Preliminary Draft Report

Gabriola Island Fixed Link Planning Study

Prepared for

BC Ministry of Transportation and Infrastructure

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1. Background

1.1 Local Context

Gabriola Island, located approximately 4.5 km due east of Downtown Nanaimo, is one of 12 Local Trust Areas administered by Islands Trust. The Gabriola Island Local Trust Area includes over 20 other islands including Mudge Island.

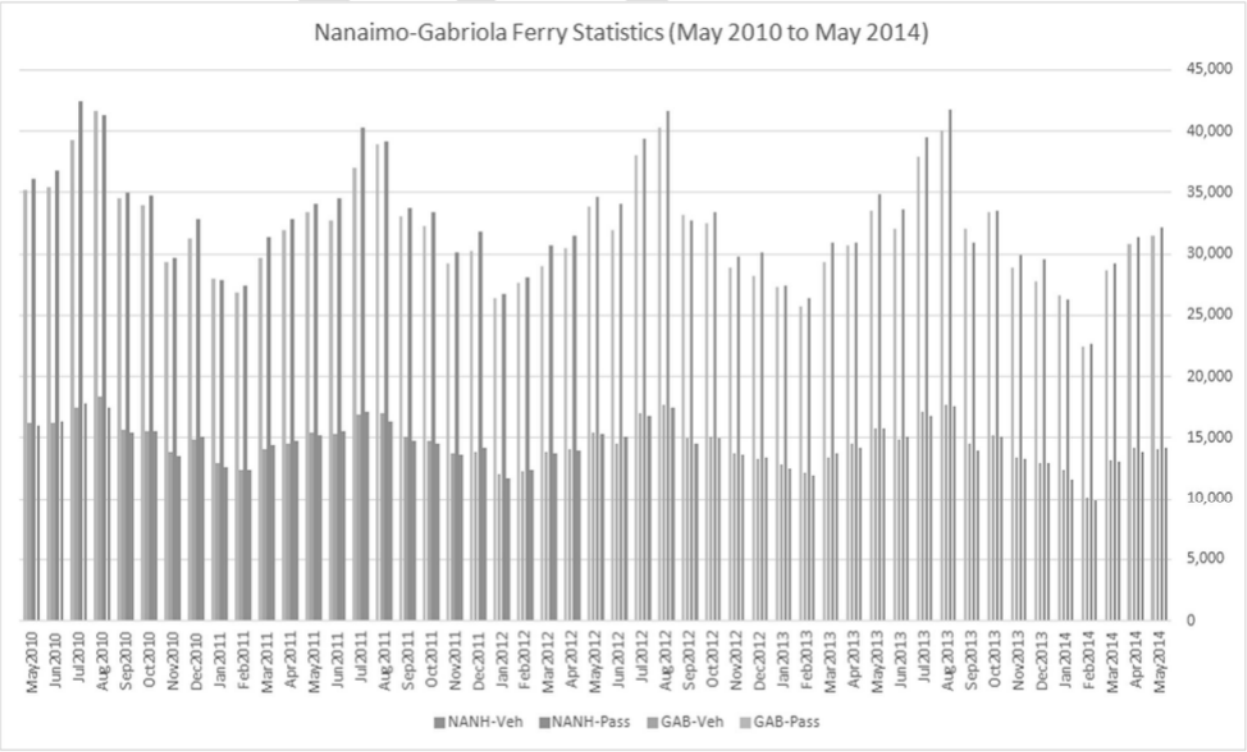
The mandate of the Islands Trust is 'to preserve and protect the trust area and its unique amenities and environment for the benefit of residents of the trust area and of the province generally. The Islands Trust is given authority for land use planning and regulation under the BC Local Government Act, specifically to develop and adopt Official Community Plans and land use bylaws.

Gabriola Island had a resident population of 4,045 in 2011. Despite a 15% increase between 2001 and 2006, the Island's population did not increase between 2006 and 2011. In summer the population of Gabriola Island almost doubles in size with the addition of tourists and visitors.

The British Columbia Ferry Corporation (BC Ferries) provides a regular service between Descanso Bay and Nanaimo Harbour (Route 19: Nanaimo Harbour – Gabriola Island). The 20 minute sailings occur approximately hourly, although less frequently during the midday period, on weekdays during the summer months. In 2013, BC Ferries served approximately 173,500 return vehicle trips and about 384,000 return passenger trips between Gabriola Island and Nanaimo Harbour. Residents of Gabriola Island who work or attend high school in Nanaimo rely on the ferry for commute trips. The ferry service also provides access for tourists and visitors to Gabriola Island.

Demand on this route varies seasonally, with peak demand experienced in July and August as shown in Figure 1-1.

FIGURE 1-1
BC Ferries Vehicle and Passenger Data for Route 19



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1.2 Reductions in Ferry Service

In May 2012, the Province announced that it would conduct public consultation with ferry dependent communities regarding adjustments to service levels. The Province also announced that it would seek public input to develop strategies to support a long-term vision for connecting coastal communities. This process concluded in December 2012 and in March 2013, the Province released its report summarizing the input it received during this consultation and engagement process. s.13
s.13

s.13,s.17

1.3 Calls for Fixed Link

The idea of a bridge link between Nanaimo and Gabriola Island is not new. In 1972, then Premier WAC Bennett commissioned a study for a BC Ferries route from a proposed new terminal on Sea Island south of Vancouver to a new terminal on southern Gabriola Island. A highway was proposed, connecting to Mudge Island via a new bridge across False Narrows, and to the Island Highway south of Nanaimo via a bridge across Dodd Narrows.

In 1985, the Gabriola Bridge Club was formed with the backing of the Chamber of Commerce. Opinions were divided on the appropriateness of a bridge. The Gulf Islands Committee campaigned against a fixed link under the slogan "real islands don't have bridges". Islanders participated in a community forum in 1987 during which the ferry-bridge scheme was rejected.

The fixed link concept was revisited as part of the Mid-Island Transportation Study in 1993, which was commissioned jointly by the then Ministry of Transportation and Highways; The British Columbia Ferry Corporation and the Crown Corporations Secretariat; to review ferry and highway operations between Vancouver Island and the Mainland.

Bridges were amongst options discussed during public engagement on the sustainability of the coastal ferry service conducted by BC MoTI and BC Ferries in 2012 and 2013. At the time, BC MoTI stated that if Gabriola residents expressed strong support for a bridge to Nanaimo, the Ministry would undertake a Feasibility Study. **The results of the engagement show divided opinions on the issue of a bridge to Gabriola Island, but that more respondents were in favour than against a bridge proposal**. BC MoTI is thus undertaking a Study to assess the feasibility of replacing the ferry service to Gabriola Island with a tolled fixed link. The Scope of Work for this Feasibility Study is set out in **Section 1.4** below.

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While these various studies were undertaken, the Islands Trust has remained unsupportive of a proposed fixed link to Gabriola Island. Both the Official Community Plans (OCP) of Gabriola and Mudge Islands explicitly oppose any fixed link or bridge between the islands and Vancouver Island or the BC Lower Mainland.

1.4 Study Objectives

The objectives of this feasibility study are as follows:

1. **Assess the technical feasibility of a potential fixed link crossing between Nanaimo and Gabriola Island** – The study will examine the merits of a fixed link crossing in terms of alignment, cost, travel time, reliability, and flexibility for potential users. It will also include a high-level assessment of the socio-economic and environmental impacts of such a connection.
2. **Evaluate feasible options against the existing ferry service** – Quantitative and qualitative analysis will be brought together in a structured Multiple Account Evaluation (MAE) framework, based on the key issues identified in **Section 3**.
3. **Obtain Stakeholder input** – The strategy will be informed by stakeholder input including: the Islands Trust, the Regional District of Nanaimo, Fisheries and Oceans Canada (DFO), Ministry of Environment (MOE), and Council of Marine Carriers.

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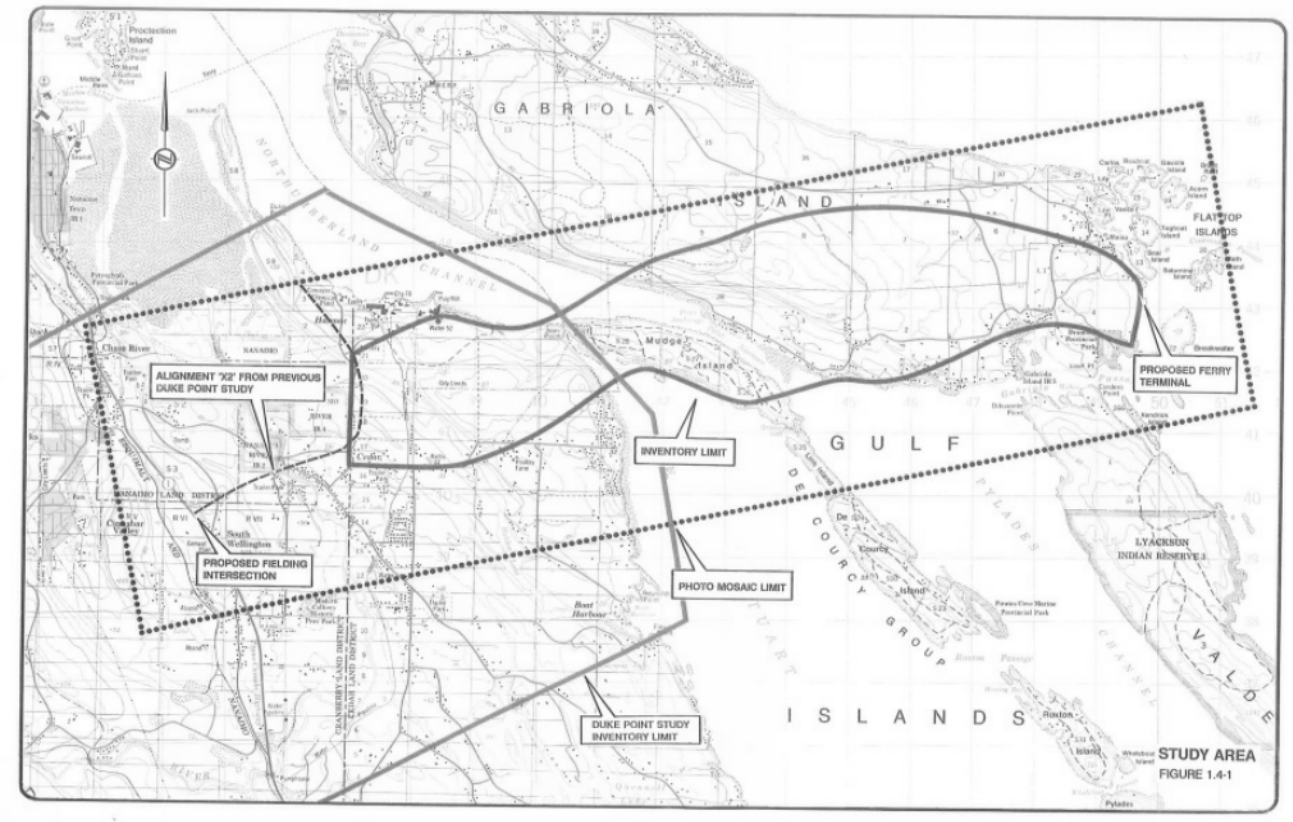
2. Review of Previous Studies

The Ministry provided access to two historic reports: the “Duke Point Corridor/Route Feasibility Study” and the “Gabriola Island Corridor/Route Feasibility Study” – both produced for the Ministry by McElhanney in 1993.

The Duke Point study expanded upon a previous report “New Vancouver Island Terminal Evaluation Study” that reviewed alternative ferry terminal sites. The preferred ferry terminal location identified in that report was at Duke Point, immediately northwest of the Harmac site. The Duke Point study generated and evaluated a wide range of controlled freeway-type connections between the ferry terminal and Highway 1.

The Gabriola Island study looked at several options for road alignment and possible bridge location sites for a fixed link connection to Gabriola Island. The study explored an alternative ferry terminal location, possibly at the south end of Gabriola Island. The proposed route was to be an expressway or freeway-type facility with no local road access. Travel patterns would be preserved on the existing, local road network. The extents of that study are reproduced in Figure 2-1.

FIGURE 2-1
Initial Duke Point Ferry Terminal Location



The study included a route level technical evaluation of a highway connection between the proposed south-end of Gabriola ferry terminal and Nanaimo. The Study concluded that the preferred route, shown in Figure 2-2, would tie into the Highway 1 near Nanaimo, and Peterson Road on Gabriola Island. The route would initially consist of two lanes, with two bridges (over Dodd Narrows and False Narrows) proving a link to Gabriola Island via Mudge Island.

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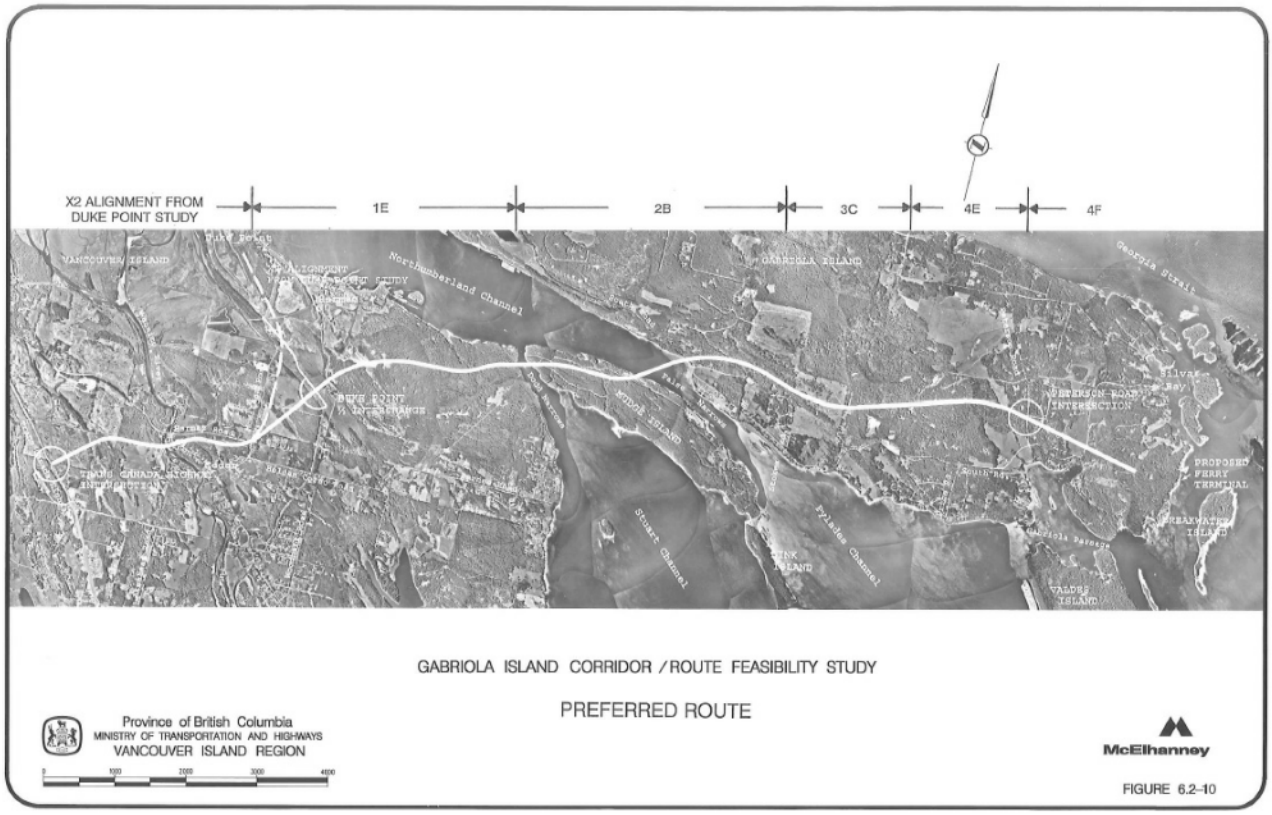
FIGURE 2-2
Preferred Route from Gabriola Island Corridor/Route Feasibility Study, 1993



All the options incorporated a bridge across Dodd Narrows and a bridge across False Narrows to connect to Gabriola Island. No direct connections between Nanaimo and Gabriola Island – spanning across Northumberland Channel – were considered due to excessive length and construction over deep water.

Dodd Narrows

Dodd Narrows was identified as a preferred crossing location on account of its relatively short crossing distance, and favourable topography. Steep embankments on both Nanaimo and Mudge Island help to achieve the specified 23 metre high navigational clearance.

At the time of the McElhanney study, the establishment of Joan Point Park was proposed but not yet in place. McElhanney stated that “with careful architectural detailing and strict construction guidelines it should be possible to minimize the bridge's disruption of the area”.

Since the study, Joan Point Park has been designated.

False Narrows

The crossing of False Narrows in McElhanney’s preferred option was aligned to satisfy the study goal of a new ferry terminal at the south end of Gabriola Island. In addition, McElhanney’s preferred option shows extensive fills placed within False Narrows to construct a causeway to shorten the bridge length.

In the current feasibility study, only a connection to South Road is being considered. Also, it is considered unlikely, given the associated environmental and hydrotechnical impacts, that Ministry of Environment or Fisheries and Oceans Canada would be receptive to this option.

Review of the previous studies was generally instructive in terms of feasible crossing locations. However, since the nature of the corridor has changed, i.e. freeway-type connection to a ferry terminal versus a ‘simple’ connection, the criteria and ultimate design will be different than what was previously envisioned.

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3. Key Issues

3.1 Planning Policy and Land Use Considerations

3.1.1 Overview

This section sets out the planning policy and land use considerations associated with a fixed link between Vancouver Island and Gabriola Island. An overall context plan of the study area is shown in Figure 3-1.

3.1.2 Gabriola Island

The Gabriola Island Official Community Plan (OCP), approved in 1997, sets out the community's goals, objectives and policies regarding land-use and future development as well as social and environmental considerations applicable in the planning area. The purpose of the OCP is to provide direction to government agencies, businesses, land owners and residents concerning future land use and the provision of services.

OCP goals include preservation of the natural environment, and discouraging projects which would reduce the health, quiet, natural and aesthetic values of the area; and to preserve the rural character and atmosphere of the area. A specific land transportation objective within the OCP is to "**oppose any fixed link or bridge** to Vancouver Island or ferry connection to the BC Lower Mainland". A further social goal in the OCP is to "encourage **gradual and appropriate, rather than rapid, change and growth**". Based on historic growth trends, the OCP estimates that the future population of Gabriola could grow to 4,720 by the year 2016.

The OCP does not designate additional land for residential development, as at the time the plan was approved (1997), it was considered that the availability of vacant residential parcels, combined with the future potential to create new parcels through the subdivision of existing residentially zoned land, was adequate to satisfy the Island's housing requirements for fifteen to twenty years. Further, it is noted in the OCP that there are known problems with inadequate soil percolation for septic disposal and groundwater supply because of the complex nature of groundwater flow through fractures in the bedrock which could limit the Island's capacity to accommodate future growth.

South Road is designated as a Main Road with in the OCP. Low density residential development is located on both sides of South Road. The area adjacent to False Narrows is more densely developed than other parcels along South Road. Parcels surrounding Hoggan Lake and further east are designated as Agricultural Land Reserve (ALR).

3.1.3 Mudge Island

A potential connection via Mudge Island was identified in previous studies. Current planning policies and land use relating to Mudge Island are thus pertinent to this planning study. A key community goal articulated in the Mudge Island OCP (2007) is to "**to keep the islands as a refuge** from the pressures of urban life, as partially facilitated by the absence of ferry service and bridges between these and other islands." Further, OCP Policy 4 states that "**no island in the Plan Area shall be connected to any other island by a bridge**."

The western half of Mudge Island is extensively subdivided. However, many of the properties are not developed, and it is understood that these subdivisions are the result of grandfathering. The Mudge Island OCP includes guidelines for development which emphasize the "rural Island Character and Local Needs". Specifically, OCP Guideline 7 states that the "preservation of the rural character, peace, quiet, privacy, tranquility, serenity and the 'slow island pace' shall continue, including the lack of paved roads and the absence of streetlights, sidewalks and other city-related services." OCP Guideline 9 states that "future development should only be permitted at a scale and rate of growth respectful of: community-held values

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pertaining to the environment; the Plan Area's rural qualities; consideration of water-only access; and the local area's limited infrastructure".

3.1.4 City of Nanaimo

The shortest crossing distance to Gabriola Island is from the northeastern boundary of the City of Nanaimo. Land use considerations in this location include:

- Joan Point Park is a designated area of Parks and Open space in the City of Nanaimo OCP (2008) and is part of a designated Environmentally Sensitive Area (ESA) which also extends to the immediate west. Both the park and the ESA are situated outside of the City's Urban Containment Boundary (UCB). The OCP specifically states that "it is not expected that any Resource Protection or Parks and Open Space lands outside the UCB will be developed for urban growth".
- The purpose of the City's Environmentally Sensitive Area designation is to "protect areas that: provide productive fish or wildlife habitat; contain sensitive, rare or depleted ecosystems and landforms; and represent sites of Nanaimo's natural diversity that are in danger of disappearing". Because ESAs are sensitive to disturbance by human activity and the impacts of development, they are afforded special treatment in order to protect their integrity. In this case the area is designated as a Development Permit Area (DPA23) in the City of Nanaimo OCP. Disturbance of vegetation, movement of soil, or other disturbance of land or water is not permitted in these areas without an appropriate development permit.
- Island Timberlands GP Ltd. owns two parcels in this area, and has developed a Conceptual Plan for a Waterfront Village at Cable Bay (west of Joan Point Park). Proposed accesses to the development is to be achieved via an extension of Phoenix Way, however it is understood that Phoenix Way was constructed by Harmac and is a private road. Proposed development of a second land parcel to further west (known as Cable Bay Waterfront Marina), also owned by Island Timberlands, requires an OCP amendment and is on hold pending resolution of site access off Phoenix Way. Both developments are arguably dependent on the resolution of these access issues.
- The Cable Bay Trail begins at a trailhead at the end of Nicola Road and terminates at the ocean. A rough private trail runs along the coast to Dodd Narrows offering good wildlife viewing opportunities, with harbour seals, sea lions, river otters and bald eagles commonly seen. Killer whales can also be observed in this area on occasion. Upon reaching Joan Point Park, the route becomes an unimproved public trail continuing to the park's southern border where the trail crosses onto private lands belonging to Oceanview. From that point, a further rough private trail extends south along Oceanview's eastern shoreline adjacent to Stuart Channel through the forested coastal fringe. At the southern border of Oceanview, the rough trail connects up with the end of Leask Road, offering the potential to loop back by road to the trailhead on Nicola Road.

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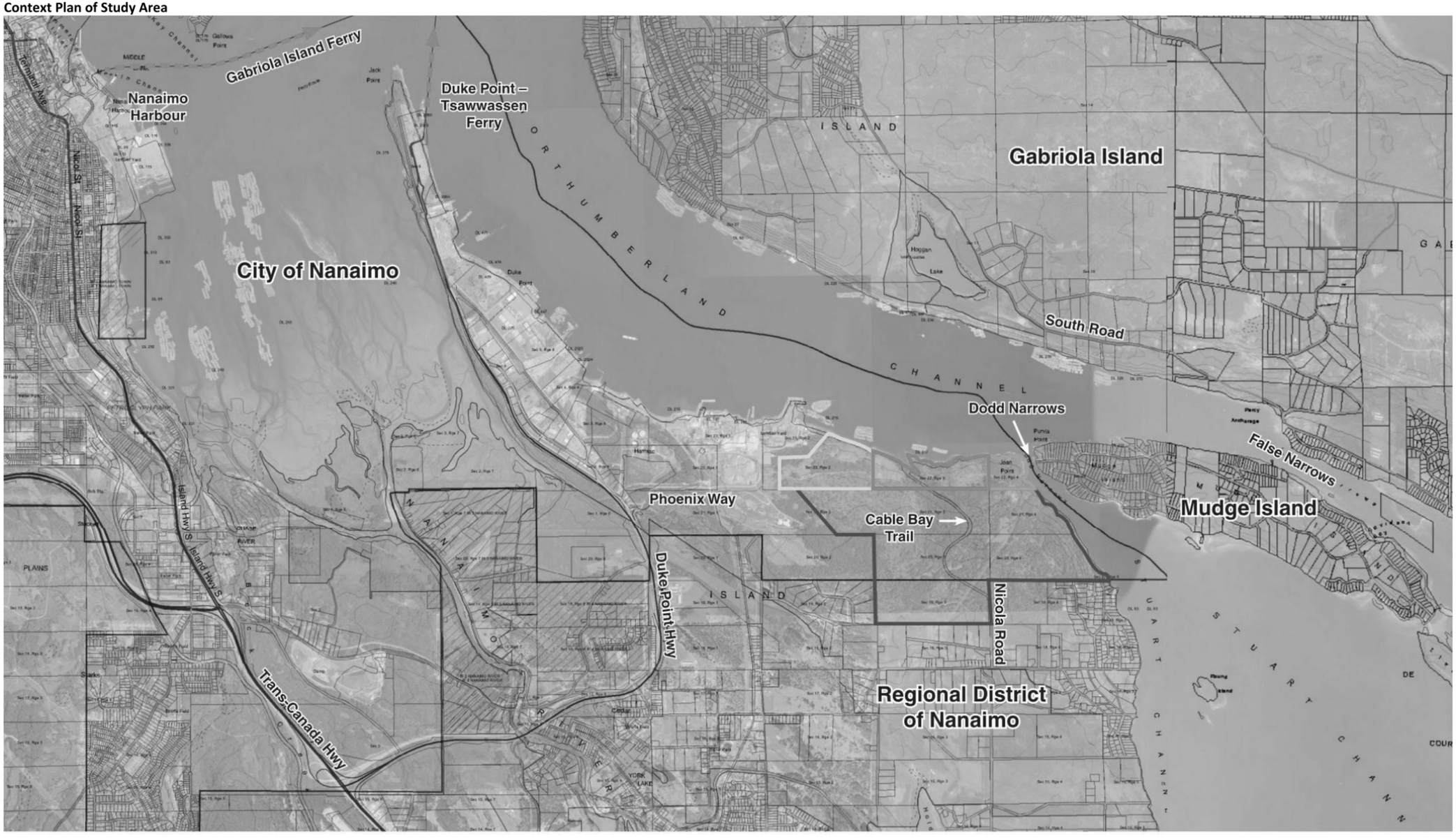
FIGURE 3-1
Context Plan of Study Area



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3.2 Transportation Planning and Engineering

3.2.1 Crossing Demand

Compared to the existing ferry service, a fixed link will provide flexibility and reliability for travelers. A demand assessment will confirm whether the crossing needs to be a 2-lane or 4-lane bridge.

The assessment will account for potential induced traffic and will include commentary on anticipated origins and destinations. Impacts on alternative modes will also be identified. These include:

- Pedestrians (based on BC Ferry foot passenger traffic);
- Bicycles – an advocate group developed route plan (http://sustainablegabriola.ca/uploads/3/1/3/4/3134017/cyclepaths_of_gabriola_report.pdf);
- Transit – GERTIE Community Bus http://gabriolacommunitybus.com;
- Goods movement; and
- Emergency services.

3.2.2 Alignment Constraints

Existing and future land uses presented in **Section 3** impose constraints on the horizontal alignment of the crossing. The crossing's vertical profile is constrained by navigational clearance requirements and by the significant elevation differences between Nanaimo and the western section of the main local road on Gabriola Island, South Road.

The horizontal alignment and vertical profile of approaches and road network connections need to conform to the challenging site topography particularly on Gabriola Island, and will determine right-of-way (ROW) impacts on surrounding properties.

3.2.3 Road Classification

The road classification for the fixed link will be determined and can be revised through the planning and concept design phase. Selecting the type of roadway for the fixed link will have some bearing on the alignment, will impact the costs of the road and bridge design and construction, and will determine the ROW impacts. The questions that will be addressed to determine the type of roadway are:

- Will this road be part of the local road network or be an arterial type roadway with a higher posted speed and some access restrictions?
- What will be the posted speed? A local road will likely have a posted speed of 50km/h. A higher design speed could be used but this could have impacts on the alignment.
- What is the estimated ADT and SADT, for the current year and the design year? These volumes are important for selecting shoulder width and clear zone width, which have implications on ROW, and pavement structure.
- Who will own the road? Some sections of the roadway will be within the City of Nanaimo, so who will have jurisdiction over the roadway in these sections?
- Will this be a multimodal facility to accommodate cyclists and pedestrians?

All of the above factors are important to determine appropriate alignment options and establishing evaluation criteria and impacts for the MAE.

3.2.4 Bridge Crossing Alignment and Location

The horizontal alignments from the McElhanney study are still relevant. Navigational clearance and crossing distance are still key to the evaluation of the bridge crossing. However, some of the technical, environmental, and social issues are likely more significant now than back in 1993 when the study was done.

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The options in the McElhanney study all incorporated a bridge across Dodd Narrows to Mudge Island, and a bridge across False Narrows to connect to Gabriola Island. A single bridge crossing Northumberland Channel would be a very long bridge, over 1,000 m.

As noted in the McElhanney report, Dodd Narrows is not very wide so the possible bridge alignments at this site are limited. A bridge at Dodd Narrows will require 23m of navigational clearance, resulting in a larger structure than might otherwise be expected.

Dodd Narrows is also the location of Joan Point Park. It is difficult to envision how a bridge and associated roadworks through this area could be constructed with minimal local impacts.

The crossing of False Narrows in McElhanney's preferred option shows extensive fills placed within False Narrows to construct a causeway and shorten the bridge length. It is unknown at this point how receptive the MOE or DFO would be to this option, and its environmental and hydrotechnical impacts. Other crossing locations across False Narrows can provide a shorter bridge crossing and more direct connections to the local road network on Gabriola Island.

3.2.5 Road Alignment Alternatives

As stated earlier, the classification of the roadway for the fixed link to Gabriola Island would need to be decided upon to assist in determining appropriate alignment options. Using the existing local roads (e.g. Nicola Road, Lindsey Road) as much as possible may reduce property impacts, but most of the existing local roads would require upgrading.

Another option is using Phoenix Way that goes through the Harmac Pulp Mill lands and was constructed by Harmac. Phoenix Way is already connected to Highway 19 (via Maughan Road) and this route would bypass most developed residential areas. This would shorten the length of the new route significantly over what was proposed in the McElhanney study, however ownership of this road will need to be addressed.

3.3 Structural Engineering

The horizontal alignment, vertical profile, and required structure clearances (navigational and otherwise) form the envelope within which a bridge may be constructed. General guidance on acceptable water depth limits for caisson construction, and aerodynamic effects on long-span structures will also help to inform selection of suitable general structural arrangements. Determination of span lengths and structure types will stem from these decisions.

The bridge is anticipated to be a 2-lane crossing with pedestrian and bicycle accommodation.

Bridge aesthetics, though not integral to the assessment of technical feasibility, will nonetheless play a part in the overall assessment of community impact.

Other marine/coastal engineering issues:

- Tides and currents – especially at Dodd Narrows
- Sea level rise

3.4 Geotechnical Engineering

Geotechnical conditions are anticipated to be favourable given the near-surface bedrock elevations. However, specific geotechnical expertise is required to guide the concept designs of the following:

- Pier/abutment foundation conditions
- Access road and network connection pavement structure
- Potential slope stability, based on the need for some cut and fill to mitigate site topographic constraints

A desktop review of available geotechnical data was undertaken, the findings of which are included later.

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3.5 Environmental Considerations

3.5.1 Sensitive Terrestrial, Freshwater, and Marine Areas

A desktop assessment was conducted to identify potential terrestrial, fresh water and marine environmental sensitivities along the proposed Gabriola Island Fixed Link alignments. This desktop study included a review of species at risk, sensitive ecological communities, and critical habitats of various species which may be encountered along and within close proximity to the alignment options. The desktop review was conducted using a variety of mapping and database tools, including the British Columbia Conservation Data Center and Fisheries and Oceans Canada online databases (BC Conservation Data Centre, 2012; Fisheries and Oceans Canada, 2009), BC iMAP, available satellite imagery, and information from previous feasibility studies. The detailed results of the assessment are presented in **Section 6**.

In general, species at risk were identified in the general study area. In British Columbia, species at risk are designated as red or blue-listed to indicate the potential need for designation and protection under the British Columbia *Wildlife Act* or to assist in ranking conservation priorities for species considered to be at risk. Red-listed species include any 'ecological community, and indigenous species and subspecies that is extirpated, endangered, or threatened in British Columbia'. It is the red-listed species which may become be legally designated under the *Wildlife Act*, if deemed necessary for their protection. Blue-listed species include any 'ecological community, and indigenous species and subspecies considered to be of special concern in British Columbia' and these are species known to be particularly sensitive to human activities and natural events (Government of British Columbia, 2015).

British Columbia's Conservation Data Center organizes species of concern into two categories: 'sensitive' and 'non-sensitive'. Due to the vulnerability of species considered to be 'sensitive', location and species specific information is not provided in the database. However, an area polygon outlining the general area of where these species may be encountered is provided. For detailed information on 'sensitive' species, additional information must be requested and obtained under an agreement with the British Columbia Conservation Data Center. For 'non-sensitive' species however, specific information is provided, including the location of observation, scientific name, and status ranking.

A summary of the environmental sensitivities found during the desktop review are provided below.

Terrestrial

No terrestrial wildlife or plant species of concern were identified in the general study area, however the mapped polygons of six red and blue-listed plant species were shown to be located in the proximity of the study area on Vancouver Island (Table 3-1). These plant species included awned cyperus, Muhlenberg's centaury, banded cord-moss, Nuttall's Quillwort, slimleaf onion, and white-top aster (BC Conservation Data Centre, 2012).

TABLE 3-1
At Risk Species Found in the Vicinity of the Gabriola Island Fixed Link Route*

Common Name	Scientific Name	Species Type	British Columbia Listing	Provincial Status	COSEWIC Status	SARA Status
Awned cyperus	*Cyperus squarrosus*	Plant	Blue	S3	–	–
Banded cord-moss	*Entosthodon fascicularis*	Plant	Blue	S2S3	Special Concern	Threatened
Douglas-fir / Dull Oregon-grape	*Pseudotsuga menziesii / Mahonia nervosa*	Ecological Community	Red	S2	–	–
Eulachon	*Thaleichthys pacificus*	Fish	Blue	S2S3	Endangered	–

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TABLE 3-1
At Risk Species Found in the Vicinity of the Gabriola Island Fixed Link Route*

Common Name	Scientific Name	Species Type	British Columbia Listing	Provincial Status	COSEWIC Status	SARA Status
Muhlenberg's centaury	*Zeltnera muehlenbergii*	Plant	Red	S1	Endangered	Endangered
Nuttall's quillwort	*Isoetes nuttallii*	Plant	Blue	S3	–	–
Slimleaf onion	*Allium amplectens*	Plant	Blue	S3	–	–
White-top aster	*Sericocarpus rigidus*	Plant	Red	S2	Special Concern	Special Concern

Notes:

*Also includes species at risk located within 100 meters from possible route options

Bald eagles were identified throughout the entire project area and were observed by CH2M HILL staff on Mudge Island during the site visit conducted on November 27, 2014. Bald eagles are considered to be abundant and secure, however the general project area, specifically the treed habitats along Gabriola Island and Mudge Island, likely provide nesting habitat for bald eagles which should be considered during construction planning, should a fixed link be feasible.

Fresh Water Aquatic

No at risk fresh water aquatic species were identified, however fresh water drainages likely connecting to Northumberland Channel were identified which may contain potential rearing and spawning habitat for salmon, trout, and char species. (McElhanney, 1993a; McElhanney, 1993b).

Marine

One at-risk marine species was found within the project area, and this included the blue-listed eulachon, marine fish. This species was encountered throughout the marine environments within the project area and has the potential to occur at the bridge crossing locations (BC Conservation Data Centre, 2012).

Although no additional at risk marine species were identified, the review highlighted potential spawning habitat for herring (BC Conservation Data Centre, 2012) and ling cod, and the presence of oyster and clam beds along the coastal shorelines near the bridge crossings (McElhanney, 1993a).

Environmentally Sensitive Areas

One sensitive ecological community is present in the study area and included the Douglas fir/dull Oregon grape ecological community. This ecological community is a Red listed environmentally sensitive area and is found throughout the terrestrial habitats, in particular on Mudge Island and in dispersed areas on Vancouver Island and Gabriola Island.

The Strait of Georgia, which encompasses the entire marine ecosystem within the project area, was also identified by DFO as an Ecologically and Biologically Important Area (Fisheries and Oceans Canada, 2009). These Ecologically and Biologically Important Areas are classified by DFO as containing significant or critical marine habitats and allows DFO to provide enhanced protection of these areas (Fisheries and Oceans Canada 2004).

No provincially designated parks, protected areas, or conservation areas were located within the project area, however Joan Point Park, a City of Nanaimo park was identified on Vancouver Island near Dodd Narrows.

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3.6 Socio-economic

Both the Gabriola and Mudge Island OCPs emphasize the value of maintaining a distinct island culture and heritage:

- Gabriola Island OCP Vision Statement: "Gabriola is a peaceful, diverse, safe, rural community in harmony with a protected, natural environment. The local economy is resilient, we walk and cycle the island, and the land and sea provide bountiful harvests for all inhabitants. Island and marine wildlife, here long before human populations, continue to flourish."
- Mudge Island strives to "keep the islands as a refuge from the pressures of urban life, as partially facilitated by the absence of ferry service and bridges between these and other islands".

Provision of a fixed link has the potential to fundamentally change social and economic networks on the islands, as well as adjacent areas of Nanaimo. Daily routines would no longer be subject to ferry schedules and a wider array of services and amenities would be more accessible to island residents. Increased accessibility may adversely impact existing local island businesses, though some new opportunities may also arise.

There may be neighbourhood impacts ranging from qualitative aesthetic/visual impacts to more quantitative measures such as noise and housing affordability.

3.7 Archaeology

No specific references were made in the 1993 McElhanney report regarding archaeological impacts, although it would seem highly likely that some archaeological sites could be present. A desktop review was done as part of this feasibility study to determine presence of any archaeological sites in the vicinity of the alignments considered, and is presented in **Section 6**.

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4. Stakeholder Consultation

BC MoTI has identified the following key stakeholders to be consulted:

- The Islands Trust
- The Regional District of Nanaimo
- The Department of Fisheries and Oceans
- The Ministry of Environment
- The Council of Marine Carriers

Telephonic discussions were help with all of these stakeholders during the study, confirming the majority of the information relevant to this study that is readily available online.

The City of Nanaimo provided information pertaining to proposed developments in the study are, which have been taken into account.

Separate feedback meetings are scheduled with the following stakeholders on March 13, 2015:

- City of Nanaimo
- District of Nanaimo
- Islands Trust

Members of the Council of Marine Carries advised that they do tow through both Dodd Narrows and False Narrows, including log and barge towing operations. As a result, any bridge at either location will require a minimum of 23 metres vertical clearance at High High Water. This would then accommodate most ramp barges and spud barges, as well as loaded chip barges. Since log towing is not uncommon in False Narrows, a minimum clear width (no piers) of 500 ft is required to accommodate about four sections wide.

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5. Demand Forecast and Future Conditions

A key element of the feasibility assessment is an estimate of the traffic demand on the fixed link. This will also advise the MAE. This section provides a brief description of the methodology adopted to produce vehicle travel demand forecasts on the proposed fixed link facility between Gabriola Island and Nanaimo. Annual vehicle travel demand forecasts between 2015 and horizon year 2044 (assuming 2020 bridge opening and a 25 year horizon from opening day)[1] are also presented in this section.

Future vehicle demand forecasts for the proposed bridge are split into two components as follows:

- Background Growth – Based on current trends in ferry usage.
- Induced Demand – New trips that might utilize the new fixed-link connection.

Future background growth was estimated using historic BC Ferries ridership data on Route #19 Nanaimo Harbour-Gabriola Island. This component of the demand estimates future growth in vehicle demand assuming current conditions (i.e. if a ferry link between Gabriola and Nanaimo continued in the future). The induced component of the demand estimates the additional (or reduction in) vehicle trips generated as result of building a fixed link.

The following sub sections describe the methodology, assumptions and outcomes for developing the forecasts of traffic for the a fixed link connection.

5.1 Background Growth

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Nanaimo and Gabriola between April 2004 and March 2014. The vehicle breakdown included several categories, such as regular vehicles, buses, trucks, passenger-vehicles over-height and passenger-vehicles under-height. The vehicle data was aggregated into distinct categories – regular vehicles and trucks. Trucks included buses and passenger-vehicle over-height in addition to regular trucks. Trucks were found to comprise only 3% of the total ridership. Figure 5-1 summarizes the average quarterly daily traffic for all vehicles (regular + trucks) between 2004 and 2014. In general, vehicle ridership has been steadily declining over the last decade (1,270 vehicles in 2004-Q3 to 1,060 vehicles in 2013-Q3, a decline of 16.5%). The figure also clearly shows a steep decline in 2008-2009 which coincided with the economic downturn. As expected, the traffic volume is highly seasonal with the highest volumes observed in the summer (quarter 3).

[1] All forecasts beyond 2030 were extrapolated.

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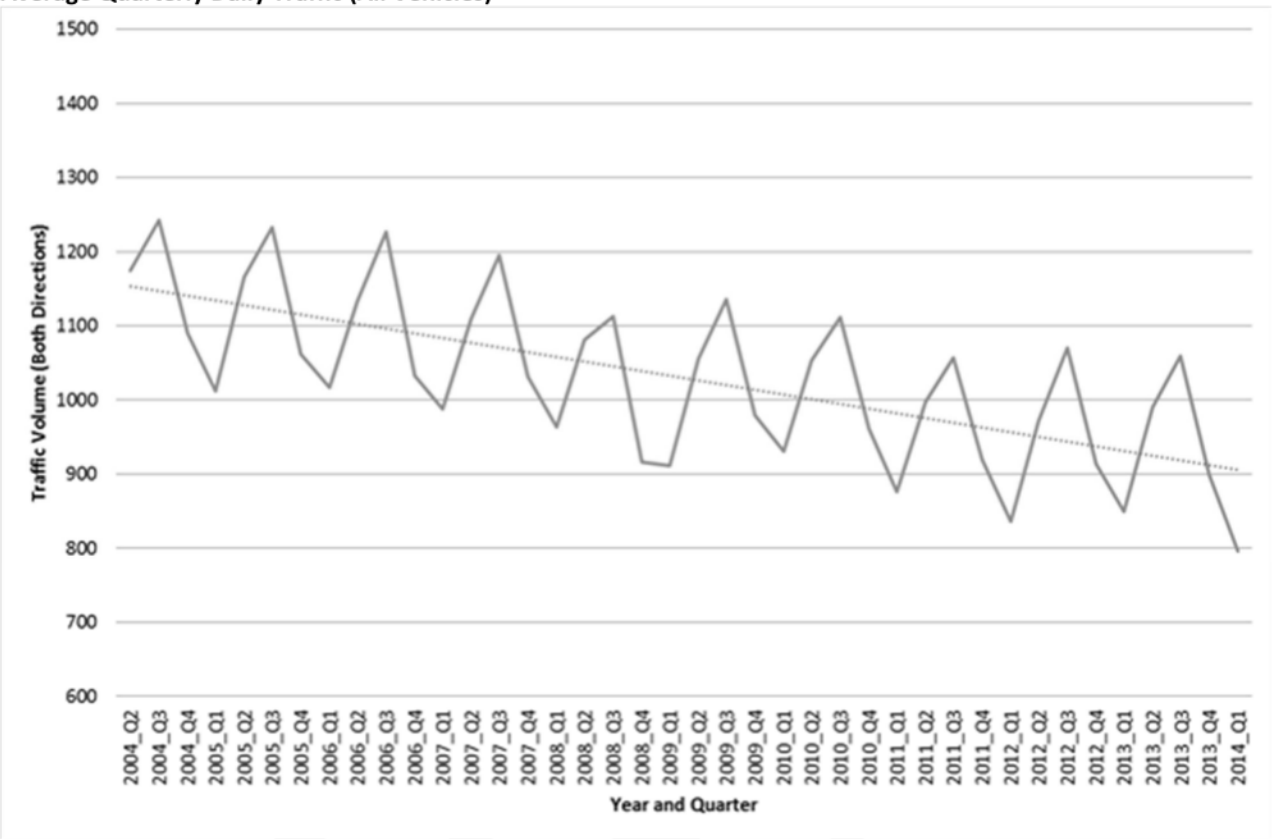
FIGURE 5-1
Average Quarterly Daily Traffic (All Vehicles)



In order to develop future forecasts, several socio-economic and cost-related variables that could potentially influence traffic levels on the ferry were selected and analyzed. Table 5-1 summarizes the list of the candidate variables[2].

TABLE 5-1
List of Variables that Could Potentially Influence Traffic Levels on the Ferry

Variable	Description	Historical Data Source
GDP	BC Gross Domestic Product	Conference Board of Canada
Employment	BC Employment	Statistics Canada
Total Population	Gulf Islands Total Population	Statistics Canada
Population age groups	Gulf Islands Population age groups	Statistics Canada
Fare	Ferry Vehicle and truck (2-way)	B.C. Ferries
Gas	Gasoline Prices (Vancouver)	Statistics Canada

GDP, employment and population are all growth-related variables and are all expected to be positively correlated with ferry vehicle traffic. Fare and gas prices[3], on the other hand, are expected to be negatively correlated.

[2] It would have been ideal to use more localized socio-economic variables specifically for GDP and employment, however no such data was found from publicly available sources. Obtaining forecasts for such variables would likely be difficult.

[3] GDP, fares and gas prices were all analyzed in real terms.

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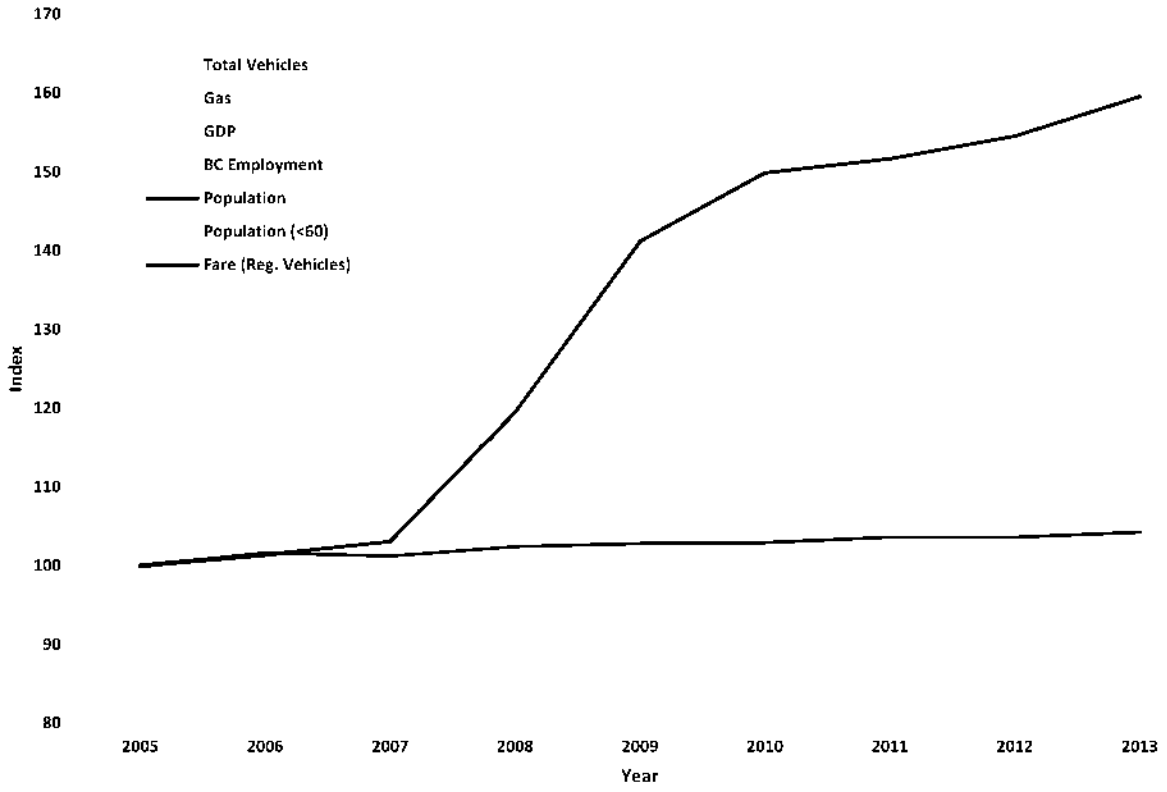
Figure 5-2 overlays average annual daily vehicle traffic with the variables described in Table 5-1. The variables were indexed to 100 to aid with the comparison. Some key findings are summarized below:

- Significant increase in fares and gas prices, to a lesser extent in 2008, coincide with a significant decline in traffic. This decline, however, might be related to the economic downturn (as shown by the GDP and employment lines).
- A second negative 'blip' in traffic is observed in 2011.
- The growth variables (population, employment, and GDP) and traffic move in opposite directions in general. This indicates that counterintuitive relationships will possibly be observed in the model development process.
- The younger population cohort (less than 60) has been steadily declining over the last 10 years. This population tends to make more trips (specially commuting trips) compared to the older age cohort.

FIGURE 5-2
Variable Indices



The population cohorts on the Gulf islands is of particular interest. Figure 5-3 compares the growth in population cohorts less than and greater than 60 years of age on the Gulf Islands over the last decade.

The figure shows a converging pattern with the less than 60 cohort declining from a peak of 9,800 in 2006 (or 66%) to 8,500 (or 55%) by 2014. What this indicates is that as the population on the island ages and with more people retiring on the island (as indicated by the overall increase in population) fewer younger people are moving to the Gulf Islands.

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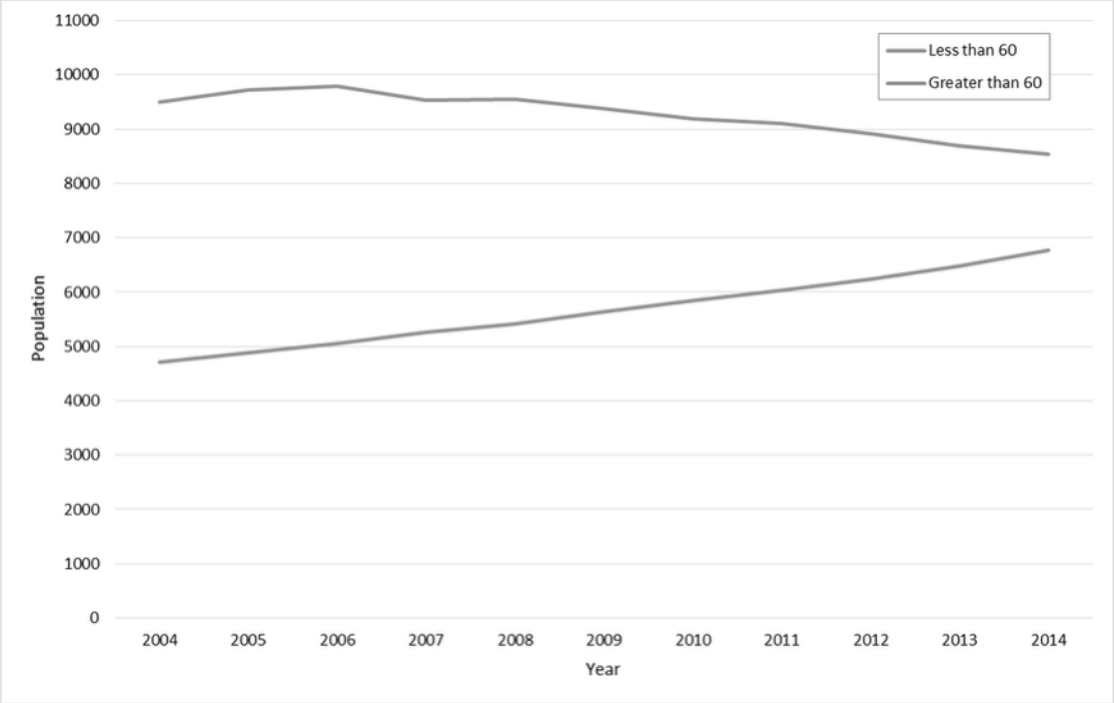
FIGURE 5-3
Population Cohorts



5.1.1 Background Growth Model Development

Several multiple linear regression model formulations were tested in the development process including segmentation for different user groups such as residents, non-residents and trucks. Initially, separate models for trucks and regular vehicles were tested given that the trends and drivers of these two vehicle types are usually distinct. However, given that trucks only make up 3% of total traffic it was decided to develop a single model for all vehicles with the trucks calculated as a percentage of the forecasts. A separate model for tourist travel was investigated looking at differences in seasonal patterns, however the analysis was inconclusive in terms of developing a separate forecasting model for the tourist sector. As such, the model was aggregated for the various user groups and then developed at the quarterly level. Table 5-2 summarizes the final model formulation and related key statistics.

TABLE 5-2
Econometric Model Coefficients and Statistics

Variable	Description	Coeff	t-stat	P-value
(Intercept)	–	0.10	0.04	0.97
Q1	Quarter 1 Dummy	-0.07	-5.61	0.0000
Q2	Quarter 2 Dummy	0.09	7.50	0.0000
Q3	Quarter 3 Dummy	0.15	13.17	0.0000
log(Popl60)	Natural logarithm of population<60	0.80	3.14	0.0036
log(CarFr)	Natural logarithm of Regular Vehicle Fare[4]	-0.19	-4.30	0.0001
Recession	Dummy Variable for Recession period	-0.04	-2.83	0.0080
Adj. Rsqd = 0.95				

[4] Regular Vehicle Fare was calculated by taking the sum of a regular vehicle and two foot passenger fares (assuming a vehicle occupancy of two persons).

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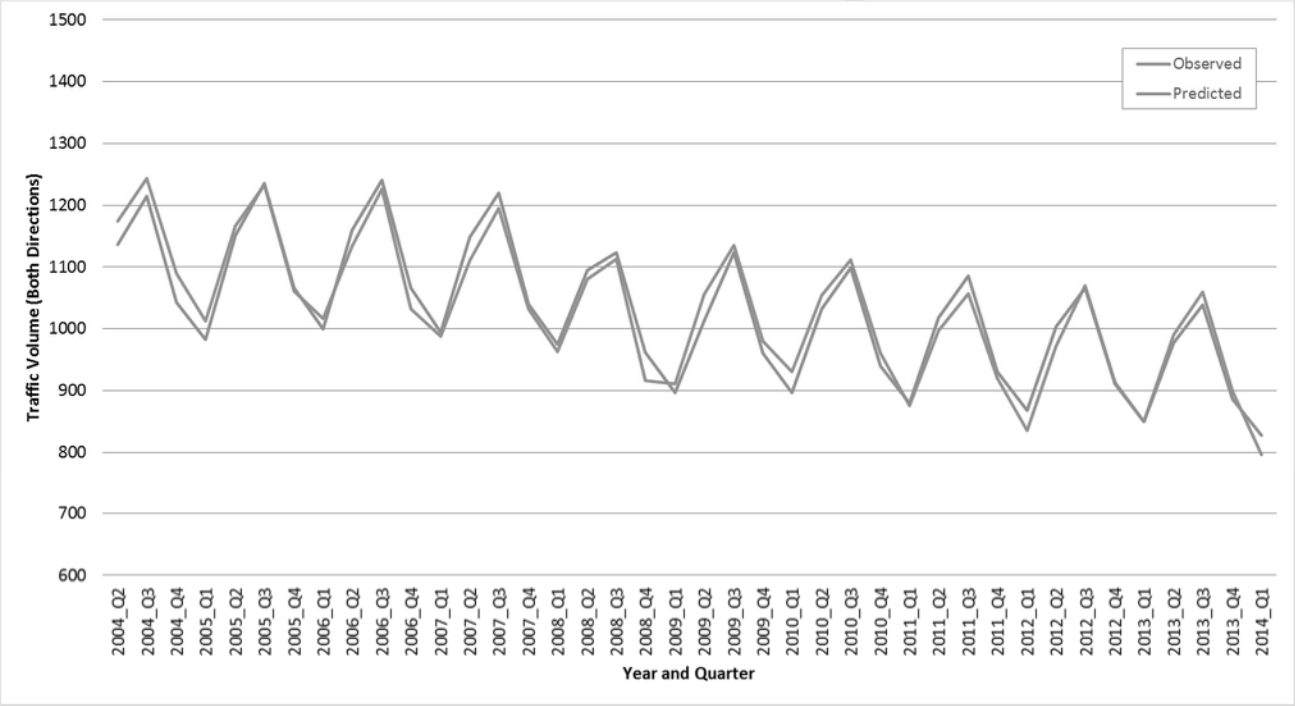
All variables exhibited the expected signs and very good t-stats[5]. GDP, employment, gas price and population were dropped from the model formulations as they either exhibited counter-intuitive relationships or were statistically insignificant. Overall, it was decided that using a simple model, with only one or two explanatory variables in addition to dummy variables is better given the limited number of sample data points (40 samples - every quarter for 10 years). The R-squared is relatively high (0.95) which indicates that the model is doing a very good job at replicating historic traffic data as shown in the model's back-cast (Figure 5-4).

FIGURE 5-4
Observed vs. Predicted Average Quarterly Daily Traffic



5.1.2 Background Growth Forecasts

In order to produce future traffic forecasts, forecasts of independent variables need to be developed or obtained. Given the model's formulation, forecasts for two variables needed to be sourced – fares and population cohort greater than 60 on the Gulf Islands. There were no readily available forecasts for these two variables. While Gulf Island population forecasts are available from StatsCan, the breakdown by population cohort is not. Thus it was decided to develop three forecast scenarios for these two variables – a low, medium (base case) and high scenarios. Table 5-3 summarizes the assumptions made in each scenario. Forecasts for the independent variables were sought till horizon year 2030.

TABLE 5-3
Scenario Assumptions

Scenario	Population less than 60	Fares
Low	Declines to 51% by 2018 and remains at that level till 2030	Increases by 2.2% annually until 2030 (in real terms)
Medium	Declines to 51% by 2018 and increases back to 2014 levels by 2030 (55%)	Increases by 2.2% annually until 2018 then increases by 1.6% annually until 2030 (in real terms)
High	Declines to 51% by 2018 and increases back to 2014 levels by 2030 (60%)	Increases by 2.2% annually until 2018 then increases by 1.1% annually until 2030 (in real terms)

[5] T-stats greater than 1.96 or less than -1.96 mean that the variable is statistically significant at the 95% confidence level.

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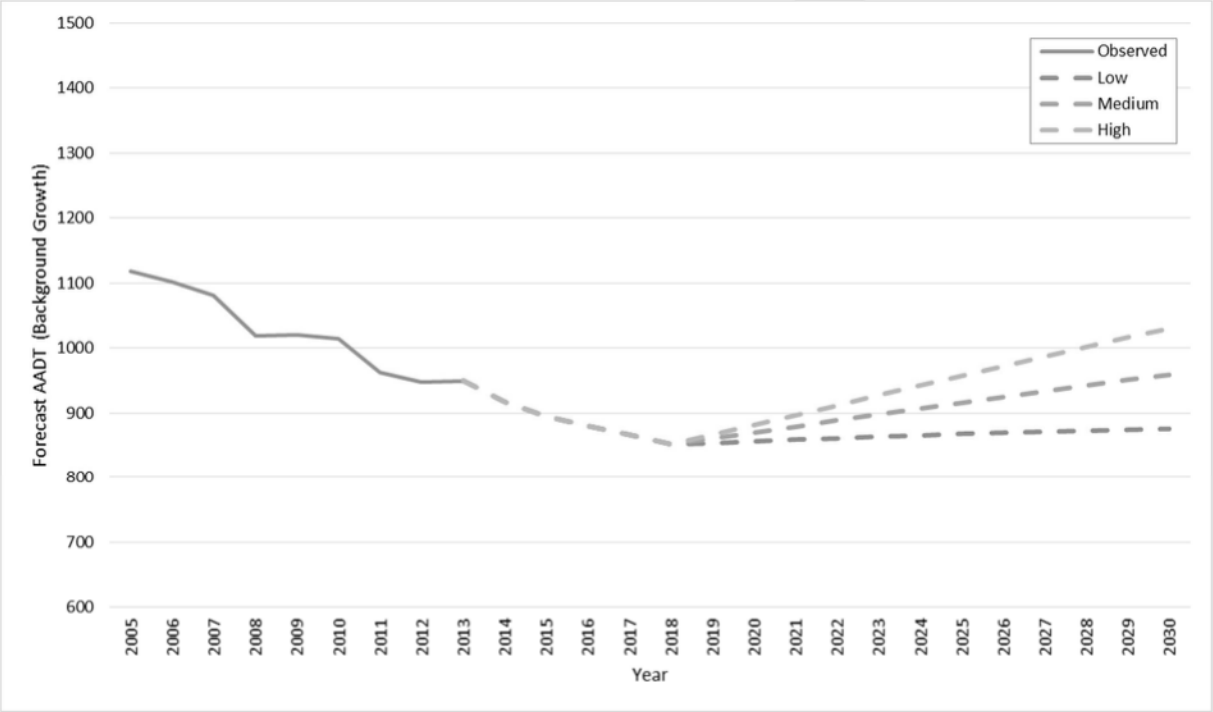
While these scenarios are hypothetical in nature, they are to a certain degree based on historic trends over the last 5 to 10 years and represent a reasonable range of future possibilities.

Figure 5-5 summarizes the forecast background traffic growth for each of the scenarios (AADT). As shown, the traffic is predicted to decline steadily 6 until 2018 and then traffic steadily rebounds after that. For the low, medium and high scenarios in 2030, the forecast annual AADT is 875, 960 and 1,030 vpd respectively. The medium scenario was adopted as a base case for background growth forecasts and the multiple account evaluation process. Table 5-4 shows the medium background forecasts till 2044, with 2030 to 2044 figures extrapolated based on average year to year absolute growths in the last 5 years.

FIGURE 5-5
Average Annual Background Traffic Growth Forecasts



6 As the forecasts use average figures (specifically for fare increases) the model will not show a step-wise trend as per the historic trends.

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TABLE 5-4
2015-2044 Background Traffic Growth Forecasts (vehicle per day)

Year	Forecast AADT (Base Case)
2015	900
2016	880
2017	870
2018	850
2019	860
2020	870
2021	880
2022	890
2023	900
2024	910
2025	920
2026	930
2027	930
2028	940
2029	950
2030	960
2031	970
2032	980
2033	990
2034	1,000
2035	1,010
2036	1,020
2037	1,030
2038	1,040
2039	1,050
2040	1,060
2041	1,070
2042	1,080
2043	1,090
2044	1,100

5.2 Induced Demand

With a more reliable fixed link connection, Gabriola residents and visitors will be more likely to travel to and from Vancouver Island. One of the key drivers of this induced demand is the reliability factor of using the ferry versus a fixed link. In order to calculate the additional trips that would use the link, an elasticity calculation based on the difference in generalized cost between the ferry option and bridge option was undertaken. The following describes the methodology and key assumptions in calculating induced demand.

5.2.1 Reliability Factor

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Quinsam vessel that provides ferry service between Nanaimo Harbour and Gabriola Island has a vehicle capacity of approximately 70 depending on the proportion of large vehicles. s.17

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s.17 In total, approximately 1.7% of all vehicles using this connection have had to wait one or two sailings to board the vessel.

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5.2.2 Value of Travel Time

One of the key inputs into the elasticity-based calculation of induced demand is the value of travel time. Income data from StatsCan for the Nanaimo and Vancouver area was used to estimate the value of travel time. Table 5-6 provides a summary of the average and median incomes in the Nanaimo region over the past five years. Note that average income has historically been higher than median income illustrating that incomes are skewed to the high side.

TABLE 5-6

Nanaimo Average and Median Income

Year	Average Income	Median Income
2008	$37,430	$28,410
2009	$37,300	$28,070
2010	$38,000	$28,530
2011	$38,800	$29260
2012	$40,250	$30,300

Much research and review has been conducted on the value of travel time for the purposes of demand modelling and project evaluation. "A review for the Government of British Columbia recommended 50 percent of the average wage as a base for value of travel time savings for the evaluation of highway projects, and with an upward adjustment for the VTTS during congested conditions."[7]

Using the above income information, and assuming that people typically work 250 days out of the year for an average of 8 hours per day, yields an average value of travel time of $10/hr.

[7] "The Value of Time Savings for the Economic Evaluation of Highway Projects in British Columbia," (W.G. Waters II) Research Report for Planning Services Branch, B.C. Ministry of Transportation and Highways, UBC Centre for Transportation Studies, March 1992, 160 pp.; published in The Value of Travel Time in British Columbia: a Compendium of Reports (Victoria: Ministry of Transportation and Highways, Planning Services Branch) 1994.

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5.2.3 Vehicle Operating Costs

The Canadian Automobile Association (CAA) publishes the cost of driving brochure[8] on a regular basis which provides useful information to estimate vehicle operating costs on a per kilometre basis. Table 5-7 provides a summary of the assumptions used to derive the average cost of operating a vehicle on a per kilometre basis. The key components of vehicle operating costs are fuel, tires and maintenance with all other costs including insurance, depreciation and financing assumed to be sunk costs. The average vehicle operating cost is 17¢/km for this analysis.

TABLE 5-7
Vehicle Operating Cost Assumptions (¢/km)

Vehicle Type	Fuel	Maintenance	Tires	Total
Sport Utility Vehicle	13.1	2.55	2.53	18.18
Full Size	12.2	2.18	1.84	16.22
			Average	**17.2**

5.2.4 Travel Generalized Costs

This section describes the assumptions used to estimate the generalized costs of travel to compare the ferry option versus the fixed link option. An average trip for the two options is assumed between Gabriola Island and the general Nanaimo area. A trip end within the 'general Nanaimo' area was assumed to be located between downtown Nanaimo, the hospital and the Vancouver Island University. This trip end is the centroid of multiple trip ends as reported in the Nanaimo Household Travel Survey and is assumed to represent an average trip. Typical trip distribution patterns from the 2012 Nanaimo Household Travel Survey for trips to and from the Cedar area were used as a proxy for likely distribution patterns of trips to and from Gabriola Island. Table 5-8 provides a summary of the travel time, distance and cost assumptions used to compare an average trip from the greater Nanaimo area to Gabriola Island. This information is then used to calculate the generalized costs of travel for the ferry option and fixed link option as summarized in

TABLE 5-9
. Note that cost items are converted to generalized costs using the value of time and expressed in equivalent minutes.

In total, the fixed link option is approximately 12% cheaper in terms of generalized cost compared to the ferry option.

TABLE 5-8
Key Assumptions for Calculating Induced Demand

Variable	Ferry Option		Fixed Link Option	
Travel from Nanaimo	1.9 km	4.0 min	14.2 km	14.0 min
Crossing Time	6.9 km	20.0 min	5.0 km	6.0 min
Travel on Gabriola	6.1 km	8.4 min	7.6 km	10.9 min
Ferry Headway	–	70 min	–	–
Reliability Factor	0.02		–	
Fare/Toll	$11.25		$11.25	
Value of Time	$10/hr		$10/hr	

[8] Canadian Automobile Association, Driving Costs, 2013 Edition

http://www.caa.ca/wp-content/uploads/2012/06/CAA_Driving_Cost_English_2013_web.pdf

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Vehicle Operating Cost	17¢/km	17¢/km

TABLE 5-9
Generalized Costs of Ferry Option vs. Fixed Link Option (minutes)

Travel Component	Ferry Option (min)	Fixed Link Option (min)
Travel from Nanaimo	4	14
Wait Time	19	-
Crossing Time	20	6
Travel on Gabriola	8	11
Fare/Toll	34	34
Vehicle Operating Cost	4	14
Total	**89**	**78**

5.2.5 Demand Elasticity Calculations

Information from the sub sections above was combined to calculate induced demand based on an assumed elasticity. Literature review and information from previous studies was used to develop a range of travel time elasticities[9] which are summarized as follows:

- Low Elasticity -0.50
- Moderate Elasticity -0.75
- High Elasticity -1.0

Since the fare/assumed toll was the same for both options, this was excluded from the elasticity calculations. As such, the percentage change in the generalized cost of travel was -19.5% (approximately 55 versus 45 minutes) when comparing the ferry option to the fixed link option. This percentage change in travel cost was multiplied by the range of elasticities to produce a range of possible traffic volume outcomes. Table 5-10 and Figure 5-6 provides a summary of the traffic outputs from the elasticity calculations.

TABLE 5-10
Elasticity-Based Forecast of Induced Traffic Demand (Vehicles per Day)

2030 Forecast	Base AADT	Low Elasticity	Moderate Elasticity	High Elasticity	
Low	875	85	130	170	Increment-al Traffic
Moderate	960	95	140	190	
High	1,030	100	150	200	
Low		960	1,005	1,045	Total Traff ic

[9] "Understanding Transport Demands and Elasticities, How Prices and Other Factors Affect Travel Behavior" (Todd Litman) Victoria Transport Policy Institute, September 2012, pp. 46

http://www.vtpi.org/elasticities.pdf

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Moderate	1,055	1,100	1,145	
High	1,130	1,180	1,230	

FIGURE 5-6
2030 Forecast AADT (Background + Induced)

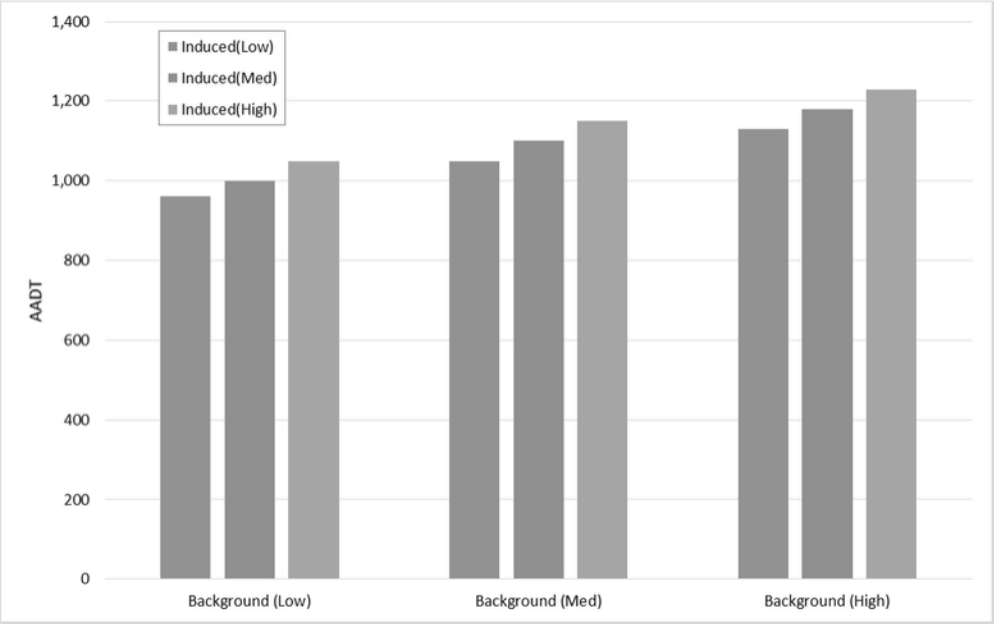

Table 5-11 shows the 2020-2044 base case forecasts including medium-level induced demand assumptions.

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TABLE 5-11
2015-2044 Forecast AADT Growth (Background+Induced) assuming 2020 Fixed Link Opening

Year	Forecast AADT (Base Case+Med Induced Demand)
2020	s.13,s.17
2021	
2022	
2023	
2024	
2025	
2026	
2027	
2028	
2029	
2030	
2031	
2032	
2033	
2034	
2035	
2036	
2037	
2038	
2039	
2040	
2041	
2042	
2043	
2044	

5.2.6 Forecast Traffic and Implications for Roadway/Bridge Design

Based on these calculations, the total forecast traffic for 2030, including growth and induced demand, ranges from a low forecast of 960 to a high forecast of 1,230 vehicles per day (vpd). The extrapolated forecast for 2044 is 1,240 vpd. **These are at a level where a two-lane bridge would provide more than sufficient capacity for the short and even long term horizons**.

In terms of roadway connections to South Road on Gabriola Island, a new fixed-link crossing can be accommodated with a stop controlled intersection. Forecast turn volumes were input into a Synchro microsimulation model and used to determine the intersection operational performance. The turn volumes for AM and PM peak hours are shown in Figure 5-7, and the subsequent table summarizes the outputs from the traffic operational analysis illustrating the turn volumes, delay and resulting levels of service. Without traffic counts on Gabriola Island, assumed volumes of 50 eastbound and westbound through vehicles per hour were used in the analysis. A stop controlled intersection would operate at a level of service A, the highest level of service, indicating no delay or capacity constraints are anticipated. Only when eastbound and westbound through volumes reach about 225 vehicles per hour in both directions, does the level of service reach B, demonstrating that there is substantial capacity for traffic growth. An alternate approach from a roadway design perspective would be to consider a roundabout at this intersection which would further reduce vehicle stopping and any delays.

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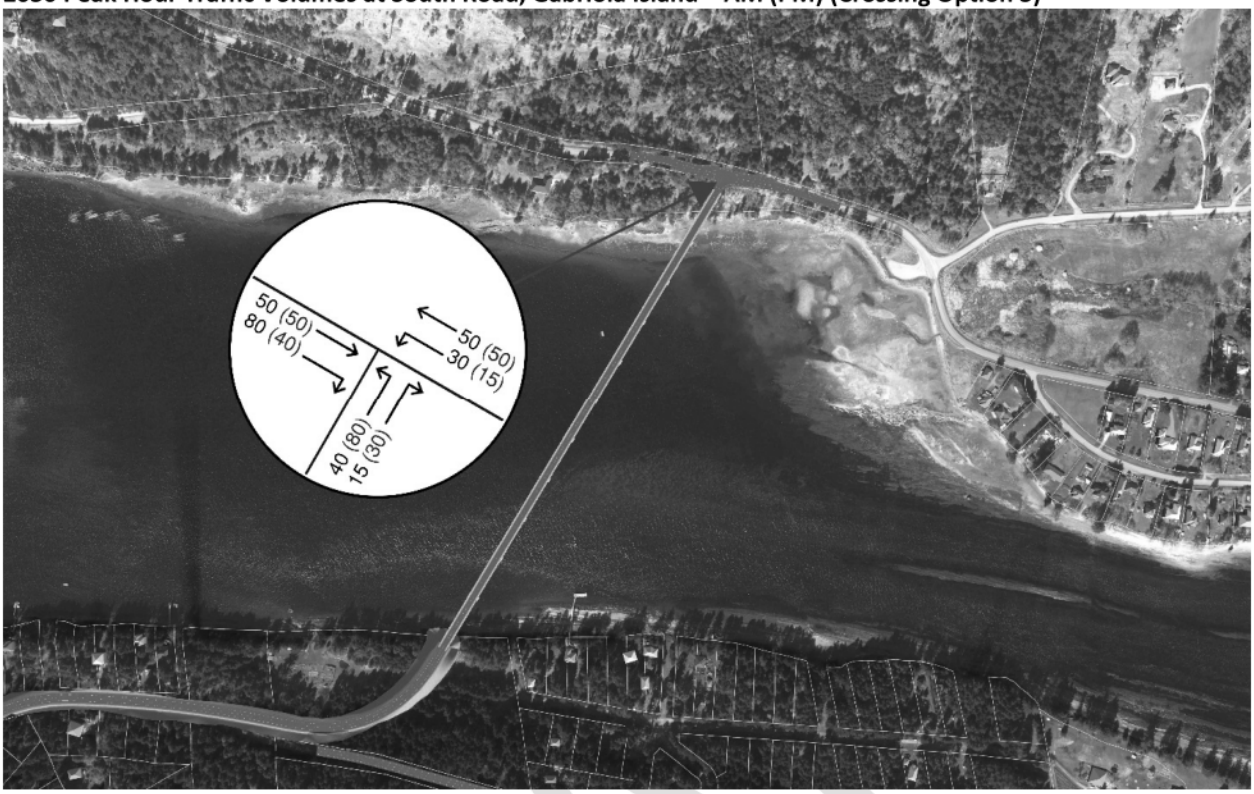
FIGURE 5-7
2030 Peak Hour Traffic Volumes at South Road, Gabriola Island – AM (PM) (Crossing Option 3)



HCM 2000 SIGNING SETTINGS	EBT	EBR	WBL	WBT	NEL	NBR
Lanes and Sharing (#RL)						
Traffic Volume (vph)	50	40	15	50	80	30
Sign Control	Stop	—	—	Stop	Stop	—
Median Width (m)	3.7	—	—	3.7	3.7	—
TWLTL Median	☐		—	☐	☐	—
Right Turn Channelized	—	None	—	None	—	None
Critical Gap, tC (s)	—	—	—	—	—	—
Follow Up Time, tF (s)	—	—	—	—	—	—
Volume to Capacity Ratio	0.11	0.11	0.09	0.09	0.14	0.14
Control Delay (s)	7.5	7.5	7.8	7.8	8.0	8.0
Level of Service	A	A	A	A	A	A
Queue Length 95th (m)	—	—	—	—	—	—
Approach Delay (s)	7.5	—	—	7.8	8.0	—
Approach LOS	A	—	—	A	A	—

On the Vancouver Island side of the fixed link, similar traffic operational performance is expected, however the presence of existing background local traffic is recognized. However, given the low volumes of fixed link traffic, operational performance is likely to be marginally reduced at the intersections primarily along Holden Corso Road, and approaching Duke Point Highway. There is also little existing background traffic on Phoenix Way.

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6. Option Development & Preliminary Screening

6.1 Design Basis / Design Criteria

6.1.1 Road Design Criteria

The road for the Gabriola Island Fixed Link will generally be a rural road supporting a projected traffic volume of approximately 1,300 vehicles per day (2044 projection). The proposed roadway traverse the jurisdictions of the Regional District of Nanaimo (RDN), the City of Nanaimo (the City), and the Islands Trust. BC MoTI retains the responsibility for the management and maintenance of all roads within the RDN and the Islands Trust. The City is responsible for all roads within its boundaries.

Based on the projected low traffic volumes a two-lane roadway will provide a high level of service (B or better). It is anticipated that this roadway will also be utilized by cyclists for commuting and recreational purposes, as well as pedestrians.

The assumed design criteria for the fixed link is based on the BC MoTI standard for a Rural Collector (BC Supplement to TAC Geometric Design Guide, 2007 – Figure 440.B), summarized in Table 6-1. The City has a similar standard for a Rural Local road (City of Nanaimo Engineering Standards & Specifications, 2013 – Drawing R7-XS5). Both standards include 3.6 metre travel lanes and 1.5 metre shoulders. The key difference is that the City's standard includes a 1.65 metre gravel shoulder.

TABLE 6-1
Proposed Design Criteria

Design Elements	Proposed Design Values	Comments/Notes
Functional Classification	RCU	Rural Collector Undivided, Figure 440.B
Design Speed (km/h)	60	
Posted Speed (km/h)	50	
Minimum Horizontal Curve Radius (m)	130	
Minimum Stopping Sight Distance (m) Sag	85	TAC Table 2.1.3.4
Minimum Stopping Sight Distance (m) Crest	85	BC Supplement Table 330.F
Minimum "K" Factor, Sag V.C.	18	TAC Table 2.1.3.4
Minimum "K" Factor, Crest V.C.	13	BC Supplement Table 330.F
Maximum Superelevation (%)	6	
Maximum Gradient (%)	6	
Lane Width(s) (m)	3.6	
Median Width(s) (m)	N/A	
Paved Shoulder Width (m)	1.5	
Clear Zone Width (m)	9.0	
Design Vehicle	WB20	
Drainage	Open ditch	

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6.1.2 Navigational Clearances

When considering replacement of an existing structure or construction of a new structure over a channel where other structures already exist, the required navigational clearance is typically limited to existing clearances. Consideration may be given to increasing clearances where warranted due to changes in prevailing vessel sizes.

For new crossings of waterways, a study of prevailing vessel traffic and potential future vessel traffic is required. This requires stakeholder engagement in order to collect data for potential vessel dimensions (draft, width, air draft). This data combined with potential future development options would serve as a basis for a submittal to Transport Canada for review and approval. Transport Canada is concerned with safety, maintenance of navigation, and limiting constraints on waterways in order to maximize all current and future potential economic development.

A comprehensive study would be done prior to detailed engineering, most likely during preliminary engineering when short-listed options are developed and evaluated. This will not be done for the purposes of the fixed link planning study. Instead, the Council of Marine Carriers, whose mandate is to further the interests and conserve the rights of its member tug and barge operators, confirmed that log towing and barge towing operations occur in both Dodd and False Narrows. The Council recommended a **minimum 23 metre vertical clearance at High High Water** to accommodate most ramp barges, spud barges and loaded chip barges.

It is assumed that there will be no piers in the water at Dodd Narrows, but there may be piers at False Narrows. The Council clarified that log tows in False Narrows are usually about four sections wide, and can transit through at high water. **A clear width in False Narrows would need to be a minimum of 500 feet (152 metres) wide**.

Given the location of the bridge crossings, there appears to be little potential for future industrial development in this area. Northumberland Channel can be accessed north of Gabriola Island and Stuart Channel and Pylades Channel can be accessed from the south.

6.2 Base Case

The Base Case consists of the existing ferry service, current as of the most recent service modifications made by BC Ferries in September 2014. The comparison (ferry versus fixed link) assumes that service levels are stabilized and no significant modifications are made henceforth.

6.3 Road Network Options

Options generated for the Gabriola Island fixed link involved developing different road alignments and bridge crossings for evaluation. The various options considered are shown in Figure 6-1. All road alignments provide a connection between Highway 19 on Vancouver Island and South Road on Gabriola Island. The proposed road alignments make use of some existing roads on Vancouver Island, Mudge Island and Gabriola Island, but also require the construction of new roadways.

Plan and profile drawings of all the options are provided in Appendix A.

Achieving the recommend design criteria will require upgrading some of the existing roadways. Alternatively, upgrades of the existing roadways can be deferred to a later date, but this may impact roadway operations, mobility and safety for users, particularly for cyclists given the limited existing paved shoulder widths.

Each option considered is described in the subsequent sections.

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FIGURE 6-1
Schematic of Road and Bridge Options

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6.3.1 Road Option A

The alignment for Option A is an extension of Phoenix Way from Maughan Road to Dodd Narrows. Drivers traveling to Gabriola Island would exit Hwy 19 onto Maughan Road, travel north on Maughan Road and turn right (east) onto Phoenix Way to access Gabriola Island. Drivers traveling from Gabriola would turn left from Phoenix Way onto Maughan Road, travel south, turn right onto the Maughan Road Bridge, then turn left onto Gordon Road and travel south to access Highway 19.

The horizontal alignment and vertical profile of Phoenix Way satisfies the design criteria, but sections will have to be upgraded with paved shoulders and proper drainage.

Two existing intersections along Phoenix Way will have to be upgraded, namely Maughan Road and the eastern access to the Harmac site. In addition, the existing bridge on Phoenix Way appears to be too narrow to provide adequate width for pedestrians and cyclists.

The alignment of Road Option A intersects with the existing Cable Bay Trail. The roadway will cross over the trail and adjacent creek. A bridge or large multiplate culvert structure is likely required to span over the trail and provide adequate clearance underneath.

All roadworks for Option A are within the City of Nanaimo's boundaries.

6.3.2 Road Option B

Option B uses the existing local road system to develop the new alignment between Highway 19 and Dodd Narrows. Drivers traveling to Gabriola Island would exit Hwy 19 onto Maughan Road, travel north on Maughan Road and turn left (west) across the Maughan Road Bridge. They would then turn left onto Gordon Road and travel south to MacMillan Road and continue south on MacMillan Road, across the MacMillan Road Bridge to the MacMillan Road/Holden Corso Road Intersection. Drivers would turn left onto Holden Corso Road and travel east to Barnes Road, turn left onto Barnes Road and travel in a easterly direction to Nicola Road, turn left onto Nicola Road and travel north to connect to the new road section connecting to Gabriola. Drivers traveling from Gabriola would generally travel in a reverse order.

To reduce the travel distance in Option B a new on-ramp and off-ramp could be constructed in the vicinity of MacMillan Road. This would provide direct access to and from MacMillan Road to Highway 19 and eliminate the travel distance to Maughan Road. This new interchange has not been included as a required network upgrade, recognizing the generally low traffic volumes in the area.

Holden Corso Road, Barnes Road and Nicola Road do not meet the recommended design criteria as there is no paved shoulder nor proper drainage. In addition, Barnes Road has a substandard horizontal and vertical alignment. There are also up to eight intersections that will require upgrading.

The roadworks for Option B are largely within the RDN except for the northern section which is within the City's boundaries.

6.3.3 Mudge Island Section

Fixed link options that have a connection between Dodd Narrows and the crossing to Gabriola Island will require the reconstruction of the roads on Mudge Island. The proposed alignment on Mudge Island uses some of the existing roads including Ling Cod Lane, Coho Boulevard, Weather Way and View Ridge Road. These existing roads are low volume, gravel roads that will require extensive upgrading to meet the design criteria for horizontal and vertical alignment as well as road width. Two new road sections would also have to be constructed to access the proposed bridge crossing locations, Crossing Option 3 and Crossing Option 4. To access Crossing Option 3, a new road would have to be constructed to connect Coho Boulevard and Weather Way. To access Crossing Option 4 an additional new road would have to be constructed between the east end of Weather Way and the easterly section of Coho Boulevard. The upgrading of the existing roads and new road construction will have significant impact on a number of private properties on Mudge Island.

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6.3.4 Gabriola Island Section

It is proposed that all bridge crossings from Vancouver Island and Mudge Island connect to South Road on Gabriola Island. The roadworks on Gabriola Island will be limited to an intersection providing access to the bridge. This will minimize the necessary upgrading required on South Road to meet the recommended design criteria.

6.4 Dodd Narrows Options

6.4.1 Dodd Narrows Crossing Option 1

A bridge at Dodd Narrows provides the shortest crossing between Vancouver Island and Mudge Island. Dodd Narrows Option 1, is the shortest potential crossing with a 210 metres long bridge. However, at this location the bridge and road would have a significant impact on Joan Point Park.

A haunched concrete box girder bridge is assumed. This segmentally constructed bridge would likely be erected via the balanced cantilever method. The deeper girder section at the pier supports tapers to a shallower section near midspan, providing sufficient room to accommodate the required 23 metre navigational clearance. A main span of 160 to 180 metres can be achieved economically. Further study is required to determine how closely piers could be located to the edge of the channel.

The profile for Option 1 (refer **Appendix A**) shows a significant fill at the west abutment on Vancouver Island, up to 20 metres in height. Building a fill of this height could be very challenging and could require large MES retaining walls. Another option would be to increase the length of the bridge. **Considering the added costs and coincident impacts to Joan Point Park, Option 1 is rejected.**

6.4.2 Dodd Narrows Crossing Option 2

To avoid direct impacts to Joan Point Park an alternative alignment was developed crossing Dodd Narrows roughly parallel to the existing BC Hydro right-of-way. This crossing, Dodd Narrows Option 2 requires a bridge of approximately 260 metres. A similar structure to that described for Dodd Narrows Option 1 is probable.

Dodd Narrows Crossing Option 2 appears feasible from a structural engineering and constructability perspective.

6.5 Main Channel Crossing Options

Four different bridge crossing locations to Gabriola Island were developed:

- Crossing Option 1 crosses directly from Vancouver Island to Gabriola Island across Northumberland Channel, avoiding impacts on Mudge Island.
- Crossing Option 2, Crossing Option 3, and Crossing Option 4 are options that cross False Narrows between Mudge Island and Gabriola Island. To achieve these crossings an additional bridge is required at Dodd Narrows between Vancouver Island and Mudge Island as described in Section 6.4.

Each crossing option is described in more detail below.

6.5.1 Crossing Option 1

Crossing Option 1 connects Vancouver Island with Gabriola Island across Northumberland Channel. Crossing Option 1 will require a bridge of over 1,500 metres long on a gradient of 2.7%. The bridge landing area on Gabriola is on a steep hillside and founding the abutment at this location could be challenging. The bridge height exceeds the required 23 metre navigational clearance, and would be in the order of 80 m above the sea level. As a point of reference, the Alex Fraser and Lions Gate Bridges in the Lower Mainland of BC have clearances of about 50 m above water level.

It is assumed that a cable-supported bridge (cable-stayed or suspension) would span across Northumberland Channel. The bridge would have a main span of 800 metres and backspans of approximately 350 metres,

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requiring that the two piers be founded on deepwater foundations. Water depths at the assumed piers locations are estimated to be approximately 20 to 30 metres. A clear span of Northumberland Channel, i.e. with bridge piers on shore, would require extensive approach spans on both Nanaimo and Gabriola sides, and would preclude tying into South Road.

A cable-supported bridge is preferred over a multi-span viaduct with spans on the order of 100 metres due to seismic risk exposure and extent/complexity of underwater construction. The water depths in the centre of the channel range from 40 to 60 metres.

Due to the excessive bridge span, an elevation of 80 m on Gabriola Island, and impacts to Joan Point Park, this option is rejected.

6.5.2 Crossing Option 2

Crossing Option 2 is the longest crossing from Mudge Island to Gabriola Island and limits impacts on Mudge Island. Crossing Option2 requires bridge approximately 840 metres in total length, at a steep 5.6% grade. The bridge landing area on Gabriola is on a steep hillside and founding the abutment at this location could be challenging.

Alternative alignments were explored to reduce the long 5.6% grade; however, these were not pursued in detail since they incurred significantly greater property impacts on Mudge Island.

A cable-stayed bridge with a main span of 700 metres and backspans of approximately 250 metres is assumed for estimating purposes. It is expected that the north pier would be founded on a deepwater foundation, but the south pier would be built on shore.

As with Crossing Option 2, due to the excessive bridge span, an elevation of 70 m on Gabriola Island, and impacts to Joan Point Park, this option is rejected.

6.5.3 Crossing Option 3

Crossings Option 3 is a connection between Weather Way and South Road. Crossing Option 3 is a proposed 800 metre long box girder viaduct, with a balanced cantilever main span to accommodate the 23 m high and 152 m wide navigation envelope. Approach gradients on either side of the main span are approximately 4.4%. The bridge landing would be in the vicinity of the South Road and Ferne Road intersection on Gabriola Island. The approach viaducts are envisioned as a series of balanced cantilever bridges utilizing an in-situ method of construction with a relatively small scale plant and site set-up.

In the event that navigation routes can be redirect to Dodd Narrows, a lower profile viaduct structure could be constructed. With a straight plan alignment and continuous gradient, the viaduct would be suitable for a push launch from the Gabriola Island side, with spans on the order of 40 to 70 m. Span length would depend on whether temporary falsework were erected between the permanent piers, which would be assessed against geotechnical conditions in False Narrows.

Crossing Option 3 appears feasible from a structural engineering and constructability perspective.

6.5.4 Crossing Option 4

Crossing Option 4 is a connection between Coho Boulevard and South Road. Crossing Option 4 is a proposed 480 metre long box girder viaduct. It is not feasible to accommodate the 23 m high and 152 m wide navigation envelope. Given the comparatively short length of the viaduct, and low elevation on either side of False Narrows, to achieve that clearance would require approach gradients in excess of 10%.

Instead, a low profile viaduct erected using a push launch construction method could be achieved economically, with the bridge landing in the vicinity of the South Road and Stokes Road Intersection on Gabriola Island.

Considering that this option cannot achieve the required navigational clearance, it is rejected.

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6.6 Additional Screening of Options

To further assess the technical feasibility of the crossing options, additional screenings were done including:

- Archaeological
- Geotechnical Engineering
- Environmental, including a review of the marine construction window

6.6.1 Archaeological

A desktop assessment of the Gabriola Island fixed link options shown in Figure 6-2 was conducted using a variety of mapping and database tools, including the BC MFLNRO Archaeology Branch Remote Access to Archaeological Data (RAAD) website, available satellite imagery and the mapping depicting the bridges and access segments. From RAAD, the relationship of the bridge options relative to the locations of previously recorded archaeological sites was determined. It is worth noting that the absence of known sites in a particular location does not equate to an absence of archaeological potential; rather, the localized nature of past Archaeological Impact Assessment (AIA) work means that certain areas may not yet have been assessed for archaeological sites. In fact, the extensive nature of coastal shell midden sites with associated First Nations burials would imply that all coastal and inland zones in the possible development area must be considered to be of high archaeological potential and of cultural importance to First Nations. The results of this assessment are presented by component under separate subheadings below.

In addition, articles concerning diachronic changes in relative sea-levels (RSL) for eastern Vancouver Island were consulted in order to understand the potential patterns of archaeological site distribution at various points in time, and the visibility of those archaeological sites relative to modern sea-levels. According to assessments of changes in RSL by Shugar et al. (2014), James et al. (2009) and James et al. (2002), along the eastern and southern coasts of Vancouver Island since the Last Glacial Maximum (circa 14,000 Before Present [BP]), RSL in the vicinity of Nanaimo and Gabriola Island fell as much as 150 m to modern sea-levels between 14,000 BP and 13,000 BP. Post-glacial RSL continued to fall below modern sea-level after 13,000 BP to approximately 20-25 m below the present RSL and did not rise again to modern sea-level until approximately 9000 BP. What this means for any of the fixed link options with an element of intertidal or submarine ground disturbance is that any intertidal or submarine ground surface down to an approximate depth of 25 m below current sea-level may potentially contain archaeological deposits, possibly deeply buried under subsequent deposits of marine sediments. Both Dodd Narrows and False Narrows were likely low-lying isthmuses linking Vancouver Island to Gabriola Island in a single, contiguous landmass at that time (Earle 2002). From an archaeological standpoint, areas of steeper coastal shelf bathymetry are less likely to have archaeological sites, and are therefore preferable for development over areas of gradually sloping and shallow coastal bathymetry. Conversely, the archaeological record of early Holocene human inhabitation of Vancouver Island may exist in locations associated with elevated palaeoshorelines, well above modern sea-level.

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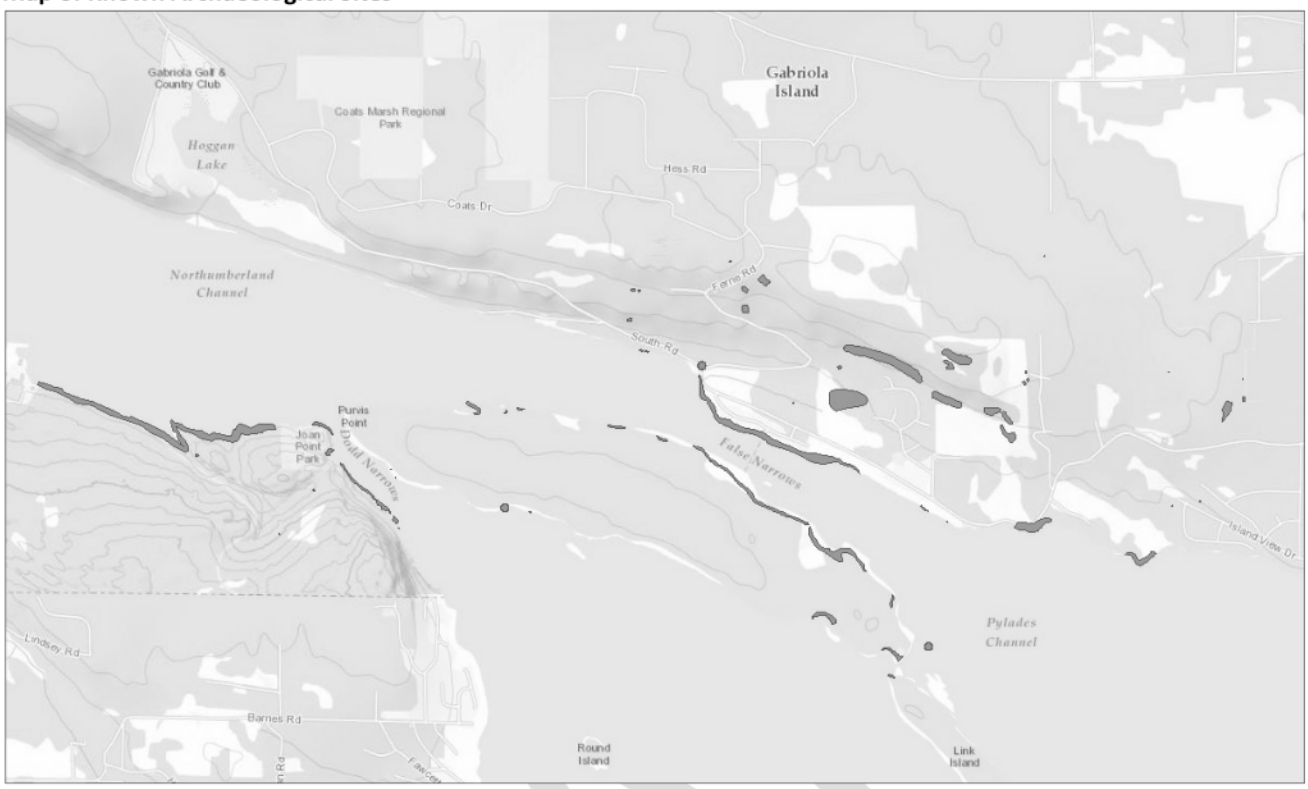
FIGURE 6-2
Map of Known Archaeological Sites



6.6.1.1 Dodd Narrows Crossing Options

The bridge crossing Dodd Narrows to Mudge Island from Vancouver Island will potentially impact previously recorded archaeological sites DgRw-172 and DgRw-44. DgRw-172 is a precontact, subsurface shell midden site with some previous erosion due to a hiking and cycling path. DgRw-44 is a precontact, subsurface shell midden and lithic artifact site. There is a strong possibility that DgRw-44 and DgRw-172 are contiguous with other midden sites such as DgRw-171 and DgRw-174 to the south and DgRw-46 to the west. There is a high potential that ground disturbance of shell midden features will uncover human burials.

Any submarine or intertidal zone ground disturbance within Dodd Narrows may potentially impact underwater or intertidal archaeological sites.

6.6.1.2 Crossing Option 1

The southern end of Crossing Option 1 from Vancouver Island to Gabriola Island will potentially impact previously recorded archaeological site DgRw-44 and possibly DgRw-46, as well. DgRw-44 is a precontact, subsurface shell midden and lithic artifact site (see also Dodd Narrows Crossing Options). DgRw-46 is a multi-component, precontact archaeological site comprised of an extensive shoreline shell midden, both surface and subsurface lithic artifacts, a rock shelter habitation feature containing scattered human remains, surface faunal remains and subsurface fire-altered rock. There is a high potential that ground disturbance of shell midden features will uncover additional human burials.

Though there are no previously recorded archaeological sites where this crossing option intersects the shoreline of Gabriola Island at South Road, this is likely due to a lack of AIA fieldwork in the area and the potential for unrecorded shell midden and burial sites at this location must be considered high.

Any submarine or intertidal zone ground disturbance within the Northumberland Channel may potentially impact underwater or intertidal archaeological sites.

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6.6.1.3 Crossing Option 2

There are no previously recorded archaeological sites at either the northern or southern end of this bridge option from Mudge Island to Gabriola Island. The nearest previously recorded archaeological site is DgRw-27, a precontact, subsurface shell midden site located approximately 150 m to the east.

Though there are no previously recorded archaeological sites where this option intersects the shorelines of Mudge Island or Gabriola Island, this is likely due to a lack of AIA fieldwork in the area and the potential for unrecorded shell midden and burial sites at both locations must be considered high.

Any submarine or intertidal zone ground disturbance within the Northumberland Channel may potentially impact underwater or intertidal archaeological sites.

6.6.1.4 Crossing Option 3

The southern end of this bridge option from Mudge Island to Gabriola Island will potentially impact previously recorded archaeological site DgRw-26, dependent upon the results of an AIA for the bridge option in order to determine the precise boundaries of the site. DgRw-26 is a precontact, subsurface shell midden and surface-collected lithic artifacts site that exhibits a degree of prior machine disturbance.

The northern end of the bridge will potentially impact previously recorded archaeological site DgRw-227, a precontact, subsurface shell midden site with some evidence for fire-altered rock. There is a high potential that ground disturbance of shell midden features will uncover additional human burials.

Any submarine or intertidal zone ground disturbance within the Northumberland Channel or False Narrows may potentially impact underwater or intertidal archaeological sites.

6.6.1.5 Crossing Option 4

The southern end of this bridge option from Mudge Island to Gabriola Island will potentially impact two previously recorded archaeological sites, including DgRw-19 and DgRw-24. DgRw-19 is a precontact, subsurface shell midden site with surface-collected lithic and faunal artifacts. DgRw-24 is a multi-component archaeological site consisting of a precontact, subsurface shell midden feature, surface-collected artifacts and a significant rock art site with two illustrated panels.

The northern end of the bridge from Mudge Island to Gabriola Island will potentially impact previously recorded archaeological site DgRw-4, an extensive precontact, subsurface shell midden, lithic and faunal artifact site, and human burial ground which extends along the southern shoreline of Gabriola Island for the entire length of False Narrows. Further documented precontact burial grounds are located further inland from DgRw-4, on the north side of South Road, including DgRw-209 and DgRw-210. There is a high potential that ground disturbance of shell midden features will uncover additional human burials.

Any submarine or intertidal zone ground disturbance within False Narrows may potentially impact submerged or intertidal archaeological sites. The archaeological potential for submerged sites below modern sea-level within False Narrows must be considered high.

6.6.1.6 Road Option A (Phoenix Way)

Ground disturbance activities associated with Road Option A, extending Phoenix Way to Dodd Narrows, may potentially impact previously recorded archaeological site DgRw-46, where part of the site extends southward along either side of an unnamed watercourse. DgRw-46 is a multi-component, precontact archaeological site comprised of an extensive shoreline shell midden, both surface and subsurface lithic artifacts, a rock shelter habitation feature containing scattered human remains, surface faunal remains and subsurface fire-altered rock (see also Crossing Option 1). Near the Dodd Narrows bridge crossings to Mudge Island, this road alignment may potentially impact previously recorded archaeological site DgRw-172 (previously described in the Dodd Narrows Crossing Options).

There is high archaeological potential for encountering unrecorded inland settlement sites and shell middens (some in association with elevated palaeoshorelines) all along this alignment.

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6.6.1.7 Road Option B (Extension of Nicola Road)

Ground disturbance activities associated with Road Option B may potentially impact previously recorded archaeological site DgRw-238, a precontact, subsurface shell midden site that has been disturbed by previous road development. Near the Dodd Narrows bridge crossings to Mudge Island, the alignment may potentially impact previously recorded archaeological site DgRw-172 (previously described in the Dodd Narrows Crossing Options).

There is high archaeological potential for encountering unrecorded inland settlement sites and shell middens (some in association with elevated palaeoshorelines) all along this alignment.

6.6.1.8 Road Segments on Mudge Island

There are no previously recorded archaeological sites within immediate proximity to the road segments on Mudge Island. However, this is likely due to a lack of AIA fieldwork conducted in the area of the alignments, rather than indicating a lack of archaeological sites. There is high archaeological potential for encountering unrecorded inland settlement sites and shell middens (some in association with elevated palaeoshorelines) all along the length of the Mudge Island alignments.

6.6.1.9 Archaeological Review Summary

There is high potential for encountering new archaeological sites anywhere within the fixed link alignment option areas, including in intertidal and submarine environments. The existence of known Aboriginal burial sites means that there is a strong likelihood that the area contains many more, undocumented burials. These sites are of cultural significance to Aboriginal groups in the area, and no disturbance of any such site can be countenanced without the full consultation and consent of the appropriate Aboriginal groups and BC MFLNRO Archaeology Branch.

For these reasons, Crossing Option 4 will likely never be approved by concerned Aboriginal Groups or BC MFLNRO Archaeology Branch. **Similarly, the Dodd Narrows Crossings, Crossing Option 1 and Crossing Option 3 also potentially impact known archaeological sites, and so these alignments might require amendment in order to have any chance of them being approved** by BC MFLNRO Archaeology Branch and concerned Aboriginal Groups.

Of the bridge crossings reviewed, Crossing Option 2 appears to have the least number of immediate archaeological concerns associated with it, though it should be pointed out that accessing this crossing is contingent upon the highly problematic Dodd Narrows Crossing between Vancouver Island and Mudge Island.

To achieve a conclusive archaeological recommendation, a full AIA is recommended of all affected inland, intertidal and marine coastal zones on Vancouver Island, Mudge Island and Gabriola Island, prior to any ground disturbance, should any of the fixed link alignment options appear technically feasible.

6.7 Geotechnical

Thurber Engineering Ltd. prepared a desktop geotechnical engineering assessment of available surficial and bedrock geology, and participated in a site visit of the Vancouver Island portion of the study area. Their technical memorandum is provided in **Appendix B**.

An overview of findings pertinent to any potential road and bridge construction includes:

- The design will need to account for seismic ground accelerations of 0.273g for the 1 in 475 year earthquake (10% probability of exceedance in 50 years);
- Soil deposits in Northumberland Channel, Percy Anchorage, and False Narrows are likely susceptible to seismic liquefaction and further study is required to ascertain the nature and thickness of those deposits;
- Bridge foundations will likely require rock socketed piles; and

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- Rock cuts need to anticipate weathering, fracturing, and sloping rock conditions.

6.8 Environmental

6.8.1 Road Option A

Road Option A connects Phoenix Way on Vancouver Island to Crossing Option 1 and the Dodd Narrows Crossing Options near Joan Point Park. Two depressions along the roadway were identified during the review and the installation of culverts to facilitate drainage at these locations has been proposed. A total of three unidentified 'sensitive' species were identified along this alignment option. An additional five listed plant species and one red-listed ecological community were identified within 100 m from the roadway.

Following a review of satellite imagery, it was noted that the depressions identified along the roadway likely drain into the Northumberland Channel, in particular the east depression. No known fish observations were identified along this route option (BC Ministry of Environment, 2011.), however previous studies identified freshwater fish species in the general project area, including chinook salmon, chum salmon, coho salmon, rainbow trout, cutthroat trout, and Dolly Varden. The previous studies also identified potential rearing and spawning habitat in unnamed watercourses located to the west of the alignment (McElhanney, 1993a; McElhanney, 1993b). Due to the likelihood that these depressions are connected to the Northumberland Channel which inhabit salmon and sea-run trout, the potential exists for these depressions to be fish bearing. Potential impacts to the fresh water ecosystems resulting from the culvert installations may include alteration or loss of fish and aquatic habitat, loss of riparian habitat, sedimentation, or the introduction of other deleterious substances.

Three unidentified 'sensitive' species were identified along this alignment option (BC Conservation Data Centre, 2012). It is unknown what type of environment these unidentified species inhabit, therefore impacts to these species as a result of the roadway cannot be adequately assessed without additional information. However, potential impacts may include loss of habitat.

A total of five BC listed plant species were also identified within 100 meters of the road way. These species included four blue-listed plants (awned cyperus, banded cord-moss, Nuttall's Quillwort, slimleaf onion) and one red-listed plant (white-top aster).

Should a detailed environmental assessment be conducted for this project, additional information should be gathered on the unidentified British Columbia listed species and DFO consulted to avoid or mitigate potential impacts to the fresh water ecosystems.

6.8.2 Road Option B

Road Option B connects Nicola Road on Vancouver Island to Crossing Option 1 and the Dodd Narrows Crossing Options near Joan Point Park. Three unidentified 'sensitive' species were identified along this alignment option (BC Conservation Data Centre, 2012). It is unknown what type of environment these unidentified species inhabit, therefore impacts to these species as a result of the bridge cannot be adequately assessed, however, impacts may include loss of habitat.

Two red-listed plant species, Muhlenberg's centaury and white-top aster, were identified within 100 meters of the roadway. Potential impacts to these plant species include removal, disturbance, alteration, or loss of habitat for construction of any roadway.

Should a detailed environmental assessment be conducted for this project, additional information should be gathered on the unidentified 'sensitive' species.

6.8.3 Dodd Narrows Crossings

The bridge crossing options at Dodd Narrows will require construction of two support pylons on each shoreline above the high tide. No instream pylons will be required for this bridge crossing. This alignment option has the potential to impact three British Columbia (BC) listed species and one red-listed ecological community.

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The blue-listed eulachon, a marine fish, was identified as occurring within the vicinity of Dodd Narrows. Marine areas including Dodd Narrows were identified as potential spawning habitat for herring (Fisheries and Oceans Canada, 2015) and ling cod (McElhanney, 1993a). The presence of oyster and clam beds along the coastal shorelines near the bridge crossing were also reported (McElhanney, 1993a).

This bridge crossing is located within the Strait of Georgia which has been identified by DFO as an Ecologically and Biologically Important Area (Fisheries and Oceans Canada, 2009). When identifying these areas, DFO evaluates habitat areas based on uniqueness (rare or distinct habitats), aggregations (relative density of a species habitat use in one area), and fitness consequences (areas containing habitat for critical life stages). These Ecologically and Biologically Important Areas are classified by DFO under Canada's *Ocean Act* and allows for DFO to provide enhanced protection of areas which are considered ecologically or biologically significant (Fisheries and Oceans Canada 2004).

Impacts to marine species and/or their habitat, may result from construction of bridge pylons if works are conducted along the shoreline or extend instream. Degradation of marine habitats may result from sedimentation or the introduction of other deleterious substances to the water.

The red-listed Douglas fir/dull Oregon-grape Ecological Community was located throughout much of Mudge Island including along the shores where vegetation removal may be required for construction of the bridge crossing. Two unidentified 'sensitive' species were also highlighted as potentially occurring in the vicinity of the crossing. It is unknown if these species inhabit terrestrial or marine environments, therefore potential impacts to these species is unknown at this time, but may include loss of or alternation of habitat as a result of removal and clearing for construction of the pylons.

Should a detailed environmental assessment be conducted for this project, additional information on these unidentified species should be requested, in particular, location data with respect to the alignment options so impacts can be avoided or appropriately mitigated (BC Conservation Data Centre, 2012).

6.8.4 Road Segments on Mudge Island

Roadway segments on Mudge Island are required to connect the respective bridges from Mudge Island to Gabriola Island (Crossing Options 2, 3, and 4). Two unidentified 'sensitive' species were identified along these alignment options (BC Conservation Data Centre, 2012). It is unknown what type of environment these unidentified species inhabit, therefore impacts to these species as a result of the road segments cannot be adequately assessed at this time, but may include loss of habitat. The red-listed Douglas fir/dull Oregon-grape Ecological Community is present throughout most of Mudge Island and overlaps with all three road segments (BC Conservation Data Centre, 2012). Potential impacts to this ecological community includes removal, disturbance, alteration, and/or loss of habitat for construction of the roadway.

Should a detailed environmental assessment be conducted for this project, additional information should be gathered on the unidentified 'sensitive' species.

6.8.5 Crossing Option 1

Crossing Option 1 connecting Vancouver Island to Gabriola Island is the longest bridge crossing and would require two deepwater pylons within the Northumberland Channel and two pylons on either shoreline. Three BC listed species were identified along this alignment option.

The blue-listed eulachon has the potential to be observed in this area and may be impacted by instream work to build the deepwater pylons. This bridge crossing location is also located within the Strait of Georgia which has been identified as an Ecologically and Biologically Important Area by DFO (Fisheries and Oceans Canada, 2009). Potential impacts resulting from construction of the deepwater pylons may result in a direct loss of marine habitat or degradation of water quality and marine habitats due to sedimentation or the introduction of other deleterious substances.

Crossing Option 1 includes the two unidentified 'sensitive' species that were highlighted for the Dodd Narrows Crossing Options (BC Conservation Data Centre, 2012). It is unknown if these species inhabit

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terrestrial or marine environments, therefore potential impacts to these species is unknown at this time, but may include loss of or alternation of habitat as a result of removal and clearing for construction of the pylons.

Should a detailed environmental assessment be conducted for this project, additional information should be gathered on the unidentified BC listed species and DFO consulted to avoid or mitigate potential impacts to these marine ecosystems.

6.8.6 Crossing Option 2

Crossing Option 2 is the longest of the crossing options from Mudge Island to Gabriola Island. It is expected that the north pylon would be constructed instream within the Northumberland Channel, while the south pylon would be construction on shore. Three BC listed species and one red-listed ecological community were identified along this alignment option.

The blue-listed eulachon has the potential to be observed in this area and may be impacted by instream work to build the deepwater pylon. This bridge crossing is also located within the Strait of Georgia and identified as an Ecologically and Biologically Important Area by DFO (Fisheries and Oceans Canada, 2009). Potential impacts resulting from construction of the deepwater pylon may result in a direct loss of marine habitat or degradation of water quality and marine habitats due to sedimentation or the introduction of other deleterious substances.

The two unidentified 'sensitive' species that were highlighted for the Dodd Narrows Crossing Options are present along this alignment option (BC Conservation Data Centre, 2012), as well as the red-listed Douglas fir/dull Oregon-grape Ecological Community throughout Mudge Island where the south pylon would be located. Potential impacts to the ecological community may include loss or alternation of habitat as a result of removal and clearing for construction of the pylons.

Should a detailed environmental assessment be conducted for this project, additional information should be gathered on the unidentified species and DFO consulted to avoid or mitigate potential impacts to marine ecosystems.

6.8.7 Crossing Option 3

Bridge Crossing Option 3 crosses the Northumberland Channel to the west of False Narrows and connects Weather Way on Mudge Island with South Road on Gabriola Island. The proposed concrete box girder bridge will contain six instream pier supports at the south end of Northumberland Channel and two supports along the shorelines of Mudge Island and Gabriola Island above the high tide. Three BC listed species and one red-listed ecological community were identified along this alignment option.

The blue-listed eulachon was observed and may be impacted by instream construction of the piers. It is unknown if this area is used by eulachon for critical life stages such as spawning. Marine areas, including False Narrows which is located to the east of this bridge crossing were identified as containing spawning habitat for herring (Fisheries and Oceans Canada, 2015). The presence of oyster and clam beds along the coastal shorelines in the vicinity of the bridge crossing were also reported (BC Conservation Data Centre, 2012; McElhanney, 1993a). This bridge crossing location is also located within the Strait of Georgia and is identified as an Ecologically and Biologically Important Area by DFO (Fisheries and Oceans Canada, 2009). Construction of the instream piers may result in a loss of habitat for these marine species. Degradation of water quality may also result from sedimentation during construction of instream piers.

The red-listed Douglas fir/dull Oregon-grape Ecological Community is present throughout most of Mudge Island where the north bridge abutment will be located (BC Conservation Data Centre, 2012).The two unidentified 'sensitive' species that were highlighted for the Dodd Narrows Crossing Options are also present along this alignment option. It is unknown if these unidentified species inhabit terrestrial or marine environments. Potential impacts to these species may include loss or alteration of habitat due to clearing and removal for construction of the pylons on either shoreline.

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Should a detailed environmental assessment be conducted for this project, additional information should be gathered on the unidentified BC listed species and DFO be consulted to avoid or mitigate potential impacts to the marine ecosystems.

6.8.8 Crossing Option 4

Crossing Option 4 crosses the east side of False Narrows and connects Coho Boulevard on Mudge Island with South Road on Gabriola Island. The proposed concrete box girder bridge will contain five instream pier supports, spaced at 60 metres through False Narrows, with an additional two supports along the north shoreline of Gabriola Island above the high tide. Three BC listed species were identified along this alignment option.

The blue-listed eulachon was found and may be impacted by instream construction of the piers. It is unknown if this area is used by eulachon for critical life stages such as spawning. Marine areas, including False Narrows, were identified as containing spawning habitat for herring (Fisheries and Oceans Canada, 2015). The presence of oyster and clam beds along the coastal shorelines in the vicinity of the bridge crossing were also reported (BC Conservation Data Centre, 2012; McElhanney, 1993a). This bridge crossing is located within the Strait of Georgia and is identified as an Ecologically and Biologically Important Area by DFO (Fisheries and Oceans Canada, 2009). Construction of the instream piers may result in a loss of habitat for these marine species. Degradation of water quality may also result from sedimentation during construction of instream piers.

The two unidentified 'sensitive' species that were highlighted for the Dodd Narrows Crossing options are also present along this alignment option (BC Conservation Data Centre, 2012). It is unknown if these unidentified species inhabit terrestrial or marine environments and therefore impacts to these species as a result of the bridge cannot be adequately assessed, however potential impacts may include loss or alteration of habitat.

While the majority of Mudge Island contains the red-listed Douglas fir/dull Oregon-grape Ecological Community, this particular bridge location does not conflict with this ecological community as the bridge is located outside of the habitat polygon.

Should a detailed environmental assessment be conducted for this project, additional information should be gathered on the unidentified BC listed species and DFO consulted to avoid or mitigate potential impacts to marine species.

6.8.9 Environmental Review Summary

Based on the desktop review of available information for the Gabriola Island Fixed Link study, **the primary environmental concerns are the unidentified 'sensitive' species which are located throughout the entire alignment and at all bridge crossing locations**. Due to the masked nature of these species within the BC Conservation Data Centre database, these species are likely to be more vulnerable to impacts and disturbances resulting from any fixed link. The red and blue-listed plant species, including the eulachon and the Douglas fir/dull Oregon-grape Ecological Community, are of secondary concern due to the listed status of these species.

Crossing Option 1 with Road Option B poses the least amount of environmental impacts when compared to the other alignment options. This option disturbs the least amount of new ground surface for the roadway, encounters fewer listed plant species than the alternatives, and does not require the installation of culverts on potentially fish bearing watercourses. Crossing Option 1 is also limited to only one bridge crossing which conveniently encounters the least number of ecologically sensitive areas and avoids potential spawning habitat for herring and ling cod.

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6.9 Property Impacts

Only the number of impacted properties have been determined based on the current level of design, and a more detailed assessment is required to more accurately determine actual impacts, and associated costs. The number of impacted properties per fixed link segment is shown in Table 6-2.

TABLE 6-2
Summary of Property Impacts

Segment	Number of Properties Impacted		
	Nanaimo	Mudge Island	Gabriola Island
Road Option A (Phoenix Extension)	5	0	0
Road Option B (Nicola Extension)	7	0	0
Crossing Option 1	1	0	1
Crossing Option 2	1	19	1
Crossing Option 3	1	39	1
Crossing Option 4	1	59	1

6.10 Marine Construction Window

If deemed technically feasible and all other identified obstacles are addressed, any marine construction for the Gabriola Island Fixed Link, whether it be temporary or permanent works, is subject to construction window restrictions specified by Fisheries and Oceans Canada. Nanaimo, Mudge Island and Gabriola Island all fall within the coast of Vancouver Island between Grave Point (excluded) and Cottam Point (excluded). It includes all the open water and all islands within an area that extends north to Lasqueti Island, east to the Trail Islands (included) and south to Sturdies Bay on Galiano Island (included). The area also includes Northwest Bay, partially includes parts of the Gulf Islands geographically north of Sturdies Bay, and includes the south-eastern tip of Lasqueti Island from Young Point to Squitty Bay.

The following are time periods when the timing windows of least construction risk are open.

- Summer Window: June 1 – September 1
  - Chemainus River and Bonsall Creek Estuary: July 1 – July 15
  - Knarston Creek Estuary: July 1 – September 1

Summer windows do not apply in the following estuary: Nanaimo River.

Winter Window: December 1 - February 15

6.11 Preliminary Technical Screening Results

The results of the preliminary technical screening undertaken in this section are provided in Table 6-3. Table 6-3 should be referred to for segment clarification.

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TABLE 6-3
Preliminary Screening Results

Segment	Preliminary Screening Based on Technical Criteria				
	Achieve Navigational Clearance	Construct-ability	Geotechnical	Environmental Impacts	Archaeological Impacts
Road Option A (Phoenix Extension)	-	Pass	Pass	Fail*	Fail*
Road Option A – Alt 2	-	Pass	Pass	Fail*	Fail*
Road Option B (Nicola Extension)	-	Pass	Pass	Pass	Fail*
Dodd Narrows Crossing 1	Pass	Pass	Pass	Fail*	Fail*
Dodd Narrows Crossing 2	Pass	Pass	Pass	Fail*	Fail*
Crossing Option 1	Pass	Fail	Pass	Pass	Fail*
Crossing Option 2	Pass	Fail	Pass	Fail*	Pass
Crossing Option 3	Pass	Pass	Pass	Fail*	Fail*
Crossing Option 4	Fail	Pass	Pass	Fail*	Fail

Note: * Preliminary findings only. Subject to a more detailed assessment before a final decision can be made.

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7. Fixed Link Alignment for Further Review

Based on the preliminary screening in Section 6, the Dodd Narrows Crossing Option 2 and Crossing Option 3 are the most technically feasible of the bridge options considered refer Exhibit 6-2). Of the road tie-in connections to Duke Point Highway, Road Option A – Alternative 2 via Phoenix Way, and Road Option B via Nicola Road and Holdon Corso Road are the most technically feasible. However, the entire fixed link alignment is subject to a more detailed archaeological assessment. In addition, a further environmental assessment is required to determine the environmental compensation and/or mitigation measures required to achieve either of these alignments.

Community consultation will likely also influence the ultimate decision regarding the non-technical feasibility of establishing a fixed link, if both archaeological and environmental issues can be properly identified and addressed.

The segments making up the two fixed link options that were progressed to the cost estimate stage (refer **Section 8**) are as follows:

1. **Fixed Link Option 3A – Alt 2**

    - Upgrading of approximately 1,300 metres of Phoenix Way and existing intersections
    - Construction of 2,630 metres of new road to extend Phoenix Way to Dodd Narrows
    - Construction of a 260 meter long bridge across Dodd Narrows
    - Upgrading and construction of 1,700 metres of roads on Mudge Island
    - Construction of a 800 metre bridge across False Narrows
    - A new intersection and localize upgrading of South Road on Gabriola Island

The following should also be noted for this option:

- There is the possibility of contaminated sites in the area of the Harmac Pulp Mill
- Property impacts should be minimal on the Vancouver Island segment
- There are significant property impacts on Mudge Island

2. Fixed Link Option 3B

- Upgrading of approximately 2,500 metres of existing roads and existing intersections between Hwy 19 and Nicola Road
- Upgrading of Barnes Road would require significant reconstruction
- Construction of 1,430 metres of new road to extend Nicola Road to Dodd Narrows
- Construction of a 260 meter long bridge across Dodd Narrows
- Upgrading and construction of 1,700 metres of roads on Mudge Island
- Construction of a 800 metre bridge across False Narrows

The following should also be noted for this option:

- Upgrading existing roads on Vancouver Island would have significant property impacts and impacts on private accesses
- There are significant property impacts on Mudge Island

A detailed property impact evaluation has not been done as part of this concept planning feasibility study.

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8. Cost Estimate

The purpose of this section is to determine a cost estimate for both Gabriola Island fixed link options described in **Section 7**. These estimates will be used when undertaking a business case analysis of the fixed link in **Section 9**.

8.1 Cost Estimate Derivation

The framework that served as the basis of the cost estimates is outlined. Typical unit costs have been derived for the major construction items in order to arrive at the overall planning level cost estimate for the work.

Itemized cost estimates were developed, and line items identifying scope of work items and quantities were included to determine a cost of construction for each segment.

For the purposes of this estimate, an all-inclusive unit rate for bridge construction was assumed based on consideration of a "complex structure" (medium span haunched concrete box girder bridge). BC MoTI typically applies a unit rate per square metre of $6,500. This was factored up by 30% to account for the uncertainty with underwater foundation conditions, site location, and expected difficulty of construction, yielding a rate of $8,450 per square metre.

Rates account for total construction cost including mobilization and site preparation, temporary works, permanent works, and professional fees, **but exclude all property related costs**.

Roadways cost estimating data was taken from various sources including:

- BC MoTI cost estimating databases
- CH2M HILL cost estimating databases

8.2 Accuracy of Cost Estimates

BC MoTI recently published Project Cost Estimating Guidelines (2013) which provides guidance on the level of accuracy to be expected at various levels of planning and design. From Table 4-1 in this document, the level of project development completed at the planning level is between 1% and 15%, and the associated level of accuracy to be expected for the cost estimates is ±35%. However, an accuracy of ±50% has been applied for this study due to the following risk factors:

- Earthworks and paving quantities were developed with minimal geotechnical input.
- The extent of bridge construction.
- The need to barge in all construction materials.
- Limited if any obvious site establishment locations especially at the bridgeheads on Mudge Island.
- The likelihood of First Nation oversight personnel on site during the entire construction period.

The cost estimates shown, and any resulting conclusions made on project financial or funding requirements, have been prepared for guidance in project evaluation and implementation from the information available at the time the estimate was prepared. The final costs of the project will depend on actual labour and material costs, competitive market conditions, actual site conditions, final project scope, implementation schedule, and other variable factors. In addition, increases or decreases in material pricing may have a significant impact that is not predictable. As a result, the final project costs will vary from the opinions of cost presented in this report.

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8.3 Unit Prices

Typical unit prices were used as the basis for developing the cost estimates from the BC MoTI Cost estimating database and applying Vancouver Island rates. A summary of unit prices and item descriptions is shown in Table 8-1.

TABLE 8-1
Summary of Unit Prices and Item Descriptions

Description of Work	Unit	Proposed Unit Price	Comment
Section 1 - General			
Mobilization	L.S.	L.S.	Based on 5% of Construction
Traffic Management (2.5% of Section 2 thru 8)	L.S.	L.S.	Based on 2% of Constrcution
Quality Management (1.0% of Section 2 thru 8)	L.S.	L.S.	Based on 1% of Construction
Section 2 - Grading			
Clearing and Grubbing Highway Construction	Ha	$30,000.00	
Remove Lamp Standard	Each	$2,000.00	
Cold Milling (50mm)	m^2	$20.00	
Saw cutting	Metre	$20.00	
Pavement Removal	m^2	$20.00	
Remove Concrete Curb	Metre	$25.00	
Organic Stripping - 300mm	m^3	$15.00	
Type "A" Excavation (neatline)	m^3	$40.00	Assumed 50% cut volume in rock
Type "D" Excavation (neatline)	m^3	$18.00	Assumed 50% cut volume in Rock
Haul Surplus Material Offsite (unfactored)	m^3	$25.00	No buliking factor in excavated material
25mm Well Graded Base Course (WGBC)	m^3	$45.00	150mm Thick
Open Graded Granular Sub Base (SGSB)	m^3	$35.00	300mm Thick
Import Material, Haul and Place into Embankment	m^3	$20.00	Assumed 100% of excavated material to be re-used.
Section 3 - Drainage			
600mm CSP 2.0 WT	Metre	$400.00	Assumed culverts every 100m
10 kg Rip Rap Outfall	m^3	$150.00	
End Wall 1000mm dia inlet with Fence and Apron	Each	$7,000.00	
Section 4 - Structures			
Supply & Install			
Bridge Structure - Concrete	m^2	$6,500	Concrete Girder, including span and approaches
Bridge Structure – Cable Stay	m^2	$20,000	Cable Stay, including span and approaches
MSE Wall (sq.m face area)	m^2		
Section 5 - Paving			
Supply Emulsified Penetrating Primer	Litre	$1.50	
Apply Emulsified Penetrating Primer	Litre	$0.40	
Class 1 Medium Mix	Tonne	$155.00	Asphalt volume x 2.4 to tonnes
Concrete Curb and Gutter	Metre	$50.00	
Supply and Install CRB	Each	$250.00	

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Supply and Install CMB	Each	$350.00
Section 6 – Signing and Pavement Marking		
Remove Existing Signs	Each	$200.00
Supply & Install Perforated Square Steel Post and Sign	Each	$400.00
Pavement Marking Layout	L.S.	$5,000.00
Line Markings	Metre	$6.00
Transverse Pavement Markings & Arrows (Thermo P)	L.S.	$20,000.00
Section 7 - Electrical		
Lamp Standard	Each	$5,000.00
Section 8 - Landscape		
Landscaping	L.S.	$50,000.00

Notes:
ha = hectare, LS = lump sum; m^2 = square metre; m^3 = cubic metre

8.4 Engineering and Supervision

As an estimate of the engineering and supervision, the following estimated rates were used, based on the total estimated construction cost:

- Engineering and design services are included at an estimate of 5-10% to cover external consultant engineering design. This is based on the following:
    - Association of Professional Engineers and Geoscientists of British Columbia (APEGBC) budget guidelines suggests approximately 5% on the first $1 million for detailed design and tender preparation.
    - However, this does not include such items as preliminary design, survey, geotechnical investigations, environmental investigations, or permitting. This would apply if the preliminary and detailed design was done by consultants. Internal engineering costs may be lower.
- Engineering services for MoTI staff is included at an estimate of 2.5% to cover engineering requirements by MoTI staff.
- Project management by MoTI staff is included at an estimate of 5% to cover project management duties by MoTI staff.
- Construction supervision is included at an estimate of 10% to cover internal or external construction management, or both.

8.4.1 Work by Others

It is expected that work by other agencies will be required. This work could include relocation of utility poles or service boxes and conduit connections.

8.4.2 Contingencies

With the conceptual level of design completed under this study, a contingency allowance of 50% has been included to account for items and conditions unknown at this level of design. Besides those items identified earlier, additional items could include sub-excavation in soft soils; additional haul for embankment materials or gravels; pit development; roadside barrier; signing and pavement marking; etc.

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8.5 Cost Estimate Summary

The summary costs for each estimating category are shown in Table 8-2. Detailed cost sheets for each fixed link segment are provided in **Appendix C**.

TABLE 8-2
Summary of Costs for Options

	s.13,s.17
Description	
Section 1 - General	
Section 2 - Grading	
Section 3 - Drainage	
Section 4 - Structures	
Section 5 - Paving	
Section 6 - Signing & Pavement Marking	
Section 7 - Electrical	
Section 8 - Miscellaneous	
TOTAL CONSTRUCTION COST	
Section A - Property Acquisition - TBD	
Section B - Engineering & Supervision	
Section C - Work By Others	
Section D - Contingencies	
TOTAL OTHER COSTS	
TOTAL PLANNING LEVEL ESTIMATE (ROUNDED TO NEAREST $10,000)	

DRAFT

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9. Business Case Evaluation

In order to determine if a business case exists for a fixed link to Gabriola Island, a Multiple Account Evaluation was done following BC MoTI guidelines.

For the purposes of the evaluation, the business as usual Base Case assumes the continuation of the BC Ferries service on Route 19, and is compared to Option 3A – Alt 2, hereafter referred to as the "Fixed Link".

9.1 Multiple Account Evaluation Accounts and Criteria

The Multiple Account Evaluation (MAE) approach was developed based on the accounts and criteria set out in BC MoTI's guidelines, adapted to the specific context of the Gabriola Island fixed link evaluation. The accounts and criteria employed in the evaluation are set out in Table 9-1.

Each account is subsequently discussed in this section.

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TABLE 9-1
Description of Multiple Account Evaluation Criteria Applied

Accounts		Discussion/ Direction	MAE criteria	Metrics / Data
FINANCIAL	Capital costs ($ millions)	Ferry cost includes operating costs as well as future ferry replacement costs and terminal upgrades. Fixed link cost includes bridge crossing(s) and associated road network connections and upgrades.	Use Class D cost estimated for comparison of shortlisted options.	Cost ($) in 2015 dollars (excluding property costs)
	Operations and maintenance costs	Ferry cost includes fuel, staff wages, maintenance costs for vessels and docks. Data to be obtained from BC Ferries, if available. Fixed link cost includes regular inspections, maintenance and repair, snow clearance	Compare BC Ferry operations and maintenance costs for the Gabriola route vs. fixed link costs over a 30 year period (based on 2015 dollars)	Costs ($) in 2015 dollars. Benchmarks for bridge/ road O&M costs used, with inputs/ verification provided from BC MOTI.
	Property impacts	Assume ferry option does not incur any additional property impacts (no additional queuing areas required on either side) Fixed link likely to involve land take to accommodate road connections and bridge Existing terminal properties at Nanaimo Harbour and Descanso Bay could conceivably be freed up for alternative land uses or revenue generation, but are not included in this account	Number of properties affected / sq.m of land take required, by land use type (e.g. residential, agricultural, commercial, other). Potential demolitions required (if any).	Estimates of land take to accommodate new bridge and roadway connections. Number of properties affected, by land use type (e.g. residential, agricultural, commercial, other). Potential demolitions required (if any).
CUSTOMER SERVICE	Travel time	Travel time from a mid-point on Gabriola Island to downtown Nanaimo Assume ferry crossing time of 20 minutes plus drive time to terminal, and wait time/ loading time (estimated as ¼ * ferry headway) Fixed link crossing time is based on additional driving time incurred. (Note: delays associated with congestion on the road network not included.)	Comparative analysis of average travel time considering ferry crossing time versus fixed link travel time (based on vkt), converted into $ value of time.	High level travel time comparison for screening Total value of time saved ($) using fixed link options relative to ferry, taking into account trip purpose to ascertain value of time. Estimate over a 30 year period. Assume consistent traffic growth across all options.
	Vehicle operating cost ($ millions)	Based on changes in vehicle kilometres travelled (vkt) (Assume user costs remain constant e.g. that a toll, equivalent to ferry fare would be applied to each crossing.)	Comparative analysis of change in operating costs, based on change to vkt.	Operating costs in 2014 dollars
	Travel time reliability/ flexibility	Delayed and/ or cancelled ferries and pass ups during the peak, converted into a value of time	Relative reliability/ flexibility of a fixed link	Ferry sailing times, potentially affected weather or mechanical problems
	Safety	Change in the number of incidents, using vkt as a proxy, and applying BC MoTI factors for safety	Number of incidents	Measure vkt and comment on road connections. Not ShortBEN/SafetyBEN
	Multimodal accessibility	Opportunities for improved transit and ped/ bike travel, taking into account convenience (trip length and directness) and safety for pedestrians and cyclists using the fixed link and connections. (Assume design of fixed link includes separated cycling/ pedestrian facilities.)	Relative attractiveness of options for transit, cycling and walking, based on travel time and directness of route	Which options are most attractive to transit, cycling and walking
	Emergency access	Gabriola has volunteer fire department that includes medical first responders, and RCMP detachment. Closest hospital is Nanaimo Regional General Hospital	Which options enable greatest accessibility for emergency services?	Hours of operation of ferry service versus near 24-hr availability of bridge
SOCIAL / COMMUNITY	Alignment with plans and policies	Consistency/ impacts of bridge on OCP policies and land use designations	Which options are most closely aligned with the policies and designations in the existing OCPs and/ or zoning bylaws?	Number and type of changes potentially required to OCPs and zoning bylaws to facilitate option
	Island identity	Gabriola and Mudge Island OCPs speak to preserving the unique nature of island living	Likely impacts of fixed link and connections on Islands' character relative to ferry service.	How might the identity of Gabriola and Mudge Islands be affected?
	Noise	Use proximity to - and increase in traffic as a proxy for noise. [Proposed crossing would be a local road (design speed 60 km/h; posted speed 50 km/h)]	Number of residential and other sensitive receptors (schools, hospitals, community centres) likely to experience a moderate to severe increase in traffic noise	Number and type of receptors, severity of impacts. Severity based on type of receptor, anticipated traffic volumes, and the relative increase in volumes.
	Visual impact	Impacts on existing views in this natural/ rural setting rather than bridge design aesthetics	Relative impacts on views, based on number of receptors affected and relative intrusiveness of the structure on views	Intrusiveness of structure based on location and visibility (where a larger, higher structure which is visible from multiple locations is considered to be more intrusive)
	Affordability	Assuming users were subject to a toll equivalent to the cost of a ferry crossing, what additional investment would be required.	Additional (public) investment required over a 25 year period	Funding required (2015 $), assuming a toll equivalent to the ferry fare is applied to each crossing. Compare investment costs relative to public subsidy of this ferry route over a 25 year period.
ENVIRONMENT	Recreation	Impacts to local parks/trails on Vancouver Island, Gabriola and Mudge Islands, relative to recreational opportunities on Gabriola and Mudge Islands	Number/ length of trails impacted and additional connections enables	Number and length (km) affected

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Accounts		Discussion/ Direction	MAE criteria	Metrics / Data
	GHG emissions – travel-related	Base case emissions associated with ferry fuel usage and vehicle from a mid-point on Gabriola Island to downtown Nanaimo compared to vehicle emissions (including induced travel) over a 30 year period.	Comparison of total GHG emissions	Total GHG emissions (tons) over a 30 year period, based on vkt and ferry fuel consumption
	Air pollution	Criteria Air Contaminant (CAC)	Relative estimates based on ferry CAC emissions and vkt	Tons of CACs – by type
	ALR impacts	Agricultural Land Reserve (ALR) areas shown on Issues Map	Total area of ALR impacted	Area (sq.m) affected
	Terrestrial (Flora/fauna) impacts	Area/ type of sensitive habitat or species affected	Area/ type/ sensitivity of habitat or species affected	Total sq.m of habitat and number/ type of species affected based on GIS database of habitat/ species at risk
	Aquatic impacts	Impacts on intertidal zone	Area/ type/ sensitivity of habitat or species affected	Total sq.m of habitat and number/ type of species affected based on GIS database
	Archaeological impacts	Impacts on archaeological sites or sites of historic interest/ importance	Are sites likely to be temporarily or permanently impacted	Number and importance of sites affected
ECONOMIC DEVELOPMENT	Goods movement	Benefits to goods movers are largely captured under the Customer Service account. However, added benefit would accrue to movement of gas/propane, dangerous cargo (DC) and livestock. Those are currently restricted to one weekly sailing where no other vehicles are permitted.	Number/ type of DC movements benefitting	BC Ferries data on DC sailings
	Development enabled	Primarily focused on resort property opportunities near Cable Bay Trail Also potential for redevelopment of existing terminals	Development supported (subject to OCP amendments)	Oceanview Master Plan and Island Timberlands OCP amendment documents
	Impact on local businesses	Positive (greater access) and negative impacts (duplication/competition)	Number and type of local businesses potentially impacted	Gabriola Island Chamber of Commerce directory (http://www.gabriolaisland.org/membership-listings)

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Withheld pursuant to/removed as

s.13;s.17

TABLE 9-4
Summary of Property Impacts

	Number of Properties Impacted		
	Nanaimo	Mudge Island	Gabriola Island
Fixed Link	6	39	1

9.3 Customer Service Account

The assumptions used in the Customer Service Account are consistent with those listed in **Section 9.2** (Financial Account).

9.3.1 Travel Time

The Fixed Link is expected to reduce travel time between Nanaimo and Gabriola by approximately 20 minutes as per Table 5-8. Using the value of time assumption of $10/hr and the Base Case forecasts presented in **Section 5**, the Fixed Link is expected to provide a net savings of $13.7 million (Net Present Value) as shown in Table 9-5. Thus, the Fixed Link is the more favourable option.

TABLE 9-5
Summary of Travel Time Impacts

Travel Time	Base Case	Fixed Link
$ millions	43.9	30.2

9.3.2 Vehicle Operating Costs

The Fixed Link is expected to increase the total vehicle kilometers travelled (vkt) over a 25-year period by approximately 201.2 million km, as shown in Table 9-6. Assuming a vehicle operating cost of 17 cents per kilometre (**Exhibit 5-12**), this translates into additional vehicle operating costs of $19.6 million for the Fixed Link. Similar to the Travel Time account, growth forecasts presented in **Section 5** were used to derive the figures shown in Table 9-6.

TABLE 9-6
Summary of Vehicle Operating Costs

Item	Base Case	Fixed Link
Million vkt 2020-2044)	71.8	273.0
$ millions (2020-2044)	7.0	26.6

9.3.3 Travel Time Reliability/ Flexibility

The value for this account is the percentage of vehicles that are expected to experience typical travel times without significant delays. The Fixed Link establishes a permanent link between Nanaimo and Gabriola Island, which will provide around the clock accessibility. Combined with the low traffic volume forecasts, it is expected that the travel time will be consistent and reliable. Analyzing the historical ferry data, it was determined that approximately 2% of all vehicles experience a sailing wait on account of limited ferry vessel capacity. Based on this the travel time reliability values would be 98% and 100% for the Base Case and Fixed Link respectively, as shown in Table 9-7.

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TABLE 9-7
Estimated Reliability

Travel Time Reliability/ Flexibility	Base Case	Fixed Link
%	98%	100%

9.3.4 Safety (Traffic Collisions)

BC MoTI's "Default Values for Benefit Cost Analysis in British Columbia – 2012" were used to determine the monetary values (2012 dollars) of collisions by severity as shown below:

- Property Damage Only: $11,367
- Injury: $135,577
- Fatal: $6,385,999

Based on observed Provincial Collision Rates (per vkt) for different road classes between 2006-2010[10] and vkt forecasts, the Fixed Link is expected to result in approximately 42 additional collisions over the project's 25 year horizon. This translates to approximately $4.5 million (net present value) of additional impact. The total collisions and cost of collisions for both the Base Case and Fixed Link are presented in Table 9-8.

TABLE 9-8
Summary of Safety Impacts (2020-2044)

Item	Base Case	Fixed Link
Number of Collisions	22	64
Cost of Collisions ($ millions)	2.3	6.8

9.3.5 Multimodal Accessibility

The Fixed Link includes segregated bicycle and pedestrian facilities (roadways with 1.5 m asphalt shoulder lanes and additional adjacent gravel shoulders as a minimum), providing a relatively safe option for pedestrians and cyclists. However, the convenience of the Fixed Link routing (considering trip length and directness) is poor, particularly for commute trips by active modes. Commute distances of over 20 km are unlikely to be attractive to many cyclists. Further, the steeper grades of the bridge and corresponding connections provide a disincentive for cyclists.

While the Fixed Link arguably provides opportunities for improved transit connections between Gabriola Island and Nanaimo, this would be dependent upon an assessment of the viability of a service and investment by BC Transit. Currently, the BC Ferries foot passenger service can itself be considered a transit service. The Base Case is therefore considered to offer more convenient multi-modal accessibility than the Fixed Link.

9.3.6 Emergency Access

The closest hospital for Gabriola Island residents is the Nanaimo Regional General Hospital. It is assumed that where patients are in need of urgent/ life threatening medical assistance, they would be airlifted to hospital. However, for less urgent hospital requirements, emergency travel times would likely be similar to those for ferry users (approximately 51 minutes) under the Base Case, with use of the Nanaimo Harbour

[10] http://www.th.gov.bc.ca/publications/planning/Safety/Average_Provincial_Collision_Rates_2006-10_Collision_Data.xls

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Patrol response vessel available for emergencies when the Gabriola ferry is not operating. It is estimated that the travel times for the latter would be similar.

Emergency travel times to Nanaimo Hospital for the Fixed Link are estimated to be slightly less than average travel times of approximately 31 minutes. It is also assumed that the costs of ground (vs water) emergency transportation would be less. The Fixed Link therefore offers benefits over the Base Case for Gabriola and Mudge residents, and would likely result in reduced costs to the BC Emergency Health Services.

9.3.7 Net Present Value

The net present value of the Fixed Link is estimated to be ($83.8 million).

9.3.8 Benefit Cost Ratio

The Fixed Link generates a negative benefit cost on account of the high relatively high vehicle operating and safety costs. The Fixed Link benefit/cost ratio relative to the Base Case is estimated to be (0.53).

However, note that a number of social/ community environmental and economic impacts (along with convenience/reliability and emergency access benefits) are not reflected in this measure. These are discussed further below.

9.4 Social/Community Account

9.4.1 Alignment with Plans and Policies

The Fixed Link is in direct contravention of the objective in the Gabriola Island Official Community Plan (OCP) (1997), to "oppose any fixed link or bridge to Vancouver Island". Similarly, Policy 4 of the Mudge Island OCP (2007) states that "no island in the Plan Area shall be connected to any other island by a bridge". The Fixed Link is therefore considered to offer no/low planning alignment benefits.

While the Base Case was found to be in keeping with the objectives and policies set out in the Gabriola Island OCP (1997), it is considered that the reduction in ferry services may fall somewhat short of the Plan objective of ensuring "the provision of a ferry service to Vancouver Island that meets the needs of the local community". For this reason the Base Case is considered to not fully align with existing plans and policies.

9.4.2 Island Identity

The character, identity and atmosphere of Gabriola and Mudge Islands are defined precisely by the fact that they are separate from the Mainland and from Vancouver Island. It is considered here that island identity is a quality worth preserving and is one of the reasons why people have chosen to live on Gabriola Island and Mudge Islands in the first instance. (The Mudge Island OCP states that Mudge Island residents and landowners favour low population density and "water access only".) This island identity is likely to be fundamentally altered by the provision of a Fixed Link, which would likely change both islands into the equivalent of the outlying suburbs of Nanaimo. The Fixed Link is therefore considered to have significant adverse impacts to island identity.

At the same time it is recognized that the ferry service provides the lifeblood of Gabriola Island. Declining ferry service can have an adverse impact on the Island's identity insofar as it undermines the sustainability of the local community and affected the potential for enjoyment of the Island by visitors. For this reason the Base Case is considered to have a moderately adverse impacts on the character and identity of Mudge and Gabriola Islands.

9.4.3 Noise

Typically, an evaluation of noise impacts would consider the number of residential and other sensitive receptors (schools, hospitals, community centres) likely to experience a moderate to severe increase in traffic noise. In this case increase in daily traffic flows was used as a proxy for noise, and the impact of increased traffic on rural residential development was considered.

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Average Annual Daily Traffic (AADT) estimates for 2044 under the Base Case are 1,100 vehicles per day (refer Exhibit 5-9). These vehicles are expected to use existing routes. The forecast increase over 2015 traffic is just 200 vehicles per day. This increase is considered to be relatively slight over the 25 year period. It is therefore considered that the Base Case will result in little to no change in noise impact to Gabriola Island and to Nanaimo residents.

For the Fixed Link it is estimated that on average, 1,240 vehicles per day (refer **Exhibit 5-17**) will make the journey between Gabriola Island and Nanaimo in 2044. This represents an increase of just 340 vehicles per day compared with AADT in 2015. However, for the Fixed Link this traffic will be following a different route to the Base Case, passing through residential areas which currently have almost no traffic (on Mudge Island), or has residential frontages (on Gabriola Island). These locations are likely to experience a noticeable increase in traffic noise where they had previously experienced little/ no traffic noise. Conversely, Gabriola Island residents currently living along the route linking to the ferry terminal may benefit from reduced noise impacts. Overall, it is considered that these noise impacts are likely to be experienced as moderately adverse.

9.4.4 Visual Impacts

While the crossing location follows the existing BC Hydro Right of Way over the water channels, the height and location of the bridge structures for the Fixed Link would result in significant visual intrusion to properties on the south side of Gabriola Island and the north side of Mudge Island. Further, it is considered that the Dodd Narrows crossing would also have adverse impacts on the views from properties on and potentially on the users of Joan Point Park. These impacts are considered to be moderate to highly adverse relative to the Base Case (with existing BC Hydro crossing) where visual impacts are considered to be low to moderate.

9.4.5 Affordability

The affordability considers the extent to which costs may be subsidized through a toll on the Fixed Link, equivalent to the ferry fare. The findings are a toll equivalent to a ferry fare could generate $81.2 million over a 25 year period, relative to costs of $211.3 million, excluding any costs associated with borrowing.

9.4.6 Recreation

The Fixed Link avoids Joan Point Park, except for a bridge pier which will result in some land take from the park, meaning that the setting of the park will be altered to a degree. Impacts to the existing Cable Bay Trail will be mitigated by the possible inclusion of a bridge structure (versus earth embankment and culvert) over the trail and creek. While the Fixed Link does not impact designated parks on Gabriola Island or Mudge Island, it is anticipated that it will adversely impact the setting of the beaches (designated as Water General in the Gabriola and Mudge Island OCPs[11]), and could compromise public recreational enjoyment of the shoreline at the crossing locations. While a fixed link will arguably increase the number of people who are able to enjoy the recreational amenities on Gabriola Island and Mudge Island, it may also compromise the enjoyment of these amenities. These combined impacts are considered to be moderately to highly adverse relative to the Base Case.

[11] Permitted uses in the Gabriola OCP include boat moorage and boat launching facilities, public parks, and ecological reserves

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9.5 Environmental Account

9.5.1 GHG Emissions – Travel-Related

The ferry *Quinsam* which serves Gabriola Island uses in average 190 litres[12] of fuel per round trip. Based on the current ferry schedule this equates to 908,960 litres of fuel per year, assuming 4,784 annual round trips based on the 2015 ferry timetable. Given this level of fuel consumption, it is estimated that the ferry service will produce 2,514 tonnes of CO_2e emissions per year, or 62,843 tonnes of CO_2e emissions over the 25 year study period.

Total forecast vehicle kilometres travelled (vkt) for road-based transportation associated with ferry trips over the study period is 71,799,440 km. This equates to an estimated 16,532 tonnes of CO_2e over the course of the study period.

Total estimated GHG emissions associated with the Base Case are equal to approximately 88,375 tonnes of GHG emissions in total - substantially less than those associated with the Fixed Link, which results in over 4.5 million tonnes of GHG emissions. If BC Ferries were to switch to alternative fuels, the Base Case would provide even greater relative GHG benefits. These emission totals are shown in Table 9-9.

TABLE 9-9
GHG Emissions of Road-Based Travel

Vehicle GHG Emissions	Base Case (tonnes)	Fixed Link (tonnes)
CO_2e	16,532	4,514,563

Note also that these GHG emission estimates exclude consideration of embedded carbon and the carbon impacts associated with construction, since the current level of design does not enable an accurate assessment. If embedded carbon and construction carbon was included, it is likely that the Fixed Link would fare more poorly relative to the Base Case owing to the impacts of construction transportation and the quantity of embedded carbon in cement and other bridge/ road construction materials.[13]

9.5.2 Air Pollution

The calculation of ferry Criteria Air Contaminant (CAC) emissions is complex and depends on a variety of considerations such as whether a ferry vessel is docked, maneuvering or underway and whether the vessel is fully loaded, engine size, and speed. In order to simplify the approach, Metro Vancouver emission factors were used as shown in Table 9-10.

[12] Island Futures "2008 GHG Emissions Gabriola Island" (February 8, 2010), available online at http://www.nickdoe.ca/pdfs/Webp638.pdf

[13] For example the production of cement and cementitious materials, from cradle to factory gate, is estimated to produce between 800 – 900 kg CO2e/tonne (see: http://cement.mineralproducts.org/documents/Factsheet_18.pdf)

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TABLE 9-10
Ferry CAC Emissions

Ferry CAC Emissions	Base Case (tonnes)
NO_X	11,554
SO_X	191

For vehicles, CAC emissions are dependent on speed, engine type and mode of operation. In order to enable a high level comparison, emissions factors[14] based on estimated fuel consumption have been applied. Estimates of total vehicle CAC emissions by type for the Fixed Link are shown in Table 9-11. As is clear from this Exhibit, CAC emissions from the Fixed Link are considerably higher than under the Base Case over the study period.

TABLE 9-11
Vehicle CAC Emissions

Vehicle CAC Emissions	Base Case (tonnes)	Fixed Link (tonnes)
CO	422	1,604
NO_X	31	8,492
PM_{10}	197	53,920
$PM_{2.5}$	0.184	50.244

Overall, based on the data available, is it estimated that the Fixed Link would result in a decrease in NOx and SO_2 emissions, but an increase in other CAC emissions.

9.5.3 ALR impacts

The Fixed Link does not impact on any Agricultural Land Reserve parcels.

9.5.4 Terrestrial (Flora/fauna) impacts

Potential impacts to plant and 'sensitive' species includes removal, disturbance, alteration, or loss of habitat as a result of construction of the roadway.

Should a detailed environmental assessment be conducted for this project, additional information should be gathered on the unidentified plant and 'sensitive' species.

9.5.5 Aquatic impacts

Impacts to marine species and/or their habitat, may result from construction of permanent bridge piers in False Narrows, as well as temporary works to support construction access along the shoreline. Degradation of marine habitats may result from sedimentation or the introduction of other deleterious substances to the water.

Should a detailed environmental assessment be conducted for this project, additional information should be gathered on the unidentified British Columbia listed species and DFO consulted to avoid or mitigate potential impacts to the fresh water ecosystems.

[14] US EPA Emission Facts (2008) " Average Annual Emissions and Fuel Consumption for Gasoline-Fueled Passenger Cars and Light Trucks" Office of Transportation and Air Quality EPA420-F-08-024 available online at http://www.epa.gov/otaq/consumer/420f08024.pdf

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9.5.6 Archaeological Impacts

Existing archaeological sites have been identified, or are expected, along the entire alignment of the Fixed Link. For the purposes of this analysis, it is assumed that the Fixed Link results in moderate archaeological impacts, recognizing that a full AIA of all affected inland, intertidal, and marine coastal zones would be required prior to any ground disturbance verify the severity of those impacts.

9.6 Economic Development Account

9.6.1 Goods Movement

Benefits to goods movers are largely captured under the Customer Service account. However, for the Fixed Link, added benefit would accrue to movement of gas/propane, dangerous cargo (DC) and livestock. Those are currently restricted to one weekly sailing (on Wednesdays) where no other vehicles are permitted on these sailings. This would likely have advantages in terms of supporting the local island economy which would benefit from reliable and unrestricted access to markets and materials. Thus, the Fixed Link is considered to be highly beneficial relative to the Base Case.

9.6.2 Development Enabled

While the Fixed Link is likely to result in increasing pressure for development on Gabriola Island and Mudge Island, it is assumed that development will occur at the pace and within the limits determined by the respective Island OCPs.

It is also recognized that the Fixed Link could provide a structure to which utilities may be attached, thereby overcoming some of the current water supply and treatment issues which constrain development on Gabriola and Mudge Islands. The Fixed Link could also enable the dismantling of the existing Ferry Terminals at Descanso Bay and downtown Nanaimo thereby freeing up these prime waterfront sites for redevelopment. If the Fixed Link was constructed, the roadway connection via Phoenix Way could potentially assist in realizing development aspirations at Cable Bay by contributing to the resolution of site access issues which are a factor preventing the development of the proposed Waterfront Village at Cable Bay as well as the Cable Bay Waterfront Marina. Thus, the Fixed Link arguably supports redevelopment in this area. Proposed development of Cable Bay includes 2,400 residential units. As well, 45,000 sq. ft. of neighbourhood retail, a 40 suite boutique resort hotel and a marina with 200 slips.[15]

9.6.3 Impacts on Local Businesses

It is considered that the Fixed Link has the potential to bring people to Gabriola Island (owing to improved accessibility), providing an increased customer base for certain types of local businesses, particularly those associated with tourism such as holiday accommodation, restaurants, galleries, and tourist retail. Many island businesses struggle in the off-season and improved access may contribute to their viability and sustainability.

However, this improved accessibility also opens up the off-island (Nanaimo and surroundings) economic and retail opportunities for Island residents. Businesses (such as professional services and grocery stores) which currently provide a mainstay for the local island community, will no longer offer the benefit of convenience. These businesses could lose out to larger operations and lower priced big box stores on Vancouver Island which will be within easier reach of Island residents with the Fixed Link. There is a risk that independent local business could lose out; that there may be a net outflow of money from the local economy; that local jobs may be placed under threat; and that the uniqueness of the local community may be undermined.

[15] See: https://www.nanaimo.ca/assets/Departments/Community~Planning/Offical~Community~Plan~-~10~Year~Review/OCP~Amendment~Applications/OCPApplicationRationale1060PhoenixWay.pdf

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Further investigation is required to assess the impacts on the local economy in greater detail. For the purposes of this analysis it is assumed that the Fixed Link is likely to adversely impact to the local economy of Gabriola Island, owing to the increased accessibility of Nanaimo.

9.7 MAE Summary

Based on the discussion of the various accounts presented in this section, the summary of the Multiple Account Evaluation is presented in Table 9-12.

TABLE 9-12
MAE Summary Table

Accounts		Base Case (Ferry Service)	Fixed Link
FINANCIAL	Capital costs ($ millions)	s.17	216.6
	Operations and maintenance costs ($ millions)		5.4
	Property impacts (number of)		46
CUSTOMER SERVICE	Travel time ($ millions)	43.9	30.2
	Vehicle operating cost ($ millions)	7.0	26.6
	Travel time reliability/ flexibility	98%	100%
	Safety ($ millions)	2.3	6.8
	Multimodal accessibility	◑	◔
	Emergency access	◑	◕
NPV	($ millions)	–	(83.8)
BENEFIT/COST RATIO		–	(0.53)
SOCIAL / COMMUNITY	Alignment with Plans and Policies	◔	○
	Island Identity	◔	○
	Noise	◑	◔
	Visual Impact	◑	◔
	Affordability	–	Tolls equivalent to a ferry fare could generate $ 81.2 million over a 25 year period.
	Recreation	◑	◔
ENVIRONMENT	GHG emissions – travel-related	◑	○
	Air Pollution	◑	○
	ALR Impacts	◑	◑
	Terrestrial (Flora/fauna) impacts	◑	◔
	Aquatic impacts	◑	◔
	Archaeological impacts	◑	◔

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Accounts		Base Case (Ferry Service)	Fixed Link
ECONOMIC DEVELOPMENT	Goods Movement	◑	●
	Development Enabled	◑	◕
	Impact on Local Businesses	◑	◔

Legend:

○	Much Worse
◔	Worse
◑	Neutral
◕	Better
●	Much Better

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Appendix A
Alignment Drawings

FOR ILLUSTRATIVE PURPOSES ONLY

SCALE 0 100 1:10,000 500m

CAD FILENAME CAD FILENAME

DATE MARCH 2015

REV	DATE	REVISIONS	SIGNATURE

BRITISH COLUMBIA

MINISTRY OF TRANSPORTATION AND INFRASTRUCTURE
HEADQUARTERS
HIGHWAY ENGINEERING AND GEOMATICS

SENIOR DESIGNER

DATE YYYY-MM-DD

DESIGNED DESIGNED BY DATE YYYY-MM-DD

QUALITY CONTROL QC BY DATE YYYY-MM-DD

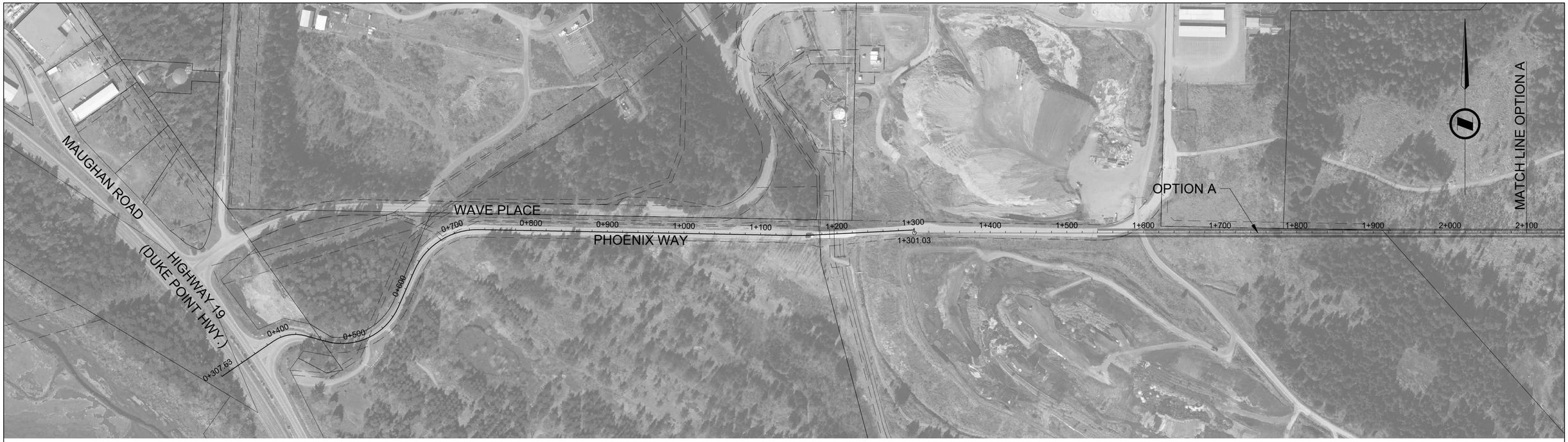
QUALITY ASSURANCE QA BY DATE YYYY-MM-DD

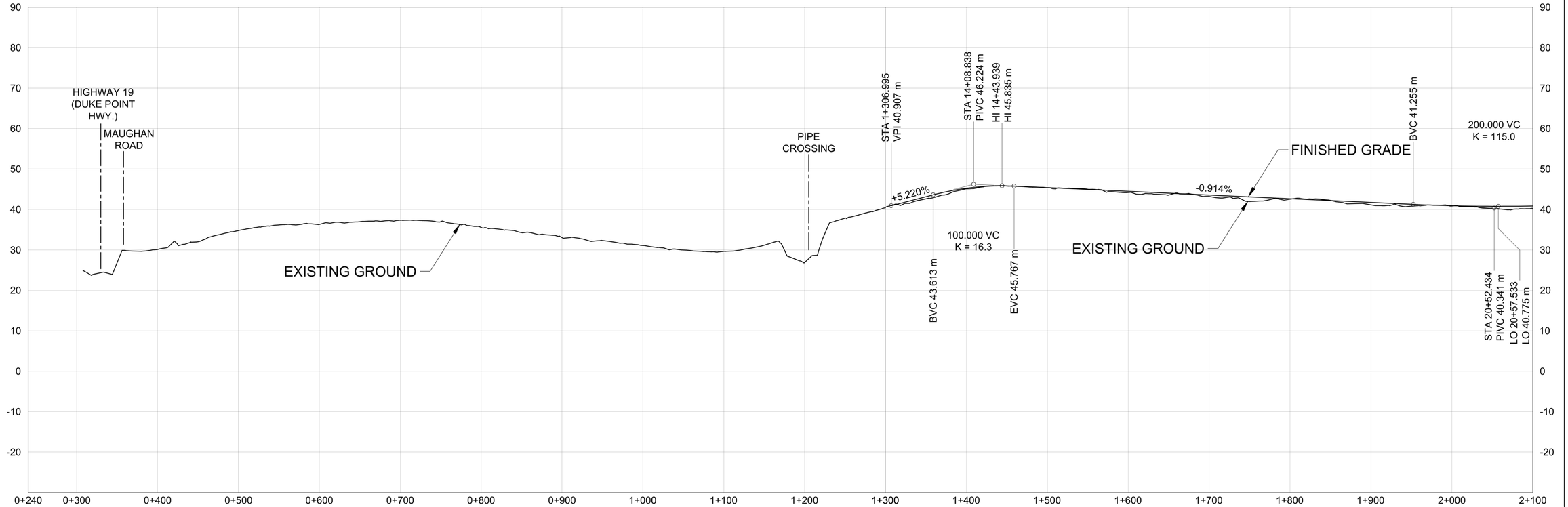
DRAWN DRAWN BY DATE YYYY-MM-DD

GENERAL LOCATION PLAN

GABRIOLA ISLAND STUDY
FIXED LINK OPTIONS

FILE NUMBER	PROJECT NUMBER	REG	DRAWING NUMBER	REV
			1	





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SCALE 0 25 1:2500 125m

CAD FILENAME CAD FILENAME

DATE MARCH 2015

REV	DATE	REVISIONS	SIGNATURE

BRITISH COLUMBIA

MINISTRY OF TRANSPORTATION AND INFRASTRUCTURE
HEADQUARTERS
HIGHWAY ENGINEERING AND GEOMATICS

SENIOR DESIGNER

DATE YYYY-MM-DD

DESIGNED DESIGNED BY DATE YYYY-MM-DD

QUALITY CONTROL QC BY DATE YYYY-MM-DD

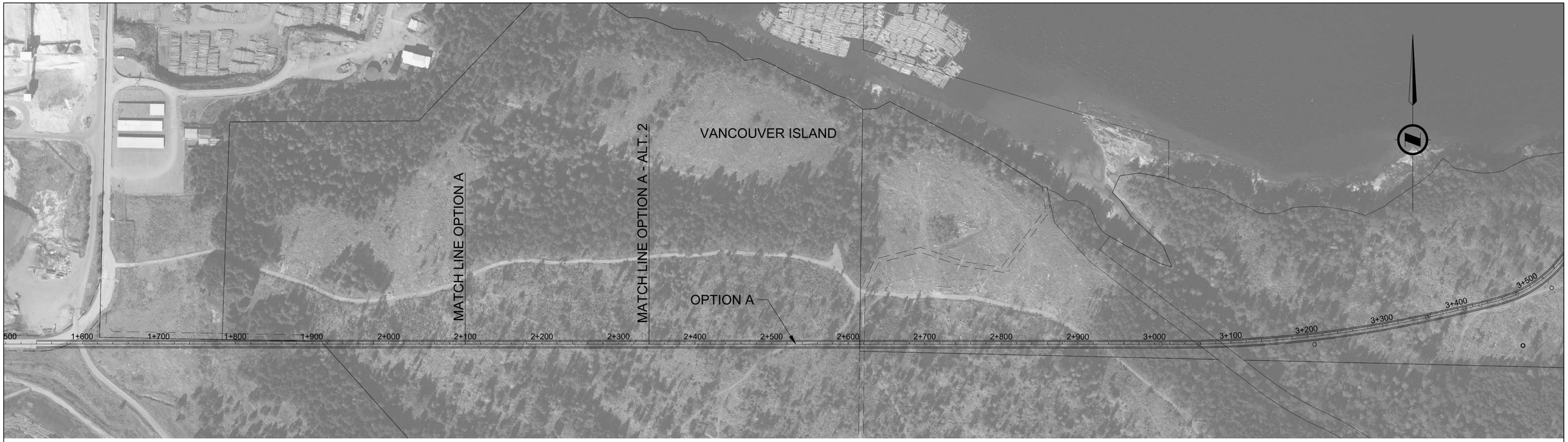
QUALITY ASSURANCE QA BY DATE YYYY-MM-DD

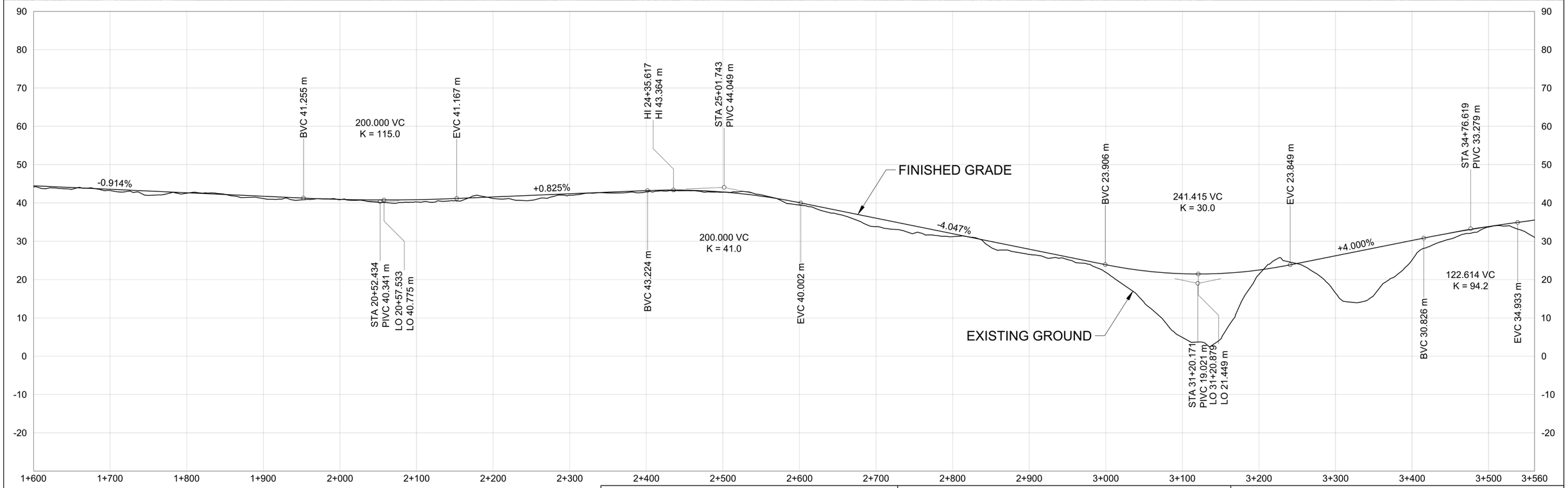
DRAWN DRAWN BY DATE YYYY-MM-DD

PLAN AND PROFILE

GABRIOLA ISLAND STUDY
ROAD OPTION A - SHEET 1

FILE NUMBER	PROJECT NUMBER	REG	DRAWING NUMBER	REV
			2	





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PLAN AND PROFILE

GABRIOLA ISLAND STUDY

ROAD OPTION A - SHEET 2

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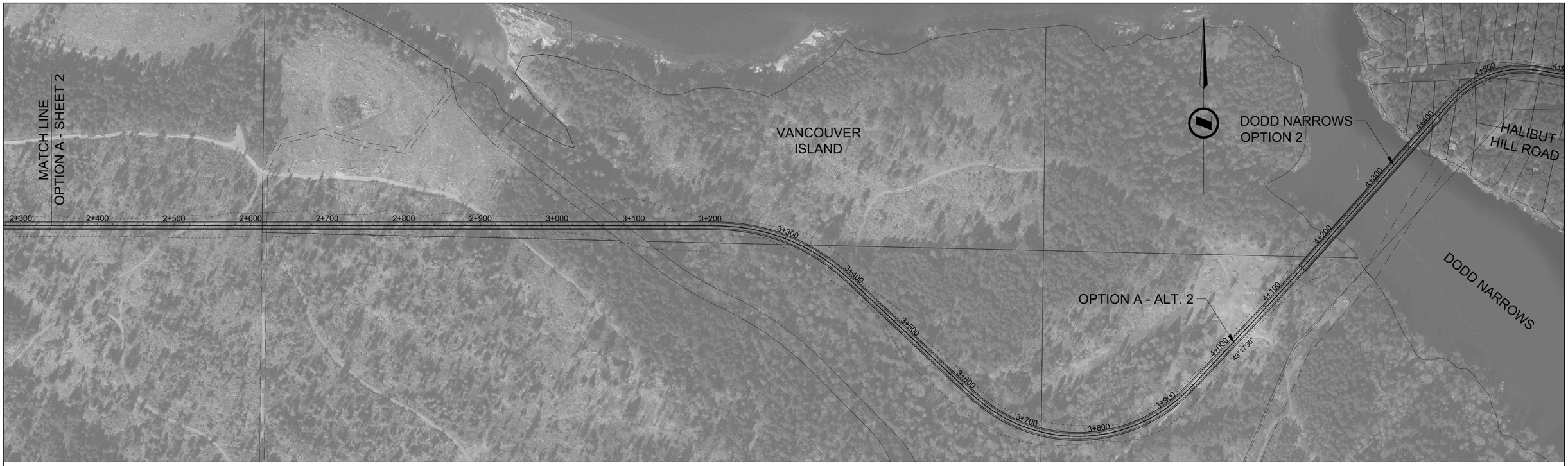

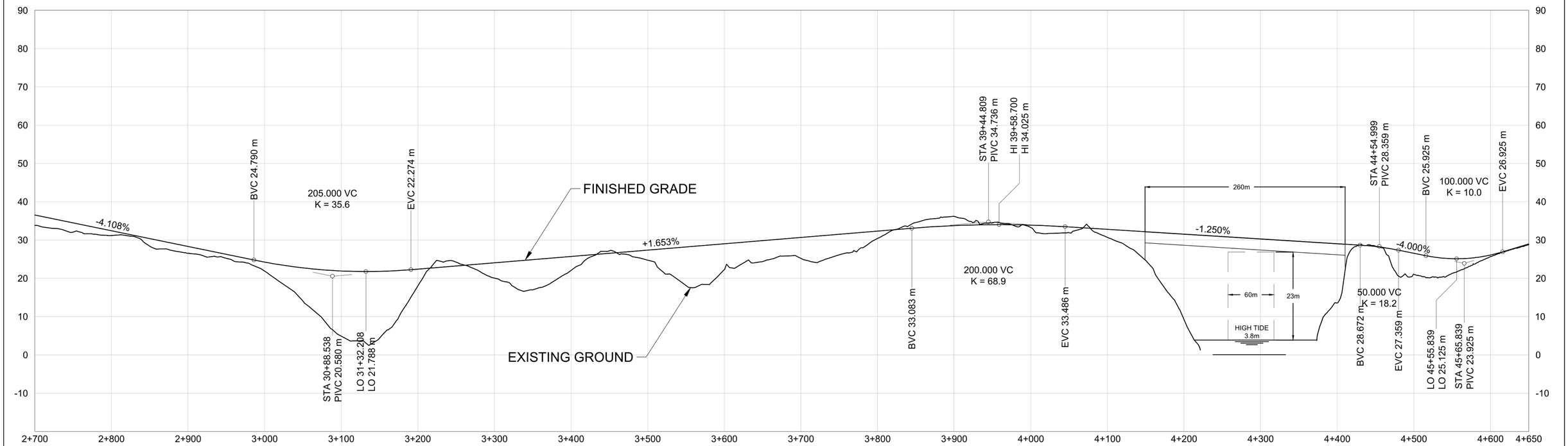

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PLAN AND PROFILE

GABRIOLA ISLAND STUDY
ROAD OPTION A - ALT. 2

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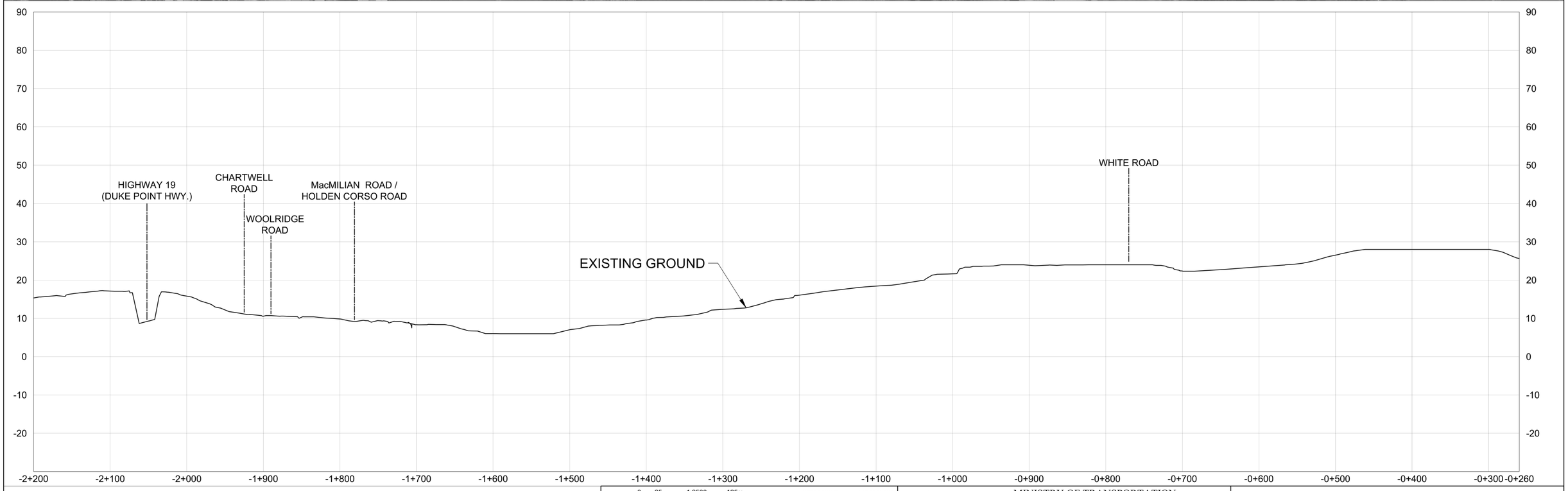

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PLAN AND PROFILE

GABRIOLA ISLAND STUDY
ROAD OPTION B - SHEET 1

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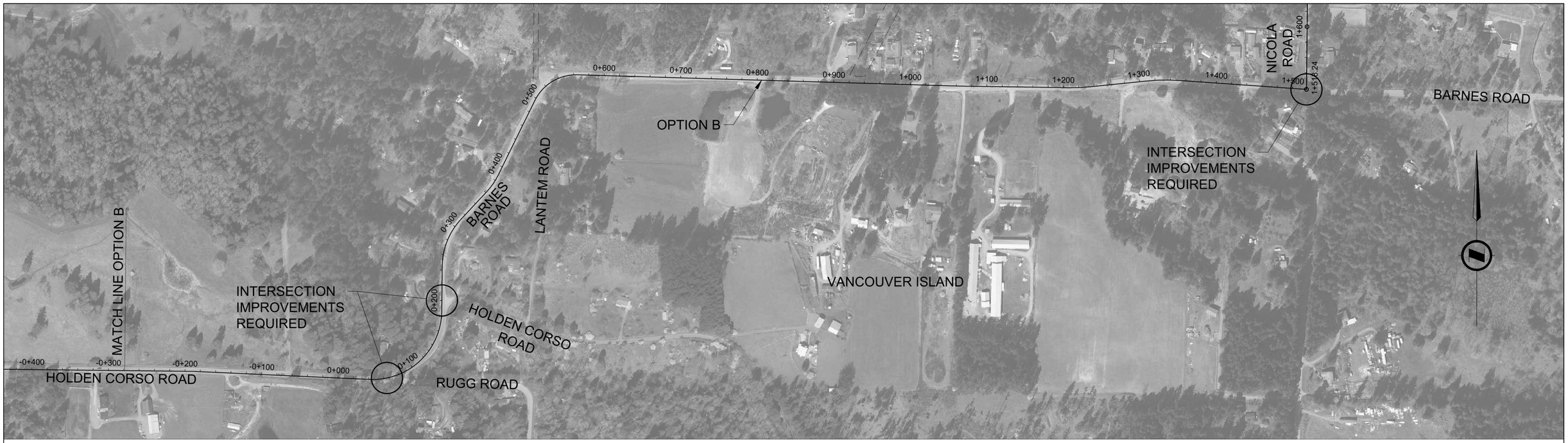

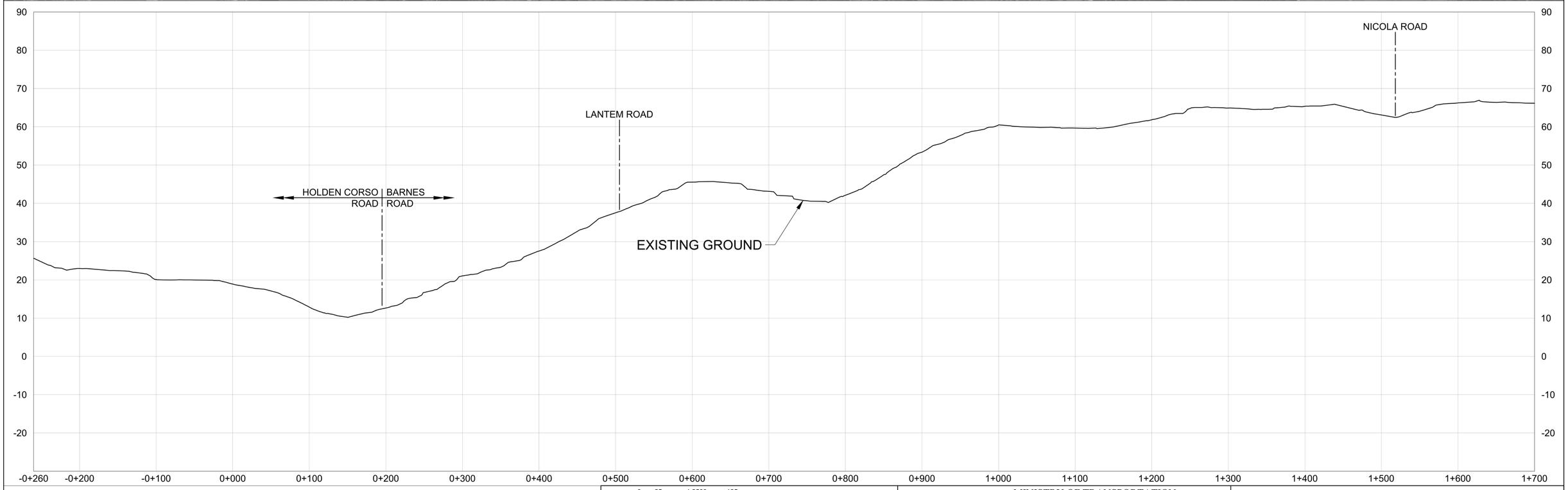

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PLAN AND PROFILE

GABRIOLA ISLAND STUDY

ROAD OPTION B - SHEET 2

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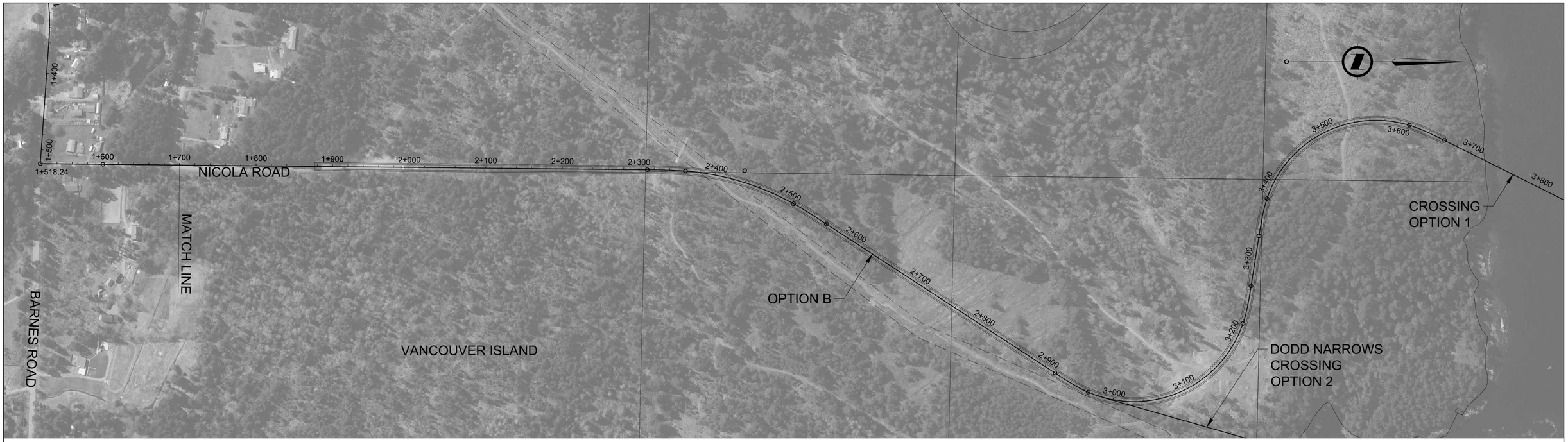

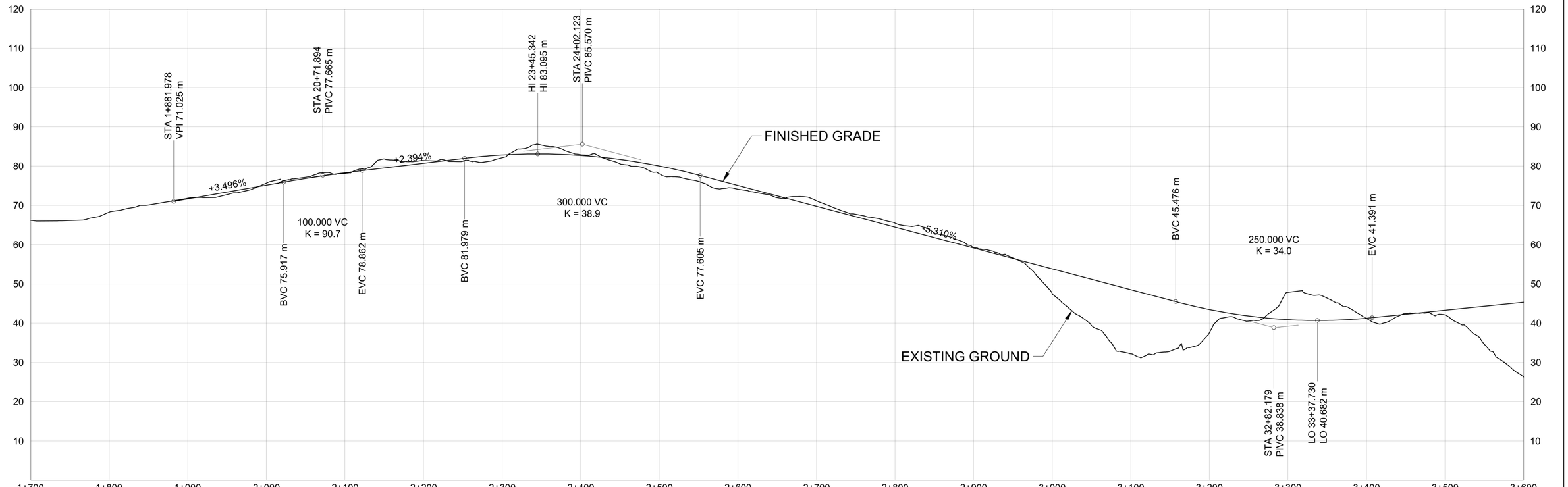

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PLAN AND PROFILE

GABRIOLA ISLAND STUDY
ROAD OPTION B - SHEET 3

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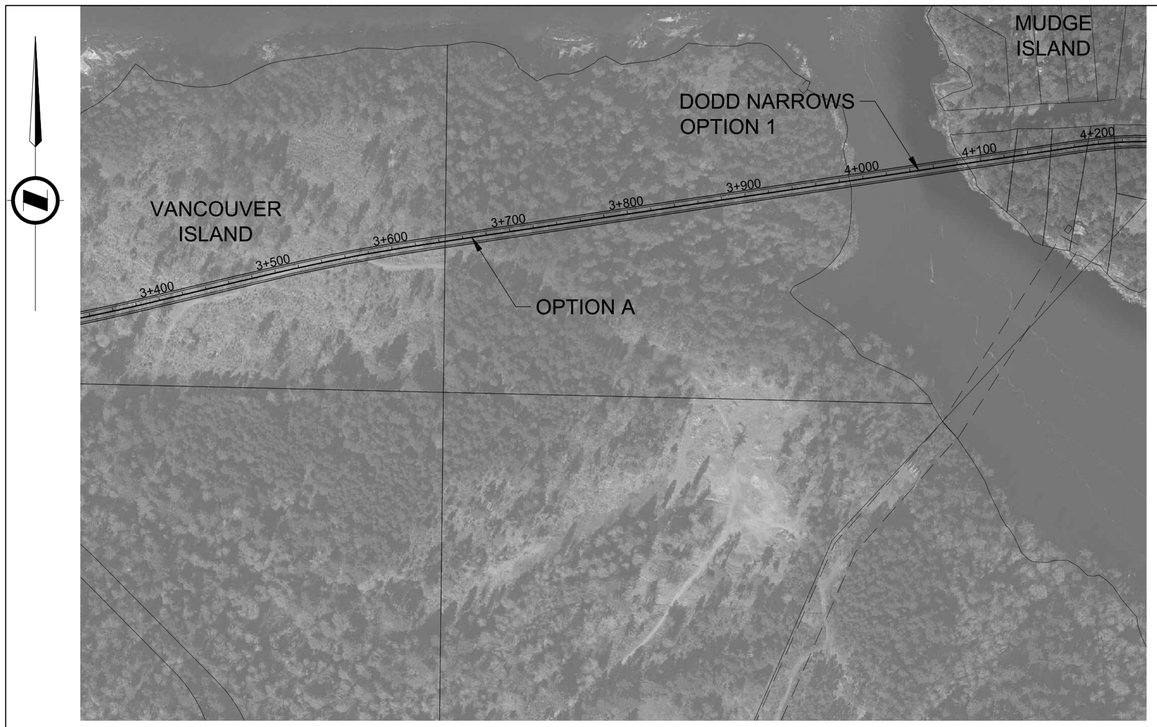

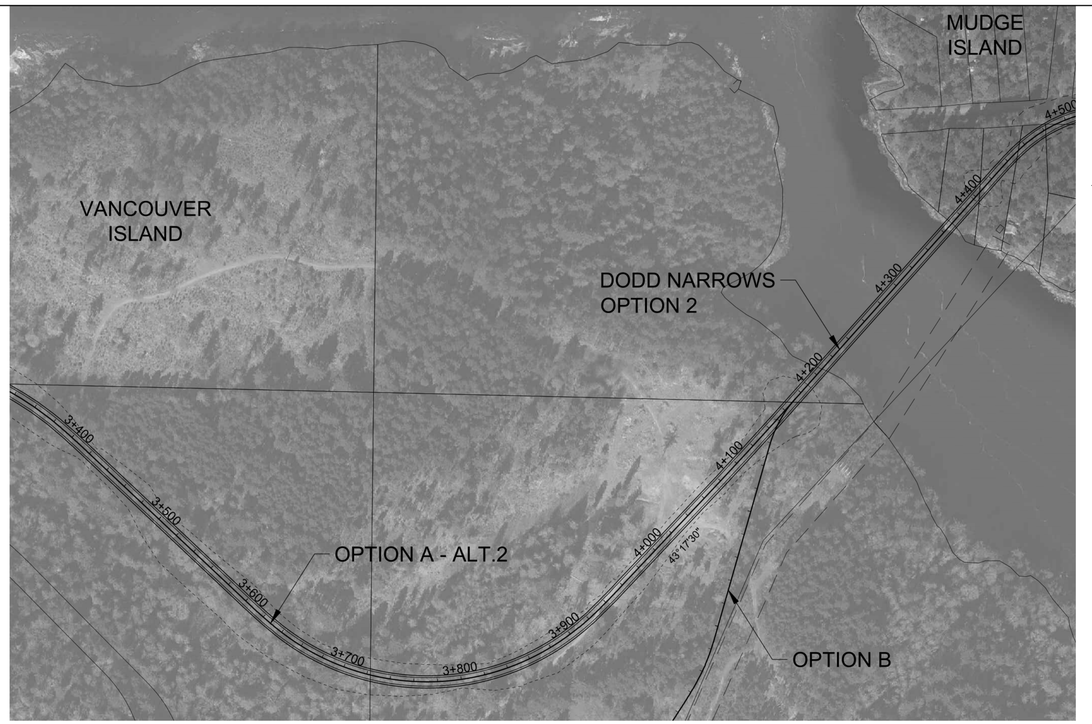

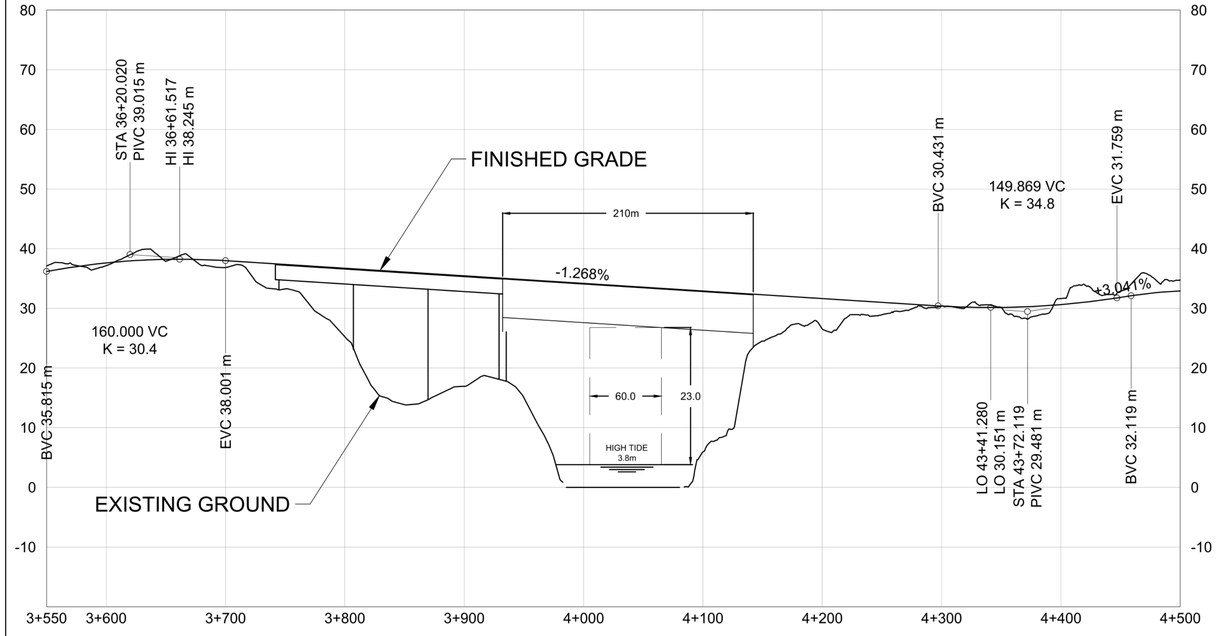

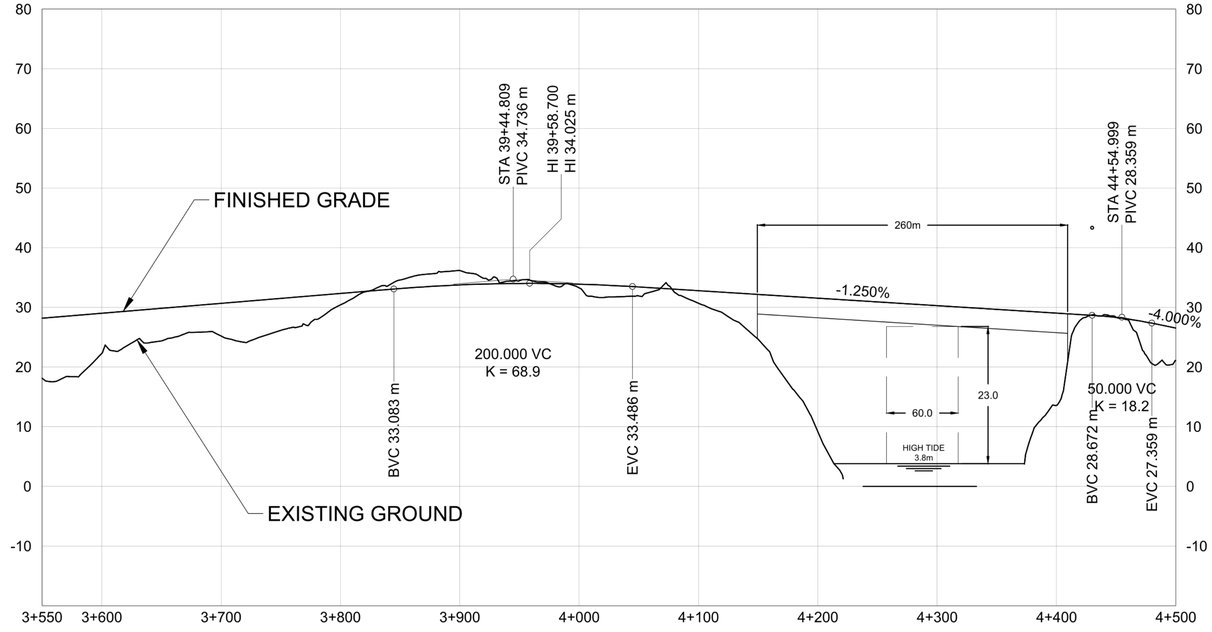

DODD NARROWS CROSSING OPTION 1

DODD NARROWS CROSSING OPTION 2

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PLAN AND PROFILE

GABRIOLA ISLAND STUDY
DODD NARROWS CROSSING OPTIONS

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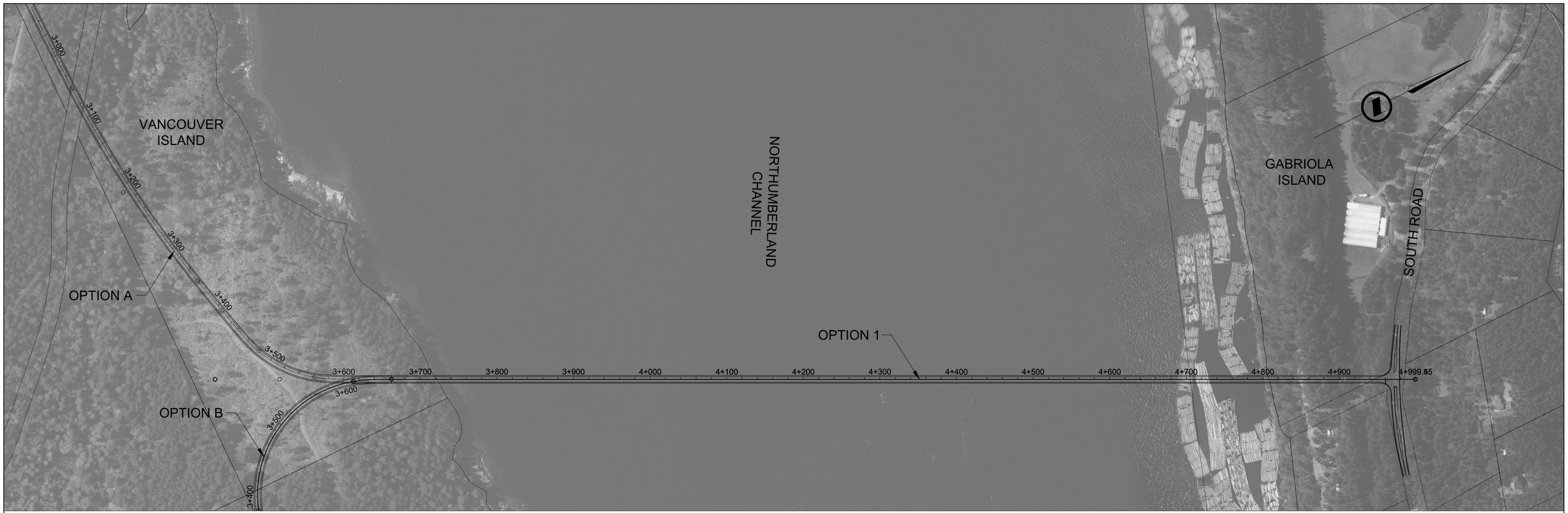

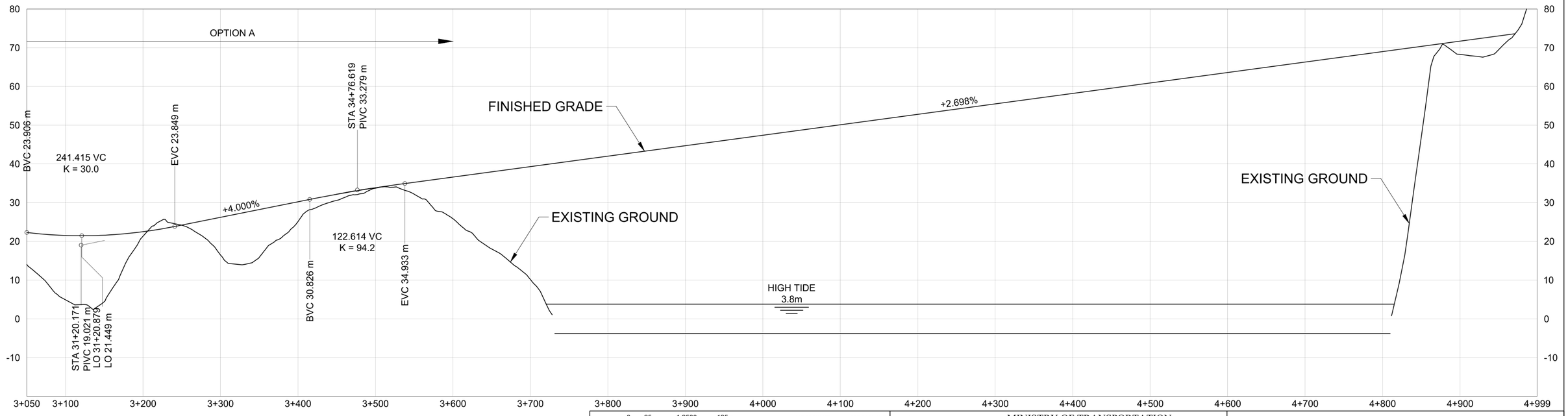

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PLAN AND PROFILE
GABRIOLA ISLAND STUDY
CROSSING OPTION 1

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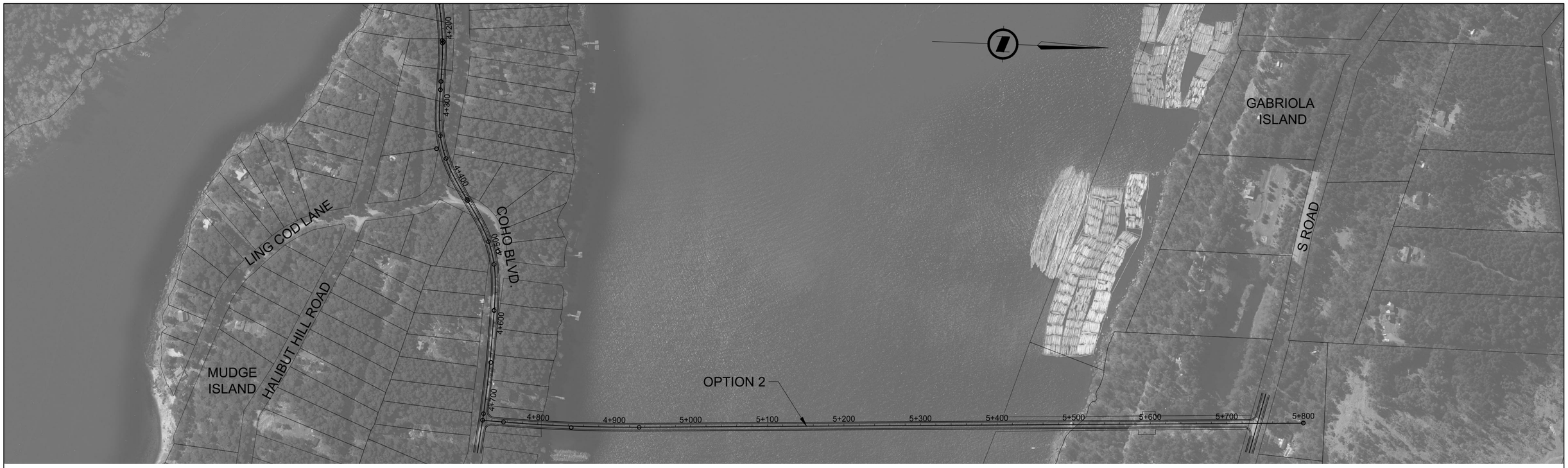

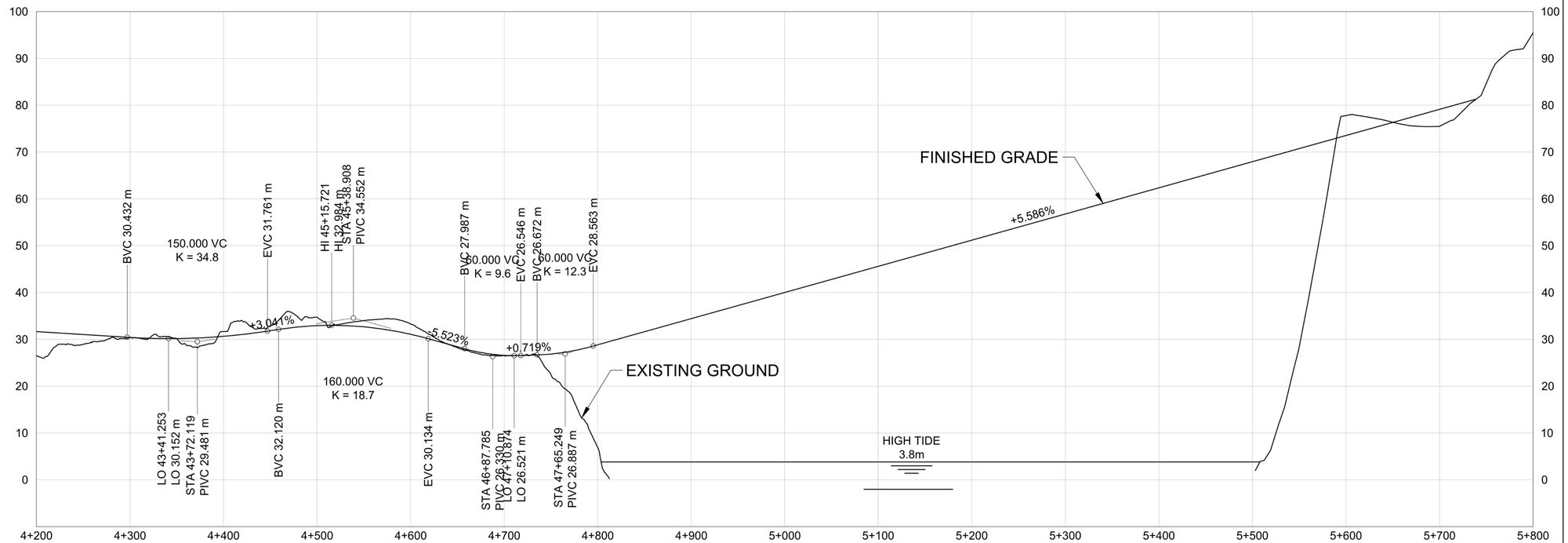

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PLAN AND PROFILE
GABRIOLA ISLAND STUDY
CROSSING OPTION 2

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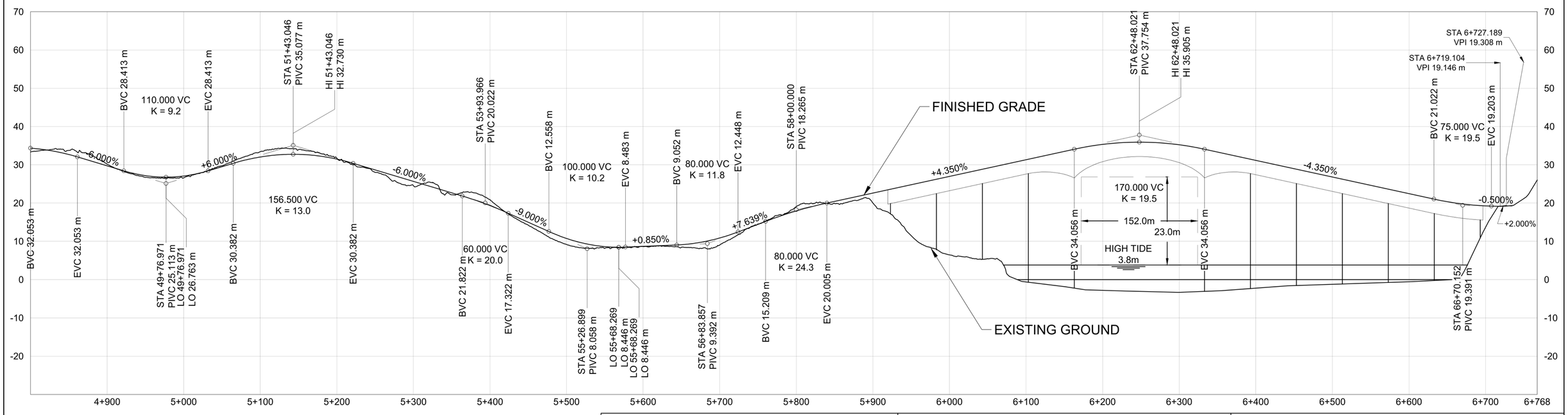

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PLAN AND PROFILE

GABRIOLA ISLAND STUDY
CROSSING OPTION 3 - HIGH PROFILE CROSSING

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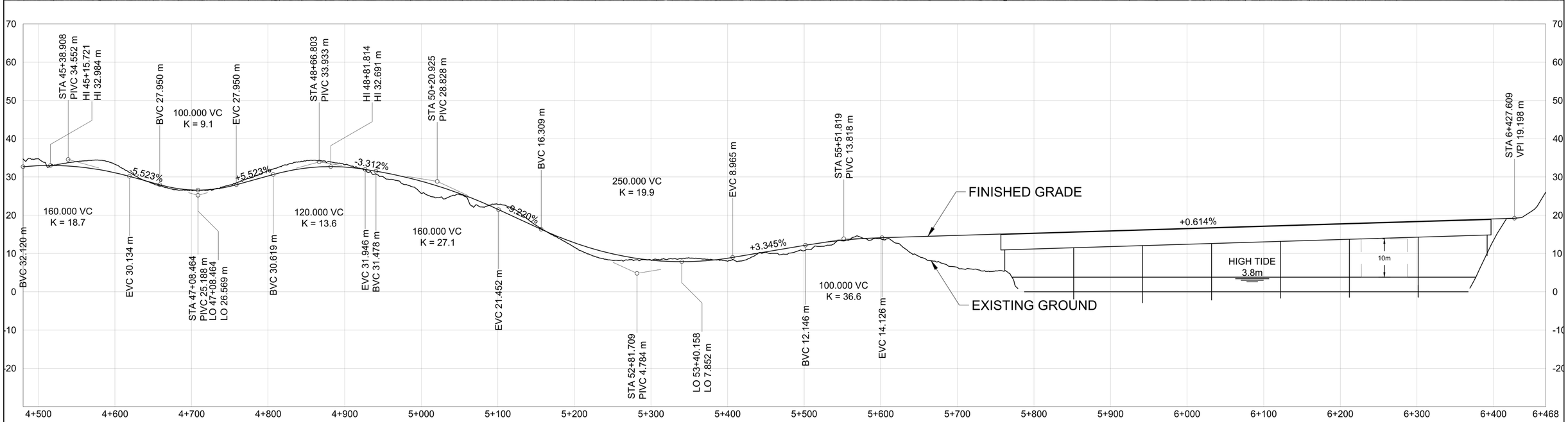

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HEADQUARTERS

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PLAN AND PROFILE

GABRIOLA ISLAND STUDY

CROSSING OPTION 3 - LOW PROFILE CROSSING

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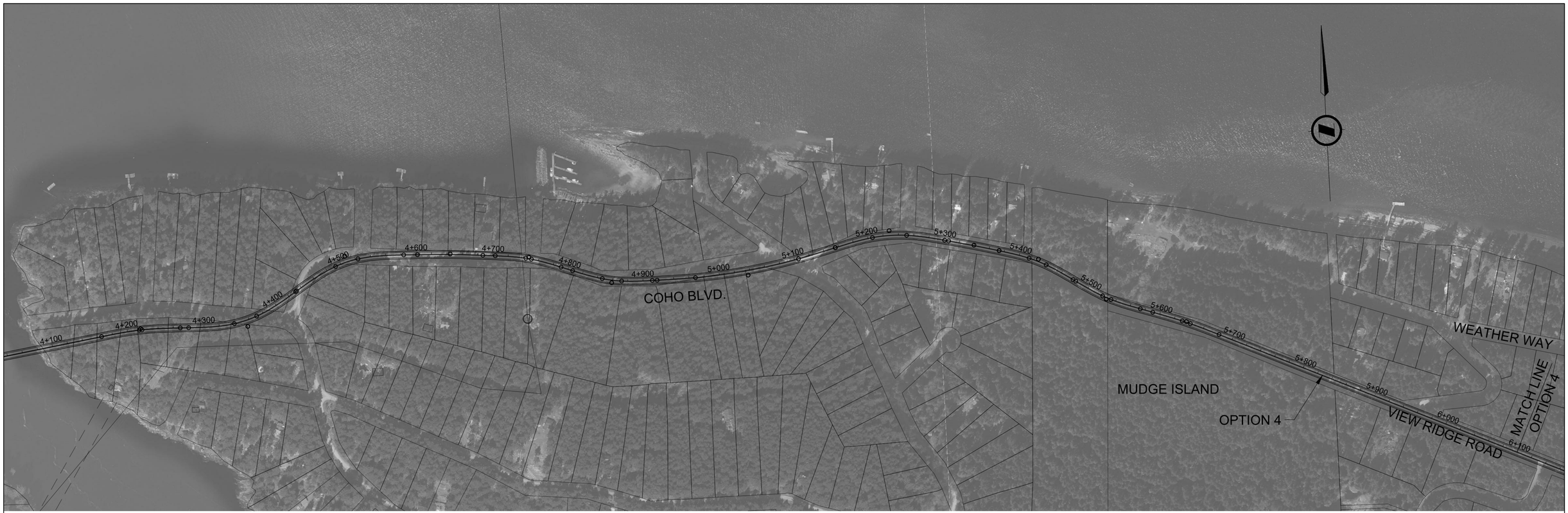

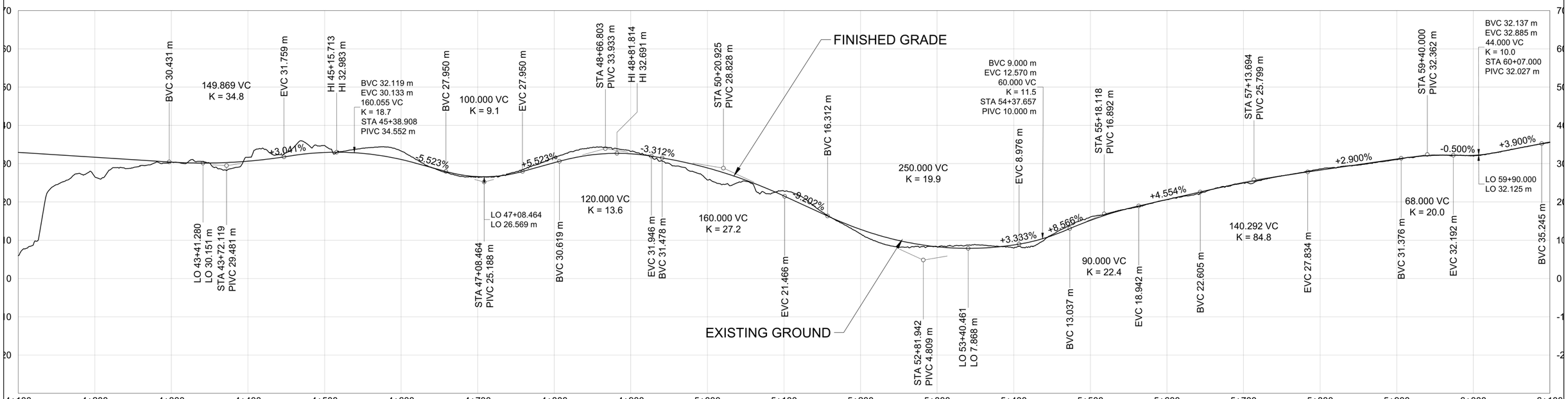

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PLAN AND PROFILE

GABRIOLA ISLAND STUDY

CROSSING OPTION 4 - SHEET 1

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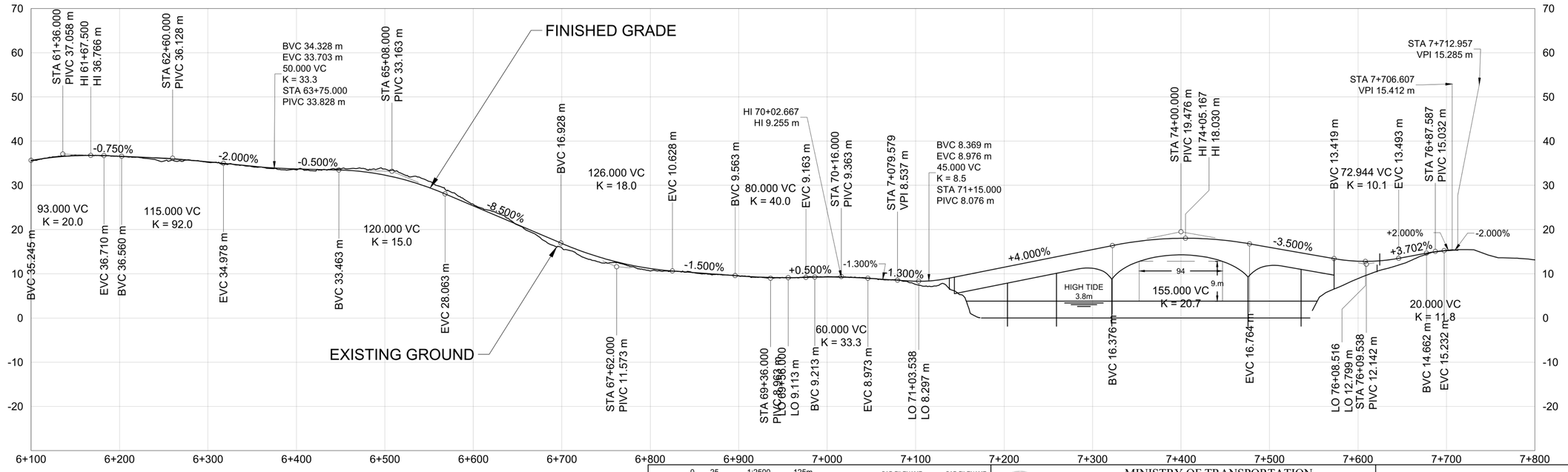

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PLAN AND PROFILE

GABRIOLA ISLAND STUDY

CROSSING OPTION 4 - SHEET 2

FILE NUMBER	PROJECT NUMBER	REG	DRAWING NUMBER	REV
			14	

Appendix B
Geotechnical Assessment

THURBER ENGINEERING LTD.

March 4, 2015 File: 17-834-185

CH2M HILL
Metrotower II, Suite 2100, 4720 KIngsway
Burnaby, BC V5H 4N2

Attention: Bernard Abelson, P.Eng.
Project Engineer

GABRIOLA FIXED LINK FEASIBILITY STUDY
GEOTECHNICAL INPUT

Dear Bernard:

As requested, Thurber Engineering Ltd. (Thurber) has completed a site reconnaissance and desktop study for the Gabriola Fixed Link Feasibility Study. This letter summarizes the results of the site reconnaissance and desktop study, and provides preliminary geotechnical recommendations to aid the conceptual design.

It is a condition of this letter that Thurber's performance of its professional services is subject to the attached Statement of Limitations and Conditions (SoLC). As noted in Item 4 of the SoLC, the report was prepared for the Client (CH2M Hill). Thurber also appoints the other members of the CH2M Hill design team and the Ministry of Transportation and Infrastructure (MoTI) as approved users of the report as described in Item 4 of the SoLC.

DRAFT

1. INTRODUCTION

We understand that MoTI requires an updated assessment of the technical feasibility of constructing a fixed link to Gabriola Island. The intent of the fixed link is to eliminate the requirement for a ferry connection to Vancouver Island. Previous studies, completed in 1972 and 1993 when new ferry terminals were being considered at the south end of Gabriola Island, contemplated bridges over Dodd Narrows and False Narrows to connect to the Island Highway and now to Duke Point Highway south of the former Harmac facility.

Four alignment alternatives (Options 1 to 4) are under consideration to connect Gabriola Island to the Island Highway south of Nanaimo as shown on Dwgs. 17-834-185-1 to -4. The four options start on Vancouver Island with connections to Phoenix Way near Harmac to the west and Nicola Road to the south and ultimately tie into South Road on Gabriola Island as shown. Option 1 includes a single bridge crossing of Northumberland Channel from Vancouver to Gabriola Island whereas the remaining three options include a short bridge over Dodd Narrows to Mudge Island and with Option 2 crossing Northumberland Channel west of Percy Anchorage, Option 3 crossing Percy Anchorage and Option 4 crossing the east end of False Narrow.

Our scope of work in this phase of the project is to complete a desktop study and prepare a brief report summarizing the general geotechnical conditions along the contemplated alignments,

identifying potential geotechnical-related risks for design and construction of the roadway, bridges and approaches, and to provide preliminary recommendations to mitigate such risks based on available existing geotechnical information.

2. BACKGROUND INFORMATION

Available information is limited to surficial and bedrock geology. Information sources are summarized below.

1. Surficial geology, Map 27-1963, Sheet 92 G/4 and 92 F/1 East, Geological Survey of Canada.
2. Surficial geology and shaded seafloor relief, Naniamo, British Columbia, Geological Survey of Canada, Map 2118A.
3. BC Ministry of Energy and Mines Geological Survey Branch Open File 1998-07 Geology of the Naniamo Coal Field, British Columbia, NTS 92G/4.
4. Doe, N.A. 2000. Sandstone and Shale – Gabriola's origins, SHALE 1, pp. 26-35.
5. BC Ministry of Environment, Water Stewardship, Ground Water Resources of British Columbia, Chapter 9 — Ground Water Resources of the Basins, Lowlands and Plains, Section 9.1.2 Naniamo and Georgia Lowlands.
6. Salish Sea Pilot, A Cruiser`s Guide to Anchorages & Marinas, 2014, 82 pages.

3. PROGRAM OF WORK

Thurber conducted a site reconnaissance of the Vancouver Island portion of the alignment on Novemer 27, 2014 and completed a desktop study in preparation of this report.

DRAFT

4. FINDINGS

4.1 Site Reconnaissance

The general area was visually assessed by automobile followed by a hike into Joan Point at Dodd Narrows via the Cable Bay Trail system accessed from Nicola Road. During the hike to Joan Point, generally undulating terrain with frequent bedrock exposures were observed. Depending on where the alignment crosses the creek that drains into Cable Bay, a small bridge may be required. Photo 1 shows the rock at Joan Point and Photo 2 shows the gently dipping rock at Purvis Point on Mudge Island.

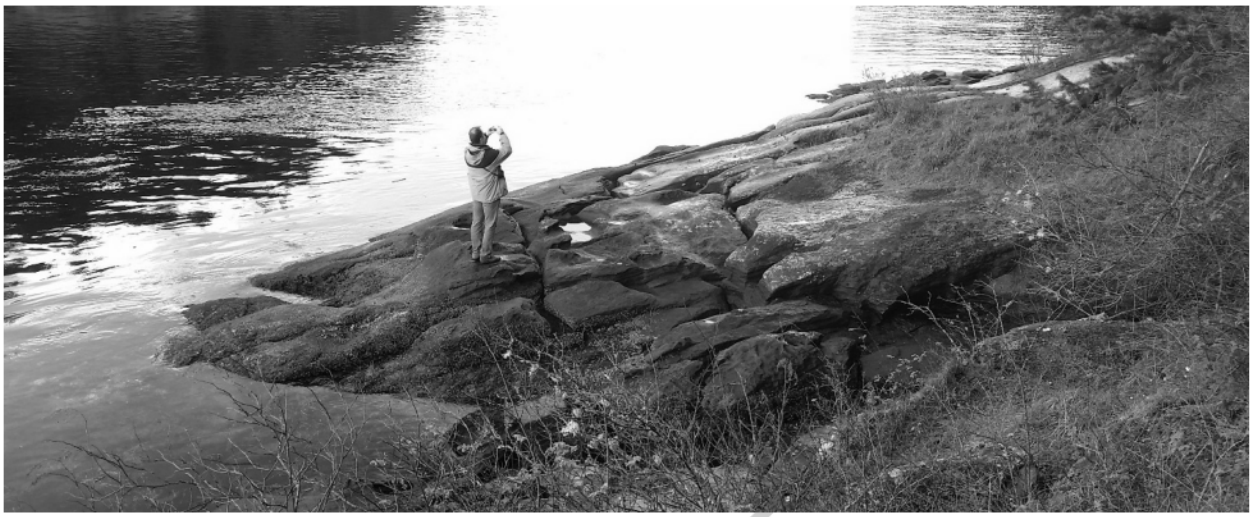

Photo 1. Sandstone exposure at Joan Point.

Photo 2. Bedrock exposure at Purvis Point on Mudge Island. Note that an existing road ties into the mossy area in the photo.

As described in “The geology of Southern Vancouver Island, A field guide” by C.J. Yorath and H.W. Nasmith, 1995, “Southeastern Vancouver Island and the Gulf Islands are largely composed of sedimentary rocks deposited during the latter stages of the cretaceous period between eighty-five and sixty-five million years ago. These strata are included in the Nanaimo Group, which is divided into nine formations consisting of various combinations of conglomerate, sandstone, siltstone, shale and coal. In the Nanaimo area these strata are horizontal or very gently dipping; however, in the Gulf Islands they have been formed into a series of northwesterly trending folds and thrust faults.”

The surficial geology of the area generally consists of marine veneer over bedrock, with the exception of the thick fluvial deposits associated with the Nanaimo river delta. Document 1 indicates that foundation conditions along the alignments are anticipated to consist primarily of

relatively thin overburden deposits overlying bedrock and that, in lowland and marine areas, thicker deposits of soft, fine grained deposits may be present.

Only limited submarine geotechnical information is available for the crossings alignments. Dodd Narrows is a relatively deep, navigation channel and will likely require an elevated structure that completely spans the channel. However, Percy Anchorage is up to about 24 m depth and, as indicated in Document 6, is underlain by recent deposits comprised of gravel and mud. False Narrows is relatively shallow and it appears that it may be underlain by recent soil deposits. We also infer that portions of Northumberland Channel are likely underlain by recent soil deposits.

5. ENGINEERING ASSESSMENT AND PRELIMINARY RECOMMENDATIONS

5.1 General

This section summarizes the results of our desktop study and site reconnaissance. For conceptual design purposes, we have assumed that the bridge crossings will be designed in general accordance with CAN/CSA S6-06, which contemplates a 1:475 year design earthquake, and that the proposed structures will be supported on pile foundations. Conceptual recommendations for design of rock cuts and embankment construction are based on our experience with similar site conditions.

DRAFT

5.2 Seismic Design

5.2.1 Site Response Spectrum

Natural Resources Canada's seismic hazards calculation website was used to predict peak firm ground accelerations equal to 0.273g for the 1 in 475 year earthquake (10% probability of exceedance in 50 years). The output from the calculator is attached. Based on the findings of our desktop study and site reconnaissance, the site condition for upland bridge foundations is classified as Soil Profile Type I following the CAN/CSA-S6-06 bridge code. The corresponding Site Coefficient (S) per Table 4.4 is 1.0. For marine foundations, it will be necessary to determine the nature and thickness of overburden present.

5.2.2 Seismic Liquefaction

Where present, recent deposits in Northumberland Channel, Percy Anchorage and False Narrows will likely be susceptible to seismic liquefaction. The nature and thickness of these deposits will have to be determined in the next phase of the work to assess the potential impacts to foundation design. For conceptual design purposes, it should be assumed that all structural loads will be transferred to bedrock.

THURBER

5.3 Bridge Foundations

Bridge foundations for the various crossings will likely require rock socketed piles. Depending on seismic load requirements, pile embedment length may be controlled by lateral fixity requirements rather than vertical compression resistance requirements. Construction of rock socketed piles typically requires advancing steel casings by drilling techniques to the bedrock surface with a socket formed below. After clean out, reinforcing steel is placed and then the socket and pile casing filled with concrete. All load transfer is typically assumed to be from concrete to rock in shear along the socket length.

The design bond stress between the concrete and the walls of the socket will be a function of the concrete compressive strength, rock strength, and degree of fracturing. We expect that it will be difficult to advance the steel casing sufficiently far into the rock to effect a total cutoff of seepage into the hole. As such, we suggest that the design and construction anticipate water seepage into the socket. This will require maintaining water in the casing and placement of concrete using good tremie techniques.

Rock socket design should anticipate weathering, fracturing, sloping rock conditions and the usual challenges of cleaning from the base of the socket. Further, if it is apparent during installation that the rock slope is steep, that there is a considerable amount of muck that cannot be cleaned from the socket, or that the concrete will be contaminated for one reason or another, then the socket should be lengthened accordingly.

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Very high loads are typically attainable with socketed caissons. Typically, the full structural resistance of a pile sections can be developed. The uplift resistance on socketed piles is governed by fracture in the rock mass and not simply by the bond length. Generally, the full uplift resistance can be developed, but the socket length is partially a factor of the proximity of other piles and must be reviewed during detailed design.

Inspection of the rock socket construction during drilling and after completion of the drilling is important to confirm that the rock conditions are as anticipated, that the sidewalls of the rock socket have been adequately cleaned, and that the required length of the socket has been obtained. The need to increase the socket length due to steeply sloping rock or inadequate cleaning of the base of the socket can only be made by an experienced inspector. For relatively shallow and dry installations, the visual inspection of the completed socket can be made using a lamp and or mirror. Deeper installations, or shallow installations where significant groundwater seepage is occurring, typically require inspection using an underwater colour camera.

5.4 Bedrock Cuts

5.4.1 Rock Cut Slope Angle

We have reviewed the regional bedrock geology mapping and information from our files for the Duke Point Ferry Access road to develop preliminary recommendations for the conceptual design.

The following assessment is not based on any site specific observations and should be considered general only. We have not been provided with details such as rock cut heights, cut slope orientations or previous studies by others. A specific bedrock mapping program will be necessary to confirm our assumptions and finalize the rock cut geometry.

The Decourcy and Gabriola Sandstone units are anticipated to consist of medium grained, massive to blocky, medium strong to strong rock. Bedding is anticipated to be the predominant discontinuity set with orthogonal secondary and tertiary jointing. The bedding is typically relatively flat lying (<20° dip) and dips of about 75° to 90° are anticipated for the orthogonal joint sets.

The design rock cut slope angle geometry attempts to balance the excavation volume and construction footprint versus the potential for kinematic instability (due to wedges, daylighting planes and toppling) and the need for stabilization. We recommend using rock cut slope angles of 0.25H:1V for conceptual design. Flatter slopes may be required if the regional jointing in the sandstone is steeper than about 30° or in zones of weaker rock types such as shale, siltstone or coal (if encountered).

It should be assumed that higher cut slopes (i.e. greater than 10 m) will likely require scaling and some rock bolting to stabilize potential daylighting planar blocks and wedges. In addition, localized shotcrete and steel mesh may also be required in more fractured or weathered areas.

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5.4.2 Rock Cut Slope Catchment Ditch Design

Typically, the minimum rockfall catchment ditch width design is based on the following documents:

- "MoTI Technical Bulletin GM02001 (Rock Slope Design)" dated September 17, 2002
- "Rockfall Containment for Rock Cuts Highway 99 – Horseshoe Bay to Whistler", submitted to MoT by Wyllie & Norrish Rock Engineers in October 2002
- "Evaluation of Rockfall and Its Control." by Ritchie in 1963, "Discussion on Rockfall Protection Measures" by P.G.D. Whiteside in 1986
- "Rockfall Catchment Design Guide" for Oregon Department of Transportation in 2001.

For conceptual planning purposes, the MoTI Technical Bulletin GM02001 provides a description of catchment ditch geometry and a table of preliminary catchment widths based on slope height. The recommended catchment widths in the MoTI document may require modification during detailed design based on the results of the investigation, analysis and construction geometry.

All rock slopes should be constructed in accordance with standard MoTI practice that includes smooth wall controlled blasting techniques (pre-shearing), rock scaling and spot rock bolting.

5.4.3 Soil Cuts above Bedrock Cut Slopes

In locations where overburden will be encountered at the top of rock cut slopes, an assessment will be required to determine the appropriate slope angle. If topography limits the height of the

slope, we expect that it will likely be feasible to cut the material to slopes of between 1.5H:1V to 2H:1V. The standard MoTI design section also requires a 3 m wide horizontal bench between the top of rock cut and the toe of the soil cut above.

Where thin overburden soils combined with steep slopes are encountered above the top of bedrock cuts, very high sliver cuts can be required in the overburden unless a retaining wall is constructed above the bedrock cut or an anchored mesh system such as Tecco Mesh is used to retain the soil.

5.4.4 Coal Mines

The greater Nanaimo area is known for the presence of coal mines that were excavated in the 1800s and early 1900s. Our cursory review of the mine records database suggests that there are no recorded mines in the vicinity of this project. However, it should be noted that there is potential for undocumented mines to exist in this area and any future design should consider the possibility of coal mine existence.

5.4.5 Metal Leaching and Acid Rock Drainage (ML-ARD)

Although we are not currently aware of any significant ML-ARD issues in the Nanaimo area, MoTI standard practice requires a screening level assessment is completed for all bedrock excavations that exceed 1000 m^3 of material in accordance with Technical Circular T04/13. As such, an assessment will be required in the preliminary design phase of this project. In general, sandstone (the primary anticipated rock type) would be anticipated to represent a low to moderate risk of ML-ARD generation. Shale and coal deposits (if encountered) would represent a moderate risk of ML-ARD generation.

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5.5 Soil Cut Slopes

Soil cut slopes in granular or till-like soils should typically be cut at a slope angle of 1.5H:1V or flatter. If fine grained soils are encountered locally, they will have to be assessed on a case by case basis.

It is important that adequate measures be provided during construction to prevent erosion of cut slopes during periods of heavy rainfall, snow melt or runoff. Erosion control measures should be implemented in accordance with the BC MoT “Manual of Control of Erosion and Shallow Slope Movement (1997)”.

Excavated slopes should be vegetated immediately following excavation. Seepage from overburden slopes may occur locally and can only be identified during excavation. Where such seepages are encountered, drainage measures should be installed. Seepage zones should be excavated to shallow depth and resloped with shotrock to match the adjacent cut slope. A geosynthetic should be placed over the overburden prior to placement of the rock fill.

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5.6 Embankments

General fill construction should be carried out in accordance with the Standard Specifications for Highway Construction, Sections 201.36 and 201.37. Embankments will generally be constructed of either blast rock fill or suitable earth backfill. Where encountered, we recommend that silt and clay material not be used in embankment construction.

Fills constructed on slopes steeper than 3H:1V should be constructed with rock fill and have their toes keyed into the slope. The keys should be constructed by excavating a horizontal bench at the toe of the fill such that the fill toe has a minimum horizontal width of 5 m. If solid bedrock is encountered before the 5 m horizontal width is reached, field assessment will be required. Benching should also be done on existing slopes to create horizontal terrace widths of at least 1.5 m.

Earth embankments should generally be constructed in accordance with SS201.37. For fill materials with less than 35% material passing the No. 200 (0.075 mm) sieve, the slopes can be constructed at 1.5H:1V to 2H:1V depending on the desired level of performance. Fill materials with greater than 35% material passing the No. 200 (0.075 mm) sieve will need to be constructed with 2H:1V or flatter slopes.

Blast rock embankments can typically be constructed at 1.5H:1V slopes. In some locations it may be preferable to use steeper slopes to fit the existing topography. These locations will have to be assessed on a case by case basis.

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6. SUPPLEMENTARY WORK DURING PRELIMINARY DESIGN

Once an alignment has been selected, we recommend that a detailed marine investigation be undertaken. The investigation should include detailed bathymetry, seismic profiling and test hole drilling at select locations to determine the nature and thickness of overburden and sufficient information regarding the nature and quality of the bedrock for design of rock sockets.

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

David J. Tara, P.Eng.
Project Engineer

Attachment: Statement of Limitations and Conditions

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.

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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.

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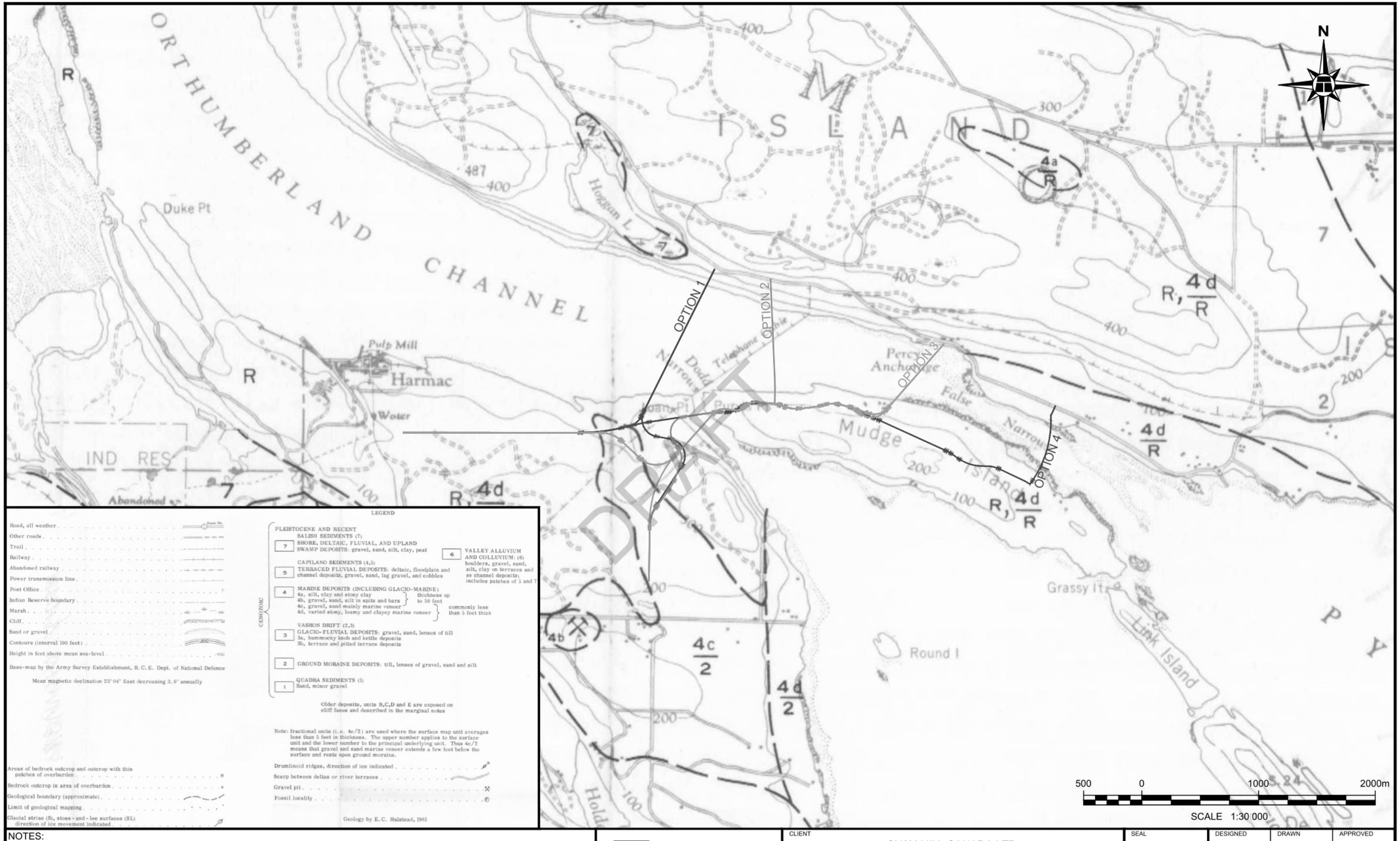
Plotted: Feb 27, 2015



LEGEND

Road, all weather
Other roads
Trail
Railway
Abandoned railway
Power transmission line
Post Office
Indian Reserve boundary
Marsh
Cliff
Sand or gravel
Contours (interval 100 feet)
Height in feet above mean sea-level

Base-map by the Army Survey Establishment, R. C. E. Dept. of National Defence

Mean magnetic declination 23° 04' East decreasing 3.0' annually

CENOZOIC

PLEISTOCENE AND RECENT

7 SALISH SEDIMENTS (7)
SHORE, DELTAIC, FLUVIAL, AND UPLAND SWAMP DEPOSITS: gravel, sand, silt, clay, peat

6 VALLEY ALLUVIUM AND COLLUVIUM: (6) boulders, gravel, sand, silt, clay on terraces and as channel deposits; includes patches of 5 and 7

CAPILANO SEDIMENTS (4,5)

5 TERRACED FLUVIAL DEPOSITS: deltaic, floodplain and channel deposits, gravel, sand, lag gravel, and cobbles

4 MARINE DEPOSITS (INCLUDING GLACIO-MARINE)
4a, silt, clay and stony clay } thickness up
4b, gravel, sand, silt in spits and bars } to 50 feet
4c, gravel, sand mainly marine veneer } commonly less
4d, varied stony, loamy and clayey marine veneer } than 5 feet thick

VASHON DRIFT (2,3)

3 GLACIO-FLUVIAL DEPOSITS: gravel, sand, lenses of till
3a, hummocky knob and kettle deposits
3b, terrace and pitted terrace deposits

2 GROUND MORAINE DEPOSITS: till, lenses of gravel, sand and silt

1 QUADRA SEDIMENTS (1)
Sand, minor gravel

Older deposits, units B,C,D and E are exposed on cliff faces and described in the marginal notes

Note: fractional units (i. e. 4c/2) are used where the surface map unit averages less than 5 feet in thickness. The upper number applies to the surface unit and the lower number to the principal underlying unit. Thus 4c/2 means that gravel and sand marine veneer extends a few feet below the surface and rests upon ground moraine.

Areas of bedrock outcrop and outcrop with thin patches of overburden
Bedrock outcrop in area of overburden
Geological boundary (approximate)
Limit of geological mapping
Glacial striae (S), stoss-and-lee surfaces (SL) direction of ice movement indicated
Drumlinoid ridges, direction of ice indicated
Scarp between deltas or river terraces
Gravel pit
Fossil locality

Geology by E. C. Halstead, 1961

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NOTES:

1. BASE PLAN TAKEN FROM GEOLOGICAL SURVEY OF CANADA'S MAP "27-1963" SHEET 92 G/4 AND 92 F/1 EAST.

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CLIENT: CH2M HILL CANADA LTD.

SURFICIAL GEOLOGY

GABRIOLA ISLAND
FIXED LINK FEASABILITY STUDY — GABRIOLA ISLAND, BC

SEAL

DESIGNED	DRAWN	APPROVED
-	NA	DJT

DATE	SCALE
FEBRUARY 26, 2015	AS SHOWN

PROJECT NO.	DWG. NO.	REV.
17-834-185-1		-

CANCEL PRINTS BEARING EARLIER LETTER

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P[illegible]d: F[illegible]r 27, 2015

PGa ***Anthropogenic deposits:*** *the dredged material found at ocean disposal sites consists of mixtures of silt, sand, rock, wood waste, and other approved material. On the map, two disposal sites are visible: Portlier Pass (49°00.75'N, 123°30.50'W) and Five Finger Island (49°13.86'N, 123°54.95'W). These sites are characterized by irregular intermediate to strong backscatter, forming round and linear backscatter features against a low-backscatter background. The spoil sediments overlie Holocene mud and bedrock.*

PGsr ***Sponge reefs:*** *massive matrix of organic-rich, olive, slightly sandy-silty clay containing siliceous (glass) sponges (Hexactinellida, Hexactinosida) found as in situ whole skeletons and fragments. On seismic records, the unit appears as 1–3 m high transparent mounds overlying glaciogenic deposits. Very low backscatter strength on top of strong acoustic backscatter characterizes this unit.*

PGs ***Postglacial sand:*** *sand or muddy sand. The unit is mostly found on the surface of some glacial sediments as it originates from the reworking of these sediments. Seismic profiles show that the unit is thin and can, in most cases, be defined as a veneer, with a distinctive low to intermediate backscatter strength. This unit is best represented in a submarine channel found northeast of Gabriola Island, where the unit infills the channel floor. See cross-section B-B'.*

PGm ***Postglacial mud (Holocene mud):*** *silty clay; sediments originating from the Fraser River and forming the Fraser River pro-delta. The clay/silt ratio in the unit increases distal to the Fraser River mouth. The unit exceeds 300 m in thickness in the deepest basins and acoustic data are masked by interstitial biogenic gas in some areas. This unit has the weakest, but most uniform acoustic backscatter signal and generally does not show much relief. This unit occupies and dominates the deepest areas of the Straight of Georgia.*

Gmd ***Glaciomarine ice-distal sediments:*** *well stratified gravelly sandy mud. On seismic profiles, the unit is represented by weak and continuous reflectors draping underlying units and is also characterized by intermediate to strong backscatter. Rare outcrops occur on the seafloor north of Gabriola Island, where exposed glacial deposits are common. In most cases, the unit fills troughs and is buried under thick postglacial mud.*

Gmp ***Glaciomarine ice-proximal sediments:*** *texturally variable mixture of sediments including mud, sand, gravel, and boulders. In some areas, the unit is acoustically stratified with discontinuous reflectors; elsewhere more acoustically incoherent and disturbed in appearance. The unit is readily defined when it overlies ice-contact sediments. These deposits are widespread north of Gabriola Island. See cross-section A-A'.*

Gmu ***Glaciomarine sediments (undefined):*** *stratigraphic relationships, setting, seafloor geomorphology and the backscatter strength of the unit share similarities with other recognized glacial units. This unit includes both ice-contact and glaciomarine ice-proximal sediments; however, these cannot be spatially defined because of the lack of geophysical or sample data available. See cross-section B-B'.*

Ic ***Ice-contact sediments:*** *glacial diamicton till up to 60 m in thickness. This unit has strong multibeam backscatter strength, similar to the bedrock units, but the glacially derived geomorphology and transparent acoustic signature permit discrimination. See cross-section A-A'.*

uKN ***Upper Cretaceous sedimentary Nanaimo Group:*** *dominated by layers of sandstone and conglomerate alternating with fine-grained sandstone and mudstone. The group includes several formations with variable sequences and bed thicknesses (Mustard, 1994; England and Bustin, 1998). Acoustically, the unit shows a discontinuous strong backscatter strength character with alternating low backscatter strength areas, resulting from the sharp and pronounced topography. The unit is most definable using the multibeam-sonar bathymetry and sun-illuminated topography.*

Geological contact (map unit boundaries are interpreted from multibeam-sonar bathymetry and geophysical seismic-profile data and are inferred contacts that may be gradational or conceptual in nature)

Fault; defined, approximate

Normal fault, defined

Oblique thrust fault, defined

Submarine channel

Boulder fields

Pockmarks

Anthropogenic disturbances:

Dredged site

Log boom

Marina pile

Undifferentiated anthropogenic disturbance

Cable

Seafloor photograph (see Figures 2–7)

NOTES:

1. BASE PLAN TA[illegible]EN FROM GEOLOGICAL SURVEY OF CANADA'S MAP "2118A SURFICIAL GEOLOGY AND SHADED SEAFLOOR RELIEF" SHEET 92 G/4.

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CLIENT: CH2M HILL CANADA LTD.

SEA FLOOR GEOLOGY

GABRIOLA ISLAND
FIXED LIN[illegible] FEASABILITY STUDY — GABRIOLA ISLAND[illegible]BC

SEAL

DESIGNED	DRAWN	APPROVED
-	NA[illegible]	DJT

DATE: FEBRUARY 26[illegible]2015 — SCALE: AS SHOWN

PROJECT N[illegible] — DWG. N[illegible] — REV.: 17-834-185-2 — -

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P d:F r r 27 2015

N

OPTION 1

OPTION 4

Duke Point

Nanaimo River

Harbour Fault

Boat Harbour Fault

Gabriola Island

Stratigraphic Legend

Upper Cretaceous
Nanaimo Group
Campanian

- 22 NORTHUMBERLAND FORMATION: shale, siltstone; minor sandstone
- 21 DE COURCY FORMATION: sandstone, minor conglomerate and siltstone
- 20 CEDAR DISTRICT FORMATION (undivided): shale, siltstone; minor sandstone
- BOAT HARBOUR MEMBER: shale and siltstone; sandstone
- 18 WOODS ISLANDS MEMBER: sandstone; minor siltstone
- 17 HOLDEN CORSO MEMBER: shale and siltstone; sandstone dikes
- 16 OYSTER HARBOUR MEMBER: sandstone; minor siltstone
- 15 GRANBY MEMBER: shale

PROTECTION FORMATION

- 14 McMILLAN MEMBER: sandstone; minor siltstone
- 13 RESERVE MEMBER: sandstone, siltstone; shale and coal
- 12 CASSIDY MEMBER: sandstone and gritstone; minor siltstone

PENDER FORMATION

- 11 NEWCASTLE MEMBER (undivided): *not mapped in this area*
- 10 SOUTHFIELD BEDS: shale; minor sandstone, gritstone and conglomerate
- DOUGLAS BEDS: conglomerate and gritstone; carbonaceous shale and coal (Douglas Seam at top, Newcastle Seam at base)
- 9 CRANBERRY MEMBER: shale and siltstone; conglomerate and sandstone

EXTENSION FORMATION

- 7 MILLSTREAM MEMBER: conglomerate and gritstone; minor sandstone

Note: Beds below Unit 7 do not outcrop within map-area

Symbols

Bedding orientation
Geologic boundary (observed, approximate, inferred)
Reverse fault (observed, approximate, inferred)
Normal fault (observed, approximate, inferred)
Anticline, surface trace (observed, approximate, inferred)
Syncline, surface trace (observed, approximate, inferred)
Coal seam trace (observed, approximate, inferred)

500 0 1000 2000m

SCALE 1:30 000

NOTES:

1. BASE PLAN TA EN FROM BC MINISTRY OF ENERGY AND MINES OPEN FILE "1998-07 GEOLOGY OF THE NANAIMO COALFIELD BRITISH COLUMBIA NTS 92G 4".

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CLIENT: CH2M HILL CANADA LTD.

SEAL

BEDROCK GEOLOGY

GABRIOLA ISLAND
FIXED LIN FEASABILITY STUDY GABRIOLA ISLAND BC

DESIGNED	DRAWN	APPROVED
-	NA	DJT

DATE: FEBRUARY 26 2015 SCALE: AS SHOWN

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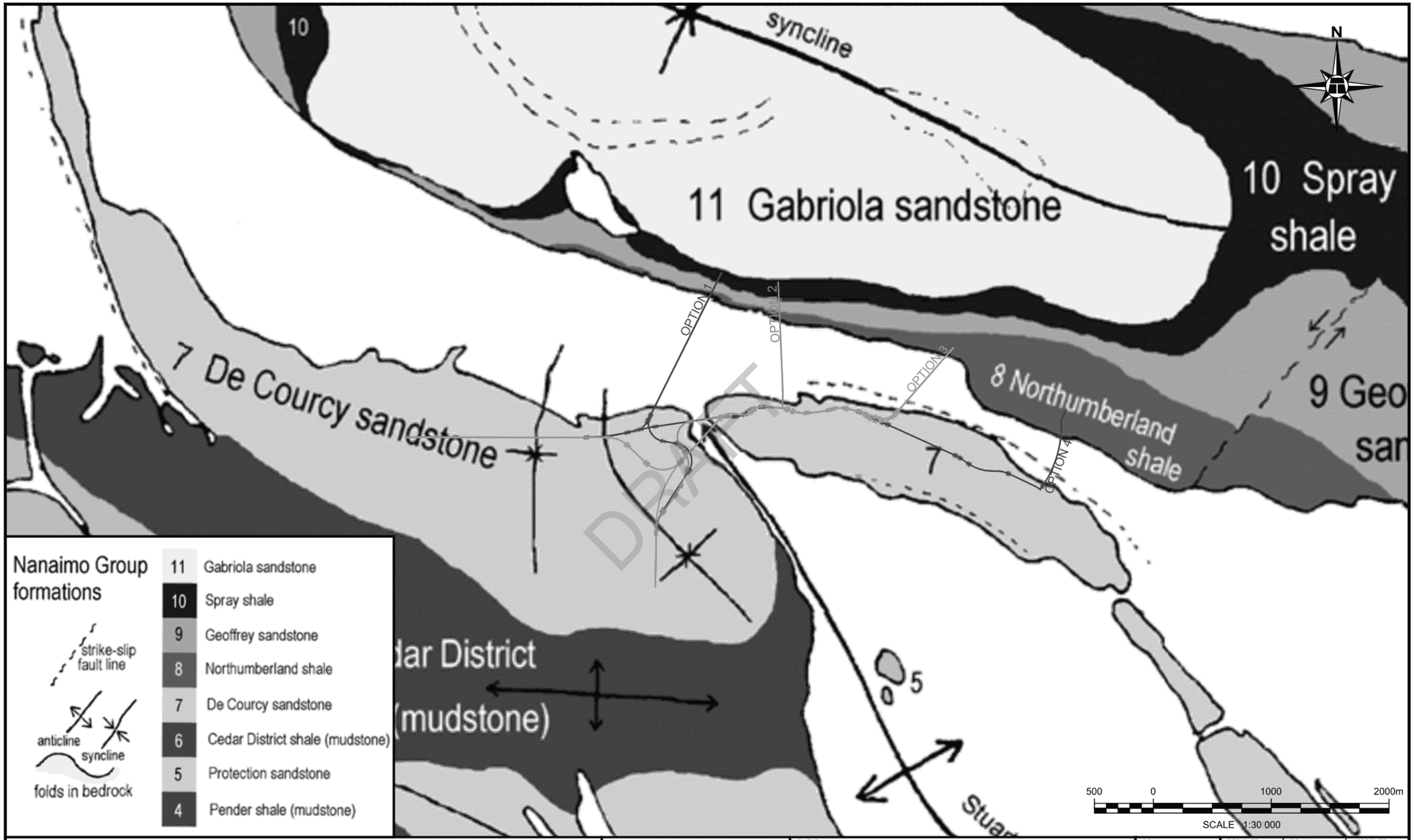
P[illegible]d: F[illegible]r. 27 2015



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NOTES:

1. BASE PLAN TA[illegible]EN FROM "SANDSTONE [illegible] SHALE - GABRIOLA\S ORIGINS" BY NIC[illegible] DOE [illegible]WWW.NIC[illegible]DOE.CA\PASS\WEBP223C.PDF.[illegible]

THURBER ENGINEERING LTD.

CLIENT: CH2M HILL CANADA LTD.

BEDROCK GEOLOGY

GABRIOLA ISLAND
FIXED LIN[illegible] FEASABILITY STUDY
GABRIOLA ISLAND[illegible]BC

SEAL

DESIGNED	DRAWN	APPROVED
-	NA[illegible]	DJT

DATE	SCALE
FEBRUARY 26[illegible]2015	AS SHOWN

PROJECT N[illegible]	DWG. N[illegible]	REV.
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2010 National Building Code Seismic Hazard Calculation

INFORMATION: Eastern Canada English (613) 995-5548 français (613) 995-0600 Facsimile (613) 992-8836
Western Canada English (250) 363-6500 Facsimile (250) 363-6565

Requested by: David Tara, Thurber Engineering Ltd. March 03, 2015

Site Coordinates: 49.136 North 123.81 West

User File Reference: Mudge Island

National Building Code ground motions:
2% probability of exceedance in 50 years (0.000404 per annum)

Sa(0.2)	Sa(0.5)	Sa(1.0)	Sa(2.0)	PGA (g)
1.028	0.700	0.354	0.179	0.507

Notes. Spectral and peak hazard values are determined for firm ground (NBCC 2010 soil class C - average shear wave velocity 360-750 m/s). Median (50th percentile) values are given in units of g. 5% damped spectral acceleration (Sa(T), where T is the period in seconds) and peak ground acceleration (PGA) values are tabulated. Only 2 significant figures are to be used. ***These values have been interpolated from a 10 km spaced grid of points. Depending on the gradient of the nearby points, values at this location calculated directly from the hazard program may vary. More than 95 percent of interpolated values are within 2 percent of the calculated values.*** Warning: You are in a region which considers the hazard from a deterministic Cascadia subduction event for the National Building Code. Values determined for high probabilities (0.01 per annum) in this region do not consider the hazard from this type of earthquake.

Ground motions for other probabilities:

Probability of exceedance per annum	0.010	0.0021	0.001
Probability of exceedance in 50 years	40%	10%	5%
Sa(0.2)	0.249	0.542	0.738
Sa(0.5)	0.166	0.363	0.496
Sa(1.0)	0.083	0.183	0.251
Sa(2.0)	0.041	0.090	0.124
PGA	0.128	0.273	0.367

DRAFT

References

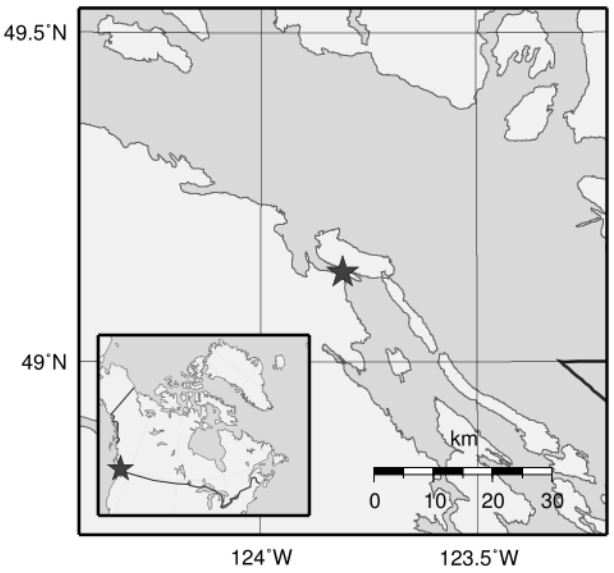
National Building Code of Canada 2010 NRCC no. 53301; sections 4.1.8, 9.20.1.2, 9.23.10.2, 9.31.6.2, and 6.2.1.3
Appendix C: Climatic Information for Building Design in Canada - table in Appendix C starting on page C-11 of Division B, volume 2

User's Guide - NBC 2010, Structural Commentaries NRCC no. 53543 (in preparation)
Commentary J: Design for Seismic Effects

Geological Survey of Canada Open File xxxx
Fourth generation seismic hazard maps of Canada: Maps and grid values to be used with the 2010 National Building Code of Canada (in preparation)

See the websites *www.EarthquakesCanada.ca* and *www.nationalcodes.ca* for more information

Aussi disponible en français



Appendix C
Construction Cost Estimate Breakdown

653997 Gabriola Island

SUMMARY CONCEPTUAL DESIGN ESTIMATE

	Option A - Alt 2	Option B	Mudge Island	Gabriola Island	Dodd Bridge	Gabriola Bridge	Gabriola Bridge	TOTAL
Description	**Phoenix Way**	**Holdon Corso Road**	**Coho Boulevard**	**South Road**	**Concrete**	**Concrete**	**Cable Stay** (For info. purposes only)	**"Fixed Link": Option 3A - Alt 2**
Section 1 - General	$1,610,000	$500,000	$330,000	$20,000	$1,260,000	$4,690,000	$11,073,000	$7,910,000
Section 2 - Grading	$2,770,000	$2,650,000	$2,640,000	$140,000	$0	$0	$0	$5,550,000
Section 3 - Drainage	$200,000	$100,000	$110,000	$10,000	$0	$0	$0	$320,000
Section 4 - Structures	$12,350,000	$0	$0	$0	$20,800,000	$77,909,000	$184,400,000	$111,059,000
Section 5 - Paving	$3,150,000	$2,810,000	$1,760,000	$20,000	$0	$0	$0	$4,930,000
Section 6 - Signing & Pavement Marking	$90,000	$130,000	$60,000	$10,000	$0	$0	$0	$160,000
Section 7 - Electrical	$300,000	$90,000	$50,000	$10,000	$50,000	$150,000	$150,000	$560,000
Section 8 - Miscellaneous	$150,000	$150,000	$150,000	$0	$150,000	$150,000	$0	$600,000
TOTAL CONSTRUCTION COST	**$20,620,000**	**$6,430,000**	**$5,100,000**	**$210,000**	**$22,260,000**	**$82,899,000**	**$195,623,000**	**$131,090,000**
Section A - Property Acquisition - TBD	*$0*	*$0*	*$0*	*$0*	*$0*	*$0*	*$0*	*$0*
Section B - Engineering & Supervision	$4,650,000	$1,450,000	$1,170,000	$50,000	$4,725,000	$13,295,530	$41,523,750	$23,890,530
Section C - Work By Others	$10,000	$10,000	$10,000	$0	$0	$0	$0	$20,000
Section D - Contingencies	$9,500,000	$2,970,000	$2,380,000	$90,000	$10,500,000	$39,104,500	$92,275,000	$61,574,500
TOTAL OTHER COSTS	**$14,160,000**	**$4,430,000**	**$3,560,000**	**$140,000**	**$15,225,000**	**$52,400,030**	**$133,798,750**	**$85,490,000**
TOTAL PLANNING LEVEL ESTIMATE (ROUNDED TO NEAREST $10,000)	**$34,780,000**	**$10,860,000**	**$8,660,000**	**$350,000**	**$37,490,000**	**$135,300,000**	**$329,420,000**	**$216,580,000**

Gabriola Island

Road Option 3A (Phoenix Way) - Nanaimo

PROJECT 653997
Conceptual Design Mar, 2015

Section Length - 4.2kms
Roadway width - 10.2m (3.6m lane, 1.5m shoulder)
Assumed new road construction from Phoenix Way to New Bridge site and roadway widening only to Duke Point Highway
Assumed new bridge over Cable Bay Trail

Item No.	Description of Work	Unit	Most Probable Quantity	Unit Price	Most Probable Extended Amount
SECTION 1 – GENERAL					
01.01	Mobilization (5.0% of Section 2 thru 8)	L.S.	100%	L.S.	$949,875.00
01.02	Traffic Management (2.5% of Section 2 thru 8)	L.S.	100%	L.S.	$474,937.50
01.03	Quality Management (1.0% of Section 2 thru 8)	L.S.	100%	L.S.	$189,975.00
TOTAL SECTION 1					**$1,614,787.50**
SECTION 2 – GRADING					
02.01	**Clearing and Grubbing**				
02.01.01	Clearing and Grubbing Highway Construction	Ha	5.00	$30,000.00	$150,000.00
02.02	**Removals**				
02.02.01	Remove Lamp Standard	Each	0.00	$2,000.00	$0.00
02.03	**Pavement Cold Milling & Removal**				
02.03.01	Pavement Removal	Square Metre	2,400	$20.00	$48,000.00
02.04	**Roadway & Drainage Excavation**				
02.04.01	Organic Stripping - 300mm	Cubic Metre	14,400	$15.00	$216,000.00
02.04.02	Type "A" Excavation (neatline)	Cubic Metre	25,000	$40.00	$1,000,000.00
02.04.03	Type "D" Excavation (neatline)	Cubic Metre	25,000	$18.00	$450,000.00
02.04.04	Haul Surplus Material Offsite (unfactored)	Cubic Metre	10,000	$25.00	$250,000.00
02.05	**Granular Materials: Production & Placement**				
02.05.01	25mm Well Graded Base Course (WGBC)	Cubic Metre	5,200	$45.00	$234,000.00
02.05.02	Open Graded Granular Sub Base (SGSB)	Cubic Metre	12,000	$35.00	$420,000.00
02.06	**Embankment Construction**				
02.06.01	Import Material, Haul and Place into Highway Embankment	Cubic Metre	0	$20.00	$0.00
TOTAL SECTION 2					**$2,768,000.00**
SECTION 3 – DRAINAGE					
03.01	**Supply & Install**				
03.01.01	600mm CSP 2.0 WT	Metre	400	$400.00	$160,000.00
03.02	**Rip Rap & End Walls**				
03.02.01	10 kg Rip Rap Outfall	Cubic Metre	50	$150.00	$7,500.00
03.02.02	End Wall 1000mm dia inlet with Fence and Apron	Each	4	$7,000.00	$28,000.00
TOTAL SECTION 3					**$195,500.00**
SECTION 4 – STRUCTURES					
04.01	**Supply & Install**				
04.01.01	Bridge Structure (over Cable Bay Trail)	Square Metre	1,900	$6,500.00	$12,350,000.00
04.01.02	MSE Wall (sq.m face area)	Square Metre			$0.00
TOTAL SECTION 4					**$12,350,000.00**
SECTION 5 – PAVING					
05.01	**Asphalt Pavement**				
05.01.01	Class 1 Medium Mix	Tonne	18,500	$155.00	$2,867,500.00
05.01.02	Asphalt Overlay - 50mm	m2	9,200	$20.00	$184,000.00
05.02	**Concrete Works**				
05.02.01	Concrete Curb and Gutter	Metre	200	$50.00	$10,000.00
05.03	**Concrete Barriers**				
05.03.01	Supply and Install CRB	Each	300	$250.00	$75,000.00
05.03.02	Supply and Install CMB	Each	30	$350.00	$10,500.00
TOTAL SECTION 5					**$3,147,000.00**
SECTION 6– SIGNING & PAVEMENT MARKING					
06.01	**Sign Installation**				
06.01.01	Remove Existing Signs	Each	10	$200.00	$2,000.00
06.01.02	Supply & Install Perforated Square Steel Post and Sign Face (SP635-3.6.1)	Each	30	$400.00	$12,000.00
06.02	**Pavement Markings**				
06.02.01	Pavement Marking Layout	L.S.	1.00	$5,000.00	$5,000.00
06.02.02	Line Markings	Metre	8,000	$6.00	$48,000.00
06.02.03	Longitudinal and Transverse Pavement Markings and Arrows	L.S.	1.00	$20,000.00	$20,000.00
TOTAL SECTION 6					**$87,000.00**
SECTION 7 – ELECTRICAL					

Gabriola Island

Road Option 3A (Phoenix Way) - Nanaimo

PROJECT 653997
Conceptual Design Mar, 2015

Section Length - 4.2kms
Roadway width - 10.2m (3.6m lane, 1.5m shoulder)
Assumed new road construction from Phoenix Way to New Bridge site and roadway widening only to Duke Point Highway
Assumed new bridge over Cable Bay Trail

Item No.	Description of Work	Unit	Most Probable Quantity	Unit Price	Most Probable Extended Amount
07.01	**Electrical Materials**				
07.01.01	Lamp Standard	Each	60	$5,000.00	$300,000.00
TOTAL SECTION 7					**$300,000.00**
SECTION 8 – LANDSCAPE AND ENVIRONMENTAL					
08.01	**Landscape and Environmental**				
08.01.01	Landscaping and Environmental Requirements	L.S.	1.0	$150,000.00	$150,000.00
TOTAL SECTION 8					**$150,000.00**
SUMMARY SECTIONS 1 – 8					
TOTAL SECTION 1 – GENERAL					**$1,614,787.50**
TOTAL SECTION 2 – GRADING					**$2,768,000.00**
TOTAL SECTION 3 – DRAINAGE					**$195,500.00**
TOTAL SECTION 4 – STRUCTURES					**$12,350,000.00**
TOTAL SECTION 5 – PAVING					**$3,147,000.00**
TOTAL SECTION 6 – SIGNING & PAVEMENT MARKING					**$87,000.00**
TOTAL SECTION 7– ELECTRICAL					**$300,000.00**
TOTAL SECTION 8 – LANDSCAPE AND ENVIRONMENTAL					**$150,000.00**
TOTAL CONSTRUCTION COSTS					**$20,612,287.50**
SECTION A – PROPERTY					
A.01	Acquisition, incl. Legal Survey	L.S.	0%		$0.00
TOTAL SECTION A					**$0.00**
SECTION B – ENGINEERING & SUPERVISION					
B.01	Engineering Design Services (7% of Section 2 thru 8)	L.S.	100%	L.S.	$1,329,825.00
B.02	MoT Engineering Services (2.5% of Section 2 thru 8)	L.S.	100%	L.S.	$474,937.50
B.03	MoT Project Management (5% of Section 2 thru 8)	L.S.	100%	L.S.	$949,875.00
B.04	MoT Construction Supervision (10% of Section 2 thru 8)	L.S.	100%	L.S.	$1,899,750.00
TOTAL SECTION B					**$4,654,387.50**
SECTION C – WORK BY OTHERS					
C.01	Hydro Relocation	Each	20.00	$400.00	$8,000.00
TOTAL SECTION C					**$8,000.00**
SECTION D – CONTINGENCIES					
D.01	Contingency for Work on Roadways (50% of Section 2 thru 8)	L.S.	100%	L.S.	$9,498,750.00
TOTAL SECTION D					**$9,498,750.00**
SUMMARY SECTIONS A – D					
TOTAL SECTION A – PROPERTY ACQUISITION					**$0.00**
TOTAL SECTION B – ENGINEERING & SUPERVISION					**$4,654,387.50**
TOTAL SECTION C – WORK BY OTHERS					**$8,000.00**
TOTAL SECTION D – CONTINGENCIES					**$9,498,750.00**
TOTAL OTHER COSTS					**$14,161,137.50**
TOTAL ESTIMATE					$34,773,425.00

Gabriola Island

Road Option 3B (Holdon Corso/Nicola Road) - Nanaimo

PROJECT 653997
Conceptual Design Mar, 2015

Section Length - 5.3 kms
Roadway width - 10.2m (3.6m lane, 1.5m shoulder)
Assumed new road construction from Nicola Road to New Bridge site and roadway widening only to Duke Point Highway
Includes intersection and ramp upgrades at Duke Point Hwy

Item No.	Description of Work	Unit	Most Probable Quantity	Unit Price	Most Probable Extended Amount
SECTION 1 – GENERAL					
01.01	Mobilization (5.0% of Section 2 thru 8)	L.S.	100%	L.S.	$296,695.00
01.02	Traffic Management (2.5% of Section 2 thru 8)	L.S.	100%	L.S.	$148,347.50
01.03	Quality Management (1.0% of Section 2 thru 8)	L.S.	100%	L.S.	$59,339.00
TOTAL SECTION 1					**$504,381.50**
SECTION 2 – GRADING					
02.01	**Clearing and Grubbing**				
02.01.01	Clearing and Grubbing Highway Construction	Ha	3.00	$30,000.00	$90,000.00
02.02	**Removals**				
02.02.01	Remove Lamp Standard	Each	0.00	$2,000.00	$0.00
02.03	**Pavement Cold Milling & Removal**				
02.03.01	Pavement Removal	Square Metre	26,000	$20.00	$520,000.00
02.04	**Roadway & Drainage Excavation**				
02.04.01	Organic Stripping - 300mm	Cubic Metre	8,000	$15.00	$120,000.00
02.04.02	Type "A" Excavation (neatline)	Cubic Metre	18,000	$40.00	$720,000.00
02.04.03	Type "D" Excavation (neatline)	Cubic Metre	18,000	$18.00	$324,000.00
02.04.04	Haul Surplus Material Offsite (unfactored)	Cubic Metre	23,000	$25.00	$575,000.00
02.05	**Granular Materials: Production & Placement**				
02.05.01	25mm Well Graded Base Course (WGBC)	Cubic Metre	2,500	$45.00	$112,500.00
02.05.02	Open Graded Granular Sub Base (SGSB)	Cubic Metre	5,500	$35.00	$192,500.00
02.06	**Embankment Construction**				
02.06.01	Import Material, Haul and Place into Highway Embankment	Cubic Metre	0	$20.00	$0.00
TOTAL SECTION 2					**$2,654,000.00**
SECTION 3 – DRAINAGE					
03.01	**Supply & Install**				
03.01.01	1000mm CSP 2.0 WT	Metre	200	$400.00	$80,000.00
03.02	**Rip Rap & End Walls**				
03.02.01	10 kg Rip Rap Outfall	Cubic Metre	20	$150.00	$3,000.00
03.02.02	End Wall 1000mm dia inlet with Fence and Apron	Each	2	$7,000.00	$14,000.00
TOTAL SECTION 3					**$97,000.00**
SECTION 4 – STRUCTURES					
04.01	**Supply & Install**				
04.01.01	Bridge Structure	Square Metre	0	$4,500.00	$0.00
04.01.02	MSE Wall (sq.m face area)	Square Metre	0	$800.00	$0.00
TOTAL SECTION 4					**$0.00**
SECTION 5 – PAVING					
05.01	**Asphalt Pavement**				
05.01.01	Class 1 Medium Mix	Tonne	12,000	$155.00	$1,860,000.00
05.01.02	Asphalt Overlay - 50mm	m2	38,000	$20.00	$760,000.00
05.02	**Concrete Works**				
05.02.01	Concrete Curb and Gutter	Metre	1,038	$50.00	$51,900.00
05.03	**Concrete Barriers**				
05.03.01	Supply and Install CRB	Each	500	$250.00	$125,000.00
05.03.02	Supply and Install CMB	Each	40	$350.00	$14,000.00
TOTAL SECTION 5					**$2,810,900.00**
SECTION 6– SIGNING & PAVEMENT MARKING					
06.01	**Sign Installation**				
06.01.01	Remove Existing Signs	Each	20	$200.00	$4,000.00
06.01.02	Supply & Install Perforated Square Steel Post and Sign Face (SP635-3.6.1)	Each	20	$400.00	$8,000.00
06.02	**Pavement Markings**				
06.02.01	Pavement Marking Layout	L.S.	1.00	$10,000.00	$10,000.00
06.02.02	Line Markings	Metre	15,000	$6.00	$90,000.00
06.02.03	Longitudinal and Transverse Pavement Markings and Arrows	L.S.	1.00	$20,000.00	$20,000.00
TOTAL SECTION 6					**$132,000.00**

Gabriola Island

Road Option 3B (Holdon Corso/Nicola Road) - Nanaimo

PROJECT 653997
Conceptual Design Mar, 2015

Section Length - 5.3 kms
Roadway width - 10.2m (3.6m lane, 1.5m shoulder)
Assumed new road construction from Nicola Road to New Bridge site and roadway widening only to Duke Point Highway
Includes intersection and ramp upgrades at Duke Point Hwy

Item No.	Description of Work	Unit	Most Probable Quantity	Unit Price	Most Probable Extended Amount
SECTION 7 – ELECTRICAL					
07.01	**Electrical Materials**				
07.01.01	Lamp Standard	Each	60	$1,500.00	$90,000.00
TOTAL SECTION 7					**$90,000.00**
SECTION 8 – LANDSCAPE AND ENVIRONMENTAL					
08.01	**Landscape and Environmental**				
08.01.01	Landscaping and Environmental Requirements	L.S.	1.0	$150,000.00	$150,000.00
TOTAL SECTION 8					**$150,000.00**
SUMMARY SECTIONS 1 – 8					
	TOTAL SECTION 1 – GENERAL				**$504,381.50**
	TOTAL SECTION 2 – GRADING				**$2,654,000.00**
	TOTAL SECTION 3 – DRAINAGE				**$97,000.00**
	TOTAL SECTION 4 – STRUCTURES				**$0.00**
	TOTAL SECTION 5 – PAVING				**$2,810,900.00**
	TOTAL SECTION 6 – SIGNING & PAVEMENT MARKING				**$132,000.00**
	TOTAL SECTION 7– ELECTRICAL				**$90,000.00**
	TOTAL SECTION 8 – LANDSCAPE				**$150,000.00**
TOTAL CONSTRUCTION COSTS					**$6,438,281.50**
SECTION A – PROPERTY					
A.01	Acquisition, incl. Legal Survey	L.S.	0%		$0.00
TOTAL SECTION A					**$0.00**
SECTION B – ENGINEERING & SUPERVISION					
B.01	Engineering Design Services (7% of Section 2 thru 8)	L.S.	100%	L.S.	$415,373.00
B.02	MoT Engineering Services (2.5% of Section 2 thru 8)	L.S.	100%	L.S.	$148,347.50
B.03	MoT Project Management (5% of Section 2 thru 8)	L.S.	100%	L.S.	$296,695.00
B.04	MoT Construction Supervision (10% of Section 2 thru 8)	L.S.	100%	L.S.	$593,390.00
TOTAL SECTION B					**$1,453,805.50**
SECTION C – WORK BY OTHERS					
C.01	Hydro Relocation	L.S.	20.00	$400.00	$8,000.00
TOTAL SECTION C					**$8,000.00**
SECTION D – CONTINGENCIES					
D.01	Contingency for Work on Roadways (50% of Section 2 thru 8)	L.S.	100%	L.S.	$2,966,950.00
TOTAL SECTION D					**$2,966,950.00**
SUMMARY SECTIONS A – D					
	TOTAL SECTION A – PROPERTY ACQUISITION				**$0.00**
	TOTAL SECTION B – ENGINEERING & SUPERVISION				**$1,453,805.50**
	TOTAL SECTION C – WORK BY OTHERS				**$8,000.00**
	TOTAL SECTION D – CONTINGENCIES				**$2,966,950.00**
TOTAL OTHER COSTS					**$4,428,755.50**
TOTAL ESTIMATE					**$10,867,037.00**

Mudge Island Works

PROJECT 653997
Conceptual Design Mar, 2015

Section Length - 2.2 kms
Roadway width - 10.2m (3.6m lane, 1.5m shoulder)
Assume new road construction for full length

Item No.	Description of Work	Unit	Most Probable Quantity	Unit Price	Most Probable Extended Amount
SECTION 1 – GENERAL					
01.01	Mobilization (5.0% of Section 2 thru 8)	L.S.	100%	L.S.	$238,200.00
01.02	Traffic Management (1% of Section 2 thru 8)	L.S.	100%	L.S.	$47,640.00
01.03	Quality Management (1.0% of Section 2 thru 8)	L.S.	100%	L.S.	$47,640.00
TOTAL SECTION 1					**$333,480.00**
SECTION 2 – GRADING					
02.01	**Clearing and Grubbing**				
02.01.01	Clearing and Grubbing Highway Construction	Ha	3.00	$30,000.00	$90,000.00
02.02	**Removals**				
02.02.01	Remove Lamp Standard	Each	0.00	$2,000.00	$0.00
02.03	**Pavement Cold Milling & Removal**				
02.03.01	Pavement Removal	Square Metre	11,000	$20.00	$220,000.00
02.04	**Roadway & Drainage Excavation**				
02.04.01	Organic Stripping - 300mm	Cubic Metre	10,000	$15.00	$150,000.00
02.04.02	Type "A" Excavation (neatline)	Cubic Metre	25,000	$40.00	$1,000,000.00
02.04.03	Type "D" Excavation (neatline)	Cubic Metre	25,000	$18.00	$450,000.00
02.04.04	Haul Surplus Material Offsite (factored)	Cubic Metre	15,000	$25.00	$375,000.00
02.05	**Granular Materials: Production & Placement**				
02.05.01	25mm Well Graded Base Course (WGBC)	Cubic Metre	3,000	$45.00	$135,000.00
02.05.02	Open Graded Granular Sub Base (SGSB)	Cubic Metre	6,200	$35.00	$217,000.00
02.06	**Embankment Construction**				
02.06.01	Import Material, Haul and Place into Highway Embankment	Cubic Metre	0	$20.00	$0.00
TOTAL SECTION 2					**$2,637,000.00**
SECTION 3 – DRAINAGE					
03.01	**Supply & Install**				
03.01.01	1000mm CSP 2.0 WT	Metre	230	$400.00	$92,000.00
03.02	**Rip Rap & End Walls**				
03.02.01	10 kg Rip Rap Outfall	Cubic Metre	20	$150.00	$3,000.00
03.02.02	End Wall 1000mm dia inlet with Fence and Apron	Each	2	$7,000.00	$14,000.00
TOTAL SECTION 3					**$109,000.00**
SECTION 4 – STRUCTURES					
04.01	**Supply & Install**				
04.01.01	Bridge Structure	Square Metre	0	$4,000.00	$0.00
04.01.02	MSE Wall (sq.m face area)	Square Metre	0	$800.00	$0.00
TOTAL SECTION 4					**$0.00**
SECTION 5 – PAVING					
05.01	**Asphalt Pavement**				
05.01.01	Class 1 Medium Mix	Tonne	11,000	$155.00	$1,705,000.00
05.01.02	Asphalt Overlay - 50mm	m2	0	$20.00	$0.00
05.02	**Concrete Works**				
05.02.01	Concrete Curb and Gutter	Metre	0	$50.00	$0.00
05.03	**Concrete Barriers**				
05.03.01	Supply and Install CRB	Each	200	$250.00	$50,000.00
05.03.02	Supply and Install CMB	Each	20	$350.00	$7,000.00
TOTAL SECTION 5					**$1,762,000.00**
SECTION 6– SIGNING & PAVEMENT MARKING					
06.01	**Sign Installation**				
06.01.01	Remove Existing Signs	Each	10	$200.00	$2,000.00
06.01.02	Supply & Install Perforated Square Steel Post and Sign Face (SP635 3.6.1)	Each	20	$400.00	$8,000.00
06.02	**Pavement Markings**				
06.02.01	Pavement Marking Layout	L.S.	1.00	$5,000.00	$5,000.00
06.02.02	Line Markings	Metre	6,000	$6.00	$36,000.00
06.02.03	Longitudinal and Transverse Pavement Markings and Arrows	L.S.	1.00	$10,000	$10,000.00
TOTAL SECTION 6					**$61,000.00**
SECTION 7 – ELECTRICAL					
07.01	**Electrical Materials**				
07.01.01	Lamp Standard	Each	30	$1,500.00	$45,000.00
TOTAL SECTION 7					**$45,000.00**
SECTION 8 – LANDSCAPE AND ENVIRONMENTAL					
08.01	**Landscape and Environmental**				
08.01.01	Landscaping and Environmental Requirements	L.S.	1.0	$150,000.00	$150,000.00

Mudge Island Works

PROJECT 653997
Conceptual Design Mar, 2015

Section Length - 2.2 kms
Roadway width - 10.2m (3.6m lane, 1.5m shoulder)
Assume new road construction for full length

Item No.	Description of Work	Unit	Most Probable Quantity	Unit Price	Most Probable Extended Amount
TOTAL SECTION 8					**$150,000.00**
SUMMARY SECTIONS 1 – 8					
TOTAL SECTION 1 – GENERAL					**$333,480.00**
TOTAL SECTION 2 – GRADING					**$2,637,000.00**
TOTAL SECTION 3 – DRAINAGE					**$109,000.00**
TOTAL SECTION 4 – STRUCTURES					**$0.00**
TOTAL SECTION 5 – PAVING					**$1,762,000.00**
TOTAL SECTION 6 – SIGNING & PAVEMENT MARKING					**$61,000.00**
TOTAL SECTION 7– ELECTRICAL					**$45,000.00**
TOTAL SECTION 8 – LANDSCAPE					**$150,000.00**
TOTAL CONSTRUCTION COSTS					**$5,097,480.00**
SECTION A – PROPERTY					
A.01	Acquisition, incl. Legal Survey	L.S.	0%		$0.00
TOTAL SECTION A					**$0.00**
SECTION B – ENGINEERING & SUPERVISION					
B.01	Engineering Design Services (7% of Section 2 thru 8)	L.S.	100%	L.S.	$333,480.00
B.02	MoT Engineering Services (2.5% of Section 2 thru 8)	L.S.	100%	L.S.	$119,100.00
B.03	MoT Project Management (5% of Section 2 thru 8)	L.S.	100%	L.S.	$238,200.00
B.04	MoT Construction Supervision (10% of Section 2 thru 8)	L.S.	100%	L.S.	$476,400.00
TOTAL SECTION B					**$1,167,180.00**
SECTION C – WORK BY OTHERS					
C.01	Hydro Relocation	Each	20.00	$400.00	$8,000.00
TOTAL SECTION C					**$8,000.00**
SECTION D – CONTINGENCIES					
D.01	Contingency for Work on Roadways (50% of Section 2 thru 8)	L.S.	100%	L.S.	$2,382,000.00
TOTAL SECTION D					**$2,382,000.00**
SUMMARY SECTIONS A – D					
TOTAL SECTION A – PROPERTY ACQUISITION					**$0.00**
TOTAL SECTION B – ENGINEERING & SUPERVISION					**$1,167,180.00**
TOTAL SECTION C – WORK BY OTHERS					**$8,000.00**
TOTAL SECTION D – CONTINGENCIES					**$2,382,000.00**
TOTAL OTHER COSTS					**$3,557,180.00**
TOTAL ESTIMATE					**$8,654,660.00**

Gabriola Island Works

PROJECT 653997
Conceptual Design Mar, 2015

Intersection at S Road
Roadway width - 10.2m (3.6m lane, 1.5m shoulder)

Item No.	Description of Work	Unit	Most Probable Quantity	Unit Price	Most Probable Extended Amount
SECTION 1 – GENERAL					
01.01	Mobilization (5.0% of Section 2 thru 8)	L.S.	100%	L.S.	$9,258.00
01.02	Traffic Management (2.5% of Section 2 thru 8)	L.S.	100%	L.S.	$4,629.00
01.03	Quality Management (1.0% of Section 2 thru 8)	L.S.	100%	L.S.	$1,851.60
TOTAL SECTION 1					**$15,738.60**
SECTION 2 – GRADING					
02.01	**Clearing and Grubbing**				
02.01.01	Clearing and Grubbing Highway Construction	Ha	1.00	$30,000.00	$30,000.00
02.02	**Removals**				
02.02.01	Remove Lamp Standard	Each	0.00	$2,000.00	$0.00
02.03	**Pavement Cold Milling & Removal**				
02.03.01	Pavement Removal	Square Metre	0	$20.00	$0.00
02.04	**Roadway & Drainage Excavation**				
02.04.01	Organic Stripping - 300mm	Cubic Metre	300	$15.00	$4,500.00
02.04.02	Type "A" Excavation (neatline)	Cubic Metre	0	$40.00	$0.00
02.04.03	Type "D" Excavation (neatline)	Cubic Metre	0	$18.00	$0.00
02.04.04	Haul Surplus Material Offsite (factored)	Cubic Metre	0	$25.00	$0.00
02.05	**Granular Materials: Production & Placement**				
02.05.01	25mm Well Graded Base Course (WGBC)	Cubic Metre	20	$45.00	$900.00
02.05.02	Open Graded Granular Sub Base (SGSB)	Cubic Metre	40	$35.00	$1,400.00
02.06	**Embankment Construction**				
02.06.01	Import Material, Haul and Place into Highway Embankment	Cubic Metre	5,000	$20.00	$100,000.00
TOTAL SECTION 2					**$136,800.00**
SECTION 3 – DRAINAGE					
03.01	**Supply & Install**				
03.01.01	1000mm CSP 2.0 WT	Metre	30	$400.00	$12,000.00
03.02	**Rip Rap & End Walls**				
03.02.01	10 kg Rip Rap Outfall	Cubic Metre	4	$150.00	$600.00
03.02.02	End Wall 1000mm dia inlet with Fence and Apron	Each	0	$7,000.00	$0.00
TOTAL SECTION 3					**$12,600.00**
SECTION 4 – STRUCTURES					
04.01	**Supply & Install**				
04.01.01	Bridge Structure	Square Metre	0	$4,000.00	$0.00
04.01.02	MSE Wall (sq.m face area)	Square Metre	0	$800.00	$0.00
TOTAL SECTION 4					**$0.00**
SECTION 5 – PAVING					
05.01	**Asphalt Pavement**				
05.01.01	Class 1 Medium Mix	Tonne	72	$155.00	$11,160.00
05.01.02	Asphalt Overlay - 50mm	m2	0	$20.00	$0.00
05.02	**Concrete Works**				
05.02.01	Concrete Curb and Gutter	Metre	0	$50.00	$0.00
05.03	**Concrete Barriers**				
05.03.01	Supply and Install CRB	Each	40	$250.00	$10,000.00
05.03.02	Supply and Install CMB	Each	4	$350.00	$1,400.00
TOTAL SECTION 5					**$22,560.00**
SECTION 6– SIGNING & PAVEMENT MARKING					
06.01	**Sign Installation**				
06.01.01	Remove Existing Signs	Each	2	$200.00	$400.00
06.01.02	Supply & Install Perforated Square Steel Post and Sign Face (SP635 3.6.1)	Each	8	$400.00	$3,200.00
06.02	**Pavement Markings**				
06.02.01	Pavement Marking Layout	L.S.	1.00	$1,000.00	$1,000.00
06.02.02	Line Markings	Metre	100	$6.00	$600.00
06.02.03	Longitudinal and Transverse Pavement Markings and Arrows	L.S.	1.00	$2,000.00	$2,000.00
TOTAL SECTION 6					**$7,200.00**
SECTION 7 – ELECTRICAL					
07.01	**Electrical Materials**				
07.01.01	Lamp Standard	Each	4	$1,500.00	$6,000.00
TOTAL SECTION 7					**$6,000.00**
SECTION 8 – LANDSCAPE AND ENVIRONMENTAL					
08.01	**Landscape and Environmental**				
08.01.01	Landscaping and Environmental Requirements	L.S.	0.0	$150,000.00	$0.00
TOTAL SECTION 8					**$0.00**

Gabriola Island Works

PROJECT 653997
Conceptual Design Mar, 2015

Intersection at S Road
Roadway width - 10.2m (3.6m lane, 1.5m shoulder)

Item No.	Description of Work	Unit	Most Probable Quantity	Unit Price	Most Probable Extended Amount
SUMMARY SECTIONS 1 – 8					
TOTAL SECTION 1 – GENERAL					**$15,738.60**
TOTAL SECTION 2 – GRADING					**$136,800.00**
TOTAL SECTION 3 – DRAINAGE					**$12,600.00**
TOTAL SECTION 4 – STRUCTURES					**$0.00**
TOTAL SECTION 5 – PAVING					**$22,560.00**
TOTAL SECTION 6 – SIGNING & PAVEMENT MARKING					**$7,200.00**
TOTAL SECTION 7– ELECTRICAL					**$6,000.00**
TOTAL SECTION 8 – LANDSCAPE					**$0.00**
TOTAL CONSTRUCTION COSTS					**$200,898.60**
SECTION A – PROPERTY					
A.01	Acquisition, incl. Legal Survey	L.S.	0%		$0.00
TOTAL SECTION A					**$0.00**
SECTION B – ENGINEERING & SUPERVISION					
B.01	Engineering Design Services (10% of Section 2 thru 8)	L.S.	100%	L.S.	$18,516.00
B.02	MoT Engineering Services (2.5% of Section 2 thru 8)	L.S.	100%	L.S.	$4,629.00
B.03	MoT Project Management (5% of Section 2 thru 8)	L.S.	100%	L.S.	$9,258.00
B.04	MoT Construction Supervision (10% of Section 2 thru 8)	L.S.	100%	L.S.	$18,516.00
TOTAL SECTION B					**$50,919.00**
SECTION C – WORK BY OTHERS					
C.01	Hydro Relocation	Each	0.00	$400.00	$0.00
TOTAL SECTION C					**$0.00**
SECTION D – CONTINGENCIES					
D.01	Contingency for Work on Roadways (50% of Section 2 thru 8)	L.S.	100%	L.S.	$92,580.00
TOTAL SECTION D					**$92,580.00**
SUMMARY SECTIONS A – D					
TOTAL SECTION A – PROPERTY ACQUISITION					**$0.00**
TOTAL SECTION B – ENGINEERING & SUPERVISION					**$50,919.00**
TOTAL SECTION C – WORK BY OTHERS					**$0.00**
TOTAL SECTION D – CONTINGENCIES					**$92,580.00**
TOTAL OTHER COSTS					**$143,499.00**
TOTAL ESTIMATE					**$344,397.60**

Gabriola Island

Dodd Narrows Bridge

PROJECT 653997
Conceptual Design Mar, 2015

Span Length - 260m
Bridge widht - 9.2m
Assumed Concrete Girder construction

Item No.	Description of Work	Unit	Most Probable Quantity	Unit Price	Most Probable Extended Amount
SECTION 1 – GENERAL					
01.01	Mobilization (5.0% of Section 2 thru 8)	L.S.	100%	L.S.	$1,050,000.00
01.02	Traffic Management (0% of Section 2 thru 8) (Allowed for in Road Construction)	L.S.	100%	L.S.	$0.00
01.03	Quality Management (1.0% of Section 2 thru 8)	L.S.	100%	L.S.	$210,000.00
TOTAL SECTION 1					**$1,260,000.00**
SECTION 2 – GRADING					
02.01	**Clearing and Grubbing**				
02.01.01	Clearing and Grubbing Highway Construction	Ha	0	$30,000.00	$0.00
02.02	**Removals**				
02.02.01	Remove Lamp Standard	Each	0	$2,000.00	$0.00
02.03	**Pavement Cold Milling & Removal**				
02.03.01	Pavement Removal	Square Metre	0	$20.00	$0.00
02.04	**Roadway & Drainage Excavation**				
02.04.01	Organic Stripping - 300mm	Cubic Metre	0	$15.00	$0.00
02.04.02	Type "A" Excavation (neatline)	Cubic Metre	0	$40.00	$0.00
02.04.03	Type "D" Excavation (neatline)	Cubic Metre	0	$18.00	$0.00
02.04.04	Haul Surplus Material Offsite (factored)	Cubic Metre	0	$25.00	$0.00
02.05	**Granular Materials: Production & Placement**				
02.05.01	25mm Well Graded Base Course (WGBC)	Cubic Metre	0	$45.00	$0.00
02.05.02	Open Graded Granular Sub Base (SGSB)	Cubic Metre	0	$35.00	$0.00
02.06	**Embankment Construction**				
02.06.01	Import Material, Haul and Place into Highway Embankment	Cubic Metre	0	$20.00	$0.00
TOTAL SECTION 2					**$0.00**
SECTION 3 – DRAINAGE					
03.01	**Supply & Install**				
03.01.01	1000mm CSP 2.0 WT	Metre	0	$400.00	$0.00
03.02	**Rip Rap & End Walls**				
03.02.01	10 kg Rip Rap Outfall	Cubic Metre	0	$150.00	$0.00
03.02.02	End Wall 1000mm dia inlet with Fence and Apron	Each	0	$7,000.00	$0.00
TOTAL SECTION 3					**$0.00**
SECTION 4 – STRUCTURES					
04.01	**Supply & Install**				
04.01.01	Bridge Structure - Concrete Girder, including span and approaches	Square Metre	3,200	$6,500.00	$20,800,000.00
04.01.02	MSE Wall (sq.m face area)	Square Metre	0	$800.00	$0.00
TOTAL SECTION 4					**$20,800,000.00**
SECTION 5 – PAVING					
05.01	**Asphalt Pavement**				
05.01.01	Class 1 Medium Mix	Tonne	0	$155.00	$0.00
05.01.02	Asphalt Overlay - 50mm	m2	0	$20.00	$0.00
05.02	**Concrete Works**				
05.02.01	Concrete Curb and Gutter	Metre	0	$50.00	$0.00
05.03	**Concrete Barriers**				
05.03.01	Supply and Install CRB	Each	0	$250.00	$0.00
05.03.02	Supply and Install CMB	Each	0	$350.00	$0.00
TOTAL SECTION 5					**$0.00**
SECTION 6– SIGNING & PAVEMENT MARKING (Included in Section 4)					
06.01	**Sign Installation**				
06.01.01	Remove Existing Signs	Each	0	$200.00	$0.00
06.01.02	Supply & Install Perforated Square Steel Post and Sign Face (SP635 3.6.1)	Each	0	$400.00	$0.00
06.02	**Pavement Markings**				
06.02.01	Pavement Marking Layout	L.S.	0	$1,000.00	$0.00
06.02.02	Line Markings	Metre	-	$6.00	$0.00
06.02.03	Longitudinal and Transverse Pavement Markings and Arrows	L.S.	0	$2,000.00	$0.00
TOTAL SECTION 6					**$0.00**
SECTION 7 – ELECTRICAL					
07.01	**Electrical Materials**				
07.01.01	Lamp Standard including wiring	Each	10	$5,000.00	$50,000.00
TOTAL SECTION 7					**$50,000.00**
SECTION 8 – LANDSCAPE AND ENVIRONMENTAL					
08.01	**Landscape and Environmental**				

Gabriola Island

Dodd Narrows Bridge

PROJECT 653997
Conceptual Design Mar, 2015

Span Length - 260m
Bridge widht - 9.2m
Assumed Concrete Girder construction

Item No.	Description of Work	Unit	Most Probable Quantity	Unit Price	Most Probable Extended Amount
08.01.01	Landscaping and Environmental Requirements	L.S.	1	$150,000.00	$150,000.00
TOTAL SECTION 8					**$150,000.00**

SUMMARY SECTIONS 1 – 8

TOTAL SECTION 1 – GENERAL	**$1,260,000.00**
TOTAL SECTION 2 – GRADING	**$0.00**
TOTAL SECTION 3 – DRAINAGE	**$0.00**
TOTAL SECTION 4 – STRUCTURES	**$20,800,000.00**
TOTAL SECTION 5 – PAVING	**$0.00**
TOTAL SECTION 6 – SIGNING & PAVEMENT MARKING	**$0.00**
TOTAL SECTION 7– ELECTRICAL	**$50,000.00**
TOTAL SECTION 8 – LANDSCAPE	**$150,000.00**
TOTAL CONSTRUCTION COSTS	**$22,260,000.00**

SECTION A – PROPERTY

A.01	Acquisition, incl. Legal Survey	L.S.	0%		$0.00
TOTAL SECTION A					**$0.00**

SECTION B – ENGINEERING & SUPERVISION

B.01	Engineering Design Services (5% of Section 2 thru 8)	L.S.	100%	L.S.	$1,050,000.00
B.02	MoT Engineering Services (2.5% of Section 2 thru 8)	L.S.	100%	L.S.	$525,000.00
B.03	MoT Project Management (5% of Section 2 thru 8)	L.S.	100%	L.S.	$1,050,000.00
B.04	MoT Construction Supervision (10% of Section 2 thru 8)	L.S.	100%	L.S.	$2,100,000.00
TOTAL SECTION B					**$4,725,000.00**

SECTION C – WORK BY OTHERS

C.01	Hydro Relocation	Each	0.00	$400.00	$0.00
TOTAL SECTION C					**$0.00**

SECTION D – CONTINGENCIES

D.01	Contingency for Work on Roadways (50% of Section 2 thru 8)	L.S.	100%	L.S.	$10,500,000.00
TOTAL SECTION D					**$10,500,000.00**

SUMMARY SECTIONS A – D

TOTAL SECTION A – PROPERTY ACQUISITION	**$0.00**
TOTAL SECTION B – ENGINEERING & SUPERVISION	**$4,725,000.00**
TOTAL SECTION C – WORK BY OTHERS	**$0.00**
TOTAL SECTION D – CONTINGENCIES	**$10,500,000.00**
TOTAL OTHER COSTS	**$15,225,000.00**
TOTAL ESTIMATE	**$37,485,000.00**

Gabriola Island

Gabriola Bridge - Concrete Box Girder

PROJECT 653997
Conceptual Design Mar, 2015

Section Length - 4.22kms
Roadway width - 10.2m (3.6m lane, 1.5m shoulder)
Assumed new bridge over Cable Bay Trail

Item No.	Description of Work	Unit	Most Probable Quantity	Unit Price	Most Probable Extended Amount
SECTION 1 – GENERAL					
01.01	Mobilization (5.0% of Section 2 thru 8)	L.S.	100%	L.S.	$3,910,450.00
01.02	Traffic Management (0% of Section 2 thru 8) (Allowed for in Road Construction)	L.S.	100%	L.S.	$0.00
01.03	Quality Management (1.0% of Section 2 thru 8)	L.S.	100%	L.S.	$782,090.00
TOTAL SECTION 1					**$4,692,540.00**
SECTION 2 – GRADING					
02.01	**Clearing and Grubbing**				
02.01.01	Clearing and Grubbing Highway Construction	Ha	0.00	$30,000.00	$0.00
02.02	**Removals**				
02.02.01	Remove Lamp Standard	Each	0.00	$2,000.00	$0.00
02.03	**Pavement Cold Milling & Removal**				
02.03.01	Pavement Removal	Square Metre	0	$20.00	$0.00
02.04	**Roadway & Drainage Excavation**				
02.04.01	Organic Stripping - 300mm	Cubic Metre	0	$15.00	$0.00
02.04.02	Type "A" Excavation (neatline)	Cubic Metre	0	$40.00	$0.00
02.04.03	Type "D" Excavation (neatline)	Cubic Metre	0	$18.00	$0.00
02.04.04	Haul Surplus Material Offsite (factored)	Cubic Metre	0	$25.00	$0.00
02.05	**Granular Materials: Production & Placement**				
02.05.01	25mm Well Graded Base Course (WGBC)	Cubic Metre	0	$45.00	$0.00
02.05.02	Open Graded Granular Sub Base (SGSB)	Cubic Metre	0	$35.00	$0.00
02.06	**Embankment Construction**				
02.06.01	Import Material, Haul and Place into Highway Embankment	Cubic Metre	0	$20.00	$0.00
TOTAL SECTION 2					**$0.00**
SECTION 3 – DRAINAGE					
03.01	**Supply & Install**				
03.01.01	1000mm CSP 2.0 WT	Metre	0	$400.00	$0.00
03.02	**Rip Rap & End Walls**				
03.02.01	10 kg Rip Rap Outfall	Cubic Metre	0	$150.00	$0.00
03.02.02	End Wall 1000mm dia inlet with Fence and Apron	Each	0	$7,000.00	$0.00
TOTAL SECTION 3					**$0.00**
SECTION 4 – STRUCTURES					
04.01	**Supply & Install**				
04.01.01	Bridge Structure - Concrete Girder, including span and approaches	Square Metre	9,220	$8,450.00	$77,909,000.00
04.01.02	MSE Wall (sq.m face area)	Square Metre	0	$800.00	$0.00
TOTAL SECTION 4					**$77,909,000.00**
SECTION 5 – PAVING					
05.01	**Asphalt Pavement**				
05.01.01	Class 1 Medium Mix	Tonne	0	$155.00	$0.00
05.01.02	Asphalt Overlay - 50mm	m2	0	$20.00	$0.00
05.02	**Concrete Works**				
05.02.01	Concrete Curb and Gutter	Metre	0	$50.00	$0.00
05.03	**Concrete Barriers**				
05.03.01	Supply and Install CRB	Each	0	$250.00	$0.00
05.03.02	Supply and Install CMB	Each	0	$350.00	$0.00
TOTAL SECTION 5					**$0.00**
SECTION 6– SIGNING & PAVEMENT MARKING (Included in Section 4)					
06.01	**Sign Installation**				
06.01.01	Remove Existing Signs	Each	0	$200.00	$0.00
06.01.02	Supply & Install Perforated Square Steel Post and Sign Face (SP635 3.6.1)	Each	0	$400.00	$0.00
06.02	**Pavement Markings**				
06.02.01	Pavement Marking Layout	L.S.	0.00	$1,000.00	$0.00
06.02.02	Line Markings	Metre	-	$6.00	$0.00
06.02.03	Longitudinal and Transverse Pavement Markings and Arrows	L.S.	0.00	$2,000.00	$0.00
TOTAL SECTION 6					**$0.00**
SECTION 7 – ELECTRICAL					
07.01	**Electrical Materials**				
07.01.01	Lamp Standard including wiring	Each	30	$5,000.00	$150,000.00
TOTAL SECTION 7					**$150,000.00**
SECTION 8 – LANDSCAPE AND ENVIRONMENTAL					
08.01	**Landscape and Environmental**				

Gabriola Island

Gabriola Bridge - Concrete Box Girder

PROJECT 653997
Conceptual Design Mar, 2015

Section Length - 4.22kms
Roadway width - 10.2m (3.6m lane, 1.5m shoulder)
Assumed new bridge over Cable Bay Trail

Item No.	Description of Work	Unit	Most Probable Quantity	Unit Price	Most Probable Extended Amount
08.01.01	Landscaping and Environmental Requirements	L.S.	1.0	$150,000.00	$150,000.00
TOTAL SECTION 8					**$150,000.00**

SUMMARY SECTIONS 1 – 8

TOTAL SECTION 1 – GENERAL	**$4,692,540.00**
TOTAL SECTION 2 – GRADING	**$0.00**
TOTAL SECTION 3 – DRAINAGE	**$0.00**
TOTAL SECTION 4 – STRUCTURES	**$77,909,000.00**
TOTAL SECTION 5 – PAVING	**$0.00**
TOTAL SECTION 6 – SIGNING & PAVEMENT MARKING	**$0.00**
TOTAL SECTION 7– ELECTRICAL	**$150,000.00**
TOTAL SECTION 8 – LANDSCAPE	**$150,000.00**
TOTAL CONSTRUCTION COSTS	**$82,901,540.00**

SECTION A – PROPERTY					
A.01	Acquisition, incl. Legal Survey	L.S.	0%		$0.00
TOTAL SECTION A					**$0.00**
SECTION B – ENGINEERING & SUPERVISION					
B.01	Engineering Design Services (5% of Section 2 thru 8)	L.S.	100%	L.S.	$3,910,450.00
B.02	MoT Engineering Services (2.5% of Section 2 thru 8)	L.S.	100%	L.S.	$782,090.00
B.03	MoT Project Management (5% of Section 2 thru 8)	L.S.	100%	L.S.	$782,090.00
B.04	MoT Construction Supervision (10% of Section 2 thru 8)	L.S.	100%	L.S.	$7,820,900.00
TOTAL SECTION B					**$13,295,530.00**
SECTION C – WORK BY OTHERS					
C.01	Hydro Relocation	Each	0.00	$400.00	$0.00
TOTAL SECTION C					**$0.00**
SECTION D – CONTINGENCIES					
D.01	Contingency for Work on Roadways (50% of Section 2 thru 8)	L.S.	100%	L.S.	$39,104,500.00
TOTAL SECTION D					**$39,104,500.00**

SUMMARY SECTIONS A – D

TOTAL SECTION A – PROPERTY ACQUISITION	**$0.00**
TOTAL SECTION B – ENGINEERING & SUPERVISION	**$13,295,530.00**
TOTAL SECTION C – WORK BY OTHERS	**$0.00**
TOTAL SECTION D – CONTINGENCIES	**$39,104,500.00**
TOTAL OTHER COSTS	**$52,400,030.00**
TOTAL ESTIMATE	**$135,301,570.00**

Gabriola Island

Gabriola Bridge - Cable Stay

PROJECT 653997
Conceptual Design Mar, 2015

Section Length - 4.22kms
Roadway width - 10.2m (3.6m lane, 1.5m shoulder)
Assumed new bridge over Cable Bay Trail

Item No.	Description of Work	Unit	Most Probable Quantity	Unit Price	Most Probable Extended Amount
SECTION 1 – GENERAL					
01.01	Mobilization (5.0% of Section 2 thru 8)	L.S.	100%	L.S.	$9,227,500.00
01.03	Traffic Management (0% of Section 2 thru 8) (Allowed for in Road Construction)	L.S.	100%	L.S.	$0.00
01.03	Quality Management (1.0% of Section 2 thru 8)	L.S.	100%	L.S.	$1,845,500.00
TOTAL SECTION 1					**$11,073,000.00**
SECTION 2 – GRADING					
02.01	**Clearing and Grubbing**				
02.01.01	Clearing and Grubbing Highway Construction	Ha	0.00	$30,000.00	$0.00
02.02	**Removals**				
02.02.01	Remove Lamp Standard	Each	0.00	$2,000.00	$0.00
02.03	**Pavement Cold Milling & Removal**				
02.03.01	Cold Milling (50mm)	Square Metre	0	$20.00	$0.00
02.03.02	Saw cutting	Metre	0	$20.00	$0.00
02.03.03	Pavement Removal	Square Metre	0	$20.00	$0.00
02.04	**Concrete Removals**				
02.04.01	Remove Concrete Curb	Metre	0	$25.00	$0.00
02.05	**Roadway & Drainage Excavation**				
02.05.01	Organic Stripping - 300mm	Cubic Metre	0	$15.00	$0.00
02.05.02	Type "A" Excavation (neatline)	Cubic Metre	0	$40.00	$0.00
02.05.02	Type "D" Excavation (neatline)	Cubic Metre	0	$18.00	$0.00
02.05.03	Haul Surplus Material Offsite (factored)	Cubic Metre	0	$25.00	$0.00
02.06	**Granular Materials: Production & Placement**				
02.06.01	25mm Well Graded Base Course (WGBC)	Cubic Metre	0	$45.00	$0.00
02.06.02	Open Graded Granular Sub Base (SGSB)	Cubic Metre	0	$35.00	$0.00
02.07	**Embankment Construction**				
02.07.01	Import Material, Haul and Place into Highway Embankment	Cubic Metre	0	$20.00	$0.00
TOTAL SECTION 2					**$0.00**
SECTION 3 – DRAINAGE					
03.01	**Supply & Install**				
03.02.01	1000mm CSP 2.0 WT	Metre	0	$400.00	$0.00
03.02	**Rip Rap & End Walls**				
03.02.01	10 kg Rip Rap Outfall	Cubic Metre	0	$150.00	$0.00
03.02.02	End Wall 1000mm dia inlet with Fence and Apron	Each	0	$7,000.00	$0.00
TOTAL SECTION 3					**$0.00**
SECTION 4 – STRUCTURES					
04.01	**Supply & Install**				
04.01.01	Bridge Structure - Cable stay, include span and approaches	Square Metre	9,220	$20,000.00	$184,400,000.00
04.01.02	MSE Wall (sq.m face area)	Square Metre	0	$800.00	$0.00
TOTAL SECTION 4					**$184,400,000.00**
SECTION 5 – PAVING					
05.01	**Emulsified Tack Coat and Spray Primer**				
05.01.01	Supply Emulsified Penetrating Primer	Litre		$1.50	$0.00
05.01.02	Apply Emulsified Penetrating Primer	Litre		$0.40	$0.00
05.02	**Asphalt Pavement**				
05.02.01	Class 1 Medium Mix	Tonne	0	$155.00	$0.00
05.03	**Concrete Works**				
05.03.01	Concrete Curb and Gutter	Metre	0	$50.00	$0.00
05.04	**Concrete Barriers**				
05.04.01	Supply and Install CRB	Each	0	$250.00	$0.00
05.04.02	Supply and Install CMB	Each	0	$350.00	$0.00
TOTAL SECTION 5					**$0.00**
SECTION 6– SIGNING & PAVEMENT MARKING (Included in Section 4)					
06.01	**Longitudinal and Transverse Pavement Markings and Arrows**				
06.01.01	Remove Existing Signs	Each	0	$200.00	$0.00
06.01.02	Supply & Install Perforated Square Steel Post and Sign Face (SP635-3.6.1)	Each	0	$400.00	$0.00
06.02	**Pavement Markings**				
06.02.01	Pavement Marking Layout	L.S.	0.00	$1,000.00	$0.00
06.02.02	Line Markings	Metre	-	$6.00	$0.00
SECTION 8 ·	Transverse Pavement Markings and Arrows (Thermo Plastic)	L.S.	0.00	$2,000.00	$0.00
TOTAL SEC	**Landscape and Environmental**				**$0.00**

Gabriola Island

Gabriola Bridge - Cable Stay

PROJECT 653997
Conceptual Design Mar, 2015

Section Length - 4.22kms
Roadway width - 10.2m (3.6m lane, 1.5m shoulder)
Assumed new bridge over Cable Bay Trail

Item No.	Description of Work	Unit	Most Probable Quantity	Unit Price	Most Probable Extended Amount
SECTION 7	**Landscaping and Environmental Requirements**			**$150,000.00**	
07.01	**Electrical Materials**				
07.01.01	Lamp Standard including wiring	Each	30	$5,000.00	$150,000.00
TOTAL SECTION 7					**$150,000.00**
SECTION 8 – Landscape					
08.01	**Landscape Materials**				
08.01.01	Landscaping	L.S.	0.0	$5,000.00	$0.00
TOTAL SECTION 8					**$0.00**

SUMMARY SECTIONS 1 – 8

TOTAL SECTION 1 – GENERAL	**$11,073,000.00**
TOTAL SECTION 2 – GRADING	**$0.00**
TOTAL SECTION 3 – DRAINAGE	**$0.00**
TOTAL SECTION 4 – STRUCTURES	**$184,400,000.00**
TOTAL SECTION 5 – PAVING	**$0.00**
TOTAL SECTION 6 – SIGNING & PAVEMENT MARKING	**$0.00**
TOTAL SECTION 7– ELECTRICAL	**$150,000.00**
TOTAL SECTION 8 – LANDSCAPE	**$0.00**
TOTAL CONSTRUCTION COSTS	**$195,623,000.00**

SECTION A – PROPERTY					
A.01	Acquisition, incl. Legal Survey	L.S.	0%		$0.00
TOTAL SECTION A					**$0.00**
SECTION B – ENGINEERING & SUPERVISION					
B.01	Engineering Design Services (5% of Section 2 thru 8)	L.S.	100%	L.S.	$9,227,500.00
B.02	MoT Engineering Services (2.5% of Section 2 thru 8)	L.S.	100%	L.S.	$4,613,750.00
B.03	MoT Project Management (5% of Section 2 thru 8)	L.S.	100%	L.S.	$9,227,500.00
B.04	MoT Construction Supervision (10% of Section 2 thru 8)	L.S.	100%	L.S.	$18,455,000.00
TOTAL SECTION B					**$41,523,750.00**
SECTION C – WORK BY OTHERS					
C.01	Hydro Relocation	Each	0.00	$400.00	$0.00
TOTAL SECTION C					**$0.00**
SECTION D – CONTINGENCIES					
D.01	Contingency for Work on Roadways (50% of Section 2 thru 8)	L.S.	100%	L.S.	$92,275,000.00
TOTAL SECTION D					**$92,275,000.00**

SUMMARY SECTIONS A – D

TOTAL SECTION A – PROPERTY ACQUISITION	**$0.00**
TOTAL SECTION B – ENGINEERING & SUPERVISION	**$41,523,750.00**
TOTAL SECTION C – WORK BY OTHERS	**$0.00**
TOTAL SECTION D – CONTINGENCIES	**$92,275,000.00**
TOTAL OTHER COSTS	**$133,798,750.00**
TOTAL ESTIMATE	**$329,421,750.00**

Appendix D
BC Ferries Capital and O&M Cost Data

BC Ferries - Capital and Operating Cost Data

Assumptions

Discount Rate	6%
Inflation	2.1%

			CAPITAL AND REFIT IMPROVEMENTS					
Year	A: Operating Expenses[1]	NPV[2] (A)	B: Terminal Costs	NPV[2] (B)	C: Vessel MOI Refit Costs[3]	NPV[2] (C)	D: Annual Maintenance Costs[4]	NPV[2] (D)
2013	$ 6,991,000		$ -		$ -		$ -	
2014	$ 7,398,000		$ -		$ -		$ -	
2015	s.17		$ -		$ -		$ s.17	
2016			$ s.17		$ -		$	
2017			$		$ -		$	
2018			$		$ s.17		$	
2019			$		$		$	
2020			$ -		$		$	
2021			$ -		$		$	
2022			$ -		$		$	
2023			$ -		$		$	
2024			$ -		$		$	
2025			$ -		$		$	
2026			$ -		$		$	
2027			$ -		$		$	
2028			$ -		$ -		$	
2029			$ -		$ -		$	
2030			$ -		$ -		$	
2031			$ -		$ -		$	
2032			$ -		$ -		$	
2033			$ -		$ -		$	
2034			$ -		$ -		$	
2035			$ -		$ -		$	
2036			$ -		$ -		$	
2037			$ -		$ -		$	
2038			$ -		$ -		$	
2039			$ -		$ -		$	
2040			$ -		$ -		$	
2041			$ -		$ -		$	
2042			$ -		$ -		$	
2043			$ -		$ -		$	
2044			$ -		$ -		$	
		$103,478,663	s.17				$	$ 8,031,322

Cost to operate ferries 2015-2019, prior to assumed opening day of potential fixed link:
s.17

Notes

1) Operating expense data was provided for 2013-2014. Given the significant uncertainties with future service levels, funding, fuel costs, etc. a detailed forecast of operating expenditures was not done. A simplifying assumption of 2.1% annual CPI adjustment has been applied.
2) Net Present Value (NPV) for operations (A) & maintenance (D) costs computed for evaluation period, 2020 to 2044.
NPV for terminal and vessel capital costs computed for evaluation period, 2015 to 2044.
3) MOI refers to Major Overhaul & Inspection activities, that are not considered capital expenditures under current International Financial Reporting Standards (IFRS) accounting guidelines. It is assumed that vessel replacement only occurs once (2026) during the 25-year planning horizon.
4) Annual maintenance and refit costs beyond 2027 are assumed, based on an average of the costs from 2015 to 2027.

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s.13;s.17

Page 117

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s.14;s.17

Draft Report

Gabriola Island Fixed Link Planning Study

Prepared for

BC Ministry of Transportation and Infrastructure

April 2015

CH2MHILL®

Metrotower II – Suite 2100
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Burnaby, BC V5H 4N2

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Executive Summary

Background

The idea of a bridge link between Nanaimo and Gabriola Island is not new:

- In 1972, as part of a BC Ferries study, a highway was proposed connecting Gabriola Island to the Island Highway south of Nanaimo via Mudge Island, with bridge crossings at False and Dodd Narrows.
- In 1985, the Gulf Islands Committee campaigned against a fixed link under the slogan “real islands don’t have bridges”.
- In 1987, Islanders participated in a community forum during which the ferry-bridge scheme was rejected.
- In 1993, the fixed link concept was revisited as part of the Mid-Island Transportation Study, which reviewed ferry and highway operations between Vancouver Island and the Mainland.
- In 2012 and 2013, bridges were amongst options discussed during public engagement on the sustainability of the coastal ferry service conducted by BC MoTI and BC Ferries. The results of the engagement show divided opinions on the issue of a bridge to Gabriola Island, but that more respondents were in favour than against a bridge proposal.

BC Ministry of Transportation and Infrastructure (BC MoTI) is therefore undertaking this study to assess the technical feasibility of establishing a fixed link to replace the ferry service to Gabriola Island.

Although these previous studies have been undertaken, the Islands Trust has remained unsupportive of a proposed fixed link to Gabriola Island, and both the Official Community Plans (OCP) of Gabriola and Mudge Islands explicitly oppose any fixed link or bridge between the Islands and Vancouver Island or the BC Lower Mainland.

Study Objectives

The objectives of this feasibility study are as follows:

1. Assess the technical feasibility of a potential fixed link crossing between Nanaimo and Gabriola Island, assessing possible crossing alignments, cost, travel time, reliability, safety, emergency access, and flexibility for potential users, as well as socio-economic and environmental impacts of such a connection, as well as alignment with community plans.
2. Undertake a quantitative and qualitative analysis in a structured Multiple Account Evaluation (MAE) framework to evaluate feasible options against the existing ferry service.
3. The study will be informed by stakeholder input including: the Islands Trust, the Regional District of Nanaimo, the City of Nanaimo, Fisheries and Oceans Canada (DFO), Ministry of Environment (MOE), and the Council of Marine Carriers.

The study, and this report, are not intended to determine the level of support for or against a fixed link. It is only meant to provide a high level, technical comparison of a fixed link versus the existing ferry service in order that all levels of government and the public can understand how the two compare.

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Key Issues and Considerations

In order to properly understand the general constraints and challenges associated with determining the feasibility of a fixed link, a wide variety of key issues and considerations were reviewed upfront. This set the context for any alignment options that might be identified.

The key issues and considerations included:

- **Planning Policy and Land Use**, which examined existing polices, Official Community Plans (OCP), and all other relevant regulatory type constraints for each of Gabriola Island, Mudge Island, Nanaimo.
- **Transportation Planning and Engineering**, which served as the basis for determining the traffic demand that might use a fixed link if it were provided, alignment constraints and alternatives, the type of roadway, structural engineering elements of the bridges, associated geotechnical conditions, and marine navigational channel requirements.
- **Environmental and Archaeological**, which identified environmental conditions that exist in the study area and how these might be impacted. The environmental assessment investigated terrestrial, fresh water aquatic, marine and Environmentally Sensitive Area impacts. The archaeological investigation was key to identifying areas to avoid due to known archaeological finds, however recognizing that any coastal area typically has a high risk of archaeological disturbance.
- **Socio-economic Impacts**, which recognized that providing a fixed link is a fundamental departure from an island as its associated constrained access.

Traffic Demand Forecast

A key element of the fixed link feasibility assessment is an estimate of the traffic expected to make use of the link between Gabriola Island and Nanaimo. This also advised on the number of lanes that would be required on the link, as well as provide input to the MAE accounts. Annual vehicle travel demand forecasts were determined between 2015 and horizon year 2044.

Future vehicle demand forecasts for the proposed fixed link were split into two components:

- Ferry Background Growth – based on current trends in ferry usage.
- Induced Demand – new trips that might occur due to a new fixed link connection.

The analysis focused on ferry vehicle traffic which generally comprises the bulk of ferry passenger ridership. Foot passengers, which includes a variety of trip makers such as school children, shoppers, cyclists, and commuters to downtown Nanaimo, were not explicitly included in the analysis as no data is available on their total volumes. It was assumed that some of these travelers will either shift modes to vehicles, such as school buses or passenger vehicles, or would cease to make the trip across to Nanaimo and back. It was also assumed that the additional vehicle demand would be captured within the induced demand component. Future ferry background growth was estimated using historic BC Ferries ridership data on Route #19, Nanaimo Harbour - Gabriola Island. This component of the traffic demand estimated future growth in vehicle demand assuming current conditions (i.e. a ferry link between Gabriola and Nanaimo) continue in the future. The induced component of the traffic demand estimated the additional vehicle trips generated as a result of providing a fixed link.

To forecast future background traffic growth, a linear regression model was developed as part of this study. A regression model relates the traffic volume variable being forecasted with corresponding historic trends of independent variables that potentially impact ferry traffic growth. These models employ statistical methods to estimate coefficients, which provide the magnitude and impact that each of the independent variables has on the dependent variable, which in this case is traffic volume.

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The primary variables applied in the model include:

- Age group (younger than 60)
- Fares
- Gross Domestic Product (GDP)
- Employment
- Gas price

The latter two variables were however subsequently dropped from the final model equation as they either exhibited counter-intuitive relationships with traffic, or were statistically insignificant.

To determine traffic demand elasticity, three elasticity assumptions and three background traffic growth scenarios were applied, namely low, moderate and high.

The traffic demand forecast took into account various travel markets segments, including:

- Residents, both permanent and seasonal
- Visitors and tourists
- Trucks and freight

The current ferry travel patterns were based on data from BC Ferries in terms of time of day, seasonality and mode type. An econometric demand forecasting approach was employed that related the key demand drivers to seasonal and annual travel on the current Route #19 to Gabriola Island.

The total forecasted traffic for the moderate scenario obtained by combining the outputs from the background traffic growth and induced traffic to the year 2044 is 1,240 vehicles per day.

To determine the number of travel lanes required for the fixed link to accommodate the forecast traffic volumes, the Highway Capacity Manual (2010) advises that the two-directional capacity of a two-lane highway (under base conditions) is 3,600 passenger vehicles per hour, which is significantly greater than the forecasted volume of 124 vehicles per hour (1,240 vehicles per day). **A two-lane bridge would therefore provide more than sufficient capacity in the long term**.

Option Development & Preliminary Technical Screening

Options generated for the Gabriola Island fixed link involved developing different road alignments and bridge crossings for evaluation. The various options considered are shown in Figure E-1. All road alignments provide a connection between Duke Point Highway on Vancouver Island and South Road on Gabriola Island. The proposed road alignments made use of some existing roads on Vancouver Island, Mudge Island and Gabriola Island, but also require the construction of new roadways.

A two-lane, 60 km/h fixed link was considered, with a cross section that allowed for cyclists on a paved shoulder lane and pedestrians on a gravel shoulder.

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FIGURE E-1. SCHEMATIC OF ROAD AND BRIDGE OPTIONS CONSIDERED

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Road Option A

The alignment for Road Option A is an extension of Phoenix Way from Maughan Road to Dodd Narrows. The horizontal alignment and vertical profile of Phoenix Way satisfies the design criteria, but sections will have to be upgraded with paved shoulders and proper drainage. The alignment of Road Option A intersects with the existing Cable Bay Trail. The roadway will cross over the trail and adjacent creek. A bridge or large multiplate culvert structure is likely required to span over the trail and provide adequate clearance underneath. All roadworks for Option A are within the City of Nanaimo's boundaries.

A key aspect of this option that will require addressing before this option can be considered further is the fact that the Harmac Pulp Mill property is zoned Class 4, Heavy Industry, and is therefore not suitable for the general population to drive through due to the safety concerns of the plant's emission points and hazardous chemical production and storage facility. It is estimated that approximately $100 million will be required to provide the necessary safety mitigation measures to allow for public access, in addition to the need to expropriate the ROW.

Road Option B

Road Option B uses the existing local road network of Holden Corso Road, Barnes Road and Nicola Road to tie-in to Duke Point Highway. Holden Corso Road, Barnes Road and Nicola Road do not meet the recommended design criteria as there is neither a paved shoulder nor proper drainage. In addition, Barnes Road has a substandard horizontal and vertical alignments. There are also up to eight intersections that will require upgrading. The roadworks for Option B are largely within the Regional District of Nanaimo (RDN) except for the northern section which is within the City's boundaries.

This option has faced significant previous objections when it was considered to provide access for the Oceanview Golf Resort and Spa development proposed in this area.

Road Option C

Road Option C follows a new local road alignment between Duke Point Highway and Dodd Narrows. The alignment lies north of designated Agricultural Land Reserve (ALR) lands that are subject to seasonal flooding, and crosses the two Harmac Pulp Mill pipelines. Following existing contours the road proceeds further east where it then generally follows the internal road network envisioned in the Oceanview Golf Resort Master Plan. Option C fall primarily within the City of Nanaimo's boundaries.

Since this option is a new road connection, a stakeholder and public consultation process is likely to take place, as well as other more detailed studies of the route (environmental, archaeological, etc.), prior to any acceptance of this option.

Mudge Island Section

Fixed link options that have a connection between Dodd Narrows and the crossing to Gabriola Island will require the reconstruction of roads on Mudge Island. The proposed alignment on Mudge Island uses some of the existing roads including Ling Cod Lane, Coho Boulevard, Weather Way and View Ridge Road. These existing roads are low volume, gravel roads that will require extensive upgrading to meet the design criteria for horizontal and vertical alignments, as well as road width. Two new road sections would also have to be constructed to access the proposed main channel bridge crossing locations described below (Crossing Option 3 and Crossing Option 4): for Crossing Option 3 a new road would have to be constructed to connect Coho Boulevard and Weather Way; and for Crossing Option 4 a new road would have to be constructed between the east end of Weather Way and the eastern section of Coho Boulevard.

The upgrading of the existing roads and new road construction will have significant impact on a number of private properties on Mudge Island.

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Gabriola Island Section

It was proposed that all bridge crossings from Vancouver Island or Mudge Island connect to South Road on Gabriola Island. For the purposes of this technical feasibility assessment, the roadworks on Gabriola Island will be limited to an intersection providing access to the bridge. However, substantial upgrading of South Road from the crossing location to the village centre will be required to meet the recommended design criteria.

Dodd Narrows Crossing

Two Dodd Narrows crossing options were considered. Option 1 has the shortest potential crossing with a 210 metres long bridge, however, at this location the bridge and road would have a significant impact on Joan Point Park. Option 2 avoids direct impacts to Joan Point Park, and runs roughly parallel to the existing BC Hydro right of way. This crossing requires a bridge of approximately 260 metres, and appears feasible from a structural engineering and constructability perspective.

Main Channel Crossing Options

Four different bridge crossing location options to Gabriola Island were developed:

- Crossing Option 1 crosses directly from Vancouver Island to Gabriola Island across Northumberland Channel, avoiding impacts on Mudge Island.
- Crossing Option 2, Crossing Option 3, and Crossing Option 4 are options that cross False Narrows between Mudge Island and Gabriola Island. To achieve these crossings an additional bridge is required at Dodd Narrows between Vancouver Island and Mudge Island as described above.

Crossing Option 1 will require a bridge of over 1,500 metres long on a gradient of 2.7%. The bridge landing area on Gabriola is on a steep hillside and founding the abutment at this location could be challenging. The bridge height exceeds the required 23 metre navigational clearance, and would be in the order of 80 metres above the sea level. As a point of reference, the Alex Fraser and Lions Gate Bridges in the Lower Mainland of BC have clearances of about 50 metres above water level. Due to the excessive bridge span, an elevation of 80 metres on Gabriola Island, and overall constructability challenges, this option is rejected.

Crossing Option 2 limits impacts on Mudge Island and will require a bridge of approximately 840 metres in total length, at a steep 5.6% grade. The bridge landing area on Gabriola is on a steep hillside and founding the abutment at this location could be challenging. As with Crossing Option 1, due to the excessive bridge span, an elevation of 70 metres on Gabriola Island, and overall constructability challenges, this option is rejected.

Crossings Option 3 is a connection between Weather Way on Mudge Island and South Road, and will require an 800 metre long box girder viaduct, with a balanced cantilever main span to accommodate the required 23 metres high and 152 metres wide navigation envelope. Approach gradients on either side of the main span are approximately 4.4%. The bridge landing would be in the vicinity of the “Brickyard” site at the South Road and Ferne Road intersection on Gabriola Island. In the event that navigation routes can be redirect to Dodd Narrows, a lower profile viaduct structure could be constructed. Crossing Option 3 appears feasible from a structural engineering and constructability perspective.

Crossing Option 4 is a connection between Coho Boulevard on Mudge Island and South Road, and will require a 480 metre long box girder viaduct. It is not feasible to accommodate the 23 metres high and 152 metres wide navigation envelope. Given the comparatively short length of the viaduct, and low elevation on either side of False Narrows, to achieve that clearance would require approach gradients in excess of 10%. Considering that this option cannot achieve the required navigational clearance, it is rejected.

The above preliminary technical screening of all the fixed link segments were also subjected to the following additional assessments, with the summary of the findings of each presented.

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Archaeological

There is high potential for encountering new archaeological sites anywhere within all the fixed link alignment option areas, including in intertidal and submarine environments. The existence of known Aboriginal burial sites means that there is a strong likelihood that the area contains many more, undocumented burials. These sites are of cultural significance to Aboriginal groups in the area, and no disturbance of any such site can be countenanced without the full consultation and consent of the appropriate Aboriginal groups and BC MFLNRO Archaeology Branch.

For these reasons, Main Channel Crossing Option 4 will likely never be approved by concerned Aboriginal Groups or BC MFLNRO Archaeology Branch. Similarly, the Dodd Narrows Crossings, Main Channel Crossing Options 1 and 3 also potentially impact known archaeological sites, and so these alignments might require amendment in order to have any chance of them being approved by BC MFLNRO Archaeology Branch and concerned Aboriginal Groups.

Of the bridge crossings reviewed, Main Channel Crossing Option 2 appears to have the least number of immediate archaeological concerns associated with it, though it should be pointed out that accessing this crossing is contingent upon the highly problematic Dodd Narrows Crossing between Vancouver Island and Mudge Island.

The proposed Road Option C access potentially impacts two archaeological sites, though a final determination of the significance and degree of intactness of the two previously disturbed shell midden sites should be made via an AIA before pursuing mitigation options; it may be that BC MFLNRO Archaeology Branch will be amenable to a controlled excavation of these sites, if avoidance by amending the project footprint is not feasible.

To achieve a conclusive archaeological recommendation, a full AIA is recommended of all affected inland, intertidal and marine coastal zones on Vancouver Island, Mudge Island and Gabriola Island, prior to any ground disturbance, should any of the fixed link alignment options seem technically feasible.

Geotechnical

Based on the desktop geotechnical engineering assessment, the fixed link is considered to be technically feasible from a geotechnical perspective. It is expected that all technical issues identified can be addressed during any potential future design and construction stages, at which time further geotechnical investigation will be required to confirm (or otherwise) the desktop review.

Once a preferred alignment has been selected, a detailed marine investigation is recommended to be undertaken. The investigation should include detailed bathymetry, seismic profiling and test hole drilling at select locations to determine the nature and thickness of overburden and sufficient information regarding the nature and quality of the bedrock for design of rock sockets.

Environmental

Based on the desktop review of available information for the Gabriola Island Fixed Link study, the primary environmental concerns are the unidentified ‘sensitive’ species which are located throughout the entire alignment and at all bridge crossing locations. Due to the masked nature of these species within the BC Conservation Data Centre database, these species are likely to be more vulnerable to impacts and disturbances resulting from any fixed link. The red and blue-listed plant species, including the eulachon and the Douglas fir/dull Oregon-grape Ecological Community, are of secondary concern due to the listed status of these species.

Main Channel Crossing Option 1 with Road Option B poses the least amount of environmental impacts when compared to the other alignment options. This option disturbs the least amount of new ground surface for the roadway, encounters fewer listed plant species than the other options, and does not require the installation of culverts on potentially fish bearing watercourses. Crossing Option 1 is also limited to only one

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bridge crossing which conveniently encounters the least number of ecologically sensitive areas and avoids potential spawning habitat for herring and ling cod.

Property Impacts

Only the number of impacted properties have been determined based on the current level of design, and a more detailed assessment is required to more accurately determine actual impacts, and associated costs. If the Phoenix Way extension option were to ever proceed due to the safety mitigation measures being implemented (at a cost of approximately $100 million), expropriation of the entire corridor would be required.

The number of impacted properties per fixed link segment is shown in Table E-1.

TABLE E-1. SUMMARY OF PROPERTY IMPACTS

Segment	Number of Properties Impacted		
	Nanaimo	Mudge Island	Gabriola Island
Road Option A (Phoenix Extension) to Dodd Narrows	5	0	0
Road Option B (Nicola Extension) to Dodd Narrows	7	0	0
Road Option C to Dodd Narrows	8	0	0
Main Channel Crossing Option 1	1	0	1
Main Channel Crossing Option 2 via Mudge Island	1	19	1
Main Channel Crossing Option 3 via Mudge Island	1	39	1
Main Channel Crossing Option 4 via Mudge Island	1	59	1

The overall results of the preliminary technical screening of all the above fixed link segments are provided in Table E-2.

TABLE E-2. PRELIMINARY SCREENING RESULTS

Segment	Preliminary Screening Based on Technical Criteria				
	Achieve Navigational Clearance	Constructability	Geotechnical *	Environmental Impacts	Archaeological Impacts
Road Option A (Phoenix Extension)	–	Pass	Pass	Fail*	Fail*
Road Option A – Alt 2	–	Pass	Pass	Fail*	Fail*
Road Option B (Nicola Extension)	–	Pass	Pass	Fail*	Fail*
Road Option C (New Road Through Oceanview Resort)	–	Pass	Pass	Fail*	Fail*
Dodd Narrows Crossing 1	Pass	Pass	Pass	Fail*	Fail*
Dodd Narrows Crossing 2	Pass	Pass	Pass	Fail*	Fail*
Main Channel Crossing Option 1	Pass	Fail	Pass	Pass	Fail*
Main Channel Crossing Option 2	Pass	Fail	Pass	Fail*	Pass
Main Channel Crossing Option 3	Pass	Pass	Pass	Fail*	Fail*
Main Channel Crossing Option 4	Fail	Pass	Pass	Fail*	Fail

Note:

* Preliminary findings only. Subject to a more detailed assessment before a final decision can be made.

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Cost Estimate

In order to arrive at the overall planning level cost estimate for the fixed link, typical unit costs were derived for the major construction items. Itemized cost estimates were developed, and line items identifying scope of work items and quantities were included to determine a cost of construction for each segment.

For the purposes of this estimate, an all-inclusive unit rate for bridge construction was assumed based on consideration of a "complex structure", which was then factored up by 30% to account for the uncertainty with underwater foundation conditions, site location, and expected difficulty of construction.

Rates account for total construction cost including mobilization and site preparation, temporary works, permanent works, and professional fees, but exclude all property and environmental compensation/ mitigation related costs.

Applying BC MoTI Project Cost Estimating Guidelines (2013), since the level of project development completed at this planning level is between 1% and 15%, the associated level of accuracy to be expected for the cost estimates is ±35%. However, an accuracy of ±50% has been applied for this study due to the following risk factors:

- Earthworks and paving quantities were developed with minimal geotechnical input
- The extent of bridge construction
- The need to barge in all construction materials
- Limited, if any, obvious site establishment locations especially at the bridgeheads on Mudge Island
- The likelihood of First Nation oversight personnel on site during the entire construction period

The cost estimates shown, and any resulting conclusions made on project financial or funding requirements, have been prepared for guidance in project evaluation and implementation from the information available at the time the estimate was prepared. The final costs of the project will depend on actual labour and material costs, competitive market conditions, actual site conditions, final project scope, implementation schedule, and other variable factors. In addition, increases or decreases in material pricing may have a significant impact that is not predictable. As a result, the final project costs will vary from the opinions of cost presented in this report.

Of the False Narrows crossing options, only Crossing Option 3 appears feasible at this stage, or an alignment in this proximity. Similarly, the Dodd Narrows crossing option that follows the BC Hydro right of way appears feasible. Therefore, for the purposes of preparing a cost estimate for a fixed link, the following segments were considered (as shown in Figure E-1):

- "Gabriola Bridge" (Crossing Option 3)
- "Dodd Bridge"
- The road segments on both Gabriola and Mudge Islands
- Three of the road segments tying in to Duke Point Highway. Option A was rejected due to its significant impact on Joan Point Park.

The summary costs for each estimating category and for each fixed link segment are provided in Table E-3.

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TABLE E-3. SUMMARY OF COSTS FOR FIXED LINK OPTIONS
s.13,s.17

Business Case Evaluation

In order to determine if a business case exists for a fixed link to Gabriola Island, a Multiple Account Evaluation (MAE) was done following BC MoTI guidelines. For the purposes of the evaluation, the "business-as-usual" Base Case assumes the continuation of the BC Ferries service on Route 19, and is compared to the Fixed Link.

The accounts and criteria set out in BC MoTI's MAE guidelines were adapted to the specific context of the Gabriola Island Fixed Link evaluation. Of particular relevance in the evaluation is the Net Present Value and the Benefit Cost Ratio.

The net present value of the Fixed Link is estimated to be ($42.1 million), or -$42.1 million. The NPV is determined by summing the incremental costs and benefits between the Base Case and the Fixed Link, based on those MAE accounts that can be monetized. The costs and benefits are presented in Table E-4.

The Fixed Link generates a negative benefit cost on account of the relatively high vehicle operating and safety costs. As a point of reference, a ratio in the order of 1.0 is deemed a viable project, unless other overarching factors exist. The Fixed Link benefit/cost ratio relative to the Base Case is estimated to be (0.33), or -0.33, also as seen in Table E-4. However, a number of social/community, environmental and economic impacts, along with convenience, reliability and emergency access benefits, are not reflected in this measure, but are captured in other MAE accounts.

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TABLE E-4. NPV AND BENEFIT/COST RATIO CALCULATIONS

Accounts	Base Case	Fixed Link	Delta
Capital Cost	s.17	193.5	s.17
O&M Cost (2015-2019)		37.7	
O&M Cost (2020-2044)		5.4	
Property Cost	tbd	tbd	tbd
Incremental Cost (Σ Capital + O&M + Property)			**-31.7**
Travel Time	43.9	30.2	13.7
Vehicle Operating Cost	7.0	26.6	-19.6
Safety	2.3	6.8	-4.5
Incremental Benefit (Σ Travel time + Veh Ops + Safety)			**-10.4**
		NPV	**-42.1**
		B/C	**-0.33**

Based on the analysis and assessment of the various accounts, the summary of the MAE is presented in Table E-5.

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TABLE E-5. MAE SUMMARY

	Accounts	Base Case (Ferry Service)	Fixed Link
FINANCIAL	Capital costs ($ millions)	s.17	193.5
	Operations and maintenance costs ($ millions)		5.4
	Property impacts (number of)		49
CUSTOMER SERVICE	Travel time ($ millions)	43.9	30.2
	Vehicle operating cost ($ millions)	7.0	26.6
	Travel time reliability/ flexibility	98%	100%
	Safety ($ millions)	2.3	6.8
	Multimodal accessibility	◑	◔
	Emergency access	◑	◕
NPV	($ millions)	–	(42.1)
BENEFIT/COST RATIO		–	(0.53)
SOCIAL/ COMMUNITY	Alignment with Plans and Policies	◔	○
	Island Identity	◔	○
	Noise	◑	◔
	Visual Impact	◑	◔
	Affordability	–	User fee equivalent to a ferry fare could generate $ 81.2 million over a 25 year period.
	Recreation	◑	◔
ENVIRONMENT	GHG emissions – travel-related	◑	○
	Air Pollution	◑	○
	ALR Impacts	◑	◑
	Terrestrial (Flora/fauna) impacts	◑	◔
	Aquatic impacts	◑	◔
	Archaeological impacts	◑	◔
ECONOMIC DEVELOPMENT	Goods Movement	◑	●
	Development Enabled	◑	◕
	Impact on Local Businesses	◑	◔

Legend:

○	Much Worse
◔	Worse
◑	Neutral
◕	Better
●	Much Better

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SECTION 1

Background

1.1 Local Context

Gabriola Island, located approximately 4.5 km due east of Downtown Nanaimo, is one of 12 Local Trust Areas administered by the Islands Trust. The Gabriola Island Local Trust Area includes over 20 other islands including Mudge Island.

The mandate of the Islands Trust is to preserve and protect the trust area and its unique amenities and environment for the benefit of residents of the trust area and of the province generally. The Islands Trust is given authority for land use planning and regulation under the BC Local Government Act, specifically to develop and adopt Official Community Plans and land use bylaws.

Gabriola Island had a resident population of 4,045 in 2011. Despite a 15% increase between 2001 and 2006, the Island's population did not increase between 2006 and 2011. In summer the population of Gabriola Island almost doubles in size with the addition of tourists and visitors.

The British Columbia Ferry Corporation (BC Ferries) provides a regular service between Descanso Bay and Nanaimo Harbour (Route 19: Nanaimo Harbour – Gabriola Island). The 20 minute sailings over 3 nautical miles occur approximately every hour and 10 minutes, with no service between approximately 11 pm and 6 am. The ferry schedule at the time of writing is shown in Table 1-1.

TABLE 1-1. BC FERRIES SCHEDULE: NANAIMO HARBOUR TO GABRIOLA ISLAND

Leave Nanaimo Harbour		Leave Gabriola Island	
6:55 am	**Daily except Sun, Dec 25 & Jan 1**	6:15 am	**Daily except Dec 25 & Jan 1**
8:10 am	*Daily*	7:35 am	Daily Except Sun
9:25 am	*Daily*	8:50 am	*Daily*
10:40 am	**Daily except Wed are (DC*)**	10:05 am	*Daily*
11:55 am	*Daily*	11:20 am	*Daily*
1:10 pm	*Daily*	12:35 pm	*Daily*
2:25 pm	**Daily except Sat-Sun**	1:50 pm	**Daily except Sat-Sun**
3:45 pm	*Daily*	3:05 pm	*Daily*
5:00 pm	*Daily*	4:20 pm	*Daily*
6:10 pm	*Daily*	5:35 pm	**Daily except Wed are (DC*)**
7:15 pm	*Daily*	6:40 pm	*Daily*
9:00 pm	*Daily*	8:25 pm	*Daily*
10:00 pm	**Daily except Wed**	9:30 pm	*Daily*
11:00 pm	*Daily*	10:30 pm	**Daily except Wed**

* DC – Wednesday sailings will be replaced by Dangerous Cargo sailings. No other passengers permitted.

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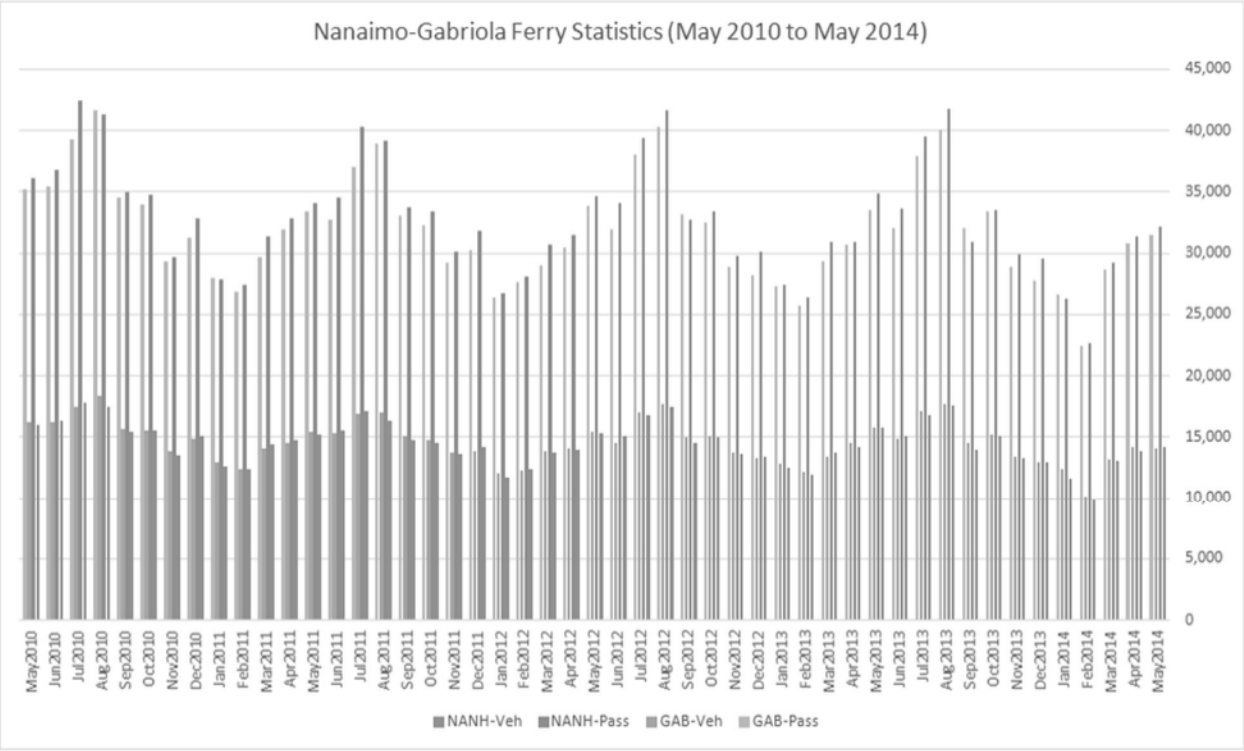
In 2013, BC Ferries served approximately 173,500 return vehicle trips and about 384,000 return passenger trips between Gabriola Island and Nanaimo Harbour. Residents of Gabriola Island who work or attend high school in Nanaimo rely on the ferry for commute trips. The ferry service also provides access for tourists and visitors to Gabriola Island.

Demand on this route varies seasonally, with peak demand experienced in July and August as shown in Figure 1-1.

FIGURE 1-1. BC FERRIES VEHICLE AND PASSENGER DATA FOR ROUTE 19



1.2 Reductions in Ferry Service

In May 2012, the Province announced that it would conduct public consultation with ferry dependent communities regarding adjustments to service levels. The Province also announced that it would seek public input to develop strategies to support a long-term vision for connecting coastal communities. This process concluded in December 2012 and in March 2013, the Province released its report summarizing the input it received during this consultation and engagement process. s.13

s.13

s.13,s.17

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s.13,s.17

1.3 Calls for Fixed Link

The idea of a bridge link between Nanaimo and Gabriola Island is not new. In 1972, then Premier WAC Bennett commissioned a study for a BC Ferries route from a proposed new terminal on Sea Island south of Vancouver to a new terminal on southern Gabriola Island. A highway was proposed, connecting to Mudge Island via a new bridge across False Narrows, and to the Island Highway south of Nanaimo via a bridge across Dodd Narrows.

In 1985, the Gabriola Bridge Club was formed with the backing of the Chamber of Commerce. Opinions were divided on the appropriateness of a bridge. The Gulf Islands Committee campaigned against a fixed link under the slogan “real islands don’t have bridges”. Islanders participated in a community forum in 1987 during which the ferry-bridge scheme was rejected.

The fixed link concept was revisited as part of the Mid-Island Transportation Study in 1993, which was commissioned jointly by the then Ministry of Transportation and Highways; the British Columbia Ferry Corporation and the Crown Corporations Secretariat; to review ferry and highway operations between Vancouver Island and the Mainland.

Bridges were amongst options discussed during public engagement on the sustainability of the coastal ferry service conducted by BC MoTI and BC Ferries in 2012 and 2013. At the time, BC Ministry of Transportation and Infrastructure (BC MoTI) stated that if Gabriola residents expressed strong support for a bridge to Nanaimo, the Ministry would undertake a Feasibility Study. **The results of the engagement show divided opinions on the issue of a bridge to Gabriola Island, but that more respondents were in favour than against a bridge proposal**. BC MoTI is thus undertaking a Study to assess the technical feasibility of establishing a fixed link to replace the ferry service to Gabriola Island. The objectives for this Feasibility Study are set out in Section 1.4.

While these previous studies were undertaken, the Islands Trust has remained unsupportive of a proposed fixed link to Gabriola Island. Both the Official Community Plans (OCP) of Gabriola and Mudge Islands explicitly oppose any fixed link or bridge between the Islands and Vancouver Island or the BC Lower Mainland.

1.4 Study Objectives

The objectives of this feasibility study are as follows:

1. **Assess the technical feasibility of a potential fixed link crossing between Nanaimo and Gabriola Island** – The study will examine the merits of a fixed link crossing in terms of alignment, cost, travel time, reliability, and flexibility for potential users. It will also include a high-level assessment of the socio-economic and environmental impacts of such a connection.
2. **Evaluate feasible options against the existing ferry service** – Quantitative and qualitative analysis will be brought together in a structured Multiple Account Evaluation (MAE) framework, based on the key issues identified in **Section 3**.
3. **Obtain Stakeholder input** – The strategy will be informed by stakeholder input including: the Islands Trust, the Regional District of Nanaimo, the City of Nanaimo, Fisheries and Oceans Canada (DFO), Ministry of Environment (MOE), and the Council of Marine Carriers.

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SECTION 2

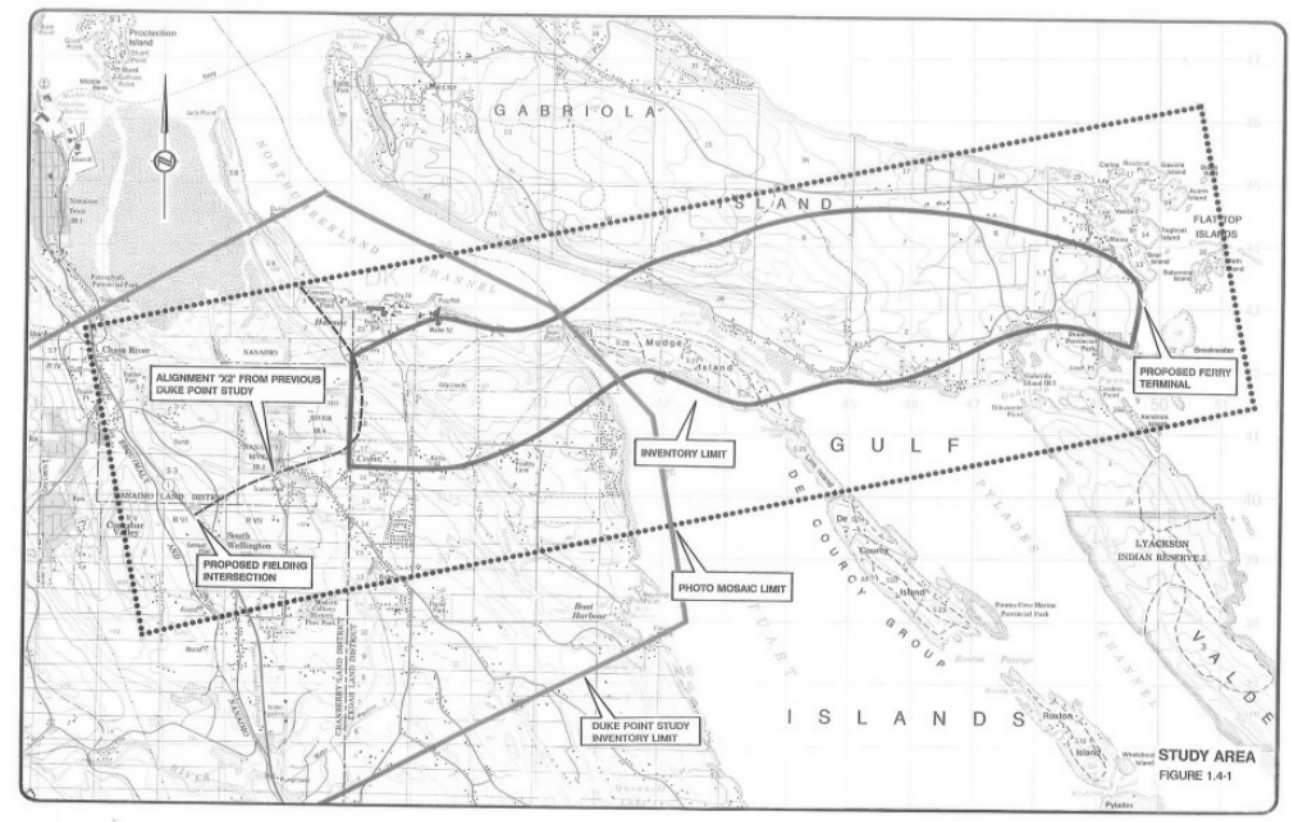
Review of Previous Studies

The Ministry provided access to two previous reports: the "Duke Point Corridor/Route Feasibility Study" and the "Gabriola Island Corridor/Route Feasibility Study" – both produced for the Ministry by McElhanney in 1993.

The Duke Point study expanded upon a previous report "New Vancouver Island Terminal Evaluation Study" that reviewed alternative ferry terminal sites. The preferred ferry terminal location identified in that report was at Duke Point, immediately northwest of the Harmac site. The Duke Point study generated and evaluated a wide range of controlled freeway-type connections between the ferry terminal and Highway 1.

The Gabriola Island study looked at several options for road alignment and possible bridge location sites for a fixed link connection to Gabriola Island. The study explored an alternative ferry terminal location, possibly at the south end of Gabriola Island. The proposed route was to be an expressway or freeway-type facility with no local road access. Travel patterns would be preserved on the existing, local road network. The extents of that study are reproduced in Figure 2-1.

FIGURE 2-1. INITIAL DUKE POINT FERRY TERMINAL LOCATION



The study included a route level technical evaluation of a highway connection between the proposed south-end of Gabriola ferry terminal and Nanaimo. The study concluded that the preferred route, shown in Figure 2-2, would tie into the Highway 1 near Nanaimo, and Peterson Road on Gabriola Island. The route would initially consist of two lanes, with two bridges (over Dodd Narrows and False Narrows) providing a link to Gabriola Island via Mudge Island.

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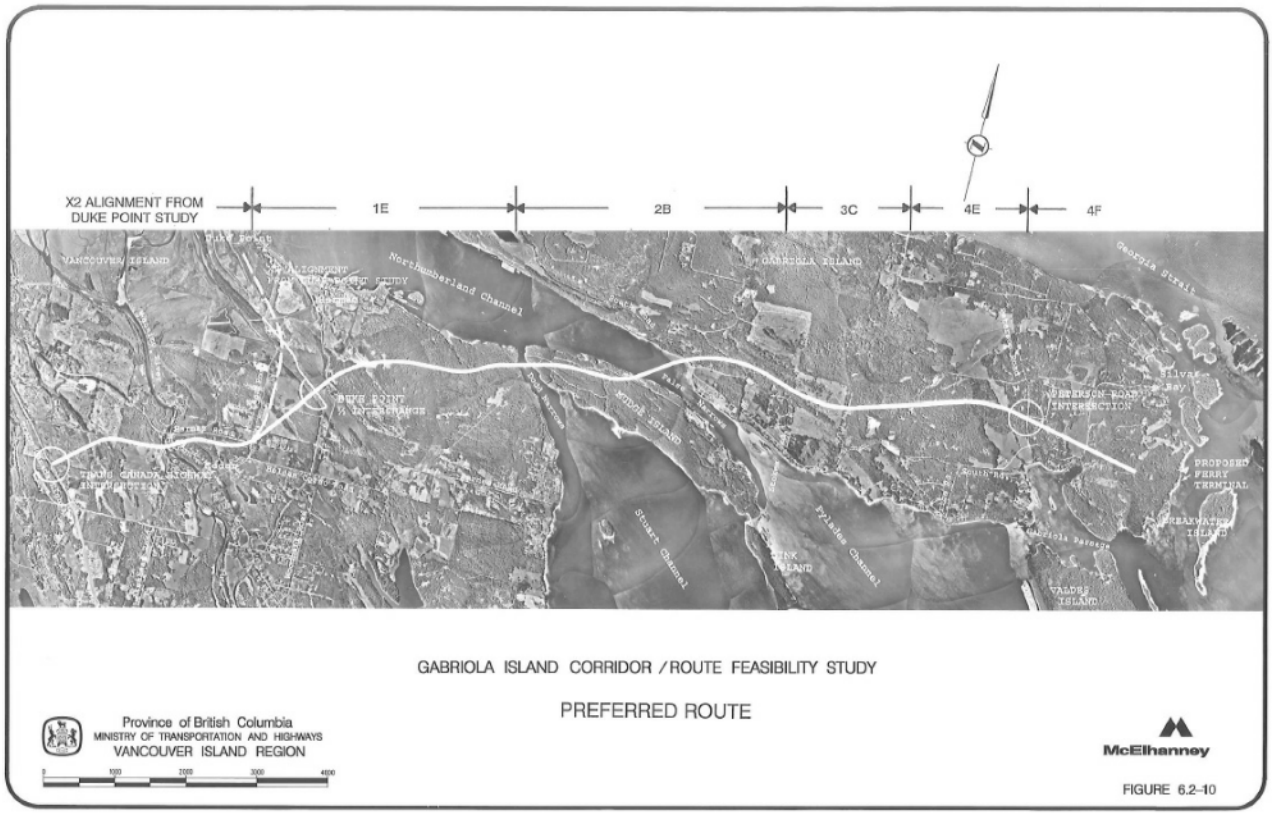
FIGURE 2-2. PREFERRED ROUTE FROM GABRIOLA ISLAND CORRIDOR/ROUTE FEASIBILITY STUDY, 1993



All the options incorporated a bridge across Dodd Narrows and a bridge across False Narrows to connect to Gabriola Island. No direct connections between Nanaimo and Gabriola Island – spanning across Northumberland Channel – were considered due to excessive length and construction over deep water.

Dodd Narrows

Dodd Narrows was identified as a preferred crossing location on account of its relatively short crossing distance, and favourable topography. Steep embankments on both Nanaimo and Mudge Island help to achieve the specified 23 metre high navigational clearance.

At the time of the McElhanney study, the establishment of Joan Point Park was proposed but not yet in place. McElhanney stated that “with careful architectural detailing and strict construction guidelines it should be possible to minimize the bridge's disruption of the area”.

Since the study, Joan Point Park has been designated.

False Narrows

The crossing of False Narrows in McElhanney’s preferred option was aligned to satisfy the study goal of a new ferry terminal at the south end of Gabriola Island. In addition, McElhanney’s preferred option shows extensive fills placed within False Narrows to construct a causeway to shorten the bridge length.

In this current study, only a connection to South Road is being considered, and due to anticipated environmental and hydrotechnical impacts, no fills will be considered in False Narrows.

Review of the previous studies was generally instructive in terms of feasible crossing locations. However, since the nature of the corridor has changed, then a freeway-type connection to a ferry terminal versus now a ‘simple’ connection, the criteria and ultimate design will be different than what was previously envisioned.

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SECTION 3

Stakeholder Consultation

BC MoTI identified the following key stakeholders to be consulted:

- The Islands Trust
- The Regional District of Nanaimo
- The City of Nanaimo
- Fisheries and Oceans Canada
- The Ministry of Environment
- The Council of Marine Carriers

Telephonic discussions were help with all of these stakeholders early on in the study, confirming relevant information, the majority of which is readily available online, and which is presented in the next section.

The City of Nanaimo also provided information pertaining to proposed developments in the study area.

After the development of concept fixed link option alignments, separate feedback meetings were held with the following stakeholders in March 2015, details of which are provided in Section 6:

- The City of Nanaimo
- The District of Nanaimo
- The Islands Trust

Members of the Council of Marine Carries advised that they do tow through both Dodd Narrows and False Narrows, including log and barge towing operations. As a result, any bridge at either location will require a minimum of 23 metres vertical clearance at High High Water. This would then accommodate most ramp barges and spud barges, as well as loaded chip barges. Since log towing is not uncommon in False Narrows, a minimum clear width (no piers) of 500 ft is required to accommodate about four sections wide.

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SECTION 4

Key Issues and Considerations

4.1 Planning Policy and Land Use

This section sets out the planning policy and land use considerations associated with a fixed link between Vancouver Island and Gabriola Island. An overall context plan of the study area is shown in Figure 4-1.

4.1.1 Gabriola Island

The Gabriola Island Official Community Plan (OCP), approved in 1997, sets out the community's goals, objectives and policies regarding land use and future development as well as social and environmental considerations applicable in the planning area. The purpose of the OCP is to provide direction to government agencies, businesses, land owners and residents concerning future land use and the provision of services.

The OCP goals include preservation of the natural environment, and discouraging projects which would reduce the health, quiet, natural and aesthetic values of the area; and to preserve the rural character and atmosphere of the area. A specific land transportation objective within the OCP is to "**oppose any fixed link or bridge** to Vancouver Island or ferry connection to the BC Lower Mainland". A further social goal in the OCP is to "encourage **gradual and appropriate, rather than rapid, change and growth**". Based on historic growth trends, the OCP estimates that the future population of Gabriola could grow to 4,720 by the year 2016.

The OCP does not designate additional land for residential development, as at the time the plan was approved (1997), it was considered that the availability of vacant residential parcels, combined with the future potential to create new parcels through the subdivision of existing residentially zoned land, was adequate to satisfy the Island's housing requirements for fifteen to twenty years. Further, it is noted in the OCP that there are known problems with inadequate soil percolation for septic disposal and groundwater supply because of the complex nature of groundwater flow through fractures in the bedrock which could limit the Island's capacity to accommodate future growth.

South Road is designated as a Main Road with in the OCP. Low density residential development is located on both sides of South Road. The area adjacent to False Narrows is more densely developed than other parcels along South Road. Parcels surrounding Hoggan Lake and further east are designated as Agricultural Land Reserve (ALR).

4.1.2 Mudge Island

A potential connection via Mudge Island was identified in previous studies. Current planning policies and land use relating to Mudge Island are thus pertinent to this planning study. A key community goal articulated in the Mudge Island OCP (2007) is to "**to keep the islands as a refuge** from the pressures of urban life, as partially facilitated by the absence of ferry service and bridges between these and other islands." Further, OCP Policy 4 states that "**no island in the Plan Area shall be connected to any other island by a bridge**."

The western half of Mudge Island is extensively subdivided. However, many of the properties are not developed, and it is understood that these subdivisions are the result of grandfathering. The Mudge Island OCP includes guidelines for development which emphasize the "rural Island Character and Local Needs". Specifically, OCP Guideline 7 states that the "preservation of the rural character, peace, quiet, privacy, tranquility, serenity and the 'slow island pace' shall continue, including the lack of paved roads and the

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absence of streetlights, sidewalks and other city-related services." OCP Guideline 9 states that "future development should only be permitted at a scale and rate of growth respectful of: community-held values pertaining to the environment; the Plan Area's rural qualities; consideration of water-only access; and the local area's limited infrastructure".

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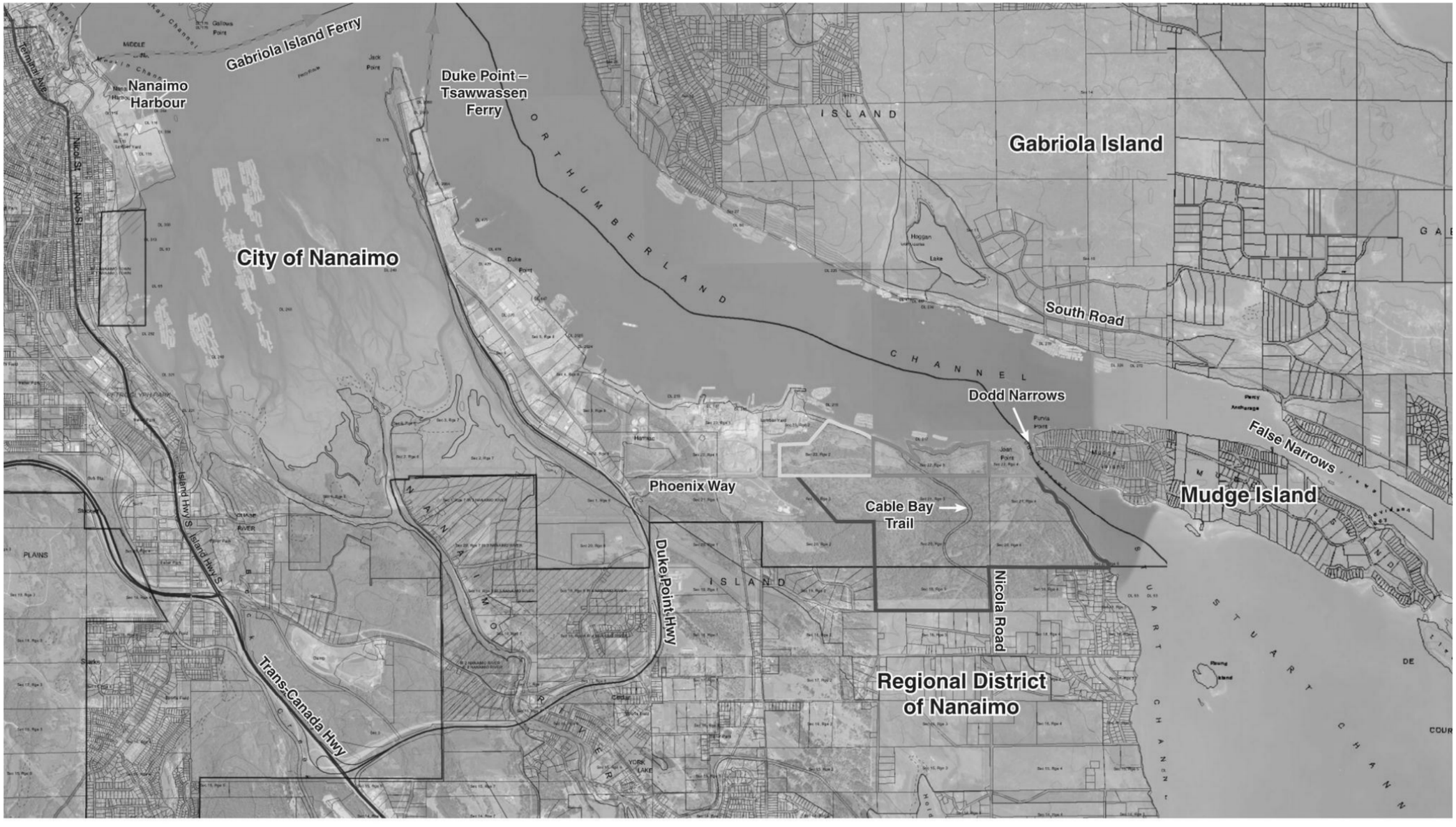
Figure 4-1. Context Plan of Study Area



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4.1.3 City of Nanaimo

The shortest crossing distance to Gabriola Island is from the northeastern boundary of the City of Nanaimo. Land use considerations in this location include:

- Joan Point Park is a designated area of Parks and Open Space in the City of Nanaimo OCP (2008) and is part of a designated Environmentally Sensitive Area (ESA) which also extends to the immediate west. Both the park and the ESA are situated outside of the City's Urban Containment Boundary (UCB). The OCP specifically states that "it is not expected that any Resource Protection or Parks and Open Space lands outside the UCB will be developed for urban growth".
- The purpose of the City's Environmentally Sensitive Area designation is to "protect areas that: provide productive fish or wildlife habitat; contain sensitive, rare or depleted ecosystems and landforms; and represent sites of Nanaimo's natural diversity that are in danger of disappearing". Because ESAs are sensitive to disturbance by human activity and the impacts of development, they are afforded special treatment in order to protect their integrity. In this case the area is designated as a Development Permit Area (DPA23) in the City of Nanaimo OCP. Disturbance of vegetation, movement of soil, or other disturbance of land or water is not permitted in these areas without an appropriate development permit.
- Island Timberlands GP Ltd. owns two parcels in this area, and has developed a Conceptual Plan for a Waterfront Village at Cable Bay (west of Joan Point Park). Proposed accesses to the development is to be achieved via an extension of Phoenix Way, however it is understood that Phoenix Way was constructed by Harmac and is a private road. Proposed development of a second land parcel further to the west (known as Cable Bay Waterfront Marina), also owned by Island Timberlands, requires an OCP amendment and is on hold pending resolution of site access off Phoenix Way. Both developments are arguably dependent on the resolution of these access issues.
- The Cable Bay Trail begins at a trailhead at the end of Nicola Road and terminates at the ocean. A rough private trail runs along the coast to Dodd Narrows offering good wildlife viewing opportunities, with harbour seals, sea lions, river otters and bald eagles commonly seen. Killer whales can also be observed in this area on occasion. Upon reaching Joan Point Park, the route becomes an unimproved public trail continuing to the park's southern border where the trail crosses onto private lands belonging to Oceanview Golf Resort and Spa. From that point, a further rough private trail extends south along Oceanview's eastern shoreline adjacent to Stuart Channel through the forested coastal fringe. At the southern border of Oceanview, the rough trail connects up with the end of Leask Road, offering the potential to loop back by road to the trailhead on Nicola Road.

4.2 Transportation Planning and Engineering

4.2.1 Crossing Demand

Compared to the existing ferry service, a fixed link will provide flexibility and reliability for travelers. A traffic demand assessment will confirm whether the crossing should have 2- or 4-lane bridge/s.

The assessment will account for potential induced traffic and will include commentary on anticipated origins and destinations. Impacts on alternative modes will also be identified. These include:

- Pedestrians (based on BC Ferry foot passenger traffic);
- Bicycles – an advocate group developed route plan (http://sustainablegabriola.ca/uploads/3/1/3/4/3134017/cyclepaths_of_gabriola_report.pdf);
- Transit – GERTIE Community Bus http://gabriolacommunitybus.com;
- Goods movement; and
- Emergency services.

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4.2.2 Alignment Constraints and Alternatives

Existing and future land uses presented in **Section 4.1** impose constraints on the horizontal alignment of the crossing. The crossing's vertical profile is constrained by navigational clearance requirements and by the significant elevation differences between Nanaimo and the western section of the main local road on Gabriola Island, South Road.

The horizontal alignment and vertical profile of approaches and road network connections need to conform to the challenging site topography particularly on Gabriola Island, and will determine right-of-way (ROW) impacts on surrounding properties.

The classification of the roadway for the fixed link to Gabriola Island would need to be decided upon to assist in determining appropriate alignment options. Using the existing local roads (e.g., Nicola Road, Holden Corso Road) as much as possible may reduce property impacts, but most of the existing local roads would require upgrading.

Another option is using Phoenix Way that goes through the Harmac Pulp Mill lands. This road was constructed by Harmac and is on their property. Phoenix Way is already connected to Highway 19 (via Maughan Road) and this route would bypass most developed residential areas. This would shorten the length of the new route significantly over what was proposed in the McElhanney study, however use of this road would require costly expropriation.

More importantly, Phoenix Way was only accepted as an emergency access route for future potential developments in the area, and not as a primary access road. This is because the property is zoned Class 4, Heavy Industry, and is therefore not suitable for the general population to drive through due to the safety concerns of the plant's emission points and hazardous chemical production and storage facility. Urban encroachment to this site is not encouraged in general.

4.2.3 Road Classification

The road classification of the fixed link will have some bearing on the alignment due varying design criteria, thereby affecting the costs of the road and bridge design and construction, and will determine the ROW impacts. Questions to be considered include:

- Will this road be part of the local road network or be an arterial type roadway with a higher posted speed and some access restrictions?
- What will be the posted speed? A local road will likely have a posted speed of 50 km/h. A higher design speed could be used but this could have impacts on the alignment.
- What is the estimated ADT and SADT, for the current year and the design year? These volumes are important for selecting shoulder width and clear zone width, which have implications on ROW, and pavement structure.
- Who will own the road? Some sections of the roadway will be within the City of Nanaimo, so who will have jurisdiction over the roadway in these sections?
- Will this be a multimodal facility to accommodate cyclists and pedestrians?

All of the above factors are important to determine appropriate alignment options and establishing evaluation criteria and impacts for the MAE.

4.3 Structural Engineering

The horizontal alignment, vertical profile, and required structure clearances (navigational and otherwise) form the envelope within which a bridge may be constructed. General guidance on acceptable water depth limits for caisson construction, and aerodynamic effects on long-span structures will also help to inform

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selection of suitable general structural arrangements. Determination of span lengths and structure types will stem from these decisions.

Bridge aesthetics, though not integral to the assessment of technical feasibility, will nonetheless play a part in the overall assessment of community impact.

Other marine and coastal engineering issues to take into account include:

- Tides and currents – especially at Dodd Narrows
- Sea level rise

4.4 Geotechnical Engineering

Geotechnical conditions are anticipated to be favourable given the near-surface bedrock elevations. However, specific geotechnical expertise is required to guide the concept designs of the following:

- Pier/abutment foundation conditions
- Access road and network connection pavement structure
- Potential slope stability, based on the need for some cut and fill to mitigate site topographic constraints

A desktop review of available geotechnical data was undertaken, the findings of which are included in Section 6.

4.5 Environmental Considerations

A desktop assessment was conducted to identify potential terrestrial, fresh water and marine environmental sensitivities along the proposed Gabriola Island Fixed Link alignments. This desktop study included a review of species at risk, sensitive ecological communities, and critical habitats of various species which may be encountered along and within close proximity to the alignment options. The desktop review was conducted using a variety of mapping and database tools, including the British Columbia Conservation Data Center and Fisheries and Oceans Canada online databases (BC Conservation Data Centre, 2012; Fisheries and Oceans Canada, 2009), BC iMAP, available satellite imagery, and information from previous feasibility studies. The detailed results of the assessment are presented in Section 6.

In general, species at risk were identified in the study area. In British Columbia, species at risk are designated as red or blue-listed to indicate the potential need for designation and protection under the British Columbia *Wildlife Act* or to assist in ranking conservation priorities for species considered to be at risk. Red-listed species include any 'ecological community, and indigenous species and subspecies that is extirpated, endangered, or threatened in British Columbia'. It is the red-listed species which may become be legally designated under the *Wildlife Act*, if deemed necessary for their protection. Blue-listed species include any 'ecological community, and indigenous species and subspecies considered to be of special concern in British Columbia' and these are species known to be particularly sensitive to human activities and natural events (Government of British Columbia, 2015).

British Columbia's Conservation Data Center organizes species of concern into two categories: 'sensitive' and 'non-sensitive'. Due to the vulnerability of species considered to be 'sensitive', location and species specific information is not provided in the database. However, an area polygon outlining the general area of where these species may be encountered is provided. For detailed information on 'sensitive' species, additional information must be requested and obtained under an agreement with the British Columbia Conservation Data Center. For 'non-sensitive' species however, specific information is provided, including the location of observation, scientific name, and status ranking.

A summary of the environmental sensitivities found during the desktop review are provided below.

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4.5.1 Terrestrial

No terrestrial wildlife or plant species of concern were identified in the general study area, however the mapped polygons of six red and blue-listed plant species were shown to be located in the proximity of the study area on Vancouver Island (Table 4-1). These plant species included awned cyperus, Muhlenberg's centaury, banded cord-moss, Nuttall's Quillwort, slimleaf onion, and white-top aster (BC Conservation Data Centre, 2012).

TABLE 4-1. AT RISK SPECIES FOUND IN THE VICINITY OF THE GABRIOLA ISLAND FIXED LINK ROUTE*

Common Name	Scientific Name	Species Type	British Columbia Listing	Provincial Status	COSEWIC Status	SARA Status
Awned cyperus	*Cyperus squarrosus*	Plant	Blue	S3	–	–
Banded cord-moss	*Entosthodon fascicularis*	Plant	Blue	S2S3	Special Concern	Threatened
Douglas-fir / Dull Oregon-grape	*Pseudotsuga menziesii / Mahonia nervosa*	Ecological Community	Red	S2	–	–
Eulachon	*Thaleichthys pacificus*	Fish	Blue	S2S3	Endangered	–
Muhlenberg's centaury	*Zeltnera muehlenbergii*	Plant	Red	S1	Endangered	Endangered
Nuttall's quillwort	*Isoetes nuttallii*	Plant	Blue	S3	–	–
Slimleaf onion	*Allium amplectens*	Plant	Blue	S3	–	–
White-top aster	*Sericocarpus rigidus*	Plant	Red	S2	Special Concern	Special Concern

Notes:

*Also includes species at risk located within 100 meters from possible route options

Bald eagles were identified throughout the entire project area and were observed by CH2M HILL staff on Mudge Island during the site visit conducted on November 27, 2014. Bald eagles are considered to be abundant and secure, however the general project area, specifically the treed habitats along Gabriola Island and Mudge Island, likely provide nesting habitat for bald eagles which should be considered during construction planning, should a fixed link be feasible.

4.5.2 Fresh Water Aquatic

No at-risk fresh water aquatic species were identified, however fresh water drainages likely connecting to Northumberland Channel were identified which may contain potential rearing and spawning habitat for salmon, trout, and char species. (McElhanney, 1993a; McElhanney, 1993b).

4.5.3 Marine

One at-risk marine species was found within the project area, and this included the blue-listed eulachon, marine fish. This species was encountered throughout the marine environments within the project area and has the potential to occur at the bridge crossing locations (BC Conservation Data Centre, 2012).

Although no additional at-risk marine species were identified, the review highlighted potential spawning habitat for herring (BC Conservation Data Centre, 2012) and ling cod, and the presence of oyster and clam beds along the coastal shorelines near the bridge crossings (McElhanney, 1993a).

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4.5.4 Environmentally Sensitive Areas

One sensitive ecological community is present in the study area and included the Douglas fir/dull Oregon grape ecological community. This ecological community is a Red listed environmentally sensitive area and is found throughout the terrestrial habitats, in particular on Mudge Island and in dispersed areas on Vancouver Island and Gabriola Island.

The Strait of Georgia, which encompasses the entire marine ecosystem within the project area, was also identified by DFO as an Ecologically and Biologically Important Area (Fisheries and Oceans Canada, 2009). These Ecologically and Biologically Important Areas are classified by DFO as containing significant or critical marine habitats and allows DFO to provide enhanced protection of these areas (Fisheries and Oceans Canada 2004).

No provincially designated parks, protected areas, or conservation areas were located within the project area, however Joan Point Park, a City of Nanaimo park was identified on Vancouver Island near Dodd Narrows.

4.6 Socio-economic

Provision of a fixed link has the potential to fundamentally change social and economic networks on the islands, as well as adjacent areas of Nanaimo. Daily routines would no longer be subject to ferry schedules and a wider array of services and amenities would be more accessible to Island residents. Increased accessibility may adversely impact existing local Island businesses, though some new opportunities may also arise.

There may be neighbourhood impacts ranging from qualitative aesthetic/visual impacts to more quantitative measures such as noise and housing affordability.

4.7 Archaeological

No specific references were made in the 1993 McElhanney report regarding archaeological impacts. A desktop review was done as part of this feasibility study to determine presence of any archaeological sites in the study area.

The desktop assessment was conducted using a variety of mapping and database tools, including the BC MFLNRO Archaeology Branch Remote Access to Archaeological Data (RAAD) website and available satellite imagery.

It is important to acknowledge that the absence of known sites in a particular location does not equate to an absence of archaeological potential; rather, the localized nature of past Archaeological Impact Assessment (AIA) work means that certain areas may not yet have been assessed for archaeological sites. In fact, the extensive nature of coastal shell midden sites with associated First Nations burials would imply that all coastal and inland zones in the possible development area must be considered to be of high archaeological potential and of cultural importance to First Nations.

In addition, articles concerning diachronic changes in relative sea-levels (RSL) for eastern Vancouver Island were consulted in order to understand the potential patterns of archaeological site distribution at various points in time, and the visibility of those archaeological sites relative to modern sea-levels. According to assessments of changes in RSL by Shugar et al. (2014), James et al. (2009) and James et al. (2002), along the eastern and southern coasts of Vancouver Island since the Last Glacial Maximum (circa 14,000 Before Present [BP]), RSL in the vicinity of Nanaimo and Gabriola Island fell as much as 150 m to modern sea-levels between 14,000 BP and 13,000 BP. Post-glacial RSL continued to fall below modern sea-level after 13,000 BP to approximately 20-25 m below the present RSL and did not rise again to modern sea-level until approximately 9000 BP. What this means for any of the fixed link options with an element of intertidal or submarine ground disturbance is that any intertidal or submarine ground surface down to an approximate

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depth of 25 m below current sea-level may potentially contain archaeological deposits, possibly deeply buried under subsequent deposits of marine sediments. Both Dodd Narrows and False Narrows were likely low-lying isthmuses linking Vancouver Island to Gabriola Island in a single, contiguous landmass at that time (Earle 2002). From an archaeological standpoint, areas of steeper coastal shelf bathymetry are less likely to have archaeological sites, and are therefore preferable for development over areas of gradually sloping and shallow coastal bathymetry. Conversely, the archaeological record of early Holocene human inhabitation of Vancouver Island may exist in locations associated with elevated palaeoshorelines, well above modern sea-level.

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SECTION 5

Traffic Demand Forecast

A key element of the fixed link feasibility assessment is an estimate of the traffic expected to make use of the link between Gabriola Island and Nanaimo. This will also advise on the number of lanes that would be required on the link, as well as provide input to the MAE accounts. This section provides a description of the methodology used to produce vehicle travel demand forecasts. Annual vehicle travel demand forecasts between 2015 and horizon year 2044 (assuming 2020 bridge opening and a 25 year horizon from opening day) are also presented in this section. All forecasts beyond 2030 were extrapolated for reasons explained in more detail in Section 5.1.3.

Future vehicle demand forecasts for the proposed fixed link are split into two components as follows:

- Ferry Background Growth – Based on current trends in ferry usage.
- Induced Demand – New trips that might occur due to a new fixed link connection.

The analysis focused on ferry vehicle traffic which generally comprises the bulk of ferry passenger ridership. Foot passengers, which includes a variety of trip makers such as school children, shoppers, cyclists, and commuters to downtown Nanaimo, were not explicitly included in the analysis as no data is available on their total volumes. It was assumed that some of these travellers will either shift modes to vehicles, such as school buses or passenger vehicles, or would cease to make the trip across to Nanaimo and back. It was also assumed that the additional vehicle demand would be captured within the induced demand component. Future ferry background growth was estimated using historic BC Ferries ridership data on Route #19 Nanaimo Harbour-Gabriola Island. This component of the traffic demand estimates future growth in vehicle demand assuming current conditions (i.e. if a ferry link between Gabriola and Nanaimo) continues in the future. The induced component of the demand estimates the additional vehicle trips generated as a result of providing a fixed link.

The approach to forecasting traffic demand on a fixed link to Gabriola Island is depicted in Figure 5-1, where the various travel markets are segmented. These segments include:

- Residents, both permanent and seasonal
- Visitors and Tourists
- Trucks and freight

The current ferry travel patterns are based on data from BC Ferries in terms of time of day, seasonality and mode type. An econometric demand forecasting approach was employed that relates the key demand drivers to seasonal and annual travel on the current Route #19 to Gabriola Island.

The following subsections describe the methodology, assumptions and outcomes for developing the forecasts of traffic for the fixed link connection.

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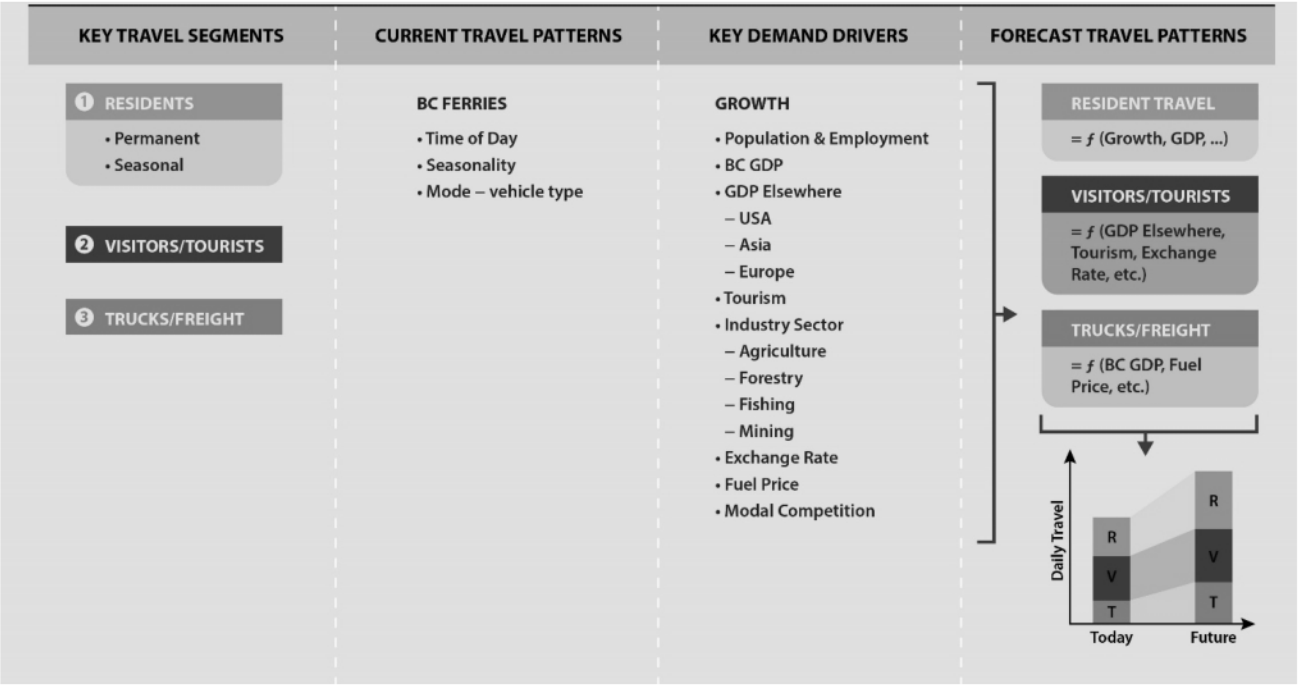
FIGURE 5-1. FORECASTING APPROACH AND METHODOLOGY



5.1 Ferry Background Growth

5.1.1 B.C. Ferries Ridership

s.17

Nanaimo and Gabriola between April 2004 and March 2014. The vehicle breakdown included several categories, such as regular vehicles, buses, trucks, passenger-vehicles over-height and passenger-vehicles under-height. For the purposes of the analysis, these vehicle data were aggregated into distinct categories – regular vehicles and trucks. Trucks included buses and passenger-vehicles over-height, in addition to regular trucks. Trucks were found to comprise only 3% of the total ridership.

Figure 5-2 summarizes the average quarterly daily traffic for all vehicles (regular + trucks) between 2004 and 2014. As expected, the traffic volume is highly seasonal with the highest volumes observed in the summer months (quarter 3). In general, vehicle ridership has been declining over the last decade: 1,270 vehicles in 2004-Q3 to 1,060 vehicles in 2013-Q3, a drop of 16.5%. This average decline is shown in the chart. The figure also clearly shows a steep decline in volumes between 2008 and 2009, which coincided with the economic downturn.

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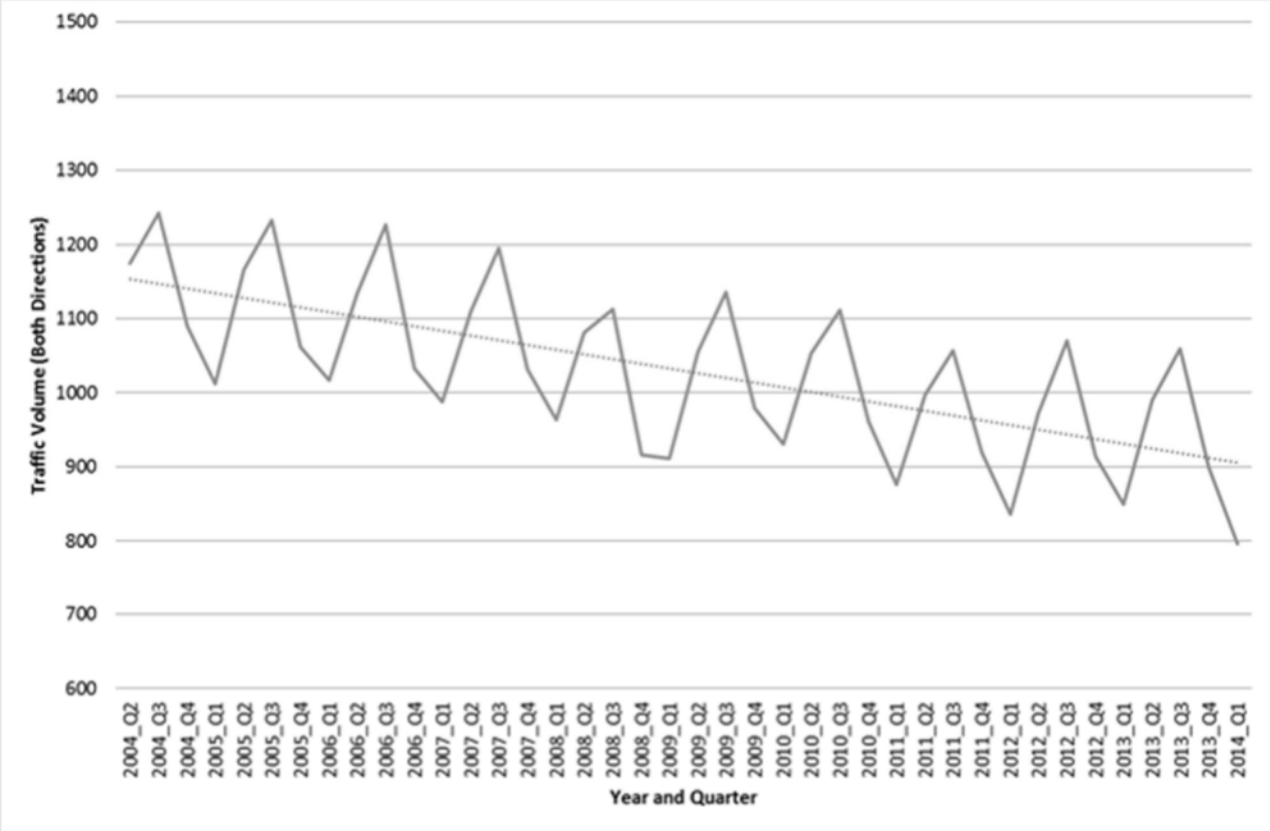
FIGURE 5-2. AVERAGE QUARTERLY DAILY TRAFFIC (ALL VEHICLES)



In order to develop future forecasts, several socio-economic and cost-related variables that could potentially influence traffic volumes on the ferry were identified and analyzed. Table 5-1 provides the list of the candidate variables. It would be preferred to use more localized socio-economic variables specifically for Gross Domestic Product (GDP) and employment, however no such data was found from publicly available sources. Obtaining forecasts for such variables would likely be difficult.

TABLE 5-1. LIST OF VARIABLES THAT COULD POTENTIALLY INFLUENCE TRAFFIC VOLUMES ON THE FERRY

Variable	Description	Historical Data Source
GDP	BC Gross Domestic Product	Conference Board of Canada
Employment	BC Employment	Statistics Canada
Total Population	Gulf Islands Total Population	Statistics Canada
Population age groups	Gulf Islands Population age groups	Statistics Canada
Fare	Vehicle and truck (2-way) in dollars	B.C. Ferries
Gas	Gasoline Prices (Vancouver) in cents per gallon	Statistics Canada

GDP, employment, and total population are all growth-related variables and are all expected to be positively correlated with ferry vehicle traffic. Fare and gas prices on the other hand, are expected to be negatively correlated. For analysis purposes, GDP, fares and gas prices were all analyzed in real terms.

Figure 5-3 overlays the average annual daily ferry vehicle traffic (total vehicles) with the variables described in Table 5-1. The variables were indexed to 100 to aid the comparison. Some key findings are:

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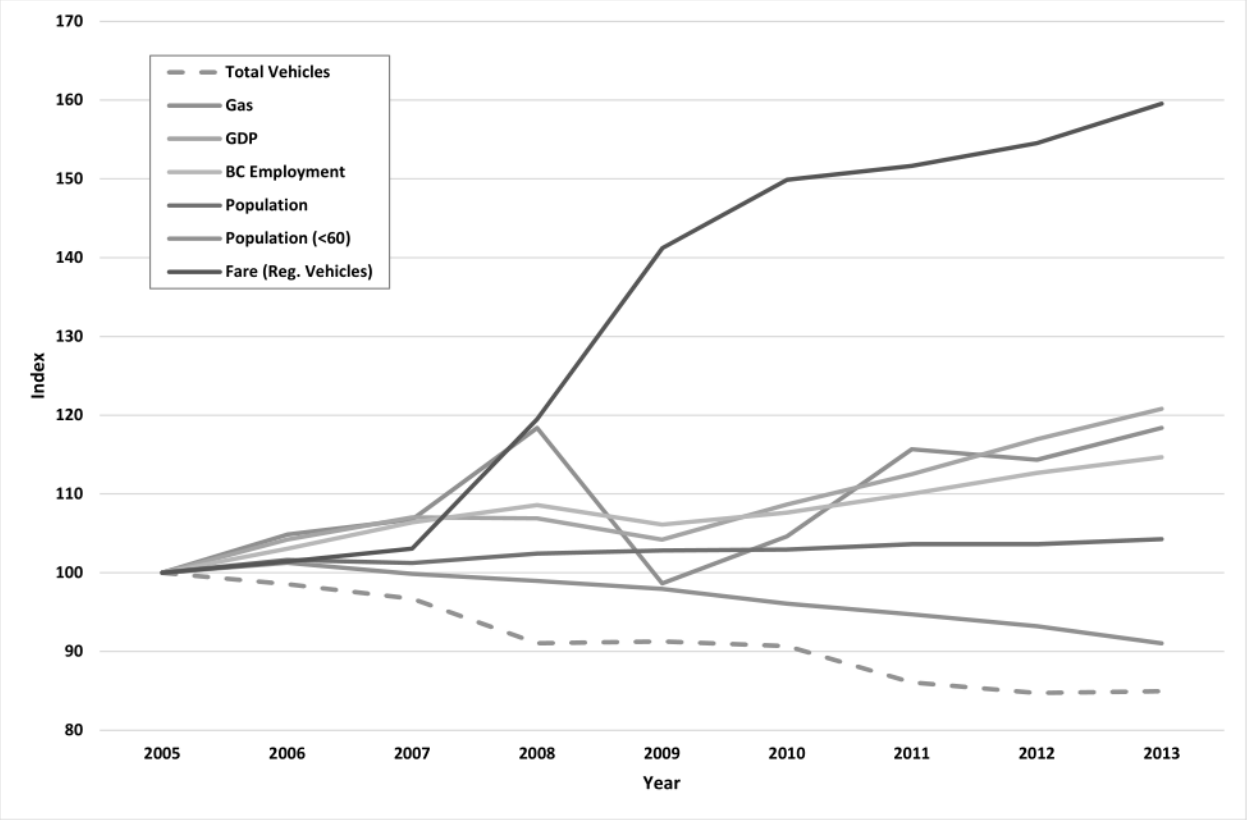
- Significant increase in fares and gas prices coincide with a significant decline in traffic especially in 2008. This decline, however, might also be related to the economic downturn (as shown by the GDP and employment lines).
- A second negative 'blip' in traffic is observed in 2011, with no obvious influencers.
- Surprisingly, the growth variables (population, employment, and GDP) and traffic volumes generally move in opposite directions. This indicates that counterintuitive relationships will possibly be observed in the model development process.
- The younger population age group (younger than 60) has been steadily declining over the last 10 years. This population tends to make more trips (specially commuting trips) compared to the older age group.

FIGURE 5-3. HISTORIC TRENDS IN VARIABLE INDICES



The population age groups on the Gulf Islands is of particular interest. Figure 5-4 compares the growth in population ages less than and greater than 60 years of age on the Gulf Islands over the last decade.

The figure shows a converging pattern with the younger than 60 age group declining from a peak of 9,800 in 2006 (or 66% of the population) to 8,500 (or 55% of the population) by 2014. This indicates that as the population on the Island ages, and with more people retiring on the Island (as indicated by the overall increase in population), fewer younger people are moving to the Islands.

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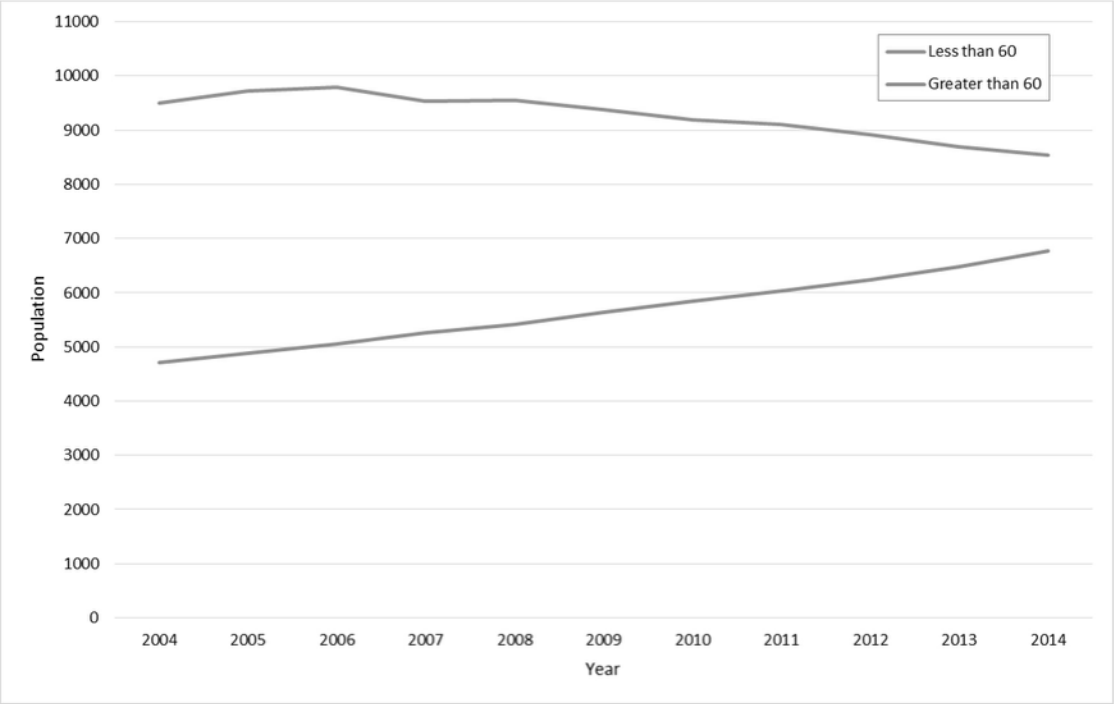
FIGURE 5-4. POPULATION AGE GROUPS



5.1.2 Ferry Background Growth Model Development

To forecast future background growth, a linear regression model was developed as part of this study. A regression model relates the traffic volume variable being forecasted with corresponding historic trends of independent variables that potentially impact ferry traffic growth.

Linear regression models employ statistical methods to estimate coefficients, which provide the magnitude and impact that each of these independent variables has on the dependent variable, which in this case is traffic volume. An example of a linear regression model relating traffic volume to GDP and fares is provided below:

Traffic Volume = (0.5 x GDP) – (0.2 x Fares)

In this example, a future unit increase in GDP will increase traffic volume by 0.5 units assuming fares are held constant. Similarly, an increase of 1 unit in fares (say $1) reduces traffic by 0.2 units assuming GDP is held constant. Typically, GDP is positively correlated to traffic, and fares are negatively correlated to traffic.

Several linear regression model formulations were tested for this study. Initially, separate models for trucks and regular vehicles were tested given that the trends and drivers of these two vehicle types are usually distinct. However, given that trucks make up only 3% of the total ferry traffic, it was decided to develop a single model for all vehicles with the trucks calculated as a percentage of the forecasts.

A separate model for tourist travel was also investigated looking at differences in seasonal travel patterns, however the analysis was inconclusive in terms of developing a separate forecasting model for this sector. As a result, the model used for this study was aggregated for the various user groups and then developed at the quarterly level:

- Quarter 1: January to March
- Quarter 2: April to June
- Quarter 3: July to September
- Quarter 4: October to December

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In total, 40 observations of traffic (derived from having quarterly BC Ferries data over the past ten years) and those variables listed in Table 5-1 were used in the development of the final model. The overall sample size of 40 is considered adequate for model development. As a rule of thumb, a minimum sample size of 30 is considered adequate for the development of regression models. In general, the more observations, the better the model.

The background model formulation, including the final variables used in the model, their description and estimated magnitude and sign of each of their corresponding coefficients is shown in Table 5-2.

TABLE 5-2. ECONOMETRIC MODEL COEFFICIENTS AND STATISTICS

Variable	Description	Coefficient	t-stat
(Intercept)	–	0.10	0.04
Q1	Quarter 1 Dummy	-0.07	-5.61
Q2	Quarter 2 Dummy	0.09	7.50
Q3	Quarter 3 Dummy	0.15	13.17
Popl60	Gulf Islands Population<60	0.80	3.14
CarFr	Regular Vehicle Fare	-0.19	-4.30
Recession	Dummy Variable for Recession period	-0.04	-2.83
Adj. Rsqd = 0.95			

The variables in the table are as follows:

- The 't-stat' is a statistical measure describing the level of confidence in each coefficient estimate. As a rule of thumb a t-stat value above 1.96 and below -1.96 indicates a high degree of confidence in the estimated coefficients.
- The quarterly dummy variables, Q1, Q2 and Q3, are calibration variables that are estimated as part of the model to control for the seasonal nature of traffic. As expected, quarter 3 exhibits the most positive magnitude among the quarterly dummy variables, indicating that summer volumes are usually the highest.
- The age group variable (younger than 60) is positively correlated and has a sizeable impact on traffic volumes.
- Fares on the other hand are negatively correlated with traffic. The regular vehicle fare was calculated by taking the sum of a regular vehicle and two foot passenger fares, assuming a vehicle occupancy of two persons.
- GDP, employment and gas price were dropped from the final model equation as they either exhibited counter-intuitive relationships with traffic, or were statistically insignificant with a low t-stat.
- A recession dummy variable was included in the model to control for the impacts of the 2008-2009 recession and improve the model fit as indicated by the Adjusted R-squared statistic.
- The Adjusted R-squared statistic (Adj. Rsqd) typically ranges between 0 and 1. The closer the value is to 1, the better the model fit.

The linear regression model developed has a very high R-squared statistic of 0.95, indicating that it replicates historic traffic data well for the purposes of this study. This replication is seen in Figure 5-5 where the orange line represents the modelled traffic volumes, and the blue lines is the observed traffic volumes.

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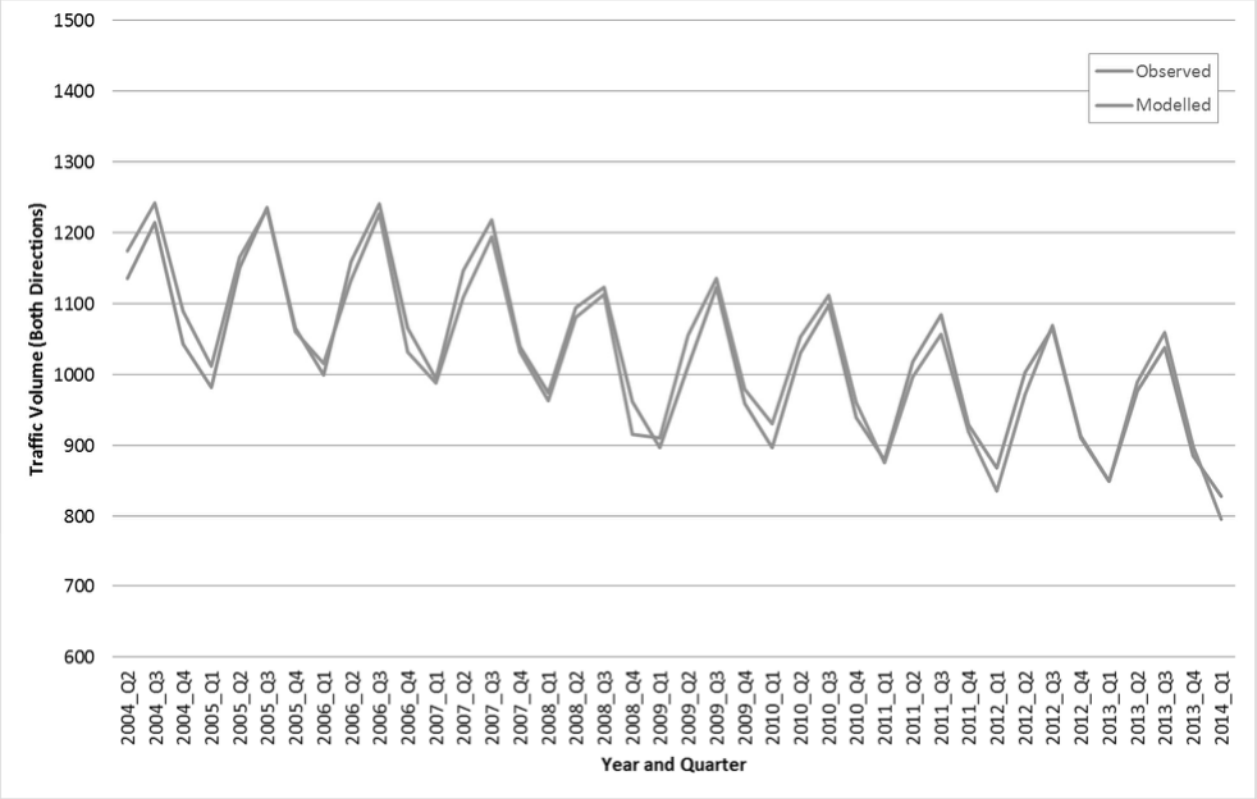
FIGURE 5-5. MODELLED VS. OBSERVED AVERAGE QUARTERLY DAILY FERRY TRAFFIC



5.1.3 Ferry Background Growth Forecasts

To predict future ferry vehicle traffic, forecasts for Gulf Islands population (younger than 60) and ferry fares need to be obtained or developed. This data was only sought until horizon year 2030. In general the reliability of such forecasts and estimated model coefficients degrade in the long term (25-30 years in the future). As such, traffic volume forecasts between 2030 and 2044 were extrapolated.

Forecasts of the total Gulf Island population was available from StatsCan. The data was not broken down by age groups and is shown in Figure 5-5. As seen in the figure, the population on the Gulf Islands is predicted to grow by 13% between 2015 and 2030, from approximately 15,400 to 17,500 people.

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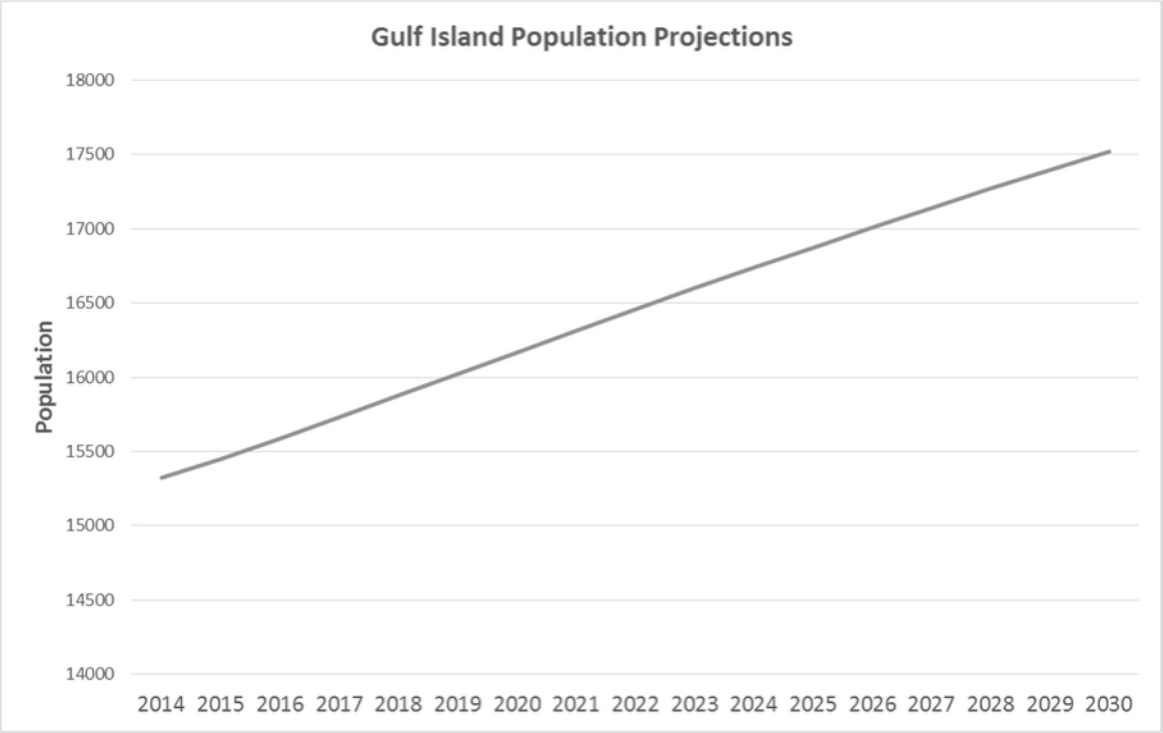
FIGURE 5-6. GULF ISLAND POPULATION (STATSCAN)



Due to forecasts of fares not being available, three scenarios of traffic growth were developed: low (pessimistic); medium (the base case); and high (optimistic). Table 5-3 summarizes the assumptions made for population (younger than 60) and fares in each scenario. All three scenarios adopted the same assumptions in the short term since little variability in traffic volumes is expected prior to the opening of the fixed link, should it ever be decided to construct it. For the purposes of the study, an assumed opening year of 2020 was used.

TABLE 5-3. SCENARIO ASSUMPTIONS

Scenario	Ratio of Population younger than 60 vs. Total Population	Fares
Low Traffic Growth	Decline from 55% in 2014 to 51% by 2018, then remain at that level till 2030	Increase by 2.2% annually until 2030 (in real terms)
Moderate Traffic Growth	Decline from 55% in 2014 to 51% by 2018, then increase back to 2014 levels by 2030 (55%)	Increase by 2.2% annually until 2018, then increase by 1.6% annually until 2030 (in real terms)
High Traffic Growth	Decline from 55% in 2014 to 51% by 2018, then increase to 60% by 2030	Increases by 2.2% annually until 2018 then increases by 1.1% annually until 2030 (in real terms)

For the age group variable (population younger than 60), StatsCan forecasts were broken down by age group as described in the table. Trends in age group distribution between 2010 and 2014, as shown earlier in Figure 5-4, were used to estimate population levels for the age group younger than 60 between 2014 and 2018. Similarly, average annual increase in real fare levels from the last five years (approximately 2.2% increase) was used to estimate fares between 2014 and 2018. Beyond 2018 the scenarios diverge to represent the three traffic growth scenarios ranging from low to high. The ranges were determined and bounded based on analysis of longer term trends from the last 10 years for population (younger than 60) and fares. While actual forecasts for these variables would be preferred but were not available, the three scenario approach provides a reasonable methodology to estimate future traffic ranges, especially considering that overall traffic volumes using the ferry are generally low.

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After applying the econometric forecast model, the growth in background average annual daily traffic (AADT) to 2030 is shown in Figure 5-7. As seen, traffic is predicted to decline steadily until 2018 and then grow after 2018 for each of the three scenarios. Since average figures (specifically for fare increases) are used in each scenario, the model will not show a step-wise trend as per the historic trends to 2014.

For the low, medium and high scenarios, the 2030 forecast ferry AADTs are 875, 960 and 1,030 vehicles per day respectively. For the purposes of the Multiple Account Evaluation, the medium scenario was adopted as a base case for background growth forecasts.

FIGURE 5-7. AVERAGE ANNUAL BACKGROUND FERRY TRAFFIC GROWTH FORECASTS

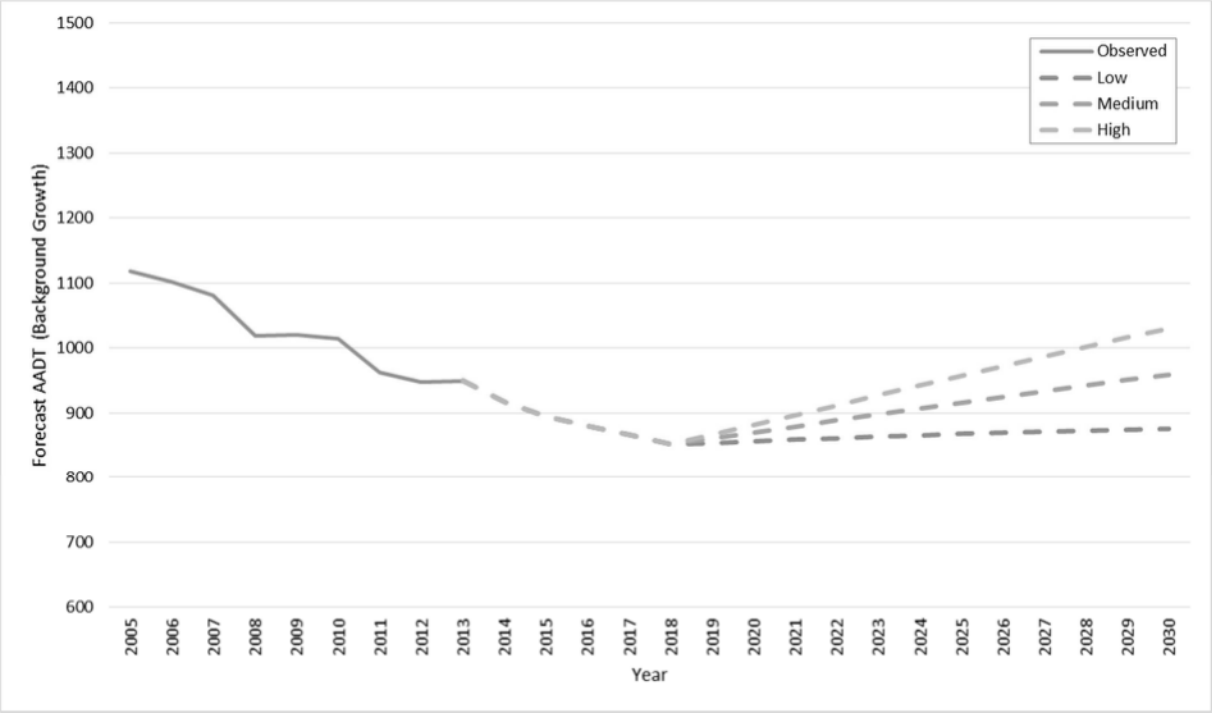

Table 5-4 shows the base case scenario forecast to 2044, with 2030 to 2044 figures extrapolated based on average year-to-year absolute growths between 2015 and 2030.

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TABLE 5-4. 2015-2044 BACKGROUND TRAFFIC GROWTH FORECASTS (VEHICLE PER DAY)

Year	Forecast AADT (Base Case)	Year	Forecast AADT (Base Case)
2015	900	2030	960
2016	880	2031	970
2017	870	2032	980
2018	850	2033	990
2019	860	2034	1,000
2020	870	2035	1,010
2021	880	2036	1,020
2022	890	2037	1,030
2023	900	2038	1,040
2024	910	2039	1,050
2025	920	2040	1,060
2026	930	2041	1,070
2027	930	2042	1,080
2028	940	2043	1,090
2029	950	2044	1,100

Compounded Annual Growth Rate (CAGR) 2014-2030: 0.27%

CAGR 2030-2044: 0.9%

5.2 Induced Demand

With a more reliable fixed link connection, Gabriola residents and visitors will be more likely to travel to and from Vancouver Island and vice versa. One of the key drivers of this induced demand is the reliability of using a fixed link versus the ferry. In order to calculate the additional trips that would use the link, an elasticity calculation based on the difference in generalized costs between the ferry option and fixed link option was undertaken. The following describes the methodology and key assumptions when calculating induced demand.

5.2.1 Reliability Factor

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Quinsam vessel that provides ferry service between Nanaimo Harbour and Gabriola Island has a vehicle capacity of approximately 70, depending on the proportion of large vehicles. s.17

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s.17 . In total, approximately 1.7% of all vehicles using this connection have had to wait one or two sailings to board the vessel.

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5.2.2 Value of Travel Time

One of the key inputs into the elasticity-based calculation of induced demand is the value of travel time. Income data from StatsCan for the Nanaimo and Vancouver area was used to estimate the value of travel time. Table 5-6 provides the average and median incomes in the Nanaimo region over the past five years. Note that average income has historically been higher than median income, illustrating that incomes are skewed to the high side.

TABLE 5-6. NANAIMO AVERAGE AND MEDIAN INCOME

Year	Average Income	Median Income
2008	$37,430	$28,410
2009	$37,300	$28,070
2010	$38,000	$28,530
2011	$38,800	$29260
2012	$40,250	$30,300

Much research and review by Transportation Ministries and reputable agencies, such as the Victoria Transport Policy Institute, has been conducted over the years on the value of travel time for the purposes of demand modelling and project evaluation. The B.C. MOTI report, "The Value of Time Savings for the Economic Evaluation of Highway Projects in British Columbia" states the following: “A review for the Government of British Columbia recommended 50 percent of the average wage as a base for value of travel time savings for the evaluation of highway projects, and with an upward adjustment for the value of travel time savings, or VTTS, during congested conditions.”[1]

Using the above income information, and assuming that people typically work 250 days out of the year for an average of 8 hours per day, yields an average value of travel time of $10/hr.

5.2.3 Vehicle Operating Costs

The Canadian Automobile Association (CAA) publishes the cost of driving brochure[2] on a regular basis which provides useful information to estimate vehicle operating costs on a per kilometre basis. Table 5-7 provides the assumptions used to derive the average cost of operating a vehicle on a per kilometre basis. The key components of vehicle operating costs are fuel, tires and maintenance, with all other costs, including insurance, depreciation and financing, assumed to be sunk costs. The average vehicle operating cost is 17¢/km for this analysis.

TABLE 5-7. VEHICLE OPERATING COST ASSUMPTIONS (¢/KM)

Vehicle Type	Fuel	Maintenance	Tires	Total
Sport Utility Vehicle	13.1	2.55	2.53	18.18
Full Size	12.2	2.18	1.84	16.22
			Average	17.2

[1] "The Value of Time Savings for the Economic Evaluation of Highway Projects in British Columbia," (W.G. Waters II) Research Report for Planning Services Branch, B.C. Ministry of Transportation and Highways, UBC Centre for Transportation Studies, March 1992, 160 pp.; published in The Value of Travel Time in British Columbia: a Compendium of Reports (Victoria: Ministry of Transportation and Highways, Planning Services Branch) 1994.

[2] Canadian Automobile Association, Driving Costs, 2013 Edition

http://www.caa.ca/wp-content/uploads/2012/06/CAA_Driving_Cost_English_2013_web.pdf

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5.2.4 Travel Generalized Costs

Various assumptions were used to estimate the generalized costs of travel when comparing the ferry option versus the fixed link option. An average trip for both options is assumed to be from the Gabriola Island town centre to the general Nanaimo area, assumed to be located between downtown Nanaimo, the hospital, and the Vancouver Island University. This location is considered to be the centroid of multiple trip origins and destinations as reported in the 2012 Nanaimo Household Travel Survey. Also from the Travel Survey, typical trip distribution patterns to and from the Cedar area were used as a proxy for the likely distribution patterns of trips to and from Gabriola Island fixed link.

Table 5-8 shows the travel time, distance, speed and cost assumptions used to compare an average trip if using the ferry versus the fixed link. Travels time and speed for existing road segments were determined from Google Maps and local experience. The ferry fare was calculated from historical ferry revenue and ridership, and is expressed as an equivalent one-way fare. If the fixed link has a user fee applied, it is assumed this fee will be the same as the ferry fare.

TABLE 5-8. KEY ASSUMPTIONS FOR CALCULATING INDUCED DEMAND

Variable	Ferry Option			Fixed Link Option		
Travel from Nanaimo	1.9 km	4.0 min	30 km/hr	14.2 km	14.0 min	60 km/hr
Crossing Time	6.9 km	20.0 min	–	5.0 km	6.0 min	50 km/hr
Travel on Gabriola	6.1 km	8.4 min	44 km/hr	7.6 km	10.9 min	42 km/hr
Ferry Headway	–	70 min	–	–	–	–
Reliability Factor	0.02			–		
Fare/User fee	$11.25			$11.25		
Value of Time	$10/hr			$10/hr		
Vehicle Operating Cost	17¢/km			17¢/km		

The resultant generalized costs of travel for the ferry option versus the fixed link option is shown in Table 5-9. Note that cost items are converted to generalized costs using the value of time and expressed in equivalent minutes. In total, the fixed link option is approximately 12% cheaper in terms of generalized costs compared to the ferry option.

TABLE 5-9. GENERALIZED COSTS OF FERRY OPTION VS. FIXED LINK OPTION (MINUTES)

Travel Component	Ferry Option (min)	Fixed Link Option (min)
Travel from Nanaimo	4	14
Wait Time	19	–
Crossing Time	20	6
Travel on Gabriola	8	11
Fare/User fee	34	34
Vehicle Operating Cost	4	14
Total	**89**	**78**

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5.2.5 Demand Elasticity Calculations

Information from the sub sections above was combined to calculate induced demand based on an assumed travel time elasticity. A literature review and information from previous studies was used to develop a range of travel time elasticities[3] as follows:

- Low Elasticity -0.50
- Moderate Elasticity -0.75
- High Elasticity -1.0

To explain the concept of travel time elasticity, assume the total number of vehicle trips between two neighborhoods is 1,000 and travel time between them is 30 minutes for a moderate elasticity. If travel time increases by 10% (or 3 minutes), then the total number of vehicle trips decreases by 7.5% (or 75 trips) if we assume an elasticity of -0.75. In other words, a 10% increase in travel time results in a -0.75% decrease in trips. Trips, on the other hand, would increase between neighbourhoods if the travel time between them decreased as a result of network improvements.

Since the ferry fare and assumed user fee was the same for both options, this was excluded from the elasticity calculations. As such, the percentage change in the generalized cost of travel was -19.5% (approximately 55 versus 45 minutes) when comparing the ferry option to the fixed link option. This percentage change in travel cost was multiplied by the range of elasticities to produce a range of possible traffic volume outcomes.

5.3 Total Forecasted Traffic

The total forecasted traffic is obtained by combining the outputs from the background traffic growth (Section 5.1) and induced traffic (Section 5.2). Table 5-10 shows induced traffic outputs for the three elasticity assumptions and three traffic background growth scenarios in 2030. For example:

- The background AADT under the moderate growth assumption in 2030 is 960 vehicles.
- The corresponding induced demand assuming a moderate elasticity is calculated as: 960 x -0.75 x -19.5% = 140 vehicles.
- The total 2030 AADT is calculated as: 960 (background traffic) + 140 = 1,100 vehicles.

TABLE 5-10. ELASTICITY-BASED FORECAST OF INDUCED TRAFFIC DEMAND (VEHICLES PER DAY)

2030 Forecast Scenario	Base AADT	Low Elasticity (-0.5)	Moderate Elasticity (-0.75)	High Elasticity (-1.0)	
Low	875	85	130	170	Incremental Traffic
Moderate	960	95	140	190	
High	1,030	100	150	200	
Low		960	1,005	1,045	Total Traffic
Moderate		1,055	1,100	1,145	
High		1,130	1,180	1,230	

[3] "Understanding Transport Demands and Elasticities, How Prices and Other Factors Affect Travel Behaviour" (Todd Litman) Victoria Transport Policy Institute, September 2012, pp. 46; http://www.vtpi.org/elasticities.pdf

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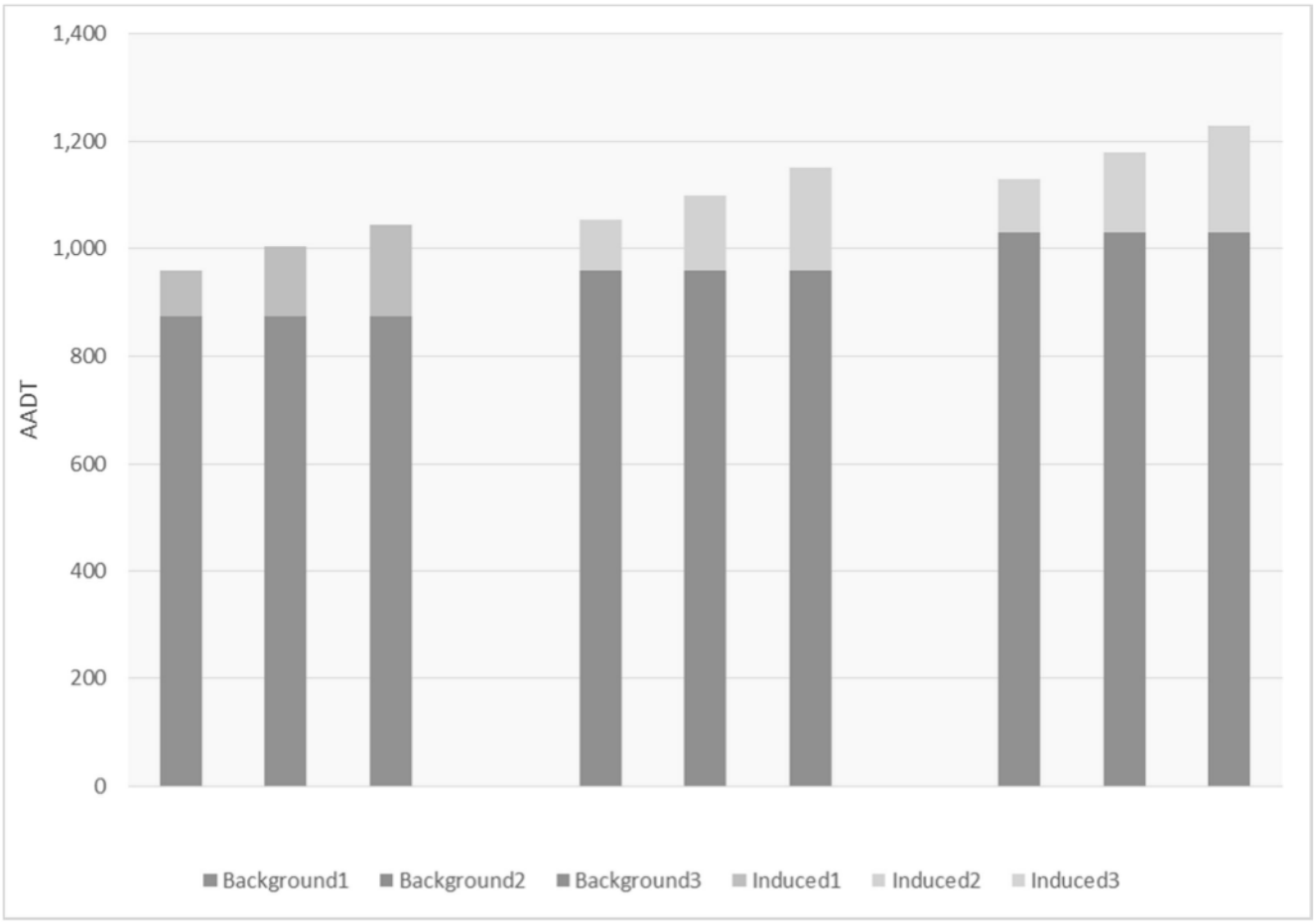
The total 2030 AADT is shown graphically in Figure 5-8.

FIGURE 5-8. 2030 FORECAST TOTAL AADT (BACKGROUND + INDUCED)



Based on these forecast traffic evaluations, the total forecast traffic for 2030, including growth and induced demand, ranges from a low forecast of 960 to a high forecast of 1,230 vehicles per day (vpd). This presents the range of possibilities for traffic on a proposed new fixed link crossing to Gabriola Island.

Table 5-11 shows the 2015 to 2044 base case forecasts including medium-level induced demand assumptions if the fixed link were to open in 2020. The extrapolated forecast to 2044 is 1,240 vehicles per day.

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TABLE 5-11. 2015-2044 FORECAST AADT GROWTH (BACKGROUND + INDUCED); 2020 FIXED LINK OPENING

Year	Forecast AADT (Base Case+Med Induced Demand)	Year	Forecast AADT (Base Case+Med Induced Demand)
2015	900	2030	1,100
2016	880	2031	1,110
2017	870	2032	1,120
2018	850	2033	1,130
2019	860	2034	1,140
2020	997	2035	1,150
2021	1,008	2036	1,160
2022	1,020	2037	1,170
2023	1,031	2038	1,180
2024	1,043	2039	1,190
2025	1,054	2040	1,200
2026	1,066	2041	1,210
2027	1,066	2042	1,220
2028	1,077	2043	1,230
2029	1,089	2044	1,240

CAGR 2014-2030: 1.1%

CAGR 2030-2044: 0.9%

To determine the number of travel lanes required for the fixed link to accommodate the forecast traffic volumes, the Highway Capacity Manual (2010) advises that the two-directional capacity of a two-lane highway (under base conditions) is 3,600 passenger vehicles per hour, which is significantly greater than the forecasted volume of 124 vehicles per hour. A two-lane bridge would therefore provide more than sufficient capacity in the long term.

5.4 Intersection Capacity Analysis

In order to determine the intersection configuration and type of traffic control that would be required to accommodate the traffic on South Road at the fixed link intersection, forecast turn volumes were input into a Synchro traffic operations model and used to determine the intersection operational performance. A stop-controlled intersection was used for the analysis. The turn volumes for AM and PM peak hours are shown in Figure 5-9, and the subsequent table provides the outputs from the analysis, illustrating the turn volumes, delay and resulting levels of service. Without traffic counts on South Road, assumed volumes of 50 eastbound and westbound through vehicles per hour were used in the analysis.

The analysis determined that a stop controlled intersection would operate at a level of service A, the highest level of service, indicating neither delay nor capacity constraints are anticipated. Only when eastbound and westbound through volumes reach about 225 vehicles per hour (a 350% increase) in both directions, does the level of service reach B, demonstrating that there is substantial capacity for traffic growth. An alternative would be to consider a roundabout at this intersection, which would further reduce vehicle stopping and any delays.

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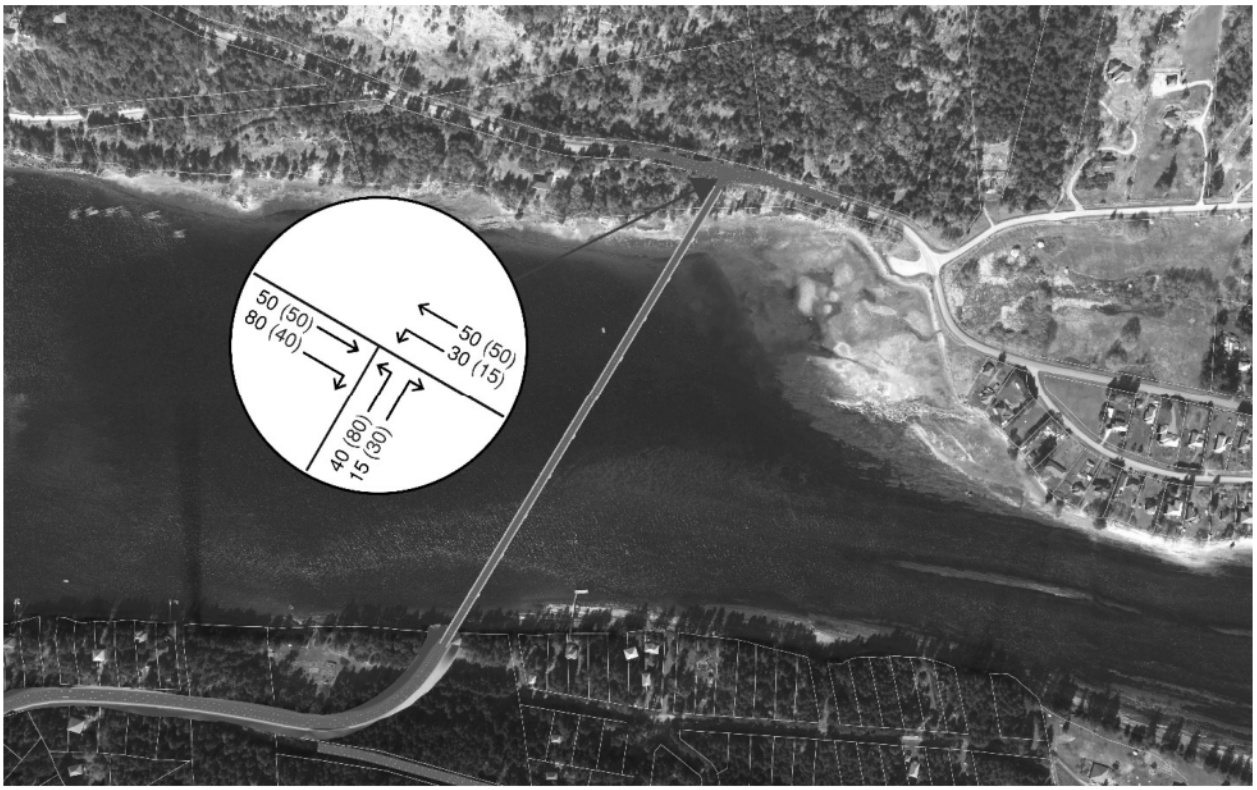
FIGURE 5-9. 2030 PEAK HOUR TRAFFIC VOLUMES AT SOUTH ROAD, GABRIOLA ISLAND – AM (PM)



HCM 2000 SIGNING SETTINGS	EBT	EBR	WBL	WBT	NBL	NBR
Lanes and Sharing (#RL)						
Traffic Volume (vph)	50	40	15	50	80	30
Sign Control	Stop	—	—	Stop	Stop	—
Median Width (m)	3.7	—	—	3.7	3.7	—
TWLTL Median	☐		—	☐	☐	—
Right Turn Channelized	—	None	—	None	—	None
Critical Gap, tC (s)	—	—	—	—	—	—
Follow Up Time, tF (s)	—	—	—	—	—	—
Volume to Capacity Ratio	0.11	0.11	0.09	0.09	0.14	0.14
Control Delay (s)	7.5	7.5	7.8	7.8	8.0	8.0
Level of Service	A	A	A	A	A	A
Queue Length 95th (m)	—	—	—	—	—	—
Approach Delay (s)	7.5	—	—	7.8	8.0	—
Approach LOS	A	—	—	A	A	—

On the Vancouver Island side of the fixed link, similar traffic operational performance is expected, however the presence of existing background local traffic is recognized. Given the low volumes of fixed link traffic, operational performance is likely to be marginally reduced at the intersections primarily along Holden Corso Road, and approaching Duke Point Highway if this were the alignment of the fixed link to access the Duke Point Highway. Similarly, if the link followed the Phoenix Way or similar alignment, the same performance is expected as there is little existing background traffic on Phoenix Way.

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SECTION 6

Option Development & Preliminary Screening

6.1 Design Basis/Design Criteria

6.1.1 Road Design Criteria

The road for the Gabriola Island Fixed Link will generally be a rural road supporting a projected traffic volume of approximately 1,300 vehicles per day (2044 projection). The proposed roadways traverse the jurisdictions of the Regional District of Nanaimo (RDN), the City of Nanaimo (the City), and the Islands Trust. BC MoTI retains the responsibility for the management and maintenance of all roads within the RDN and the Islands Trust. The City is responsible for all roads within its boundaries.

Based on the projected low traffic volumes, a two-lane roadway will provide a high level of service (B or better). It is anticipated that this roadway will also be utilized by cyclists for commuting and recreational purposes, as well as pedestrians.

The assumed design criteria for the fixed link is based on the BC MoTI standard for a Rural Collector (BC Supplement to TAC Geometric Design Guide, 2007 – Figure 440.B), summarized in Table 6-1. The City has a similar standard for a Rural Local road (City of Nanaimo Engineering Standards & Specifications, 2013 – Drawing R7-XS5). Both standards include 3.6 metre travel lanes and 1.5 metre shoulders. The key difference is that the City's standard includes a 1.65 metre gravel shoulder.

TABLE 6-1. PROPOSED DESIGN CRITERIA

Design Elements	Proposed Design Values	Comments/Notes
Functional Classification	RCU	Rural Collector Undivided, Figure 440.B
Design Speed (km/h)	60	
Posted Speed (km/h)	50	
Minimum Horizontal Curve Radius (m)	130	
Minimum Stopping Sight Distance (m) Sag	85	TAC Table 2.1.3.4
Minimum Stopping Sight Distance (m) Crest	85	BC Supplement Table 330.F
Minimum "K" Factor, Sag V.C.	18	TAC Table 2.1.3.4
Minimum "K" Factor, Crest V.C.	13	BC Supplement Table 330.F
Maximum Superelevation (%)	6	
Maximum Gradient (%)	6	
Lane Width(s) (m)	3.6	
Median Width(s) (m)	N/A	
Paved Shoulder Width (m)	1.5	
Clear Zone Width (m)	9.0	
Design Vehicle	WB20	
Drainage	Open ditch	

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6.1.2 Navigational Clearances

When considering replacement of an existing structure or construction of a new structure over a channel where other structures already exist, the required navigational clearance is typically limited to existing clearances. Consideration may be given to increasing clearances where warranted due to changes in prevailing vessel sizes.

For new crossings of waterways, a study of prevailing vessel traffic and potential future vessel traffic is required. This requires stakeholder engagement in order to collect data for potential vessel dimensions (draft, width, air draft). This data combined with potential future development options would serve as a basis for a submittal to Transport Canada for review and approval. Transport Canada is concerned with safety, maintenance of navigation, and limiting constraints on waterways in order to maximize all current and future potential economic development.

Typically, a comprehensive study would be done prior to detailed engineering, most likely during preliminary engineering when the short-listed options for a project are developed and evaluated. This will not be done for the purposes of this fixed link planning study which is only in the technical feasibility stage. Instead, the Council of Marine Carriers, whose mandate is to further the interests and conserve the rights of its member tug and barge operators, confirmed that log towing and barge towing operations occur in both Dodd and False Narrows. The Council recommended a **minimum 23 metre vertical clearance at High High Water** to accommodate most ramp barges, spud barges and loaded chip barges.

It is assumed that there will be no piers in the water at Dodd Narrows, but there may be piers at False Narrows. The Council clarified that log tows in False Narrows are usually about four sections wide, and can transit through at high water. **A clear width in False Narrows would need to be a minimum of 500 feet (152 metres) wide**.

Given the location of the bridge crossings, there appears to be little potential for future industrial development in this area. Northumberland Channel can be accessed north of Gabriola Island and Stuart Channel and Pylades Channel can be accessed from the south.

6.2 Road Network Options

Options generated for the Gabriola Island fixed link involved developing different road alignments and bridge crossings for evaluation. The various options considered are shown in Figure 6-1. All road alignments provide a connection between Highway 19 on Vancouver Island and South Road on Gabriola Island. The proposed road alignments make use of some existing roads on Vancouver Island, Mudge Island and Gabriola Island, but also require the construction of new roadways.

Plan and profile drawings of all the options are provided in Appendix A.

Achieving the recommend design criteria will require upgrading some of the existing roadways. Alternatively, upgrades of the existing roadways can be deferred to a later date, but this may impact roadway operations, mobility and safety for users, particularly for cyclists given the limited existing paved shoulder widths.

Each option considered is described in the subsequent sections.

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FIGURE 6-1. SCHEMATIC OF ROAD AND BRIDGE OPTIONS

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6.2.1 Road Option A

The alignment for Option A is an extension of Phoenix Way from Maughan Road to Dodd Narrows. Drivers traveling to Gabriola Island would exit Hwy 19 onto Maughan Road, travel north on Maughan Road and turn right (east) onto Phoenix Way to access Gabriola Island. Drivers traveling from Gabriola would turn left from Phoenix Way onto Maughan Road, travel south, turn right onto the Maughan Road Bridge, then turn left onto Gordon Road and travel south to access Highway 19.

The horizontal alignment and vertical profile of Phoenix Way satisfies the design criteria, but sections will have to be upgraded with paved shoulders and proper drainage.

Two existing intersections along Phoenix Way will have to be upgraded, namely Maughan Road and the eastern access to the Harmac site. In addition, the existing bridge on Phoenix Way appears to be too narrow to provide adequate width for pedestrians and cyclists.

The alignment of Road Option A intersects with the existing Cable Bay Trail. The roadway will cross over the trail and adjacent creek. A bridge or large multiplate culvert structure is likely required to span over the trail and provide adequate clearance underneath.

All roadworks for Option A are within the City of Nanaimo's boundaries.

A key aspect of this option that will require addressing before this option can be considered further is the fact that the Harmac Pulp Mill property is zoned Class 4, Heavy Industry, and is therefore not suitable for the general population to drive through due to the safety concerns of the plant's emission points and hazardous chemical production and storage facility. It is estimated that approximately $100 million will be required to provide the necessary mitigation measures to allow for public access, in addition to the need to expropriate the ROW.

6.2.2 Road Option B

Option B uses the existing local road system to develop the new alignment between Highway 19 and Dodd Narrows. Drivers traveling to Gabriola Island would exit Hwy 19 onto Maughan Road, travel north on Maughan Road and turn left (west) across the Maughan Road Bridge. They would then turn left onto Gordon Road and travel south to MacMillan Road and continue south on MacMillan Road, across the MacMillan Road Bridge to the MacMillan Road/Holden Corso Road Intersection. Drivers would turn left onto Holden Corso Road and travel east to Barnes Road, turn left onto Barnes Road and travel in a easterly direction to Nicola Road, turn left onto Nicola Road and travel north to connect to the new road section connecting to Gabriola. Drivers traveling from Gabriola would generally travel in a reverse order.

To reduce the travel distance in Option B a new on-ramp and off-ramp could be constructed in the vicinity of MacMillan Road. This would provide direct access to and from MacMillan Road to Highway 19 and eliminate the travel distance to Maughan Road. This new interchange has not been included as a required network upgrade, recognizing the generally low traffic volumes in the area.

However, the provision of such an interchange would be in contravention of the agreement signed at the time of constructing the Duke Point Highway, which states that the highway would only be accepted by the local community if it did not impact the rural nature of the Cedar area. This explains why access to McMillan Road and other roads off the highway is circuitous and not standard diamond-type interchanges.

Holden Corso Road, Barnes Road and Nicola Road do not meet the recommended design criteria as there is no paved shoulder nor proper drainage. In addition, Barnes Road has a substandard horizontal and vertical alignment. There are also up to eight intersections that will require upgrading.

The roadworks for Option B are largely within the RDN except for the northern section which is within the City's boundaries.

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6.2.3 Road Option C

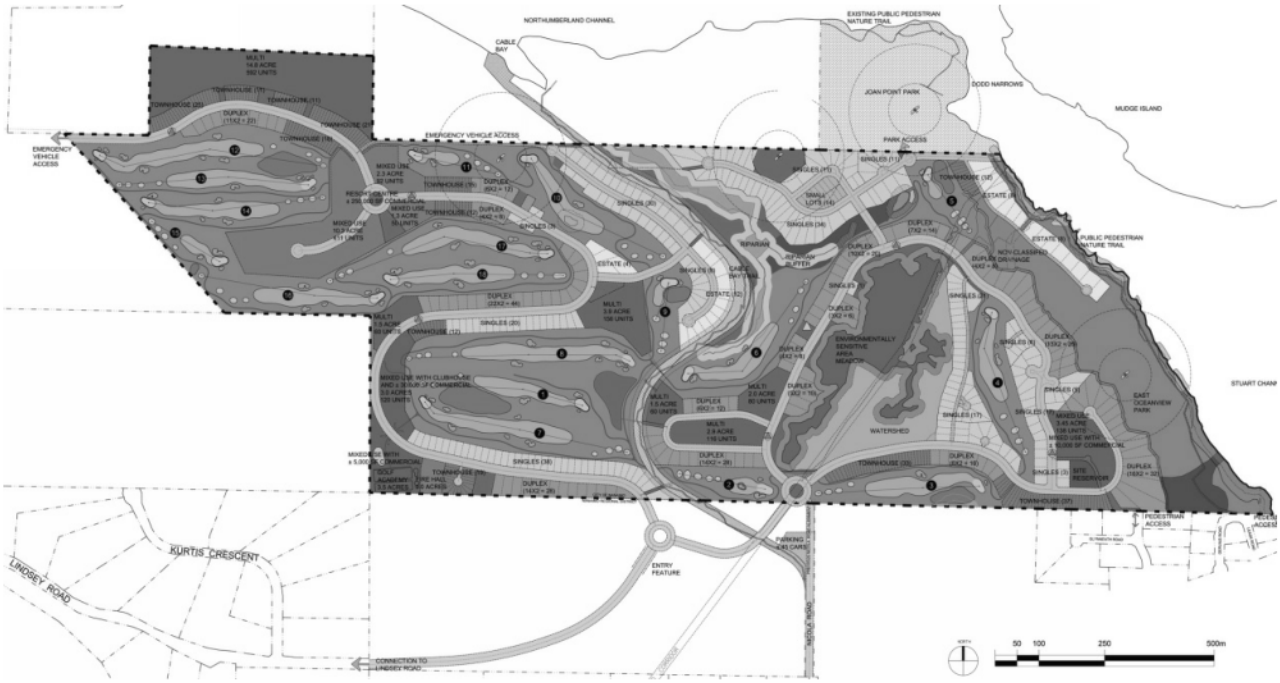
Option C follows a new local road alignment between Highway 19 and Dodd Narrows. Drivers traveling to Gabriola Island would exit Hwy 19 onto Maughan Road, then turn right to the new road. The alignment lies north of designated ALR lands that are subject to seasonal flooding and crosses the two Harmac Pulp Mill pipelines via culverts. Following existing contours through legal parcels Sec 21, Rge1 and Sec 20, Rge1, the alignment then deviates due east, immediately north of the White Road and Kurtis Crescent (Sec 20, Rge 2). The road proceeds further east into Sec 20, Rge 3, where it generally follows the internal road network envisioned in the Oceanview Golf Resort and Spa Master Plan shown in Figure 6-2.

A new intersection, where Maughan Road meets the new local road, will have to be constructed.

Outside of the short segment through Sec 20, Rge 1, the roadworks for Option C fall within the City of Nanaimo's boundaries.

An alignment option further south via Lindsey Road (as proposed in the Oceanview Master Plan) is a challenge as Lindsey Road currently terminates at First Nations lands, preventing it from extending to Phoenix Way at Duke Point Highway. Besides requiring First Nation agreement to achieve this link, ALR and drainage issues will also need to be addressed.

FIGURE 6-2. OCEANVIEW GOLF RESORT AND SPA MASTER PLAN ROAD NETWORK



6.2.4 Mudge Island Section

Fixed link options that have a connection between Dodd Narrows and the crossing to Gabriola Island will require the reconstruction of the roads on Mudge Island. The proposed alignment on Mudge Island uses some of the existing roads including Ling Cod Lane, Coho Boulevard, Weather Way and View Ridge Road. These existing roads are low volume, gravel roads that will require extensive upgrading to meet the design criteria for horizontal and vertical alignment as well as road width. Two new road sections would also have to be constructed to access the proposed bridge crossing locations, Crossing Option 3 and Crossing Option 4. To access Crossing Option 3, a new road would have to be constructed to connect Coho Boulevard and Weather Way. To access Crossing Option 4 an additional new road would have to be constructed between the east end of Weather Way and the easterly section of Coho Boulevard. The upgrading of the existing

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roads and new road construction will have significant impact on a number of private properties on Mudge Island.

There is however, a privately owned land parcel on the Island that is under a Common Law Right of Way agreement which would need to be addressed in order to achieve the road connection on the Island. The existing road through this property does not appear as a gazetted road on the Islands Trust's cadastral. The relevant property is shown in Figure 6-3.

FIGURE 6-3. COMMON LAW RIGHT OF WAY PROPERTY ON MUDGE ISLAND

6.2.5 Gabriola Island Section

It is proposed that all bridge crossings from Vancouver Island and Mudge Island connect to South Road on Gabriola Island. For the purposes of this technical feasibility assessment, the roadworks on Gabriola Island will be limited to an intersection providing access to the bridge. However, as presented later in this section, substantial upgrading of South Road from the crossing location to the village centre will be required to meet the recommended design criteria.

6.3 Dodd Narrows Crossing Options

6.3.1 Dodd Narrows Crossing Option 1

A bridge at Dodd Narrows provides the shortest crossing between Vancouver Island and Mudge Island. Dodd Narrows Option 1 is the shortest potential crossing with a 210 metres long bridge. However, at this location the bridge and road would have a significant impact on Joan Point Park.

A haunched concrete box girder bridge is assumed. This segmentally constructed bridge would likely be erected via the balanced cantilever method. The deeper girder section at the pier supports tapers to a shallower section near midspan, providing sufficient room to accommodate the required 23 metre navigational clearance. A main span of 160 to 180 metres can be achieved economically. Further study is required to determine how closely piers could be located to the edge of the channel.

The profile for Option 1 (refer Appendix A) shows a significant fill at the west abutment on Vancouver Island, up to 20 metres in height. Building a fill of this height could be very challenging and could require large MES retaining walls. Another option would be to increase the length of the bridge. **Considering the added costs and coincident impacts to Joan Point Park, Option 1 is rejected.**

6.3.2 Dodd Narrows Crossing Option 2

To avoid direct impacts to Joan Point Park, an alternative alignment was developed crossing Dodd Narrows roughly parallel to the existing BC Hydro right-of-way. This crossing, Dodd Narrows Option 2, requires a

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bridge of approximately 260 metres. A similar structure to that described for Dodd Narrows Option 1 is probable.

Dodd Narrows Crossing Option 2 appears feasible from a structural engineering and constructability perspective.

6.4 Main Channel Crossing Options

Four different bridge crossing location options to Gabriola Island were developed:

- Crossing Option 1 crosses directly from Vancouver Island to Gabriola Island across Northumberland Channel, avoiding impacts on Mudge Island.
- Crossing Option 2, Crossing Option 3, and Crossing Option 4 are options that cross False Narrows between Mudge Island and Gabriola Island. To achieve these crossings an additional bridge is required at Dodd Narrows between Vancouver Island and Mudge Island as described in Section 6.4.

Each crossing option is described in more detail below.

6.4.1 Main Channel Crossing Option 1

Crossing Option 1 connects Vancouver Island with Gabriola Island across Northumberland Channel. This option will require a bridge of over 1,500 metres long on a gradient of 2.7%. The bridge landing area on Gabriola is on a steep hillside and founding the abutment at this location could be challenging. The bridge height exceeds the required 23 metre navigational clearance, and would be in the order of 80 m above the sea level. As a point of reference, the Alex Fraser and Lions Gate Bridges in the Lower Mainland of BC have clearances of about 50 m above water level.

It is assumed that a cable-supported bridge (cable-stayed or suspension) would span across Northumberland Channel. The bridge would have a main span of 800 metres and backspans of approximately 350 metres, requiring that the two piers be founded on deepwater foundations. Water depths at the assumed piers locations are estimated to be approximately 20 to 30 metres. A clear span of Northumberland Channel, i.e. with bridge piers on shore, would require extensive approach spans on both Nanaimo and Gabriola sides, and would preclude tying into South Road.

A cable-supported bridge is preferred over a multi-span viaduct with spans on the order of 100 metres due to seismic risk exposure and extent/complexity of underwater construction. The water depths in the centre of the channel range from 40 to 60 metres.

Due to the excessive bridge span, an elevation of 80 m on Gabriola Island, and overall constructability challenges, this option is rejected.

6.4.2 Main Channel Crossing Option 2

Crossing Option 2 is the longest crossing from Mudge Island to Gabriola Island and limits impacts on Mudge Island. This option will require a bridge of approximately 840 metres in total length, at a steep 5.6% grade. The bridge landing area on Gabriola is on a steep hillside and founding the abutment at this location could be challenging.

Alternative alignments were explored to reduce the long 5.6% grade; however, these were not pursued in detail since they incurred significantly greater property impacts on Mudge Island.

A cable-stayed bridge with a main span of 700 metres and backspans of approximately 250 metres is assumed for estimating purposes. It is expected that the north pier would be founded on a deepwater foundation, but the south pier would be built on shore.

As with Crossing Option 1, due to the excessive bridge span, an elevation of 70 m on Gabriola Island, and overall constructability challenges, this option is rejected.

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6.4.3 Main Channel Crossing Option 3

Crossings Option 3 is a connection between Weather Way on Mudge Island and South Road. This option will require an 800 metre long box girder viaduct, with a balanced cantilever main span to accommodate the 23 m high and 152 m wide navigation envelope. Approach gradients on either side of the main span are approximately 4.4%. The bridge landing would be in the vicinity of the South Road and Ferne Road intersection on Gabriola Island. The approach viaducts are envisioned as a series of balanced cantilever bridges utilizing an in-situ method of construction with a relatively small scale plant and site set-up.

In the event that navigation routes can be redirect to Dodd Narrows, a lower profile viaduct structure could be constructed. With a straight plan alignment and continuous gradient, the viaduct would be suitable for a push launch from the Gabriola Island side, with spans on the order of 40 to 70 m. Span length would depend on whether temporary falsework were erected between the permanent piers, which would be assessed against geotechnical conditions in False Narrows.

Crossing Option 3 appears feasible from a structural engineering and constructability perspective.

6.4.4 Main Channel Crossing Option 4

Crossing Option 4 is a connection between Coho Boulevard on Mudge Island and South Road. This option will require a 480 metre long box girder viaduct. It is not feasible to accommodate the 23 m high and 152 m wide navigation envelope. Given the comparatively short length of the viaduct, and low elevation on either side of False Narrows, to achieve that clearance would require approach gradients in excess of 10%.

Instead, a low profile viaduct erected using a push launch construction method could be achieved economically, with the bridge landing in the vicinity of the South Road and Stokes Road Intersection on Gabriola Island.

Considering that this option cannot achieve the required navigational clearance, it is rejected.

6.5 Additional Screening of Options

To further assess the technical feasibility of the crossing options, additional screenings were done including:

- Archaeological
- Geotechnical Engineering
- Environmental, including a review of the marine construction window
- Stakeholder feedback

6.5.1 Archaeological

As stated in Section 4, a desktop assessment of the Gabriola Island fixed link options shown in Figure 6-1 was conducted. From RAAD, the relationship of the bridge options relative to the locations of previously recorded archaeological sites was determined. **It is repeated that the absence of known sites in a particular location does not equate to an absence of archaeological potential; rather, the localized nature of past Archaeological Impact Assessment (AIA) work means that certain areas may not yet have been assessed for archaeological sites. In fact, the extensive nature of coastal shell midden sites with associated First Nations burials would imply that all coastal and inland zones in the possible development area must be considered to be of high archaeological potential and of cultural importance to First Nations.** The results of the desktop assessment are presented by component under separate subheadings below.

6.5.1.1 Dodd Narrows Crossing Options

The bridge crossing Dodd Narrows to Mudge Island from Vancouver Island will potentially impact previously recorded archaeological sites DgRw-172 and DgRw-44. DgRw-172 is a precontact, subsurface shell midden site with some previous erosion due to a hiking and cycling path. DgRw-44 is a precontact, subsurface shell midden and lithic artifact site. There is a strong possibility that DgRw-44 and DgRw-172 are contiguous with

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other midden sites such as DgRw-171 and DgRw-174 to the south and DgRw-46 to the west. There is a high potential that ground disturbance of shell midden features will uncover human burials.

Any submarine or intertidal zone ground disturbance within Dodd Narrows may potentially impact underwater or intertidal archaeological sites.

6.5.1.2 Main Channel Crossing Option 1

The southern end of Crossing Option 1 from Vancouver Island to Gabriola Island will potentially impact previously recorded archaeological site DgRw-44 and possibly DgRw-46, as well. DgRw-44 is a precontact, subsurface shell midden and lithic artifact site (see also Dodd Narrows Crossing Options). DgRw-46 is a multi-component, precontact archaeological site comprised of an extensive shoreline shell midden, both surface and subsurface lithic artifacts, a rock shelter habitation feature containing scattered human remains, surface faunal remains and subsurface fire-altered rock. There is a high potential that ground disturbance of shell midden features will uncover additional human burials.

Though there are no previously recorded archaeological sites where this crossing option intersects the shoreline of Gabriola Island at South Road, this is likely due to a lack of AIA fieldwork in the area and the potential for unrecorded shell midden and burial sites at this location must be considered high.

Any submarine or intertidal zone ground disturbance within the Northumberland Channel may potentially impact underwater or intertidal archaeological sites.

6.5.1.3 Main Channel Crossing Option 2

There are no previously recorded archaeological sites at either the northern or southern end of this bridge option from Mudge Island to Gabriola Island. The nearest previously recorded archaeological site is DgRw-27, a precontact, subsurface shell midden site located approximately 150 m to the east.

Though there are no previously recorded archaeological sites where this option intersects the shorelines of Mudge Island or Gabriola Island, this is likely due to a lack of AIA fieldwork in the area and the potential for unrecorded shell midden and burial sites at both locations must be considered high.

Any submarine or intertidal zone ground disturbance within the Northumberland Channel may potentially impact underwater or intertidal archaeological sites.

6.5.1.4 Main Channel Crossing Option 3

The southern end of this bridge option from Mudge Island to Gabriola Island will potentially impact previously recorded archaeological site DgRw-26, dependent upon the results of an AIA for the bridge option in order to determine the precise boundaries of the site. DgRw-26 is a precontact, subsurface shell midden and surface-collected lithic artifacts site that exhibits a degree of prior machine disturbance.

The northern end of the bridge ties-in to the Island at Brick Yard Bay, an area owned by the Province and likely to have historical significance. It will potentially impact previously recorded archaeological site DgRw-227, a precontact, subsurface shell midden site with some evidence for fire-altered rock. There is a high potential that ground disturbance of shell midden features will uncover additional human burials.

Any submarine or intertidal zone ground disturbance within the Northumberland Channel or False Narrows may potentially impact underwater or intertidal archaeological sites.

6.5.1.5 Main Channel Crossing Option 4

The southern end of this bridge option from Mudge Island to Gabriola Island will potentially impact two previously recorded archaeological sites, including DgRw-19 and DgRw-24. DgRw-19 is a precontact, subsurface shell midden site with surface-collected lithic and faunal artifacts. DgRw-24 is a multi-component archaeological site consisting of a precontact, subsurface shell midden feature, surface-collected artifacts and a significant rock art site with two illustrated panels.

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The northern end of the bridge from Mudge Island to Gabriola Island will potentially impact previously recorded archaeological site DgRw-4, an extensive precontact, subsurface shell midden, lithic and faunal artifact site, and human burial ground which extends along the southern shoreline of Gabriola Island for the entire length of False Narrows. Further documented precontact burial grounds are located further inland from DgRw-4, on the north side of South Road, including DgRw-209 and DgRw-210. **There is a high potential that ground disturbance of shell midden features will uncover additional human burials**.

Any submarine or intertidal zone ground disturbance within False Narrows may potentially impact submerged or intertidal archaeological sites. The archaeological potential for submerged sites below modern sea-level within False Narrows must be considered high.

6.5.1.6 Road Option A (Phoenix Way)

Ground disturbance activities associated with Road Option A, extending Phoenix Way to Dodd Narrows, may potentially impact previously recorded archaeological site DgRw-46, where part of the site extends southward along either side of an unnamed watercourse. DgRw-46 is a multi-component, precontact archaeological site comprised of an extensive shoreline shell midden, both surface and subsurface lithic artifacts, a rock shelter habitation feature containing scattered human remains, surface faunal remains and subsurface fire-altered rock (see also Main Channel Crossing Option 1). Near the Dodd Narrows bridge crossings to Mudge Island, this road alignment may potentially impact previously recorded archaeological site DgRw-172 (previously described in the Dodd Narrows Crossing Options).

There is high archaeological potential for encountering unrecorded inland settlement sites and shell middens (some in association with elevated palaeoshorelines) all along this alignment.

6.5.1.7 Road Option B (Extension of Nicola Road)

Ground disturbance activities associated with Road Option B may potentially impact previously recorded archaeological site DgRw-238, a precontact, subsurface shell midden site that has been disturbed by previous road development. Near the Dodd Narrows bridge crossings to Mudge Island, the alignment may potentially impact previously recorded archaeological site DgRw-172 (previously described in the Dodd Narrows Crossing Options).

There is high archaeological potential for encountering unrecorded inland settlement sites and shell middens (some in association with elevated palaeoshorelines) all along this alignment.

6.5.1.8 Road Option C

From the start point of Option C at the Duke Point highway, the proposed access climbs eastward over continuous, uneven slopes for approximately three kilometres to the summit of a ridgeline at an elevation of approximately 90 m asl. The proposed access then trends in a northeast direction, where it joins with the southern terminus of the proposed Dodd Narrow Option 2 bridge to Mudge Island. Archaeological potential is highest on level benches atop the ridgeline and in the final 1.1 km as the proposed access approaches Dodd Narrows. The final 1.1 km of the proposed access appears to intersect previously recorded site DgRw-239 and possibly DgRw-238, as well. DgRw-239 and DgRw-238 are both subsurface shell midden sites that have been previously disturbed by road construction and logging activities.

There is high archaeological potential for encountering unrecorded inland settlement sites and shell middens (some in association with elevated palaeoshorelines) all along the proposed route of Option C.

6.5.1.9 Road Segments on Mudge Island

There are no previously recorded archaeological sites within immediate proximity to the road segments on Mudge Island. However, this is likely due to a lack of AIA fieldwork conducted in the area of the alignments, rather than indicating a lack of archaeological sites. There is high archaeological potential for encountering unrecorded inland settlement sites and shell middens (some in association with elevated palaeoshorelines) all along the length of the Mudge Island alignments.

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6.5.1.10 Archaeological Review Summary

There is high potential for encountering new archaeological sites anywhere within the fixed link alignment option areas, including in intertidal and submarine environments. The existence of known Aboriginal burial sites means that there is a strong likelihood that the area contains many more, undocumented burials. These sites are of cultural significance to Aboriginal groups in the area, and no disturbance of any such site can be countenanced without the full consultation and consent of the appropriate Aboriginal groups and BC MFLNRO Archaeology Branch.

For these reasons, Main Channel Crossing Option 4 will likely never be approved by concerned Aboriginal Groups or BC MFLNRO Archaeology Branch. **Similarly, the Dodd Narrows Crossings, Main Channel Crossing Options 1 and 3 also potentially impact known archaeological sites, and so these alignments might require amendment in order to have any chance of them being approved** by BC MFLNRO Archaeology Branch and concerned Aboriginal Groups.

Of the bridge crossings reviewed, Main Channel Crossing Option 2 appears to have the least number of immediate archaeological concerns associated with it, though it should be pointed out that accessing this crossing is contingent upon the highly problematic Dodd Narrows Crossing between Vancouver Island and Mudge Island.

The proposed Option C access potentially impacts two archaeological sites, though a final determination of the significance and degree of intactness of the two previously disturbed shell midden sites should be made via an AIA before pursuing mitigation options; it may be that BC MFLNRO Archaeology Branch will be amenable to a controlled excavation of these sites, if avoidance by amending the Project Footprint is not feasible.

To achieve a conclusive archaeological recommendation, a full AIA is recommended of all affected inland, intertidal and marine coastal zones on Vancouver Island, Mudge Island and Gabriola Island, prior to any ground disturbance, should any of the fixed link alignment options appear technically feasible.

6.6 Geotechnical

Thurber Engineering Ltd. prepared a desktop geotechnical engineering assessment of available surficial and bedrock geology, and participated in a site visit of the Vancouver Island portion of the study area. Their technical memorandum is provided in **Appendix B**.

An overview of findings pertinent to any potential road and bridge construction includes:

- The design will need to account for seismic ground accelerations of 0.273g for the 1 in 475 year earthquake (10% probability of exceedance in 50 years);
- Soil deposits in Northumberland Channel, Percy Anchorage, and False Narrows are likely susceptible to seismic liquefaction and further study is required to ascertain the nature and thickness of those deposits;
- Bridge foundations will likely require rock socketed piles; and
- Rock cuts need to anticipate weathering, fracturing, and sloping rock conditions.

Once a preferred alignment has been selected, a detailed marine investigation is recommended to be undertaken. The investigation should include detailed bathymetry, seismic profiling and test hole drilling at select locations to determine the nature and thickness of overburden and sufficient information regarding the nature and quality of the bedrock for design of rock sockets.

Based on the preliminary assessment, the project is considered to be technically feasible from a geotechnical perspective. It is expected that all technical issues identified can be addressed during any potential future design and construction stages.

Other geotechnical aspects to note:

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- The greater Nanaimo area is known for the presence of coal mines that were excavated in the 1800s and early 1900s. A cursory review of the mine records database suggests that there are no recorded mines in the vicinity of this project. However, it should be noted that there is potential for undocumented mines to exist in this area and any future design should consider the possibility of coal mine existence.
- Although not currently aware of any significant Metal Leaching and Acid Rock Drainage (ML-ARD) issues in the Nanaimo area, BC MoTI standard practice requires a screening level assessment is completed for all bedrock excavations that exceed 1000 m^3 of material in accordance with Technical Circular T04/13. As such, an assessment will be required in the preliminary design phase of this project. In general, sandstone (the primary anticipated rock type) would be anticipated to represent a low to moderate risk of ML-ARD generation. Shale and coal deposits (if encountered) would represent a moderate risk of ML-ARD generation.

6.7 Environmental

6.7.1 Road Option A

Road Option A connects Phoenix Way on Vancouver Island to Crossing Option 1 and the Dodd Narrows Crossing Options near Joan Point Park. Two depressions along the roadway were identified during the review and the installation of culverts to facilitate drainage at these locations has been proposed. A total of three unidentified 'sensitive' species were identified along this alignment option. An additional five listed plant species and one red-listed ecological community were identified within 100 meters from the roadway with two red-listed plant species within 300 m from the Option A – Alt 2 roadway.

Following a review of satellite imagery, it was noted that the depressions identified along the roadway likely drain into the Northumberland Channel, in particular the east depression. No known fish observations were identified along this route option (BC Ministry of Environment, 2011.), however previous studies identified freshwater fish species in the general project area, including chinook salmon, chum salmon, coho salmon, rainbow trout, cutthroat trout, and Dolly Varden. The previous studies also identified potential rearing and spawning habitat in unnamed watercourses located to the west of the alignment (McElhanney, 1993a; McElhanney, 1993b). Due to the likelihood that these depressions are connected to the Northumberland Channel which inhabit salmon and sea-run trout, the potential exists for these depressions to be fish bearing. Potential impacts to the fresh water ecosystems resulting from the culvert installations may include alteration or loss of fish and aquatic habitat, loss of riparian habitat, sedimentation, or the introduction of other deleterious substances.

Three unidentified 'sensitive' species were identified along this alignment option (BC Conservation Data Centre, 2012). It is unknown what type of environment these unidentified species inhabit, therefore impacts to these species as a result of the roadway cannot be adequately assessed without additional information. However, potential impacts may include loss of habitat.

A total of five BC listed plant species were also identified within 100 meters of the road way. These species included four blue-listed plants (awned cyperus, banded cord-moss, Nuttall's Quillwort, slimleaf onion) and one red-listed plant (white-top aster).

Two red-listed plant species, Muhlenberg's centaury and white-top aster, were identified within 300 meters of the roadway along road Option A – Alt 2. Potential impacts to these plant species include removal, disturbance, alteration, or loss of habitat for construction of any roadway.

Should a detailed environmental assessment be conducted for this project, additional information should be gathered on the unidentified British Columbia listed species and DFO consulted to avoid or mitigate potential impacts to the fresh water ecosystems.

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6.7.2 Road Option B

Road Option B connects Nicola Road on Vancouver Island to Crossing Option 1 and the Dodd Narrows Crossing Options near Joan Point Park. Three unidentified 'sensitive' species were identified along this alignment option (BC Conservation Data Centre, 2012). It is unknown what type of environment these unidentified species inhabit, therefore impacts to these species as a result of the bridge cannot be adequately assessed, however, impacts may include loss of habitat.

Two red-listed plant species, Muhlenberg's centaury and white-top aster, were identified within 100 meters of the roadway. Potential impacts to these plant species include removal, disturbance, alteration, or loss of habitat for construction of any roadway.

Should a detailed environmental assessment be conducted for this project, additional information should be gathered on the unidentified 'sensitive' species.

6.7.3 Road Option C

Road Option C connects Phoenix Way on Vancouver Island to the Dodd Narrows Crossing Option 2 near Joan Point Park. Three unidentified 'sensitive' species were identified along this alignment option (BC Conservation Data Centre, 2012). It is unknown what type of environment these unidentified species inhabit, therefore impacts to these species as a result of the bridge cannot be adequately assessed, however, impacts may include loss of habitat.

One blue-listed plant species, Nuttall's Quillwort, was identified within 100 meters of the roadway. Potential impacts to this plant species includes removal, disturbance, alteration, or loss of habitat for construction of the roadway.

Two red-listed plant species, Muhlenberg's centaury and white-top aster, were identified within 300 meters of the roadway. Potential impacts to these plant species include removal, disturbance, alteration, or loss of habitat for construction of any roadway.

Should a detailed environmental assessment be conducted for this project, additional information should be gathered on the unidentified 'sensitive' species.

6.7.4 Dodd Narrows Crossings

The bridge crossing options at Dodd Narrows will require construction of two support pylons on each shoreline above the high tide. No instream pylons will be required for this bridge crossing. This alignment option has the potential to impact three British Columbia (BC) listed species and one red-listed ecological community.

The blue-listed eulachon, a marine fish, was identified as occurring within the vicinity of Dodd Narrows. Marine areas including Dodd Narrows were identified as potential spawning habitat for herring (Fisheries and Oceans Canada, 2015) and ling cod (McElhanney, 1993a). The presence of oyster and clam beds along the coastal shorelines near the bridge crossing were also reported (McElhanney, 1993a).

This bridge crossing is located within the Strait of Georgia which has been identified by DFO as an Ecologically and Biologically Important Area (Fisheries and Oceans Canada, 2009). When identifying these areas, DFO evaluates habitat areas based on uniqueness (rare or distinct habitats), aggregations (relative density of a species habitat use in one area), and fitness consequences (areas containing habitat for critical life stages). These Ecologically and Biologically Important Areas are classified by DFO under Canada's *Ocean Act* and allows for DFO to provide enhanced protection of areas which are considered ecologically or biologically significant (Fisheries and Oceans Canada 2004).

Impacts to marine species and/or their habitat, may result from construction of bridge pylons if works are conducted along the shoreline or extend instream. Degradation of marine habitats may result from sedimentation or the introduction of other deleterious substances to the water.

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The red-listed Douglas fir/dull Oregon-grape Ecological Community was located throughout much of Mudge Island including along the shores where vegetation removal may be required for construction of the bridge crossing. Two unidentified 'sensitive' species were also highlighted as potentially occurring in the vicinity of the crossing. It is unknown if these species inhabit terrestrial or marine environments, therefore potential impacts to these species is unknown at this time, but may include loss of or alternation of habitat as a result of removal and clearing for construction of the pylons.

Should a detailed environmental assessment be conducted for this project, additional information on these unidentified species should be requested, in particular, location data with respect to the alignment options so impacts can be avoided or appropriately mitigated (BC Conservation Data Centre, 2012).

6.7.5 Road Segments on Mudge Island

Roadway segments on Mudge Island are required to connect the respective bridges from Mudge Island to Gabriola Island (Crossing Options 2, 3, and 4). Two unidentified 'sensitive' species were identified along these alignment options (BC Conservation Data Centre, 2012). It is unknown what type of environment these unidentified species inhabit, therefore impacts to these species as a result of the road segments cannot be adequately assessed at this time, but may include loss of habitat. The red-listed Douglas fir/dull Oregon-grape Ecological Community is present throughout most of Mudge Island and overlaps with all three road segments (BC Conservation Data Centre, 2012). Potential impacts to this ecological community includes removal, disturbance, alteration, and/or loss of habitat for construction of the roadway.

Should a detailed environmental assessment be conducted for this project, additional information should be gathered on the unidentified 'sensitive' species.

6.7.6 Main Channel Crossing Option 1

Main Channel Crossing Option 1 connecting Vancouver Island to Gabriola Island is the longest bridge crossing and would require two deepwater pylons within the Northumberland Channel and two pylons on either shoreline. Three BC listed species were identified along this alignment option.

The blue-listed eulachon has the potential to be observed in this area and may be impacted by instream work to build the deepwater pylons. This bridge crossing location is also located within the Strait of Georgia which has been identified as an Ecologically and Biologically Important Area by DFO (Fisheries and Oceans Canada, 2009). Potential impacts resulting from construction of the deepwater pylons may result in a direct loss of marine habitat or degradation of water quality and marine habitats due to sedimentation or the introduction of other deleterious substances.

Crossing Option 1 includes the two unidentified 'sensitive' species that were highlighted for the Dodd Narrows Crossing Options (BC Conservation Data Centre, 2012). It is unknown if these species inhabit terrestrial or marine environments, therefore potential impacts to these species is unknown at this time, but may include loss of or alternation of habitat as a result of removal and clearing for construction of the pylons.

Should a detailed environmental assessment be conducted for this project, additional information should be gathered on the unidentified BC listed species and DFO consulted to avoid or mitigate potential impacts to these marine ecosystems.

6.7.7 Main Channel Crossing Option 2

Main Channel Crossing Option 2 is the longest of the crossing options from Mudge Island to Gabriola Island. It is expected that the north pylon would be constructed instream within the Northumberland Channel, while the south pylon would be construction on shore. Three BC listed species and one red-listed ecological community were identified along this alignment option.

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The blue-listed eulachon has the potential to be observed in this area and may be impacted by instream work to build the deepwater pylon. This bridge crossing is also located within the Strait of Georgia and identified as an Ecologically and Biologically Important Area by DFO (Fisheries and Oceans Canada, 2009). Potential impacts resulting from construction of the deepwater pylon may result in a direct loss of marine habitat or degradation of water quality and marine habitats due to sedimentation or the introduction of other deleterious substances.

The two unidentified 'sensitive' species that were highlighted for the Dodd Narrows Crossing Options are present along this alignment option (BC Conservation Data Centre, 2012), as well as the red-listed Douglas fir/dull Oregon-grape Ecological Community throughout Mudge Island where the south pylon would be located. Potential impacts to the ecological community may include loss or alternation of habitat as a result of removal and clearing for construction of the pylons.

Should a detailed environmental assessment be conducted for this project, additional information should be gathered on the unidentified species and DFO consulted to avoid or mitigate potential impacts to marine ecosystems.

6.7.8 Main Channel Crossing Option 3

Main Channel Crossing Option 3 crosses the Northumberland Channel to the west of False Narrows and connects Weather Way on Mudge Island with South Road on Gabriola Island. The proposed concrete box girder bridge will contain six instream pier supports at the south end of Northumberland Channel and two supports along the shorelines of Mudge Island and Gabriola Island above the high tide. Three BC listed species and one red-listed ecological community were identified along this alignment option.

The blue-listed eulachon was observed and may be impacted by instream construction of the piers. It is unknown if this area is used by eulachon for critical life stages such as spawning. Marine areas, including False Narrows which is located to the east of this bridge crossing were identified as containing spawning habitat for herring (Fisheries and Oceans Canada, 2015). The presence of oyster and clam beds along the coastal shorelines in the vicinity of the bridge crossing were also reported (BC Conservation Data Centre, 2012; McElhanney, 1993a). This bridge crossing location is also located within the Strait of Georgia and is identified as an Ecologically and Biologically Important Area by DFO (Fisheries and Oceans Canada, 2009). Construction of the instream piers may result in a loss of habitat for these marine species. Degradation of water quality may also result from sedimentation during construction of instream piers.

The red-listed Douglas fir/dull Oregon-grape Ecological Community is present throughout most of Mudge Island where the north bridge abutment will be located (BC Conservation Data Centre, 2012).The two unidentified 'sensitive' species that were highlighted for the Dodd Narrows Crossing Options are also present along this alignment option. It is unknown if these unidentified species inhabit terrestrial or marine environments. Potential impacts to these species may include loss or alteration of habitat due to clearing and removal for construction of the pylons on either shoreline.

Should a detailed environmental assessment be conducted for this project, additional information should be gathered on the unidentified BC listed species and DFO be consulted to avoid or mitigate potential impacts to the marine ecosystems.

6.7.9 Main Channel Crossing Option 4

Main Channel Crossing Option 4 crosses the east side of False Narrows and connects Coho Boulevard on Mudge Island with South Road on Gabriola Island. The proposed concrete box girder bridge will contain five instream pier supports, spaced at 60 metres through False Narrows, with an additional two supports along the north shoreline of Gabriola Island above the high tide. Three BC listed species were identified along this alignment option.

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The blue-listed eulachon was found and may be impacted by instream construction of the piers. It is unknown if this area is used by eulachon for critical life stages such as spawning. Marine areas, including False Narrows, were identified as containing spawning habitat for herring (Fisheries and Oceans Canada, 2015). The presence of oyster and clam beds along the coastal shorelines in the vicinity of the bridge crossing were also reported (BC Conservation Data Centre, 2012; McElhanney, 1993a). This bridge crossing is located within the Strait of Georgia and is identified as an Ecologically and Biologically Important Area by DFO (Fisheries and Oceans Canada, 2009). Construction of the instream piers may result in a loss of habitat for these marine species. Degradation of water quality may also result from sedimentation during construction of instream piers.

The two unidentified 'sensitive' species that were highlighted for the Dodd Narrows Crossing options are also present along this alignment option (BC Conservation Data Centre, 2012). It is unknown if these unidentified species inhabit terrestrial or marine environments and therefore impacts to these species as a result of the bridge cannot be adequately assessed, however potential impacts may include loss or alteration of habitat.

While the majority of Mudge Island contains the red-listed Douglas fir/dull Oregon-grape Ecological Community, this particular bridge location does not conflict with this ecological community as the bridge is located outside of the habitat polygon.

Should a detailed environmental assessment be conducted for this project, additional information should be gathered on the unidentified BC listed species and DFO consulted to avoid or mitigate potential impacts to marine species.

6.7.10Environmental Review Summary

Based on the desktop review of available information for the Gabriola Island Fixed Link study, **the primary environmental concerns are the unidentified 'sensitive' species which are located throughout the entire alignment and at all bridge crossing locations**. Due to the masked nature of these species within the BC Conservation Data Centre database, these species are likely to be more vulnerable to impacts and disturbances resulting from any fixed link. The red and blue-listed plant species, including the eulachon and the Douglas fir/dull Oregon-grape Ecological Community, are of secondary concern due to the listed status of these species.

Main Channel Crossing Option 1 with Road Option B poses the least amount of environmental impacts when compared to the other alignment options. This option disturbs the least amount of new ground surface for the roadway, encounters fewer listed plant species than the alternatives, and does not require the installation of culverts on potentially fish bearing watercourses. Crossing Option 1 is also limited to only one bridge crossing which conveniently encounters the least number of ecologically sensitive areas and avoids potential spawning habitat for herring and ling cod.

6.8 Property Impacts

Only the number of impacted properties have been determined based on the current level of design, and a more detailed assessment is required to more accurately determine actual impacts, and associated costs. If the Phoenix Way option were to ever proceed due to the safety mitigation measures being implemented (at a cost of approximately $100 million), expropriation of the entire corridor would be required. The implications of the Common Law ROW property on Mudge Island will also need to be understood. The number of impacted properties per fixed link segment is shown in Table 6-2.

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TABLE 6-2. SUMMARY OF PROPERTY IMPACTS

Segment	Number of Properties Impacted		
	Nanaimo	Mudge Island	Gabriola Island
Road Option A (Phoenix Extension) to Dodd Narrows	5	0	0
Road Option B (Nicola Extension) to Dodd Narrows	7	0	0
Road Option C to Dodd Narrows	8	0	0
Main Channel Crossing Option 1	1	0	1
Main Channel Crossing Option 2 via Mudge Island	1	19	1
Main Channel Crossing Option 3 via Mudge Island	1	39	1
Main Channel Crossing Option 4 via Mudge Island	1	59	1

6.9 Marine Construction Window

If deemed technically feasible and all other identified obstacles are addressed, any marine construction for the Gabriola Island Fixed Link, whether it be temporary or permanent works, is subject to construction window restrictions specified by Fisheries and Oceans Canada. Nanaimo, Mudge Island and Gabriola Island all fall within the coast of Vancouver Island between Grave Point (excluded) and Cottam Point (excluded). It includes all the open water and all islands within an area that extends north to Lasqueti Island, east to the Trail Islands (included) and south to Sturdies Bay on Galiano Island (included). The area also includes Northwest Bay, partially includes parts of the Gulf Islands geographically north of Sturdies Bay, and includes the south-eastern tip of Lasqueti Island from Young Point to Squitty Bay.

The following are periods when the timing windows of least construction risk are open:

Summer Window: June 1 – September 1

- Chemainus River and Bonsall Creek Estuary: July 1 – July 15
- Knarston Creek Estuary: July 1 – September 1

Summer windows do not apply in the following estuary: Nanaimo River.

Winter Window: December 1 - February 15

6.10 Stakeholder Review and Feedback

Meetings were held with the following Stakeholders in March 2015:

- The District of Nanaimo
- The City of Nanaimo
- The Islands Trust

The concept alignment options plan was presented and comments were received as well as overall feedback on broader issues that are relevant to the study. The general themes of the discussion are summarized below, and are presented collectively due to the substantial overlap in the feedback and areas of interest.

6.10.1 Bridge Options

- Main Channel Crossing Option 3 was considered the most reasonable crossing option to Gabriola Island, noting however that it ties-in to the Island at Brick Yard Bay, an area owned by the Province and is likely to have historical significance.

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- Any possible tie-in options west of this location are unlikely to be approved due to archaeological impacts, including a cemetery in the area. This would therefore exclude Main Channel Crossing Option 4 from further consideration.

6.10.2 Gabriola Island Considerations

- Portions of Gabriola Island fall within the Agricultural Land Reserve (ALR), so development opportunities at the crossing tie-in location at South Road are unlikely. This applies to all the bridge crossing options.
- Gabriola has invested in the village centre, located close to the ferry harbour. Its proximity is linked to the ferry harbour location, and this investment could be put at risk were a fixed link to be constructed.
- If a fixed link were constructed, it would need to consider the connection to the village centre and not just to the South Road tie-in.
- Besides the village centre, there is currently limited opportunity for commercial development due to the community plan limiting commercial development. Traffic demand on a fixed link is therefore further constrained under existing plans.
- The village is approximately 7 km from the bridge crossing tie-in locations on South Road, which would result in significantly higher traffic volumes on South Road compared to the existing conditions, with associated road maintenance issues.
- It is likely that given the condition of the existing South Road, a full reconstruction would be required as part of the fixed link project.
- Local residents without their own vehicle make foot passenger ferry trips. These trips would require a vehicle were the ferry discontinued, with associated socio-cultural impacts.
- Ferry foot passengers generally have multimodal connections in downtown Nanaimo, whether by foot, bike or transit. The nature of all these trips would change with a fixed link. This is especially applicable for school children, and school field trips.
- In many ways the ferry service, especially for foot passengers, integrates Nanaimo with Gabriola residents and is a natural desire line. Removal of this ferry connection in favour of a fixed link will likely fundamentally affect this integration.
- The Island has a limited ability to support further development due to water capacity constraints. Sewer is by septic tank. If the fixed link enables further development, additional services would be required, which could be tacked to the fixed link bridge crossings and constructed within the road right of way. However, this is in contravention of the OCP which is to preserve and protect the Island lifestyle and cap densification.
- A water connection to the Island would have to be provided by the City of Nanaimo, while a sewer treatment plant could be located on the Island to accommodate future development.
- In general, more traffic on the Island due to a fixed link will increase the need for, and therefore the cost of maintenance on the Island's infrastructure, including maintenance of the fixed link itself. Who pays for this would need to be addressed.
- The Regional District does infrastructure servicing, etc. on the Islands, while the Islands Trust does all the planning related work.
- The past 30 to 40 years of planning for the Islands has taken the ferry into account. Replacing the ferry with a fixed link would require a complete reevaluation going forward.
- There is a community funded bus service ("Gertie") on the Island. There is the opportunity for BC Transit to provide such a service via a fixed link connection to Nanaimo.

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- The elementary school also operates a school bus.
- Ferry foot passengers include several types, all of which would be negatively impacted by the removal of the ferry:
  - Workers, including those going for interviews on Vancouver Island
  - High school students (both for school and extra-curricular activities)
  - Elementary school day trips and extra-curricular activities
  - Recreational visitors
  - Those attending evening entertainment events in Nanaimo
  - Shoppers
  - Others
- There is a small campsite on the Island, demand for which could increase beyond its capacity with a fixed link.

6.10.3Mudge Island Considerations

- The Island is currently only accessed by private water craft and its residents are primarily retirees.
- Access is typically either via either the El Verano Drive wharf, or the Wharf Road wharf. Both impact Gabriola Island local residents due to parked cars, etc. A fixed link would reduce this parking demand.
- All roads on the Island are under Ministry jurisdiction.
- There are archaeological sites along the Island's coastline.
- The subdivision of the Island occurred around the 1970s. Water and septic tank constraints likely affected the ability to develop these lots. These lots were subsequently grandfathered, with more recent lots not less than 10 acres. Land use bylaws have since replaced the subdivision freeze.

6.10.4Nanaimo / Vancouver Island Considerations

- The Oceanview Golf Resort and Spa is controversial due to the anticipated impacts on the local areas, specifically Cedar.
- The resort master plan was approved in October 2009, and has OCP Resort designation, but only that portion in the City of Nanaimo. Plan approval took several years with ALR and residential impact concerns. Access has still not been resolved, neither via Holden Corso Road nor another secondary access. A Nicola Road access was rejected in the OCP, which required that the rural character of the area be maintained.
- The Holden Corso Road area has no significant development plans, and there is a general community fear of increased traffic in the area and associated social impacts, whether from the proposed resort or a fixed link.
- The high school location at the intersection of Holden Corso Road and McMillan Road is currently closed and a "super elementary school" is proposed at this site. Pedestrian safety at this location is a concern, which concern would increase if a fixed link tie-in was via Holden Corso Road.
- Roads in the Cedar area are under Ministry jurisdiction and generally have no sidewalks.
- There is an opportunity to share infrastructure and services costs with the Oceanview Golf Resort, since any fixed link connection to Duke Point Highway would be used by development traffic.
- Of the proposed Island Timberlands development sites, the west-side site has Resort designation in the OCP, and has a pending OCP Amendment. The east-side site is currently designated Resources and a Resort designation has been applied for. There is a desire to combine these two sites into one master plan, however neither has road access, which could be addressed with a fixed link connection.

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- Ownership and maintenance of a fixed link connection will need to be addressed, which will also influence the road cross section.
- Cable Bay Trail is a formal road right of way, and Joan Point Park is a designated park.

6.11 Preliminary Technical Screening Results

The results of the preliminary technical screening undertaken in this section are provided in Table 6-3. Figure 6-1 should be referred to for segment clarification.

TABLE 6-3. PRELIMINARY SCREENING RESULTS

Segment	Preliminary Screening Based on Technical Criteria				
	Achieve Navigational Clearance	Constructability	Geotechnical	Environmental Impacts	Archaeological Impacts
Road Option A (Phoenix Extension)	–	Pass	Pass	Fail	Fail*
Road Option A – Alt 2	–	Pass	Pass	Fail	Fail*
Road Option B (Nicola Extension)	–	Pass	Pass	Fail*	Fail*
Road Option C (New Road Through Resort Development)	–	Pass	Pass	Pass	Fail*
Dodd Narrows Crossing 1	Pass	Pass	Pass	Fail*	Fail*
Dodd Narrows Crossing 2	Pass	Pass	Pass	Fail*	Fail*
Crossing Option 1	Pass	Fail	Pass	Pass	Fail*
Crossing Option 2	Pass	Fail	Pass	Fail*	Pass
Crossing Option 3	Pass	Pass	Pass	Fail*	Fail*
Crossing Option 4	Fail	Pass	Pass	Fail*	Fail

Note:

* Preliminary findings only. Subject to a more detailed assessment before a final decision can be made.

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SECTION 7

Fixed Link Alignment for Further Review

Based on the preliminary screening in Section 6, the Dodd Narrows Crossing Option 2 (BC Hydro alignment) and Main Channel Crossing Option 3 appear to be the most technically feasible of the bridge options considered, or bridges in those vicinities. Of the road tie-in connections to Duke Point Highway, all the road options are technically feasible, however connections via Phoenix Way and Nicola/Holden Corso Roads will be challenging to achieve for reasons other than pure engineering. In which case, Road Option C might be the most feasible, however being a new link, is still subject to further assessments and in particular, stakeholder and public consultation.

It must be stressed that the entire fixed link alignment is still subject to the following assessments before being deemed feasible:

- A more detailed archaeological assessment.
- An environmental assessment to determine if the identified environmental issues can be addressed, and if so, the extent of compensation and/or mitigation measures required.

Stakeholder and community consultation will likely also influence the ultimate decision regarding the non-technical feasibility of establishing a fixed link, if both archaeological and environmental issues can be properly identified and addressed, and OCP amendments will be required.

The segments making up the three fixed link options that were progressed to the cost estimate stage (refer Section 8) are listed below, named according to the following convention:

- "3" - Main Channel Crossing Option 3
- "A", "B", or "C" – the Road Option number tie-in to Duke Point Highway

1. Fixed Link Option 3A – Alt 2

- Upgrading of approximately 1,300 metres of Phoenix Way and existing intersections
- Construction of 2,630 metres of new road to extend Phoenix Way to Dodd Narrows
- Construction of a 260 meter long bridge across Dodd Narrows
- Upgrading and construction of 1,700 metres of roads on Mudge Island
- Construction of a 800 metre bridge across False Narrows
- A new intersection and localize upgrading of South Road on Gabriola Island

The following should also be noted for this option:

- There is the possibility of contaminated sites in the area of the Harmac Pulp Mill
- Safety mitigation measures related to the pulp mill could total over $100 million
- The existing section of Phoenix Way will require expropriation at a cost not yet determined
- Property impacts should be minimal on the Vancouver Island segment
- There are significant property impacts on Mudge Island

2. Fixed Link Option 3B

- Upgrading of approximately 2,500 metres of existing roads and existing intersections between Hwy 19 and Nicola Road

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- Upgrading of Barnes Road would require significant reconstruction
- Construction of 1,430 metres of new road to extend Nicola Road to Dodd Narrows
- Construction of a 260 meter long bridge across Dodd Narrows
- Upgrading and construction of 1,700 metres of roads on Mudge Island
- Construction of a 800 metre bridge across False Narrows

The following should also be noted for this option:

- Upgrading existing roads on Vancouver Island would have significant property impacts and impacts on private accesses
- There are significant property impacts on Mudge Island

3. Fixed Link Option 3C

- Upgrading of approximately 200 metres of Phoenix Way
- Construction of new intersection on Phoenix Way
- Construction of 4,070 metres of new road from Phoenix Way to Dodd Narrows, avoiding the Harmac Pulp Mill site
- Construction of culverts to cross the two Harmac Pulp Mill pipelines
- Construction of a 260 meter long bridge across Dodd Narrows
- Upgrading and construction of 1,700 metres of roads on Mudge Island
- Construction of a 800 metre bridge across False Narrows
- A new intersection and localized upgrading of South Road on Gabriola Island

The following should also be noted for this option:

- The road alignment runs adjacent to First Nations territory
- Property impacts should be minimal on the Vancouver Island segment
- There are significant property impacts on Mudge Island

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SECTION 8

Cost Estimate

The purpose of this section is to determine a cost estimate for both Gabriola Island fixed link options described in Section 7. These estimates will be used when undertaking a business case analysis of the fixed link in Section 9.

8.1 Cost Estimate Derivation

Typical unit costs have been derived for the major construction items in order to arrive at the overall planning level cost estimate for the work.

Itemized cost estimates were developed, and line items identifying scope of work items and quantities were included to determine a cost of construction for each segment.

For the purposes of this estimate, an all-inclusive unit rate for bridge construction was assumed based on consideration of a "complex structure" (medium span haunched concrete box girder bridge). BC MoTI typically applies a unit rate per square metre of $6,500. This was factored up by 30% to account for the uncertainty with underwater foundation conditions, site location, and expected difficulty of construction, yielding a rate of $8,450 per square metre.

Rates account for total construction cost including mobilization and site preparation, temporary works, permanent works, and professional fees, **but exclude all property and environmental compensation/ mitigation related costs**.

Roadways cost estimating data was taken from various sources including:

- BC MoTI cost estimating databases
- CH2M HILL cost estimating databases

8.2 Accuracy of Cost Estimates

BC MoTI recently published Project Cost Estimating Guidelines (2013) which provides guidance on the level of accuracy to be expected at various levels of planning and design. Applying Table 4-1 in the guideline document, the level of project development completed at the planning level is between 1% and 15%, and the associated level of accuracy to be expected for the cost estimates is ±35%. However, an accuracy of ±50% has been applied for this study due to the following risk factors:

- Earthworks and paving quantities were developed with minimal geotechnical input.
- The extent of bridge construction.
- The need to barge in all construction materials.
- Limited if any obvious site establishment locations especially at the bridgeheads on Mudge Island.
- The likelihood of First Nation oversight personnel on site during the entire construction period.

The cost estimates shown, and any resulting conclusions made on project financial or funding requirements, have been prepared for guidance in project evaluation and implementation from the information available at the time the estimate was prepared. The final costs of the project will depend on actual labour and material costs, competitive market conditions, actual site conditions, final project scope, implementation schedule, and other variable factors. In addition, increases or decreases in material pricing may have a significant impact that is not predictable. As a result, the final project costs will vary from the opinions of cost presented in this report.

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8.3 Unit Prices

Typical unit prices were used as the basis for developing the cost estimates from the BC MoTI Cost estimating database and applying Vancouver Island rates. Unit prices and item descriptions is shown in Table 8-1.

TABLE 8-1. UNIT PRICES AND ITEM DESCRIPTIONS

Description of Work	Unit	Proposed Unit Price	Comment
SECTION 1 – GENERAL			
Mobilization	L.S.	L.S.	Based on 5% of Construction
Traffic Management (2.5% of Section 2 thru 8)	L.S.	L.S.	Based on 2% of Construction
Quality Management (1.0% of Section 2 thru 8)	L.S.	L.S.	Based on 1% of Construction
SECTION 2 – GRADING			
Clearing and Grubbing Highway Construction	Ha	$30,000.00	
Remove Lamp Standard	each	$2,000.00	
Cold Milling (50 mm)	m^2	$20.00	
Saw cutting	metre	$20.00	
Pavement Removal	m^2	$20.00	
Remove Concrete Curb	metre	$25.00	
Organic Stripping – 300 mm	m^3	$15.00	
Type "A" Excavation (neatline)	m^3	$40.00	Assumed 50% cut volume in rock
Type "D" Excavation (neatline)	m^3	$18.00	Assumed 50% cut volume in Rock
Haul Surplus Material Offsite (unfactored)	m^3	$25.00	No bulking factor in excavated material
25 mm Well Graded Base Course (WGBC)	m^3	$45.00	150 mm Thick
Open Graded Granular Sub Base (SGSB)	m^3	$35.00	300 mm Thick
Import Material, Haul and Place into Embankment	m^3	$20.00	Assumed 100% of excavated material to be re-used.
SECTION 3 – DRAINAGE			
600 mm CSP 2.0 WT	metre	$400.00	Assumed culverts every 100 m
10 kg Rip Rap Outfall	m^3	$150.00	
End Wall 1,000 mm dia inlet with Fence and Apron	each	$7,000.00	
SECTION 4 – STRUCTURES			
Supply & Install			
Bridge Structure - Concrete	m^2	$6,500 (+ 30%)	Concrete Girder, including span and approaches
Bridge Structure – Cable Stay	m^2	$20,000	Cable Stay, including span and approaches
MSE Wall (sq.m face area)	m^2		
SECTION 5 – PAVING			
Supply Emulsified Penetrating Primer	litre	$1.50	
Apply Emulsified Penetrating Primer	litre	$0.40	
Class 1 Medium Mix	tonne	$155.00	Asphalt volume x 2.4 to tonnes
Concrete Curb and Gutter	metre	$50.00	
Supply and Install CRB	each	$250.00	
Supply and Install CMB	each	$350.00	

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TABLE 8-1. UNIT PRICES AND ITEM DESCRIPTIONS

Description of Work	Unit	Proposed Unit Price	Comment
SECTION 6 – SIGNING AND PAVEMENT MARKING			
Remove Existing Signs	each	$200.00	
Supply & Install Perforated Square Steel Post and Sign	each	$400.00	
Pavement Marking Layout	L.S.	$5,000.00	
Line Markings	metre	$6.00	
Transverse Pavement Markings & Arrows (Thermo P)	L.S.	$20,000.00	
SECTION 7 – ELECTRICAL			
Lamp Standard	each	$5,000.00	
SECTION 8 – LANDSCAPE			
Landscaping	L.S.	$50,000.00	

Notes:

ha = hectare, LS = lump sum; m^2 = square metre; m^3 = cubic metre

8.4 Engineering and Supervision

As an estimate of the engineering and supervision, the following estimated rates were used, based on the total estimated construction cost:

- Engineering and design services are included at an estimate of 5-10% to cover external consultant engineering design. This is based on the following:
  - Association of Professional Engineers and Geoscientists of British Columbia (APEGBC) budget guidelines suggests approximately 5% on the first $1 million for detailed design and tender preparation.
  - However, this does not include such items as preliminary design, survey, geotechnical investigations, environmental investigations, or permitting. This would apply if the preliminary and detailed design was done by consultants. Internal engineering costs may be lower.
- Engineering services for MoTI staff is included at an estimate of 2.5% to cover engineering requirements by MoTI staff.
- Project management by MoTI staff is included at an estimate of 5% to cover project management duties by MoTI staff.
- Construction supervision is included at an estimate of 10% to cover internal or external construction management, or both.

8.4.1 Work by Others

It is expected that work by other agencies will be required. This work could include relocation of utility poles or service boxes and conduit connections.

8.4.2 Contingencies

With the conceptual level of design completed under this study, a contingency allowance of 50% has been included to account for items and conditions unknown at this level of design. Besides those items identified earlier, additional items could include sub-excavation in soft soils; additional haul for embankment materials or gravels; pit development; roadside barrier; signing and pavement marking; etc.

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8.5 Cost Estimate Summary

The summary costs for each estimating category and for each fixed link segment are shown in Table 8-2. Detailed cost sheets for each fixed link segment are provided in **Appendix C**.

TABLE 8-2. SUMMARY OF COSTS FOR FIXED LINK OPTIONS
s.13,s.17

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SECTION 9

Business Case Evaluation

In order to determine if a business case exists for a fixed link to Gabriola Island, a Multiple Account Evaluation was done following BC MoTI guidelines.

For the purposes of the evaluation, the "business-as-usual" Base Case assumes the continuation of the BC Ferries service on Route 19, and is compared to Option 3C, hereafter referred to as the "Fixed Link".

9.1 Multiple Account Evaluation Accounts and Criteria

The Multiple Account Evaluation (MAE) approach was developed based on the accounts and criteria set out in BC MoTI's guidelines, adapted to the specific context of the Gabriola Island fixed link evaluation. The accounts and criteria employed in the evaluation are set out in Table 9-1.

Each account is subsequently discussed in this section.

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TABLE 9-1. DESCRIPTION OF MULTIPLE ACCOUNT EVALUATION CRITERIA APPLIED

Accounts		Discussion/ Direction	MAE criteria	Metrics / Data
FINANCIAL	Capital costs ($ millions)	Ferry cost includes operating costs as well as future ferry replacement costs and terminal upgrades. Fixed link cost includes bridge crossing(s) and associated road network connections and upgrades.	Use Class D cost estimated for comparison of shortlisted options.	Cost ($) in 2015 dollars (property costs may be included depending on the availability of data from MoTI))
	Operations and maintenance costs	Ferry cost includes fuel, staff wages, maintenance costs for vessels and docks. Data to be obtained from BC Ferries, if available. Fixed link cost includes regular inspections, maintenance and repair, snow clearance	Compare BC Ferry operations and maintenance costs for the Gabriola route vs. fixed link costs over a 30 year period (based on 2015 dollars)	Costs ($) in 2015 dollars. Benchmarks for bridge/ road O&M costs used, with inputs/ verification provided from BC MOTI.
	Property impacts	Assume ferry option does not incur any additional property impacts (no additional queuing areas required on either side) Fixed link likely to involve land take to accommodate road connections and bridge Existing terminal properties at Nanaimo Harbour and Descanso Bay could conceivably be freed up for alternative land uses or revenue generation, but are not included in this account since any value estimates would be speculative	Number of properties affected/sq.m of land take required, by land use type (e.g. residential, agricultural, commercial, other). Potential demolitions required (if any).	Estimates of land take to accommodate new bridge and roadway connections. Number of properties affected, by land use type (e.g. residential, agricultural, commercial, other). Potential demolitions required (if any).
CUSTOMER SERVICE	Travel time	Travel time from a mid-point on Gabriola Island to downtown Nanaimo Assume ferry crossing time of 20 minutes plus drive time to terminal, and wait time/loading time (estimated as ¼ * ferry headway) Fixed link crossing time is based on additional driving time incurred. (Note: delays associated with congestion on the road network not included.)	Comparative analysis of average travel time considering ferry crossing time versus fixed link travel time (based on vkt), converted into $ value of time.	High level travel time comparison for screening Total value of time saved ($) using fixed link options relative to ferry, taking into account trip purpose to ascertain value of time. Estimate over a 30 year period. Assume consistent traffic growth across all options.
	Vehicle operating cost ($ millions)	Based on changes in vehicle kilometres travelled (vkt) (Assume user costs remain constant e.g. that a user fee, equivalent to ferry fare would be applied to each crossing.)	Comparative analysis of change in operating costs, based on change to vkt.	Operating costs in 2014 dollars
	Travel time reliability/ flexibility	Delayed and/ or cancelled ferries and pass ups during the peak, converted into a value of time	Relative reliability/ flexibility of a fixed link	Ferry sailing times, potentially affected by weather or mechanical problems
	Safety	Change in the number of incidents, using vkt as a proxy, and applying BC MoTI factors for safety	Number of incidents	Measure vkt and comment on road connections. Not ShortBEN/SafetyBEN
	Multimodal accessibility	Opportunities for improved transit and ped/bike travel, taking into account convenience (trip length and directness) and safety for pedestrians and cyclists using the fixed link and connections. (Assume design of fixed link includes separated cycling/pedestrian facilities.)	Relative attractiveness of options for transit, cycling and walking, based on travel time and directness of route	Which options are most attractive to transit, cycling and walking
	Emergency access	Gabriola has volunteer fire department that includes medical first responders, and RCMP detachment. Closest hospital is Nanaimo Regional General Hospital	Which options enable greatest accessibility for emergency services?	Hours of operation of ferry service versus 24-hr availability of fixed link
SOCIAL/COMMUNITY	Alignment with plans and policies	Consistency/impacts of fixed link on OCP policies and land use designations	Which options are most closely aligned with the policies and designations in the existing OCPs and/ or zoning bylaws?	Number and type of changes potentially required to OCPs and zoning bylaws to facilitate fixed link
	Island identity	Gabriola and Mudge Island OCPs speak to preserving the unique nature of island living	Likely impacts of fixed link and connections on Islands' character relative to ferry service.	How might the identity of Gabriola and Mudge Islands be affected?
	Noise	Use proximity to, and increase in, traffic as a proxy for noise. [Proposed crossing would be a local road (design speed 60 km/h; posted speed 50 km/h)]	Number of residential and other sensitive receptors (schools, hospitals, community centres) likely to experience a moderate to severe increase in traffic noise	Number and type of receptors, severity of impacts. Severity based on type of receptor, anticipated traffic volumes, and the relative increase in volumes.
	Visual impact	Impacts on existing views in this natural/rural setting rather than bridge design aesthetics	Relative impacts on views, based on number of receptors affected and relative intrusiveness of the structure on views	Intrusiveness of structure based on location and visibility (where a larger, higher structure which is visible from multiple locations is considered to be more intrusive)
	Affordability	Assuming users were subject to a user fee equivalent to the cost of a ferry crossing, what additional investment would be required.	Additional (public) investment required over a 25 year period	Funding required (2015 $), assuming a user fee equivalent to the ferry fare is applied to the fixed link. Compare investment costs relative to public subsidy of this ferry route over a 25 year period.
	Recreation	Impacts to local parks/trails and camp sites on Vancouver Island, Gabriola and Mudge Islands, relative to recreational opportunities on Gabriola and Mudge Islands	Number/ length of trails and camp sites impacted and additional recreational opportunities enabled	Number and length (km) affected

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TABLE 9-1. DESCRIPTION OF MULTIPLE ACCOUNT EVALUATION CRITERIA APPLIED

Accounts		Discussion/ Direction	MAE criteria	Metrics / Data
ENVIRONMENT	GHG emissions – travel-related	Emissions associated with ferry fuel usage and vehicle usage from a mid-point on Gabriola Island to downtown Nanaimo compared to fixed link vehicle emissions (including induced travel) over a 30 year period.	Comparison of total GHG emissions	Total GHG emissions (tons) over a 30 year period, based on vkt and ferry fuel consumption
	Air pollution	Pollutant emissions – Criteria Air Contaminants (CAC) – associated with ferry and vehicle usage	Relative estimates based on ferry CAC emissions and vkt	Tons of CACs – by type
	ALR impacts	Agricultural Land Reserve (ALR) areas shown on Issues Map (see Figure 4-1)	Total area of ALR impacted	Parcels affected
	Terrestrial (Flora/fauna) impacts	Area/ type of sensitive habitat or species affected	Area/ type/ sensitivity of habitat or species affected	Type of habitat and local species based on GIS database of habitat/ species at risk
	Aquatic impacts	Impacts on intertidal zone	Area/ type/ sensitivity of habitat or species affected	Type of habitat and local species based on GIS database of habitat/ species at risk
	Archaeological impacts	Impacts on archaeological sites or sites of historic interest/ importance	Are sites likely to be temporarily or permanently impacted	Number and importance of sites affected
ECONOMIC DEVELOPMENT	Goods movement	Benefits to goods movers are largely captured under the Customer Service account. However, added benefit would accrue to movement of gas/propane, dangerous cargo (DC) and livestock. Those are currently restricted to one weekly sailing where no other vehicles are permitted.	Number/ type of DC movements benefitting	BC Ferries DC sailings schedule
	Development enabled	Primarily focused on resort property opportunities near Cable Bay Trail Also potential for redevelopment of existing terminals. Development of land parcels on Mudge and Gabriola could also be enabled, but would require OCP amendment.	Development supported (subject to OCP amendments)	Oceanview Golf Resort and Spa Master Plan and Island Timberlands OCP amendment documents
	Impact on local businesses	Positive (greater access) and negative impacts (duplication/competition)	General assessment of local businesses potentially impacted by increased accessibility due to fixed link	Gabriola Island Chamber of Commerce directory (http://www.gabriolaisland.org/membership-listings)

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9.2.3 Property Impacts

Property impacts are primarily incurred on Mudge Island, where it is assumed that a new road will have to be constructed. Only the number of impacted properties have been determined based on the current level of design, and a more detailed assessment is required to more accurately determine actual impacts, and associated costs. The estimated number of properties impacts is provided in Table 9-4.

TABLE 9-4. SUMMARY OF PROPERTY IMPACTS

	Number of Properties Impacted		
	Nanaimo	Mudge Island	Gabriola Island
Fixed Link	6	39	1

Existing terminal properties at Nanaimo Harbour and Descanso Bay could conceivably be freed up for alternative land uses or revenue generation, but are not included in this account since any value estimates would be speculative

9.3 Customer Service Account

The assumptions used in the Customer Service Account are consistent with those listed in Section 9.2 (Financial Account).

9.3.1 Travel Time

The Fixed Link is expected to reduce travel time between Nanaimo and Gabriola by approximately 20 minutes as per Table 5-8, when counting drive time between origin and ferry terminal, ferry wait time, ferry crossing time, and drive time between ferry terminal and destination. Using the value of time assumption of $10/hr and the Base Case traffic forecasts presented in Section 5, the Fixed Link is expected to provide a net savings of $13.7 million (Net Present Value) as shown in Table 9-5. Thus, the Fixed Link is the more favourable option.

TABLE 9-5. SUMMARY OF TRAVEL TIME IMPACTS

Travel Time	Base Case	Fixed Link
$ millions	43.9	30.2

9.3.2 Vehicle Operating Costs

The Fixed Link is expected to increase the total vehicle kilometers travelled (vkt) over a 25-year period by approximately 201.2 million km, as shown in Table 9-6. Assuming a vehicle operating cost of 17 cents per kilometre (Table 5-8), this translates into additional vehicle operating costs of $19.6 million for the Fixed Link. Similar to the Travel Time account, growth forecasts presented in Section 5 were used to derive the figures shown in Table 9-6.

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TABLE 9-6. SUMMARY OF VEHICLE OPERATING COSTS

Item	Base Case	Fixed Link
Million vkt 2020-2044)	71.8	273.0
$ millions (2020-2044)	7.0	26.6

9.3.3 Travel Time Reliability/Flexibility

This account gauges the travel time reliability differences between the Base Case and the Fixed Link. It also aims to combine this with an assigned value that accounts for the flexibility in travel to/from the island afforded by a fixed link (available 24-hours a day) versus a ferry service that is unavailable overnight.

In the first instance, reliability is taken as the percentage of vehicles that are expected to experience typical travel times without significant delays. The Fixed Link establishes a permanent link between Nanaimo and Gabriola Island, which will provide around the clock accessibility. Combined with the low traffic volume forecasts, it is expected that the travel time will be consistent and reliable. Analyzing the historical ferry data, it was determined that approximately 2% of all vehicles experience a sailing wait on account of limited ferry vessel capacity. Based on this the travel time reliability values would be 98% and 100% for the Base Case and Fixed Link respectively, as shown in Table 9-7.

A query of BC Ferries data on evening trips between Nanaimo and Gabriola revealed that final ferry sailings were not at capacity. This reinforces that overnight travel demand is limited. However, there is still a need to account for trips that are currently not made due to unavailability of service. This inconvenience is captured in an additional 8% penalty assigned to the Travel Time Reliability/Flexibility account, bringing the overall value of the Base Case to 90%.

TABLE 9-7. ESTIMATED RELIABILITY

Travel Time Reliability/ Flexibility	Base Case	Fixed Link
%	90%	100%

9.3.4 Safety (Traffic Collisions)

BC MoTI's "Default Values for Benefit Cost Analysis in British Columbia – 2012" were used to determine the monetary values (2012 dollars) of collisions by severity as shown below:

- Property Damage Only: $11,367
- Injury: $135,577
- Fatal: $6,385,999

Based on observed Provincial Collision Rates (per vkt) for different road classes between 2006 and 2010[4] and vkt forecasts, the Fixed Link is expected to result in approximately 42 additional collisions over the project's 25 year horizon. This translates to approximately $4.5 million (net present value) of additional impact. The total collisions and cost of collisions for both the Base Case and Fixed Link are presented in Table 9-8.

[4] http://www.th.gov.bc.ca/publications/planning/Safety/Average_Provincial_Collision_Rates_2006-10_Collision_Data.xls

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TABLE 9-8. SUMMARY OF SAFETY IMPACTS (2020-2044)

Item	Base Case	Fixed Link
Number of Collisions	22	64
Cost of Collisions ($ millions)	2.3	6.8

9.3.5 Multimodal Accessibility

The Fixed Link includes segregated bicycle and pedestrian facilities (roadways with 1.5 m asphalt shoulder lanes and additional adjacent gravel shoulders as a minimum), providing a relatively safe option for pedestrians and cyclists. However, the convenience of the Fixed Link routing (considering trip length and directness) is poor, particularly for commute trips by active modes. Commute distances of over 20 km are unlikely to be attractive to many cyclists. Further, the steeper grades of the bridge and corresponding connections provide a disincentive for cyclists.

While the Fixed Link arguably provides opportunities for improved transit connections between Gabriola Island and Nanaimo, this would be dependent upon an assessment of the viability of a service and investment by BC Transit. Currently, the BC Ferries foot passenger service can itself be considered a transit service. The Base Case is therefore considered to offer more convenient multi-modal accessibility than the Fixed Link.

9.3.6 Emergency Access

The closest hospital for Gabriola Island residents is the Nanaimo Regional General Hospital. It is assumed that where patients are in need of urgent/ life threatening medical assistance, they would be airlifted to hospital. However, for less urgent hospital requirements, emergency travel times would likely be similar to those for ferry users (approximately 51 minutes) under the Base Case, with use of the Nanaimo Harbour Patrol response vessel available for emergencies when the Gabriola ferry is not operating. It is estimated that the travel times for the latter would be similar.

Emergency travel times to Nanaimo Hospital for the Fixed Link are estimated to be slightly less than average travel times of approximately 31 minutes. It is also assumed that the costs of ground (versus water) emergency transportation would be less. The Fixed Link therefore offers benefits over the Base Case for Gabriola and Mudge residents, and would likely result in reduced costs to the BC Emergency Health Services.

9.3.7 Net Present Value

The net present value of the Fixed Link is estimated to be ($42.1 million). The NPV is determined by summing the incremental costs and benefits between the Base Case and the Fixed Link, based on those accounts that can be monetized. The costs and benefits are presented in Table 9-9.

For the purposes of this study, the Fixed Link capital costs derived in Section 8 are assumed to be spent in 2015, in advance of opening day in 2020. In reality, the design and construction costs would be spread out between 2015 and 2020.

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TABLE 9-9. NPV CALCULATION

Accounts	Base Case	Fixed Link	Delta
Capital Cost	s.17	193.5	s.17
O&M Cost (2015-2019)		37.7	
O&M Cost (2020-2044)		5.4	
Property Cost	tbd	tbd	tbd
Incremental Cost (Σ Capital + O&M + Property)			**-31.7**
Travel Time	43.9	30.2	13.7
Vehicle Operating Cost	7.0	26.6	-19.6
Safety	2.3	6.8	-4.5
Incremental Benefit (Σ Travel time + Veh Ops + Safety)			**-10.4**
		NPV	**-42.1**
		B/C	**-0.33**

9.3.8 Benefit Cost Ratio

The Fixed Link generates a negative benefit cost on account of the relatively high vehicle operating and safety costs. As a point of reference, a ratio in the order of 1.0 is deemed a viable project, unless other overarching factors exist. The Fixed Link benefit/cost ratio relative to the Base Case is estimated to be (0.33).

However, a number of social/community, environmental and economic impacts (along with convenience, reliability and emergency access benefits) are not reflected in this measure. These are discussed further below.

9.4 Social/Community Account

9.4.1 Alignment with Plans and Policies

The Fixed Link is in direct contravention of the objective in the Gabriola Island Official Community Plan (OCP) (1997) to "oppose any fixed link or bridge to Vancouver Island". Similarly, Policy 4 of the Mudge Island OCP (2007) states that "no island in the Plan Area shall be connected to any other island by a bridge". The Fixed Link is therefore considered to offer no/low planning alignment benefits.

While the Base Case was found to be in keeping with the objectives and policies set out in the Gabriola Island OCP, it is considered that the reduction in ferry services may fall somewhat short of the Plan objective of ensuring "the provision of a ferry service to Vancouver Island that meets the needs of the local community". For this reason the Base Case is considered to not fully align with existing plans and policies.

9.4.2 Island Identity

The character, identity and atmosphere of Gabriola and Mudge Islands are defined precisely by the fact that they are separate from the Mainland and from Vancouver Island. It is considered here that island identity is a quality worth preserving and is one of the reasons why people have chosen to live on Gabriola and Mudge Islands in the first instance. (The Mudge Island OCP states that Mudge Island residents and landowners favour low population density and "water access only".) This island identity is likely to be fundamentally altered by the provision of a Fixed Link, and could change both islands into the equivalent of outlying suburbs of Nanaimo. The Fixed Link is therefore considered to have significant adverse impacts to island identity.

At the same time it is recognized that the ferry service provides the lifeblood of Gabriola Island. Declining ferry service can have an adverse impact on the Island's identity insofar as it undermines the sustainability of the local community and affected the potential for enjoyment of the Island by visitors. For this reason the

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Base Case is considered to have a moderately adverse impacts on the character and identity of Mudge and Gabriola Islands.

9.4.3 Noise

Typically, an evaluation of noise impacts would consider the number of residential and other sensitive receptors (schools, hospitals, community centres) likely to experience a moderate to severe increase in traffic noise. In this case, the increase in daily traffic flows was used as a proxy for noise, and the impact of increased traffic on rural residential development was considered.

Average Annual Daily Traffic (AADT) estimates for 2044 under the Base Case are 1,100 vehicles per day (refer to Table 5-4). These vehicles are expected to use existing routes. The forecast increase over 2015 traffic is just 200 vehicles per day. This increase is considered to be relatively slight over the 25 year period. It is therefore considered that the Base Case will result in little to no change in noise impact to Gabriola Island and Nanaimo residents.

For the Fixed Link it is estimated that on average 1,240 vehicles per day (refer to Table 5-10) will make the journey between Gabriola Island and Nanaimo in 2044. This represents an increase of 340 vehicles per day compared with AADT in 2015 of 900 vpd. However, for the Fixed Link this traffic will be following a different route to the Base Case, passing through residential areas which currently have almost no traffic (on Mudge Island), or has residential frontages (on Gabriola Island). These locations are likely to experience a noticeable increase in traffic noise where they had previously experienced little to no traffic noise. Conversely, Gabriola Island residents currently living along the route linking to the ferry terminal may benefit from reduced noise impacts. Overall, it is considered that these noise impacts are likely to be experienced as moderately adverse.

9.4.4 Visual Impacts

While the crossing locations approximately follow the existing BC Hydro Right of Way over the water channels, the height and location of the bridge structures for the Fixed Link would result in significant visual intrusion to properties on the south side of Gabriola Island and the north side of Mudge Island. Further, it is considered that the Dodd Narrows crossing would also have adverse impacts on the views from adjacent properties and on the users of Joan Point Park. These impacts are considered to be moderate to highly adverse relative to the Base Case (with existing BC Hydro crossing) where visual impacts are considered to be low to moderate.

9.4.5 Affordability

The affordability criteria considers the extent to which costs may be subsidized through a user fee on the Fixed Link. For comparison purposes, the user fee is assumed to be equivalent to an average ferry fare for a vehicle with two passengers. In 2014, this fare was $28.85.

The revenue from the user fee is derived by multiplying the number of auto trips forecast for the Fixed Link (including baseline growth and induced demand) over the 25-year study period by 50% (since the ferry fare is for a return trip) by the average fare. The fare is adjusted for 2.1% CPI growth.

Based on these assumptions, a Fixed Link could generate $81.2 million over a 25 year period, relative to a Fixed Link cost of $193.5 million.

9.4.6 Recreation

The Fixed Link avoids Joan Point Park, except for a bridge pier which will result in some land take from the park, meaning that the setting of the park will be altered to a degree. Impacts to the existing Cable Bay Trail will be mitigated by the possible inclusion of a bridge structure (versus earth embankment and culvert) over the trail and creek. While the Fixed Link does not impact designated parks on Gabriola Island or Mudge Island, it is anticipated that it will adversely impact the setting of the beaches (designated as Water General

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in the Gabriola and Mudge Island OCPs[5]), and could compromise public recreational enjoyment of the shoreline at the crossing locations. While a Fixed Link will arguably increase the number of people who are able to access the recreational amenities on Gabriola Island and Mudge Island, it may also compromise the enjoyment of these amenities. These combined impacts are considered to be moderately to highly adverse relative to the Base Case.

9.5 Environmental Account

9.5.1 GHG Emissions – Travel-Related

The ferry *Quinsam* which serves Gabriola Island uses in average 190 litres[6] of fuel per round trip. Based on the current ferry schedule this equates to 908,960 litres of fuel per year, assuming 4,784 annual round trips based on the 2015 ferry timetable. Given this level of fuel consumption, it is estimated that the ferry service will produce 2,514 tonnes of CO_2e emissions per year, or 62,843 tonnes of CO_2e emissions over the 25 year study period.

Total forecast vehicle kilometres travelled (vkt) for road-based transportation associated with ferry trips over the study period is 71,799,440 km. This equates to an estimated 16,532 tonnes of CO_2e over the course of the study period.

Total estimated GHG emissions associated with the Base Case are equal to approximately 88,375 tonnes of GHG emissions in total - substantially less than those associated with the Fixed Link, which results in over 4.5 million tonnes of GHG emissions. If BC Ferries were to switch to alternative fuels, the Base Case would provide even greater relative GHG benefits. These emission totals are shown in Table 9-10.

TABLE 9-10. GHG EMISSIONS OF ROAD-BASED TRAVEL

Vehicle GHG Emissions	Base Case (tonnes)	Fixed Link (tonnes)
CO_2e	16,532	4,514,563

Note also that these GHG emission estimates exclude consideration of embedded carbon and the carbon impacts associated with construction, since the current level of design does not enable an accurate assessment. If embedded carbon and construction carbon was included, it is likely that the Fixed Link would fare more poorly relative to the Base Case owing to the impacts of construction transportation and the quantity of embedded carbon in cement and other bridge/ road construction materials.[7]

9.5.2 Air Pollution

The calculation of ferry Criteria Air Contaminant (CAC) emissions is complex and depends on a variety of considerations such as whether a ferry vessel is docked, maneuvering or underway and whether the vessel is

[5] Permitted uses in the Gabriola OCP include boat moorage and boat launching facilities, public parks, and ecological reserves

[6] Island Futures "2008 GHG Emissions Gabriola Island" (February 8, 2010), available online at http://www.nickdoe.ca/pdfs/Webp638.pdf

[7] For example the production of cement and cementitious materials, from cradle to factory gate, is estimated to produce between 800 – 900 kg CO2e/tonne (see: http://cement.mineralproducts.org/documents/Factsheet_18.pdf)

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fully loaded, engine size, and speed. In order to simplify the approach, Metro Vancouver emission factors were used as shown in Table 9-11.

TABLE 9-11. FERRY CAC EMISSIONS

Ferry CAC Emissions	Base Case (tonnes)
NO_X	11,554
SO_X	191

For vehicles, CAC emissions are dependent on speed, engine type and mode of operation. In order to enable a high level comparison, emissions factors[8] based on estimated fuel consumption have been applied. Estimates of total vehicle CAC emissions by type for the Fixed Link are shown in Table 9-12. As seen in this Table, CAC emissions from the Fixed Link are considerably higher than under the Base Case over the study period.

TABLE 9-12. VEHICLE CAC EMISSIONS

Vehicle CAC Emissions	Base Case (tonnes)	Fixed Link (tonnes)
CO	422	1,604
NO_X	31	8,492
PM_{10}	197	53,920
$PM_{2.5}$	0.184	50.244

Overall, based on the data available, is it estimated that the Fixed Link would result in a decrease in NOx and SO_2 emissions, but an increase in other CAC emissions.

9.5.3 ALR Impacts

The Fixed Link does not impact on any Agricultural Land Reserve parcels. The road connection between Phoenix Way and Dodd Narrows is aligned to avoid ALR impacts.

9.5.4 Terrestrial (Flora/Fauna) Impacts

Potential impacts to plant and 'sensitive' species includes removal, disturbance, alteration, or loss of habitat as a result of construction of the roadway.

Should a detailed environmental assessment be conducted for this project, additional information should be gathered on the unidentified plant and 'sensitive' species.

9.5.5 Aquatic Impacts

Impacts to marine species and/or their habitat, may result from construction of permanent bridge piers in False Narrows, as well as temporary works to support construction access along the shoreline. Degradation of marine habitats may result from sedimentation or the introduction of other deleterious substances to the water.

[8] US EPA Emission Facts (2008) " Average Annual Emissions and Fuel Consumption for Gasoline-Fueled Passenger Cars and Light Trucks" Office of Transportation and Air Quality EPA420-F-08-024 available online at http://www.epa.gov/otaq/consumer/420f08024.pdf

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Should a detailed environmental assessment be conducted for this project, additional information should be gathered on the unidentified British Columbia listed species and DFO consulted to avoid or mitigate potential impacts to the fresh water ecosystems.

9.5.6 Archaeological Impacts

Existing archaeological sites have been identified, or are expected, along the entire alignment of the Fixed Link. For the purposes of this analysis, it is assumed that the Fixed Link results in high archaeological impacts, recognizing that a full AIA of all affected inland, intertidal, and marine coastal zones would be required prior to any ground disturbance verify the severity of those impacts.

9.6 Economic Development Account

9.6.1 Goods Movement

Benefits to goods movers are largely captured under the Customer Service account. However, for the Fixed Link, added benefit would accrue to movement of gas/propane, dangerous cargo (DC) and livestock. Those are currently restricted to one weekly sailing (on Wednesdays) where no other vehicles are permitted on these sailings. This would likely have advantages in terms of supporting the local island economy which would benefit from reliable and unrestricted access to markets and materials. Thus, the Fixed Link is considered to be highly beneficial relative to the Base Case.

9.6.2 Development Enabled

While the Fixed Link is likely to result in increasing pressure for development on Gabriola Island and Mudge Island, it is assumed that development will occur at the pace and within the limits determined by the respective Island OCPs.

It is also recognized that the Fixed Link could provide bridge structures to which utilities may be attached, thereby overcoming some of the current water supply and treatment issues which constrain development on Gabriola and Mudge Islands. The Fixed Link could also enable the dismantling of the existing Ferry Terminals at Descanso Bay and downtown Nanaimo thereby freeing up these prime waterfront sites for redevelopment. If the Fixed Link was constructed, the roadway connection to Duke Point Highway could potentially assist in realizing the proposed Waterfront Village at Cable Bay, the Cable Bay Waterfront Marina, and the Oceanview Golf Resort.

9.6.3 Impacts on Local Businesses

It is considered that the Fixed Link has the potential to bring people to Gabriola Island (owing to improved accessibility), providing an increased customer base for certain types of local businesses, particularly those associated with tourism such as holiday accommodation, restaurants, galleries, and tourist retail. Many island businesses struggle in the off-season and improved access may contribute to their viability and sustainability.

However, this improved accessibility also opens up the off-Island (Nanaimo and surroundings) economic and retail opportunities for Gabriola Island residents. Businesses (such as professional services and grocery stores) which currently provide a mainstay for the local Island community, will no longer offer the benefit of convenience. These businesses could lose out to larger operations and lower priced “big box” stores on Vancouver Island which will be within easier reach of Island residents with the Fixed Link. There is a risk that independent local business could lose out; that there may be a net outflow of money from the local economy; that local jobs may be placed under threat; and that the uniqueness of the local community may be undermined.

Further investigation is required to assess the impacts on the local economy in greater detail. For the purposes of this analysis it is assumed that the Fixed Link is likely to adversely impact to the local economy of Gabriola Island, owing to the increased accessibility of Nanaimo.

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9.7 MAE Summary

Based on the discussion of the various accounts presented in this section, the summary of the Multiple Account Evaluation is presented in Table 9-13.

TABLE 9-13. MAE SUMMARY TABLE

	Accounts	Base Case (Ferry Service)	Fixed Link
FINANCIAL	Capital costs ($ millions)	s.17	193.5
	Operations and maintenance costs ($ millions)		5.4
	Property impacts (number of)		49
CUSTOMER SERVICE	Travel time ($ millions)	43.9	30.2
	Vehicle operating cost ($ millions)	7.0	26.6
	Travel time reliability/ flexibility	98%	100%
	Safety ($ millions)	2.3	6.8
	Multimodal accessibility	◑	◔
	Emergency access	◑	◕
NPV	($ millions)	–	(42.1)
BENEFIT/COST RATIO		–	(0.53)
SOCIAL/ COMMUNITY	Alignment with Plans and Policies	◔	○
	Island Identity	◔	○
	Noise	◑	◔
	Visual Impact	◑	◔
	Affordability	–	User fee equivalent to a ferry fare could generate $ 81.2 million over a 25 year period.
	Recreation	◑	◔
ENVIRONMENT	GHG emissions – travel-related	◑	○
	Air Pollution	◑	○
	ALR Impacts	◑	◑
	Terrestrial (Flora/fauna) impacts	◑	◔
	Aquatic impacts	◑	◔
	Archaeological impacts	◑	◔
ECONOMIC DEVELOPMENT	Goods Movement	◑	●
	Development Enabled	◑	◕
	Impact on Local Businesses	◑	◔

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Legend:

○	Much Worse
◔	Worse
◑	Neutral
◕	Better
●	Much Better

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SECTION 10

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APPENDIX A
ALIGNMENT DRAWINGS

FOR ILLUSTRATIVE PURPOSES ONLY

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GENERAL LOCATION PLAN

GABRIOLA ISLAND STUDY
FIXED LINK OPTIONS

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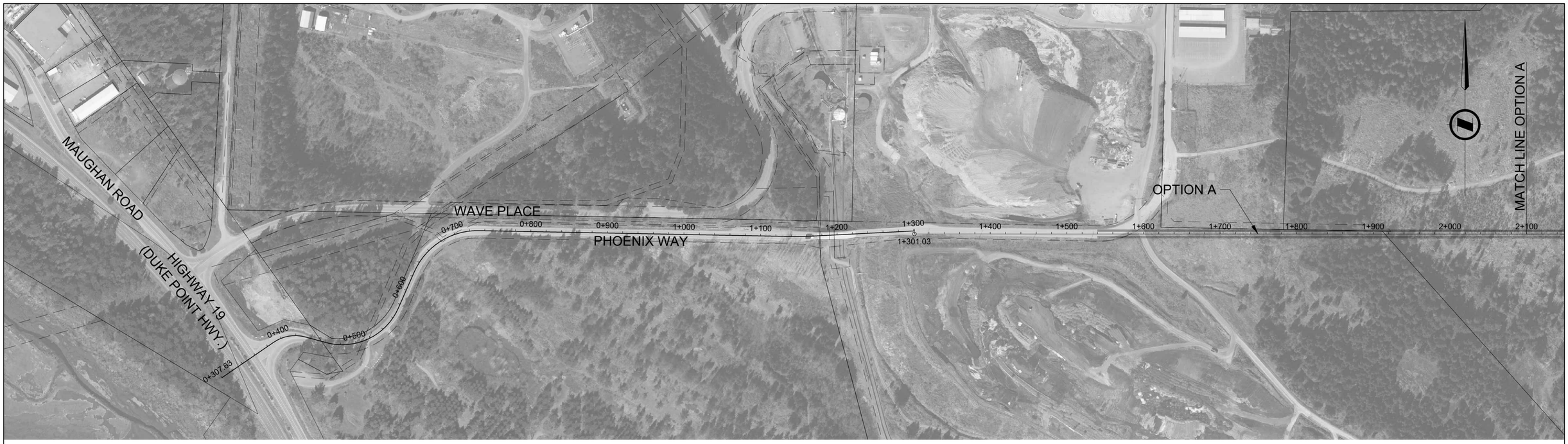

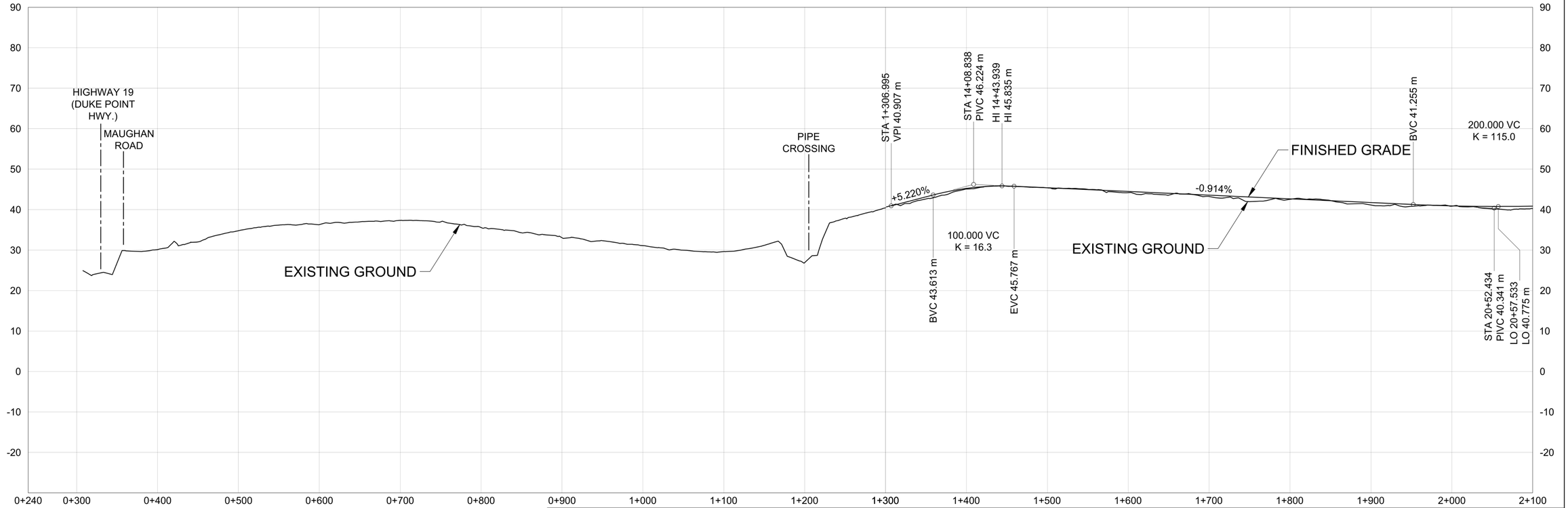

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PLAN AND PROFILE

GABRIOLA ISLAND STUDY
ROAD OPTION A - SHEET 1

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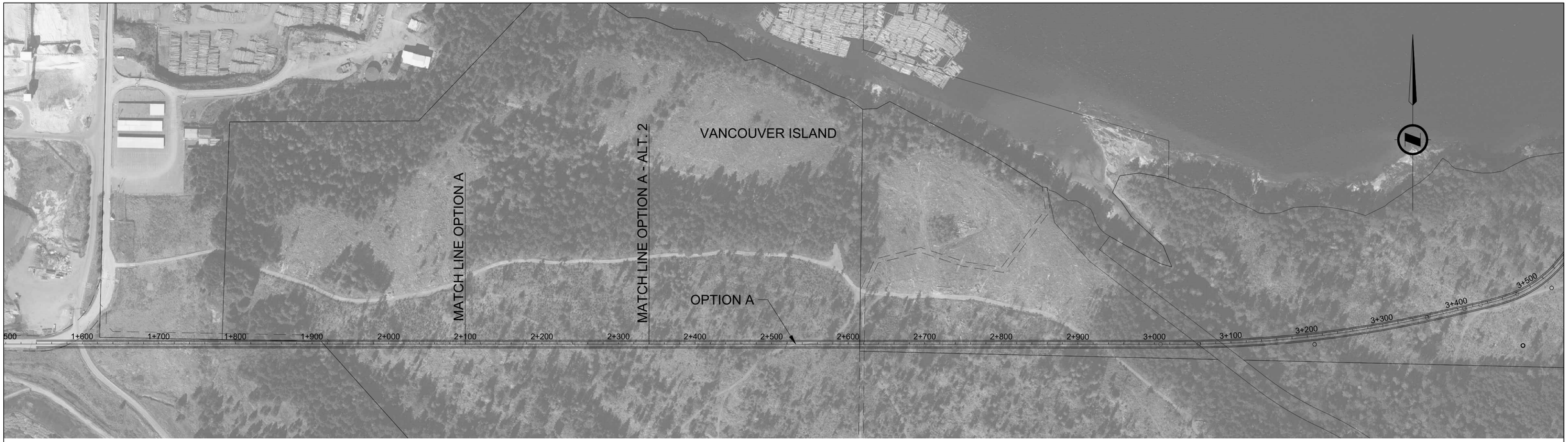

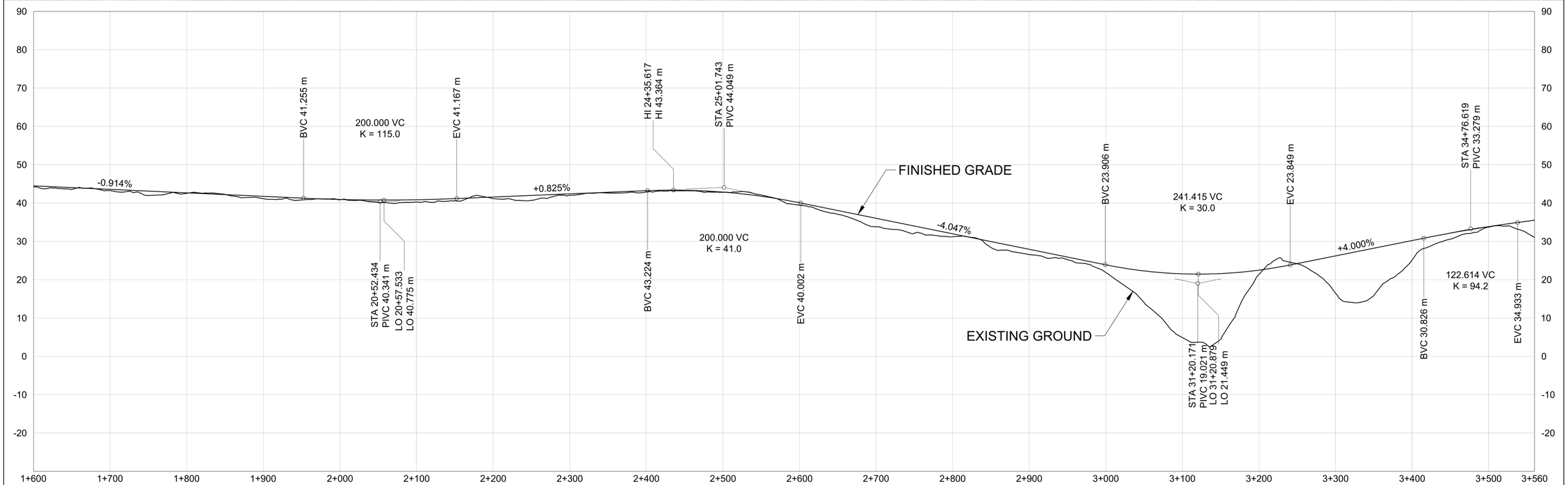

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PLAN AND PROFILE

GABRIOLA ISLAND STUDY
ROAD OPTION A - SHEET 2

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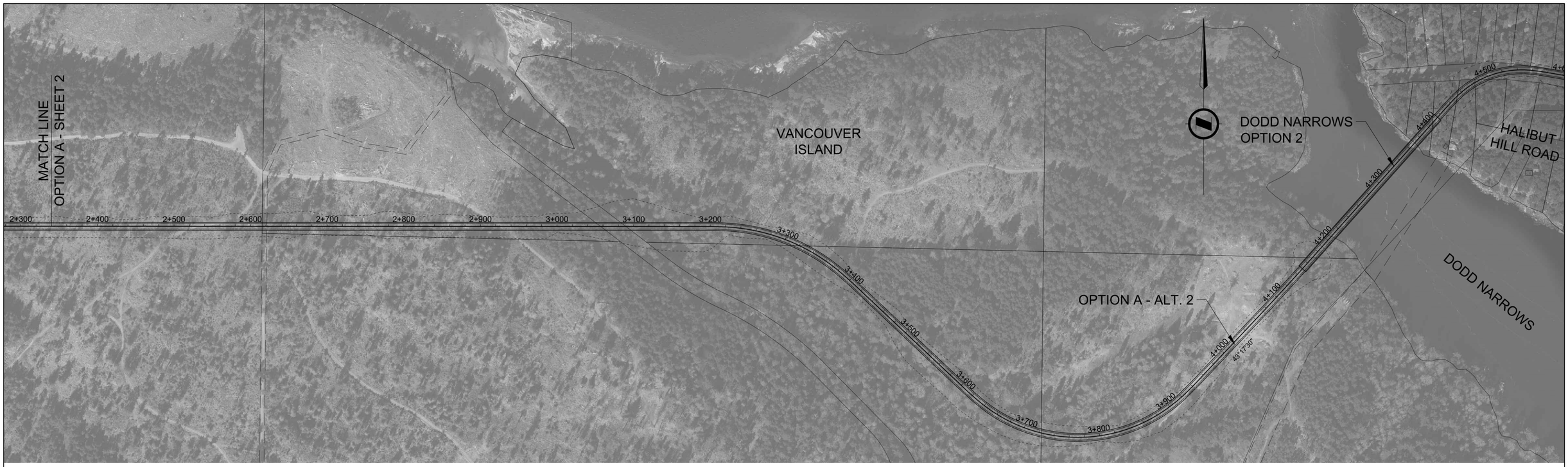

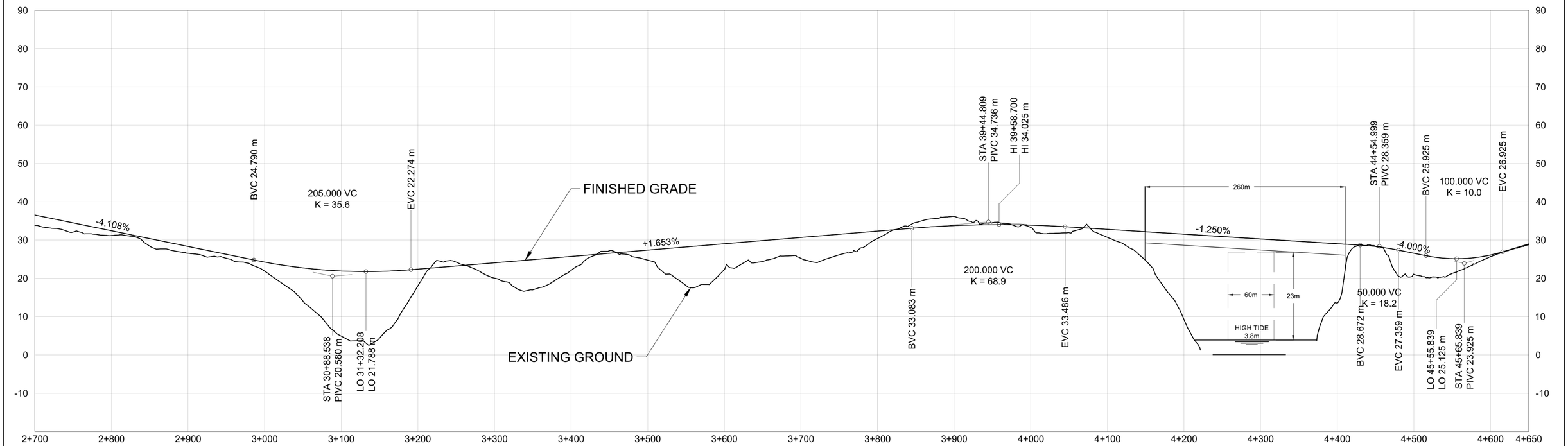

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PLAN AND PROFILE

GABRIOLA ISLAND STUDY
ROAD OPTION A - ALT. 2

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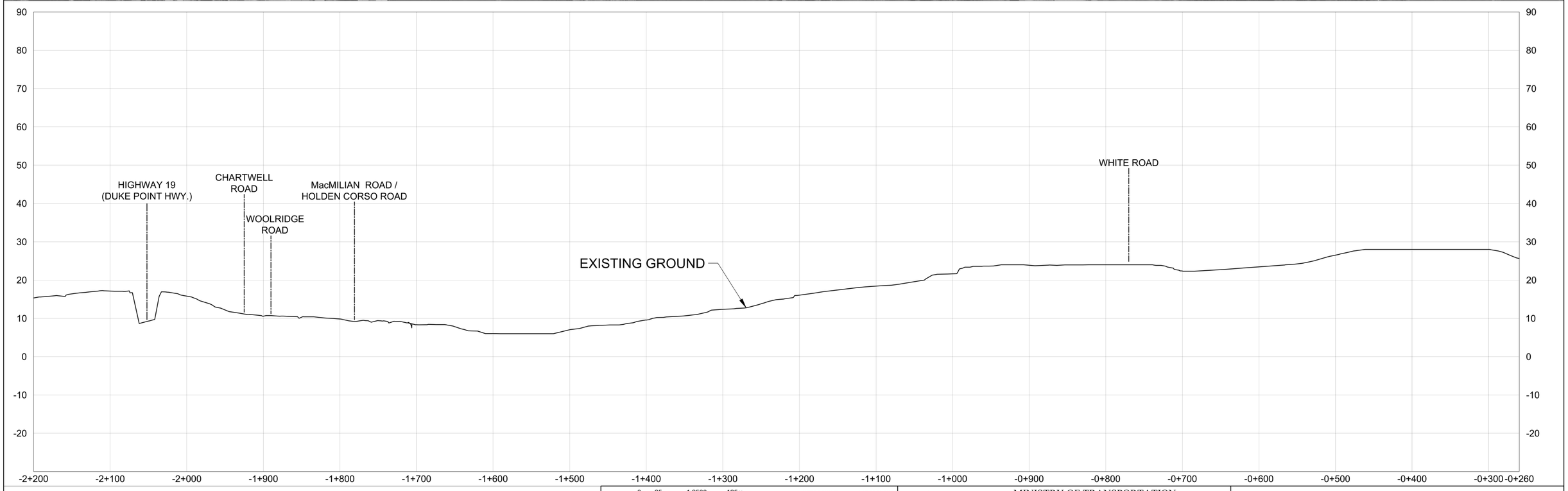

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PLAN AND PROFILE

GABRIOLA ISLAND STUDY
ROAD OPTION B - SHEET 1

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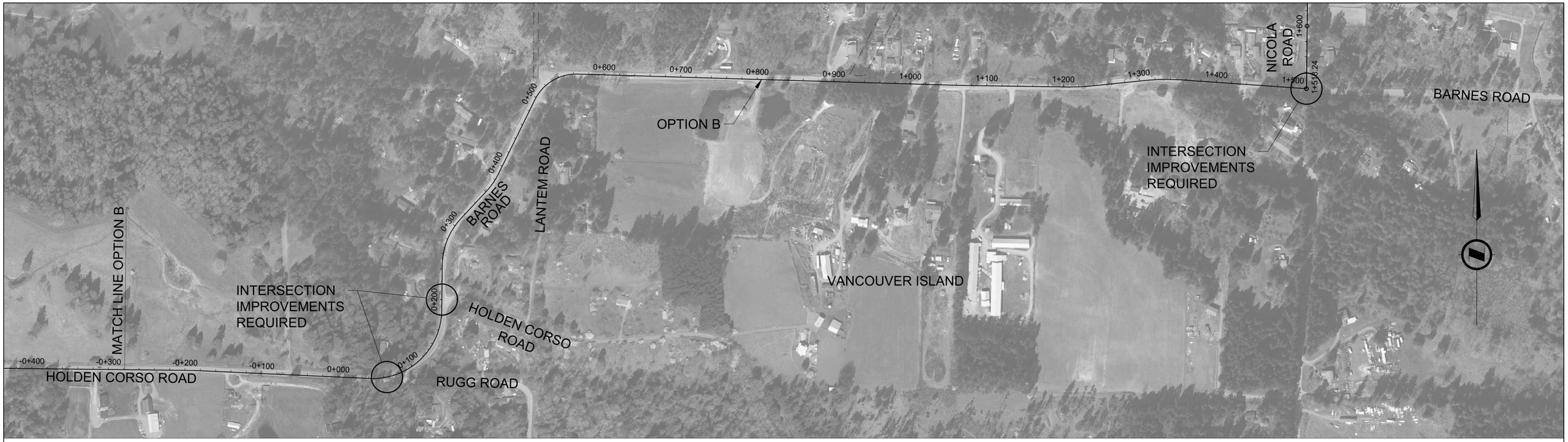

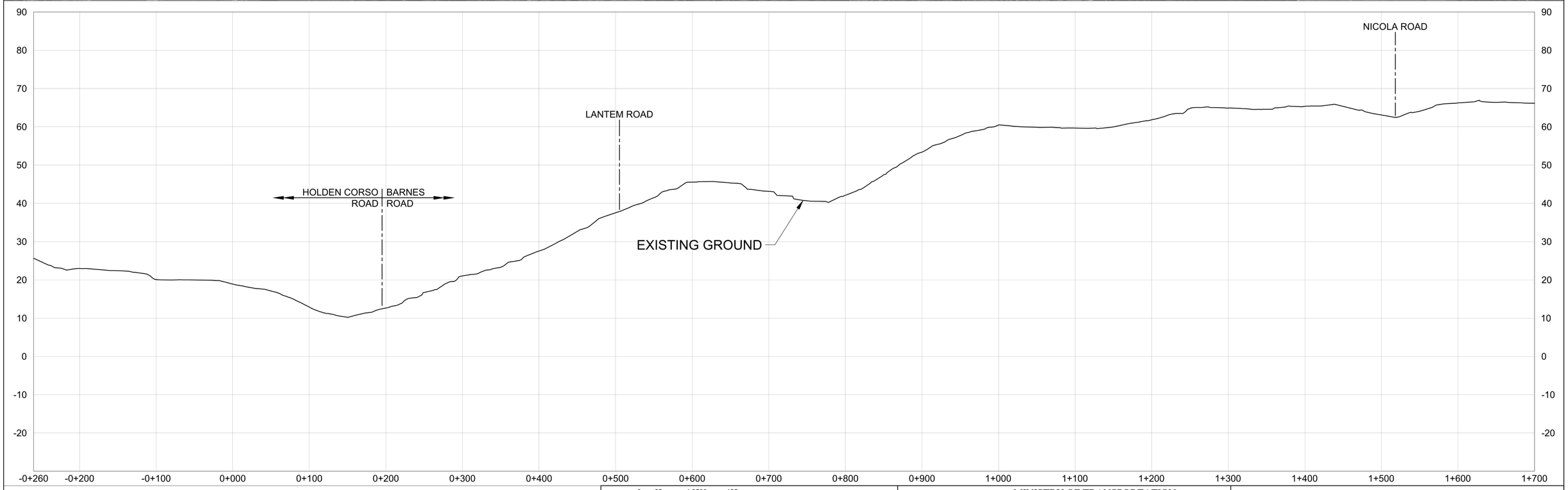

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PLAN AND PROFILE

GABRIOLA ISLAND STUDY

ROAD OPTION B - SHEET 2

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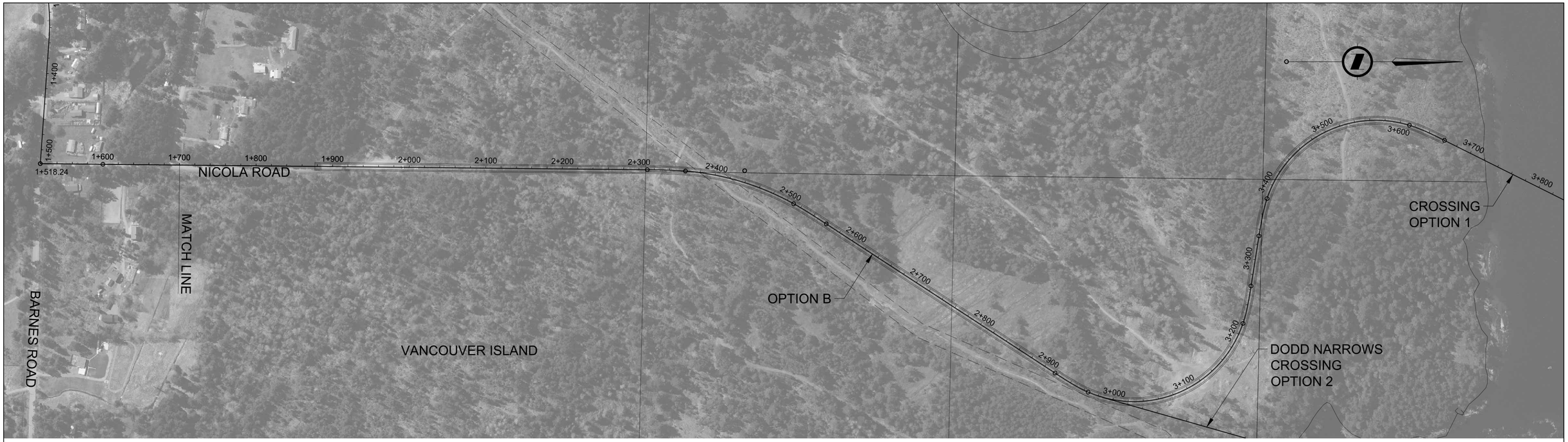

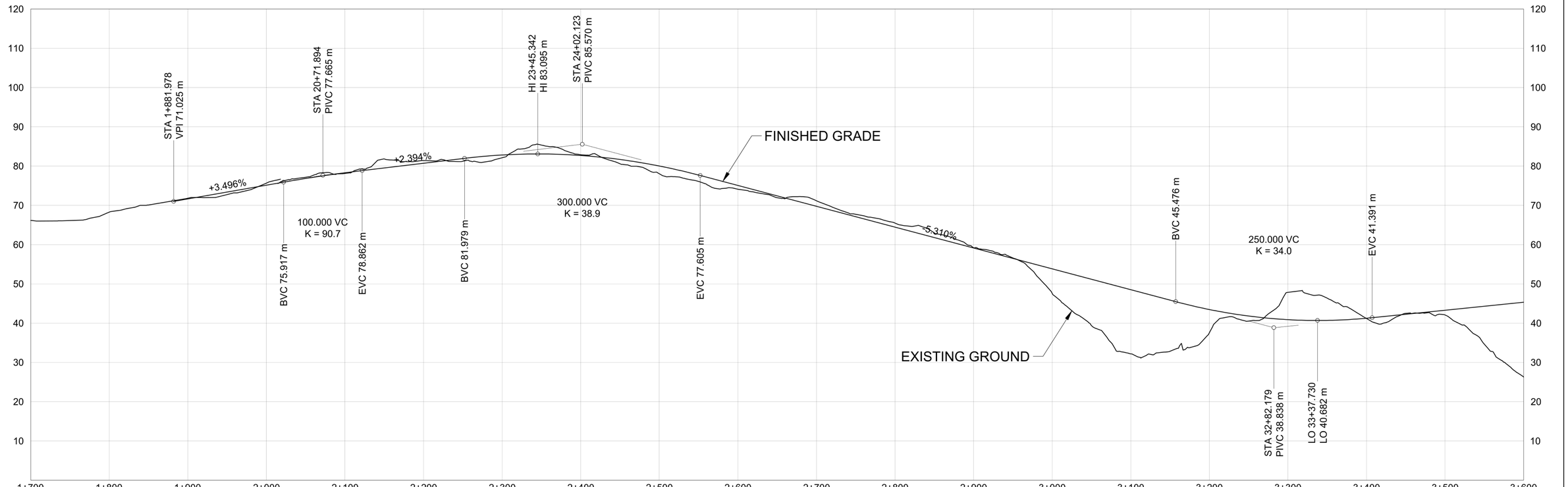

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PLAN AND PROFILE

GABRIOLA ISLAND STUDY
ROAD OPTION B - SHEET 3

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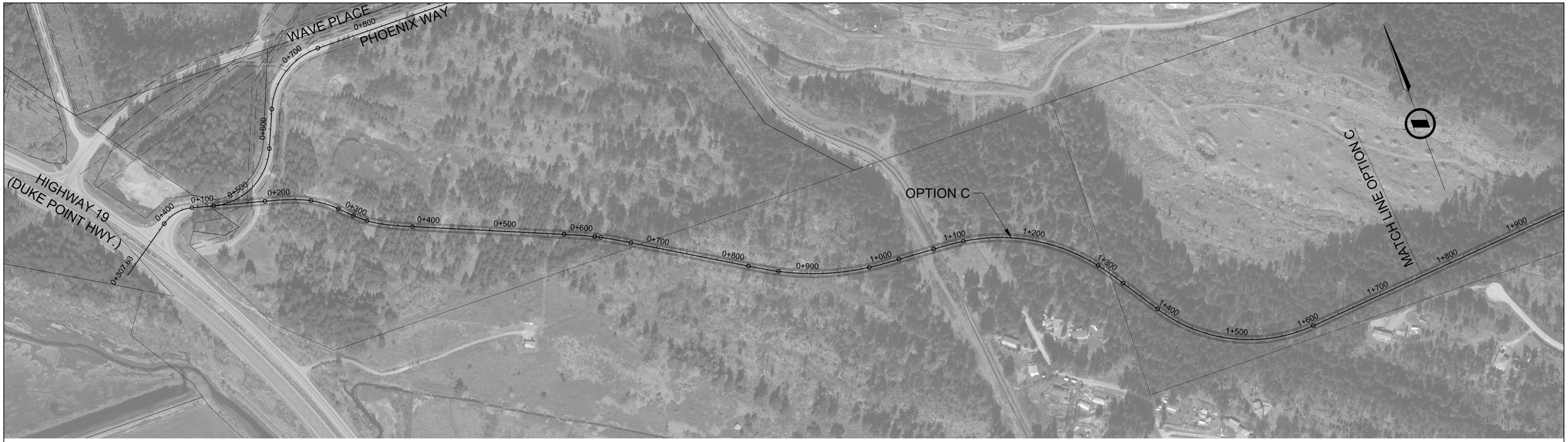

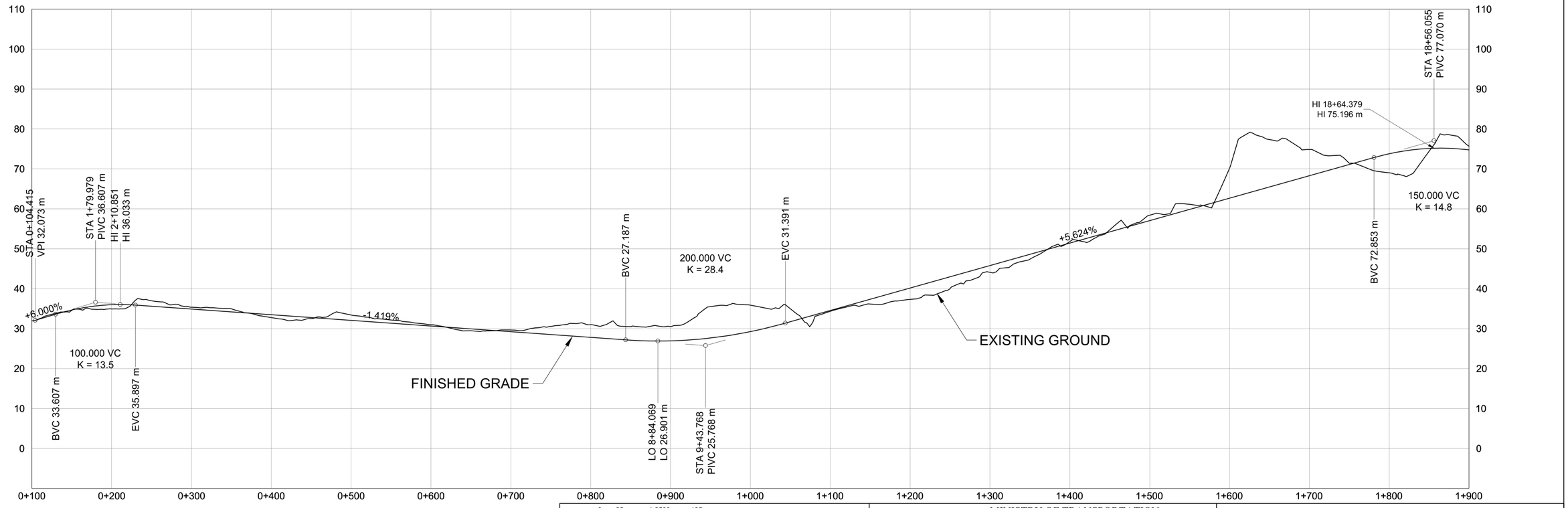

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PLAN AND PROFILE
GABRIOLA ISLAND STUDY
ROAD OPTION C - SHEET 1

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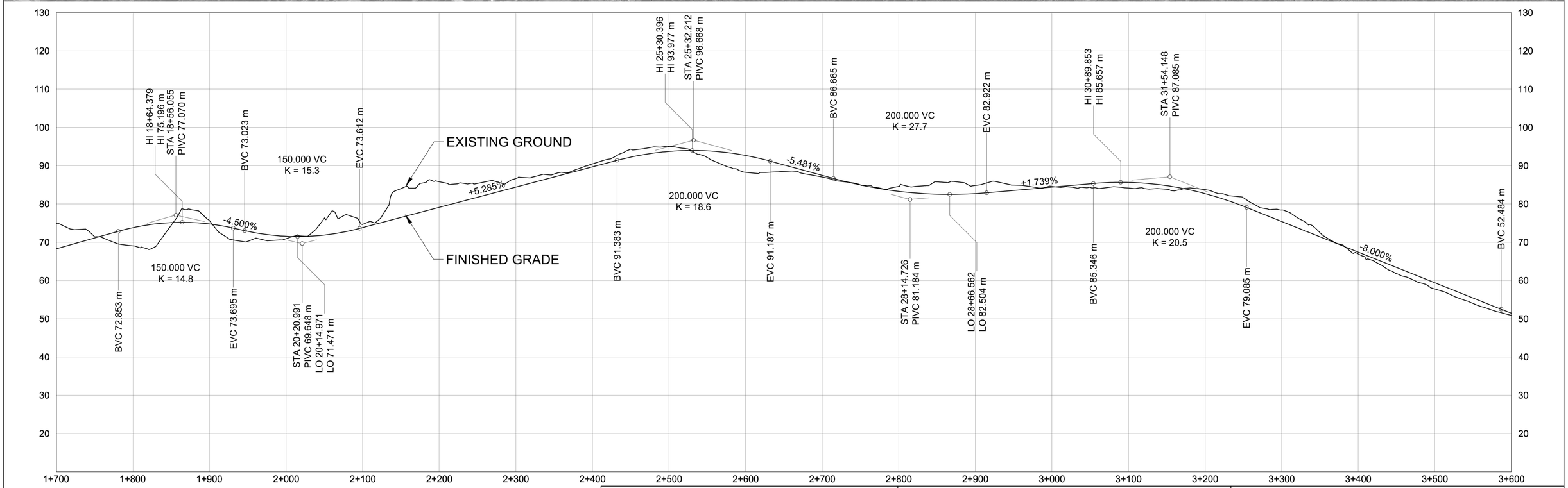

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GABRIOLA ISLAND STUDY
ROAD OPTION C - SHEET 2

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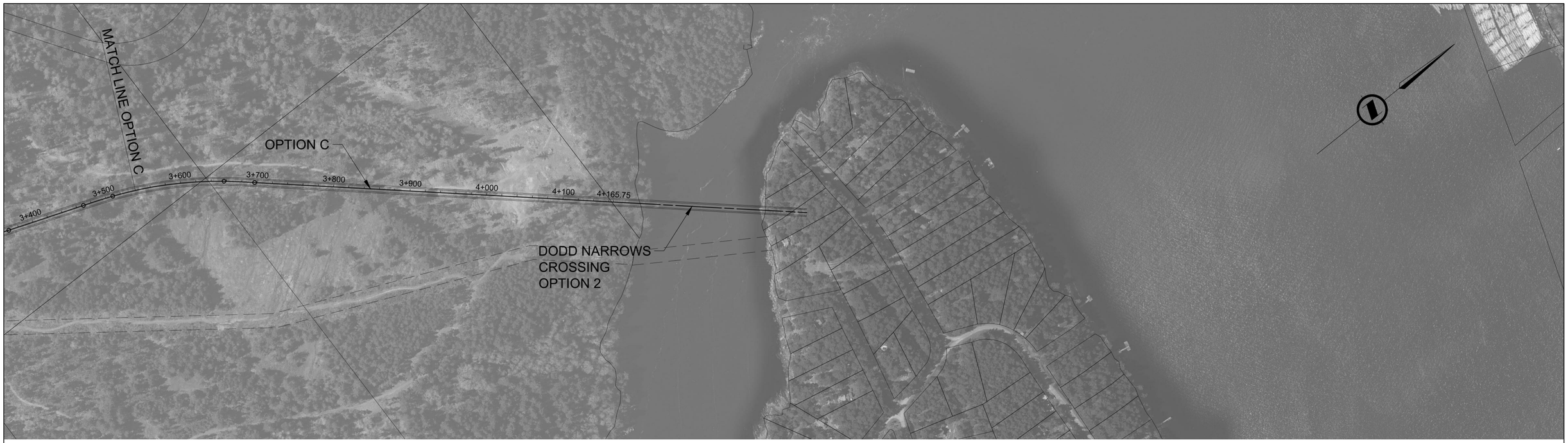

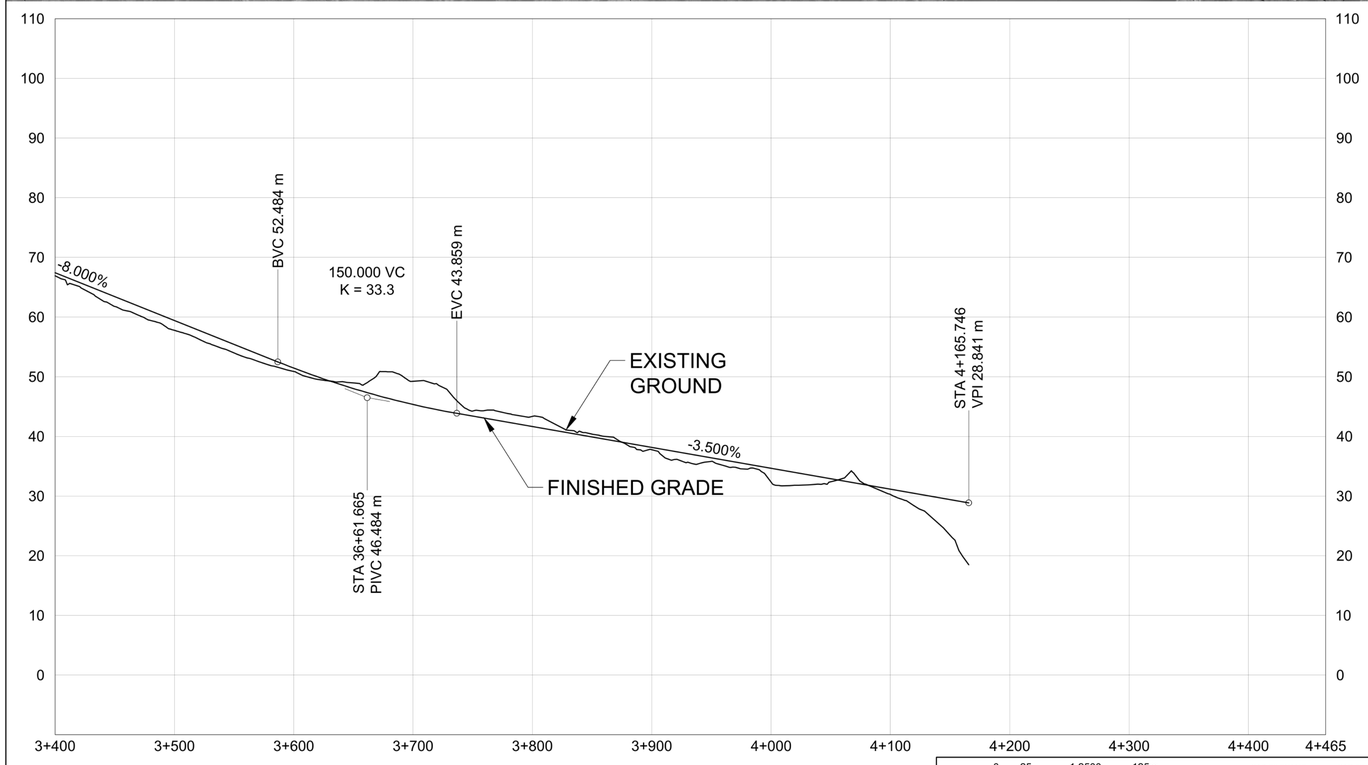

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PLAN AND PROFILE

GABRIOLA ISLAND STUDY
ROAD OPTION C - SHEET 3

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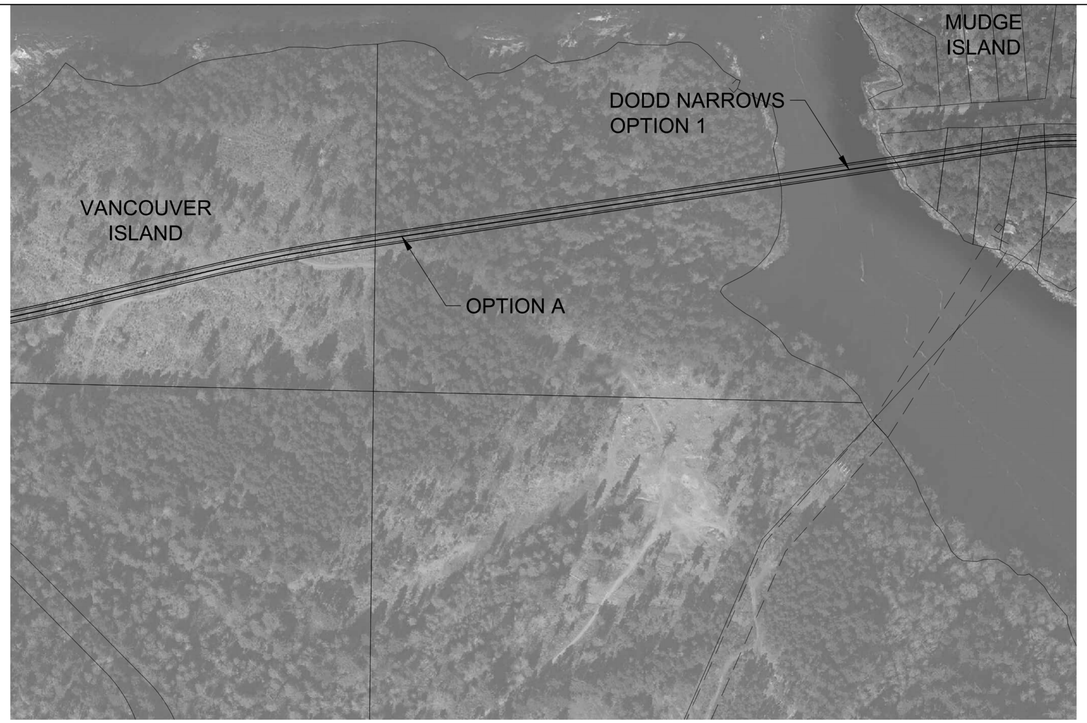

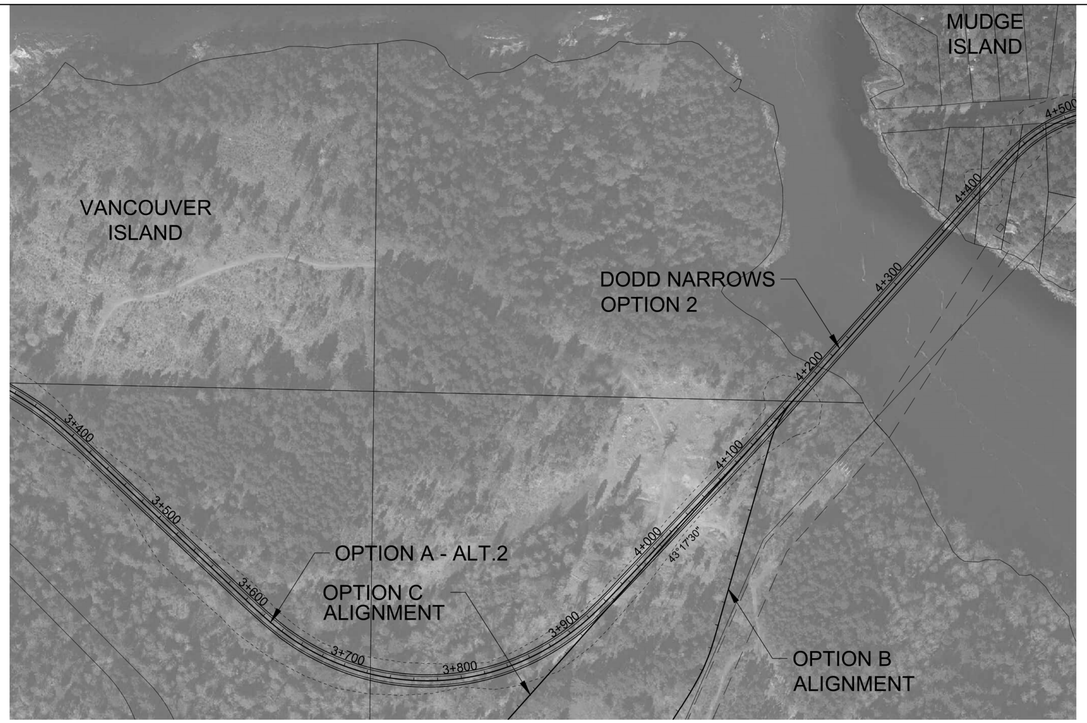

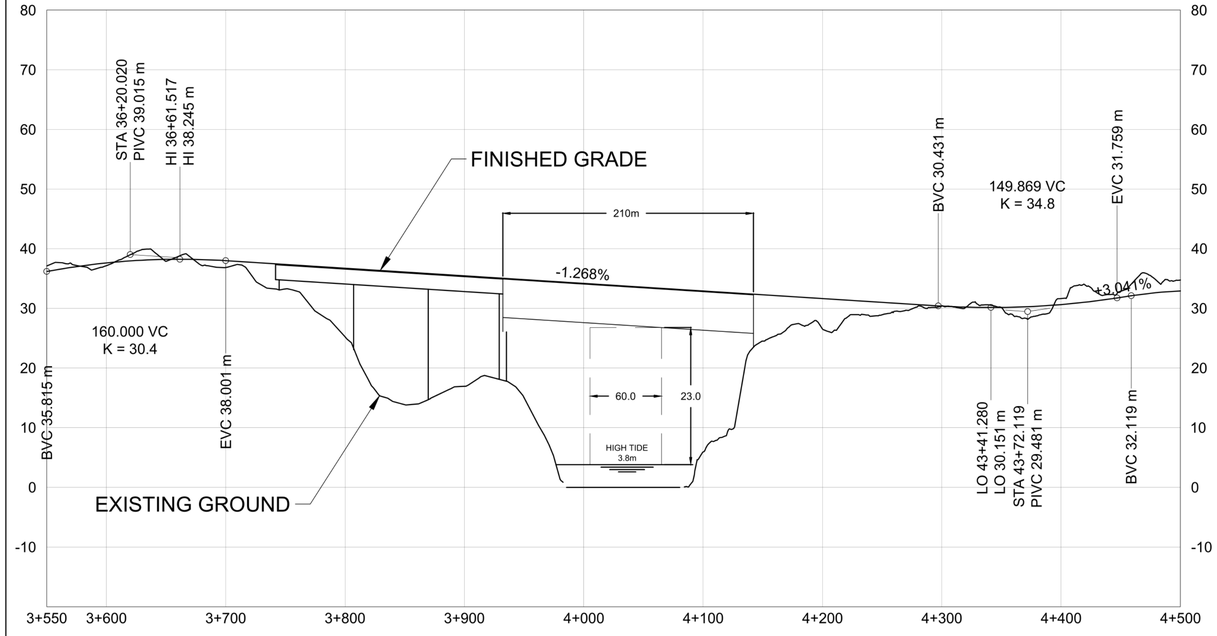

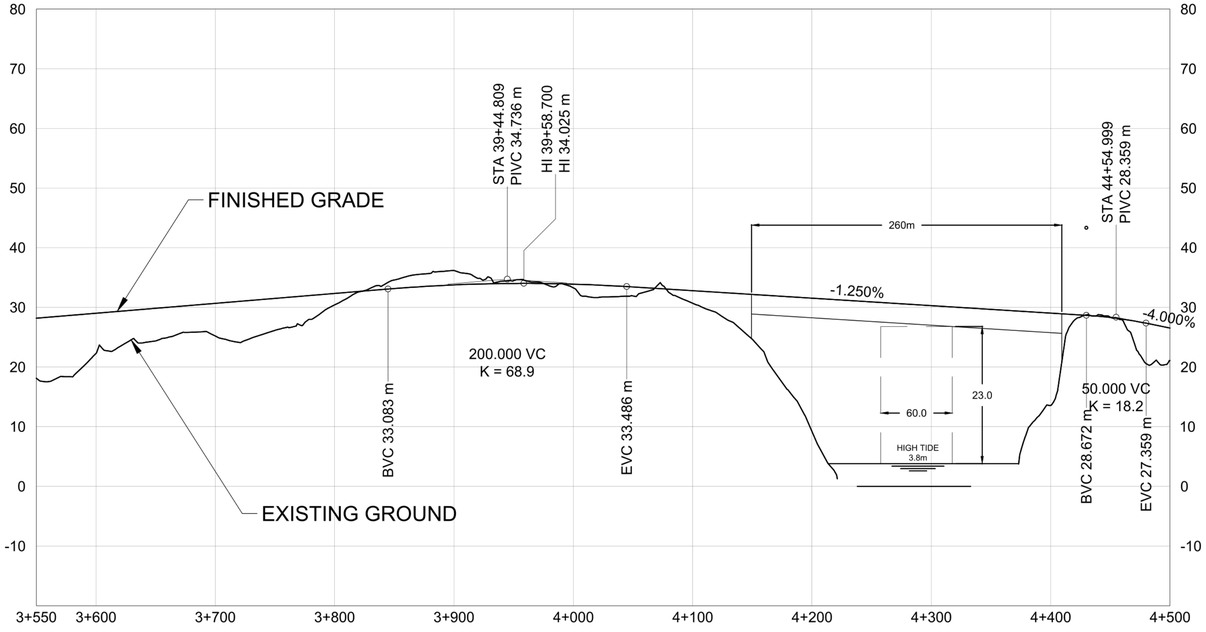

DODD NARROWS CROSSING OPTION 1

DODD NARROWS CROSSING OPTION 2

FOR ILLUSTRATIVE PURPOSES ONLY

SCALE 0 25 1:2500 125m

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DATE MARCH 2015

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PLAN AND PROFILE

GABRIOLA ISLAND STUDY
DODD NARROWS CROSSING OPTIONS

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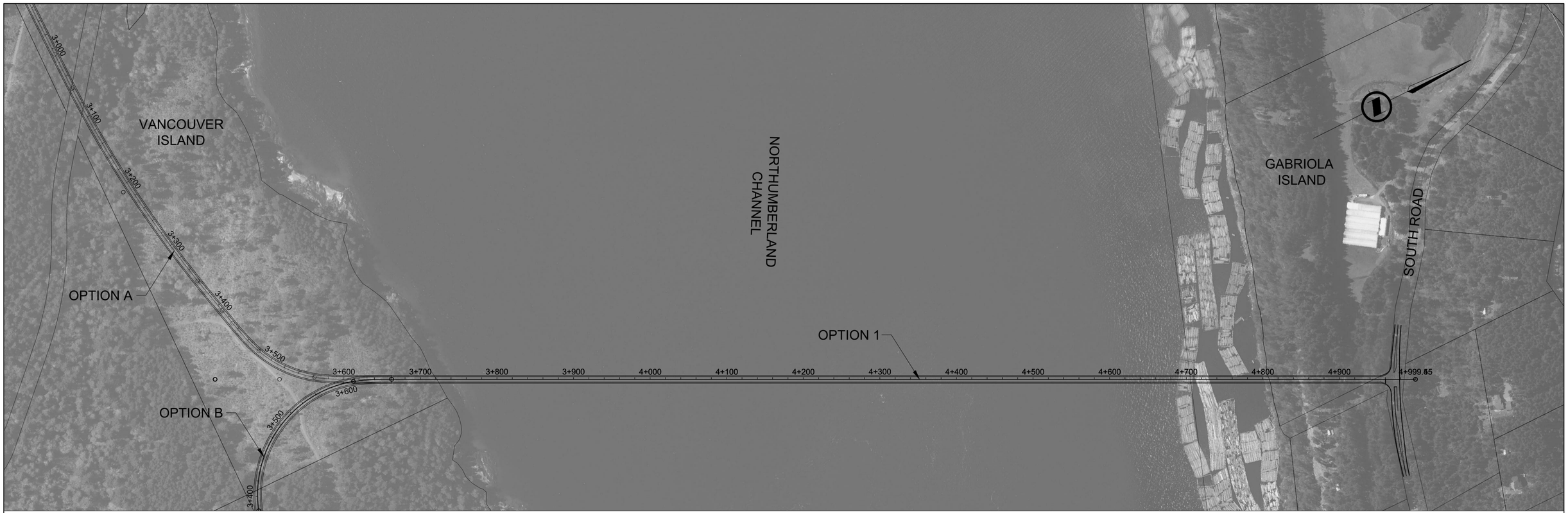

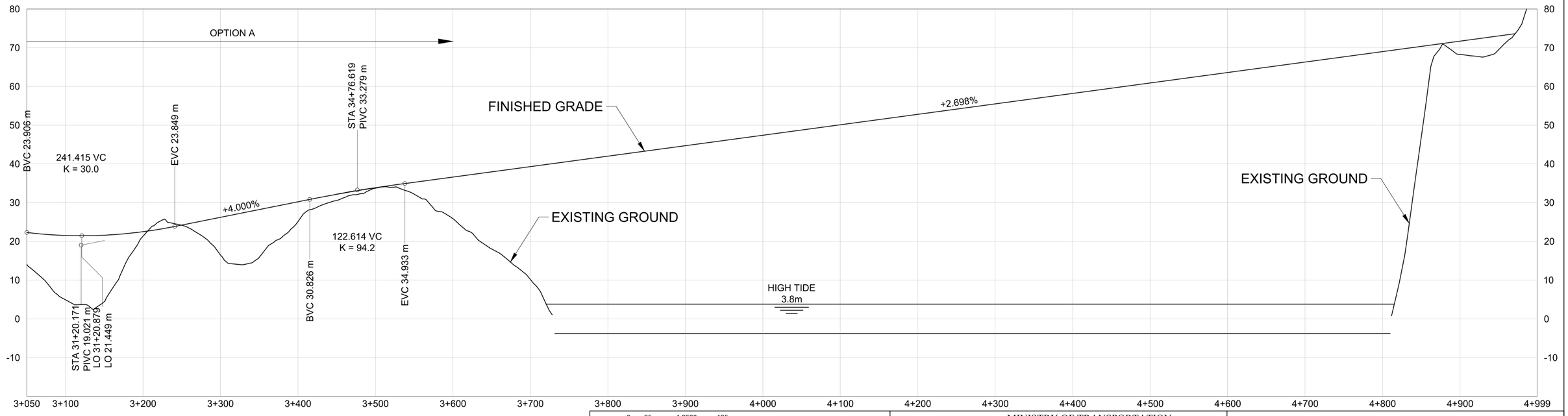

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PLAN AND PROFILE
GABRIOLA ISLAND STUDY
CROSSING OPTION 1

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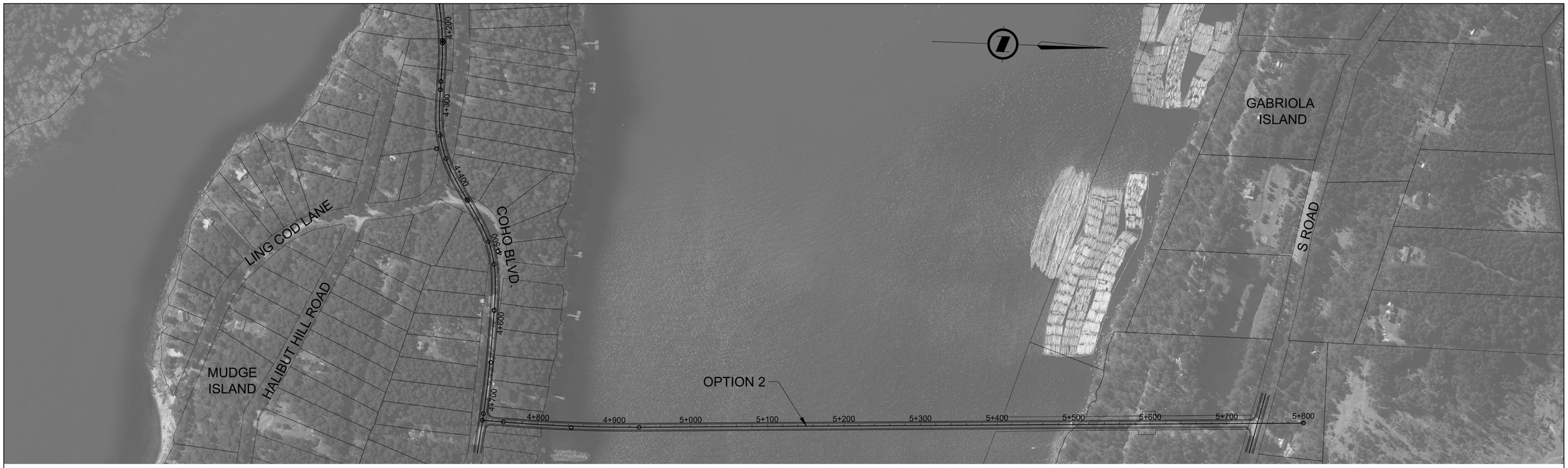

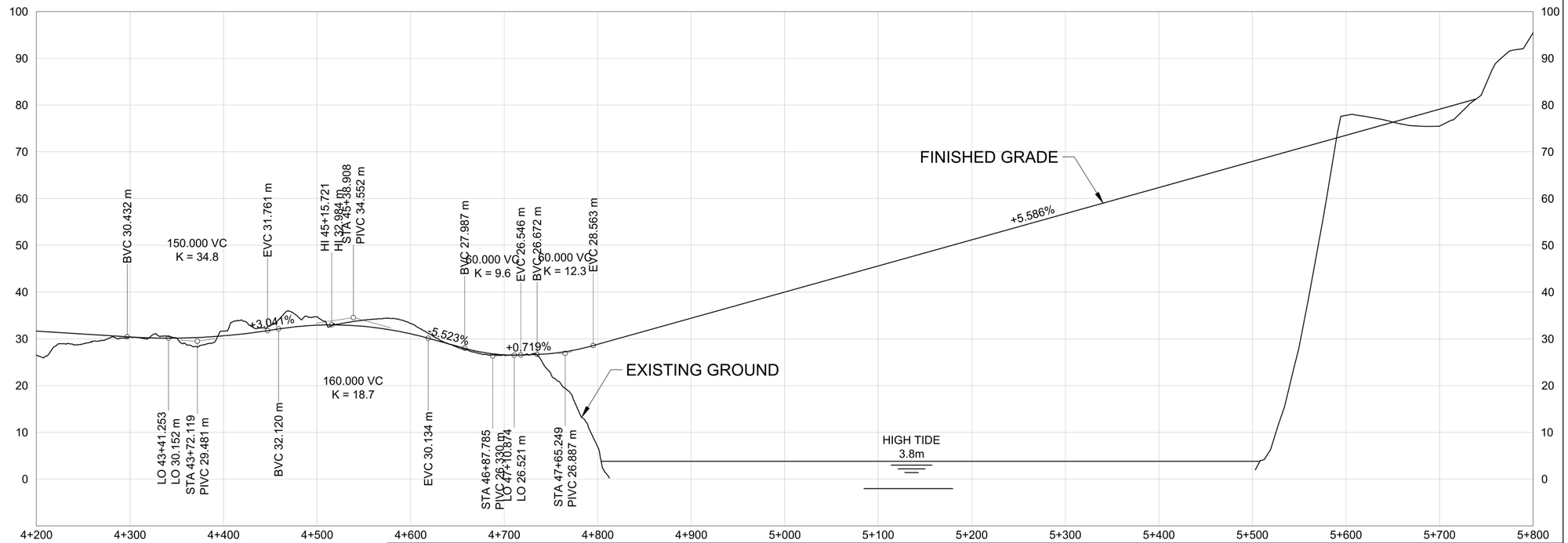

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PLAN AND PROFILE
GABRIOLA ISLAND STUDY
CROSSING OPTION 2

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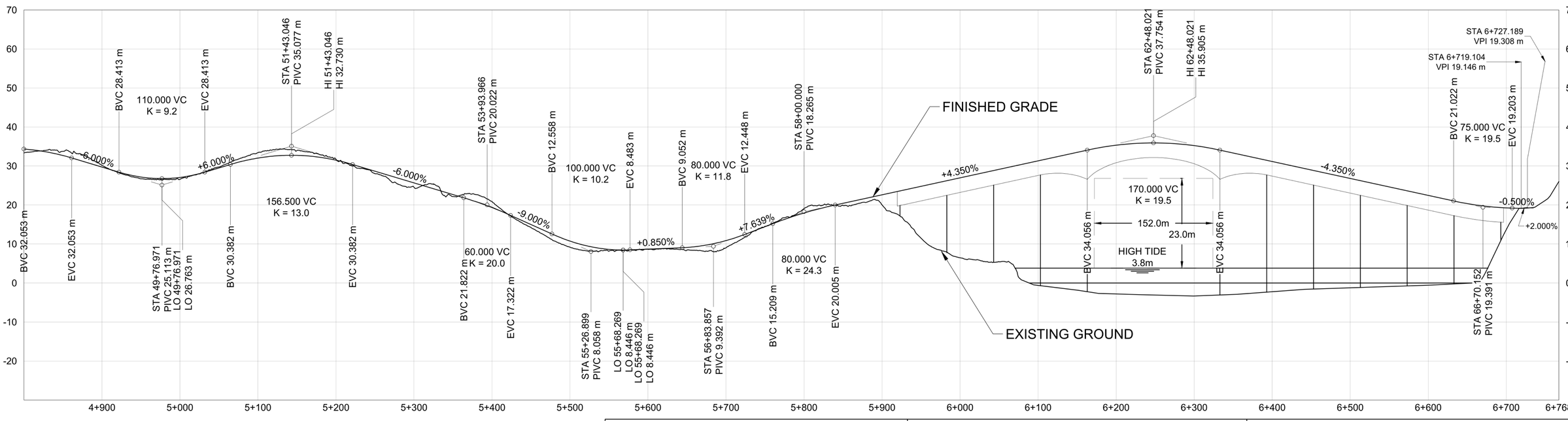

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PLAN AND PROFILE

GABRIOLA ISLAND STUDY
CROSSING OPTION 3 - HIGH PROFILE CROSSING

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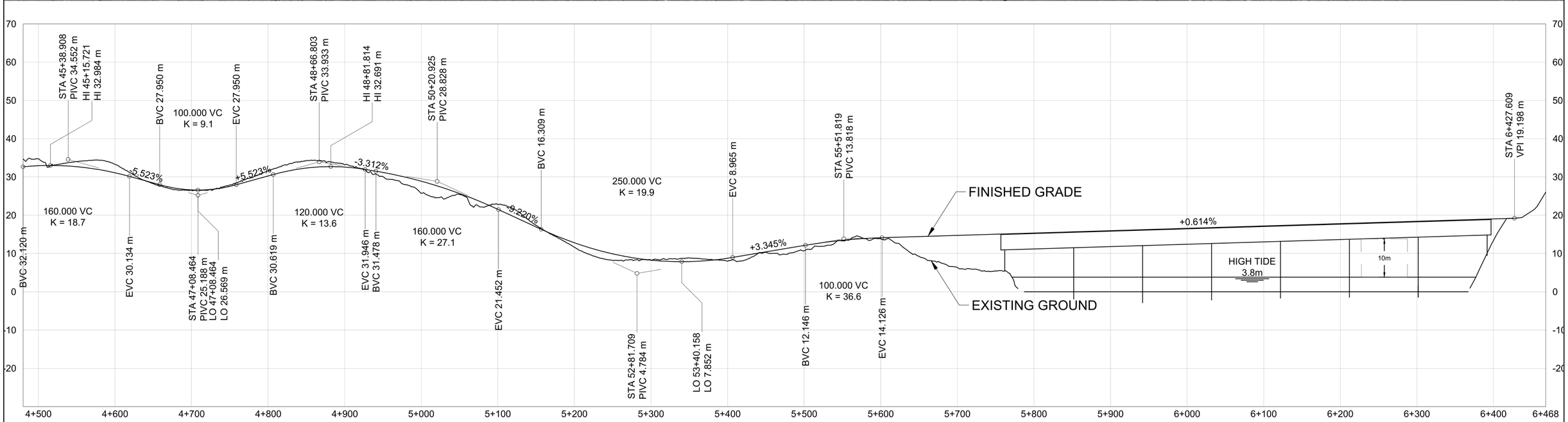

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PLAN AND PROFILE

GABRIOLA ISLAND STUDY

CROSSING OPTION 3 - LOW PROFILE CROSSING

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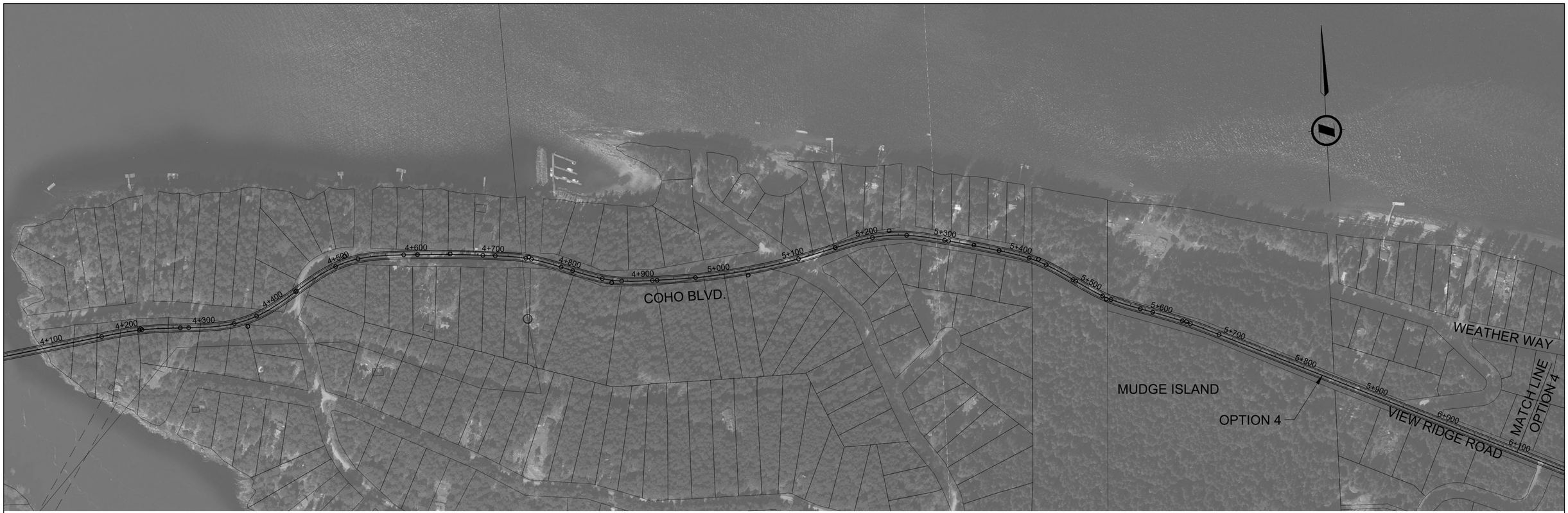

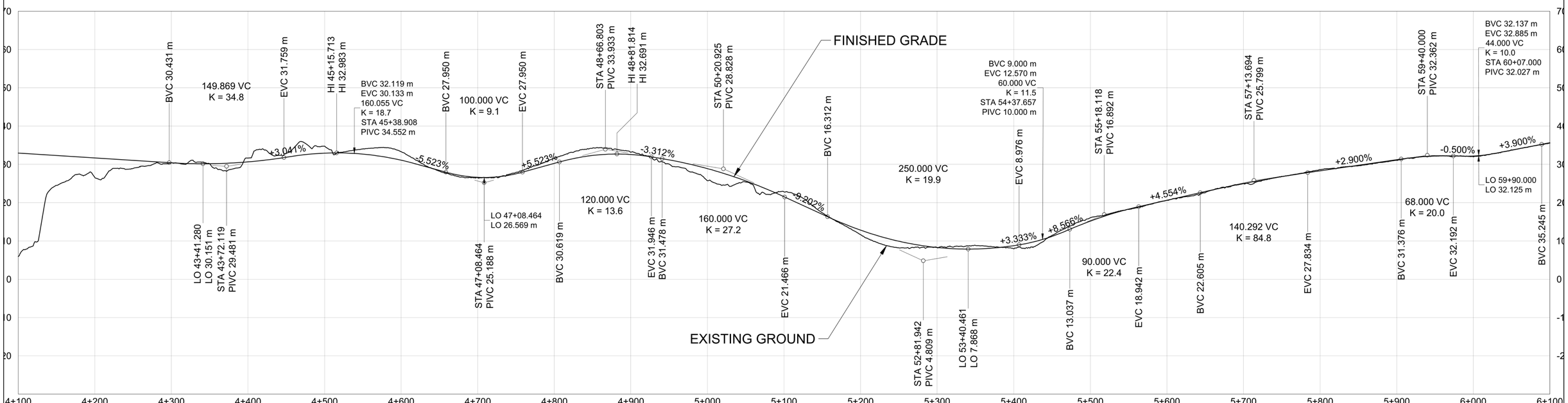

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PLAN AND PROFILE
GABRIOLA ISLAND STUDY
CROSSING OPTION 4 - SHEET 1

FILE NUMBER	PROJECT NUMBER	REG	DRAWING NUMBER	REV
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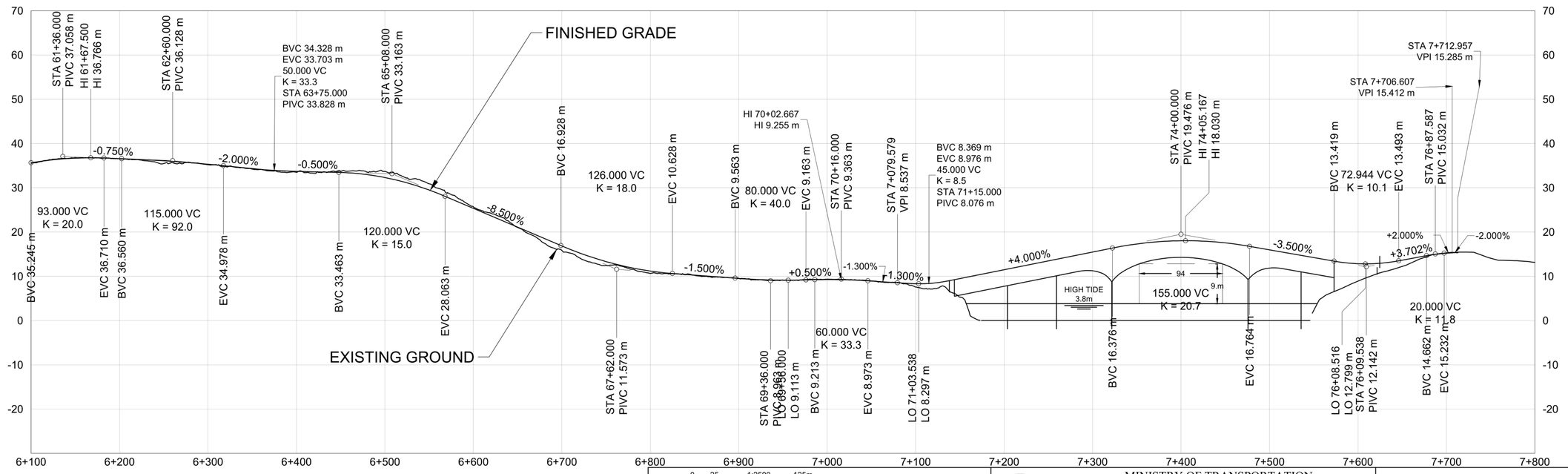

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DATE MARCH 2015

REV	DATE	REVISIONS	SIGNATURE

SENIOR DESIGNER

DATE YYYY-MM-DD

BRITISH COLUMBIA

MINISTRY OF TRANSPORTATION AND INFRASTRUCTURE

HEADQUARTERS

HIGHWAY ENGINEERING AND GEOMATICS

DESIGNED DESIGNED BY DATE YYYY-MM-DD

QUALITY CONTROL QC BY DATE YYYY-MM-DD

QUALITY ASSURANCE QA BY DATE YYYY-MM-DD

DRAWN DRAWN BY DATE YYYY-MM-DD

PLAN AND PROFILE

GABRIOLA ISLAND STUDY

CROSSING OPTION 4 - SHEET 2

FILE NUMBER	PROJECT NUMBER	REG	DRAWING NUMBER	REV
			17	

APPENDIX B
GEOTECHNICAL ASSESSMENT

THURBER ENGINEERING LTD.

April 24, 2015 File: 17-834-185

CH2M HILL
Metrotower II, Suite 2100, 4720 KIngsway
Burnaby, BC V5H 4N2

Attention: Bernard Abelson, P.Eng.
Project Engineer

GABRIOLA FIXED LINK FEASIBILITY STUDY
GEOTECHNICAL INPUT

Dear Bernard:

As requested, Thurber Engineering Ltd. (Thurber) has completed a site reconnaissance and desktop study for the Gabriola Fixed Link Feasibility Study. This letter summarizes the results of the site reconnaissance and desktop study, and provides preliminary geotechnical recommendations to aid the conceptual design. Recommendations in this report supercede those previously provided.

It is a condition of this letter that Thurber's performance of its professional services is subject to the attached Statement of Limitations and Conditions (SoLC). As noted in Item 4 of the SoLC, the report was prepared for the Client (CH2M Hill). Thurber also appoints the other members of the CH2M Hill design team and the Ministry of Transportation and Infrastructure (MoTI) as approved users of the report as described in Item 4 of the SoLC.

1. INTRODUCTION

We understand that MoTI requires an updated assessment of the technical feasibility of constructing a fixed link to Gabriola Island. The intent of the fixed link is to eliminate the requirement for a ferry connection to Vancouver Island. Previous studies, completed in 1972 and 1993 when new ferry terminals were being considered at the south end of Gabriola Island, contemplated bridges over Dodd Narrows and False Narrows to connect to the Island Highway and now to Duke Point Highway south of the former Harmac facility.

Four crossing alternatives (Options 1 to 4) are under consideration to connect South Road on Gabriola Island to Vancouver Island south of Nanaimo as shown on MoTI Dwgs. 1 to 17 and Thurber Dwgs. 17-834-185-1 to -4 (attached). Option 1 includes a single bridge crossing of Northumberland Channel from Vancouver to Gabriola Island whereas the remaining three options include a short bridge over Dodd Narrows to Mudge Island and with Option 2 crossing Northumberland Channel west of Percy Anchorage, Option 3 crossing Percy Anchorage and Option 4 crossing the east end of False Narrows.

The selected crossing would tie into one of three alignment alternatives (Options A to C) on Vancouver Island that would connect to Duke Point Highway. Alignment alternative Option A

would connect to Phoenix Way near Harmac, Option B to Nicola, Barnes and Holden Corso Roads and Option C would be a new alignment tying into the intersection of Phoenix Way and Duke Point Highway. Locally cuts and fills exceeding 10 m are anticipated.

Our scope of work in this phase of the project is to complete a desktop study and prepare a brief report summarizing the general geotechnical conditions along the contemplated alignments, identifying potential geotechnical-related risks for design and construction of the roadway, bridges and approaches, and to provide preliminary recommendations to mitigate such risks based on available existing geotechnical information.

2. BACKGROUND INFORMATION

Available information is limited to surficial and bedrock geology. Information sources are summarized below.

1. Surficial geology, Map 27-1963, Sheet 92 G/4 and 92 F/1 East, Geological Survey of Canada.
2. Surficial geology and shaded seafloor relief, Naniamo, British Columbia, Geological Survey of Canada, Map 2118A.
3. BC Ministry of Energy and Mines Geological Survey Branch Open File 1998-07 Geology of the Naniamo Coal Field, British Columbia, NTS 92G/4.
4. Doe, N.A. 2000. Sandstone and Shale – Gabriola's origins, SHALE 1, pp. 26-35.
5. BC Ministry of Environment, Water Stewardship, Ground Water Resources of British Columbia, Chapter 9 — Ground Water Resources of the Basins, Lowlands and Plains, Section 9.1.2 Naniamo and Georgia Lowlands.
6. Salish Sea Pilot, A Cruiser`s Guide to Anchorages & Marinas, 2014, 82 pages.

For discussion purposes, we refer to the document numbers listed above.

3. PROGRAM OF WORK

Thurber conducted a site reconnaissance of the Vancouver Island portion of the alignment on Novemer 27, 2014 and completed a desktop study in preparation of this report.

4. FINDINGS

4.1 Site Reconnaissance

The general area was visually assessed by automobile followed by a hike into Joan Point at Dodd Narrows via the Cable Bay Trail system accessed from Nicola Road. During the hike to Joan Point, generally undulating terrain with frequent bedrock exposures were observed. Depending on where the alignment crosses the creek that drains into Cable Bay, a small bridge may be required. Photo 1 shows the rock at Joan Point and Photo 2 shows the gently dipping rock at Purvis Point on Mudge Island.

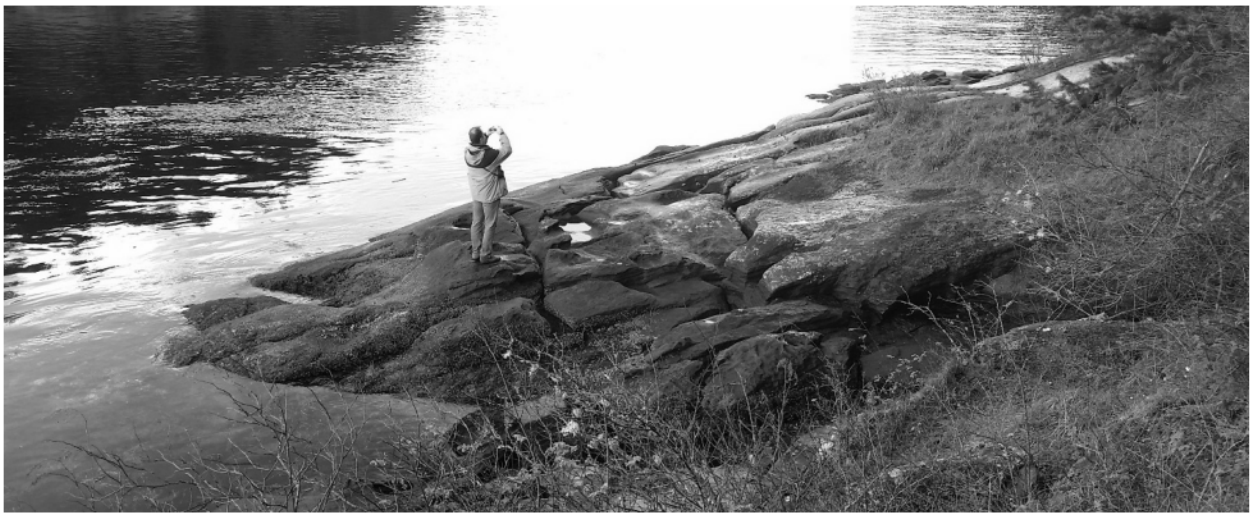


Photo 1. Sandstone exposure at Joan Point.

Photo 2. Bedrock exposure at Purvis Point on Mudge Island. Note that an existing road ties into the mossy area in the photo.

4.2 Surficial Geology

As described in "The geology of Southern Vancouver Island, A field guide" by C.J. Yorath and H.W. Nasmith, 1995, "Southeastern Vancouver Island and the Gulf Islands are largely composed of sedimentary rocks deposited during the latter stages of the cretaceous period between eighty-five and sixty-five million years ago. These strata are included in the Nanaimo Group, which is divided into nine formations consisting of various combinations of conglomerate, sandstone, siltstone, shale and coal. In the Nanaimo area these strata are horizontal or very gently dipping; however, in the Gulf Islands they have been formed into a series of northwesterly trending folds and thrust faults."

Dwgs. 17-834-185-1, -2, -3 and -4 show the various alignments superimposed on maps excerpted from Documents 1, 2, 3 and 4, respectively. As shown on Dwg. 17-834-185-1, the surficial

geology of the area generally consists of marine veneer over bedrock, with the exception of the thick fluvial deposits associated with the Nanaimo river delta. Information on the drawing suggests that foundation conditions along the alignments are anticipated to consist primarily of relatively thin overburden deposits overlying bedrock and that, in lowland areas, thicker deposits of soft, fine grained deposits may be present.

Only limited submarine geotechnical information is available for the crossings alignments as shown on Dwgs. 17-834-185-1, -2 and -3 and in Document 6. Dodd Narrows is a relatively deep, navigation channel and will likely require an elevated structure that completely spans the channel. However, Percy Anchorage is up to about 24 m deep and, as indicated in Document 6, is underlain by recent deposits comprised of gravel and mud. False Narrows is relatively shallow and may be underlain by recent soil deposits. We also infer that portions of Northumberland Channel are likely underlain by recent soil deposits.

5. ENGINEERING ASSESSMENT AND PRELIMINARY RECOMMENDATIONS

5.1 General

This section summarizes the results of our desktop study and site reconnaissance. For conceptual design purposes, we have assumed that the bridge crossings will be designed in general accordance with CAN/CSA S6-06, which contemplates a 1:475 year design earthquake, and that the proposed structures will be supported on pile foundations. Conceptual recommendations for design of rock cuts and embankment construction are based on our experience with similar site conditions.

5.2 Seismic Design

5.2.1 Site Response Spectrum

Natural Resources Canada's seismic hazards calculation website was used to predict peak firm ground accelerations equal to 0.273g for the 1 in 475 year earthquake (10% probability of exceedance in 50 years). The 2010 National Building Code Seismic Hazard Calculation out for the site is attached. Based on the findings of our desktop study and site reconnaissance, the site condition for upland bridge foundations is classified as Soil Profile Type I following the CAN/CSA-S6-06 bridge code. The corresponding Site Coefficient (S) per Table 4.4 is 1.0. For marine foundations, it will be necessary to determine the nature and thickness of overburden present.

5.2.2 Seismic Liquefaction

Where present, recent deposits in Northumberland Channel, Percy Anchorage and False Narrows will likely be susceptible to seismic liquefaction. The nature and thickness of these deposits will have to be determined in the next phase of the work to assess the potential impacts to foundation

design. For conceptual design purposes, it should be assumed that all structural loads will be transferred to bedrock.

5.3 Bridge Foundations

Bridge foundations for the various crossings will likely require rock socketed piles. Depending on seismic load requirements, pile embedment length may be controlled by lateral fixity requirements rather than vertical compression resistance requirements. Construction of rock socketed piles typically requires advancing steel casings by drilling techniques to the bedrock surface with a socket formed below. After clean out, reinforcing steel is placed and then the socket and pile casing filled with concrete. All load transfer is typically assumed to be from concrete to rock in shear along the socket length.

The design bond stress between the concrete and the walls of the socket will be a function of the concrete compressive strength, rock strength, and degree of fracturing. We expect that it will be difficult to advance the steel casing sufficiently far into the rock to effect a total cutoff of seepage into the hole. As such, we suggest that the design and construction anticipate water seepage into the socket. This will require maintaining water in the casing and placement of concrete using good tremie techniques.

Rock socket design should anticipate weathering, fracturing, sloping rock conditions and the usual challenges of cleaning from the base of the socket. Further, if it is apparent during installation that the rock slope is steep, that there is a considerable amount of muck that cannot be cleaned from the socket, or that the concrete will be contaminated for one reason or another, then the socket should be lengthened accordingly.

Very high loads are typically attainable with socketed caissons. Typically, the full structural resistance of a pile sections can be developed. The uplift resistance on socketed piles is governed by fracture in the rock mass and not simply by the bond length. Generally, the full uplift resistance can be developed, but the socket length is partially a factor of the proximity of other piles and must be reviewed during detailed design.

Inspection of the rock socket construction during drilling and after completion of the drilling is important to confirm that the rock conditions are as anticipated, that the sidewalls of the rock socket have been adequately cleaned, and that the required length of the socket has been obtained. The need to increase the socket length due to steeply sloping rock or inadequate cleaning of the base of the socket can only be made by an experienced inspector. For relatively shallow and dry installations, the visual inspection of the completed socket can be made using a lamp and or mirror. Deeper installations, or shallow installations where significant groundwater seepage is occurring, typically require inspection using an underwater colour camera.

5.4 Bedrock Cuts

5.4.1 Rock Cut Slope Angle

We have reviewed the regional bedrock geology mapping shown on Dwgs. 17-834-185-3 and -4 and information from our files for the Duke Point Ferry Access road to develop preliminary recommendations for the conceptual design. The following assessment is not based on any site specific observations and should be considered general only. We have not been provided with details such as rock cut heights, cut slope orientations or previous studies by others. A specific bedrock mapping program will be necessary to confirm our assumptions and finalize the rock cut geometry.

The Decourcy and Gabriola Sandstone units are anticipated to consist of medium grained, massive to blocky, medium strong to strong rock. Bedding is anticipated to be the predominant discontinuity set with orthogonal secondary and tertiary jointing. The bedding is typically relatively flat lying (<20° dip) and dips of about 75° to 90° are anticipated for the orthogonal joint sets.

The design rock cut slope angle geometry attempts to balance the excavation volume and construction footprint versus the potential for kinematic instability (due to wedges, daylighting planes and toppling) and the need for stabilization. We recommend using rock cut slope angles of 0.25H:1V for conceptual design. Flatter slopes may be required if the regional jointing in the sandstone is steeper than about 30° or in zones of weaker rock types such as shale, siltstone or coal (if encountered).

It should be assumed that higher cut slopes (i.e. greater than 10 m) will likely require scaling and some rock bolting to stabilize potential daylighting planar blocks and wedges. In addition, localized shotcrete and steel mesh may also be required in more fractured or weathered areas.

5.4.2 Rock Cut Slope Catchment Ditch Design

Typically, the minimum rockfall catchment ditch width design is based on the following documents:

- “MoTI Technical Bulletin GM02001 (Rock Slope Design)” dated September 17, 2002
- “Rockfall Containment for Rock Cuts Highway 99 – Horseshoe Bay to Whistler”, submitted to MoT by Wyllie & Norrish Rock Engineers in October 2002
- “Evaluation of Rockfall and Its Control.” by Ritchie in 1963, “Discussion on Rockfall Protection Measures” by P.G.D. Whiteside in 1986
- “Rockfall Catchment Design Guide” for Oregon Department of Transportation in 2001.

For conceptual planning purposes, the MoTI Technical Bulletin GM02001 provides a description of catchment ditch geometry and a table of preliminary catchment widths based on slope height. The recommended catchment widths in the MoTI document may require modification during detailed design based on the results of the investigation, analysis and construction geometry.

All rock slopes should be constructed in accordance with standard MoTI practice that includes smooth wall controlled blasting techniques (pre-shearing), rock scaling and spot rock bolting.

5.4.3 Soil Cuts above Bedrock Cut Slopes

In locations where overburden will be encountered at the top of rock cut slopes, an assessment will be required to determine the appropriate slope angle. If topography limits the height of the slope, we expect that it will likely be feasible to cut the material to slopes of between 1.5H:1V to 2H:1V. The standard MoTI design section also requires a 3 m wide horizontal bench between the top of rock cut and the toe of the soil cut above.

Where thin overburden soils combined with steep slopes are encountered above the top of bedrock cuts, very high sliver cuts can be required in the overburden unless a retaining wall is constructed above the bedrock cut or an anchored mesh system such as Tecco Mesh is used to retain the soil.

5.4.4 Coal Mines

The greater Nanaimo area is known for the presence of coal mines that were excavated in the 1800s and early 1900s. Our cursory review of the mine records database suggests that there are no recorded mines in the vicinity of this project. However, it should be noted that there is potential for undocumented mines to exist in this area and any future design should consider the possibility of coal mine existence.

5.4.5 Metal Leaching and Acid Rock Drainage (ML-ARD)

Although we are not currently aware of any significant ML-ARD issues in the Nanaimo area, MoTI standard practice requires a screening level assessment is completed for all bedrock excavations that exceed 1000 m^3 of material in accordance with Technical Circular T04/13. As such, an assessment will be required in the preliminary design phase of this project. In general, sandstone (the primary anticipated rock type) would be anticipated to represent a low to moderate risk of ML-ARD generation. Shale and coal deposits (if encountered) would represent a moderate risk of ML-ARD generation.

5.5 Soil Cut Slopes

Soil cut slopes in granular or till-like soils should typically be cut at a slope angle of 1.5H:1V or flatter. If fine grained soils are encountered locally, they will have to be assessed on a case by case basis.

It is important that adequate measures be provided during construction to prevent erosion of cut slopes during periods of heavy rainfall, snow melt or runoff. Erosion control measures should be implemented in accordance with the BC MoT “Manual of Control of Erosion and Shallow Slope Movement (1997)”.

Excavated slopes should be vegetated immediately following excavation. Seepage from overburden slopes may occur locally and can only be identified during excavation. Where such seepages are encountered, drainage measures should be installed. Seepage zones should be excavated to shallow depth and resloped with shotrock to match the adjacent cut slope. A geosynthetic should be placed over the overburden prior to placement of the rock fill.

5.6 Embankments

General fill construction should be carried out in accordance with the Standard Specifications for Highway Construction, Sections 201.36 and 201.37. Embankments will generally be constructed of either blast rock fill or suitable earth backfill. Where encountered, we recommend that silt and clay material not be used in embankment construction.

Fills constructed on slopes steeper than 3H:1V should be constructed with rock fill and have their toes keyed into the slope. The keys should be constructed by excavating a horizontal bench at the toe of the fill such that the fill toe has a minimum horizontal width of 5 m. If solid bedrock is encountered before the 5 m horizontal width is reached, field assessment will be required. Benching should also be done on existing slopes to create horizontal terrace widths of at least 1.5 m.

Earth embankments should generally be constructed in accordance with SS201.37. For fill materials with less than 35% material passing the No. 200 (0.075 mm) sieve, the slopes can be constructed at 1.5H:1V to 2H:1V depending on the desired level of performance. Fill materials with greater than 35% material passing the No. 200 (0.075 mm) sieve will need to be constructed with 2H:1V or flatter slopes.

Blast rock embankments can typically be constructed at 1.5H:1V slopes. In some locations it may be preferable to use steeper slopes to fit the existing topography. These locations will have to be assessed on a case by case basis.

6. SUPPLEMENTARY WORK DURING PRELIMINARY DESIGN

Once a preferred alignment has been selected, we recommend that a detailed marine investigation be undertaken. The investigation should include detailed bathymetry, seismic profiling and test hole drilling at select locations to determine the nature and thickness of overburden and sufficient information regarding the nature and quality of the bedrock for design of rock sockets.

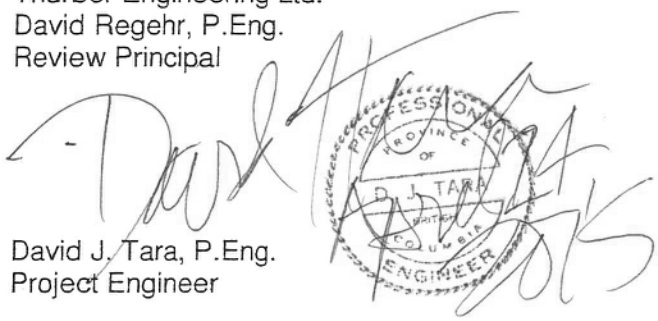
7. CONCLUSIONS

Based on the findings of our assessment, we consider the project to be technically feasible from a geotechnical perspective. Further, we believe that all technical issues identified in this report can be addressed during the design and construction stages of the fixed link project.

THURBER

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



David J. Tara, P.Eng.
Project Engineer

Attachment: Statement of Limitations and Conditions
Dwg. 17-834-185-1 Surficial Geology
Dwg. 17-834-185-2 Sea Floor Geology
Dwg. 17-834-185-3 Bedrock Geology
Dwg. 17-834-185-4 Bedrock Geology
2010 National Building Code Seismic Hazard Calculation

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

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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.

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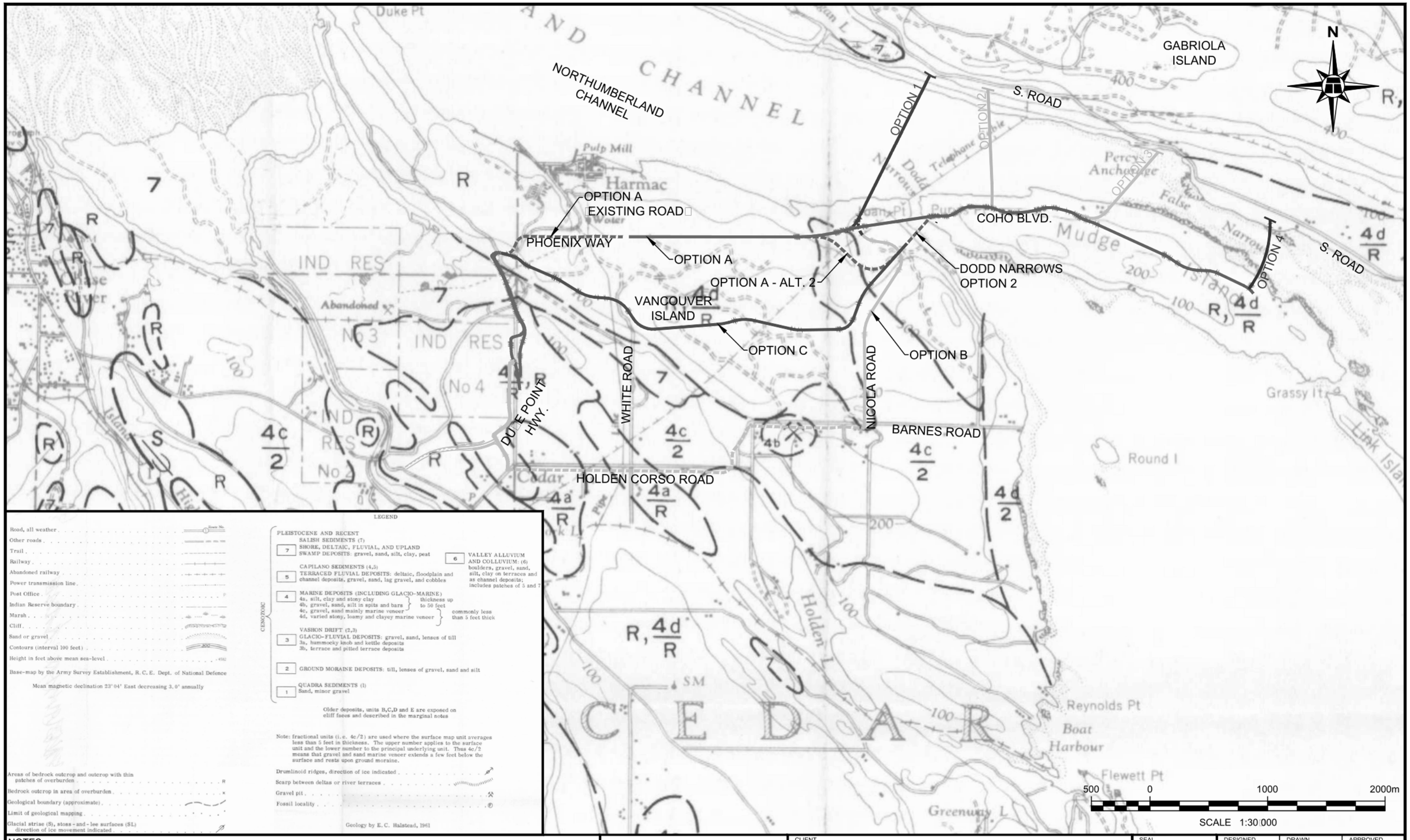

LEGEND

Road, all weather
Other roads
Trail
Railway
Abandoned railway
Power transmission line
Post Office
Indian Reserve boundary
Marsh
Cliff
Sand or gravel
Contours (interval 100 feet)
Height in feet above mean sea-level

Base-map by the Army Survey Establishment, R. C. E. Dept. of National Defence

Mean magnetic declination 23° 04' East decreasing 3.0' annually

PLEISTOCENE AND RECENT

CENOZOIC

SALISH SEDIMENTS (7)

7 SHORE, DELTAIC, FLUVIAL, AND UPLAND SWAMP DEPOSITS: gravel, sand, silt, clay, peat

CAPILANO SEDIMENTS (4,5)

5 TERRACED FLUVIAL DEPOSITS: deltaic, floodplain and channel deposits; gravel, sand, lag gravel, and cobbles

4 MARINE DEPOSITS (INCLUDING GLACIO-MARINE)
4a, silt, clay and stony clay } thickness up
4b, gravel, sand, silt in spits and bars } to 50 feet
4c, gravel, sand mainly marine veneer } commonly less
4d, varied stony, loamy and clayey marine veneer } than 5 feet thick

VASHON DRIFT (2,3)

3 GLACIO-FLUVIAL DEPOSITS: gravel, sand, lenses of till
3a, hummocky knob and kettle deposits
3b, terrace and pitted terrace deposits

2 GROUND MORAINE DEPOSITS: till, lenses of gravel, sand and silt

1 QUADRA SEDIMENTS (1)
Sand, minor gravel

6 VALLEY ALLUVIUM AND COLLUVIUM: (6) boulders, gravel, sand, silt, clay on terraces and as channel deposits; includes patches of 5 and 7

Older deposits, units B,C,D and E are exposed on cliff faces and described in the marginal notes

Note: fractional units (i. e. 4c/2) are used where the surface map unit averages less than 5 feet in thickness. The upper number applies to the surface unit and the lower number to the principal underlying unit. Thus 4c/2 means that gravel and sand marine veneer extends a few feet below the surface and rests upon ground moraine.

Areas of bedrock outcrop and outcrop with thin patches of overburden
Bedrock outcrop in area of overburden
Geological boundary (approximate)
Limit of geological mapping
Glacial striae (S), stoss-and-lee surfaces (SL) direction of ice movement indicated
Drumlinoid ridges, direction of ice indicated
Scarp between deltas or river terraces
Gravel pit
Fossil locality

Geology by E. C. Halstead, 1961

NOTES:

1. BASE PLAN TA□EN FROM GEOLOGICAL SURVEY OF CANADA'S MAP "27-1963" SHEET 92 G/4 AND 92 F/1 EAST.

THURBER ENGINEERING LTD.

CLIENT: CH2M HILL CANADA LTD.

SURFICIAL GEOLOGY

GABRIOLA ISLAND
FIXED LIN□ FEASIBILITY STUDY — GABRIOLA ISLAND□BC

SEAL

DESIGNED	DRAWN	APPROVED
-	NA□	DJT

DATE: APRIL 21□2015 — SCALE: AS SHOWN

PROJECT N□: 17-834-185-1 — DWG. N□: — REV.: -

CANCEL PRINTS BEARING EARLIER LETTER

S:□CAD F□□□/ACDDATA PROJECTS 17 VED03330 R1.d□□

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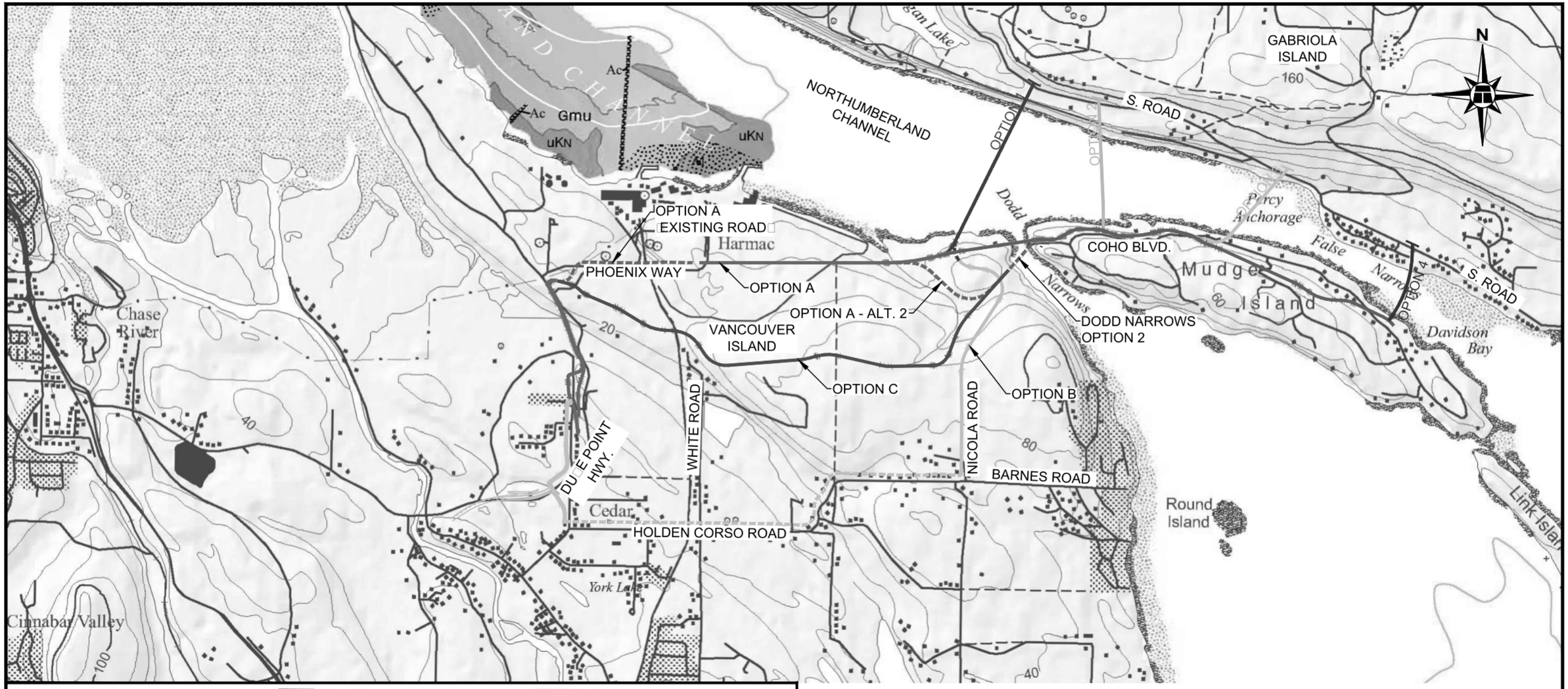
Plotted: Apr 23, 2015



Geological contact (map unit boundaries are interpreted from multibeam-sonar bathymetry and geophysical seismic-profile data and are inferred contacts that may be gradational or conceptual in nature)

Fault; defined, approximate

Normal fault, defined

Oblique thrust fault, defined

Submarine channel

Boulder fields

Pockmarks

Anthropogenic disturbances:

- *Dredged site*
- *Log boom*
- *Marina pile*
- *Undifferentiated anthropogenic disturbance*
- *Cable*

Seafloor photograph (see Figures 2–7)

PGa — ***Anthropogenic deposits:*** *the dredged material found at ocean disposal sites consists of mixtures of silt, sand, rock, wood waste, and other approved material. On the map, two disposal sites are visible: Portier Pass (49°00.75'N, 123°30.50'W) and Five Finger Island (49°13.86'N, 123°54.95'W). These sites are characterized by irregular intermediate to strong backscatter, forming round and linear backscatter features against a low-backscatter background. The spoil sediments overlie Holocene mud and bedrock.*

PGsr — ***Sponge reefs:*** *massive matrix of organic-rich, olive, slightly sandy-silty clay containing siliceous (glass) sponges (Hexactinellida, Hexactinosida) found as in situ whole skeletons and fragments. On seismic records, the unit appears as 1–3 m high transparent mounds overlying glaciogenic deposits. Very low backscatter strength on top of strong acoustic backscatter characterizes this unit.*

PGs — ***Postglacial sand:*** *sand or muddy sand. The unit is mostly found on the surface of some glacial sediments as it originates from the reworking of these sediments. Seismic profiles show that the unit is thin and can, in most cases, be defined as a veneer, with a distinctive low to intermediate backscatter strength. This unit is best represented in a submarine channel found northeast of Gabriola Island, where the unit infills the channel floor. See cross-section B-B'.*

PGm — ***Postglacial mud (Holocene mud):*** *silty clay; sediments originating from the Fraser River and forming the Fraser River pro-delta. The clay/silt ratio in the unit increases distal to the Fraser River mouth. The unit exceeds 300 m in thickness in the deepest basins and acoustic data are masked by interstitial biogenic gas in some areas. This unit has the weakest, but most uniform acoustic backscatter signal and generally does not show much relief. This unit occupies and dominates the deepest areas of the Straight of Georgia.*

Ic — ***Ice-contact sediments:*** *glacial diamicton till up to 60 m in thickness. This unit has strong multibeam backscatter strength, similar to the bedrock units, but the glacially derived geomorphology and transparent acoustic signature permit discrimination. See cross-section A-A'.*

uKN — ***Upper Cretaceous sedimentary Nanaimo Group:*** *dominated by layers of sandstone and conglomerate alternating with fine-grained sandstone and mudstone. The group includes several formations with variable sequences and bed thicknesses (Mustard, 1994; England and Bustin, 1998). Acoustically, the unit shows a discontinuous strong backscatter strength character with alternating low backscatter strength areas, resulting from the sharp and pronounced topography. The unit is most definable using the multibeam-sonar bathymetry and sun-illuminated topography.*

Gmd — ***Glaciomarine ice-distal sediments:*** *well stratified gravelly sandy mud. On seismic profiles, the unit is represented by weak and continuous reflectors draping underlying units and is also characterized by intermediate to strong backscatter. Rare outcrops occur on the seafloor north of Gabriola Island, where exposed glacial deposits are common. In most cases, the unit fills troughs and is buried under thick postglacial mud.*

Gmp — ***Glaciomarine ice-proximal sediments:*** *texturally variable mixture of sediments including mud, sand, gravel, and boulders. In some areas, the unit is acoustically stratified with discontinuous reflectors; elsewhere more acoustically incoherent and disturbed in appearance. The unit is readily defined when it overlies ice-contact sediments. These deposits are widespread north of Gabriola Island. See cross-section A-A'.*

Gmu — ***Glaciomarine sediments (undefined):*** *stratigraphic relationships, setting, seafloor geomorphology and the backscatter strength of the unit share similarities with other recognized glacial units. This unit includes both ice-contact and glaciomarine ice-proximal sediments; however, these cannot be spatially defined because of the lack of geophysical or sample data available. See cross-section B-B'.*

NOTES:

1. BASE PLAN TAKEN FROM GEOLOGICAL SURVEY OF CANADA'S MAP "2118A SURFICIAL GEOLOGY AND SHADED SEAFLOOR RELIEF" SHEET 92 G/4.

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SEA FLOOR GEOLOGY

GABRIOLA ISLAND
FIXED LINK FEASIBILITY STUDY — GABRIOLA ISLAND, BC

SEAL

DESIGNED	DRAWN	APPROVED
-	NA	DJT

DATE	SCALE
APRIL 21, 2015	AS SHOWN

PROJECT NO.	DWG. NO.	REV.
17-834-185-2		-

CANCEL PRINTS BEARING EARLIER LETTER

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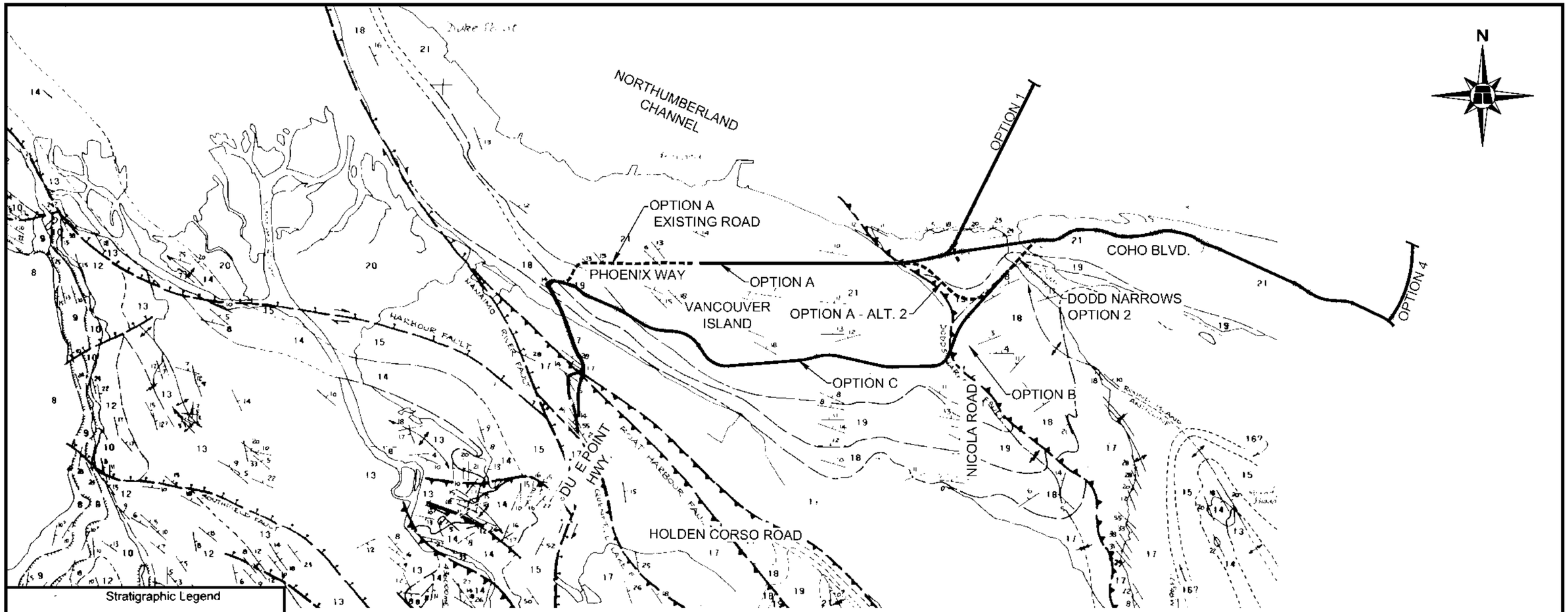

Stratigraphic Legend

Upper Cretaceous
Nanaimo Group
Campanian

- [22] NORTHUMBERLAND FORMATION: shale, siltstone; minor sandstone
- [21] DE COURCY FORMATION: sandstone; minor conglomerate and siltstone
- [20] CEDAR DISTRICT FORMATION (undivided): shale, siltstone; minor sandstone
- BOAT HARBOUR MEMBER: shale and siltstone; sandstone
- [18] WOODS ISLANDS MEMBER: sandstone; minor siltstone
- [17] HOLDEN CORSO MEMBER: shale and siltstone; sandstone dikes
- [16] OYSTER HARBOUR MEMBER: sandstone; minor siltstone
- [15] GRANBY MEMBER: shale

PROTECTION FORMATION

- [14] McMILLAN MEMBER: sandstone; minor siltstone
- [13] RESERVE MEMBER: sandstone, siltstone, shale and coal
- [12] CASSIDY MEMBER: sandstone and grit/stone; minor siltstone

PENDER FORMATION

- [11] NEWCASTLE MEMBER (undivided): *not mapped in this area*
- [10] SOUTHFIELD BEDS: shale; minor sandstone, grit/stone and conglomerate
- DOUGLAS BEDS: conglomerate and grit/stone; carbonaceous shale and coal (Douglas Seam at top, Newcastle Seam at base)
- [8] CRANBERRY MEMBER: shale and siltstone; conglomerate and sandstone

EXTENSION FORMATION

- [7] MILLSTREAM MEMBER: conglomerate and grit/stone; minor sandstone

Note: Beds below Unit 7 do not outcrop within map-area

Symbols

- Bedding orientation
- Geologic boundary (observed, approximate, inferred)
- Reverse fault (observed, approximate, inferred)
- Normal fault (observed, approximate, inferred)
- Anticline, surface trace (observed, approximate, inferred)
- Syncline, surface trace (observed, approximate, inferred)
- Coal seam trace (observed, approximate, inferred)

NOTES:

1. BASE PLAN TA EN FROM BC MINISTRY OF ENERGY AND MINES OPEN FILE "1998-07 GEOLOGY OF THE NANAIMO COALFIELD BRITISH COLUMBIA NTS 92G 4".

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CLIENT: CH2M HILL CANADA LTD.

BEDROCK GEOLOGY

GABRIOLA ISLAND
FIXED LIN FEASIBILITY STUDY GABRIOLA ISLAND BC

SEAL

DESIGNED	DRAWN	APPROVED
-	NA	DJT

DATE: APRIL 21 2015 SCALE: AS SHOWN

PROJECT N: 17-834-185-3 DWG. N. REV. -

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Nanaimo Group formations

strike-slip fault line

anticline

syncline

folds in bedrock

11	Gabriola sandstone
10	Spray shale
9	Geoffrey sandstone
8	Northumberland shale
7	De Courcy sandstone
6	Cedar District shale (mudstone)
5	Protection sandstone
4	Pender shale (mudstone)

11 Gabriola sandstone

GABRIOLA ISLAND

N

NORTHUMBERLAND CHANNEL

OPTION 1

OPTION 2

OPTION 3

OPTION 4

7 De Courcy sandstone

OPTION A

EXISTING ROAD

PHOENIX WAY

OPTION A

OPTION A - ALT. 2

VANCOUVER ISLAND

OPTION B

OPTION C

COHO BLVD.

FALSE NARROWS

8 Northumberland shale

MUDGE ISLAND

7

DODD NARROWS OPTION 2

NICOLA ROAD

DUKE POINT HWY.

6 Cedar District

HOLDEN CORSO ROAD

shale (mudstone)

5

Protection sandstone

Stuart Channel anticline

Boat Harbour syncline

7

500 0 1000 2000m

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NOTES:

1. BASE PLAN TA[illegible]EN FROM "SANDSTONE [illegible] SHALE - GABRIOLA\S ORIGINS" BY NIC[illegible] DOE [illegible]WWW.NIC[illegible]DOE.CA\PASS\WEBP223C.PDF.[illegible]

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BEDROCK GEOLOGY

GABRIOLA ISLAND
FIXED LIN[illegible] FEASIBILITY STUDY GABRIOLA ISLAND[illegible]BC

SEAL

DESIGNED	DRAWN	APPROVED
-	NA[illegible]	DJT

DATE	SCALE
APRIL 21[illegible]2015	AS SHOWN

PROJECT N[illegible]	DWG. N[illegible]	REV.
17-834-185-4		-

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2010 National Building Code Seismic Hazard Calculation

INFORMATION: Eastern Canada English (613) 995-5548 français (613) 995-0600 Facsimile (613) 992-8836
Western Canada English (250) 363-6500 Facsimile (250) 363-6565

Requested by: David Tara, Thurber Engineering Ltd. March 03, 2015

Site Coordinates: 49.136 North 123.81 West

User File Reference: Mudge Island

National Building Code ground motions:
2% probability of exceedance in 50 years (0.000404 per annum)

Sa(0.2)	Sa(0.5)	Sa(1.0)	Sa(2.0)	PGA (g)
1.028	0.700	0.354	0.179	0.507

Notes. Spectral and peak hazard values are determined for firm ground (NBCC 2010 soil class C - average shear wave velocity 360-750 m/s). Median (50th percentile) values are given in units of g. 5% damped spectral acceleration (Sa(T), where T is the period in seconds) and peak ground acceleration (PGA) values are tabulated. Only 2 significant figures are to be used. ***These values have been interpolated from a 10 km spaced grid of points. Depending on the gradient of the nearby points, values at this location calculated directly from the hazard program may vary. More than 95 percent of interpolated values are within 2 percent of the calculated values.*** Warning: You are in a region which considers the hazard from a deterministic Cascadia subduction event for the National Building Code. Values determined for high probabilities (0.01 per annum) in this region do not consider the hazard from this type of earthquake.

Ground motions for other probabilities:

Probability of exceedance per annum	0.010	0.0021	0.001
Probability of exceedance in 50 years	40%	10%	5%
Sa(0.2)	0.249	0.542	0.738
Sa(0.5)	0.166	0.363	0.496
Sa(1.0)	0.083	0.183	0.251
Sa(2.0)	0.041	0.090	0.124
PGA	0.128	0.273	0.367

References

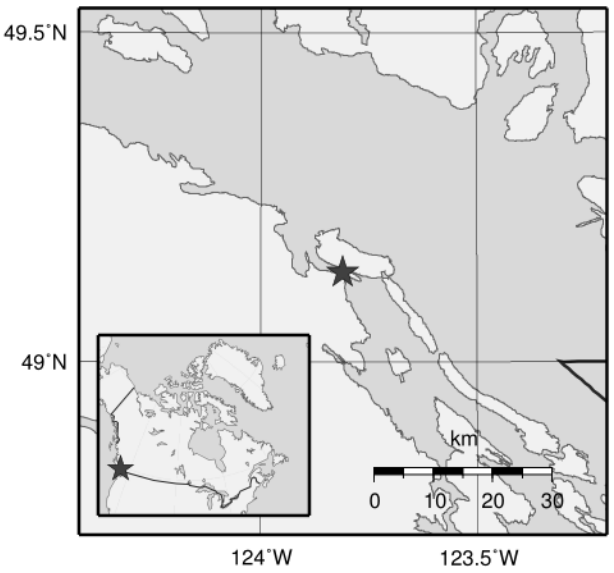
National Building Code of Canada 2010 NRCC no. 53301; sections 4.1.8, 9.20.1.2, 9.23.10.2, 9.31.6.2, and 6.2.1.3
Appendix C: Climatic Information for Building Design in Canada - table in Appendix C starting on page C-11 of Division B, volume 2

User's Guide - NBC 2010, Structural Commentaries NRCC no. 53543 (in preparation)
Commentary J: Design for Seismic Effects

Geological Survey of Canada Open File xxxx
Fourth generation seismic hazard maps of Canada: Maps and grid values to be used with the 2010 National Building Code of Canada (in preparation)

See the websites *www.EarthquakesCanada.ca* and *www.nationalcodes.ca* for more information

Aussi disponible en français



APPENDIX C

CONSTRUCTION COST ESTIMATE BREAKDOWN

653997 Gabriola Island

SUMMARY CONCEPTUAL DESIGN ESTIMATE

	Option A - Alt 2	Option B	Option C	Mudge Island	Gabriola Island	Dodd Bridge	Gabriola Bridge	TOTAL
Description	**Phoenix Way**	**Holdon Corso Road**	**New Alignment**	**Coho Boulevard**	**South Road**	**Concrete**	**Concrete**	**"Fixed Link": Option 3C**
Section 1 - General	$1,610,000	$500,000	$580,000	$330,000	$20,000	$1,260,000	$4,690,000	$6,880,000
Section 2 - Grading	$2,770,000	$2,650,000	$4,590,000	$2,640,000	$140,000	$0	$0	$7,370,000
Section 3 - Drainage	$200,000	$100,000	$290,000	$110,000	$10,000	$0	$0	$410,000
Section 4 - Structures	$12,350,000	$0	$0	$0	$0	$20,800,000	$77,909,000	$98,709,000
Section 5 - Paving	$3,150,000	$2,810,000	$1,690,000	$1,760,000	$20,000	$0	$0	$3,470,000
Section 6 - Signing & Pavement Marking	$90,000	$130,000	$140,000	$60,000	$10,000	$0	$0	$210,000
Section 7 - Electrical	$300,000	$90,000	$90,000	$50,000	$10,000	$50,000	$150,000	$350,000
Section 8 - Miscellaneous	$150,000	$150,000	$50,000	$150,000	$0	$150,000	$150,000	$500,000
TOTAL CONSTRUCTION COST	**$20,620,000**	**$6,430,000**	**$7,430,000**	**$5,100,000**	**$210,000**	**$22,260,000**	**$82,899,000**	**$117,900,000**
Section A - Property Acquisition - TBD	*$0*	*$0*	$0	*$0*	*$0*	*$0*	*$0*	*$0*
Section B - Engineering & Supervision	$4,650,000	$1,450,000	$1,880,000	$1,170,000	$50,000	$4,725,000	$13,295,530	$21,120,530
Section C - Work By Others	$10,000	$10,000	$10,000	$10,000	$0	$0	$0	$20,000
Section D - Contingencies	$9,500,000	$2,970,000	$2,400,000	$2,380,000	$90,000	$10,500,000	$39,104,500	$54,474,500
TOTAL OTHER COSTS	**$14,160,000**	**$4,430,000**	**$4,290,000**	**$3,560,000**	**$140,000**	**$15,225,000**	**$52,400,030**	**$75,620,000**
TOTAL PLANNING LEVEL ESTIMATE (ROUNDED TO NEAREST $10,000)	**$34,780,000**	**$10,860,000**	**$11,720,000**	**$8,660,000**	**$350,000**	**$37,490,000**	**$135,300,000**	**$193,520,000**

Gabriola Island

Road Option 3A (Phoenix Way) - Nanaimo

PROJECT 653997
Conceptual Design Mar, 2015

Section Length - 4.2kms
Roadway width - 10.2m (3.6m lane, 1.5m shoulder)
Assumed new road construction from Phoenix Way to New Bridge site and roadway widening only to Duke Point Highway
Assumed new bridge over Cable Bay Trail

Item No.	Description of Work	Unit	Most Probable Quantity	Unit Price	Most Probable Extended Amount
SECTION 1 – GENERAL					
01.01	Mobilization (5.0% of Section 2 thru 8)	L.S.	100%	L.S.	$949,875.00
01.02	Traffic Management (2.5% of Section 2 thru 8)	L.S.	100%	L.S.	$474,937.50
01.03	Quality Management (1.0% of Section 2 thru 8)	L.S.	100%	L.S.	$189,975.00
TOTAL SECTION 1					**$1,614,787.50**
SECTION 2 – GRADING					
02.01	**Clearing and Grubbing**				
02.01.01	Clearing and Grubbing Highway Construction	Ha	5.00	$30,000.00	$150,000.00
02.02	**Removals**				
02.02.01	Remove Lamp Standard	Each	0.00	$2,000.00	$0.00
02.03	**Pavement Cold Milling & Removal**				
02.03.01	Pavement Removal	Square Metre	2,400	$20.00	$48,000.00
02.04	**Roadway & Drainage Excavation**				
02.04.01	Organic Stripping - 300mm	Cubic Metre	14,400	$15.00	$216,000.00
02.04.02	Type "A" Excavation (neatline)	Cubic Metre	25,000	$40.00	$1,000,000.00
02.04.03	Type "D" Excavation (neatline)	Cubic Metre	25,000	$18.00	$450,000.00
02.04.04	Haul Surplus Material Offsite (unfactored)	Cubic Metre	10,000	$25.00	$250,000.00
02.05	**Granular Materials: Production & Placement**				
02.05.01	25mm Well Graded Base Course (WGBC)	Cubic Metre	5,200	$45.00	$234,000.00
02.05.02	Open Graded Granular Sub Base (SGSB)	Cubic Metre	12,000	$35.00	$420,000.00
02.06	**Embankment Construction**				
02.06.01	Import Material, Haul and Place into Highway Embankment	Cubic Metre	0	$20.00	$0.00
TOTAL SECTION 2					**$2,768,000.00**
SECTION 3 – DRAINAGE					
03.01	**Supply & Install**				
03.01.01	600mm CSP 2.0 WT	Metre	400	$400.00	$160,000.00
03.02	**Rip Rap & End Walls**				
03.02.01	10 kg Rip Rap Outfall	Cubic Metre	50	$150.00	$7,500.00
03.02.02	End Wall 1000mm dia inlet with Fence and Apron	Each	4	$7,000.00	$28,000.00
TOTAL SECTION 3					**$195,500.00**
SECTION 4 – STRUCTURES					
04.01	**Supply & Install**				
04.01.01	Bridge Structure (over Cable Bay Trail)	Square Metre	1,900	$6,500.00	$12,350,000.00
04.01.02	MSE Wall (sq.m face area)	Square Metre			$0.00
TOTAL SECTION 4					**$12,350,000.00**
SECTION 5 – PAVING					
05.01	**Asphalt Pavement**				
05.01.01	Class 1 Medium Mix	Tonne	18,500	$155.00	$2,867,500.00
05.01.02	Asphalt Overlay - 50mm	m2	9,200	$20.00	$184,000.00
05.02	**Concrete Works**				
05.02.01	Concrete Curb and Gutter	Metre	200	$50.00	$10,000.00
05.03	**Concrete Barriers**				
05.03.01	Supply and Install CRB	Each	300	$250.00	$75,000.00
05.03.02	Supply and Install CMB	Each	30	$350.00	$10,500.00
TOTAL SECTION 5					**$3,147,000.00**
SECTION 6– SIGNING & PAVEMENT MARKING					
06.01	**Sign Installation**				
06.01.01	Remove Existing Signs	Each	10	$200.00	$2,000.00
06.01.02	Supply & Install Perforated Square Steel Post and Sign Face (SP635-3.6.1)	Each	30	$400.00	$12,000.00
06.02	**Pavement Markings**				
06.02.01	Pavement Marking Layout	L.S.	1.00	$5,000.00	$5,000.00
06.02.02	Line Markings	Metre	8,000	$6.00	$48,000.00
06.02.03	Longitudinal and Transverse Pavement Markings and Arrows	L.S.	1.00	$20,000.00	$20,000.00
TOTAL SECTION 6					**$87,000.00**
SECTION 7 – ELECTRICAL					

Gabriola Island

Road Option 3A (Phoenix Way) - Nanaimo

PROJECT 653997
Conceptual Design Mar, 2015

Section Length - 4.2kms
Roadway width - 10.2m (3.6m lane, 1.5m shoulder)
Assumed new road construction from Phoenix Way to New Bridge site and roadway widening only to Duke Point Highway
Assumed new bridge over Cable Bay Trail

Item No.	Description of Work	Unit	Most Probable Quantity	Unit Price	Most Probable Extended Amount
07.01	**Electrical Materials**				
07.01.01	Lamp Standard	Each	60	$5,000.00	$300,000.00
TOTAL SECTION 7					**$300,000.00**
SECTION 8 – LANDSCAPE AND ENVIRONMENTAL					
08.01	**Landscape and Environmental**				
08.01.01	Landscaping and Environmental Requirements	L.S.	1.0	$150,000.00	$150,000.00
TOTAL SECTION 8					**$150,000.00**
SUMMARY SECTIONS 1 – 8					
TOTAL SECTION 1 – GENERAL					**$1,614,787.50**
TOTAL SECTION 2 – GRADING					**$2,768,000.00**
TOTAL SECTION 3 – DRAINAGE					**$195,500.00**
TOTAL SECTION 4 – STRUCTURES					**$12,350,000.00**
TOTAL SECTION 5 – PAVING					**$3,147,000.00**
TOTAL SECTION 6 – SIGNING & PAVEMENT MARKING					**$87,000.00**
TOTAL SECTION 7– ELECTRICAL					**$300,000.00**
TOTAL SECTION 8 – LANDSCAPE AND ENVIRONMENTAL					**$150,000.00**
TOTAL CONSTRUCTION COSTS					**$20,612,287.50**
SECTION A – PROPERTY					
A.01	Acquisition, incl. Legal Survey	L.S.	0%		$0.00
TOTAL SECTION A					**$0.00**
SECTION B – ENGINEERING & SUPERVISION					
B.01	Engineering Design Services (7% of Section 2 thru 8)	L.S.	100%	L.S.	$1,329,825.00
B.02	MoT Engineering Services (2.5% of Section 2 thru 8)	L.S.	100%	L.S.	$474,937.50
B.03	MoT Project Management (5% of Section 2 thru 8)	L.S.	100%	L.S.	$949,875.00
B.04	MoT Construction Supervision (10% of Section 2 thru 8)	L.S.	100%	L.S.	$1,899,750.00
TOTAL SECTION B					**$4,654,387.50**
SECTION C – WORK BY OTHERS					
C.01	Hydro Relocation	Each	20.00	$400.00	$8,000.00
TOTAL SECTION C					**$8,000.00**
SECTION D – CONTINGENCIES					
D.01	Contingency for Work on Roadways (50% of Section 2 thru 8)	L.S.	100%	L.S.	$9,498,750.00
TOTAL SECTION D					**$9,498,750.00**
SUMMARY SECTIONS A – D					
TOTAL SECTION A – PROPERTY ACQUISITION					**$0.00**
TOTAL SECTION B – ENGINEERING & SUPERVISION					**$4,654,387.50**
TOTAL SECTION C – WORK BY OTHERS					**$8,000.00**
TOTAL SECTION D – CONTINGENCIES					**$9,498,750.00**
TOTAL OTHER COSTS					**$14,161,137.50**
TOTAL ESTIMATE					$34,773,425.00

Gabriola Island

Road Option 3B (Holdon Corso/Nicola Road) - Nanaimo

PROJECT 653997
Conceptual Design Mar, 2015

Section Length - 5.3 kms
Roadway width - 10.2m (3.6m lane, 1.5m shoulder)
Assumed new road construction from Nicola Road to New Bridge site and roadway widening only to Duke Point Highway
Includes intersection and ramp upgrades at Duke Point Hwy

Item No.	Description of Work	Unit	Most Probable Quantity	Unit Price	Most Probable Extended Amount
SECTION 1 – GENERAL					
01.01	Mobilization (5.0% of Section 2 thru 8)	L.S.	100%	L.S.	$296,695.00
01.02	Traffic Management (2.5% of Section 2 thru 8)	L.S.	100%	L.S.	$148,347.50
01.03	Quality Management (1.0% of Section 2 thru 8)	L.S.	100%	L.S.	$59,339.00
TOTAL SECTION 1					**$504,381.50**
SECTION 2 – GRADING					
02.01	**Clearing and Grubbing**				
02.01.01	Clearing and Grubbing Highway Construction	Ha	3.00	$30,000.00	$90,000.00
02.02	**Removals**				
02.02.01	Remove Lamp Standard	Each	0.00	$2,000.00	$0.00
02.03	**Pavement Cold Milling & Removal**				
02.03.01	Pavement Removal	Square Metre	26,000	$20.00	$520,000.00
02.04	**Roadway & Drainage Excavation**				
02.04.01	Organic Stripping - 300mm	Cubic Metre	8,000	$15.00	$120,000.00
02.04.02	Type "A" Excavation (neatline)	Cubic Metre	18,000	$40.00	$720,000.00
02.04.03	Type "D" Excavation (neatline)	Cubic Metre	18,000	$18.00	$324,000.00
02.04.04	Haul Surplus Material Offsite (unfactored)	Cubic Metre	23,000	$25.00	$575,000.00
02.05	**Granular Materials: Production & Placement**				
02.05.01	25mm Well Graded Base Course (WGBC)	Cubic Metre	2,500	$45.00	$112,500.00
02.05.02	Open Graded Granular Sub Base (SGSB)	Cubic Metre	5,500	$35.00	$192,500.00
02.06	**Embankment Construction**				
02.06.01	Import Material, Haul and Place into Highway Embankment	Cubic Metre	0	$20.00	$0.00
TOTAL SECTION 2					**$2,654,000.00**
SECTION 3 – DRAINAGE					
03.01	**Supply & Install**				
03.01.01	1000mm CSP 2.0 WT	Metre	200	$400.00	$80,000.00
03.02	**Rip Rap & End Walls**				
03.02.01	10 kg Rip Rap Outfall	Cubic Metre	20	$150.00	$3,000.00
03.02.02	End Wall 1000mm dia inlet with Fence and Apron	Each	2	$7,000.00	$14,000.00
TOTAL SECTION 3					**$97,000.00**
SECTION 4 – STRUCTURES					
04.01	**Supply & Install**				
04.01.01	Bridge Structure	Square Metre	0	$4,500.00	$0.00
04.01.02	MSE Wall (sq.m face area)	Square Metre	0	$800.00	$0.00
TOTAL SECTION 4					**$0.00**
SECTION 5 – PAVING					
05.01	**Asphalt Pavement**				
05.01.01	Class 1 Medium Mix	Tonne	12,000	$155.00	$1,860,000.00
05.01.02	Asphalt Overlay - 50mm	m2	38,000	$20.00	$760,000.00
05.02	**Concrete Works**				
05.02.01	Concrete Curb and Gutter	Metre	1,038	$50.00	$51,900.00
05.03	**Concrete Barriers**				
05.03.01	Supply and Install CRB	Each	500	$250.00	$125,000.00
05.03.02	Supply and Install CMB	Each	40	$350.00	$14,000.00
TOTAL SECTION 5					**$2,810,900.00**
SECTION 6– SIGNING & PAVEMENT MARKING					
06.01	**Sign Installation**				
06.01.01	Remove Existing Signs	Each	20	$200.00	$4,000.00
06.01.02	Supply & Install Perforated Square Steel Post and Sign Face (SP635-3.6.1)	Each	20	$400.00	$8,000.00
06.02	**Pavement Markings**				
06.02.01	Pavement Marking Layout	L.S.	1.00	$10,000.00	$10,000.00
06.02.02	Line Markings	Metre	15,000	$6.00	$90,000.00
06.02.03	Longitudinal and Transverse Pavement Markings and Arrows	L.S.	1.00	$20,000.00	$20,000.00
TOTAL SECTION 6					**$132,000.00**

Gabriola Island

Road Option 3B (Holdon Corso/Nicola Road) - Nanaimo

PROJECT 653997
Conceptual Design Mar, 2015

Section Length - 5.3 kms
Roadway width - 10.2m (3.6m lane, 1.5m shoulder)
Assumed new road construction from Nicola Road to New Bridge site and roadway widening only to Duke Point Highway
Includes intersection and ramp upgrades at Duke Point Hwy

Item No.	Description of Work	Unit	Most Probable Quantity	Unit Price	Most Probable Extended Amount
SECTION 7 – ELECTRICAL					
07.01	**Electrical Materials**				
07.01.01	Lamp Standard	Each	60	$1,500.00	$90,000.00
TOTAL SECTION 7					**$90,000.00**
SECTION 8 – LANDSCAPE AND ENVIRONMENTAL					
08.01	**Landscape and Environmental**				
08.01.01	Landscaping and Environmental Requirements	L.S.	1.0	$150,000.00	$150,000.00
TOTAL SECTION 8					**$150,000.00**
SUMMARY SECTIONS 1 – 8					
	TOTAL SECTION 1 – GENERAL				**$504,381.50**
	TOTAL SECTION 2 – GRADING				**$2,654,000.00**
	TOTAL SECTION 3 – DRAINAGE				**$97,000.00**
	TOTAL SECTION 4 – STRUCTURES				**$0.00**
	TOTAL SECTION 5 – PAVING				**$2,810,900.00**
	TOTAL SECTION 6 – SIGNING & PAVEMENT MARKING				**$132,000.00**
	TOTAL SECTION 7– ELECTRICAL				**$90,000.00**
	TOTAL SECTION 8 – LANDSCAPE				**$150,000.00**
TOTAL CONSTRUCTION COSTS					**$6,438,281.50**
SECTION A – PROPERTY					
A.01	Acquisition, incl. Legal Survey	L.S.	0%		$0.00
TOTAL SECTION A					**$0.00**
SECTION B – ENGINEERING & SUPERVISION					
B.01	Engineering Design Services (7% of Section 2 thru 8)	L.S.	100%	L.S.	$415,373.00
B.02	MoT Engineering Services (2.5% of Section 2 thru 8)	L.S.	100%	L.S.	$148,347.50
B.03	MoT Project Management (5% of Section 2 thru 8)	L.S.	100%	L.S.	$296,695.00
B.04	MoT Construction Supervision (10% of Section 2 thru 8)	L.S.	100%	L.S.	$593,390.00
TOTAL SECTION B					**$1,453,805.50**
SECTION C – WORK BY OTHERS					
C.01	Hydro Relocation	L.S.	20.00	$400.00	$8,000.00
TOTAL SECTION C					**$8,000.00**
SECTION D – CONTINGENCIES					
D.01	Contingency for Work on Roadways (50% of Section 2 thru 8)	L.S.	100%	L.S.	$2,966,950.00
TOTAL SECTION D					**$2,966,950.00**
SUMMARY SECTIONS A – D					
	TOTAL SECTION A – PROPERTY ACQUISITION				**$0.00**
	TOTAL SECTION B – ENGINEERING & SUPERVISION				**$1,453,805.50**
	TOTAL SECTION C – WORK BY OTHERS				**$8,000.00**
	TOTAL SECTION D – CONTINGENCIES				**$2,966,950.00**
TOTAL OTHER COSTS					**$4,428,755.50**
TOTAL ESTIMATE					**$10,867,037.00**

Gabriola Island

Option 3C - Nanaimo

PROJECT 653997
Conceptual Design Mar, 2015

Item No.	Description of Work	Unit	Most Probable Quantity	Unit Price	Most Probable Extended Amount
SECTION 1 – GENERAL					
01.01	Mobilization (5.0% of Section 2 thru 8)	L.S.	100%	L.S.	$342,625.00
01.02	Traffic Management (2.5% of Section 2 thru 8)	L.S.	100%	L.S.	$171,312.50
01.03	Quality Management (1.0% of Section 2 thru 8)	L.S.	100%	L.S.	$68,525.00
TOTAL SECTION 1					**$582,462.50**
SECTION 2 – GRADING					
02.01	**Clearing and Grubbing**				
02.01.01	Clearing and Grubbing Highway Construction	Ha	8.10	$30,000.00	$243,000.00
02.02	**Removals**				
02.02.01	Remove Lamp Standard	Each	0.00	$2,000.00	$0.00
02.03	**Pavement Cold Milling & Removal**				
02.03.01	Pavement Removal	Square Metre	0	$20.00	$0.00
02.04	**Roadway & Drainage Excavation**				
02.04.01	Organic Stripping - 300mm	Cubic Metre	24,000	$15.00	$360,000.00
02.04.02	Type "A" Excavation (neatline)	Cubic Metre	46,000	$40.00	$1,840,000.00
02.04.03	Type "D" Excavation (neatline)	Cubic Metre	46,000	$18.00	$828,000.00
02.04.04	Haul Surplus Material Offsite (unfactored)	Cubic Metre	0	$25.00	$0.00
02.05	**Granular Materials: Production & Placement**				
02.05.01	25mm Well Graded Base Course (WGBC)	Cubic Metre	4,500	$45.00	$202,500.00
02.05.02	Open Graded Granular Sub Base (SGSB)	Cubic Metre	9,000	$35.00	$315,000.00
02.06	**Embankment Construction**				
02.06.01	Import Material, Haul and Place into Highway Embankment	Cubic Metre	40,000	$20.00	$800,000.00
TOTAL SECTION 2					**$4,588,500.00**
SECTION 3 – DRAINAGE					
03.01	**Supply & Install**				
03.01.01	1000mm CSP 2.0 WT	Metre	600	$400.00	$240,000.00
03.02	**Rip Rap & End Walls**				
03.02.01	10 kg Rip Rap Outfall	Cubic Metre	80	$150.00	$12,000.00
03.02.02	End Wall 1000mm dia inlet with Fence and Apron	Each	6	$7,000.00	$42,000.00
TOTAL SECTION 3					**$294,000.00**
SECTION 4 – STRUCTURES					
04.01	**Supply & Install**				
04.01.01	Bridge Structure	Square Metre	0	$4,500.00	$0.00
04.01.02	MSE Wall (sq.m face area)	Square Metre	0	$800.00	$0.00
TOTAL SECTION 4					**$0.00**
SECTION 5 – PAVING					
05.01	**Asphalt Pavement**				
05.01.01	Class 1 Medium Mix	Tonne	10,000	$155.00	$1,550,000.00
05.01.02	Asphalt Overlay - 50mm	m2	0	$20.00	$0.00
05.02	**Concrete Works**				
05.02.01	Concrete Curb and Gutter	Metre	0	$50.00	$0.00
05.03	**Concrete Barriers**				
05.03.01	Supply and Install CRB	Each	500	$250.00	$125,000.00
05.03.02	Supply and Install CMB	Each	40	$350.00	$14,000.00
TOTAL SECTION 5					**$1,689,000.00**
SECTION 6– SIGNING & PAVEMENT MARKING					
06.01	**Sign Installation**				
06.01.01	Remove Existing Signs	Each	0	$200.00	$0.00
06.01.02	Supply & Install Perforated Square Steel Post and Sign Face (SP635-3.6.1)	Each	40	$400.00	$16,000.00
06.02	**Pavement Markings**				
06.02.01	Pavement Marking Layout	L.S.	1.00	$15,000.00	$15,000.00
06.02.02	Line Markings	Metre	15,000	$6.00	$90,000.00
06.02.03	Transverse Pavement Markings and Arrows (Thermo Plastic)	L.S.	1.00	$20,000.00	$20,000.00
TOTAL SECTION 6					**$141,000.00**

Gabriola Island

Option 3C - Nanaimo

PROJECT 653997
Conceptual Design Mar, 2015

Item No.	Description of Work	Unit	Most Probable Quantity	Unit Price	Most Probable Extended Amount
SECTION 7 – ELECTRICAL					
07.01	**Electrical Materials**				
07.01.01	Lamp Standard	Each	60	$1,500.00	$90,000.00
TOTAL SECTION 7					**$90,000.00**
SECTION 8 – Landscape					
08.01	**Landscape Materials**				
08.01.01	Landscaping	L.S.	1.0	$50,000.00	$50,000.00
TOTAL SECTION 8					**$50,000.00**
SUMMARY SECTIONS 1 – 8					
	TOTAL SECTION 1 – GENERAL				**$582,462.50**
	TOTAL SECTION 2 – GRADING				**$4,588,500.00**
	TOTAL SECTION 3 – DRAINAGE				**$294,000.00**
	TOTAL SECTION 4 – STRUCTURES				**$0.00**
	TOTAL SECTION 5 – PAVING				**$1,689,000.00**
	TOTAL SECTION 6 – SIGNING & PAVEMENT MARKING				**$141,000.00**
	TOTAL SECTION 7– ELECTRICAL				**$90,000.00**
	TOTAL SECTION 8 – LANDSCAPE				**$50,000.00**
TOTAL CONSTRUCTION COSTS					**$7,434,962.50**
SECTION A – PROPERTY					
A.01	Acquisition, incl. Legal Survey	L.S.	0%		$0.00
TOTAL SECTION A					**$0.00**
SECTION B – ENGINEERING & SUPERVISION					
B.01	Engineering Design Services	L.S.	100%	L.S.	$685,250.00
B.02	MoT Engineering Services (2.5% of Section 2 thru 8)	L.S.	100%	L.S.	$171,312.50
B.03	MoT Project Management (5% of Section 2 thru 8)	L.S.	100%	L.S.	$342,625.00
B.04	MoT Construction Supervision (10% of Section 2 thru 8)	L.S.	100%	L.S.	$685,250.00
TOTAL SECTION B					**$1,884,437.50**
SECTION C – WORK BY OTHERS					
C.01	Hydro Relocation	L.S.	20.00	$400.00	$8,000.00
TOTAL SECTION C					**$8,000.00**
SECTION D – CONTINGENCIES					
D.01	Contingency for Work on Roadways (35% of Section 2 thru 8)	L.S.	100%	L.S.	$2,398,375.00
TOTAL SECTION D					**$2,398,375.00**
SUMMARY SECTIONS A – D					
	TOTAL SECTION A – PROPERTY ACQUISITION				**$0.00**
	TOTAL SECTION B – ENGINEERING & SUPERVISION				**$1,884,437.50**
	TOTAL SECTION C – WORK BY OTHERS				**$8,000.00**
	TOTAL SECTION D – CONTINGENCIES				**$2,398,375.00**
TOTAL OTHER COSTS					**$4,290,812.50**
TOTAL ESTIMATE					$11,725,775.00

Gabriola Island

Mudge Island Works

PROJECT 653997
Conceptual Design Mar, 2015

Section Length - 2.2 kms
Roadway width - 10.2m (3.6m lane, 1.5m shoulder)
Assume new road construction for full length

Item No.	Description of Work	Unit	Most Probable Quantity	Unit Price	Most Probable Extended Amount
SECTION 1 – GENERAL					
01.01	Mobilization (5.0% of Section 2 thru 8)	L.S.	100%	L.S.	$238,200.00
01.02	Traffic Management (1% of Section 2 thru 8)	L.S.	100%	L.S.	$47,640.00
01.03	Quality Management (1.0% of Section 2 thru 8)	L.S.	100%	L.S.	$47,640.00
TOTAL SECTION 1					**$333,480.00**
SECTION 2 – GRADING					
02.01	**Clearing and Grubbing**				
02.01.01	Clearing and Grubbing Highway Construction	Ha	3.00	$30,000.00	$90,000.00
02.02	**Removals**				
02.02.01	Remove Lamp Standard	Each	0.00	$2,000.00	$0.00
02.03	**Pavement Cold Milling & Removal**				
02.03.01	Pavement Removal	Square Metre	11,000	$20.00	$220,000.00
02.04	**Roadway & Drainage Excavation**				
02.04.01	Organic Stripping - 300mm	Cubic Metre	10,000	$15.00	$150,000.00
02.04.02	Type "A" Excavation (neatline)	Cubic Metre	25,000	$40.00	$1,000,000.00
02.04.03	Type "D" Excavation (neatline)	Cubic Metre	25,000	$18.00	$450,000.00
02.04.04	Haul Surplus Material Offsite (factored)	Cubic Metre	15,000	$25.00	$375,000.00
02.05	**Granular Materials: Production & Placement**				
02.05.01	25mm Well Graded Base Course (WGBC)	Cubic Metre	3,000	$45.00	$135,000.00
02.05.02	Open Graded Granular Sub Base (SGSB)	Cubic Metre	6,200	$35.00	$217,000.00
02.06	**Embankment Construction**				
02.06.01	Import Material, Haul and Place into Highway Embankment	Cubic Metre	0	$20.00	$0.00
TOTAL SECTION 2					**$2,637,000.00**
SECTION 3 – DRAINAGE					
03.01	**Supply & Install**				
03.01.01	1000mm CSP 2.0 WT	Metre	230	$400.00	$92,000.00
03.02	**Rip Rap & End Walls**				
03.02.01	10 kg Rip Rap Outfall	Cubic Metre	20	$150.00	$3,000.00
03.02.02	End Wall 1000mm dia inlet with Fence and Apron	Each	2	$7,000.00	$14,000.00
TOTAL SECTION 3					**$109,000.00**
SECTION 4 – STRUCTURES					
04.01	**Supply & Install**				
04.01.01	Bridge Structure	Square Metre	0	$4,000.00	$0.00
04.01.02	MSE Wall (sq.m face area)	Square Metre	0	$800.00	$0.00
TOTAL SECTION 4					**$0.00**
SECTION 5 – PAVING					
05.01	**Asphalt Pavement**				
05.01.01	Class 1 Medium Mix	Tonne	11,000	$155.00	$1,705,000.00
05.01.02	Asphalt Overlay - 50mm	m2	0	$20.00	$0.00
05.02	**Concrete Works**				
05.02.01	Concrete Curb and Gutter	Metre	0	$50.00	$0.00
05.03	**Concrete Barriers**				
05.03.01	Supply and Install CRB	Each	200	$250.00	$50,000.00
05.03.02	Supply and Install CMB	Each	20	$350.00	$7,000.00
TOTAL SECTION 5					**$1,762,000.00**
SECTION 6– SIGNING & PAVEMENT MARKING					
06.01	**Sign Installation**				
06.01.01	Remove Existing Signs	Each	10	$200.00	$2,000.00
06.01.02	Supply & Install Perforated Square Steel Post and Sign Face (SP635-3.6.1)	Each	20	$400.00	$8,000.00
06.02	**Pavement Markings**				
06.02.01	Pavement Marking Layout	L.S.	1.00	$5,000.00	$5,000.00
06.02.02	Line Markings	Metre	6,000	$6.00	$36,000.00
06.02.03	Longitudinal and Transverse Pavement Markings and Arrows	L.S.	1.00	$10,000	$10,000.00
TOTAL SECTION 6					**$61,000.00**

Gabriola Island

Mudge Island Works

PROJECT 653997
Conceptual Design Mar, 2015

Section Length - 2.2 kms
Roadway width - 10.2m (3.6m lane, 1.5m shoulder)
Assume new road construction for full length

Item No.	Description of Work	Unit	Most Probable Quantity	Unit Price	Most Probable Extended Amount
SECTION 7 – ELECTRICAL					
07.01	**Electrical Materials**				
07.01.01	Lamp Standard	Each	30	$1,500.00	$45,000.00
TOTAL SECTION 7					**$45,000.00**
SECTION 8 – LANDSCAPE AND ENVIRONMENTAL					
08.01	**Landscape and Environmental**				
08.01.01	Landscaping and Environmental Requirements	L.S.	1.0	$150,000.00	$150,000.00
TOTAL SECTION 8					**$150,000.00**

SUMMARY SECTIONS 1 – 8	
TOTAL SECTION 1 – GENERAL	**$333,480.00**
TOTAL SECTION 2 – GRADING	**$2,637,000.00**
TOTAL SECTION 3 – DRAINAGE	**$109,000.00**
TOTAL SECTION 4 – STRUCTURES	**$0.00**
TOTAL SECTION 5 – PAVING	**$1,762,000.00**
TOTAL SECTION 6 – SIGNING & PAVEMENT MARKING	**$61,000.00**
TOTAL SECTION 7– ELECTRICAL	**$45,000.00**
TOTAL SECTION 8 – LANDSCAPE	**$150,000.00**
TOTAL CONSTRUCTION COSTS	**$5,097,480.00**

SECTION A – PROPERTY					
A.01	Acquisition, incl. Legal Survey	L.S.	0%		$0.00
TOTAL SECTION A					**$0.00**
SECTION B – ENGINEERING & SUPERVISION					
B.01	Engineering Design Services (7% of Section 2 thru 8)	L.S.	100%	L.S.	$333,480.00
B.02	MoT Engineering Services (2.5% of Section 2 thru 8)	L.S.	100%	L.S.	$119,100.00
B.03	MoT Project Management (5% of Section 2 thru 8)	L.S.	100%	L.S.	$238,200.00
B.04	MoT Construction Supervision (10% of Section 2 thru 8)	L.S.	100%	L.S.	$476,400.00
TOTAL SECTION B					**$1,167,180.00**
SECTION C – WORK BY OTHERS					
C.01	Hydro Relocation	Each	20.00	$400.00	$8,000.00
TOTAL SECTION C					**$8,000.00**
SECTION D – CONTINGENCIES					
D.01	Contingency for Work on Roadways (50% of Section 2 thru 8)	L.S.	100%	L.S.	$2,382,000.00
TOTAL SECTION D					**$2,382,000.00**

SUMMARY SECTIONS A – D	
TOTAL SECTION A – PROPERTY ACQUISITION	**$0.00**
TOTAL SECTION B – ENGINEERING & SUPERVISION	**$1,167,180.00**
TOTAL SECTION C – WORK BY OTHERS	**$8,000.00**
TOTAL SECTION D – CONTINGENCIES	**$2,382,000.00**
TOTAL OTHER COSTS	**$3,557,180.00**
TOTAL ESTIMATE	$8,654,660.00

Gabriola Island Works

PROJECT 653997
Conceptual Design Mar, 2015

Intersection at S Road
Roadway width - 10.2m (3.6m lane, 1.5m shoulder)

Item No.	Description of Work	Unit	Most Probable Quantity	Unit Price	Most Probable Extended Amount
SECTION 1 – GENERAL					
01.01	Mobilization (5.0% of Section 2 thru 8)	L.S.	100%	L.S.	$9,258.00
01.02	Traffic Management (2.5% of Section 2 thru 8)	L.S.	100%	L.S.	$4,629.00
01.03	Quality Management (1.0% of Section 2 thru 8)	L.S.	100%	L.S.	$1,851.60
TOTAL SECTION 1					**$15,738.60**
SECTION 2 – GRADING					
02.01	**Clearing and Grubbing**				
02.01.01	Clearing and Grubbing Highway Construction	Ha	1.00	$30,000.00	$30,000.00
02.02	**Removals**				
02.02.01	Remove Lamp Standard	Each	0.00	$2,000.00	$0.00
02.03	**Pavement Cold Milling & Removal**				
02.03.01	Pavement Removal	Square Metre	0	$20.00	$0.00
02.04	**Roadway & Drainage Excavation**				
02.04.01	Organic Stripping - 300mm	Cubic Metre	300	$15.00	$4,500.00
02.04.02	Type "A" Excavation (neatline)	Cubic Metre	0	$40.00	$0.00
02.04.03	Type "D" Excavation (neatline)	Cubic Metre	0	$18.00	$0.00
02.04.04	Haul Surplus Material Offsite (factored)	Cubic Metre	0	$25.00	$0.00
02.05	**Granular Materials: Production & Placement**				
02.05.01	25mm Well Graded Base Course (WGBC)	Cubic Metre	20	$45.00	$900.00
02.05.02	Open Graded Granular Sub Base (SGSB)	Cubic Metre	40	$35.00	$1,400.00
02.06	**Embankment Construction**				
02.06.01	Import Material, Haul and Place into Highway Embankment	Cubic Metre	5,000	$20.00	$100,000.00
TOTAL SECTION 2					**$136,800.00**
SECTION 3 – DRAINAGE					
03.01	**Supply & Install**				
03.01.01	1000mm CSP 2.0 WT	Metre	30	$400.00	$12,000.00
03.02	**Rip Rap & End Walls**				
03.02.01	10 kg Rip Rap Outfall	Cubic Metre	4	$150.00	$600.00
03.02.02	End Wall 1000mm dia inlet with Fence and Apron	Each	0	$7,000.00	$0.00
TOTAL SECTION 3					**$12,600.00**
SECTION 4 – STRUCTURES					
04.01	**Supply & Install**				
04.01.01	Bridge Structure	Square Metre	0	$4,000.00	$0.00
04.01.02	MSE Wall (sq.m face area)	Square Metre	0	$800.00	$0.00
TOTAL SECTION 4					**$0.00**
SECTION 5 – PAVING					
05.01	**Asphalt Pavement**				
05.01.01	Class 1 Medium Mix	Tonne	72	$155.00	$11,160.00
05.01.02	Asphalt Overlay - 50mm	m2	0	$20.00	$0.00
05.02	**Concrete Works**				
05.02.01	Concrete Curb and Gutter	Metre	0	$50.00	$0.00
05.03	**Concrete Barriers**				
05.03.01	Supply and Install CRB	Each	40	$250.00	$10,000.00
05.03.02	Supply and Install CMB	Each	4	$350.00	$1,400.00
TOTAL SECTION 5					**$22,560.00**
SECTION 6– SIGNING & PAVEMENT MARKING					
06.01	**Sign Installation**				
06.01.01	Remove Existing Signs	Each	2	$200.00	$400.00
06.01.02	Supply & Install Perforated Square Steel Post and Sign Face (SP635-3.6.1)	Each	8	$400.00	$3,200.00
06.02	**Pavement Markings**				
06.02.01	Pavement Marking Layout	L.S.	1.00	$1,000.00	$1,000.00
06.02.02	Line Markings	Metre	100	$6.00	$600.00
06.02.03	Longitudinal and Transverse Pavement Markings and Arrows	L.S.	1.00	$2,000.00	$2,000.00
TOTAL SECTION 6					**$7,200.00**

Gabriola Island Works

PROJECT 653997
Conceptual Design Mar, 2015

Intersection at S Road
Roadway width - 10.2m (3.6m lane, 1.5m shoulder)

Item No.	Description of Work	Unit	Most Probable Quantity	Unit Price	Most Probable Extended Amount
SECTION 7 – ELECTRICAL					
07.01	**Electrical Materials**				
07.01.01	Lamp Standard	Each	4	$1,500.00	$6,000.00
TOTAL SECTION 7					**$6,000.00**
SECTION 8 – LANDSCAPE AND ENVIRONMENTAL					
08.01	**Landscape and Environmental**				
08.01.01	Landscaping and Environmental Requirements	L.S.	0.0	$150,000.00	$0.00
TOTAL SECTION 8					**$0.00**

SUMMARY SECTIONS 1 – 8	
TOTAL SECTION 1 – GENERAL	**$15,738.60**
TOTAL SECTION 2 – GRADING	**$136,800.00**
TOTAL SECTION 3 – DRAINAGE	**$12,600.00**
TOTAL SECTION 4 – STRUCTURES	**$0.00**
TOTAL SECTION 5 – PAVING	**$22,560.00**
TOTAL SECTION 6 – SIGNING & PAVEMENT MARKING	**$7,200.00**
TOTAL SECTION 7– ELECTRICAL	**$6,000.00**
TOTAL SECTION 8 – LANDSCAPE	**$0.00**
TOTAL CONSTRUCTION COSTS	**$200,898.60**

SECTION A – PROPERTY					
A.01	Acquisition, incl. Legal Survey	L.S.	0%		$0.00
TOTAL SECTION A					**$0.00**
SECTION B – ENGINEERING & SUPERVISION					
B.01	Engineering Design Services (10% of Section 2 thru 8)	L.S.	100%	L.S.	$18,516.00
B.02	MoT Engineering Services (2.5% of Section 2 thru 8)	L.S.	100%	L.S.	$4,629.00
B.03	MoT Project Management (5% of Section 2 thru 8)	L.S.	100%	L.S.	$9,258.00
B.04	MoT Construction Supervision (10% of Section 2 thru 8)	L.S.	100%	L.S.	$18,516.00
TOTAL SECTION B					**$50,919.00**
SECTION C – WORK BY OTHERS					
C.01	Hydro Relocation	Each	0.00	$400.00	$0.00
TOTAL SECTION C					**$0.00**
SECTION D – CONTINGENCIES					
D.01	Contingency for Work on Roadways (50% of Section 2 thru 8)	L.S.	100%	L.S.	$92,580.00
TOTAL SECTION D					**$92,580.00**

SUMMARY SECTIONS A – D	
TOTAL SECTION A – PROPERTY ACQUISITION	**$0.00**
TOTAL SECTION B – ENGINEERING & SUPERVISION	**$50,919.00**
TOTAL SECTION C – WORK BY OTHERS	**$0.00**
TOTAL SECTION D – CONTINGENCIES	**$92,580.00**
TOTAL OTHER COSTS	**$143,499.00**
TOTAL ESTIMATE	**$344,397.60**

Gabriola Island

Dodd Narrows Bridge

PROJECT 653997
Conceptual Design Mar, 2015

Span Length - 260m
Bridge widht - 9.2m
Assumed Concrete Girder construction

Item No.	Description of Work	Unit	Most Probable Quantity	Unit Price	Most Probable Extended Amount
SECTION 1 – GENERAL					
01.01	Mobilization (5.0% of Section 2 thru 8)	L.S.	100%	L.S.	$1,050,000.00
01.02	Traffic Management (0% of Section 2 thru 8) (Allowed for in Road Construction)	L.S.	100%	L.S.	$0.00
01.03	Quality Management (1.0% of Section 2 thru 8)	L.S.	100%	L.S.	$210,000.00
TOTAL SECTION 1					**$1,260,000.00**
SECTION 2 – GRADING					
02.01	**Clearing and Grubbing**				
02.01.01	Clearing and Grubbing Highway Construction	Ha	0	$30,000.00	$0.00
02.02	**Removals**				
02.02.01	Remove Lamp Standard	Each	0	$2,000.00	$0.00
02.03	**Pavement Cold Milling & Removal**				
02.03.01	Pavement Removal	Square Metre	0	$20.00	$0.00
02.04	**Roadway & Drainage Excavation**				
02.04.01	Organic Stripping - 300mm	Cubic Metre	0	$15.00	$0.00
02.04.02	Type "A" Excavation (neatline)	Cubic Metre	0	$40.00	$0.00
02.04.03	Type "D" Excavation (neatline)	Cubic Metre	0	$18.00	$0.00
02.04.04	Haul Surplus Material Offsite (factored)	Cubic Metre	0	$25.00	$0.00
02.05	**Granular Materials: Production & Placement**				
02.05.01	25mm Well Graded Base Course (WGBC)	Cubic Metre	0	$45.00	$0.00
02.05.02	Open Graded Granular Sub Base (SGSB)	Cubic Metre	0	$35.00	$0.00
02.06	**Embankment Construction**				
02.06.01	Import Material, Haul and Place into Highway Embankment	Cubic Metre	0	$20.00	$0.00
TOTAL SECTION 2					**$0.00**
SECTION 3 – DRAINAGE					
03.01	**Supply & Install**				
03.01.01	1000mm CSP 2.0 WT	Metre	0	$400.00	$0.00
03.02	**Rip Rap & End Walls**				
03.02.01	10 kg Rip Rap Outfall	Cubic Metre	0	$150.00	$0.00
03.02.02	End Wall 1000mm dia inlet with Fence and Apron	Each	0	$7,000.00	$0.00
TOTAL SECTION 3					**$0.00**
SECTION 4 – STRUCTURES					
04.01	**Supply & Install**				
04.01.01	Bridge Structure - Concrete Girder, including span and approaches	Square Metre	3,200	$6,500.00	$20,800,000.00
04.01.02	MSE Wall (sq.m face area)	Square Metre	0	$800.00	$0.00
TOTAL SECTION 4					**$20,800,000.00**
SECTION 5 – PAVING					
05.01	**Asphalt Pavement**				
05.01.01	Class 1 Medium Mix	Tonne	0	$155.00	$0.00
05.01.02	Asphalt Overlay - 50mm	m2	0	$20.00	$0.00
05.02	**Concrete Works**				
05.02.01	Concrete Curb and Gutter	Metre	0	$50.00	$0.00
05.03	**Concrete Barriers**				
05.03.01	Supply and Install CRB	Each	0	$250.00	$0.00
05.03.02	Supply and Install CMB	Each	0	$350.00	$0.00
TOTAL SECTION 5					**$0.00**
SECTION 6– SIGNING & PAVEMENT MARKING (Included in Section 4)					
06.01	**Sign Installation**				
06.01.01	Remove Existing Signs	Each	0	$200.00	$0.00
06.01.02	Supply & Install Perforated Square Steel Post and Sign Face (SP635-3.6.1)	Each	0	$400.00	$0.00
06.02	**Pavement Markings**				
06.02.01	Pavement Marking Layout	L.S.	0	$1,000.00	$0.00
06.02.02	Line Markings	Metre	-	$6.00	$0.00
06.02.03	Longitudinal and Transverse Pavement Markings and Arrows	L.S.	0	$2,000.00	$0.00
TOTAL SECTION 6					**$0.00**

Gabriola Island

Dodd Narrows Bridge

PROJECT 653997
Conceptual Design Mar, 2015

Span Length - 260m
Bridge widht - 9.2m
Assumed Concrete Girder construction

Item No.	Description of Work	Unit	Most Probable Quantity	Unit Price	Most Probable Extended Amount
SECTION 7 – ELECTRICAL					
07.01	**Electrical Materials**				
07.01.01	Lamp Standard including wiring	Each	10	$5,000.00	$50,000.00
TOTAL SECTION 7					**$50,000.00**
SECTION 8 – LANDSCAPE AND ENVIRONMENTAL					
08.01	**Landscape and Environmental**				
08.01.01	Landscaping and Environmental Requirements	L.S.	1	$150,000.00	$150,000.00
TOTAL SECTION 8					**$150,000.00**
SUMMARY SECTIONS 1 – 8					
	TOTAL SECTION 1 – GENERAL				**$1,260,000.00**
	TOTAL SECTION 2 – GRADING				**$0.00**
	TOTAL SECTION 3 – DRAINAGE				**$0.00**
	TOTAL SECTION 4 – STRUCTURES				**$20,800,000.00**
	TOTAL SECTION 5 – PAVING				**$0.00**
	TOTAL SECTION 6 – SIGNING & PAVEMENT MARKING				**$0.00**
	TOTAL SECTION 7– ELECTRICAL				**$50,000.00**
	TOTAL SECTION 8 – LANDSCAPE				**$150,000.00**
TOTAL CONSTRUCTION COSTS					**$22,260,000.00**
SECTION A – PROPERTY					
A.01	Acquisition, incl. Legal Survey	L.S.	0%		$0.00
TOTAL SECTION A					**$0.00**
SECTION B – ENGINEERING & SUPERVISION					
B.01	Engineering Design Services (5% of Section 2 thru 8)	L.S.	100%	L.S.	$1,050,000.00
B.02	MoT Engineering Services (2.5% of Section 2 thru 8)	L.S.	100%	L.S.	$525,000.00
B.03	MoT Project Management (5% of Section 2 thru 8)	L.S.	100%	L.S.	$1,050,000.00
B.04	MoT Construction Supervision (10% of Section 2 thru 8)	L.S.	100%	L.S.	$2,100,000.00
TOTAL SECTION B					**$4,725,000.00**
SECTION C – WORK BY OTHERS					
C.01	Hydro Relocation	Each	0.00	$400.00	$0.00
TOTAL SECTION C					**$0.00**
SECTION D – CONTINGENCIES					
D.01	Contingency for Work on Roadways (50% of Section 2 thru 8)	L.S.	100%	L.S.	$10,500,000.00
TOTAL SECTION D					**$10,500,000.00**
SUMMARY SECTIONS A – D					
	TOTAL SECTION A – PROPERTY ACQUISITION				**$0.00**
	TOTAL SECTION B – ENGINEERING & SUPERVISION				**$4,725,000.00**
	TOTAL SECTION C – WORK BY OTHERS				**$0.00**
	TOTAL SECTION D – CONTINGENCIES				**$10,500,000.00**
TOTAL OTHER COSTS					**$15,225,000.00**
TOTAL ESTIMATE					$37,485,000.00

Gabriola Island

Gabriola Bridge - Concrete Box Girder

PROJECT 653997
Conceptual Design Mar, 2015

Section Length - 4.22kms
Roadway width - 10.2m (3.6m lane, 1.5m shoulder)
Assumed new bridge over Cable Bay Trail

Item No.	Description of Work	Unit	Most Probable Quantity	Unit Price	Most Probable Extended Amount
SECTION 1 – GENERAL					
01.01	Mobilization (5.0% of Section 2 thru 8)	L.S.	100%	L.S.	$3,910,450.00
01.02	Traffic Management (0% of Section 2 thru 8) (Allowed for in Road Construction)	L.S.	100%	L.S.	$0.00
01.03	Quality Management (1.0% of Section 2 thru 8)	L.S.	100%	L.S.	$782,090.00
TOTAL SECTION 1					**$4,692,540.00**
SECTION 2 – GRADING					
02.01	**Clearing and Grubbing**				
02.01.01	Clearing and Grubbing Highway Construction	Ha	0.00	$30,000.00	$0.00
02.02	**Removals**				
02.02.01	Remove Lamp Standard	Each	0.00	$2,000.00	$0.00
02.03	**Pavement Cold Milling & Removal**				
02.03.01	Pavement Removal	Square Metre	0	$20.00	$0.00
02.04	**Roadway & Drainage Excavation**				
02.04.01	Organic Stripping - 300mm	Cubic Metre	0	$15.00	$0.00
02.04.02	Type "A" Excavation (neatline)	Cubic Metre	0	$40.00	$0.00
02.04.03	Type "D" Excavation (neatline)	Cubic Metre	0	$18.00	$0.00
02.04.04	Haul Surplus Material Offsite (factored)	Cubic Metre	0	$25.00	$0.00
02.05	**Granular Materials: Production & Placement**				
02.05.01	25mm Well Graded Base Course (WGBC)	Cubic Metre	0	$45.00	$0.00
02.05.02	Open Graded Granular Sub Base (SGSB)	Cubic Metre	0	$35.00	$0.00
02.06	**Embankment Construction**				
02.06.01	Import Material, Haul and Place into Highway Embankment	Cubic Metre	0	$20.00	$0.00
TOTAL SECTION 2					**$0.00**
SECTION 3 – DRAINAGE					
03.01	**Supply & Install**				
03.01.01	1000mm CSP 2.0 WT	Metre	0	$400.00	$0.00
03.02	**Rip Rap & End Walls**				
03.02.01	10 kg Rip Rap Outfall	Cubic Metre	0	$150.00	$0.00
03.02.02	End Wall 1000mm dia inlet with Fence and Apron	Each	0	$7,000.00	$0.00
TOTAL SECTION 3					**$0.00**
SECTION 4 – STRUCTURES					
04.01	**Supply & Install**				
04.01.01	Bridge Structure - Concrete Girder, including span and approaches	Square Metre	9,220	$8,450.00	$77,909,000.00
04.01.02	MSE Wall (sq.m face area)	Square Metre	0	$800.00	$0.00
TOTAL SECTION 4					**$77,909,000.00**
SECTION 5 – PAVING					
05.01	**Asphalt Pavement**				
05.01.01	Class 1 Medium Mix	Tonne	0	$155.00	$0.00
05.01.02	Asphalt Overlay - 50mm	m2	0	$20.00	$0.00
05.02	**Concrete Works**				
05.02.01	Concrete Curb and Gutter	Metre	0	$50.00	$0.00
05.03	**Concrete Barriers**				
05.03.01	Supply and Install CRB	Each	0	$250.00	$0.00
05.03.02	Supply and Install CMB	Each	0	$350.00	$0.00
TOTAL SECTION 5					**$0.00**
SECTION 6– SIGNING & PAVEMENT MARKING (Included in Section 4)					
06.01	**Sign Installation**				
06.01.01	Remove Existing Signs	Each	0	$200.00	$0.00
06.01.02	Supply & Install Perforated Square Steel Post and Sign Face (SP635-3.6.1)	Each	0	$400.00	$0.00
06.02	**Pavement Markings**				
06.02.01	Pavement Marking Layout	L.S.	0.00	$1,000.00	$0.00
06.02.02	Line Markings	Metre	-	$6.00	$0.00
06.02.03	Longitudinal and Transverse Pavement Markings and Arrows	L.S.	0.00	$2,000.00	$0.00
TOTAL SECTION 6					**$0.00**

Gabriola Island

Gabriola Bridge - Concrete Box Girder

PROJECT 653997
Conceptual Design Mar, 2015

Section Length - 4.22kms
Roadway width - 10.2m (3.6m lane, 1.5m shoulder)
Assumed new bridge over Cable Bay Trail

Item No.	Description of Work	Unit	Most Probable Quantity	Unit Price	Most Probable Extended Amount
SECTION 7 – ELECTRICAL					
07.01	**Electrical Materials**				
07.01.01	Lamp Standard including wiring	Each	30	$5,000.00	$150,000.00
TOTAL SECTION 7					**$150,000.00**
SECTION 8 – LANDSCAPE AND ENVIRONMENTAL					
08.01	**Landscape and Environmental**				
08.01.01	Landscaping and Environmental Requirements	L.S.	1.0	$150,000.00	$150,000.00
TOTAL SECTION 8					**$150,000.00**
SUMMARY SECTIONS 1 – 8					
	TOTAL SECTION 1 – GENERAL				**$4,692,540.00**
	TOTAL SECTION 2 – GRADING				**$0.00**
	TOTAL SECTION 3 – DRAINAGE				**$0.00**
	TOTAL SECTION 4 – STRUCTURES				**$77,909,000.00**
	TOTAL SECTION 5 – PAVING				**$0.00**
	TOTAL SECTION 6 – SIGNING & PAVEMENT MARKING				**$0.00**
	TOTAL SECTION 7– ELECTRICAL				**$150,000.00**
	TOTAL SECTION 8 – LANDSCAPE				**$150,000.00**
TOTAL CONSTRUCTION COSTS					**$82,901,540.00**
SECTION A – PROPERTY					
A.01	Acquisition, incl. Legal Survey	L.S.	0%		$0.00
TOTAL SECTION A					**$0.00**
SECTION B – ENGINEERING & SUPERVISION					
B.01	Engineering Design Services (5% of Section 2 thru 8)	L.S.	100%	L.S.	$3,910,450.00
B.02	MoT Engineering Services (2.5% of Section 2 thru 8)	L.S.	100%	L.S.	$782,090.00
B.03	MoT Project Management (5% of Section 2 thru 8)	L.S.	100%	L.S.	$782,090.00
B.04	MoT Construction Supervision (10% of Section 2 thru 8)	L.S.	100%	L.S.	$7,820,900.00
TOTAL SECTION B					**$13,295,530.00**
SECTION C – WORK BY OTHERS					
C.01	Hydro Relocation	Each	0.00	$400.00	$0.00
TOTAL SECTION C					**$0.00**
SECTION D – CONTINGENCIES					
D.01	Contingency for Work on Roadways (50% of Section 2 thru 8)	L.S.	100%	L.S.	$39,104,500.00
TOTAL SECTION D					**$39,104,500.00**
SUMMARY SECTIONS A – D					
	TOTAL SECTION A – PROPERTY ACQUISITION				**$0.00**
	TOTAL SECTION B – ENGINEERING & SUPERVISION				**$13,295,530.00**
	TOTAL SECTION C – WORK BY OTHERS				**$0.00**
	TOTAL SECTION D – CONTINGENCIES				**$39,104,500.00**
TOTAL OTHER COSTS					**$52,400,030.00**
TOTAL ESTIMATE					$135,301,570.00

APPENDIX D
BC FERRIES CAPITAL AND O&M COST DATA

BC Ferries - Capital and Operating Cost Data

Assumptions	
Discount Rate	6%
Inflation	2.1%

			CAPITAL AND REFIT IMPROVEMENTS					
Year	A: Operating Expenses[1]	NPV[2] (A)	B: Terminal Costs	NPV[2] (B)	C: Vessel MOI Refit Costs[3]	NPV[2] (C)	D: Annual Maintenance Costs[4]	NPV[2] (D)
2013	$ 6,991,000		$ -		$ -		$ -	
2014	$ 7,398,000		$ -		$ -		$ -	
2015	s.17		$ -		$ -		$ s.17	
2016			$ s.17		$ -		$	
2017			$		$ -		$	
2018			$		$ s.17		$	
2019			$		$		$	
2020			$ -		$		$	
2021			$ -		$		$	
2022			$ -		$		$	
2023			$ -		$		$	
2024			$ -		$		$	
2025			$ -		$		$	
2026			$ -		$		$	
2027			$ -		$		$	
2028			$ -		$ -		$	
2029			$ -		$ -		$	
2030			$ -		$ -		$	
2031			$ -		$ -		$	
2032			$ -		$ -		$	
2033			$ -		$ -		$	
2034			$ -		$ -		$	
2035			$ -		$ -		$	
2036			$ -		$ -		$	
2037			$ -		$ -		$	
2038			$ -		$ -		$	
2039			$ -		$ -		$	
2040			$ -		$ -		$	
2041			$ -		$ -		$	
2042			$ -		$ -		$	
2043			$ -		$ -		$	
2044			$ -		$ -		$	
		$103,478,663	s.17				$	$ 8,031,322

Base Case Capital Cost	s.17
Base Case O&M Cost	

Cost to operate ferries 2015-2019, prior to assumed opening day of potential fixed link:
s.17

Ferry O&M Cost (2015-2019) Associated with Fixed Link	s.17

Notes

1) Operating expense data was provided for 2013-2014. Given the significant uncertainties with future service levels, funding, fuel costs, etc. a detailed forecast of operating expenditures was not done. A simplifying assumption of 2.1% annual CPI adjustment has been applied.

2) Net Present Value (NPV) for operations (A) & maintenance (D) costs are computed for the evaluation period, 2020 to 2044, such that they are directly comparable to road/bridge O&M costs over the same period. NPV for terminal (B) and vessel (C) capital costs are computed for the evaluation period, 2015 to 2044.

3) MOI refers to Major Overhaul & Inspection activities, that are not considered capital expenditures under current International Financial Reporting Standards (IFRS) accounting guidelines. It is assumed that vessel replacement only occurs once (2026) during the 25-year planning horizon.

4) Annual maintenance and refit costs beyond 2027 are assumed, based on an average of the costs from 2015 to 2027.

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Withheld pursuant to/removed as

s.13;s.17