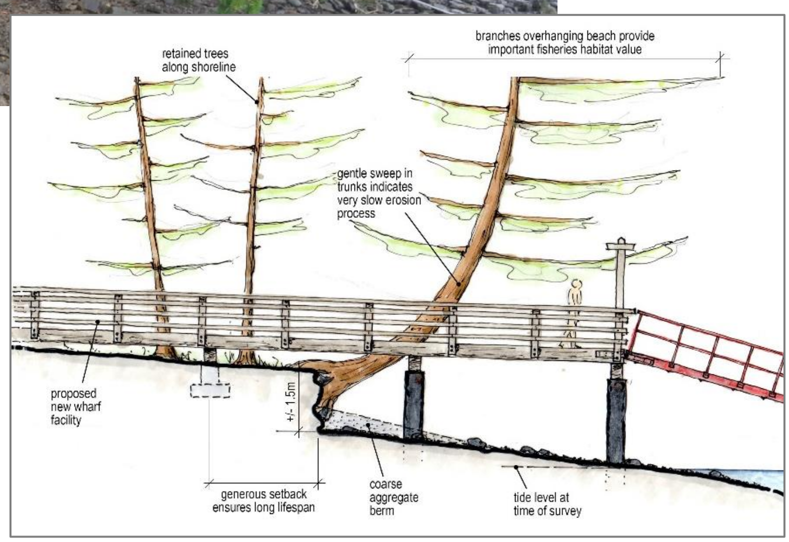
CORI Project: 19-02

24 February 2020

Shoreline Stability Assessment:

Anson Rd Property, Horton Bay, Mayne Is



prepared for: The Capital Regional District

prepared by: John Harper, P.Geo., Coastal & Ocean Resources
Paul de Greeff, Murdoch de Greeff Inc. Landscape Architects

Coastal and Ocean Resources

Cover Annotations

A representative photo of the eroding sea cliff at the Anson Rd property showing trees protruding from the cliff face. The cliff height is approximately 1.5m at this location. Note the coarse pebble-cobble veneer on the beach face (8 Nov 2019).

Conceptual design of a preferred soft alternative to mitigate potential erosion issues of the proposed wharf facility (by PdG).

[redacted]

John R. Harper, P.Geo.

PROFESSIONAL
PROVINCE OF
DR. J. R. HARPER
COLUMBIA
GEOSCIENTIST

Summary

This assessment reviews potential shoreline stability issues at a proposed location for a community dock in Horton Bay, Mayne Island. The dock would replace an existing Horton Bay dock approximately 0.5 km east of the new proposed location. The existing facility is very small, provides limited access for Mayne Island residents, is poorly suited for use in emergencies and has no associated parking.

This report summarizes observations from a site visit to the proposed Anson Rd Wharf Site and implications of these observations to project planning. The shoreline site was visited on 8 November 2019 for a period of approximately 3 hours. Observations were made of the upper intertidal beach and the upland area just landward of the high-water line. The Anson Road Right of Way has 50 m of beach frontage. There is a 1-2m high bluff or scarp at the high-water line position along most of the property. The beach to seaward is a mix of sand, pebble and cobble with a few boulders; at the time of the survey (mid-tide), the beach was approximately 10m in width.

The near-vertical scarp indicates that there is active erosion occurring. Roots and tree trunks are protruding from the scarp. The scarp is cut into what appears to be a diamicton[1] ; this may be a poorly-sorted glacial till or it may be till material that was excavated from upslope during a previous leveling process at the site. The rate of erosion is uncertain but is likely slow (probably <30cm/yr) as evidenced by trees that grow vertically, even after their main trunk has been undermined by the erosion. There are several larger trees located within ±1 m of the scarp. Some of the trees, estimated to be in the range of 50 years old, have a gentle sweeping arc-shape to their trunks. The gentle sweep (as opposed to a straight trunk leaning out over the shoreline with a vertical tree tip) indicates a very slow, gradual erosion process and year-after-year 'self-righting' of the tree through gravitropism. These trees provide a riparian overhang of up to 10 m over most of the 50 m of frontage along the foreshore.

Some type of erosion mitigation should be considered with the construction planning of the proposed wharf. Two general mitigation alternatives are:

- **Set-back of the walkway <u>landing pad</u> from the scarp edge** – even if the erosion were stopped immediately the upper cliff edge is likely to retreat until the angle of repose is reached, or until a balance between the resisting force of tree roots and gravity is reached (i.e., a meta-stable slope that will continue to erode if trees are removed). So set-back of the permanent landing pad is recommended.

- **Stabilizing the erosion** – without any foreshore mitigation the erosion of the scarp is likely to continue. In addition to protecting the wharf infrastructure, mitigation will contribute to the maintaining the existing trees and riparian canopy overhang that provides considerable and very important habitat value. Alternatives include:
    - **Hard sea wall** (concrete) – probably the most expensive alternative and least in character with the site. Although DFO is generally not in favour of hard mitigation alternatives such as this, it

[1] terrigenous sediment that is unsorted to poorly sorted and contains particles ranging in size from clay to boulders, suspended in a matrix of mud or sand.

might be permitted if the case is made that such a hard seawall will not substantially alter sediment movement around the site.

- **Rip-rap** – properly designed rip-rap with sufficient toe burial and filtering will reduce cliff erosion. Again, while rip rap mitigation is not DFO's preferred mitigation alternative, such protection *might* be permitted if there is minimal disruption of sediment transport at the site.
- **Protective intertidal berm** – placement of natural, coarse (pebble-cobble sized sediment) to reduce the direct contact of waves with the scarp. Such mitigation will reduce toe erosion of the scarp and is unlikely to cause any significant alteration of sedimentation patterns at the site, including those near the nearshore eelgrass bed. This type of mitigation is generally a preferred mitigation alternative of Fisheries and Oceans Canada.

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1.0 Introduction

The Capital Regional District (CRD) is proposing to construct a small wharf in Horton Bay, Mayne Island as a replacement for an existing public wharf in Horton Bay, approximately 0.5 km to the east. The existing wharf is very small, inadequate for use in emergencies and there is no associated parking. The new, proposed wharf will be accessed through Anson Rd, a yet-to-be constructed laneway off Horton Bay Rd. The proposed wharf will consist of a pile-supported walkway and a floating wharf in the offshore. Parking will also be constructed on the Anson Rd. right-of-way.

There is presently a small scarp or sea cliff along the waterfront of the Anson Road right-of-way and there is concern that coastal stability at the site could impact the proposed infrastructure. A coastal geologist (Harper, P.Geo.) and landscape architect (deGreeff; Registered Landscape Architect) visited the site on 8 November 2019 to conduct an initial assessment of shore stability with respect to the proposed wharf development.

The overall objective of the site visit was to document site conditions so that further construction planning, vis a vis shoreline erosion risks, could be undertaken. The site morphology and geology were examined, and representative beach profiles surveyed. Ecologically significant vegetation was noted.

Figure 1. Location of proposed Anson Rd wharf (arrow).

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2.0 Site Visit

During the 8 November Site Visit, it was cloudy with fog patches. Tides were about mid tide (>1.7 m) and rising throughout the morning, so the beach was gradually disappearing. A number of tasks were undertaken, including:

- A general reconnaissance of the site foreshore and neighboring properties,
- Systematic observations of the sea cliff (scarp), coastal riparian vegetation and beach substrate along the frontage of the property,
- Surveys of two representative across-shore beach profiles, and
- Collection of both ground and aerial photos.

Overall Site Character

The Anson Rd property is shown (Fig. 2) in relation to neighboring properties, including the existing water lease that will accommodate the proposed wharf and floats.

Figure 2. General layout of the Anson Rd Property with respect to adjacent properties and the foreshore lease area that will accommodate the proposed wharf. A tape was laid out along the shore from a boundary post (0-m) immediately above the High-Water Line (HWL) just beyond the eastern side of the property to a boundary post at the western edge of the property (50m). The blue line spacing indicates 10-m long sections along the shore and are used to reference other observations.

There is bedrock cropping out on the beach to the east of the Anson Rd property and bedrock strata was noted at the base of the cliff at Section 0-m. No bedrock was noted on the Anson Rd right of way or to the west of the right of way. The cliff was bare sediment from about the 15-m marker and beyond the 50-m marker to the west. The sediment exposed in the cliff is a silt-clay matrix with pebble-cobble and boulder-sized rocks within the matrix (Fig. 3). Some larger pieces of shale bedrock (boulder-sized) were observed. Wood pieces were observed protruding from the cliff face in places (Fig. 3) suggesting that the material is possibly landfill that was excavated from the slopes above during landscape leveling. There is anecdotal evidence that the site, including property to the west, of the right-of-way was a log dump at some point in the past (M. Dunn, Mayne Island Conservation Society, pers com, 2019).

Figure 3. Close up photo of the cliff face. Note that many of the pebbles and cobble within the matrix are quite angular, which is not typical of a glacial till. Note also the large piece of wood protruding from the cliff; this wood did not appear to be a root but rather a trunk or branch. These observations point to excavated glacial till mixed with bedrock fragments that was pushed over an existing shoreline slope. The darker material to lower right may be the original till deposit at the site (photo collected to the west of the Anson Rd right-of-way).

The shoreline is almost straight except for a protuberance or "nose" in the 10 to 40 m area of the survey. The beach is more or less uniform in composition along the shore with a pebble-cobble veneer over a mixture of sand-pebble-cobble (Fig 4). Occasional boulders (glacial erratics) were observed on the beach (Fig. 5). There is a stiff clay layer near the base of the cliff around Sections 25 m to 40 m (Fig. 6) and this stiff glacial-marine clay extends out 1-2m onto the upper beach near the "nose" of the cliff (Fig. 6); the clay layer may be the reason that the nose is there (more resistant to erosion).

Figure 4a. Photo of typical beach surface showing pebble-cobble veneer.

Figure 4b. Photo of same area with surface veneer of pebbles scraped away. Note the predominantly sand substrate in the immediate sub-surface.

Figure 5. Glacial erratic boulders (>26 cm in diameter) on beach to the west of the Anson Rd property.

Figure 6. A photo of the cliff base near the 35-m mark. The dotted line indicates the approximate seaward limit of the stiff clay outcrop that occurs near the "nose" of the Anson Rd right-of-way.

The site is a low exposure site. Maximum wave fetches to the site are <1 km (from east) and the convoluted, narrow channel between Mayne and Curlew Islands prevents larger waves from the Strait of Georgia from reaching the site. Barnacles, which need a stable substrate on which to grow, are present on very small pebbles, suggesting that these pebbles are not rolled around very often (Fig 7).

Figure 7. Photograph of small, 5-cm, pebble with attached barnacles. The very angular nature of the pebble and the attached barnacles suggest that this is a very low energy site and sediments are not reworked very often by wave or tidal currents.

Site Observations

As previously mentioned, a tape was laid along the beach to provide a spatial reference for observations (Fig. 2). Wooden blocks were placed at 10m intervals and these blocks are visible in the drone photos. (Appendix A). Observations were made at each 10-m along the shore including: scarp height, cliff material, beach type and the riparian overhang of the intertidal zone (Table 1; ground photos are shown in Appendix B).

Several observations are important relative to the shoreline stability at the site as follows:

- The scarps indicate that the shore is eroding despite this being a very low energy site. This appears to be due to the fine nature of the eroding substrate with over 90% of the material being “fine” (silt & clay) so when erosion occurs, the fine material is easily carried offshore by even weak wave and tidal currents. There is little coarse material left to provide a protective buffer – generally a thin veneer of pebble-cobble, one clast thick;

- The scarp increases in height along the property from east to west;

- Bedrock is at the surface on Section 0-m and may be just below the surface of the beach in the 20-m to 30-m sections (“the nose”), where cobbles and pebbles are mostly angular and plate shaped, indicating little re-working (Fig. 7). The stiff clay layer noted on the beach near the nose may be just above the slate bedrock;

- Trees growing at the site have grown vertically (with a gentle arc in the trunk) in spite of being undercut, suggesting the rate of erosion at “the nose” is relatively low (<30cm/yr). Root masses associated with the trees appear to have a stabilizing influence; and,

- The large Douglas Fir trees provide significant riparian overhang of the intertidal zone (~8-10m).

Table 1 Summary of Observations Made Along the Shore

Section Distance (m)	Scarp Height (m)	Riparian Overhang (m)	Notes
0	None	4	White, wooden 30cm-high property boundary marker noted on the upper scarp (not visible in photos); bedrock at base of vegetated scarp; beach is pebble-cobble-boulder veneer (sub-angular) over sandy gravel; small bedrock outcrop in upper intertidal zone (Fig. B-1).
10	0.8	6	Mostly vegetated scarp with v poorly sorted diamicton including angular cobbles; beach has a concentration of well-rounded cobbles on surface, maybe moved from west to create a sandy area to haul up boats (analogous to a canoe run). (Fig. B-2)
17	1.5		Stairs; scarp cut into diamicton w well-rounded cobbles; beach is angular pebble-cobble veneer w clear zone of cobbles suggesting people selectively moved the cobbles (Fig. B-3).
20	1.7	8	Diamicton with pebbles & cobbles in a fine matrix; large roots growing from the cliff face; large Douglas Fir w trunk 40cm dia; beach is barnacle-covered, sub-angular cobble-pebble veneer (Fig. B-4).
30	1.8	10	"nose" of shoreline w large Douglas Fir and roots protruding from bank; scarp is undercut so there is an overhang; there is a stiff clay layer outcropping on the upper beach (~2m in width); the lower portion of the visible beach is angular to sub-angular pebble-cobble veneer over sandy gravel (Fig. B-5).
40	1.9	11	Poorly-sorted diamicton noted on scarp face with pebbles and cobble within a fine matrix; a large Douglas Fir (~75 cm dia) is protruding from the cliff face; beach is a cobble-pebble veneer over sandy gravel; cobbles are generally well-rounded suggesting a glacial till origin (Fig. B-6).
50	2.5	4.5	The scarp here is cut into mostly fine material with some pebbles, cobbles and boulders visible; trees above the scarp have been de-limbed (lower branches removed); The beach has a coarser veneer than other stations (Fig. B-7) – well rounder cobble-pebble, probably of mostly glacial origin; property boundary marker seen just about the 50m in drone photo (Fig. A-6).

Two beach profiles were surveyed at the site (Fig. 8) to show differences in the beach slope of the "nose" of the property, which is the location of the proposed walkway, and the area to the east of the nose. The slope of the eastern beach is 4.8° and the slope of "nose" beach is 6.6°, so about 2° greater slope on "the nose".

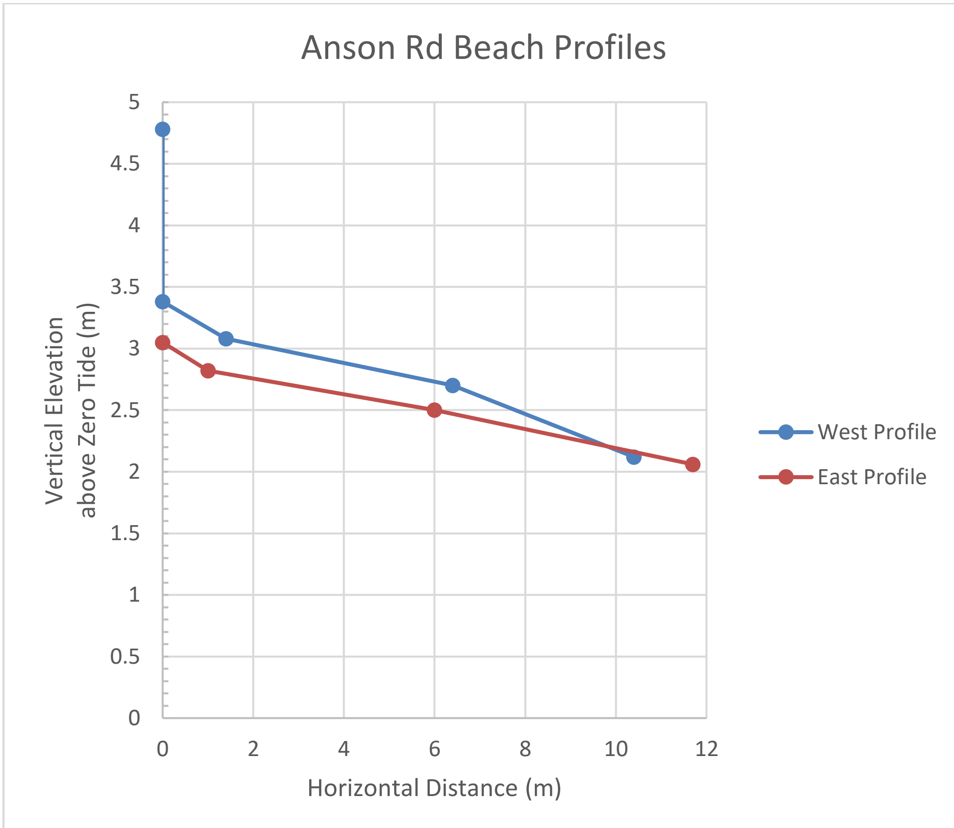

Figure 8. Across-shore beach profiles showing the beach slopes of the West (at approximately 27-m Section; refer to Fig 1 for location) and East (at approximately the 5-m Section; refer to Fig.1 for location) profiles. The beach is slightly steeper on the “nose” of the property (West Profile) than the adjacent eastern portion of the property. The cliff face at the West Profile is 1.4 m high and is slightly undercut at this location (Fig. B-5).

3.0 Discussion and Recommendations

It is clear there is a coastal erosion problem at the Anson Rd right-of-way. The actively eroding, near-vertical sea cliff is evidence of this erosion. The site is unusual in that it is a low exposure site (maximum wave fetches less than 1 km) and one would not expect such an erosional feature. The erosion is occurring because the material exposed in the cliff is mostly fine sediment and when eroded is easily carried offshore; there is insufficient coarse material (sand and gravel) to form a protective beach seaward of the cliff.

The erosion rate appears to be slow enough to allow several large fir trees to accommodate to the changing morphologic condition at the site. As the cliff face has retreated, the large trees have developed root systems embedded into the cliff face to support the trees; tree tips have oriented vertically as the cliff has retreated resulting in a gentle curve to 50+ year old trees. An accurate estimate of the erosion rate is not possible without longer term measurement. Where the use of historical air photo analysis is sometimes helpful in estimating erosion rates, the substantial tree canopy makes this measurement approach difficult in this case.

It is likely that the construction of a dock with a connecting walkway to the upland will require some type of shoreline erosion mitigation to protect the proposed infrastructure. The walkway will require a shore landing and anchoring foundation. To prevent instability of such a structure, several mitigation alternatives are possible (Table 2).

Alternatives are categorized as either soft or hard (Table 2) as a general index of their "naturalness" and minimal impact on the shoreline ecology.

A preferred, conceptual alternative is shown in Figure 9. Key elements include:

1. A generous setback that minimizes the need for hard beach protection to totally arrest cliff erosion,
2. Use of beach nourishment to create a protective berm at the toe of the cliff; material should be sufficiently coarse so as (a) to minimize transport from the site and (b) to provide infiltration for waves action. Preliminary specifications for a protective berm are provided in Appendix C.
3. Working around existing trees as much as possible to preserve riparian overhang and to leave root systems to help bind cliff material.

Table 2 Summary of Possible Erosion Mitigation Alternatives

Mitigation Category	Mitigation Type	Premise of Mitigation	Advantages	Disadvantages
Soft Solutions	Set-back	Sufficient set back from the cliff edge will allow many years of operation without mitigation	• Simple – "bridges" over dynamic area (sea cliff) • Causes minimal impact	• May complicate design and construction
	Protective Beach Berm (Beach-nourishment)	A protective beach berm would slow or arrest erosion	• Relatively simple • Would look natural • Has potential environmental benefit (sandlance habitat)	• Would probably require barge-scaled volume of placed material
Hard Solutions	Placement of Rip-Rap along cliff base	Stops toe erosion cliff and allows cliff to stabilize	• Engineered performance	• Proper toe burial would require disturbance of cliff • Unnatural alternative
	Construction of concrete wall or lock blocks along cliff base	Stops toe erosion cliff and allows cliff to stabilize	• Engineered performance	• Proper toe burial would require disturbance of cliff • Least natural alternative

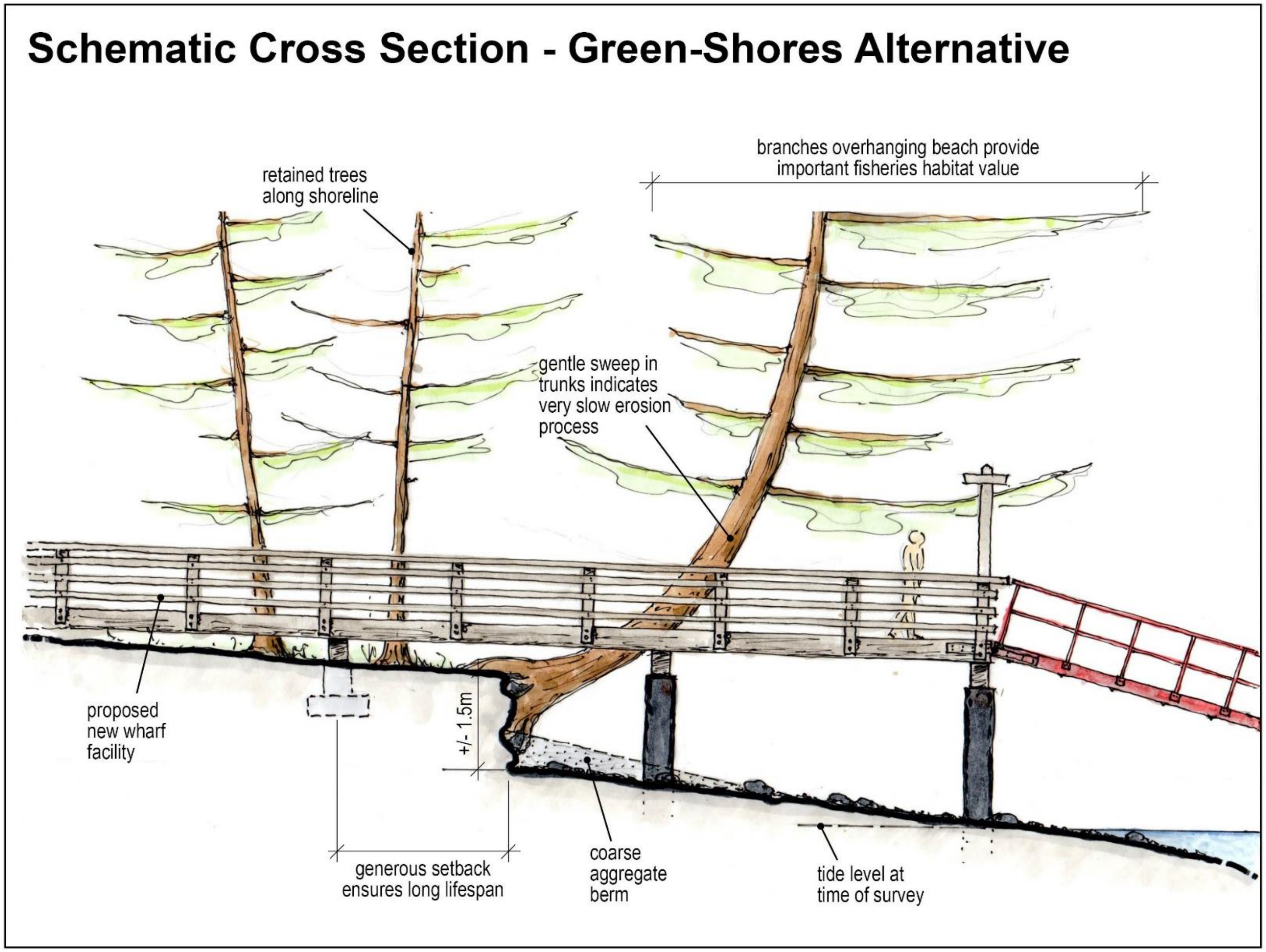

Figure 9. Schematic cross-section showing a preferred design alternative that preserves basic site characteristics and is sensitive to site dynamics.

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APPENDIX A

Aerial Photos

(Altitude generally about 10 m above water level)

Figure A-1. Drone photo of Section 0-m looking east.

Figure A-2. Drone photo of Sections 0-m, 10-m and 20-m looking east.

Figure A-3. Drone photo of Sections 10-m and 20-m looking west.

Figure A-4. Drone photo of Sections 20-m, 30-m and 40-m looking south.

Figure A-5. Drone photo of Sections 40-m and 50-m looking west.

Figure A-6. Drone photo of Section 50-m looking west.

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APPENDIX B

Ground Photos

Figure. B-1. Section 0-m looking upslope.

Figure. B-2. Section 10-m looking upslope.


Figure. B-3. Section 17-m looking upslope.


Figure B-4. Section 20-m looking upslope.

Figure B-5. Section 30-m, “the nose” looking upslope. Note outcropping clay layer near trunk and plate-shaped cobbles on beach.


Figure B-6. Section 40-m looking upslope.


Figure B-7. Section 50-m looking upslope.

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APPENDIX C

Protective Berm Specifications

The two surveyed profiles along the Anson Road seaward property boundary are shown in Figures C-1 and C-2 along with the approximate profile of the proposed protective berm. The planimetric extent of the proposed protective berm is shown in Figure C-3 and C-4. Fill Volume calculations are summarized in Table C-1.

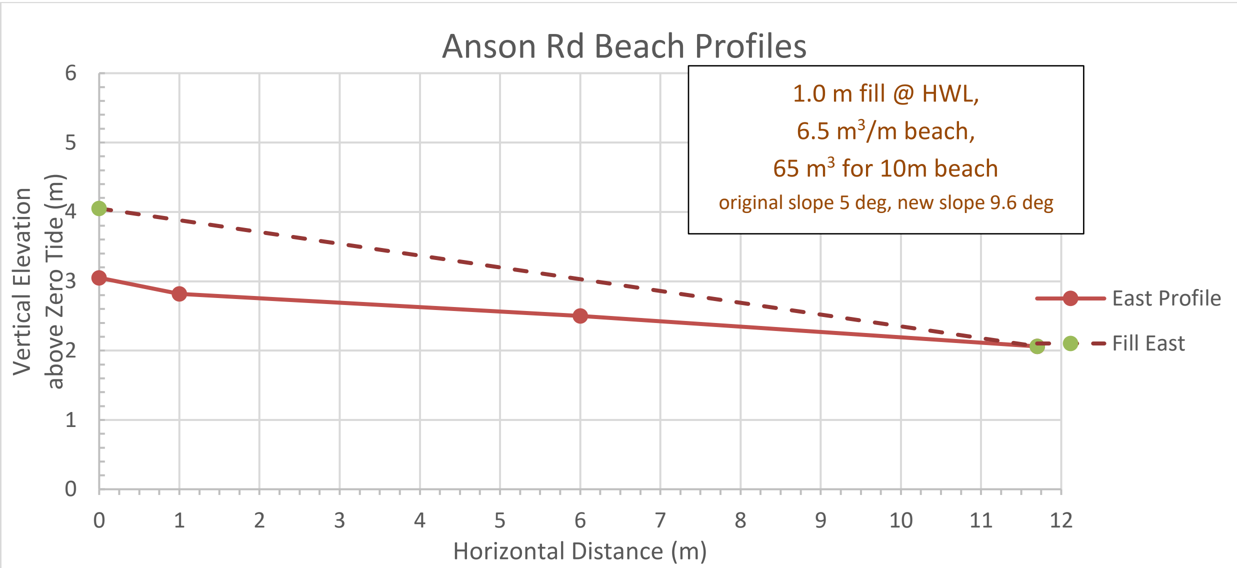

Figure C-1. The eastern shore-profile, located near the current stairs (Fig. 2, Section 10). The dashed line shows the recommended fill area with approximately 1-m thickness at the cliff edge/HWL and tapering to 0 m thickness 11 m seaward of the HWL.

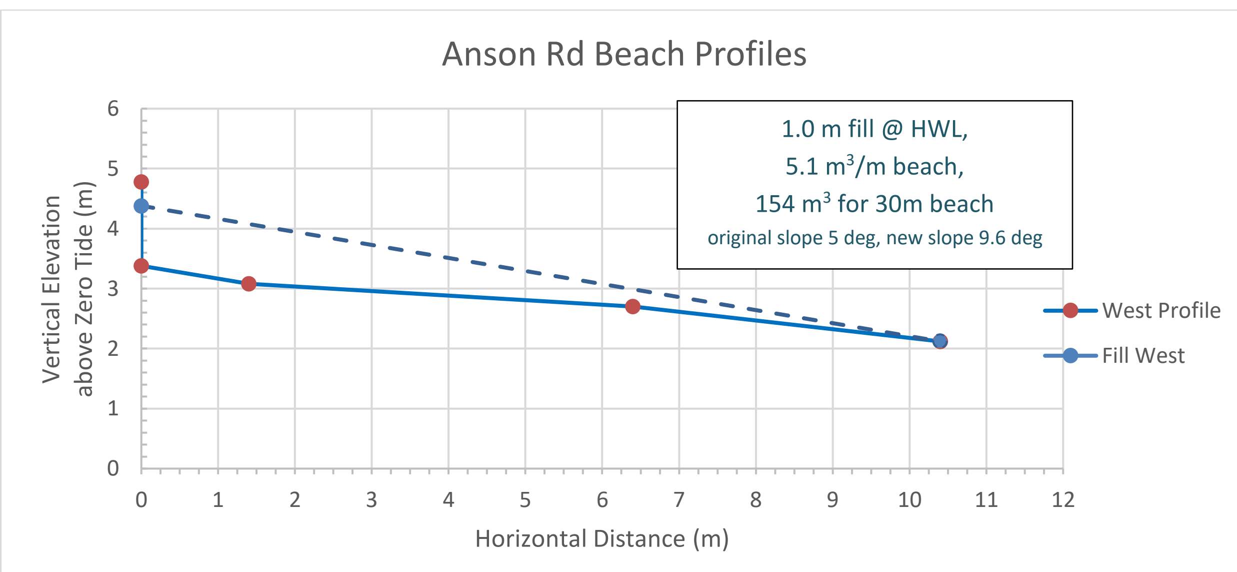

Figure C-2. The western shore-profile, located near the current stairs (Fig. 2, Sections 20-50). The dashed line shows the recommended fill area with approximately 1-m thickness at the cliff edge/HWL and tapering to 0 m thickness 10.5 m seaward of the HWL.

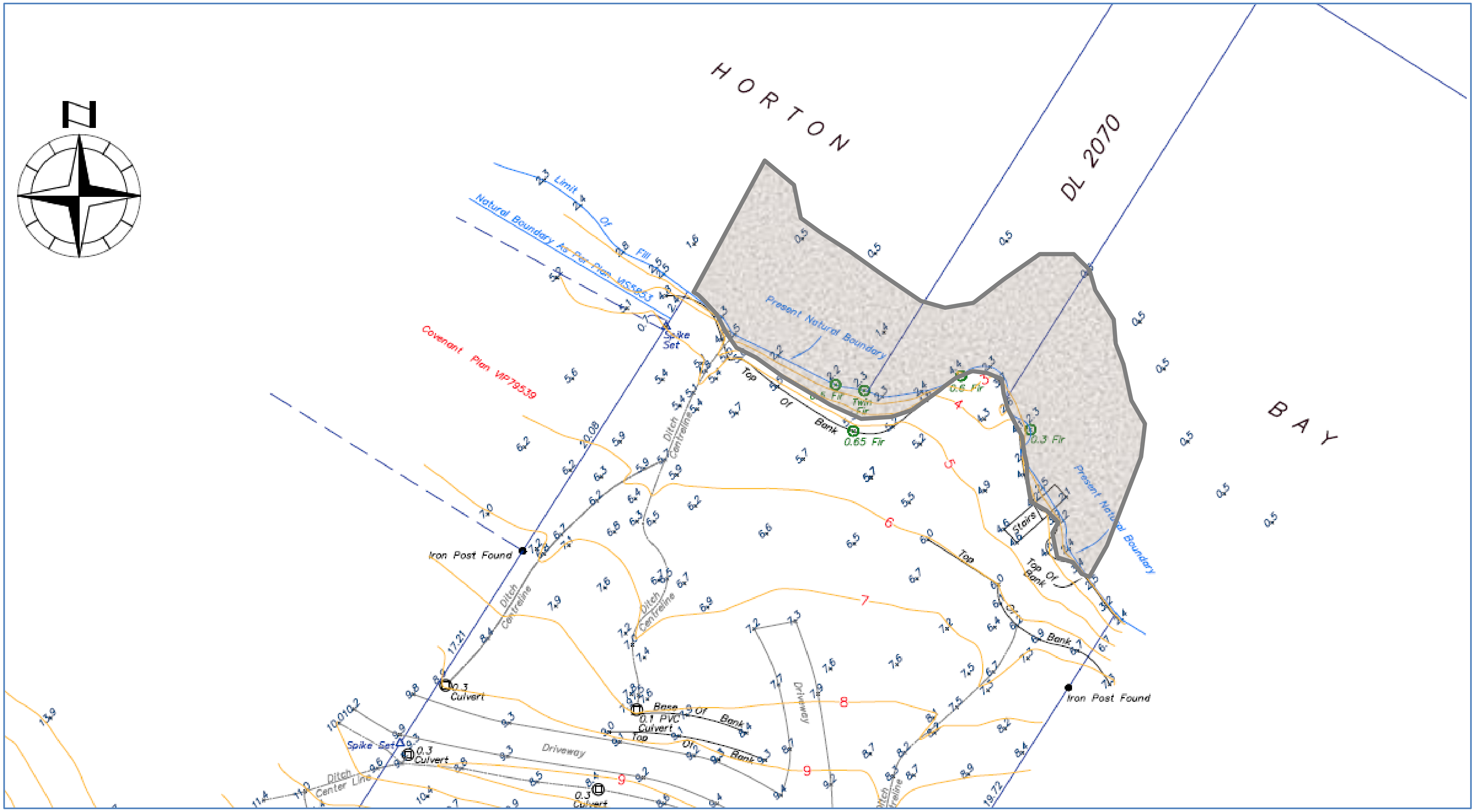

Figure C-3 CRD Site Plan of Anson Rd, Mayne Island (Plan 21413) showing extent of proposed protective berm – approximately 10m seaward of *natural boundary*.

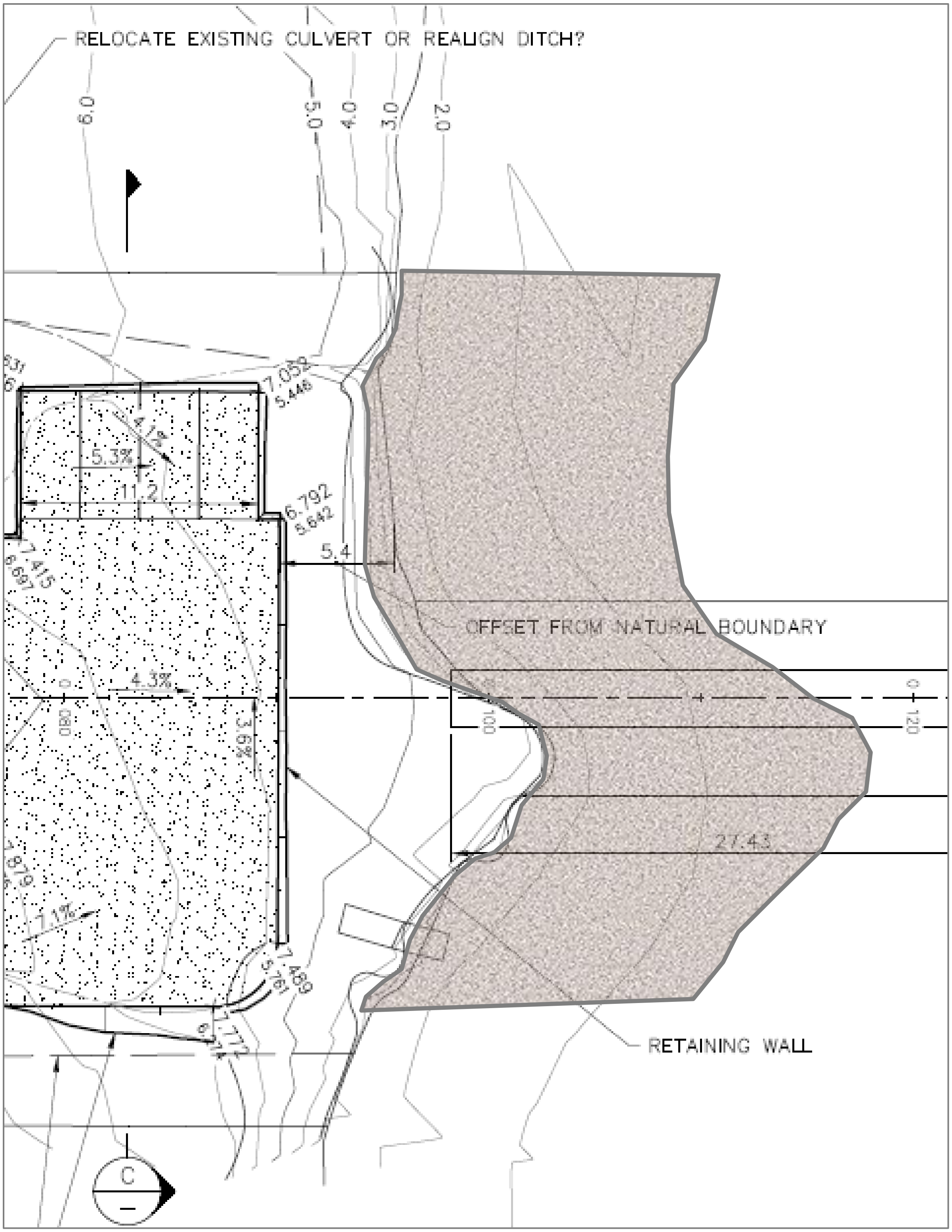

Figure C-4 CRD Plan showing approximate extent of proposed protective berm. Landward limit is along cliff, 1-m thickness, tapering to <0.1m thickness 10 m seaward of *natural boundary*.

The total estimated volume of protective berm aggregate is approximately 220 m^3. The aggregate material used on similar projects in the Capital Regional District for a protected shoreline (Tod Inlet) is approximately 19 mm (0.75") and this is the aggregate size recommended for the proposed protective berm.

Table C-1 Protective Berm Volume Requirements

Foreshore Section	Unit Volume per linear m of beach m^3/m	Volume per section m^3
10-20m	6.5	65
20m-50m	5.1	154
Total Volume:		218

Costs to provide the aggregate by tug and barge are summarized in Tables C-2 and C-3 and are based on quotes from Lehigh Materials (Table C-4) and Mercury Launch and Tug (Table C-5). The assumption is that the ramp barge could lower the ramp to the upper intertidal during high tide, the loader would offload the gravel to the beach and the gravel would be spread by excavator.

Table C-2 Estimated Costs of Protective Berm Aggregate, Sechelt Source

Item	Units	Unit Rate	Subtotal
Aggregate	220 m^3 (440 t)	[redacted]	
Tug and Barge (barge with 80' ramp)	1 delivery (Vancouver to Sechelt to Horton Bay to Vancouver)	[redacted]	
Tug and Barge standby	8 hr(2hr Sechelt, 6 hr Horton Bay)	[redacted]	
Excavator w operator	1 day	[redacted]	
Loader w operator	1 day	[redacted]	
	Total:		[redacted]
	30% contingency:		[redacted]
	Total w contingency:		[redacted]

Note: Aggregate loaded directly on barge at Sechelt loader.

Table C-3 Estimated Costs of Protective Berm Aggregate, Delta Depot Source

Item	Units	Unit Rate	Subtotal
Aggregate	220 m^3 (440 t)	[redacted]	
Tug and Barge (barge with 80' ramp)	1 delivery (Vancouver to Delta to Horton Bay to Vancouver)	[redacted]	
Tug and Barge standby	12 hr(6hr Delta, 6 hr Horton Bay)	[redacted]	
Excavator w operator	1 day	[redacted]	
Loader w operator	1 day	[redacted]	
	Total:		[redacted]
	30% contingency:		[redacted]
	Total w contingency:		[redacted]

Note: "River" gravel trucked from Chilliwack to Lehigh Delta Depot.

Table C-4 Quote on Aggregate from Lehigh Materials (Copy of email, 21 February 2020)

As per the attached you will see the 20mm stone and 28mm stone from our Sechelt mine, this natural stone is angular shape. As well our Riverstone from our Chilliwack mine.

Sechelt Stone: (FOB per metric tonne)

223: 20mm natural stone [redacted] ECF loaded onto a barge
224: 28mm natural stone [redacted] ECF loaded onto a barge
(Berm product must be loaded to contain moisture from barge – est 600 mt)

Chilliwack River rock: (FOB Delta barge ramp per metric tonne)

241: 20mm River rock [redacted] ECF + 12.00 trucking to Delta barge ramp
227: 35mm River rock [redacted] ECF + 12.00 trucking to Delta barge ramp

Thanks,
Nick Dawydiuk
Sales Manager
Lehigh Materials
8955 Shaughnessy Street
Vancouver, BC V6P 3Y7

			
Product 223 – 20mm natural stone	Product 224 -28mm natural stone	Product 242 – 21mm river rock	Product 227 - 35mm river rock

Table C-5 Quote from Mercury Launch and Tug (from email 21 February 2020)

Tow Ramp barge to Sechelt load 400 tonnes aggregates to Horton Bay Mayne Island offload return empty barge to Vancouver Hbr.

[redacted]

Standby offload [redacted].

Quote subject to tides at offload site.

Rob Errington, President
[redacted]