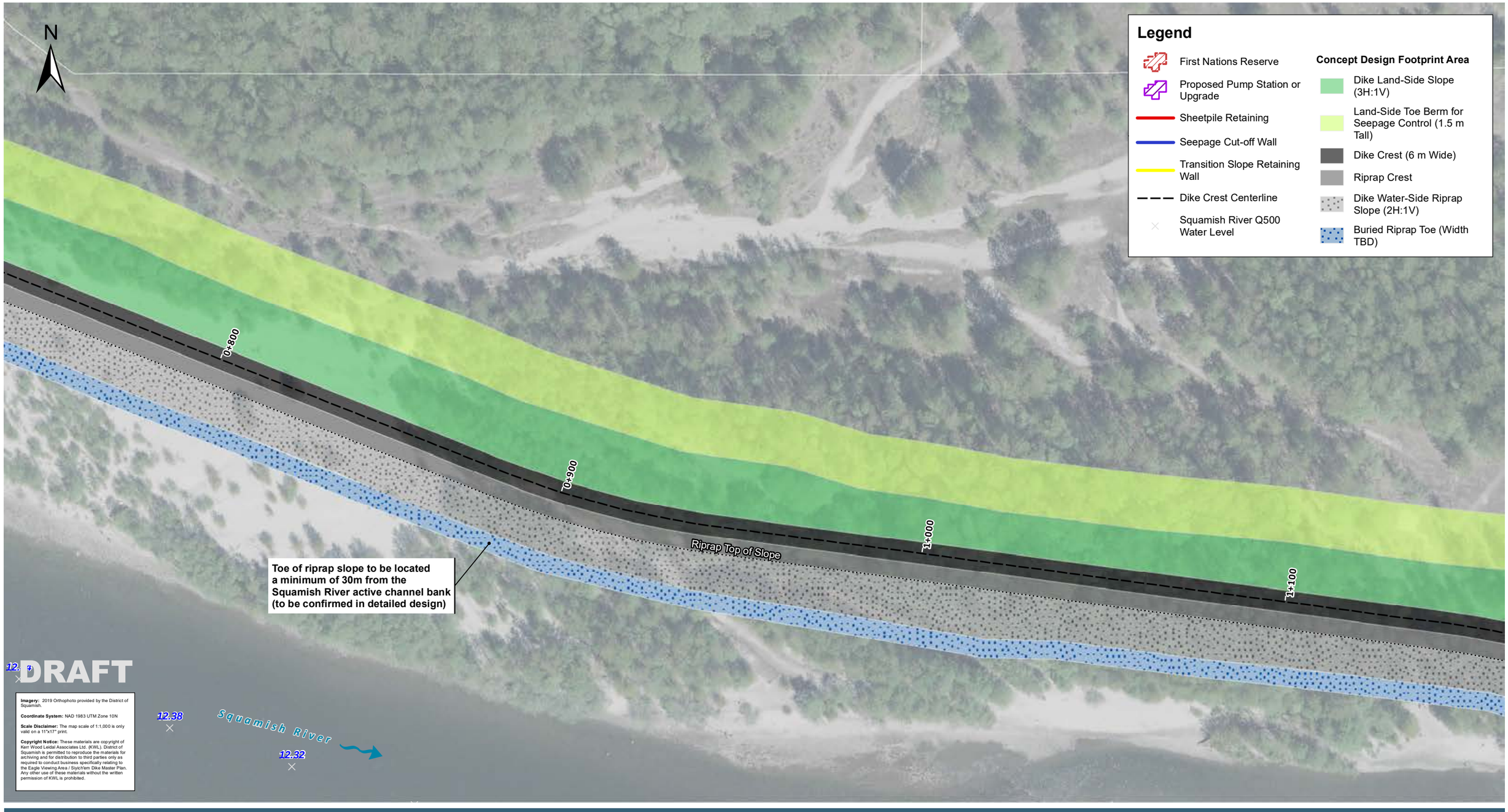
Preferred Dike Conceptual Design Alignment and Footprint

Figure 2

District of Squamish / Squamish Nation

Eagle Viewing Area / Siyich'em Dike Master Plan

KERR WOOD LEIDAL consulting engineers



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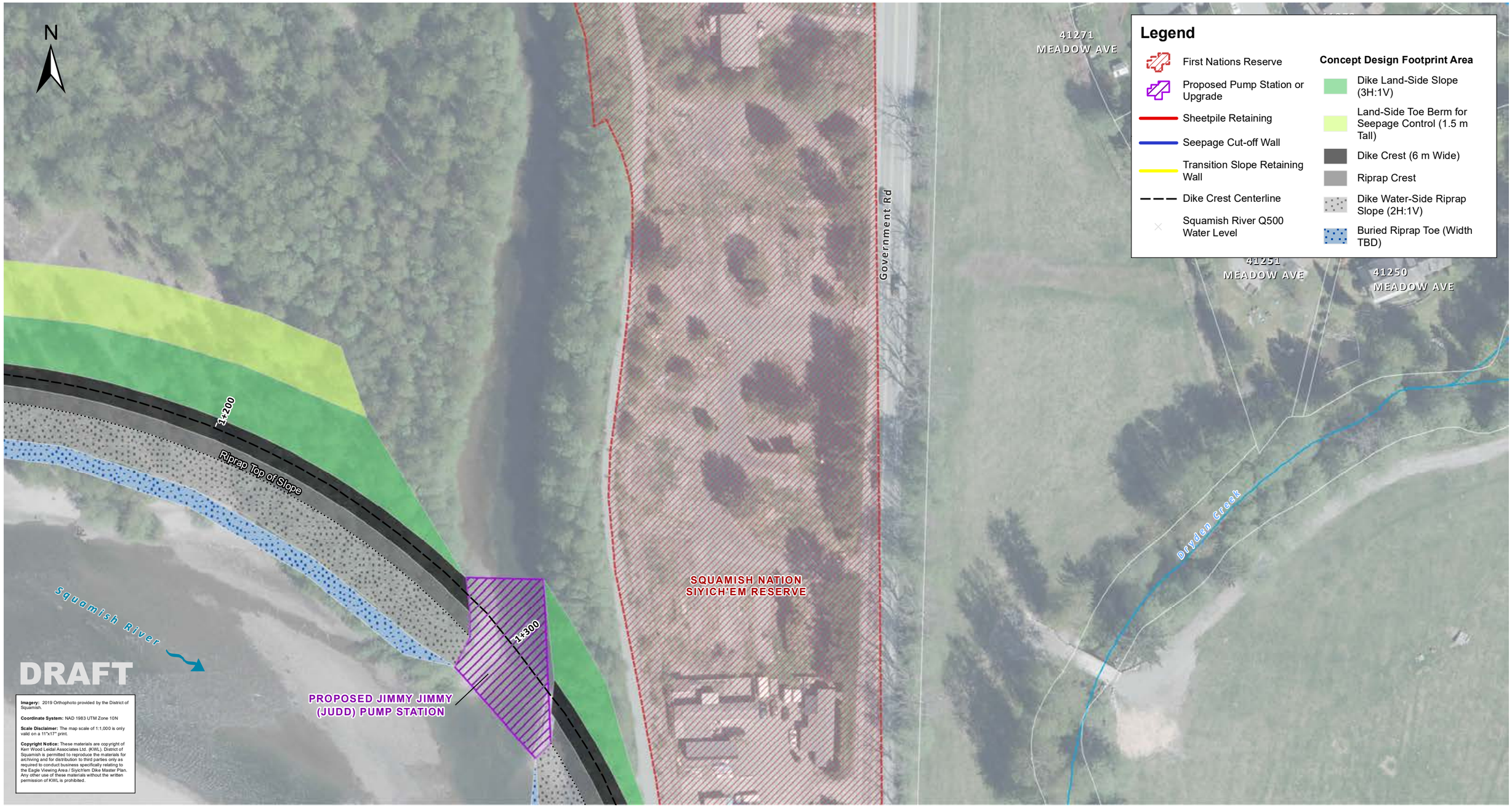
Preferred Dike Conceptual Design Alignment and Footprint

Figure 3

District of Squamish / Squamish Nation

Eagle Viewing Area / Siyich'em Dike Master Plan

KERR WOOD LEIDAL consulting engineers



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Preferred Dike Conceptual Design Alignment and Footprint

Figure 4

District of Squamish / Squamish Nation

Eagle Viewing Area / Siyich'em Dike Master Plan

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Legend

- First Nations Reserve
- Proposed Pump Station or Upgrade
- Sheetpile Retaining
- Seepage Cut-off Wall
- Transition Slope Retaining Wall
- Dike Crest Centerline
- Squamish River Q500 Water Level

Concept Design Footprint Area

- Dike Land-Side Slope (3H:1V)
- Land-Side Toe Berm for Seepage Control (1.5 m Tall)
- Dike Crest (6 m Wide)
- Riprap Crest
- Dike Water-Side Riprap Slope (2H:1V)
- Buried Riprap Toe (Width TBD)

SQUAMISH NATION SIYICH'EM RESERVE

1+400

Retaining wall to prevent impact to existing residential structures

Steel Sheetpile Retaining and Seepage Cutoff Wall

Riprap Top of Slope

Remove portion of restaurant building that is attached to the existing dike crest. Potential replacement to be confirmed during detailed design by the Squamish Nation. Potential opportunity to shift dike alignment to the west and reduce impacts to Siyich'em Reserve. Consider tradeoff with potential increase in habitat impact.

1+500

Refer to Government Road relocation concept figure (to resolve trespass on reserve)

Government Rd

41041 GOVERNMENT RD

41050 GOVERNMENT RD

Squamish River

Dryden Creek

12.06

11.99

11.8

11.74

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Imagery: 2019 Orthophoto provided by the District of Squamish.

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Scale 1:1,000 0 5 10 20 (m)

Preferred Dike Conceptual Design Alignment and Footprint

Figure 5

District of Squamish / Squamish Nation

Eagle Viewing Area / Siyich'em Dike Master Plan

KERR WOOD LEIDAL consulting engineers

N

11.67

11.6

41041 GOVERNMENT RD

Dryden Creek

11.58

PROPOSED DRYDEN CREEK PUMP STATION UPGRADE

11.56

11.51

11.45

Dike access ramp - geometry to be determined during detailed design to provide acceptable slope for vehicle access

1+600

Government Rd

41030 GOVERNMENT RD

41015 GOVERNMENT RD

Replace existing pump station during dike construction (preferred) or defer dike upgrade over pump station until pump station replacement. Government Road culvert upgrade also required.

Over-width dike crest for eagle viewing area shelter and potential other public amenity features - refer to public amenity concept plan

1+700

Riprap Bottom of Slope (excludes buried toe)

Riprap Top of Slope

Legend

- First Nations Reserve
- Proposed Pump Station or Upgrade
- Sheetpile Retaining
- Seepage Cut-off Wall
- Transition Slope Retaining Wall
- Dike Crest Centerline
- Squamish River Q500 Water Level

Concept Design Footprint Area

- Dike Land-Side Slope (3H:1V)
- Land-Side Toe Berm for Seepage Control (1.5 m Tall)
- Dike Crest (6 m Wide)
- Riprap Crest
- Dike Water-Side Riprap Slope (2H:1V)
- Buried Riprap Toe (Width TBD)

DRAFT

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Project No. 463-341

Date May 2020

Scale 1:1,000 0 5 10 20 (m)

Preferred Dike Conceptual Design Alignment and Footprint

Figure 6

District of Squamish / Squamish Nation

Eagle Viewing Area / Siyich'em Dike Master Plan

KERR WOOD LEIDAL consulting engineers

N

40963 GOVERNMENT RD

41015 GOVERNMENT RD

11.41

11.35

11.29

11.22

0+800

1+900

Government Rd

Steel Sheetpile Retaining and Seepage Cutoff Wall

Squamish River

Riprap Bottom of Slope (excludes buried toe)

Riprap Top of Slope

Dike Crest Top of Slope

Transition Slope / Retaining Wall

Retaining wall to prevent impact to Government Rd

Pedestrian access point - refer to public amenity concept plan

Legend

- First Nations Reserve
- Proposed Pump Station or Upgrade
- Sheetpile Retaining
- Seepage Cut-off Wall
- Transition Slope Retaining Wall
- Dike Crest Centerline
- Squamish River Q500 Water Level

Concept Design Footprint Area

- Dike Land-Side Slope (3H:1V)
- Land-Side Toe Berm for Seepage Control (1.5 m Tall)
- Dike Crest (6 m Wide)
- Riprap Crest
- Dike Water-Side Riprap Slope (2H:1V)
- Buried Riprap Toe (Width TBD)

DRAFT

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Project No. 463-341

Date May 2020

Scale 1:1,000 0 5 10 20 (m)

Preferred Dike Conceptual Design Alignment and Footprint

Figure 7

District of Squamish / Squamish Nation

Eagle Viewing Area / Siyich'em Dike Master Plan

KERR WOOD LEIDAL consulting engineers

N

11.19

11.15

11.02

10.86

10.86

Squamish River

Z+000

Z+100

40827 GOVERNMENT RD

40813 GOVERNMENT RD

40820 GOVERNMENT RD

Government Rd

Meighan Creek

Bottom of Slope (excludes buried toe)

Riprap Top of Slope

Dike Crest Top of Slope

Transition Slope / Retaining Wall

Potential parking area can be incorporated with land-side toe berm. Refer to public amenity plan. (TBD during future design phase)

Retaining wall to prevent impact to existing residential structure and landscaping

Legend

- First Nations Reserve
- Proposed Pump Station or Upgrade
- Sheetpile Retaining
- Seepage Cut-off Wall
- Transition Slope Retaining Wall
- Dike Crest Centerline
- Squamish River Q500 Water Level

Concept Design Footprint Area

- Dike Land-Side Slope (3H:1V)
- Land-Side Toe Berm for Seepage Control (1.5 m Tall)
- Dike Crest (6 m Wide)
- Riprap Crest
- Dike Water-Side Riprap Slope (2H:1V)
- Buried Riprap Toe (Width TBD)

DRAFT

Imagery: 2019 Orthophoto provided by the District of Squamish.

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Project No. 463-341

Date May 2020

Scale 1:1,000 0 5 10 20 (m)

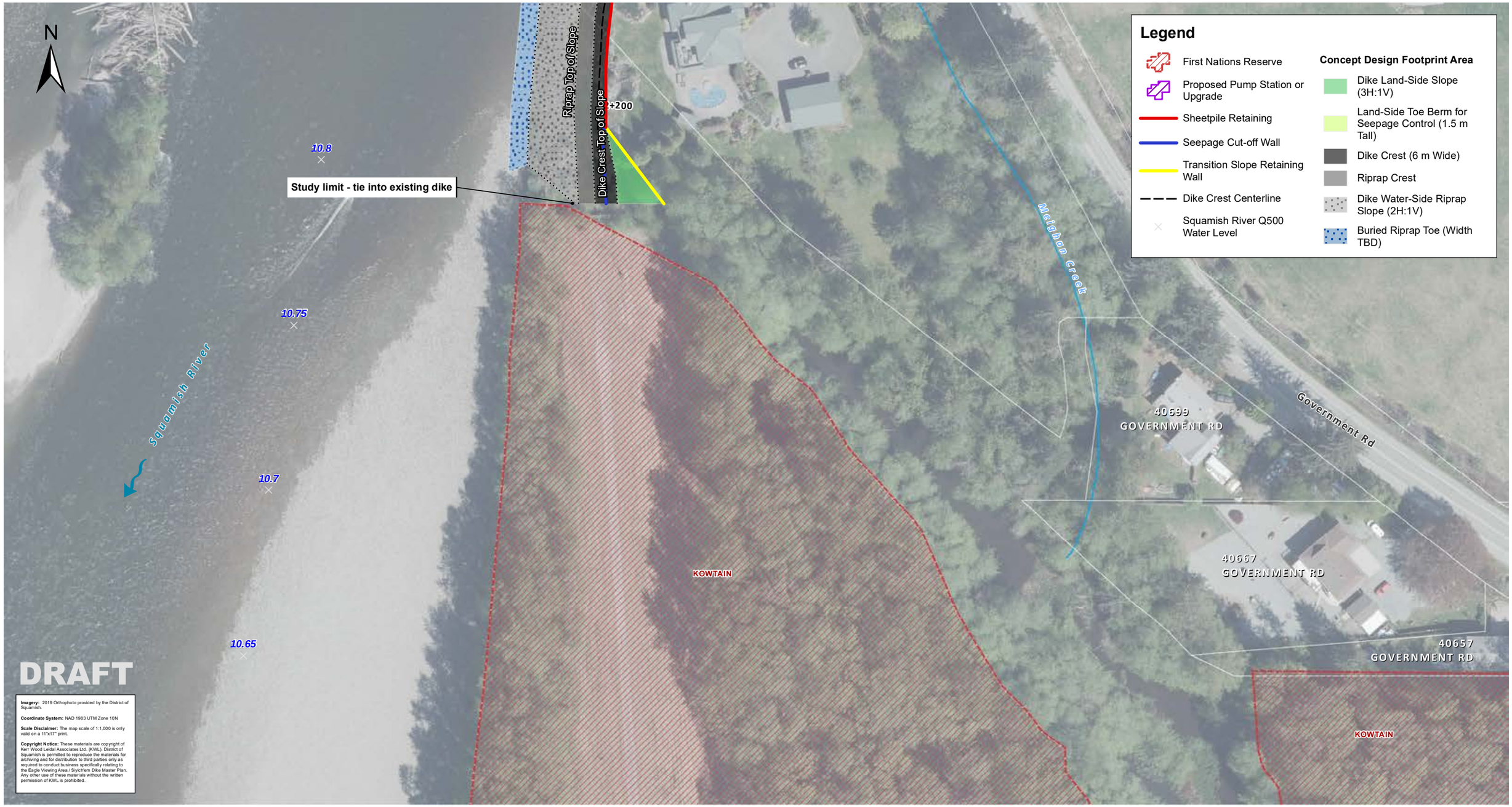
Preferred Dike Conceptual Design Alignment and Footprint

Figure 8

District of Squamish / Squamish Nation

Eagle Viewing Area / Siyich'em Dike Master Plan

KERR WOOD LEIDAL consulting engineers



DRAFT

Imagery: 2019 Orthophoto provided by the District of Squamish.

Coordinate System: NAD 1983 UTM Zone 10N

Scale Disclaimer: The map scale of 1:1,000 is only valid on a 11"x17" print.

Project No. 463-341

Date May 2020

Scale 1:1,000 0 5 10 20 (m)

Preferred Dike Conceptual Design Alignment and Footprint

Figure 9

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Appendix K

Preliminary Public Amenity Concept Plan for the Eagle Viewing Area (Hapa)

AMENITY CONCEPT PLAN

A CONCEPT AMENITY PLAN, NORTH

Government Road
- moved off of Siyich'em;
- bike lanes made more visible to improve safety;
- "gateway" markers.

Main Park Amenity Area
- new parking lot located on dike side, at site of former road alignment
- permanent washroom location;
- stair and vehicle access to top of dike;
- wayfinding, bike parking, garbage/ recycling bins;
- highlight sheet pile wall as unique site feature;
- tour/ shuttle bus pull-in located on East side of road.

Dryden Creek Pump Station
- future pump station replacement should consider opportunities for seating, views, access to water and storytelling;

Eagle Watch Shelter
- reuse existing shelter or consider future replacement with shelter that provides additional weather protection;
- provide flexible social seating and outdoor education opportunities.

Sheet Pile Wall
- guardrails required at top of dike;
- opportunity for wall to showcase public art;

SCALE
1:1500

B CONCEPT AMENITY PLAN, SOUTH

Sheet Pile Wall
- use planting and trees where possible to soften visual impact of wall;
- guardrails required at top.

Shoulder Parking
- opportunity for shoulder parking at Easter Seals Camp. Further study required to ensure safety.

Planting
- plant trees and along dike and road where possible;
- dike should be planted with native grasses, wildflowers and shrubs.

South Parking
- proposed additional parking lot on tow berm;
- further study required to determine appropriate size and elevation;
- long, meandering accessible (8%) path to top of dike.

Dike Trail
- 6m wide gravel path for vehicle access.
- bike parking, wayfinding to other sites of interest and ample seating opportunities along dike trail.

South Entry
- use gateway elements such as local art to signify entry into Eagle Viewing Area.

SCALE
1:1500

MAIN PARK AMENITY AREA

Government road moved off Siyich'em

"Gateway"

gravel parking lot with 23 stalls located on former road alignment

sheet pile wall

dike access stairs

permanent washrooms and gathering area with signage, bike parking and garbage/ recycling

thematic marked crossing

vehicle access with removable bollards

tour/ shuttle bus pick-up and drop off or additional parking

marked bike lanes

SCALE 1:800

PHASING AMENITY PLAN AND ROAD ALIGNMENT

sheet pile wall

planted area

existing parking lot

access ramp

semi permanent washroom

PH 1: Current Alignment

sheet pile wall

road moved off Siyich'em

parking lot

permanent washroom

same access ramp

PH 2: Alignment off Siyich'em

CONCEPT AMENITY PRECEDENTS

VISITOR FACILITIES

Permanent Washrooms

Additional and Expanded Parking

EDUCATION AND RECREATION

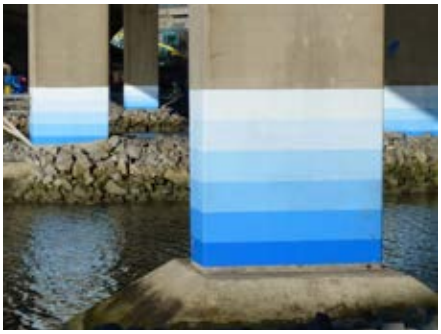
Ample seating opportunities that are flexible and social.

Outdoor education and access to water.

Eagle Watch shelter to be re-purposed or replaced.

Opportunity for views or educational experiences at future pump stations.

Recreational opportunities along vertical dike walls



Educational public art along dike.

ARRIVAL AND WAYFINDING

celebrate local Squamish Nation art through wayfinding and park gateways.

Trail Wayfinding connecting trail to local sites and providing educational information.

PLANTING IMPROVEMENTS

Native grasses, shrubs and wildflowers along dike. Trees where possible.

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Appendix L

Government Road Realignment Concept

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District of Squamish / Squamish Nation

Squamish River Dike Master Plan - Eagle Viewing/Siyich'em

KERR WOOD LEIDAL consulting engineers

Legend

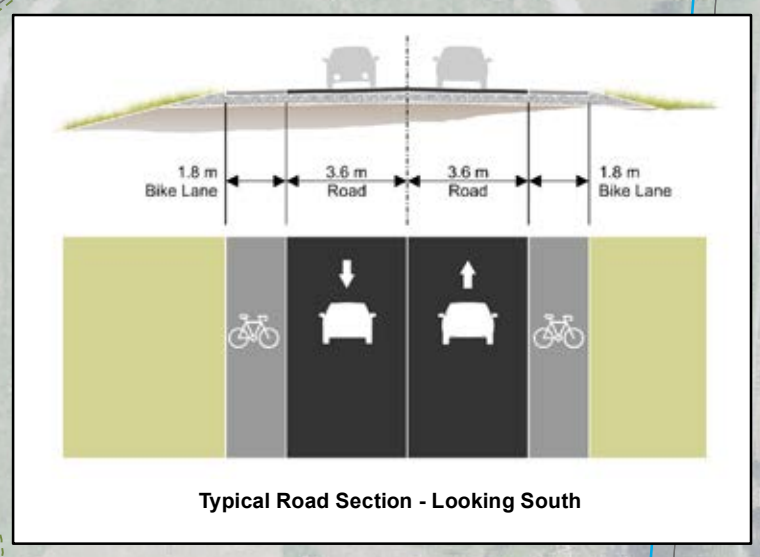
- Land_Parcels
- Crown Right-of-Way
- Existing Storm Pump Station
- Existing Sanitary Lift Station
- Contour (1m Interval)
- Watercourse
- Top of Bank
- Existing Storm Main
- Storm Culvert
- Existing Watermain
- Existing Sanitary Main
- Dike Centerline

STUDY LIMIT

Curve radius = 100 m
(4% reverse crown)

Design Criteria for Roadway:
- Design speed = 50 km/h
- Road classification = RCU
- Assume DHV Less than 450 VPH
- Lane width = 3.6 m (MOTI Section 430)
- Shoulder bikeway width =1.8 m (BC Active Transp. Design Guide)
- 2% Cross Fall
- 4:1 Fill Slope

SEAICHEM 16



Typical Road Section - Looking South

Curve radius = 100 m
(4% reverse crown)

Existing Dryden Creek
culvert crossing

Existing road centreline

DRAFT

Project No. 463.341

Date May 2020

Scale 1:2,000 0 10 20 40 (m)

Eagle Viewing / Siyich'em Dike Master Plan
Government Road Alignment

Figure 1