5.2 Marine Resources

5.2.1 Introduction

This Section of the Environmental Assessment Certificate (EAC) Application / Environmental Impact Statement (EIS) (hereafter referred to as the EA) has been prepared by Golder Associates Ltd. (Golder). It addresses the effects of the Proposed BURNCO Aggregate Project (hereafter referred to as the 'Proposed Project') identified in the construction, operations, and reclamation and closure phases on Valued Components (VCs) related to the marine biophysical environment. Mitigation measures are proposed to eliminate or reduce any identified adverse effects to acceptable levels and any residual effects have been characterized. Cumulative effects potentially resulting from the Project are assessed considering past, present and reasonably foreseeable future projects in combination with the residual effects of the Proposed Project.

This Section should be read in conjunction with the following documents provided in Volume 4, Part G – Section 22.0: Appendices

- Appendix 5.2-A - BURNCO Aggregate Project: Marine Biophysical Baseline Report.
- Appendix 5.2-B - BURNCO Aggregate Project: Marine Mammal Baseline Report
- Appendix 5.2-C - BURNCO Aggregate Project: Propeller Scour Assessment – Technical Memorandum
- Appendix 7.2-A - BURNCO Aggregate Project: Vessel Wake Analysis Report

5.2.2 Regulatory and Policy Setting

Table 5.2-1 provides a summary of the federal and provincial regulatory and policy settings of the Proposed Project as it relates to the marine environment.

Table 5.2-1: Regulatory and Policy Setting for Marine Resources

Legislation	Agency	Description and Application to the Project
	FEDERAL	
Navigation Protection Act R.S.C., 1985	Transport Canada	Regulates works that that may result in permanent or temporary navigational interference or hazards within navigable Canadian waters (*Navigation Protection Act* 1985).
Canadian Environmental Protection Act R.S.C., 1999	Environment and Climate Change Canada	An Act respecting pollution prevention and the protection of the environment and human health in order to contribute to sustainable development.
Fisheries Act R.S.C., 1985	Fisheries and Oceans Canada	Section 35 – Prohibits any work, undertaking or activity that results in serious harm to fish that are part of a commercial, recreational, or Aboriginal fishery, or to fish that support such a fishery. 'Serious harm to fish' is defined in Section 2 of the *Fisheries Act* as the death of fish, or permanent alteration to or destruction of fish habitat. Section 36 - Prohibits the deposit of a deleterious substance in waters frequented by fish (administered by ECCC). Section 38(4) – Duty to report provisions which require notification to an inspector, fishery office or prescribed authority, of an occurrence that results in serious harm to that are part of a commercial, recreational, or Aboriginal fishery, or to fish that supports such fishery, that is not authorized under the Act, or a serious and imminent danger of such an occurrence. Section 38(5) – Duty to report provisions which require notification to an inspector, fishery office or prescribed authority, of the deposit or imminent danger of deposit, of a deleterious substance in waters frequented by fish, and detriment to fish habitat or fish or to the use by humans of fish results ore may reasonably be expected to result from the occurrence. Section 38(6) – Duty to take all reasonable measures provisions which require that all reasonable measures consistent with safety and with the conservation of fish and fish habitat to prevent any occurrence referred to in subsection (4) or (5) or to counteract, mitigate or remedy any adverse effects that result or may reasonably be expected to result from the occurrence. The '*Deposit out of the Normal Course of Events Notification Regulations'* specify the BC Provincial Emergency Program as the 24-hr emergency telephone service for notification. The reportable levels specified in the provincial *Spill Reporting Regulation* pursuant to the *Environmental Management Act* do not necessarily define a "deleterious substance". The requirements of these sections are to be considered in the development of the Spill Response Plan (Volume 3, Part E - Section 16.0).

Legislation	Agency	Description and Application to the Project
Marine Mammal Regulations (pursuant to the *Fisheries Act*)	Fisheries and Oceans Canada	Section 7 – Prohibition against disturbing marine mammals unless fishing for them under authority of the Regulations. Section 10 – Requires a person who kills or wounds a marine mammal to make a reasonable effort to retrieve the animal and prohibits abandoning the animal.
Species at Risk Act (2002, c.29)	Environment and Climate Change Canada (formerly Environment Canada)	Protects Canadian indigenous species, subspecies, and distinct populations from becoming extirpated or extinct, provides for the recovery of endangered or threatened species, and encourages the management of other species to prevent them from becoming at-risk. To kill, harm, harass, capture or take wildlife listed as Extirpated, Endangered or Threatened is prohibited. The Act prohibits damage to residences or critical habitat of listed species and applies only on federal land with the exception of aquatic species and migratory birds listed in the federal Migratory Birds Convention Act, 1994. In some circumstances, the federal prohibitions can be applied to other species on private or provincial Crown land if it is deemed that provincial or voluntary measures do not adequately protect a species and its residence (*Species at Risk Act* 2002). Section 32 – Prohibition against killing, harming, harassing, capturing or taking an individual of a species listed as extirpated, endangered, or threatened. Section 33 – Prohibition against damaging or destroying the residence of individuals of a species listed as extirpated, endangered, or threatened.
Migratory Birds Convention Act, 1994 (S.C. 1994, c.22)	Environment and Climate Change Canada	Implements an internationally recognized convention between Canada and the United States to protect various species of migratory game birds, migratory insectivorous birds, and migratory non-game birds. This Act prohibits the deposit of substances harmful to migratory birds. The Migratory Birds Regulations and the Migratory Birds Sanctuary Regulations protect migratory birds under this Act (*Migratory Birds Convention Act* 1994). Section 5 – Prohibits the deposit by a person or vessel of a substance, or combination of substances, that is harmful to migratory birds, in waters or an area frequented by migratory birds. Prohibits the disturbance, destruction or removal of a nest or related shelter, or egg of a migratory bird, or possession of a live migratory bird, or a carcass, nest or egg of a migratory bird.
Canadian Shipping Act, 2001 (2001, c.26)	Transport Canada	Promotes marine transportation and recreational boating safety and protection of the marine environment from damage due to navigation and shipping activities (e.g., discharges) through provisions under the Act and a series of regulations and orders pursuant to the Act (e.g., the *Collision Regulation; Regulations for the Prevention of Pollution from Ships and for Dangerous Chemicals*) (*Canadian Shipping Act* 2001).

Legislation	Agency	Description and Application to the Project
Transportation of Dangerous Goods Act, 1992 (S.C. 1992, c.34)	Transport Canada	Regulates the transport of all dangerous goods in Canada, whether by rail, road, air, or water, and establishes safety standards and documentation to be complied with such that all containers, packages, and means of transport are clearly marked with prescribed safety marks. Also established requirements regarding emergency response assistance plans (*Transportation of Dangerous Goods Act* 1992).
PROVINCIAL		
Wildlife Act [RSBC 1996] Chapter 488	Ministry of Forests, Lands and Natural Resource Operations	Protects wildlife and wildlife habitat in the province by identifying wildlife areas, defining human interactions with wildlife, and regulating hunting, trapping and angling. It is an offence to capture wildlife, alter wildlife habitat, deposit substances into wildlife habitat or destroy eggs or nests under this Act (*Wildlife Act* 1996). Section 29 – prohibits attempts to capture wildlife unless authorized. Section 34 – prohibits the possession, removal, injury or destruction of a bird or its egg, or the nest when it is occupied by a bird or its egg.
Environmental Management Act [SBC 2003] Chapter 53	BC Ministry of Environment	Prohibits the introduction of waste into the environment in such a manner or quantity as to cause pollution, unless the introduction of that waste is conducted in accordance with a permit, approval, order, or regulation. EMA also has a general prohibition against causing pollution which is defined in the Act as "…the presence in the environment of substances or contaminants that substantially alter or impair the usefulness of the environment" (*Environmental Management Act* 2003).
Environmental Management Act – Hazardous Waste Regulations, 1998 [includes amendments up to B.C. Reg 63/2009, April 1, 2009]	BC Ministry of Environment	Hazardous wastes are wastes that could harm human health or the environment if not properly handled and disposed of. The Hazardous Waste Regulations include the identification, handling, transport, disposal and treatment of hazardous wastes.
Environmental Management Act – Spill Reporting Regulations, 1990 [Includes amendments up to B.C. Reg. 376/2008, December 9, 2008]	BC Ministry of Environment	The regulation defines a "spill" as an unauthorized release or discharge of a listed substance into the environment in an amount exceeding the listed quantity and specifies reporting to the Provincial Emergency Program (PEP).

Legislation	Agency	Description and Application to the Project
MUNICIPAL		
Islands Trust Council Bylaw No. 17	Islands Trust Council	Policy Statement is to establish a vision for the future of the Islands Trust Area, shared by residents of the Trust Area and of the Province generally. Achieving this vision depends on the actions of many stakeholders. The Policy Statement provides a general strategy for land use planning which translates the broad goals of the Province and the Islands Trust into specific actions to preserve and protect the Trust Area, including marine areas.

5.2.3 Assessment Methodology

This section provides a description of the assessment methodology used in preparing the Environmental Assessment Certificate Application for Marine Resources.

Please refer to Volume 2, Part B - Section 4.0: Assessment Methods for a detailed description of the assessment methodology and scope including: selection of valued components, establishing boundaries, describing existing conditions, identification of Proposed Project VC interactions, mitigation measures, evaluating residual effects and assessing cumulative effects.

5.2.3.1 Valued Component (VC) Selection and Rationale

This section describes the VCs and measureable indicators identified for this assessment related to the marine environment and provides rationale for excluding VCs. The selected VCs reflect issues and guidelines, potential Aboriginal concerns, issues identified by BC EAO and the CEA Agency, First Nations, other stakeholders, professional judgment and key sensitive resources, species or social and heritage values. VC were excluded for the following reasons:

- The candidate VC is not known to be present (based on information review) or has not been observed (based on field work) in the study areas;
- The Proposed Project does not have the potential to interact with the candidate VC; and/or
- The candidate VC is better represented by another VC or can be effectively considered within the assessment of another VC (e.g., is it already duplicated by another species, economic activity).

Additional details regarding the methods used to exclude VCs is provided in Part B, Volume 2 – Section 4.2.4.

Marine Resource VCs were selected based on the following criteria:

- Presence in the Proposed Project Area;
- Potential to be affected by the Proposed Project;
- Ecological importance – role in food chain, regionally important species in the marine environment;
- Local/regional presence of important / critical habitat requirements;

- Vulnerability to potential environmental threats;
- Availability of measurable parameters to assess Proposed Project-specific effects and cumulative effects;
- Regulatory status – federal and provincial species-at-risk (SAR) designations;
- Traditional importance to First Nations communities (i.e., subsistence, cultural or spiritual values);
- Recreational importance (i.e., sports fishing);
- Commercial and economic importance; and
- Input from government agencies.

Five broad-based Marine Resource VCs were identified for the Proposed Project using the criteria outlined above. One of the VCs (marine water quality / sediment quality) has been identified as a Pathway VC as it does not represent an assessment endpoint but rather a linkage pathway through which other VCs may be affected. A summary of identified VCs, rationale for their inclusion in the assessment, and measurable parameters and endpoints are presented in Table 5.2-2.

Table 5.2-2: Value Components and Measurable Parameters/Endpoints

Valued Component	Rationale	Measurable Parameters/Endpoints
Marine Water and Sediment Quality (Pathway VC)[1]	▪ Potential to be affected by Proposed Project activities (e.g., sediment re-suspension, siltation or accidental release of chemicals) ▪ Direct and indirect linkage to other marine VCs ▪ Directly measurable to assess effects	▪ Change in sediment quantity (particle size distribution) ▪ Change in water quality (physicochemical properties)
Marine Benthic Communities (Epifauna / Epiflora[2] and Infauna[3])	▪ Potential to be affected by Proposed Project activities (e.g., installation of marine facilities, vessel wake, propeller scour and accidental spills). ▪ Biological indicator for marine ecosystem health ▪ Potential presence of federal or provincial species-at-risk (e.g., northern abalone) or sensitive marine habitats (e.g., eelgrass)	▪ Loss of habitat ▪ Change in habitat quality ▪ Incidence of mortality
Marine Fish[4]	▪ Potential to be affected by Proposed Project activities (e.g., installation of marine infrastructure) ▪ Important food source for other key marine species ▪ Potential presence of sensitive marine habitats in Howe Sound (e.g., herring spawning grounds) ▪ Commercial, social, cultural and ecological importance in Proposed Project Area	▪ Loss of habitat ▪ Change in habitat quality ▪ Incidence of Injury/Mortality

---

[1] Pathway components are identified when the component does not represent an assessment endpoint but a pathway through which other VCs may be affected.

[2] Marine vegetation and invertebrates that live on, or near the surface, of marine substrate.

[3] Marine organisms living within marine substrate (e.g., burrowing invertebrates).

[4] Marine fish include all marine forage fish and predator fish excluding anadromous fish such as salmonids which are assessed separately in the Fisheries and Freshwater Habitat assessment (Volume 2, Part B - Section 5.1),

Valued Component	Rationale	Measurable Parameters/Endpoints
Marine Mammals	▪ Potential to be affected by Proposed Project activities (e.g., potential ship strikes and underwater noise disturbance from vessel movements and terminal construction). ▪ Biological indicator for marine ecosystem health ▪ Potential presence of federal or provincial species-at-risk ▪ Social, cultural and ecological importance in Proposed Project Area	▪ Incidence of Injury/Mortality ▪ Change in behavior ▪ Change in prey availability
Marine Birds	▪ Potential to be affected by Proposed Project activities (e.g., potential sensory disturbance due to site lighting and construction / operational noise, potential physical interference with infrastructure). ▪ Biological indicator for marine ecosystem health ▪ Potential presence of federal or provincial species-at-risk ▪ Migratory species protected by legislation ▪ Social, cultural and ecological importance in Project Area	▪ Incidence of Injury/Mortality ▪ Change in behavior ▪ Change in prey availability

One candidate marine resources VC was identified for the Proposed Project but was excluded from the assessment based on the criteria outlined above. A summary of the candidate VC and rationale for its exclusion in the assessment is presented in **Table 5.2-3**.

Table 5.2-3: Rationale for the Exclusion of Valued Components: Marine Resources

Issue	Candidate VCs	Rationale for Exclusion
Marine Resources	Northern Abalone	No known occurrences of Northern abalone occur within the Proposed Project Area. This is based on a desktop review (SARA registry, BC Conservation Data Centre) and a review of habitat suitability in the area. The desktop review was confirmed by dive and underwater video survey. In addition, abalone are considered part of the marine benthic community, therefore potential effects assessed under this more general umbrella will cover potential effects on this specific species.

5.2.3.2 Assessment Boundaries

5.2.3.2.1 Spatial Boundaries

The spatial boundaries for the EA have been selected to take into account the physical extent of the Proposed Project, the physical extent of Proposed Project-related effects and the physical extent of any key environmental systems. The specific study areas for the Marine Resources component are provided in Table 5.2-4.

Table 5.2-4: Spatial Boundaries

Study Area	Description
Local Study Area (LSA)	Intertidal and subtidal areas within the Proposed Project footprint including the proposed marine terminal facilities in Thornbrough Channel (barge load-out jetty and walkway, conveyor, mooring buoy) and 500 m buffer on either side of the shipping route in Howe Sound from the Proposed Project through Ramillies, Thornbrough and Queen Charlotte channels (Figure 5.2-1).
Regional Study Area (RSA)	Howe Sound up to the mouth of the Squamish River including the shipping route from the Proposed Project through Ramillies, Thornbrough and Queen Charlotte channels (Figure 5.2-1).

5.2.3.2.2 Temporal Boundaries

Based on the Proposed Project schedule, the temporal boundaries for the Marine Resources effects assessment is as follows:

- Proposed Project construction – up to 2 years;
- Proposed Project operations – 16 years; and
- Proposed Project reclamation and closure – ongoing and one year beyond operations.

For a full description of the temporal boundaries of the Proposed Project please refer to Volume 2, Part B - Section 4.0.

5.2.3.2.3 Administrative Boundaries

No administrative boundaries are applicable to Marine Resources VCs.

5.2.3.2.4 Technical Boundaries

Technical Boundaries for the EA include seasonal effects which may not be fully captured by field surveys conducted for this assessment as well as species presence, absence or abundance for which the spatial and/or temporal scope of field surveys may not have fully captured the entire range of species distributions within the LSA.

5.2.3.3 Assessment Methods

5.2.3.3.1 Existing Conditions

A comprehensive literature review was completed to characterize the existing environment in and adjacent to the Proposed Project Area and provided in in Volume 4, Part G – Section 22.0: Appendix 5.2-A and 5.2-B.

Sources of information included, but were not limited to, the following:

- Available grey literature and scientific publications for the Proposed Project Area;
- Governmental and non-governmental reports and environmental resource databases;
- Regional fisheries information available from Fisheries and Oceans Canada (DFO), including fisheries catch statistics (annual catch data) and DFO's fish and fish habitat electronic databases (e.g., Mapster);
- British Columbia Cetacean Sightings Network (BCCSN);
- Previous marine-based investigations and research programs, environmental resource surveys, and environmental reports completed in the Proposed Project Area including, but not limited to DFO's Cetacean Research Program (population and distribution studies);
- A review of existing provincial and federal species-at-risk databases, including the provincial Species-At-Risk BC database, COSEWIC's Wildlife Species Search Registry, and the federal SARA Registry including any relevant species recovery plans, action plans or species update reports;
- Previous marine-focused environmental reports completed within the Proposed Project Area (as available in the public domain);
- Consultation with applicable regulatory agencies and individual/groups with knowledge of the local area;
- Traditional Ecological Knowledge (TEK) of culturally important marine resources, marine habitat areas, and subsistence hunting and fishing areas in the Proposed Project Area; and
- Canadian Environmental Assessment Agency (The CEA Agency) Guidelines for Environmental Impact Assessment.

Seasonal field studies were completed to characterize existing conditions within the LSA. This included:

- Biophysical surveys along three shore-perpendicular transects extending from the upper intertidal to the shallow subtidal zone within the Proposed Project Area (August 2012);
- Underwater towed video survey in the Proposed Project Area (August and November 2012);
- In situ measurements of marine water quality in the Proposed Project Area and a Reference area (June, August, September and November 2012);
- Marine phytoplankton and zooplankton sampling in the Proposed Project and Reference area (June and August 2012);
- Marine sediment sampling in the Proposed Project and Reference area for subsequent physicochemical analyses and taxonomic analysis of infauna (August 2012);
- Marine bird identification along the Proposed Project foreshore (spring, summer, fall and winter) from 2009 to 2012; and
- Nearshore fish sampling using beach seine techniques (May to October 2011).

Field sampling design was consistent with the following guidelines and methodologies where applicable:

- Water and Air Baseline Monitoring Guidance Document for Mine Proponents and Operators (BC MoE 2012a);
- Marine Foreshore Assessment Procedure (DFO 2013a);
- Metal Mining Technical Guidance for Environmental Effect Monitoring (Environment Canada (EC) 2012);
- British Columbia Field Sampling Manual (BC MoE 2003d); and
- Pulp and Paper Environmental Effect Monitoring (EEM) Technical Guidance Document (EC 2010).

5.2.3.3.2 Identifying Project Interactions

A preliminary evaluation of identified interactions between the various physical works and activities and the selected VCs was undertaken to allow the assessment to be focused on those Proposed Project-VC interactions of greatest importance. Potential Project-VC interactions were characterized as follows:

a) Positive, none or negligible, requiring no further consideration; or

b) Potential interaction resulting in an effect requiring further consideration and possibly additional mitigation.

The evaluation of potential Project-VC interactions is presented in Section 5.2.5.1. A rationale is provided for each determination whether there is no interaction or negligible interaction, which would indicate that no further consideration is required. For those Proposed Project-VC interactions that may result in potential effects requiring further consideration, the nature of the effects (both adverse and/or positive) arising from those interactions are described. Potential effects include direct, indirect and induced effects.

As a first stage in the EA process, activities during all stages of the Proposed Project (construction, operations and reclamation and closure phases) were examined to identify those activities most likely to interact with the receiving environment and resulting in potential effects. An assessment of Proposed Project-VC interactions was based on a comprehensive review of the literature, an appraisal of the environmental setting, information provided by the Proponent including a summary of Proposed Project activities and professional judgment.

In addition, as part of initial consultations with regulatory agencies during Proposed Project planning, Fisheries and Oceans Canada (DFO) conducted an internal review of the Proposed Project and of a series of technical reports provided by Golder regarding the Proposed Project in October 2010. A report was provided by DFO to BURNCO Rock Products Ltd. on March 7, 2011 with the results of the review. The assessment of Proposed Project interactions considered the findings presented in the DFO report.

Assessed Project activities included planned and unplanned (accidental) events. Proposed Project-VC interactions considered in the effects assessment are identified in Section 5.2.5. Proposed Project activities with no potential Proposed Project-Environment interaction were not considered any further in the assessment.

5.2.3.3.3 Evaluating Residual Effects

Potential Proposed Project-related residual effects were characterized as the basis for determining the significance of potential residual adverse effects for each VC. The characterization of effects was undertaken following application of appropriate mitigation measures.

Potential residual effects were characterized using the following standard residual effects criteria:

- **Context** – the current and future sensitivity and resilience of the VC to change caused by the Proposed Project;
- **Magnitude** – the expected size or severity of the residual effect;
- **Extent** – the spatial scale over which the residual physical, biological and/or social effect is expected to occur;
- **Duration** – the length of time the residual effect persists;
- **Reversibility** - indicating whether the effect is reversible, partially reversible, or permanent; and
- **Frequency** – how often the residual effect occurs.

The criteria defined in Table 5.2-5 have been used to characterise and determine the significance of potential effects of Marine Resources VCs.

Where possible, definitions have taken into account the technical guidance that has been produced. The following documents are considered to be relevant to Marine Resources:

- British Columbia Water Quality Guidelines: 2006 Edition (BC MoE 2006);
- Canadian Environmental Quality Guidelines (CCME 2013);
- Best Management Practices for Pile Driving and Related Operations (DFO 2003);
- Policy for the management of fish habitat (DFO 1986);
- B.C. and Yukon Marine / Estuarine Timing Windows (DFO 2010);
- Shoreline Structures Environmental Design: A Guide For Structures Along Estuaries and Large Rivers (Adams 2002);
- Metal Mining Technical Guidance for Environmental Effect Monitoring (Environment Canada 2012); and
- NOAA Fisheries, West Coast Region. Interim Sound Threshold Guidance (NOAA 2014).

Please refer to Volume 2, Part B - Section 4.0: Assessment Methods of this EA. for a description of the criteria used to characterise potential effects for all disciplines.

The likelihood of potential residual effects occurring was also characterized for each VC using appropriate quantitative or qualitative terms. To derive a likelihood rating that indicates the probability of a certain effect to occur, implementation of mitigation measures were considered. For example, the likelihood of a certain effect is low, if there is a low potential of the event leading to the effect to occur, or if there are effective controls in place that can eliminate or reduce the magnitude of frequency of the effect. The following criteria were used to define likelihood:

- Low - likelihood of occurrence (0 to 40%) – Residual effect is possible but unlikely;
- Medium - likelihood of occurrence (41 to 80%) - Residual effect may occur, but is not certain to occur; and
- High - Likelihood of occurrence (81% to 100%) - Residual effect is likely to occur or is certain to occur.

5.2.3.3.4 Evaluating Significance of Residual Effects

The significance of potential residual adverse effects on marine resources was determined based on residual effect criteria and the likelihood of a potential residual effect occurring described in Section 5.2.3.3.3, a review of background information and available field study results, consultation with government agencies and other experts, and professional judgement. The significance of predicted residual effects of the Proposed Project on marine resources was characterized as negligible (and not significant), not significant or significant.

- **Negligible (and not significant).** Negligible residual effects are either not measurable, within the range of natural variability, or so small they may be safely disregarded. They do not warrant further consideration and are not carried forward into a cumulative effects assessment.
- **Not Significant.** Residual effects may be characterized as not significant if they are determined to be measurable but do not exceed established environmental standards, guidelines, or objectives and/or are not beyond the natural variability of the environmental conditions and/or are not likely to result in substantial changes to the viability of aquatic health (i.e., the ability of the population, ecosystem or community to work and function over time within the defined spatial and temporal boundary).
- **Significant.** Residual effects may be characterized as significant if there is a reasonable expectation that the effect of the Proposed Project would:
  - Exceed established environmental standards, guidelines, or objectives;
  - Be beyond the natural variability of existing environmental conditions; and/or
  - Affect the viability of self-sustaining populations (i.e., the ability of the population, ecosystem or community to maintain their ecological function within the defined spatial and temporal boundary).

The rationale and determination of the significance of potential residual effects on marine resources are provided in Section 5.2.5.4. All non-negligible residual adverse effects (i.e., significant and non-significant) will be considered for inclusion in a cumulative effects assessment.

5.2.3.3.5 Level of Confidence

The level of confidence for each predicted effect is discussed to characterize the level of uncertainty associated with both the significance and likelihood determinations. Level of confidence is, in general, a degree of certainty that the likelihood or the consequence rating of the assessment reflects the reality. Level of confidence is typically based on expert judgement and is characterized as:

- Low: Limited evidence is available, models and calculations are highly uncertain, and/or evidence about potential effects is contradictory.
- Moderate: Sufficient evidence is available and generally supports the prediction.
- High: Sufficient evidence is available and most or all available evidence supports the prediction.

Level of confidence is based on the knowledge that the certain Proposed Project planned activities, design configurations, or mitigation measures take place. Level of confidence also takes into the account existing environmental conditions and degrees of ecosystem variability.

Table 5.2-5: Criteria for Characterizing Potential Residual Effects: Marine Resources

VC	Context	Magnitude	Extent	Duration	Reversibility	Frequency
Marine Water and Sediment Quality	**Resilient:** The system has low susceptibility to potential changes caused by the Proposed Project; **Moderately Resilient:** The system has moderate susceptibility to potential changes caused by the Proposed Project; or **Sensitive:** The system is susceptible to potential changes caused by the Proposed Project.	**Negligible:** Proposed Project will have no measurable effect; **Low:** Proposed Project will result in changes in water and sediment quality parameters that will not exceed Canadian or BC guidelines or baseline conditions; **Medium:** Proposed Project will result in localized contamination above the established sediment quality criteria or water quality guidelines by less than 10 times; or **High:** Proposed Project will result in widespread contamination in excess of established sediment quality criteria or water quality guidelines by more than 10 times.	**Local:** Effect restricted to LSA; **Regional:** Effect extends beyond the LSA into the RSA; or **Beyond Regional:** Effect extends beyond the RSA.	**Short-term**: <1 year; **Medium-term**: 1 Year to life of Proposed Project; or **Long-term**: >life of Proposed Project.	**Fully reversible:** Effect reversible with reclamation and/or over time; **Partially Reversible:** Effect can be reversed partially; or **Irreversible:** Effect irreversible and cannot be reversed with reclamation and/or over time.	**Low:** Occurs rarely or during a specific period; **Medium:** Occurs intermittently; or **High:** Occurs continuously.

VC	Context	Magnitude	Extent	Duration	Reversibility	Frequency
Marine Benthic Communities	**Resilient:** The system has low susceptibility to potential changes caused by the Proposed Project; **Moderately Resilient:** The system has moderate susceptibility to potential changes caused by the Proposed Project; or **Sensitive:** The system is susceptible to potential changes caused by the Proposed Project.	**Negligible:** Proposed Project will have no measurable effect on abundance and diversity; **Low:** Proposed Project will result in measureable changes above background conditions but are within the scope of natural variability and do not exceed scientific threshold level (±2SD); **Medium:** Proposed Project will result in detectable changes above baseline conditions exceeding the threshold level but the effect is not expected at population level; or **High:** Proposed Project will result in detectable changes above background conditions, exceeding the threshold levels with effects potentially occurring at population level.	**Local:** Effect restricted to LSA; **Regional:** Effect extends beyond the LSA into the RSA; or **Beyond Regional:** Effect extends beyond the RSA.	**Short-term**: <1 year; **Medium-term**: 1 Year to life of Proposed Project; or **Long-term**: >life of Proposed Project.	**Fully reversible:** Effect reversible with reclamation and/or over time; **Partially Reversible:** Effect can be reversed partially; or **Irreversible:** Effect irreversible and cannot be reversed with reclamation and/or over time.	**Low:** Occurs rarely or during a specific period; **Medium:** Occurs intermittently; or **High:** Occurs continuously.

VC	Context	Magnitude	Extent	Duration	Reversibility	Frequency
Marine Fish	**Resilient:** The system has low susceptibility to potential changes caused by the Proposed Project; **Moderately Resilient:** The system has moderate susceptibility to potential changes caused by the Proposed Project; or **Sensitive:** The system is susceptible to potential changes caused by the Proposed Project.	**Negligible:** Proposed Project will have no measurable effect on fish and fish habitat **Low:** Proposed Project will result in measureable changes above background conditions but are within the scope of natural variability. **Medium:** Proposed Project will result in detectable changes in population or occasional or temporary disruption of critical activities (e.g., breeding, foraging); and/or localized damage to spawning or rearing habitats. **High:** Proposed Project will result in detectable changes above background conditions, exceeding the threshold levels with effects potentially occurring at population levels, and/or extensive disruption of critical activities or damage to important habitats.	**Local:** Effect restricted to LSA; **Regional:** Effect extends beyond the LSA into the RSA; or **Beyond Regional:** Effect extends beyond the RSA.	**Short-term**: <1 year; **Medium-term**: 1 Year to life of Proposed Project; or **Long-term**: >life of Proposed Project.	**Fully reversible:** Effect reversible with reclamation and/or over time; **Partially Reversible:** Effect can be reversed partially; or **Irreversible:** Effect irreversible and cannot be reversed with reclamation and/or over time.	**Low:** Occurs rarely or during a specific period; **Medium:** Occurs intermittently; or **High:** Occurs continuously.

VC	Context	Magnitude	Extent	Duration	Reversibility	Frequency
Marine Birds	**Resilient:** The system has low susceptibility to potential changes caused by the Proposed Project; **Moderately Resilient:** The system has moderate susceptibility to potential changes caused by the Proposed Project; or **Sensitive:** The system is susceptible to potential changes caused by the Proposed Project.	**Negligible:** Proposed Project will have no measurable effect. **Low:** Proposed Project will result in localized changes in behaviour or changes in habitat quality that can be monitored and measured above background conditions, but are within the scope of the natural variability, do not exceed established criteria or scientific threshold levels, and do not meet any of the 'medium' or 'high' magnitude definitions. **Medium:** Proposed Project will result in in one or more of the following: 1) localized contamination of habitat in excess of water or sediment quality standards, guidelines or baseline conditions – less than 10 times; 2) ≥1 death or injury of a VC species; or, 3) Occasional or temporary disruption of critical activities (e.g., breeding, nursing); and/or localized damage to sensitive habitats.	**Local:** Effect restricted to LSA; **Regional:** Effect extends beyond the LSA into the RSA; or **Beyond Regional:** Effect extends beyond the RSA.	**Short-term**: <1 year; **Medium-term**: 1 Year to life of Proposed Project; or **Long-term**: >life of Proposed Project.	**Fully reversible:** Effect reversible with reclamation and/or over time; **Partially Reversible:** Effect can be reversed partially; or **Irreversible:** Effect irreversible and cannot be reversed with reclamation and/or over time.	**Low:** Occurs rarely or during a specific period; **Medium:** Occurs intermittently; or **High:** Occurs continuously.

VC	Context	Magnitude	Extent	Duration	Reversibility	Frequency
		High: Proposed Project is likely to result in one or more of the following: 1) Widespread degradation of habitat in excess of water or sediment quality standards, guidelines or baseline conditions – more than 10 times; 2) ≥1 death or injury of a SARA, Blue or Red -listed species; or, 3) extensive disruption of critical activities or damage to sensitive habitats				

VC	Context	Magnitude	Extent	Duration	Reversibility	Frequency
Marine Mammals	**Resilient:** The system has low susceptibility to potential changes caused by the Proposed Project; **Moderately Resilient:** The system has moderate susceptibility to potential changes caused by the Proposed Project; or **Sensitive:** The system is susceptible to potential changes caused by the Proposed Project.	**Negligible:** Project will have no measurable effect. **Low:** Project will result in localized changes in behaviour or in habitat quality that can be monitored and measured above background conditions, but are within the scope of natural variability, do not exceed established criteria or scientific threshold levels, and do not meet any of the 'medium' or 'high' magnitude definitions. **Medium:** Project will result in in one or more of the following: 1) localized contamination of habitat in excess of water or sediment quality standards, guidelines or baseline conditions – less than 10 times; 2) ≥1 death or injury of a VC species; or, 3) Occasional or temporary disruption of critical activities (e.g., breeding, nursing); and/or localized damage to sensitive habitats.	**Local:** Effect restricted to LSA; **Regional:** Effect extends beyond the LSA into the RSA; or **Beyond Regional:** Effect extends beyond the RSA.	**Short-term**: <1 year; **Medium-term**: 1 Year to life of Proposed Project; or **Long-term**: >life of Proposed Project.	**Fully reversible:** Effect reversible with reclamation and/or over time; **Partially Reversible:** Effect can be reversed partially; or **Irreversible:** Effect irreversible and cannot be reversed with reclamation and/or over time.	**Low:** Occurs rarely or during a specific period; **Medium:** Occurs intermittently; or **High:** Occurs continuously.

VC	Context	Magnitude	Extent	Duration	Reversibility	Frequency
		High: Project is likely to result in one or more of the following: 1) Widespread degradation of habitat in excess of water or sediment quality standards, guidelines or baseline conditions – more than 10 times; 2) ≥1 death or injury of a Sara, Blue or Red -listed species; or, 3) extensive disruption of critical activities or damage to sensitive habitats				

5.2.4 Baseline Conditions

Baseline conditions for marine resources were characterized through a comprehensive literature review supplemented by site-specific field studies conducted between 2009 and 2012. This section presents a summary of marine resource baseline data collected in the Proposed Project Area, including an overview of existing conditions for marine sediment, marine water quality, plankton, benthic communities (epifauna/epiflora/infauna), marine fish, marine birds and marine mammals. Detailed baseline information, including mapping of ecologically sensitive areas (e.g., eelgrass), is presented in the marine resources technical baseline report (Volume 4, Part G – Section 22.0, Appendix 5.2-A) and the marine mammal technical baseline report (Volume 4, Part G – Section 22.0, Appendix 5.2-B) of this EA.

5.2.4.1 Traditional Ecological and Community Knowledge Incorporation

Traditional ecological and community knowledge (TEK/CK) information was gathered from a Project-specific study undertaken by *Sḵwx̱wú7mesh* (Squamish Nation) and from publicly-available sources. The TEK/CK information available at the time of writing was used to inform existing conditions and this effects assessment.

TEK/CK informed BURNCO's understanding of marine resources. The main sources of this information include:

- Occupation and Use Studies (OUS) undertaken by *Sḵwx̱wú7mesh* (Traditions 2015 a,b)
- An expert report produced on behalf of Tsleil-Waututh Nation for another project (Morin 2015)
- Regulatory documents for other projects in close proximity to the Proposed Project Area (e.g., Eagle Mountain – WGP 2015 a,b; PMV 2015; WLNG 2015).

For a full summary of Aboriginal Group use and occupancy of Howe Sound refer to Part C of this Application.

TEK/CK sources available at the time of writing provided limited specific information on harvest locations, abundance or quality of marine resources, or other environmental knowledge regarding marine resources in the RSA, including changes to these resources over time. Following is a general discussion of Aboriginal Groups' harvesting of marine resources within Howe Sound.

Sḵwx̱wú7mesh report Howe Sound as an important area for harvesting marine resources, including, but not limited to, fish, marine invertebrates and marine mammals. Marine fish harvested include eulachon, herring, smelt, lingcod, rockfish, sturgeon, perch and flounder. Marine invertebrates include sea urchins, crabs, clams, mussels, cockles and scallops (SN 2001). Marine mammals harvested include harbour porpoises, harbour seals and sea lions (AMEC 2010; SN 2001).

Kw'ech'tenm, a village site on McNab Creek, was a significant resource area for S*ḵwx̱wú7mesh* ancestors. The name *kw'ech'tenm* means fish cutting, which may also refer to the north side of the valley being the source location for the slate that was used to make fish cutting knives. A variety of aquatic resources were harvested in the waters surrounding McNab Creek and throughout Thornbrough Channel (Traditions 2015 a,b).

S<u>k</u>w<u>x</u>wú7mesh report that industry has adversely affected marine life in Howe Sound. *S<u>k</u>w<u>x</u>wú7mesh* also reports that there has been a revitalization in marine life over the last ten years. For example, a commercial pink salmon fishery opened in 2013, herring abundance has returned with large predators following, and sightings of whales and dolphins continue to increase. *S<u>k</u>w<u>x</u>wú7mesh* also notes that the health of the water and animals is improving. The abundance and health of marine resources has also led to a recent revitalization of harvest by *S<u>k</u>w<u>x</u>wú7mesh stelmexw* (Traditions 2015b).

S*<u>k</u>w<u>x</u>wú7mesh* previously report harvesting a total of twenty bird species, including, but not limited to, red throated loons, geese, grebes, and ducks (surf scooters, mallards, mergansers) (Eagle Mountain – WGP 2015b, Kennedy and Bouchard 1976b in Millennia 1997, SN 2001). Gulls were harvested throughout Howe Sound and the upper end of Howe Sound was identified as a place to harvest gull eggs (Kennedy and Bouchard 1976b in Millennia 1997).

Tsleil-Waututh Nation reports that there are several locations for fishing and harvesting marine invertebrates in Howe Sound. Tsleil-Waututh identify a large part of Howe Sound to be a priority prawn harvesting area (WLNG 2015).

Tsleil-Waututh Nation reports harvesting waterfowl throughout Howe Sound at locations where larger flocks gather (Eagle Mountain – WGP 2015b; WLNG 2015).

5.2.4.2 Marine Substrate and Sediment Quality

The intertidal zone in the Project Area consists of a gradual sloping beach (~7 to 12°) extending seaward from the Higher High Water Level (HHWL) to the Lower Water Level (LWL) over a linear distance of ~150 m. Substrate in the intertidal was comprised mainly of cobble and gravel which collectively made up between 50% of 100% of the substrate in this zone. Boulders were mostly distributed in the upper intertidal areas of the Project site constituting less than 5% of the areal coverage, except for near Transect 3 where boulders, in combination with cobble and bedrock, form a rocky outcrop in the lower intertidal / upper subtidal zone. Sand and silt were evenly distributed throughout the intertidal zone (from 25% to 50% coverage), except for the bedrock outcrop near Transect 3. Shell fragments were also present mostly in the lower littoral segments, with 80% cover in some locations.

In the subtidal zone, the seafloor drops off fairly rapidly. A gentler slope presides towards the west of the water lot (~20° slope on Transect 2) with a steeper gradient slope present in the eastern margin of the water lot (~40° slope on Transect 3; reaching a depth of -17 m CD at less than 60 m linear distance from the LWL). Soft sediment (sand and silt) is the dominant substrate type in the shallow subtidal segments of Transects 1 and 2 with sand dominating the upper level (from 0 to ~-2 m) and silt dominating the lower level (from -2 to -5.5 m). Hard substrate (boulders and cobble) dominate the upper subtidal area of Transect 3 up to a depth of -3.4 m at which point the substrate transitions to silt-dominated soft sediment.

Historical log handling activities in the subtidal zone of the Project Area have resulted in extensive carpeting of the seafloor with wood and bark debris, particularly in the western portions of the water lot (~100% coverage along Transects 1 and 2 and ~50% coverage along Transect 3). The accumulation of wood debris increases with depth (distance offshore), extending to an unknown distance beyond the depth limits of the dive survey (-17.1 m CD). In shallower waters, the wood debris is mixed with sand. Towards the eastern margin of the water lot, the layer of woody debris tapers off approximately 150 m east of Transect 3. Other physical features that were observed in the subtidal zone at the site include a semi-submerged abandoned dock located at the Project foreshore and fragments of cable and other miscellaneous metal debris scattered on the seafloor, particularly on the log dump debris substrate. Marine sediment quality in the subtidal footprint of the Project site is indicative of prolonged decomposition of wood debris which has altered the physicochemical characteristics of the natural substrate. Sediment in this area is characterized by a higher content of silt-clay fractions, TOC, trace metals and PAHs. Exceedances of SQG were recorded for certain trace metals including arsenic, cadmium, copper and zinc; although AVS-SEM results suggest that metals are largely insoluble (low biological availability). Exceedances of SQG were also observed for a number of PAHs (mostly by less than a factor of 2).

5.2.4.3 Marine Water Quality

Water quality depth profiles and discrete water quality samples were collected during sampling events in July, August and September of 2012. Water quality depth profiles were collected at five stations (three in Project Area; two in the Reference area) with an YSI 6600 water quality sonde to measure temperature, specific conductivity, salinity, pH, dissolved oxygen (DO), turbidity, and chlorophyll a. Stratification of the water column was evident in June and August – likely influenced by freshwater discharge and temperature events during summer. In June, stratification appeared mostly driven by a vertical salinity gradient between the relatively freshwater surface (2.1 ‰ and 3 ‰) and more saline bottom water (27.1 ‰ at 13 m). A halocline was observed between -3 m and -8 m depth (CD). The temperature gradient between the surface (13°C) and bottom (8.8°C) was weaker than the salinity gradient; with a thermocline (layer with rapid change in temperature) occurring between -7 and -8 m. In August, vertical density stratification was stronger, driven by both temperature and salinity gradients. The temperature gradient between the surface (22.9°C) and bottom (10.8°C) and the thermocline were more prominent in August than June. Salinity at deep-water station MCM1 was 5.6‰ at the surface and 27.1‰ at the bottom (-13 m). Both the thermocline and halocline observed in August were shallower (-1 m and -6 m CD, respectively) than those observed in June.

Vertical profiles conducted in September (up to -5 m depth) and November (up to -2.5 m depth) demonstrated that the water column (particularly the upper layer) was more mixed in terms of salinity and temperature than in June and August. In September, surface water was more saline than in June and August (salinity at the surface ranged from 15.3 ‰ to 19.4 ‰), which, most likely, resulted from reduced levels of freshwater discharge due to lower than normal precipitation rates during the summer months of 2012. Field measurements and estimates based on the laboratory conductivity analysis from discrete water quality samples suggested that sharper changes in salinity occurred within the upper 4 to 5 m and were more gradual at depths below 5 m. The temperature gradient within the upper 5 m of the water column was less than 1°C.

Salinity in the upper water column was highest in November and relatively well-mixed. A thin freshwater plume was present at the surface at some stations near the mouth of McNab Creek and the foreshore inlets, although this only extended a limited distance offshore. Surface salinity ranged from 2.2 ‰ to 21.1 ‰; with lower salinity values at the surface extending no deeper than -1 m. Surface temperature in November was lower than deeper water, most likely due to the influence of a freshwater lens at the surface.

Discrete water quality samples were also collected at five stations (three in Project Area; two in the Reference area) with a Niskin bottle. Samples were collected at two depth intervals for stations with water depths >10 m, as follows: surface (<1m) and mid-column (1 m below the pycnocline). At stations with water depths <10 m, only one depth interval (surface) was collected. Discrete water samples were analyzed for metals, hydrocarbons (PAH, LEPH/HEPH), PCBs, major anions and nutrients, total organic carbon (TOC), conductivity, salinity, total dissolved solids (TDS), turbidity, acidity, alkalinity, hardness and pH.

In general, levels of potential contaminants in the water samples were shown to be low. Exceedances of BC WQG were limited to boron in several samples from the Project Area; as well as for boron, copper and zinc in at least one sample from the Reference area. Detectable concentrations of PAHs were found in one water sample collected from the mouth of McNab Creek in September. Extractable petroleum hydrocarbons (EPH) and PCBs were not detected in any water quality samples.

The upper water column was shown to be nutrient poor with nitrogen being the limiting nutrient. Nitrogen in water was mostly in the form of organic nitrogen and ammonia; nitrite was not detected and nitrate was below the detection limit in all but two samples. Ammonia was detected in six out of 20 samples (two out of four in June, one out of eight in August and two out of eight in September). In contrast to nitrogen; levels of phosphorus were high, particularly in near-bottom samples. The vertical density stratification resulted in a higher concentration of nutrients accumulating in the lower water column below the thermocline.

5.2.4.4 Plankton

5.2.4.4.1 Phytoplankton and chlorophyll a

Phytoplankton and chlorophyll a samples were collected during daylight hours in June (two stations) and August 2013 (three stations) using a Niskin bottle deployed at 0.5 m below the surface. Secchi depths were also measured to provide an estimate of water clarity and for the calculation of the depth of the euphotic zone[5].

Secchi depth results indicated low levels of total suspended solids (TSS) in the water column, with euphotic depth exceeding water column depth at the point of measurement. The overall high transparency of the water suggested there was adequate light to support local phytoplankton growth throughout the water column and macroalgal growth on the seafloor. Phytoplankton biomass was shown to be higher in June (mean chlorophyll a biomass values at two Project Area stations were 2.6 and 3.2 µg/L), when the density stratification was weaker, corresponding to lower eutrophic-higher mesotrophic status of marine ecosystems according to the Trophic Index for Marine Systems (TRIX). In August, when a strong thermocline formed, biomass was shown to decrease (mean chlorophyll a biomass values at two Project Area stations were 1.2 µg/L and 1.5 µg/L), corresponding to lower mesotrophic status of marine ecosystems. Phytoplankton species diversity also decreased in August when phytoplankton communities consisted almost entirely of diatoms (based on cell density).

5.2.4.4.2 Zooplankton

Zooplankton tow samples (vertical and oblique horizontal) were collected during daylight hours in August 2013 (three stations) using a 250-µm mesh net (0.5-m diameter mouth). Zooplankton community structure in the Project Area varied with salinity. The zooplankton community at the lower-salinity shallower station (MCM2) consisted

[5] depth to which sufficient light exists for net photosynthesis to occur

mostly of cladocerans (74%), while communities at the deeper and more saline stations (MCM1 and BMREF1) were shown to be more diverse and dominated by calanoid and cyclopoid copepods.

5.2.4.5 Benthic Communities

5.2.4.5.1 Epiflora and Epifauna

Marine epiflora and epifauna were characterized along three shore-perpendicular transects in the intertidal and subtidal areas of the Project site during August 2012. This was supplemented by observational data collected during towed underwater video surveys conducted along the shoreline between the -3 and -25 m depth contours during June and November 2012 sampling events.

Epifaunal and epifloral distribution along the intertidal transects demonstrated obvious vertical zonation. Green algae (sea lettuce: *Ulva intestinalis*) was abundant in the mid and upper littoral areas of Transects 1 and 2 (with coverage up to 75%). Brown algae, including fringed sea colander kelp (*Agarum fibriatum*), *Laminaria* sp. and unidentified filamentous brown algae, were present in the lower intertidal and upper subtidal transect segments.

Epifauna in the intertidal zone consisted primarily of sessile invertebrate taxa, such as barnacles, mussels and oysters. Barnacles were distributed throughout the entire intertidal zone covering up to 50% of substrate in some areas. Mussels were abundant between the mid-intertidal to the LLW, ranging in density from “many” (11 to 100 individuals per quadrat) to “abundant” (> 100 per quadrat). Oysters were less abundant and were sparsely distributed from the mid-intertidal to the LWL, ranging in density from “few” (two to 10 individuals per quadrat) to “many” (11 to 100 per quadrat). A single clam siphon hole was also observed in the soft substrate in lower intertidal segment.

Epiflora and epifauna communities were mostly determined by available substrate type in the Project Area, categorized as either ‘hard substrate’, ‘soft substrate’ or ‘woody debris zone’. Highest species density/diversity occurred in hard substrate habitat, dominated primarily by sessile organisms (barnacles, mussels and oysters) particularly in the shallower areas. Sessile cnidarians, including anemones and soft corals, were observed at the eastern extremity of the water lot along the exposed bedrock shore. Sea lettuce, *Laminaria* sp. and rockweed were the common macroalgal taxa associated with this habitat type. Soft substrate habitat supported low to moderate occurrences of motile invertebrates such as sea stars and sea cucumbers along with observations of sessile anemones and burrowing clams (based on the presence of siphon holes). Macroalgae associated with soft substrate habitat in the Project Area included brown algae (*Laminaria* sp. and *Alaria marginata*) and red algae (*Ceramium pacificum*). The woody debris zone supported the lowest density and diversity of epibenthic species in the Project Area. Epifauna in this zone included sparse occurrences of echinoderms (mottled star, sunflower star, sun star and giant sea cucumber) and several plumose anemones. Vegetation in the woody debris zone was sparse and consisted mostly of *Laminaria* sp.

5.2.4.5.2 Benthic Infauna

Marine infaunal invertebrates were characterized in sediment samples collected from three stations in the Project Area and one station in the Reference area during August of 2012. Samples collected from the Project Area had notably lower density values than those collected in the Reference Area, ranging from 4,062±719 organisms/m^2 at MCM1 to 20,135±4,775 organisms/m^2 at BMREF1. Taxonomic richness (number of taxa) was notably lower at the three stations in the Project Area than at the reference station, ranging from a low of 34.7±1.2 taxa (MCM1) to a high of 81±3.2 taxa (BMREF1). Simpson's Index of Diversity (1-D) was used to calculate the mean diversity of benthic communities at each sampling station. Mean diversity was generally high at all sampling stations ranging between 0.90±0.1 at MCM1 and 0.94±0.1 at BMREF1.

The benthic infaunal community at sites MCM1 and MCM4 was dominated by mobile polychaete species, with sedentary polychaetes and nemertean worms the next most abundant groups. Stations MCM3 and BMREF1 contained higher proportions of sedentary polychaetes and other sedentary species such as bivalve mollusks than stations MCM1 and MCM4. In total, there were 194 benthic invertebrate taxa identified in the infaunal samples collected from the Project Area. Several taxa were only present in the Reference area including several sponges, peanut worms, chitons, nut shells, barnacles, goblet worms, sea cucumbers, and tunicates. Other species were ubiquitous in both areas including hydroids, ribbon worms, mobile and sedentary polychaete worms, sea snails, clams, amphipods, and brittle stars. Benthic macrofauna are affected by sediment type and organic matter content with some species showing behavioural preference for sediments of a particular grain size (Meadows 1964; Gray 1981). Stations MCM1 and MCM4 were sampled from the areas affected by the former log dump. Sediment samples from these two stations had higher fine particle fraction (silt-clay) content, and higher TOC, metal and PAH concentrations. This may have an influence on the infaunal community inhabiting these areas, with potential adverse effects on density and species diversity.

Shellfish tissue samples collected in the lower intertidal-upper subtidal zones adjacent to the log-dump area contained concentrations of several metals that greatly exceeding those in the samples from the Reference Area, including cadmium, copper, lead, mercury, uranium and zinc.

5.2.4.6 Marine Fish

To characterize marine fish presence in the Project Area, beach seine sampling was conducted over seven sampling events between May and October 2011, with up to eight sampling locations per event. These surveys focused on juvenile salmonid presence/absence, distribution and abundance of in the nearshore areas for the time period including the end of spring freshwater out-migration extending to the start of overwintering. Nearshore fish sampling locations included deeper water embayment, intertidal watercourses and outlets of groundwater-fed watercourses. Beach seine sampling was supplemented by fish observations made during towed underwater video surveys conducted along the shoreline between the -3 and -25 m depth contours during June and November 2012 sampling events.

The most abundant species observed in the Project Area were sculpin (staghorn and tidepool), starry flounder and shiner perch. Overall fish density was variable and generally highest between May 26 and July 20. Taxonomic diversity was highest between July 6 and September 21 sampling events. Sandlance were only recorded in the Project Area during late spring (May). Flatfishes recorded in the Project Area (Pacific sanddab, starry flounder and English sole) were closely associated with soft substrate habitat. Fish presence in the woody debris zone was sporadic. No sensitive fish habitats overlap with the proposed Project Area, including no known spawning sites for key forage fish species (e.g., herring or capelin).

Salmonid species recorded in the Project Area included chinook, chum, coho and cutthroat trout. No pink salmon were recorded during the fish sampling program, although this species is known to frequent the area and non-detection was assumed to be related to sampling design. Juvenile salmon density generally declined from May 25 to August 10 with no captures occurring after August 10. A more detailed summary of salmon occurrence and distribution in the Project Area is presented in Volume 4, Part G - Section 22.0: Appendix 5.1 (Fish and Fish Habitat Baseline Report) of this EA.

5.2.4.7 Marine Mammals

Baseline conditions for marine mammals in the Project Area were based on a desktop literature review using primary literature sources and publicly accessible databases to characterize marine mammal distribution, seasonal occurrence and sensitive habitat areas within the Project Area and along the proposed barge routes. At least 11 species of marine mammals are known to occur in the southern Strait of Georgia and Howe Sound. Five of these are considered ‘at risk’ species listed under Schedule 1 of the *Species at Risk Act* (SARA), including southern resident killer whale (*Endangered*), harbour porpoise (Special Concern), humpback whale (*Threatened*), grey whale (Special Concern), and Steller sea lion (*Special Concern*). Harbour seals are year-round residents in Howe Sound. Sea lions (California and Steller) and porpoise (harbour and Dall’s) are considered occasional visitors throughout the year. Other cetacean species have been generally absent from Howe Sound over the last few decades until recently with sightings of Pacific white-sided dolphins, killer whales, grey whales and humpback whales having notably increased since 2009. This pattern has been unofficially tied to improved water quality conditions in the Sound and associated increased prey returns in the area, including herring and salmonids.

The proposed barge routes in Howe Sound are not known to overlap with marine mammal ‘critical habitat’. However, existing barge routes in southeast Strait of Georgia overlap with southern resident killer whale ‘critical habitat’. Other important habitat in the area of Project activities includes grey whale forage and migratory areas in southeast Strait of Georgia, Boundary Bay and Haro Strait.

5.2.4.8 Marine Birds

Baseline conditions for marine birds were based on a desktop literature review supplemented by field surveys (marine bird counts) conducted over four consecutive seasons (2009-2012) along a 1.0 km shore-parallel transect extending along the shore from the Project site eastward to McNab Creek. During each site visit, two observers walked the length of the transect and recorded all birds observed within a 200 m strip of the transect, with information collected on species and group size.

The Proposed Project Area supports a moderately diverse marine bird community with 36 species (11,264 observations) identified during surveys from 2009 to 2012. Five species observed during the surveys are identified as species at risk (SAR), defined as provincially Red and Blue listed species and/or species listed under SARA as Special Concern, Threatened or Endangered. This includes surf scoter (BC Blue-listed), western grebe (BC Red-listed), double-crested cormorant (BC Blue-listed), pelagic cormorant (BC Red-listed) and marbled murrelet (BC Blue-listed, Threatened under SARA), with surf scoters being the most common SAR species in the Project Area. Other species observed include the Barrow's goldeneye, glaucous-winged gull, common goldeneye, Canada goose, bufflehead, and mallard.

Low observations in 2009 (five site visits) compared to 2010 (21 site visits), 2011 (26 site visits) and 2012 (61 site visits) is likely a function of fewer site visits in that year rather than a trend in use of the site by marine birds. Seasonal trends based on the mean number of observations per site visit suggest that the Proposed Project Area is used more frequently during migratory periods (spring and fall) and for overwintering birds.

Seasonal counts (not corrected for effort) summarized by bird groups produced low overall counts for cormorants, shorebirds (i.e., black oystercatchers, spotted sandpiper, etc.), and birds of prey (BOP). Cormorant counts were highest during the winter, shorebird counts highest during the summer and fall, and BOP counts were highest during the spring and fall. Seasonal counts (not corrected for effort) summarized by bird groups produced high overall counts for waterfowl (geese and swans), ducks (i.e., mergansers, bufflehead, mallard, etc.), pelagic birds (i.e., pigeon guillemot, marbled murrelet, and common loon) and gulls. Waterfowl counts were the highest during the spring and summer; duck, gull, and pelagic bird counts were highest during the spring and winter. Overall, the summer period had the fewest number of observations of for all marine bird groups. No ‘Important Bird Areas’ overlap with the proposed Project Area or along the proposed barge routes.

5.2.5 Effects Assessment

5.2.5.1 Project-VC Interactions

A preliminary evaluation of identified interactions between the various physical works and activities and the selected VCs across all spatial and temporal phases of the Proposed Project is presented in Table 5.2-6 to Table 5.2-10. Potential Proposed Project-VC interactions are characterized as:

a) No or negligible interaction, requiring no further consideration; or

b) Existing interaction with potential direct, indirect and induced effect(s) requiring further consideration and possibly additional mitigation.

Rationale is provided for all determinations where there is no interaction or negligible interaction and where no further consideration is required.

For those Proposed Project-VC interactions that may result in potential direct, indirect and induced effects requiring further consideration, the nature of the effects (both adverse and positive) arising from those interactions is described below.

Table 5.2-6: Proposed Project-VC Interaction: Marine Water and Sediment Quality

Proposed Project Activities	Description	Marine Water and Sediment Quality	
		Potential Interaction (See Notes)	Potential Effect / Rationale for Exclusion
Construction			
1. Crew and equipment transport	▪ Daily water taxi ▪ Tug and barge transport of machinery/materials (est. 8 loads) ▪ Barge household and industrial solid waste barged off-site	●	▪ Physical changes to substrate due to Project vessel wakes and propeller scour. ▪ Change to water quality due to sediment disturbance/re-suspension from Project vessel wakes and propeller scour.
2. Site preparation, including the construction of the berms and dyke	▪ Logging, clearing and grubbing ▪ Grading ▪ Construction of the berms and dyke ▪ Compaction and laying of gravel base ▪ Limited improvements to existing on-site road infrastructure	O	▪ Proposed Project design features and mitigation for Surface Water Quality (Volume 2, Part B - Section 5.5: Surface Water Resources) limits interactions with marine water and sediment quality. No effects on marine water or sediment quality are anticipated.
3. Processing area installation, including conveyors and materials handling system)	▪ Installation and use of portable concrete batch plant for construction ▪ Installation of concrete foundations ▪ Installation of screens, crushers, wash plant, conveyor system and automated materials-handling system (i.e., reclaim tunnels) ▪ Installation of groundwater well as a source of make-up water for the wash plant	O	▪ Proposed Project design features and mitigation for Surface Water Quality (Volume 2, Part B - Section 5.5: Surface Water Resources) limits interactions with marine water and sediment quality. No effects on marine water or sediment quality are anticipated.
4. Substation construction and connection	▪ Construct electrical substation adjacent to existing BC Hydro transmission line ▪ Construct outdoor switchyard, electric building, and 100 m transmission line	O	▪ No effects on marine water or sediment quality are anticipated.

Proposed Project Activities	Description	Marine Water and Sediment Quality	
		Potential Interaction (See Notes)	Potential Effect / Rationale for Exclusion
5. Installation of barge load-out facility and conveyor system	▪ Remove existing mooring dolphins ▪ Steel pile installation ▪ Installation of conveyor, barge movement winch and mooring dolphins	●	▪ Change to water quality due to: - Sediment disturbance/re-suspension from pile installation. - Release of creosote during pile removal - Release of cementitious (alkaline) material from concrete works
6. Pit development	▪ Dry excavation to remove overburden/topsoil ▪ Installation of clamshell and floating conveyor	O	▪ Proposed Project design features and mitigation for Surface Water Quality (Volume 2, Part B - Section 5.5: Surface Water Resources) limits interactions with marine water and sediment quality. No effects on marine water or sediment quality are anticipated.
7. Other ancillary land-based construction works	▪ Temporary construction infrastructure set up (trailers, temporary power, etc.) ▪ Upgrades to the existing heavy equipment maintenance shop and warehouse ▪ Upgrades to the existing fuelling facility for the storage of diesel and gasoline for on-site equipment ▪ Construct site office, communications building, workers lunch/dry room, caretaker's cabin, first aid facility and helipad ▪ Install contained washroom facilities ▪ Construct pump room for well/stream intake water distribution and fire-fighting	O	▪ Proposed Project design features and mitigation for Surface Water Quality (Volume 2, Part B - Section 5.5: Surface Water Resources) limits interactions with marine water and sediment quality. No effects on marine water or sediment quality are anticipated.

<table>
<tr><th rowspan="2">Proposed Project Activities</th><th rowspan="2">Description</th><th colspan="2">Marine Water and Sediment Quality</th></tr>
<tr><th>Potential Interaction (See Notes)</th><th>Potential Effect / Rationale for Exclusion</th></tr>
<tr><td>8. Other ancillary marine construction works</td><td>▪ Removal of existing small craft dock; install temporary dock for worker access
▪ Construct new floating small craft dock, the with tie-up area for a float plane, serviced with 30 amp (A) 125 volt (V) shore power
▪ Barge household and industrial solid waste off-site</td><td>●</td><td>▪ Change to water quality due to:
- Release of creosote during pile removal
- Release of cementitious (alkaline) material from concrete works</td></tr>
<tr><td colspan="4">Operations</td></tr>
<tr><td>9. Crew transport</td><td>▪ Daily water taxi</td><td>●</td><td>▪ Physical changes to substrate due to Project vessel wakes.
▪ Change to water quality due to sediment disturbance/re-suspension from Project vessel wakes.</td></tr>
<tr><td>10. Aggregate mining</td><td>▪ Use of electric powered floating clamshell dredge
▪ Primary screening and conveyance of extracted material to processing area
▪ Install channel plug in WC 2</td><td>○</td><td>▪ Proposed Project design features and mitigation for Surface Water Quality (Volume 2, Part B - Section 5.5: Surface Water Resources) limits interactions with marine water and sediment quality. No effects on marine water or sediment quality are anticipated.</td></tr>
<tr><td>11. Processing (screening, crushing, washing)</td><td>▪ Screening to separate aggregate sizes
▪ Oversized gravels crushed
▪ Operation of wash plant fed using recycled water from two large storage tanks, supplemented with make-up water by a groundwater well.
▪ Drying and storage of fines and silt</td><td>●</td><td>▪ Changes to water quality from groundwater seepage</td></tr>
<tr><td>12. Progressive reclamation</td><td>▪ Ongoing earth works (including site clearing, surface material removal)
▪ Fines and silt mixed with organic overburden material and used for infilling, re-vegetation and landscaping</td><td>○</td><td>▪ Proposed Project design features and mitigation for Surface Water Quality (Volume 2, Part B - Section 5.5: Surface Water Resources) limits interactions with marine water and sediment quality. No effects on marine water or sediment quality are anticipated.</td></tr>
</table>

Proposed Project Activities	Description	Marine Water and Sediment Quality	
		Potential Interaction (See Notes)	Potential Effect / Rationale for Exclusion
13. Stockpile storage	▪ Processed sand and gravel conveyed to stockpile area ▪ Storage of processed materials in stockpiles	○	▪ Proposed Project design features and mitigation for Surface Water Quality (Volume 2, Part B - Section 5.5: Surface Water Resources) limits interactions with marine water and sediment quality. No effects on marine water or sediment quality are anticipated.
14. Marine loading	▪ Transfer of stored material using marine conveyor system ▪ Barge loading ▪ Site and navigational lighting	○	▪ Proposed Project design mitigates potential effects on marine water and sediment quality from aggregate transfer and barge loading. Covered conveyor belt, enclosed transfer points and water spray over the conveyor will prevent dust emission.
15. Shipping	▪ Barge traffic (delivery/collection) in Howe Sound, Ramillies Channel, Thornbrough Channel, and Queen Charlotte Channel ▪ Tug and barge transport of fuel and consumables ▪ Navigational lighting	●	▪ Physical changes to substrate due to Project vessel wakes and propeller scour. ▪ Change to water quality due to sediment disturbance/re-suspension from Project vessel wakes and propeller scour.
16. Refueling and maintenance	▪ Refueling and maintenance of on-site equipment	○	▪ No refueling or equipment maintenance works in the Proposed Project foreshore. No effects on marine water or sediment quality are anticipated.
Reclamation and Closure			
17. Crew and equipment transport	▪ Daily water taxi movements ▪ Tug and barge transport of machinery/materials ▪ Barge household and industrial solid waste barged off-site	●	▪ Physical changes to substrate due to Project vessel wakes. ▪ Change to water quality due to sediment disturbance/re-suspension from Project vessel wakes.

Proposed Project Activities	Description	Marine Water and Sediment Quality	
		Potential Interaction (See Notes)	Potential Effect / Rationale for Exclusion
18. Removal of land-based infrastructure	▪ Remove surface facilities, including clamshell dredge, conveyor system, screens, crushers, wash plant, automated materials-handling system, heavy equipment maintenance shop and warehouse, fuelling facility, site office, communications building, workers lunch/dry room, caretaker's cabin, first aid facility, helipad and contained washroom facilities	○	▪ Proposed Project design features and mitigation for Surface Water Quality (Volume 2, Part B - Section 5.5: Surface Water Resources) limits interactions with marine water and sediment quality. No effects on marine water or sediment quality are anticipated.
19. Removal of marine infrastructure	▪ Remove marine facilities, in marine load out facility, jetty, conveyors and piles; ▪ Tug and barge transport of machinery/materials (est. 8 loads)	●	▪ Change to water quality due to: - Sediment disturbance/re-suspension from pile removal. - Release of creosote during pile removal. ▪ Physical changes to substrate due to Project vessel propeller scour. ▪ Change to water quality due to sediment disturbance/re-suspension from Project vessel propeller scour.
20. Site reclamation	▪ Final completion of the pit lake, landscaping and re-vegetation to develop a functional ecosystem in the freshwater pit ▪ Landscaping and re-vegetation of processing area, berms and dyke	○	▪ No effects on marine water or sediment quality are anticipated.

Proposed Project Activities	Description	Marine Water and Sediment Quality	
		Potential Interaction (See Notes)	Potential Effect / Rationale for Exclusion
Accidents and Malfunctions			
21. Toxic and Hazardous Material Spills	▪ Releases due to equipment malfunction or improper maintenance, containment breach or storm water runoff ▪ Major accidents including vessel sinking, running aground or collision with another vessel of shoreline facility or fuel truck rollover ▪ Extreme weather and other natural events ▪ Fire	●	▪ Change in marine water and sediment quality due to release of toxic and hazardous materials.
22. Aggregate Spills	▪ Spill during barge loading ▪ Loss of barge containment during transition due to an accident	●	▪ Physical changes to substrate (sediment particle composition) due to aggregate spill. ▪ Change to water quality due to aggregate spill.

Notes:
- ○ = Potential effect of Proposed Project activity on VC is positive, none or negligible; no further consideration warranted.
- ● = Potential effect of Proposed Project activity on VC that may require mitigation; warrants further consideration.

Table 5.2-7: Proposed Project-VC Interaction: Marine Benthic Communities

Proposed Project Activities	Description	Marine Benthic Communities	
		Potential Interaction (See Notes)	Potential Effect / Rationale for Exclusion
Construction			
1. Crew and equipment transport	▪ Daily water taxi ▪ Tug and barge transport of machinery/materials (est. 8 loads) ▪ Barge household and industrial solid waste barged off-site	●	▪ Change in habitat quality (i.e., reduced water quality) due to sediment disturbance from Project vessel wakes and/or propeller scour. ▪ Potential mortality from direct physical disturbance or smothering / toxic effects from sediment resuspension due to Project vessel wakes and/or propeller scour.
2. Site preparation, including construction of the berms and dyke	▪ Logging, clearing and grubbing ▪ Grading ▪ Construction of the berms and dyke ▪ Compaction and laying of gravel base ▪ Limited improvements to existing on-site road infrastructure	○	▪ Proposed Project design features and mitigation for Surface Water Quality (Volume 2, Part B - Section 5.5: Surface Water Resources) limits interactions with marine benthic communities. No effects on marine benthic communities are anticipated.
3. Processing area installation, including conveyors and materials handling system)	▪ Installation and use of portable concrete batch plant for construction ▪ Installation of concrete foundations ▪ Installation of screens, crushers, wash plant, conveyor system and automated materials-handling system (i.e., reclaim tunnels) ▪ Installation of groundwater well as a source of make-up water for the wash plant	○	▪ Proposed Project design features and mitigation for Surface Water Quality (Volume 2, Part B - Section 5.5: Surface Water Resources) limits interactions with marine benthic communities. No effects on marine benthic communities are anticipated.
4. Substation construction and connection	▪ Construct electrical substation adjacent to existing BC Hydro transmission line ▪ Construct outdoor switchyard, electric building, and 100 m transmission line	○	▪ No effects on marine benthic communities are anticipated.

Proposed Project Activities	Description	Marine Benthic Communities	
		Potential Interaction (See Notes)	Potential Effect / Rationale for Exclusion
5. Installation of barge load-out facility and conveyor system	▪ Remove existing mooring dolphins ▪ Steel pile installation ▪ Installation of conveyor, barge movement winch and mooring dolphins	●	▪ Loss of habitat from pile installation and shading effects. ▪ Change in habitat quality (i.e., reduced water quality) due to: - Sediment disturbance/re-suspension from pile installation. - Release of creosote during pile removal - Release of cementitious (alkaline) material from concrete works ▪ Potential mortality due to: - Direct physical disturbance due to pile installation. - Smothering and toxic effects from sediment resuspension during pile installation. - Toxic effect of creosote during pile removal. - Toxic effect of cementitious (alkaline) material from concrete works.
6. Pit development	▪ Dry excavation to remove overburden/topsoil ▪ Installation of clamshell and floating conveyor	○	▪ Proposed Project design features and mitigation for Surface Water Quality (Volume 2, Part B - Section 5.5: Surface Water Resources) limits interactions with marine benthic communities. No effects on marine benthic communities are anticipated.
7. Other ancillary land-based construction works	▪ Temporary construction infrastructure set up (trailers, temporary power, etc.) ▪ Upgrades to the existing heavy equipment maintenance shop and warehouse ▪ Upgrades to the existing fuelling facility for the storage of diesel and gasoline for on-site equipment ▪ Construct site office, communications building, workers lunch/dry room, caretaker's cabin, first aid facility and helipad ▪ Install contained washroom facilities ▪ Construct pump room for well/stream intake water distribution and fire-fighting	○	▪ Proposed Project design features and mitigation for Surface Water Quality (Volume 2, Part B - Section 5.5: Surface Water Resources) limits interactions with marine benthic communities. No effects on marine benthic communities are anticipated.

Proposed Project Activities	Description	Marine Benthic Communities	
		Potential Interaction (See Notes)	Potential Effect / Rationale for Exclusion
8. Other ancillary marine construction works	▪ Removal of existing small craft dock; install temporary dock for worker access ▪ Construct new floating small craft dock, the with tie-up area for a float plane, serviced with 30 amp (A) 125 volt (V) shore power ▪ Barge household and industrial solid waste off-site	●	▪ Loss of habitat from shading effects. ▪ Change in habitat quality (i.e., reduced water quality) due to: - Release of creosote during pile removal - Release of cementitious (alkaline) material from concrete works ▪ Potential mortality due to: - Toxic effect of creosote during pile removal. - Toxic effect of cementitious (alkaline) material from concrete works.
Operations			
9. Crew transport	▪ Daily water taxi movements ▪ Tug and barge transport of machinery/materials ▪ Barge household and industrial solid waste barged off-site	●	▪ Change in habitat quality (i.e., reduced water quality) due to sediment disturbance from Project vessel wakes. ▪ Potential mortality from direct physical disturbance or smothering / toxic effects from sediment resuspension due to Project vessel wakes.
10. Aggregate mining	▪ Use of electric powered floating clamshell dredge ▪ Primary screening and conveyance of extracted material to processing area ▪ Install channel plug in WC 2	○	▪ Proposed Project design features and mitigation for Surface Water Quality (Volume 2, Part B - Section 5.5: Surface Water Resources) limits interactions with marine benthic communities. No effects on marine benthic communities are anticipated.

Proposed Project Activities	Description	Marine Benthic Communities	
		Potential Interaction (See Notes)	Potential Effect / Rationale for Exclusion
11. Processing (screening, crushing, washing)	▪ Screening to separate aggregate sizes ▪ Oversized gravels crushed ▪ Operation of wash plant fed using recycled water from two large storage tanks, supplemented with make-up water by a groundwater well. ▪ Drying and storage of fines and silt	●	▪ Changes to marine benthic habitat quality as a result of reduced water quality from groundwater seepage.
12. Progressive reclamation	▪ Ongoing earth works (including site clearing, surface material removal) ▪ Fines and silt mixed with organic overburden material and used for infilling, re-vegetation and landscaping	○	▪ Proposed Project design features and mitigation for Surface Water Quality (Volume 2, Part B - Section 5.5: Surface Water Resources) limits interactions with marine benthic communities. No effects on marine benthic communities are anticipated.
13. Stockpile storage	▪ Processed sand and gravel conveyed to stockpile area ▪ Storage of processed materials in stockpiles	○	▪ Proposed Project design features and mitigation for Surface Water Quality (Volume 2, Part B - Section 5.5: Surface Water Resources) limits interactions with marine benthic communities. No effects on marine benthic communities are anticipated.
14. Marine loading	▪ Transfer of stored material using marine conveyor system ▪ Barge loading ▪ Site and navigational lighting	○	▪ Proposed Project design mitigates potential effects on marine habitat from aggregate transfer and barge loading. Covered conveyor belt, enclosed transfer points and water spray over the conveyor will prevent dust emission. Therefore, no interaction anticipated between this Proposed Project activity and VC. ▪ Proposed Project design mitigates potential effects on marine environment from infrastructure lighting. All operational activities will be carried out during daylight hours. The amount of anthropogenic light emitted by the Proposed Project in the marine environment will be negligible and limited to security lighting on the barge load-out jetty and walkway, and these will be shielded and oriented such to avoid direct illumination of marine waters. Therefore, no interaction anticipated between this Proposed Project activity and VC. ▪ Potential aggregate spills during barge loading are assessed under Accidents and Malfunctions.

Proposed Project Activities	Description	Marine Benthic Communities	
		Potential Interaction (See Notes)	Potential Effect / Rationale for Exclusion
15. Shipping	▪ Barge traffic (delivery/collection) in Howe Sound, Ramillies Channel, Thornbrough Channel, and Queen Charlotte Channel ▪ Tug and barge transport of fuel and consumables ▪ Navigational lighting	●	▪ Change in habitat quality (i.e., reduced water quality) due to sediment disturbance from Project vessel wakes and/or propeller scour. ▪ Potential mortality from direct physical disturbance or smothering / toxic effects from sediment resuspension due to Project vessel wakes and/or propeller scour.
16. Refueling and maintenance	▪ Refueling and maintenance of on-site equipment	○	▪ No refueling or equipment maintenance works are proposed in the Project foreshore area. No effects are anticipated on marine benthic communities.
Reclamation and Closure			
17. Crew and equipment transport	▪ Daily water taxi movements ▪ Tug and barge transport of machinery/materials ▪ Barge household and industrial solid waste barged off-site	●	▪ Change in habitat quality (i.e., reduced water quality) due to sediment disturbance from Project vessel wakes. ▪ Potential mortality from direct physical disturbance or smothering / toxic effects from sediment resuspension due to Project vessel wakes.
18. Removal of land-based infrastructure	▪ Remove surface facilities, including clamshell dredge, conveyor system, screens, crushers, wash plant, automated materials-handling system, heavy equipment maintenance shop and warehouse, fuelling facility, site office, communications building, workers lunch/dry room, caretaker's cabin, first aid facility, helipad and contained washroom facilities	○	▪ Proposed Project design features and mitigation for Surface Water Quality (Volume 2, Part B - Section 5.5: Surface Water Resources) limits interactions with marine benthic communities. No effects on marine benthic communities are anticipated.
19. Removal of marine infrastructure	▪ Remove marine facilities, in marine load out facility, jetty, conveyors and piles	●	▪ Change in habitat quality (i.e., reduced water quality) due to: - Sediment disturbance/re-suspension from pile removal. - Release of creosote during pile removal ▪ Potential mortality due to: - Smothering and toxic effects from sediment resuspension during pile removal - Toxic effect of creosote during pile removal.

Proposed Project Activities	Description	Marine Benthic Communities	
		Potential Interaction (See Notes)	Potential Effect / Rationale for Exclusion
20. Site reclamation	▪ Final completion of the pit lake, landscaping and re-vegetation to develop a functional ecosystem in the freshwater pit ▪ Landscaping and re-vegetation of processing area, berms and dyke	○	▪ No effects on marine benthic communities are anticipated.
Accidents and Malfunctions			
21. Toxic and Hazardous Material Spills	▪ Releases due to equipment malfunction or improper maintenance, containment breach or storm water runoff ▪ Major accidents including vessel sinking, running aground or collision with another vessel of shoreline facility or fuel truck rollover ▪ Extreme weather and other natural events ▪ Fire	●	▪ Change in habitat quality (i.e., reduced water quality) due to release of toxic and hazardous materials. ▪ Potential mortality from toxic / chronic effects due to interaction with hazardous material spill.
22. Aggregate Spills	▪ Spill during barge loading ▪ Loss of barge containment during transition due to an accident	●	▪ Change in habitat quality (i.e., change in sediment composition or reduced water quality) due to accidental release of aggregate materials. ▪ Potential mortality from smothering / crushing due to accidental release of aggregate materials.

Notes:
- ○ = Potential effect of Proposed Project activity on VC is positive, none or negligible; no further consideration warranted.
- ● = Potential effect of Proposed Project activity on VC that may require mitigation; warrants further consideration.

Table 5.2-8: Proposed Project-VC Interaction: Marine Fish

Proposed Project Activities	Description	Marine Fish	
		Potential Interaction (See Notes)	Potential Effect / Rationale for Exclusion
Construction			
1. Crew and equipment transport	▪ Daily water taxi ▪ Tug and barge transport of machinery/materials (est. 8 loads) ▪ Barge household and industrial solid waste barged off-site	●	▪ Change in habitat quality (i.e., reduced water quality) due to sediment disturbance from Project vessel wakes and/or propeller scour.
2. Site preparation, including construction of the berms and dyke	▪ Logging, clearing and grubbing ▪ Grading ▪ Construction of the berms and dyke ▪ Compaction and laying of gravel base ▪ Limited improvements to existing on-site road infrastructure	○	▪ Proposed Project design features and mitigation for Surface Water Quality (Volume 2, Part B - Section 5.5: Surface Water Resources) limits interactions with marine fish and fish habitat. No effects on marine fish of fish habitat are anticipated.
3. Processing area installation, including conveyors and materials handling system)	▪ Installation and use of portable concrete batch plant for construction ▪ Installation of concrete foundations ▪ Installation of screens, crushers, wash plant, conveyor system and automated materials-handling system (i.e., reclaim tunnels) ▪ Installation of groundwater well as a source of make-up water for the wash plant	○	▪ Proposed Project design features and mitigation for Surface Water Quality (Volume 2, Part B - Section 5.5: Surface Water Resources) limits interactions with marine fish and fish habitat. No effects on marine fish of fish habitat are anticipated.
4. Substation construction and connection	▪ Construct electrical substation adjacent to existing BC Hydro transmission line ▪ Construct outdoor switchyard, electric building, and 100 m transmission line	○	▪ Proposed Project design features and mitigation for Surface Water Quality (Volume 2, Part B - Section 5.5: Surface Water Resources) limits interactions with marine fish and fish habitat. No effects on marine fish of fish habitat are anticipated.

Proposed Project Activities	Description	Marine Fish	
		Potential Interaction (See Notes)	Potential Effect / Rationale for Exclusion
5. Installation of barge load-out facility and conveyor system	▪ Remove existing mooring dolphins ▪ Steel pile installation ▪ Installation of conveyor, barge movement winch and mooring dolphins	●	▪ Loss of habitat from pile installation and shading effects. ▪ Change in habitat quality (i.e., reduced water quality) due to: - Sediment disturbance/re-suspension from pile installation. - Release of creosote during pile removal. - Release of cementitious (alkaline) material from concrete works. ▪ Potential Mortality/Injury from underwater noise during pile installation.
6. Pit development	▪ Dry excavation to remove overburden/topsoil ▪ Installation of clamshell and floating conveyor	○	▪ Proposed Project design features and mitigation for Surface Water Quality (Volume 2, Part B - Section 5.5: Surface Water Resources) limits interactions with marine fish and fish habitat. No effects on marine fish of fish habitat are anticipated.
7. Other ancillary land-based construction works	▪ Temporary construction infrastructure set up (trailers, temporary power, etc.) ▪ Upgrades to the existing heavy equipment maintenance shop and warehouse ▪ Upgrades to the existing fuelling facility for the storage of diesel and gasoline for on-site equipment ▪ Construct site office, communications building, workers lunch/dry room, caretaker's cabin, first aid facility and helipad ▪ Install contained washroom facilities ▪ Construct pump room for well/stream intake water distribution and fire-fighting	○	▪ Proposed Project design features and mitigation for Surface Water Quality (Volume 2, Part B - Section 5.5: Surface Water Resources) limits interactions with marine fish and fish habitat. No effects on marine fish of fish habitat are anticipated.

Proposed Project Activities	Description	Marine Fish	
		Potential Interaction (See Notes)	Potential Effect / Rationale for Exclusion
8. Other ancillary marine construction works	▪ Removal of existing small craft dock; install temporary dock for worker access ▪ Construct new floating small craft dock, the with tie-up area for a float plane, serviced with 30 amp (A) 125 volt (V) shore power ▪ Barge household and industrial solid waste off-site	●	▪ Loss of habitat from shading effects. ▪ Change in habitat quality (i.e., reduced water quality) due to: - Release of creosote during pile removal - Release of cementitious (alkaline) material from concrete works
Operations			
9. Crew transport	▪ Daily water taxi	●	▪ Change in habitat quality (i.e., reduced water quality) due to sediment disturbance from Project vessel wakes.
10. Aggregate mining	▪ Use of electric powered floating clamshell dredge ▪ Primary screening and conveyance of extracted material to processing area ▪ Install channel plug in WC 2	○	▪ Proposed Project design features and mitigation for Surface Water Quality (Volume 2, Part B - Section 5.5: Surface Water Resources) limits interactions with marine fish and fish habitat. No effects on marine fish of fish habitat are anticipated.
11. Processing (screening, crushing, washing)	▪ Screening to separate aggregate sizes ▪ Oversized gravels crushed ▪ Operation of wash plant fed using recycled water from two large storage tanks, supplemented with make-up water by a groundwater well. ▪ Drying and storage of fines and silt	●	▪ Changes to marine fish habitat quality as a result of reduced water quality from groundwater seepage.
12. Progressive reclamation	▪ Ongoing earth works (including site clearing, surface material removal) ▪ Fines and silt mixed with organic overburden material and used for infilling, re-vegetation and landscaping	○	▪ Proposed Project design features and mitigation for Surface Water Quality (Volume 2, Part B - Section 5.5: Surface Water Resources) limits interactions with marine fish and fish habitat. No effects on marine fish of fish habitat are anticipated.

Proposed Project Activities	Description	Marine Fish	
		Potential Interaction (See Notes)	Potential Effect / Rationale for Exclusion
13. Stockpile storage	▪ Processed sand and gravel conveyed to stockpile area ▪ Storage of processed materials in stockpiles	○	▪ Proposed Project design features and mitigation for Surface Water Quality (Volume 2, Part B - Section 5.5: Surface Water Resources) limits interactions with marine fish and fish habitat. No effects on marine fish of fish habitat are anticipated.
14. Marine loading	▪ Transfer of stored material using marine conveyor system ▪ Barge loading ▪ Site and navigational lighting	●	▪ Proposed Project design mitigates potential effects on marine habitat from aggregate transfer and barge loading. Covered conveyor belt, enclosed transfer points and water spray over the conveyor will prevent dust emissions. Therefore, no interaction anticipated between this Proposed Project activity and VC. ▪ Proposed Project design mitigates potential effects on marine environment from infrastructure lighting. All operational activities will be carried out during daylight hours. The amount of anthropogenic light emitted by the Proposed Project in the marine environment will be negligible and limited to security lighting on the barge load-out jetty and walkway, and these will be shielded and oriented such to avoid direct illumination of marine waters. Therefore, no interaction anticipated between this Proposed Project activity and VC. ▪ Potential aggregate spills during barge loading are assessed under Accidents and Malfunctions.
15. Shipping	▪ Barge traffic (delivery/collection) in Howe Sound, Ramillies Channel, Thornbrough Channel, and Queen Charlotte Channel ▪ Tug and barge transport of fuel and consumables ▪ Navigational lighting	●	▪ Change in habitat quality (i.e., reduced water quality) due to sediment disturbance from Project vessel wakes and/or propeller scour.
16. Refueling and maintenance	▪ Refueling and maintenance of on-site equipment	○	▪ No refueling or equipment maintenance works are proposed in the Project foreshore area. No effects are anticipated on marine fish and fish habitat.

Proposed Project Activities	Description	Marine Fish	
		Potential Interaction (See Notes)	Potential Effect / Rationale for Exclusion
Reclamation and Closure			
17. Crew and equipment transport	▪ Daily water taxi movements ▪ Tug and barge transport of machinery/materials ▪ Barge household and industrial solid waste barged off-site	●	▪ Change in habitat quality (i.e., reduced water quality) due to sediment disturbance from Project vessel wakes. ▪
18. Removal of land-based infrastructure	▪ Remove surface facilities, including clamshell dredge, conveyor system, screens, crushers, wash plant, automated materials-handling system, heavy equipment maintenance shop and warehouse, fuelling facility, site office, communications building, workers lunch/dry room, caretaker's cabin, first aid facility, helipad and contained washroom facilities	○	▪ Proposed Project design features and mitigation for Surface Water Quality (Volume 2, Part B - Section 5.5: Surface Water Resources) limits interactions with marine fish and fish habitat. No effects on marine fish of fish habitat are anticipated.
19. Removal of marine infrastructure	▪ Remove marine facilities, in marine load out facility, jetty, conveyors and piles	●	▪ Change in habitat quality (i.e., reduced water quality) due to: - Sediment disturbance/re-suspension from pile removal. - Release of creosote during pile removal
20. Site reclamation	▪ Final completion of the pit lake, landscaping and re-vegetation to develop a functional ecosystem in the freshwater pit ▪ Landscaping and re-vegetation of processing area, berms and dyke	○	▪ No effects on marine fish and fish habitats are anticipated.

Proposed Project Activities	Description	Marine Fish	
		Potential Interaction (See Notes)	Potential Effect / Rationale for Exclusion
Accidents and Malfunctions			
21. Toxic and Hazardous Material Spills	▪ Releases due to equipment malfunction or improper maintenance, containment breach or storm water runoff ▪ Major accidents including vessel sinking, running aground or collision with another vessel of shoreline facility or fuel truck rollover ▪ Extreme weather and other natural events ▪ Fire	●	▪ Change in habitat quality (i.e., reduced water quality) due to release of toxic and hazardous materials. ▪ Mortality from toxic / chronic effects due to interaction with hazardous material spill.
22. Aggregate Spills	▪ Spill during barge loading ▪ Loss of barge containment during transition due to an accident	●	▪ Change in habitat quality (i.e., change in sediment composition or reduced water quality) due to accidental release of aggregate materials.

Notes:
○ = Potential effect of Proposed Project activity on VC is positive, none or negligible; no further consideration warranted.
● = Potential effect of Proposed Project activity on VC that may require mitigation; warrants further consideration.

Table 5.2-9: Proposed Project-VC Interaction: Marine Mammals

Proposed Project Activities	Description	Marine Mammals	
		Potential Interaction (See Notes)	Potential Effect / Rationale for Exclusion
Construction			
1. Crew and equipment transport	▪ Daily water taxi ▪ Tug and barge transport of machinery/materials (est. 8 loads) ▪ Barge household and industrial solid waste barged off-site	●	▪ Potential injury/mortality from vessel strikes. ▪ Potential injury or behavioral disturbance due to underwater noise from Project vessels. ▪ Potential reduced prey availability due to reduced water quality from Project vessel wake wash and/or propeller scour.
2. Site preparation, including construction of the berms and dyke	▪ Logging, clearing and grubbing ▪ Grading ▪ Construction of the berms and dyke ▪ Compaction and laying of gravel base ▪ Limited improvements to existing on-site road infrastructure	○	▪ Proposed Project design features and mitigation for Surface Water Quality (Volume 2, Part B - Section 5.5: Surface Water Resources) limits interactions with marine mammals. No effects on marine mammals or their habitats are anticipated.
3. Processing area installation, including conveyors and materials handling system)	▪ Installation and use of portable concrete batch plant for construction ▪ Installation of concrete foundations ▪ Installation of screens, crushers, wash plant, conveyor system and automated materials-handling system (i.e., reclaim tunnels) ▪ Installation of groundwater well as a source of make-up water for the wash plant	○	▪ Proposed Project design features and mitigation for Surface Water Quality (Volume 2, Part B - Section 5.5: Surface Water Resources) limits interactions with marine mammals. No effects on marine mammals or their habitats are anticipated.
4. Substation construction and connection	▪ Construct electrical substation adjacent to existing BC Hydro transmission line ▪ Construct outdoor switchyard, electric building, and 100 m transmission line	○	▪ Proposed Project design features and mitigation for Surface Water Quality (Volume 2, Part B - Section 5.5: Surface Water Resources) limits interactions with marine mammals. No effects on marine mammals or their habitats are anticipated.

Proposed Project Activities	Description	Marine Mammals	
		Potential Interaction (See Notes)	Potential Effect / Rationale for Exclusion
5. Marine loading facility installation	▪ Remove existing mooring dolphins ▪ Steel pile installation ▪ Installation of conveyor, barge movement winch and mooring dolphins	●	▪ Potential Mortality/Injury from underwater noise during pile installation. ▪ Potential behavioral disturbance from underwater noise during pile installation. ▪ Potential reduced prey availability due to reduced water quality from pile installation, pile removal and other in-water works.
6. Pit development	▪ Dry excavation to remove overburden/topsoil ▪ Installation of clamshell and floating conveyor	○	▪ Proposed Project design features and mitigation for Surface Water Quality (Volume 2, Part B - Section 5.5: Surface Water Resources) limits interactions with marine mammals. No effects on marine mammals or their habitats are anticipated.
7. Other ancillary land-based construction works	▪ Temporary construction infrastructure set up (trailers, temporary power, etc.) ▪ Upgrades to the existing heavy equipment maintenance shop and warehouse ▪ Upgrades to the existing fuelling facility for the storage of diesel and gasoline for on-site equipment ▪ Construct site office, communications building, workers lunch/dry room, caretaker's cabin, first aid facility and helipad ▪ Install contained washroom facilities ▪ Construct pump room for well/stream intake water distribution and fire-fighting	○	▪ Proposed Project design features and mitigation for Surface Water Quality (Volume 2, Part B - Section 5.5: Surface Water Resources) limits interactions with marine mammals. No effects on marine mammals or their habitats are anticipated.

Proposed Project Activities	Description	Marine Mammals	
		Potential Interaction (See Notes)	Potential Effect / Rationale for Exclusion
8. Other ancillary marine construction works	▪ Removal of existing small craft dock; install temporary dock for worker access ▪ Construct new floating small craft dock, the with tie-up area for a float plane, serviced with 30 amp (A) 125 volt (V) shore power ▪ Barge household and industrial solid waste off-site	●	▪ Potential reduced prey availability due to reduced water quality from pile removal and other in-water works.
Operations			
9. Crew transport	▪ Daily water taxi	●	▪ Potential injury/mortality from vessel strikes. ▪ Potential injury or behavioral disturbance due to underwater noise from Project vessels. ▪ Potential reduced prey availability due to reduced water quality from Project vessel wake wash.
10. Aggregate mining	▪ Use of electric powered floating clamshell dredge ▪ Primary screening and conveyance of extracted material to processing area ▪ Install channel plug in WC 2	○	▪ Proposed Project design features and mitigation for Surface Water Quality (Volume 2, Part B - Section 5.5: Surface Water Resources) limits interactions with marine mammals. No effects on marine mammals or their habitats are anticipated.
11. Processing (screening, crushing, washing)	▪ Screening to separate aggregate sizes ▪ Oversized gravels crushed ▪ Operation of wash plant fed using recycled water from two large storage tanks, supplemented with make-up water by a groundwater well ▪ Drying and storage of fines and silt	○	▪ Proposed Project design features and mitigation for Surface Water Quality (Volume 2, Part B - Section 5.5: Surface Water Resources) limits interactions with marine mammals. No effects on marine mammals or their habitats are anticipated.
12. Progressive reclamation	▪ Ongoing earth works (including site clearing, surface material removal) ▪ Fines and silt mixed with organic overburden material and used for infilling, re-vegetation and landscaping	○	▪ Proposed Project design features and mitigation for Surface Water Quality (Volume 2, Part B - Section 5.5: Surface Water Resources) limits interactions with marine mammals. No effects on marine mammals or their habitats are anticipated.

Proposed Project Activities	Description	Marine Mammals	
		Potential Interaction (See Notes)	Potential Effect / Rationale for Exclusion
13. Stockpile storage	▪ Processed sand and gravel conveyed to stockpile area ▪ Storage of processed materials in stockpiles	○	▪ Proposed Project design features and mitigation for Surface Water Quality (Volume 2, Part B - Section 5.5: Surface Water Resources) limits interactions with marine mammals. No effects on marine mammals or their habitats are anticipated.
14. Marine loading	▪ Transfer of stored material using marine conveyor system ▪ Barge loading ▪ Site and navigational lighting	●	▪ Potential behavioral disturbance from underwater noise generated during barge loading. ▪ Proposed Project design mitigates potential effects on marine habitat from aggregate transfer and barge loading. Covered conveyor belt, enclosed transfer points and water spray over the conveyor will prevent dust emission. Therefore, no interaction anticipated between this Proposed Project activity and VC. ▪ Proposed Project design mitigates potential effects on marine environment from infrastructure lighting. All operational activities will be carried out during daylight hours. The amount of anthropogenic light emitted by the Proposed Project in the marine environment will be negligible and limited to security lighting on the barge load-out jetty and walkway, and these will be shielded and oriented such to avoid direct illumination of marine waters. Therefore, no interaction anticipated between this Proposed Project activity and VC.
15. Shipping	▪ Barge traffic (delivery/collection) in Howe Sound, Ramillies Channel, Thornbrough Channel, and Queen Charlotte Channel ▪ Tug and barge transport of fuel and consumables ▪ Navigational lighting	●	▪ Potential injury/mortality from vessel strikes. ▪ Potential injury or behavioral disturbance due to underwater noise from Project vessels. ▪ Potential reduced prey availability due to reduced water quality from Project vessel wake wash and/or propeller scour.
16. Refueling and maintenance	▪ Refueling and maintenance of on-site equipment	○	▪ No refueling or equipment maintenance works are proposed in the Project foreshore area. No effects are anticipated on marine mammals or their habitats.

Proposed Project Activities	Description	Marine Mammals	
		Potential Interaction (See Notes)	Potential Effect / Rationale for Exclusion
Reclamation and Closure			
17. Crew and equipment transport	▪ Daily water taxi movements ▪ Tug and barge transport of machinery/materials ▪ Barge household and industrial solid waste barged off-site	●	▪ Potential injury/mortality from vessel strikes. ▪ Potential injury or behavioral disturbance due to underwater noise from Project vessels. ▪ Potential reduced prey availability due to reduced water quality from Project vessel wake wash.
18. Removal of land-based infrastructure	▪ Remove surface facilities, including clamshell dredge, conveyor system, screens, crushers, wash plant, automated materials-handling system, heavy equipment maintenance shop and warehouse, fuelling facility, site office, communications building, workers lunch/dry room, caretaker's cabin, first aid facility, helipad and contained washroom facilities	○	▪ Proposed Project design features and mitigation for Surface Water Quality (Volume 2, Part B - Section 5.5: Surface Water Resources) limits interactions with marine mammals. No effects on marine mammals or their habitats are anticipated.
19. Removal of marine infrastructure	▪ Remove marine facilities, in marine load out facility, jetty, conveyors and piles	●	▪ Direct toxic and indirect effects from creosote release ▪ Indirect effect (habitat degradation and reduced prey availability) from siltation and sediment re-suspension.
20. Site reclamation	▪ Final completion of the pit lake, landscaping and re-vegetation to develop a functional ecosystem in the freshwater pit ▪ Landscaping and re-vegetation of processing area, berms and dyke	○	▪ No effects on marine mammals or their habitats are anticipated.

Proposed Project Activities	Description	Marine Mammals	
		Potential Interaction (See Notes)	Potential Effect / Rationale for Exclusion
Accidents and Malfunctions			
21. Toxic and Hazardous Material Spills	▪ Releases due to equipment malfunction or improper maintenance, containment breach or storm water runoff ▪ Major accidents including vessel sinking, running aground or collision with another vessel of shoreline facility or fuel truck rollover ▪ Extreme weather and other natural events ▪ Fire	●	▪ Change in habitat quality (i.e., reduced water quality) due to release of toxic and hazardous materials. ▪ Potential mortality (chronic/toxic effects) due to direct interaction with hazardous materials. ▪ Potential reduced prey availability as a result of reduced water quality due to release of toxic and hazardous materials.
22. Aggregate Spills	▪ Spill during barge loading ▪ Loss of barge containment during transition due to an accident	●	▪ Potential reduced prey availability as a result of reduced water quality due to accidental release of aggregate materials.

Notes:
○ = Potential effect of Proposed Project activity on VC is positive, none or negligible; no further consideration warranted.
● = Potential effect of Proposed Project activity on VC that may require mitigation; warrants further consideration.

Table 5.2-10: Proposed Project-VC Interaction: Marine Birds

Proposed Project Activities	Description	Marine Birds	
		Potential Interaction (See Notes)	Potential Effect / Rationale for Exclusion
Construction			
1. Crew and equipment transport	▪ Daily water taxi ▪ Tug and barge transport of machinery/materials (est. 8 loads) ▪ Barge household and industrial solid waste barged off-site	●	▪ Potential reduced prey availability due to changes in water quality from Project vessel wake wash and/or propeller scour.
2. Site preparation, including construction of the berms and dyke	▪ Logging, clearing and grubbing ▪ Grading ▪ Construction of the berms and dyke ▪ Compaction and laying of gravel base ▪ Limited improvements to existing on-site road infrastructure	○	▪ Proposed Project design features and mitigation for Surface Water Quality (Volume 2, Part B - Section 5.5: Surface Water Resources) limits interactions with marine birds. No effects on marine birds or their marine habitats are anticipated.
3. Processing area installation, including conveyors and materials handling system)	▪ Installation and use of portable concrete batch plant for construction ▪ Installation of concrete foundations ▪ Installation of screens, crushers, wash plant, conveyor system and automated materials-handling system (i.e., reclaim tunnels) ▪ Installation of groundwater well as a source of make-up water for the wash plant	○	▪ Proposed Project design features and mitigation for Surface Water Quality (Volume 2, Part B - Section 5.5: Surface Water Resources) limits interactions with marine birds. No effects on marine birds or their marine habitats are anticipated.
4. Substation construction and connection	▪ Construct electrical substation adjacent to existing BC Hydro transmission line ▪ Construct outdoor switchyard, electric building, and 100 m transmission line	○	▪ Proposed Project design features and mitigation for Surface Water Quality (Volume 2, Part B - Section 5.5: Surface Water Resources) limits interactions with marine birds. No effects on marine birds or their marine habitats are anticipated.

Proposed Project Activities	Description	Marine Birds	
		Potential Interaction (See Notes)	Potential Effect / Rationale for Exclusion
5. Installation of barge load-out facility and conveyor system	▪ Remove existing mooring dolphins/piles ▪ Steel pile installation ▪ Installation of conveyor, barge movement winch and mooring dolphins	●	▪ Potential behavioral disturbance from in-air noise during pile installation and construction. ▪ Potential reduced prey availability due to reduced water quality from pile installation, pile removal and other in-water works.
6. Pit development	▪ Dry excavation to remove overburden/topsoil ▪ Installation of clamshell and floating conveyor	○	▪ Proposed Project design features and mitigation for Surface Water Quality (Volume 2, Part B - Section 5.5: Surface Water Resources) limits interactions with marine birds. No effects on marine birds or their marine habitats are anticipated.
7. Other ancillary land-based construction works	▪ Temporary construction infrastructure set up (trailers, temporary power, etc.) ▪ Upgrades to the existing heavy equipment maintenance shop and warehouse ▪ Upgrades to the existing fuelling facility for the storage of diesel and gasoline for on-site equipment ▪ Construct site office, communications building, workers lunch/dry room, caretaker's cabin, first aid facility and helipad ▪ Install contained washroom facilities ▪ Construct pump room for well/stream intake water distribution and fire-fighting	○	▪ Proposed Project design features and mitigation for Surface Water Quality (Volume 2, Part B - Section 5.5: Surface Water Resources) limits interactions with marine birds. No effects on marine birds or their marine habitats are anticipated.
8. Other ancillary marine construction works	▪ Removal of existing small craft dock; install temporary dock for worker access ▪ Construct new floating small craft dock, the with tie-up area for a float plane, serviced with 30 amp (A) 125 volt (V) shore power ▪ Barge household and industrial solid waste off-site	●	▪ Potential reduced prey availability due to reduced water quality from pile installation, pile removal and other in-water works.

Proposed Project Activities	Description	Marine Birds	
		Potential Interaction (See Notes)	Potential Effect / Rationale for Exclusion
Operations			
9. Crew transport	▪ Daily water taxi	●	▪ Potential reduced prey availability due to changes in water quality from Project vessel wake wash.
10. Aggregate mining	▪ Use of electric powered floating clamshell dredge ▪ Primary screening and conveyance of extracted material to processing area ▪ Install channel plug in WC 2	○	▪ Proposed Project design features and mitigation for Surface Water Quality (Volume 2, Part B - Section 5.5: Surface Water Resources) limits interactions with marine birds. No effects on marine birds or their marine habitats are anticipated.
11. Processing (screening, crushing, washing)	▪ Screening to separate aggregate sizes ▪ Oversized gravels crushed ▪ Operation of wash plant fed using recycled water from two large storage tanks, supplemented with make-up water by a groundwater well ▪ Drying and storage of fines and silt	○	▪ Proposed Project design features and mitigation for Surface Water Quality (Volume 2, Part B - Section 5.5: Surface Water Resources) limits interactions with marine birds. No effects on marine birds or their marine habitats are anticipated.
12. Progressive reclamation	▪ Ongoing earth works (including site clearing, surface material removal) ▪ Fines and silt mixed with organic overburden material and used for infilling, re-vegetation and landscaping	○	▪ Proposed Project design features and mitigation for Surface Water Quality (Volume 2, Part B - Section 5.5: Surface Water Resources) limits interactions with marine birds. No effects on marine birds or their marine habitats are anticipated.
13. Stockpile storage	▪ Processed sand and gravel conveyed to stockpile area ▪ Storage of processed materials in stockpiles	○	▪ Proposed Project design features and mitigation for Surface Water Quality (Volume 2, Part B - Section 5.5: Surface Water Resources) limits interactions with marine birds. No effects on marine birds or their marine habitats are anticipated.

Proposed Project Activities	Description	Marine Birds	
		Potential Interaction (See Notes)	Potential Effect / Rationale for Exclusion
14. Marine loading	▪ Transfer of stored material using marine conveyor system ▪ Barge loading ▪ Site and navigational lighting	●	▪ Potential behavioral disturbance due to in-air noise during barge loading. ▪ Proposed Project design mitigates potential effects on marine environment from infrastructure lighting. All operational activities will be carried out during daylight hours. The amount of anthropogenic light emitted by the Proposed Project in the marine environment will be negligible and limited to security lighting on the barge load-out jetty and walkway, and these will be shielded and oriented such to avoid direct illumination of marine waters. Therefore, no interaction anticipated between this Proposed Project activity and VC.
15. Shipping	▪ Barge traffic (delivery/collection) in Howe Sound, Ramillies Channel, Thornbrough Channel, and Queen Charlotte Channel ▪ Tug and barge transport of fuel and consumables ▪ Navigational lighting	●	▪ Potential reduced prey availability due to changes in water quality from Project vessel wake wash and/or propeller scour.
16. Refueling and maintenance	▪ Refueling and maintenance of on-site equipment	○	▪ No refueling or equipment maintenance works are proposed in the Project foreshore area. No effects are anticipated on marine birds or their marine habitats.
Reclamation and Closure			
17. Crew and equipment transport	▪ Daily water taxi movements ▪ Tug and barge transport of machinery/materials ▪ Barge household and industrial solid waste barged off-site	●	▪ Changes to marine bird habitat associated with reduced water quality (e.g., increased sedimentation, creosote releases) as a result of Project vessel wakes.

Proposed Project Activities	Description	Marine Birds	
		Potential Interaction (See Notes)	Potential Effect / Rationale for Exclusion
18. Removal of land-based infrastructure	▪ Remove surface facilities, including clamshell dredge, conveyor system, screens, crushers, wash plant, automated materials-handling system, heavy equipment maintenance shop and warehouse, fuelling facility, site office, communications building, workers lunch/dry room, caretaker's cabin, first aid facility, helipad and contained washroom facilities	○	▪ Proposed Project design features and mitigation for Surface Water Quality (Volume 2, Part B - Section 5.5: Surface Water Resources) limits interactions with marine birds. No effects on marine birds or their marine habitats are anticipated.
19. Removal of marine infrastructure	▪ Remove marine facilities, in marine load out facility, jetty, conveyors and piles	●	▪ Indirect loss of habitat (avoidance) due to noise disturbance ▪ Direct toxic and indirect effects from creosote release ▪ Indirect effect (habitat degradation and reduced prey availability) from siltation and sediment re-suspension
20. Site reclamation	▪ Final completion of the pit lake, landscaping and re-vegetation to develop a functional ecosystem in the freshwater pit ▪ Landscaping and re-vegetation of processing area, berms and dyke	○	▪ No effects on marine birds are anticipated.
Accidents and Malfunctions			
21. Toxic and Hazardous Material Spills	▪ Releases due to equipment malfunction or improper maintenance, containment breach or storm water runoff ▪ Major accidents including vessel sinking, running aground or collision with another vessel of shoreline facility or fuel truck rollover ▪ Extreme weather and other natural events ▪ Fire	●	▪ Change in habitat quality (i.e., reduced water quality) due to release of toxic and hazardous materials. ▪ Potential mortality (chronic/toxic effects) due to direct interaction with hazardous materials. ▪ Potential reduced prey availability as a result of reduced water quality due to release of toxic and hazardous materials.

Proposed Project Activities	Description	Marine Birds	
		Potential Interaction (See Notes)	Potential Effect / Rationale for Exclusion
22. Aggregate Spills	▪ Spill during barge loading ▪ Loss of barge containment during transition due to an accident	●	▪ Potential reduced prey availability as a result of reduced water quality due to accidental release of aggregate materials.

Notes:
○ = Potential effect of Proposed Project activity on VC is positive, none or negligible; no further consideration warranted.
● = Potential effect of Proposed Project activity on VC that may require mitigation; warrants further consideration.

5.2.5.2 Potential Project-Related Effects

5.2.5.2.1 Marine Water and Sediment Quality

Potential Project-related effects on marine water and sediment quality throughout the life of the Proposed Project include:

- Sediment disturbance and re-suspension due to placement or removal of marine structures (construction and reclamation/closure phases);
- Release of creosote (hydrocarbons) during removal of old creosote-treated wood piles (construction and reclamation/closure phases);
- Release of cementitious materials during construction (construction phase);
- Sediment disturbance and re-suspension due to propeller scour (all phases);
- Sediment disturbance and re-suspension due to vessel wake wash (all phases); and
- Release of deleterious substances due to accidental spills of hazardous, toxic or aggregate material (all phases).

5.2.5.2.1.1 Construction

5.2.5.2.1.1.1 Change in Marine Water and Sediment Quality

Marine water and sediment quality in the Proposed Project Area may be affected during the construction phase of the Proposed Project through the following pathways:

- Re-suspension of sediments due to seafloor disturbance during construction works (placement of new marine structures and removal of old structures);
- Release of cementitious material during concrete works;
- Creosote release during old pile removal;
- Sediment disturbance and re-suspension due to propeller scour; and
- Sediment disturbance and re-suspension due to vessel wake wash.

5.2.5.2.1.1.1.1 Removal, Upgrade and Installation of Marine Structures

Seabed disturbance caused by placement of new marine infrastructure and removal of old structures (in-water works) could result in increased levels of turbidity and total suspended solids (TSS) in the water column. The increased particle load in the water may, in turn, change the physical composition of sediments by increasing the concentration of particles with finer grain size (silt-clay). A decrease in sediment grain size is typically correlated with an increase in concentration of metals and organic matter. Trace metals tend to concentrate more in sediments with higher organic matter by forming physical (adsorption) and chemical bonds with organic molecules (Goldberg 1954; Krauskopf 1956; Kononova 1966). Metals tend to accumulate more in finer-grained sediments (Goldberg 1954; Krauskopf 1956; Thorne and Nickless 1981) primarily through adsorption and cation exchange due to the larger surface areas of fine particles (Jones and Bowser 1978). Another mechanism of metal accumulation in sediments is precipitation in chemical compounds, such as carbonates, oxides, silicates, clay minerals and sulfides (Gibbs 1977). This accumulation also tends to occur predominantly in fine particle sediments, particularly clay minerals (Goldberg 1954; Krauskopf 1956). Increase in organic content may induce anoxic conditions in sediment (Libes 1992). Changes to marine water and sediment quality may also occur as a result of potential releases of creosote and cementitious materials during in-water construction works.

Potential adverse effects from in-water works on marine water and sediment quality in the Project Area are carried forward in the assessment. Potential adverse effects of in-water works on marine biological receptors are discussed in detail in the assessment of Marine Benthic Communities (Section 5.2.5.2.2) and Marine Fish (Section 5.2.5.2.3).

5.2.5.2.1.1.1.2 Vessel Wake

Vessel wake occurs when vessel movements create secondary waves (i.e., free surface waves that propagate out from the vessel). The amplitude of the wave is related to the speed of the vessel. Large wakes could result in increased wave activity along the shoreline with potential to alter existing shoreline conditions in the RSA, which could in turn result in benthic habitat modifications due to changes in local sedimentation effects and nutrient transport rate, particularly in narrow waterways and in sensitive biological areas (Kelpsaite et al. 2009; Kofoed-Hansen et al. 1999; Dauphin 2000; Curtiss et al. 2009).

Shoreline sensitivity to vessel wake effects is considered low in the RSA, given the majority of the shoreline in this region consists of hard substrate (boulder and cobble beaches, bedrock platforms and modified/man-made structures); alternating in some locations with sand and gravel beaches, based on data available from the BC Shorezone Mapping System (BCMCA 2014). These shorelines are regularly exposed to waves generated by strong winds, particularly from the south that generate wave heights ranging from 0.6 to 1.8 m (Volume 4, Part G - Section 22.0: Appendix 7.2-A).

Golder undertook a vessel wake wash analysis (Volume 4, Part G - Section 22.0: Appendix 7.2-A) in order to compare potential wake energy generated by Project vessels to waves generated during natural wind or storm events. Two navigation routes shown in Figure 5.2-2 were considered in the wake analysis: Thornbrough Channel (Route 1) and Ramillies Channel / Queen Charlotte Channel (Route 2). Detailed results from the wake wash analysis are presented in Volume 4, Part G - Section 22.0: Appendix 7.2-A, with a brief summary provided below.

Cumulative annual wave energy from Project vessels and wind were estimated to provide total wave energy flux along the shorelines that bordered the RSA, as summarized in Table 5.2-11. Percent contributions to wave energy fluxes from Project vessels (particularly water taxis) and wind were computed for several extraction points along the shorelines that bordered the RSA. Annual energy fluxes and percentage energy contributions for water taxi and wind-waves are shown in Figure 5.2-3 through Figure 5.2-6.

Table 5.2-11: Maximum Cumulative Annual Wave Energy Flux along RSA Shoreline for Proposed Project Vessels and Southerly Wind Waves

Route	Wind Wave Energy kW/m/year	Water Taxi kW/m/year	Tug boat kW/m/year	Barge kW/m/year
1	1,324,000	388,000	16	4.0
2	3,578,000	358,000	6.2	4.0

Wakes generated by Project tug movements were shown to have lower energy than wind waves generated in the RSA during natural storm events. Consequently, potential wake wash effects from Project tug activities on shoreline conditions (changes to marine water and sediment quality) in the RSA were considered negligible and are not considered further in the assessment.

The estimated annual wake energy from water taxi movements was considerably lower than wind-wave energy at almost all shoreline locations in the RSA; with average taxi wake being 9% that of wind wave energy in this region. One exception to this was an approximately 500-m segment of shoreline (sand and gravel beach) on the west side of Gambier Island (eastern shoreline of Thornbrough Channel; Figure 5.2-2), in which water taxi wake energy was shown to be roughly equivalent to wind wave energy, given the wind-sheltered nature of this shoreline. Given energy levels do not exceed natural wind wave conditions, potential wake wash effects from Project water taxi movements on shoreline conditions (changes to marine water and sediment quality) in the RSA were considered negligible and are not considered further in the assessment.

5.2.5.2.1.1.1.3 Propeller Scour

Propeller wash is the movement of water created by the rotation of the propellers on a vessel. In shallow waters, unconfined propeller wash can induce propeller scour on the seabed when the seabed is erodible (Sumer and Fredsoe 2002). Propeller scour may occur while a vessel is in transit or while being maneuvered into place during berthing. High velocity propeller wash can result in sediment disturbance and scouring of the seabed, which could in turn affect benthic communities and their habitats.

Golder undertook a propeller scour assessment in order to evaluate the potential for seabed scour from Project tug propeller wash, and subsequent effects on marine water and sediment quality. Detailed results from the propeller scour assessment are presented in Volume 4, Part G - Section 22.0: Appendix 5.2-C, with a brief summary provided below. Propeller wash impacts on the seabed were assessed at a modelled depth of -20 m (chart datum), to correspond with the uppermost depths of glass sponge habitat. At this depth, the jet velocities of the proposed tug-assisted barge movements were shown to be within the same magnitude as tidal currents at this depth, and below the velocity threshold (0.25 m/s) required for seabed particle mobilization (USACE 1998). Given that water depths along the proposed shipping route in the RSA are typically below -25 m (chart datum), the potential effects of tug propeller scour on marine VCs in this area are considered negligible. However, water depths in the vicinity of the barge loading facility are between -7 m and -10 m (chart datum). Tug propeller jet velocities within this depth range are estimated to be limited to velocities less than 0.77 m/s (Volume 4, Part G - Section 22.0: Appendix 5.2-C); and may exceed the velocity threshold for seabed particle mobilization (0.25 m/s) at distances up to 120 m astern of the tug, where ‘astern” assumes that tugs are oriented with the bow facing open water and they are pushing away from shoreline. Mobilization / re-suspension of seabed sediment are therefore possible within this area during active tug movements, along with associated effects on water quality (increased concentration of TSS, turbidity, PAH and metals). These effects would be limited to the immediate area of the loading facility; an area presently associated with extensive woody/bark debris cover[6] and unfavorable habitat conditions.

[6] Note that wood waste and log debris may likely increase the required threshold velocity for particle redistribution in this area, so 0.25 m/s is considered a conservative estimate.

Potential adverse effects from tug propeller wash on marine water and sediment quality in the Project Area are carried forward in the assessment. Potential effects from propeller scour on marine biological receptors are discussed in detail in Section 5.2.5.2.2 (Marine Benthic Communities) and Section 5.2.5.2.3 (Marine Fish).

5.2.5.2.1.2 Operations

5.2.5.2.1.2.1 Change in Marine Water and Sediment Quality

Marine water and sediment quality during the operations phase of the Proposed Project may be affected through the following pathways:

- Reduced water quality due to groundwater seepage;
- Sediment disturbance and re-suspension due to vessel wakes; and
- Sediment disturbance and re-suspension to propeller scour.

5.2.5.2.1.2.1.1 Groundwater Seepage

Groundwater seepage from the pit lake to the marine environment will meet applicable water quality guidelines or background levels, with the exception of phosphorus (Volume 2, Part B - Section 5.6: Groundwater Resources). Elevated concentrations of phosphorus are naturally occurring in existing groundwater. Although high levels of phosphorus are of potential concern for the freshwater environment due to potential nutrient over-enrichment issues, they are not of concern for the marine environment as phosphorus is not a limiting nutrient in the marine ecosystem (CCME 2007). Given the existing marine environment is already nitrogen-poor and subject to dilution effects from freshwater runoff events in Howe Sound, any increase of phosphorus concentrations in seawater are not likely to result in an increase of phytoplankton growth resulting in harmful effects on the marine ecosystem (e.g., hypoxia/anoxia). Therefore, the potential effect of groundwater seepage on marine water quality is considered negligible, and is not carried forward in the assessment.

5.2.5.2.1.2.1.2 Vessel Wakes

Potential effects from Project generated vessel wakes are similar to those described in Section 5.2.5.2.1.1 for construction.

5.2.5.2.1.2.1.3 Propeller Scour

Potential effects from Project generated propeller scour are similar to those described in Section 5.2.5.2.1.1 for construction.

5.2.5.2.1.3 Reclamation and Closure

5.2.5.2.1.3.1 Change in Marine Water and Sediment Quality

Marine water and sediment quality during the Proposed Project reclamation/closure phase may be affected by:

- Re-suspension of sediments following sediment disturbance during in-water works (removal of old structures);
- Creosote release during pile removal;
- Sediment disturbance and re-suspension due to propeller scour; and
- Sediment disturbance and re-suspension due to vessel wakes.

Potential effects from these Project activities are similar to those described in Section 5.2.5.2.1.1 for construction.

5.2.5.2.1.4 Accidents and Malfunctions

Accidents and malfunctions, that may potentially affect marine water and sediment quality include:

- Events involving spills of toxic or hazardous materials (e.g., hydrocarbon fuels, lubricants, concrete and other chemicals or wastes);
- Explosion or fire;
- Fuel truck rollover;
- Marine vessel accident (sinking, running aground, collision with a marine facility or another vessel); and
- Loss of barge containment (aggregate).

5.2.5.2.1.4.1 Toxic and Hazardous Material Spills

During the Proposed Project life, various hazardous or toxic materials have the potential to be stored, used or generated at the site, including:

- fuel (gasoline or diesel);
- lubricating oils;
- paints and solvents; and
- untreated sewage.

While all hazardous materials used for and generated by the Proposed Project will be handled and stored according to applicable regulations, a spill could occur and potentially release one or more of the substances listed above to the marine environment, depending on the inventory spilled and the spill location.

Spills of toxic or hazardous materials (e.g., hydrocarbon fuels, lubricant, sewage, concrete and wastes) can result in contamination of marine water resulting in increases in hydrocarbons, pH, total suspended solids (TSS), metals, nutrients and other constituents. Depending on the type of material, volume and location, a spill could result in exceedances of water quality guidelines (WQGs) for the protection of aquatic life.

Hydrocarbon spills may result directly, from a ruptured fuel tank (or tanks) after a collision, or indirectly, from fire damage or explosion damage. During construction and reclamation/closure phases of the Proposed Project, there is the potential for a release of hazardous materials from construction equipment or vehicles as a result of equipment failure or leaks (e.g., a broken hydraulic line). During operations, the Proposed Project will use electrically powered equipment to extract, process, and load the aggregate limiting the amount of hydrocarbon fuel used. A spill during the operations could happen through failure of the hazardous materials onsite storage tank; however the spill would be contained within the boundaries of the processing facility which will be designed to contain leaks. Hydrocarbons and other hazardous materials can also be released into the environment from runoff of storm water on the barge load-out jetty or Project vessel decks, lubricant and hydraulic fluid leaks, spills during fuel transfer and disposal of lubricant containers.

Fuel and other equipment supplies will be delivered to the Project site on trucks over land and by barges via water. Wastes, including sewage, will be transported offsite by barges. There is potential for a release of hazardous materials into the marine environment during the material transfer off or onto the barge and during barge travel.

Spills or leaks of hazardous materials are most often caused by operator error, maintenance activities, neglect or some combination of these factors. Spills or leaks can also result from vehicle accidents, extreme weather and weather-related events (e.g., flooding and extreme temperatures), wildfire, or equipment failure or malfunction.

The magnitude of environmental effects associated with a hazardous materials spill depends on the chemical composition of the spilled product, the volume that is released, the exact location where the release occurs (e.g., proximity to a sensitive environment), the timing of the spill (e.g., whether meteorological conditions will contribute to evaporation of spilled hydrocarbons) and the success of response operations. Depending on the amount of released material, there could be a minor (small-scale) spill or a major (large-scale) spill. The most likely spill scenario would involve the release of small quantities of hazardous materials as a result of equipment failure or operator error. The release of small quantities of hazardous materials to marine habitat could occur during construction if equipment were to leak fluids such as fuels, lubricating oils, hydraulic fluids and triethylene glycol (i.e., antifreeze) while working in or near the foreshore or in or around a watercourse.

A major spill could occur as a result of running aground or sinking of a Project vessel, collision of a vessel with the marine facilities, a severe collision between two vessels, or a truck rollover during transfer from barge to shore. The worst case scenario considered is an accident involving a Project tug and barge that would lead to a breach in the hull or truck tanker, causing release of fuel to the marine environment. The maximum fuel capacity of a Seaspan Commander tug is 81 m^3.

The fate and toxic effect of spilled hydrocarbon material depends on its properties, released volume and environmental conditions, such as wind, depth, temperature, and distance to the shore. The most severe consequences occur when spills happen near shore, in shallow waters, or areas with slow water circulations (Patin 1999).

Hydrocarbons released in the environment undergo weathering processes that depend on the physical properties of the spilled material. For instance, gasoline is highly volatile and evaporates quickly but is one of the most acutely toxic hydrocarbons and generally affects aquatic life that lives in the upper water column (US FWS 2004). Diesel fuel is moderately volatile and can leave a residue of up to one third of the amount spilled after several days. While there is a number of hydrocarbons and other chemicals that may be present onboard the Proposed Project vessel and may be accidently spilled, fuel is the largest material by volume and, therefore, represents the highest risk. The Seaspan Commander (similar class tug vessel proposed for tug-assisted barge movements) uses diesel fuel which is considered light oil which is moderately volatile with moderate amounts of toxic substances (NOAA 1992). Diesel fuel is typically a blend of hydrocarbons of different molecular weights with variable compositions The different fractions behave differently in water; lighter components have greater solubility (ability to dissolve in a solvent) and higher toxicity but are the most volatile (evaporate more quickly) while more dense fractions are less soluble but are also less volatile and tend to remain in the environment longer; some very dense hydrocarbons may even sink to the bottom assuming tar-like consistency (CONCAWE 1998).

Oil weathering processes, such as volatilization, dispersion, biodegradation, oxidation and sedimentation are likely to occur and are affected by weather conditions during the time of the spill. Weather conditions during and after the oil spill will significantly influence the degree of oil spreading and persistency. Wind and wave actions disperse oil in the water column breaking it into smaller fragments and droplets, therefore increasing exposure to biodegradation; and higher temperature increases oil volatilization. The wind and current directions determine the direction the oil is spreading and the nature of the shoreline will determine how much oil is deposited within the intertidal habitat. For example, oil does not deposit readily on steep rocky shorelines except in the very high intertidal as most of it gets washed away while much more oil can become deposited and buried on sand/gravel beaches and estuarine flats (NOAA 2010).

The potential effects of toxic and hazardous material spills (e.g., hydrocarbon spills) are carried forward in the assessment for all Marine Resource VCs.

5.2.5.2.1.4.2 Aggregate spills

Aggregate spills into the marine environment could occur during barge loading operations or during barge transit as a result of a vessel collision with the barge or with the loading facility. These accidents may result in a release of a large amount of aggregate causing an aggregate plume and could have negative effects on biological organisms in the water column, and marine benthic habitats within and adjacent to the area of release.

The descent of the aggregate plume would be governed primarily by the density difference between the plume and the ambient water rather than the settling velocity of individual sediment particles (Pequegnat et al. 1990). Sediment clumps or aggregates have a much greater vertical speed than individual particles and therefore the majority of the plume settles out of the water column relatively rapidly. The Project proposes to remove silt and clay-sized fractions from the aggregate material prior to transport offsite therefore the aggregate material in transit on the barge will consist primarily of sand and gravel sized particles. Aggregate consisting primarily of sand and gravel particles will more readily clump together and would produce a more dense plume than material with more fine particles as commonly found in dredged sediments. There is limited information regarding spills of aggregate of this size composition. Studies conducted on surface discharge of dredged sediments with high proportions of silt and clay (60-90%) to depths of 180 m concluded that most of the material released was confined to a depositional area of approximately 150 m by 300 m (Truitt 1988). An aggregate spill from the Proposed Project would likely result in a smaller depositional area due to the faster settling rate of larger particles.

Accidental releases of deleterious substances into marine habitats may reduce the suitability of the receiving environments for various marine species. Introduction of deleterious substances (e.g., toxic and hazardous material spills, aggregate spills) into marine habitats could result in a loss or alteration of habitat for marine organisms with low mobility such as those belonging to marine benthic communities and certain marine fish species.

The potential effects of aggregate spills are carried forward in the assessment for Marine Benthic Communities given their dependence on nearshore marine habitats and their limited ability to leave an area following a disturbance event. Benthic organisms with limited mobility would consequently be subject to longer exposure periods and at higher exposure levels. Marine fish, marine mammals and marine birds are expected to be able to access alternate marine habitat areas if a spill was to occur locally given they are highly mobile species with extensive foraging ranges; therefore this effect is not carried forward in the assessment for these VCs (Marine Fish, Marine Mammals, Marine Birds).

5.2.5.2.2 Marine Benthic Communities

Potential effects on marine benthic communities during the construction, operations and reclamation and closure phases of the Proposed Project are as follows:

- Loss of habitat due to the physical presence of the Proposed Project facilities (footprint) including shading effects (construction and operation phases); and
- Change in habitat quality due to:
  - Sediment disturbance and re-suspension due to placement and removal of marine structures (construction and reclamation/closure phases);
  - Release of creosote during removal of old piles (construction and reclamation/closure phases);
  - Release of cementitious material during concrete works (construction phase);
  - Sediment disturbance and re-suspension due to propeller scour (all phases);
  - Sediment disturbance and re-suspension due to vessel wake wash (all phases);
  - Groundwater seepage to the marine environment (operations phase); and
  - Release of deleterious substances due to accidental spills of hazardous / toxic materials (all phases).
- Potential mortality from:
  - Direct physical disturbance from pile installation (construction);
  - Direct physical disturbance from propeller scour (all phases);
  - Smothering and toxic effects from sediment re-suspension due to in-water works (construction and reclamation/closure phases);

- Release of creosote during removal of old piles (construction and reclamation/closure phases);
- Release of cementitious material during concrete works (construction phase); and
- Release of deleterious substances due to accidental spills of hazardous / toxic materials (all phases).

5.2.5.2.2.1 Construction

5.2.5.2.2.1.1 Loss of Habitat

The marine footprint of the Proposed Project includes the barge load-out jetty, the covered conveyor system and the new floating small craft dock. The use of piles rather than fill to support marine infrastructure will reduce the amount of direct habitat loss in the intertidal and subtidal environment. A total of 18 steel piles (each pile = 0.42 m diameter) will be installed in the marine environment to support the barge load-out jetty, walkway and conveyor system. This will include eight piles in the intertidal resulting in 1.1 m^2 of habitat loss, and 10 piles in the subtidal resulting in 1.4 m^2 of habitat loss. The use of steel piles will minimize adverse impacts on the marine environment associated with leachate of toxins from treated wood or concrete fill.

The majority of the piles in the subtidal environment will be installed in the existing log dump area where the substrate is presently covered with extensive woody/bark debris and associated with relatively low value benthic habitat. Sediment in this area is characterized by high silt-clay content and elevated concentrations of trace metals and PAHs. The benthic invertebrate community (epifauna and infauna) in this area is characterized by low species density and diversity in comparison to the other habitat zones in the LSA and the reference area (See Volume 4, Part G - Section 22.0: Appendix 5.2-A).

The installed marine infrastructure may result in some shading effects on marine vegetation in the intertidal and shallow subtidal (e.g., sea lettuce [*Ulva intestinalis*], fringed sea colander kelp [*Agarum fibriatum*], *Laminaria sp*.); however, no eelgrass presence or high-density macrophyte assemblages (e.g., kelp beds) have been identified in the marine footprint of the Proposed Project. The total intertidal and subtidal areas potentially affected by shading effects are approximately 249 m^2 (150 m x 1.66 m intertidal footprint) and 46 m^2 (28 m x 1.66 m subtidal footprint), respectively. In the intertidal zone, shading effects will be mitigated by means of design features with respect to platform height, grating, and orientation. The conveyor platform is partially grated and will be approximately +5 m above ground in the intertidal zone, thus allowing light to penetrate beneath the structure to the underlying substrate. This type of design is known to be effective in decreasing shading effects on intertidal vegetation (Witherspoon 1994). In addition, the south facing orientation of the platform will further minimize potential shading effects to the underlying benthic habitat. Given the proposed design features in place, potential loss of intertidal habitat due to shading effects is considered negligible. In the subtidal zone, potential shading effects would overlap with an area extensively blanketed with woody/log debris resulting from historical log dump activities (see Figure 36 of Appendix 5.2-A in Volume 4, Part G – Section 22.0). Marine vegetation in this area is suppressed and virtually absent. Given the degraded habitat conditions in the subtidal Project footprint, potential loss of subtidal benthic habitat due to shading effects is considered negligible.

Given that construction of the Proposed Project will result in the direct loss of 2.5 m^2 of marine habitat as a result of pile installation, this effect is carried forward in the assessment.

5.2.5.2.2.1.2 Change in Habitat Quality

5.2.5.2.2.1.2.1 Removal, Upgrade and Installation of Marine Structures

Seabed disturbance caused by placement of new marine infrastructure and removal of old structures (in-water works) could result in increased levels of turbidity and total suspended solids (TSS) in the water column which may result in a disruption of feeding by visual predators (Berg and Northcote 1985) or create a shading effect that could disrupt photosynthesis by algae (Bilotta and Brazier 2008; CCME 1999). Sediment disturbance may also result in increased concentrations of pollutants in the water column, such as trace metals that are mainly adsorbed onto suspended sediment particles of smaller size fractions (Chapman 1992; Horowitz 1985). Once re-suspended, these pollutants can be ingested by lower trophic level organism (i.e., filter feeders) and be then transferred through the food chain to higher trophic levels (CCME 2013).

Potential changes in marine benthic habitat quality from in-water works are carried forward in the assessment.

5.2.5.2.2.1.2.2 Vessel Wake

Golder undertook a vessel wake wash analysis, with detailed results presented in Volume 4, Part G - Section 22.0: Appendix 7.2-A. The potential effects of wake wash from tug-assisted barge and water taxi movements on marine water and sediment quality in the RSA were assessed in Section 5.2.5.2.1.1.1.2. This activity is also assessed below with specific reference to potential impacts on marine benthic communities.

Large vessel wakes could result in increased wave activity along the shoreline and cause shoreline erosion, which could in turn affect nearshore benthic habitats. Benthic communities along the shoreline may be affected in several ways: marine vegetation may be exposed to increased turbidity levels in the water column resulting in reduced potential for photosynthesis (Eriksson et al. 2004; Cragg et al. 1980; Woodruff et al. 2001), shorelines may be eroded of fine and organic rich sediment from bottom substrate (Ali et al. 1999), and vegetation may be up-rooted due to sediment removal (Asplund and Cook 1997; Liddle and Scorgie 1980; Woodruff et al. 2001). Wake effects have been reported to cause shifts in benthic invertebrate density and diversity (infauna and epifauna) by eroding living substrate and changing sediment size composition, one of the main factors controlling distribution of benthic communities (Schoch and Dethier 2001; Bishop 2007). Physical properties of substrate play an important role in determining shoreline sensitivities to wake effects. For instance, benthic infauna are sensitive to changes in grain size composition with grains of a larger diameter (e.g., 200 μm) constituting a barrier for a number of burrowing animals (Weiser 1959).

As discussed in Section 5.2.5.2.1.1.1.2, the majority of the shoreline within the Proposed Project assessment areas consists of hard substrate (boulder and cobble beaches, bedrock ramps) alternating, at some places, with coarse sediment (gravel and sand-and-gravel beaches). The shoreline is regularly exposed to strong winds and wind-waves and the estimated wake energy generated by Project vessels do not exceed existing wind-wave energy regimes in the RSA (Volume 4, Part G - Section 22.0: Appendix 7.2-A). Therefore, Project-related wake effects are unlikely to result in detectable changes to marine benthic communities during any phase of the Proposed Project and are not carried forward in the assessment.

5.2.5.2.2.1.2.3 Propeller Scour

Golder undertook a propeller scour assessment in order to evaluate the potential for seabed scour from Project tug propeller wash, with detailed results presented in Volume 4, Part G - Section 22.0: Appendix 5.2-C. The potential effects of tug propeller scour on marine water and sediment quality in the RSA were assessed in Section 5.2.5.2.1.1.1.3. This activity is also assessed below with specific reference to potential impacts on marine benthic communities.

Glass sponges in Howe Sound live at depths as shallow as -20 m (chart datum) and have the potential to occur throughout the RSA. Propeller scour impacts on the seabed were assessed at a modelled depth of -20 m (chart datum) to correspond with the uppermost depths of glass sponge habitat. Jet velocities generated by the tug propeller at -20 m were compared to natural velocities derived from wave and tidal activity in Howe Sound. Estimates of maximum horizontal velocity associated with wind waves were developed from wave hindcasts from available wind data for the Strait of Georgia using the Halibut Bank Ocean Buoy (Environment Canada Station 46146) and are summarized in Table 5.2-12.

Table 5.2-12: Summary of Velocity Estimates at 20 m Water Depth (Chart Datum)

Condition	Velocity Estimate (m/s) at -20 m Water Depth
Specified tug operating near dock at 150 rpm	0.19
Specified tug in transit at 320 rpm	0.04
Average Annual Wind Wave	~0
5-year Wind Wave	0.24
100-year Wind Wave	0.44
Tidal Current (peak ebb and flood) [(a)]	0.50 or higher

At -20 m depth, the jet velocities of the proposed tug-assisted barge movements were shown to be within the same magnitude as tidal currents present at this depth, and below the velocity threshold (0.25 m/s) required for seabed particle mobilization (USACE 1989). Given that water depths along the proposed shipping route in the RSA are typically below -25 m (chart datum), the potential effects of tug propeller scour on marine benthic communities and associated benthic habitat (e.g., glass sponge assemblages) in the proposed shipping corridors are considered negligible and are not carried forward in the assessment.

Water depths in the vicinity of the barge loading facility are between -7 m and -10 m (chart datum). Tug propeller jet velocities within this depth range are estimated to be limited to velocities less than 0.77 m/s (Volume 4, Part G - Section 22.0: Appendix 5.2-C); and may exceed the velocity threshold for seabed particle mobilization (0.25 m/s) at distances up to 120 m astern of the tug, where ‘astern” assumes that tugs are oriented with the bow facing open water and they are pushing away from shoreline. Mobilization / re-suspension of seabed sediment are therefore possible within this area during active tug movements, along with associated effects on water quality (increased concentration of TSS, turbidity, PAH and metals). These effects would be limited to the immediate area of the barge offloading facility, an area presently associated with extensive woody/bark debris cover and unfavorable habitat conditions.

Potential changes in marine benthic habitat quality from tug propeller scour at the barge offloading facility are carried forward in the assessment.

5.2.5.2.2.1.3 Potential Mortality

5.2.5.2.2.1.3.1 Removal, Upgrade and Installation of Marine Structures

The removal, upgrade and installation of marine infrastructure (in-water works) can result in the direct mortality of benthic organisms within the immediate area of these activities by means of direct burial or crushing from physical interactions with infrastructure or equipment, as well as smothering or chronic/toxic effects from sediment dispersal / re-suspension and/or release of cementitious materials or creosote to the marine environment during in-water works.

Pile installation/removal will physically disturb benthic habitat, resulting in direct mortality of benthic organisms living in the immediate footprint of these activities by means of burial or crushing. Species most likely to be affected include sedentary or slow-moving benthic invertebrates that live on or burrow in the soft substrate and are unable to emigrate from the area of disturbance. Mobile benthic organisms are less vulnerable to this effect given their ability to move away from the area of disturbance. Most infaunal invertebrates live in the top 10 cm of the substrate where they have access to the sediment-water interface for feeding and oxygen exchange (Miller et al. 2002). Most benthic invertebrate species are well adapted to burrow through a thin (~30 cm) layer of newly-deposited sediment and avoid suffocation (Ferretted and French 2004; Bola and Rees 2003; Newell et al. 1998). For example, mortality of Dungeness crab (*Metacarcinus magister*) has been reported if individuals are buried by sediment exceeding 20 cm in depth (Pearson 2005). Although juveniles are more susceptible to burial effects than adults, both can burrow out of thin layers (< 20 cm) of newly deposited sediment to avoid suffocation. Depending on existing habitat conditions in the affected area, re-suspended sediment may also smother existing benthic organisms by settling on existing individuals or their spawn, as well as by reducing the filtering capabilities of filter-feeding invertebrates such as clams and mussels (Wilber and Clarke 2001). Re-suspension of sediments can also expose benthic organisms to toxic contaminants such as heavy metals and PAHs previously bound in the sediments, and can transfer toxic compounds through the trophic chain to higher trophic organisms (CCME 2013).

Sources of environmental concern from concrete works include (i) toxicity from the alkaline pH of concrete and (ii) physical effects of smothering through the release of solids. Uncured concrete produces a highly alkaline material when it contacts water. The degree of alkalinity (or conversely the acidity) of a substance can be expressed in terms of the pH scale. The pH scale ranges from a pH of 0 (extremely acidic) to a pH of 14 (extremely alkaline). The middle of the pH scale, pH 7, represents a neutral pH. Safe levels for the protection of aquatic life in marine waters range from 7.0 to 8.7 pH units (CCME 2013). At pH values greater than 9, the alkaline pH begins to have a corrosive effect on the gills and other external tissues (e.g., the eye) with mortality being reported at just slightly higher values. For the purposes of concrete work, DFO has typically required that pH in the marine environment be help to the same standards as for the protection of aquatic life in freshwater (pH 6.5 to 9.0), recognizing that these pH differences are small, short-term in nature, are not harmful, and with marine water buffering, pH water quality guidelines for the protection of marine life (CCME 2013) will be met very quickly. The pH of uncured concrete and wash-off water from concrete is 12 pH units at a temperature of 25°C. At lower temperatures, more likely to be encountered in BC waters, the pH of concrete water increases. At these pH values, uncured concrete will rapidly kill fish and must be kept out of surface waters, even for brief episodes. In addition to toxic effects, concrete also contains a considerable amount of fine sediments. When these are washed or otherwise enter the aquatic environment, the fine sediments can smother benthic organisms or their spawn as described above.

Creosote could be released into the water during the removal of the pilings and from storage of the pilings near the water as well as from removal of old docks and structures. Creosote, a distillate of coal tar, is a complex chemical mixture, up to 80% of which is comprised of PAHs. PAH compounds share common properties but are highly variable in terms of their toxicity (Eisler 1987). For example, low-molecular weight PAH (LPAH) compounds exhibit acute toxicity to some organisms, with toxicity increasing as alkyl substitution increases (Van Luik 1984). However, they are considered non-carcinogenic. Conversely, high-molecular weight (HPAH) compounds are less toxic but can be carcinogenic, mutagenic or teratogenic (causing birth defects) to a wide variety of organisms (Moore and Ramamoorthy 1984; Eisler 1987; EC 1994). Although PAHs are rapidly bioaccumulate, they can also be quickly metabolized and eliminated from most organisms (e.g., forage fish and birds; Eisler 1987). In most fish, PAHs are metabolized and excreted, and concentrations in fish tissue are generally low.

In most cases, these effects, while potentially lethal to individual organisms, are generally temporary in terms of the overall abundance and diversity of benthic populations in the larger surrounding area (Cruz-Motta and Collins 2004). Benthic communities physically disturbed by marine construction activities are typically recolonized by adult organisms from surrounding areas and from larvae of benthic invertebrates that occupy the water column near the disposal site (Newell et al. 1998). The rate at which recolonization occurs depends upon the magnitude of disturbance incurred, the existing substrate characteristics, the type of species originally inhabiting the disturbance zone, and the level of natural disturbance to which the benthic community is already subjected.

In circumstances where the quantity of disturbed sediment does not differ greatly from natural sedimentation rates in the area, effects on benthos are relatively minor as most species are already tolerant of higher levels of sediment in the water column and/or capable of migrating up through deposited sediments following disturbance (Essink 1999; Schratzberger et al. 2006; Wilber et al. 2007). In circumstances where the quantity of sediment re-suspended or deposited is too great for species to survive, longer-term effects on benthic community structure are observed as recovery of the community is dependent on recolonization of and immigration to the new sediment surface (Stronkhorst 2003; Bolam et al. 2006a,b). In shallow water and estuarine conditions, where the community is typically dominated by opportunistic species, recovery to a benthic community's original species composition may be very rapid (several months to a year). In the stable environmental conditions of deeper waters, recovery may take several years (Newell et al. 1998).

Potential mortality of marine benthic species due to in-water works is carried forward in the assessment.

5.2.5.2.2.1.3.2 Vessel Wakes

As discussed in Section 5.2.5.2.1.1.1.2, the shoreline within the Proposed Project assessment areas is regularly exposed to strong winds and wind-waves and the estimated wake energy generated by Project vessels does not exceed existing wind-wave energy regimes in the RSA (Volume 4, Part G - Section 22.0: Appendix 7.2-A). Therefore, Project-related wake effects are unlikely to result in detectable changes of mortality of benthic organisms during any phase of the Proposed Project and are not carried forward in the assessment.

5.2.5.2.2.1.3.3 Propeller Scour

Physical interactions between tug propeller wash and marine benthic organisms are possible in the vicinity of the barge offloading facility, as described in Section 5.2.5.2.2.1.2.3. Effects may include direct mortality as a result of physical forces from the propeller jet plume, as well as from smothering, burial or chronic/toxic effects associated with sediment re-suspension. These effects are discussed in Section 5.2.5.2.2.1.3.1 for in-water works. Potential mortality of marine benthic species due to propeller scour is carried forward in the assessment.

5.2.5.2.2.2 Operations

5.2.5.2.2.2.1 Loss of Habitat

Direct loss of marine benthic habitat due to the physical footprint of the Proposed Project facilities, including associated shading effects, was assessed under the construction phase in Section 5.2.5.2.2.1.1.

5.2.5.2.2.2.2 Change in Habitat Quality

5.2.5.2.2.2.2.1 Groundwater Seepage

Groundwater seepage from the pit lake to the marine environment will meet applicable water quality guidelines or background levels, with the exception of phosphorus (Volume 2, Part B - Section 5.6: Groundwater Resources). Elevated concentrations of phosphorus are naturally occurring in existing groundwater. Although high levels of phosphorus are of potential concern for the freshwater environment due to potential nutrient over-enrichment issues, they are not of concern for the marine environment as phosphorus is not a limiting nutrient in the marine ecosystem (CCME 2007). Given the existing marine environment is nitrogen-poor and subject to dilution effects from freshwater runoff events in Howe Sound, any increase of phosphorus concentrations in seawater is not likely to result in an increase of phytoplankton growth resulting in harmful effects on the marine ecosystem (e.g., hypoxia/anoxia). Therefore, the potential effect of groundwater seepage on habitat quality for marine benthic communities is considered negligible, and is not carried forward in the assessment.

5.2.5.2.2.2.2.2 Vessel Wake

Potential effects from Project generated vessel wakes on marine benthic habitat are similar to those described in Section 5.2.5.2.1.1.1.2 for construction.

5.2.5.2.2.2.2.3 Propeller Scour

Potential effects from propeller scour on marine benthic habitat are similar to those described in Section 5.2.5.2.2.1.2.3 for construction.

5.2.5.2.2.2.3 Potential Mortality

Potential mortality of benthic organisms during operational activities (i.e., vessel wakes and propeller scour) is similar to that described in Section 5.2.5.2.2.1.3 for construction.

5.2.5.2.2.3 Reclamation and Closure

5.2.5.2.2.3.1 Loss of Habitat

Support piles for the barge load-out jetty, walkway and conveyor structures will serve as hard substrate habitat in the marine environment that will be colonized by sessile invertebrates (e.g., barnacles and mussels) and macroalgal species. Removal of the pile infrastructure following the Proposed Project completion will result in a loss of this vertical habitat. Given the low number of piles to be removed during closure and the anticipated negligible impacts on benthic habitat productivity in the LSA, this effect is not carried forward in the assessment.

5.2.5.2.2.3.2 Change in Habitat Quality

5.2.5.2.2.3.2.1 Removal of Marine Structures

Marine benthic communities may be affected during the Proposed Project reclamation and closure by sediment disturbance and re-suspension during removal of marine structures and potential release of creosote with removal of old piles. These effects have been assessed as part of the construction phase, as described in Section 5.2.5.2.2.1.2.

5.2.5.2.2.3.2.2 Vessel Wake

Potential effects from Project generated vessel wakes on marine benthic communities are similar to those described in Section 5.2.5.2.1.1.1.2 for construction.

5.2.5.2.2.3.2.3 Propeller Scour

Potential effects from propeller scour on marine benthic communities are similar to those described in Section 5.2.5.2.2.1.2.3 for construction.

5.2.5.2.2.3.3 Potential Mortality

Potential mortality of benthic organisms during closure activities (i.e., pile removal, vessel wakes and propeller scour) is similar to that described in Section 5.2.5.2.2.1.3 for construction.

5.2.5.2.2.4 Accidents and Malfunctions

Accidents and malfunctions potentially resulting in release of toxic/hazardous and non-toxic (aggregate) materials in the marine environment are described in Section 5.2.5.2.1.4. The following section described how these events may result in adverse impacts on marine benthic communities.

5.2.5.2.2.4.1 Toxic and Hazardous Material Spills

Hydrocarbon spills in the marine environment have the potential to result in toxic effects on marine benthic communities if the spilled fuel reaches the shoreline and is deposited within intertidal habitats. The degree to which intertidal benthic communities are affected depends upon the physical nature of the shoreline and the degree and direction of wind and wave action near the spill. The most severe consequences occur when spills happen near shore, in shallow waters, or areas with slow water circulations (Patin 1999). Weather conditions during and after the fuel spill will significantly influence the degree of oil spreading and persistency. The wind and current directions determine the direction the oil is spreading, and the nature of the shoreline will determine how much oil is deposited within the intertidal habitat. For example, oil does not deposit readily on steep rocky shorelines except in the very high intertidal as most of it gets washed away, while much more oil can become deposited and buried on sand/gravel beaches and estuarine flats (NOAA 2010).

Shorelines within Howe Sound are predominantly rocky cliffs mixed with sand/gravel beaches (BCMCA 2014). The intertidal zone in the proposed terminal footprint and adjacent waters of McNab Estuary is predominantly sand/gravel beach, with some exposed rocky substrate. Effects on benthic communities occupying rocky intertidal habitats would be short-term and minimal as oil would mostly be held offshore or washed away quickly and very little would become deposited on the steep shoreline habitat (NOAA 2010). Effects on benthic communities occupying sand/gravel intertidal habitat would be more pronounced as both light and heavy oil fractions could become deposited and smother benthic invertebrates. Indirect long-term effects may be substantial as oil could become buried in the sand resulting in long term contamination of intertidal organisms (NOAA 2010).

Some heavier hydrocarbon fractions resulting from a diesel fuel spill can sink and have negative effects on subtidal benthic invertebrates (NOAA 1992). The amount of sinking oil or sorption of dispersed diesel fuel in water is generally minimal (NOAA 2010). Sinking or dispersed oil can also affect benthic invertebrate behaviour by altering the ability of certain species to catch or avoid prey (Pearson et al. 1981).

Accidental release of sewage and other domestic wastes into the marine environment during shipping can cause a wide range of adverse environmental effects. Decomposed sewage depletes dissolved oxygen in the water increasing biochemical oxygen demand. Sewage and other domestic waste discharges can produce toxins and cause nutrient enrichment in the marine environment leading to algal blooms, reducing light penetration through the water column, and creating anoxic conditions.

Given the limited mobility of marine benthic organisms and their dependency on nearshore benthic habitat, the potential effect of a toxic or hazardous material spill on marine benthic communities is carried forward in the assessment.

5.2.5.2.2.4.2 Aggregate Spills

An aggregate spill may result in adverse effects on marine benthic habitats within and surrounding the area of aggregate release, on biological organisms within the water column, and/or on nearby fish and fish habitat.

Potential impacts associated with an aggregate spill on benthic communities would depend upon the amount of material deposited and the degree of dispersion following settlement on the seafloor. Direct mortality of some benthic organisms could occur through smothering effects; however, these effects would be localized. In addition, recolonization of the affected areas from neighboring benthic communities would likely occur within several months (Van Dolah et al. 1984; Cruz-Motta and Collins 2004).

Benthic species which are sensitive to increased levels of sedimentation may be negatively affected by aggregate and re-suspension of aggregate materials and may not be able to recolonize if impacted. Glass sponges (class

Hexactinellida) are a group of filter feeding organisms which can form large sponge reefs that provide habitat for other marine invertebrate and fish species (Leys et al. 2004). Increased levels of sedimentation can result in smothering of glass sponges which reduces their filtering capabilities and limits their ability to feed and grow (Leys et al. 2004). Increased sedimentation may also reduce the filtering capabilities of other bivalves such as clams and mussels (Wilber and Clarke 2001). Indirect changes to benthic community composition could occur as a result of an aggregate spill where more tolerant species would recolonize and less tolerant species may be extirpated from the immediate area.

Given the limited mobility of marine benthic organisms and their dependency on nearshore benthic habitat, the potential effect of an aggregate spill on marine benthic communities is carried forward in the assessment.

5.2.5.2.3 Marine Fish

Marine fish contribute to the overall ecosystem health in the region and provide social, cultural and economic benefits to communities in the Project Area. Potential environmental effects of the Project on marine fish and fish habitat during construction, operations and reclamation/closure include:

- Loss of habitat due to the physical presence of the barge load-out jetty, walkway and covered conveyor including shading effects (construction and operation phases);
- Change in fish habitat quality due to sediment disturbance and re-suspension as a result of in-water construction works, vessel wakes and propeller scour (all phases);
- Potential injury or mortality from underwater noise generated during impact pile driving (construction); and
- Release of deleterious substances due to accidental spills of hazardous, toxic or aggregate material (all phases).

5.2.5.2.3.1 Construction

5.2.5.2.3.1.1 Loss of Habitat

The majority of the piles are intended to be installed in the subtidal environment in the existing log dump area where the substrate is presently covered with extensive woody/bark debris and associated with relatively low value fish habitat. Sediment in this area is characterized by high silt-clay content and elevated concentrations of trace metals and PAHs. The proposed marine terminal footprint does not overlap with any rockfish conservation areas (RCAs) or previously identified herring spawning sites. The predominant substrate in the subtidal area consists of wood and bark debris from local log dump operations. Hard substrate such as boulders and bedrock outcrops present in the lower intertidal and upper subtidal areas of the foreshore are not likely to be suitable herring spawning substrate due to fine sediments from the log dump area that inhibit spawning, incubation and larval development (Haegele and Schweigert 1985; Lassuy 1989; Stacey and Hourston 1982).

Since the Proposed Project foreshore is not used as spawning habitat, the spawning habitat loss effect from the Proposed Project footprint is negligible. Presence of the Proposed Project marine facilities may result in some loss of prey habitat and rearing habitat for larval and juvenile forage fish, corresponding to the habitat loss for marine benthic communities discussed in Section 5.2.5.2.1.1.

Given that construction of the Proposed Project will result in the direct loss of 1.4 m^2 of subtidal fish habitat as a result of pile installation, this effect is carried forward in the assessment.

5.2.5.2.3.1.2 Change in Habitat Quality

5.2.5.2.3.1.2.1 Removal, Upgrade and Installation of Marine Infrastructure

Marine fish habitat during the construction phase may be affected by changes in water quality caused by sediment disturbance during in-water works (removal of old pilings, installation of marine infrastructure). This may include increased levels of suspended sediments, pH, metals, and hydrocarbons (creosote) in the water column.

Seabed disturbance caused by placement of new marine infrastructure and removal of old structures (in-water works) could result in increased levels of turbidity and total suspended solids (TSS) in the water column which may result in a disruption of feeding by visual fish predators (Berg and Northcote 1985). As the suspended particles settle out, they have the potential to smother existing benthic fish habitat including fish rearing and/or spawning habitats, as well as fill in spaces occupied by fish prey, depending on the habitat characteristics where the disturbance occurs. Sediment disturbance may also result in increased concentrations of pollutants in the water column, such as trace metals that are mainly adsorbed onto suspended sediment particles of smaller size fractions (Chapman 1992; Horowitz 1985). Once re-suspended, these pollutants can be ingested by forage fish (e.g., herring) and transferred through the food chain to higher trophic species such as salmon or rockfish (CCME 2013).

No sensitive fish areas (e.g., spawning grounds, rockfish conservation areas) occur in the marine terminal footprint of the Proposed Project. Several fish species have been recorded in the nearshore environment of the Proposed Project Area, including sculpin, flounder, perch and juvenile salmon (Section 5.2.4 and Volume 4, Part G - Section 22.0: Appendix 5.2-A). No forage fish were identified during baseline sampling (beach seine sampling); although local marine waters are known to support herring and other important forage fish species such as Pacific sand lance, capelin and surf smelt. Juvenile and larval fish would be particularly sensitive to smothering and toxic effects of increased levels of turbidity and other contaminants, or from indirect effects of reduced food base (planktonic and benthic invertebrates) caused by Proposed Project activities.

Potential changes in marine fish habitat quality from in-water works are carried forward in the assessment.

5.2.5.2.3.1.2.2 Vessel Wake

Changes in fish habitat quality due to vessel wake wash are related to changes in marine water and sediment quality, as discussed in Section 5.2.5.2.1.1.1.2. Given no adverse effects are anticipated to marine water and sediment quality from these activities, potential effects on marine fish habitat quality are also considered to be negligible and are not carried forward in the assessment.

5.2.5.2.3.1.2.3 Propeller Scour

Changes in fish habitat quality due to vessel propeller scour effects will be similar to that described for marine benthic communities (Section 5.2.5.2.2.1.2.3). In the proposed shipping corridor, no propeller scour effects are predicted. In the barge offloading area, potential propeller scour effects will be largely confined to a subtidal area presently covered with extensive woody/bark debris cover and associated with marginal[7] fish habitat. Potential changes in marine fish habitat quality from tug propeller scour are carried forward in the assessment.

5.2.5.2.3.1.3 Effects of Underwater Noise

The main sources of Project-generated underwater noise considered in the marine fish assessment include:

- Impact pile driving (construction);
- Vessel traffic (all Project phases); and
- Loading of aggregate onto barges (operations)

The potential impacts of underwater sound on marine fish generated during the construction phase are assessed in this section. This includes underwater noise impacts related to impact pile driving and vessel traffic. Potential underwater noise effects from loading of aggregate onto barges is discussed under Project operations (Section 5.2.5.2.3.2.3). To frame this assessment, a brief overview is first provided below on sound terminology, acoustic threshold criteria and hearing sensitivity in marine fish.

Existing ambient noise has not been measured in the LSA and no published data or publicly available information exists on ambient underwater noise levels could be identified for the Howe Sound region. It is believed that the dominant sources of underwater ambient noise within the LSA would include residential and commercial vessel noise (e.g., fishing vessels, ferries, water taxis, tug-assisted barges, cargo and container ships), surface agitation noise from wind, waves, rainfall, and inherent biological noise.

Overview of Sound Terminology

Underwater sound can be described through a source-path-receiver model. An acoustic source emits sound energy that radiates outward and travels through the water and the seafloor as pressure waves. The sound level decreases with increasing distance from the acoustic source as the sound pressure waves spread out under the influence of the surrounding environment. The amount by which the sound levels decrease between a source and receiver is called transmission loss. The amount of transmission loss that occurs depends on the source-receiver separation, the frequency of the sound, the properties of the water column and the properties of the seafloor layers. An animal senses the sound at a level that is dependent on the amount of transmission loss between the source and the receiver (Richardson et al. 1995). The potential for impact depends on the received sound level and the frequency content of the received sound signal relative to the hearing abilities of the animal and the level of natural background sound. Potential effects range from subtle changes in behaviour at low received levels to strong disturbance effects or physical injury at high received levels.

Anthropogenic sound sources can be categorized generally as pulsed (e.g., pile driving) or non-pulsed/ continuous (e.g., vessel traffic, barge loading). Sounds from moving sources (ships) are considered to be transient relative to

[7] Habitat considered to have low productive capacity and to contribute only marginally to fish production (DFO 1998).

the receivers. Underwater sound levels are expressed in decibels (dB) which is a logarithmic ratio relative to a fixed reference pressure of 1 µPa (equal to 10-6 Pa or 10-11 bar). Underwater sound is typically quantified using one of the following metrics:

- Sound Pressure Level (SPL) - measured in dB re 1 uPa:
  - Peak SPL (SPL_{peak}) – greatest absolute instantaneous sound pressure over a stated time interval.
  - Root mean square SPL (SPL_{rms}) - average root mean square pressure level over a stated time interval.
- Sound Exposure Level (SEL) - measured in dB re 1 uPa^2-s:
  - Cumulative SEL ($_{c}SEL$) –the cumulative energy associated with multiple consecutive sound sources. Considered a conservative measure that does not account for hearing recovery that may occur between pulses.

Marine Fish Acoustic Impact Thresholds

Assessment of the potential effects of underwater anthropogenic noise on fish requires acoustic impact thresholds for which to compare emitted sound levels and establish potential for injury and behavioral disturbance. Currently, there are no legislated underwater noise criteria in Canada for assessing injury in fish. In absence of specific legislated criteria, assessing potential for 'serious harm[8]' to fish from underwater noise is typically based on 'best available evidence', as documented in the scientific literature, available Best Management Practices (BMPs) and/or established by other government agencies.

DFO have established "best practice" guidelines for mitigating the effects of underwater noise emissions from pile driving on fish (DFO 2003). These guidelines state that any pile driving activity that produces a peak pressure exceeding 30 kPa (equivalent to ~210 dB re 1 µPa SPL_{peak}), or that causes a fish kill, must employ sound mitigation (such as a bubble curtain) in order to reduce sound levels to an acceptable level.

The U.S. National Marine Fisheries Service (NMFS) have also adopted interim acoustic threshold criteria specific to impact pile driving that are based on SPL that are known to potentially result in physical effects in fish (Stadler and Woodbury 2009). The current NMFS interim SPL thresholds protective of injury disturbance to fish are as follows:

- SPL_{peak} for potential injury to fish is 206 dB re 1 uPa (Stadler and Woodbury 2009).

Marine Fish Hearing Sensitivity

Fish use sound for communication, detection of predators and prey, and learning about their environment (Popper and Fay 1999; Zelick et al. 1999; Fay and Popper 2000; Popper et al. 2003). All fish species can hear with varying degrees of sensitivity within the frequency range of sound produced by industrial sound sources (Hawkins 1973;

[8] includes the destruction of fish habitat or an alteration of fish habitat of a spatial scale, duration and intensity that limits or diminishes the ability of fish to use such habitats as spawning grounds, or as nursery, rearing, or food supply areas, or as a migration corridor, or any other area in order to carry out one or more of their life processes (DFO 2013b)

Popper and Fay 1973; Tavolga et al. 1981; Fay 1988; Popper and Fay 1993; Fay 2000). The hearing range for most fish is believed to be in the frequency range of 100 to 1,000 Hz (Fay 1988). A smaller number of species can detect sounds to over 3,000 Hz, while a very few can detect sounds to well over 100 kHz. Because of wide differences in hearing capability and morphologies among fish species, behavioral responses and the susceptibility of fish to auditory trauma varies greatly.

There is considerable anatomical and physiological variation amongst fish with respect to hearing structures, suggesting that various species may detect, process, and react to sound in different ways (Popper and Fay 1993). Physical variability in a fish species' hearing anatomy generally determines its overall hearing sensitivity (Popper et al. 2003; Yan et al. 2000). Fish can be divided into two broad categories: hearing generalists ("non-specialists") and hearing specialists[9] (Popper et al. 2003; Ladich and Popper 2004).

Hearing generalists are fish species without any auditory system specializations with relatively poor auditory sensitivity characterized by a narrow bandwidth of hearing, and typically detecting sounds from below 50 Hz up to 1 or 1.5 kHz (Popper et al. 2003). This includes most bottom-dwelling species This includes fish species lacking a swim bladder (elasmobranchs such as sharks and skates), those that have a small or reduced swim bladder (most bottom-dwelling species such as flatfish), or those that have a swim bladder that is not in close proximity to, or mechanically connected to, the ears (e.g., toadfish) (Popper et al. 2003). The majority of fish species that fall into this category generally do not hear frequencies much above 1 kHz, with peak sensitivities around 300 to 500 Hz (Ladich and Popper 2004). The sound pressure detection threshold can be as high as 120 dB re 1 µPa at the most sensitive frequency (Nedwell et al. 2004).

Hearing specialists have specialized auditory structures connected to well-developed pressure sensitive organs (Popper and Fay 1993). These morphological adaptations allow hearing specialists to detect sound pressure with greater sensitivity (i.e., lowering their hearing threshold) and in a wider bandwidth than "generalists", and makes hearing specialists generally more sensitive to high-amplitude sound introduced into the marine environment. Herring and other pelagic forage fish are considered 'hearing specialists' as they have specialized auditory structures (prootic bullas) connected to well-developed pressure sensitive organs (swim bladders) (Popper and Fay 1993). These morphological adaptations enhance a species' hearing bandwidth and sensitivity (i.e., lowering their hearing threshold). Hearing "specialists" tend to detect sound pressure with greater sensitivity and in a wider bandwidth than "generalists", and are generally more sensitive to high-amplitude noise introduced to the marine environment (i.e., impact pile driving). The main factor affecting this is the close proximity and/or connection of the swim bladder to the inner ear (otophysic connection). The density of the gas within the swim bladder is much lower than that of seawater and that of a fish's body. As a result, the gas in the swim bladder can be easily compressed by sound pressure waves. The swim bladder changes in volume cyclically in reaction to passing sound waves. If the movements of the swim bladder wall are transmitted to the ear, this results in the stimulation of the sensory cells of the ear. Quite often, hearing specialists will detect signals up to 3,000 to 4,000 Hz, with thresholds that are 20 dB or more lower than generalists (Hastings and Popper 2005).

[9] The grouping of fish into hearing generalists and specialists may serve as a general guideline for determining hearing sensitivity of a species but does not replace the accuracy of species-specific audiograms, which are only available for a limited number of species. Many species have not yet been classified as hearing generalists or specialists.

Physical Effects of Underwater Noise on Fish

Specific, systematic studies regarding the effects of underwater noise and vibrations of fish are few and in some cases contradictory. Popper and Hastings (2009) reviewed the available studies, which addressed the following potential effects mechanisms: behavioural responses; stress and other physiological responses; hearing loss and damage to auditory tissues; structural and cellular damage on non-auditory tissues; and mortality.

Depending on the species of fish and the nature of the noise exposure (e.g., duration, peak pressure, rise times, accumulation of energy with time), underwater noise may result in:

- Startle responses or migration out of areas exposed to underwater noise;
- Increased levels of corticosteroid levels, which is an indicator of stress. Stress may impair a fish's ability to avoid predation;
- Hearing loss. Inability to hear may affect a fish's ability to respond to other noise cues and thus be more susceptible to predation or less able to find food items; and
- Tears or rupture of the swim bladder or other tissues, which may affect buoyancy or cause internal bleeding and ultimately mortality.

Impact Pile Driving Noise

Elevated underwater noise levels will occur during construction as a result of impact pile driving in the nearshore environment. Installation of the barge load-out jetty, walkway and conveyor system will require impact driving of eight steel piles (0.42 m diameter) in the intertidal, and 10 equivalent piles in the subtidal. The generation of underwater noise during pile driving is dependent on the type of pile being driven, the type of hammer, substrate type and water depth (ICF Jones and Stokes and Illingworth and Rodkin Inc. 2009).

The threshold SPL_{peak} for direct physical trauma in marine fish is generally considered to be >200 dB re 1 uPa (McCauley 1994). Except at close range, the effects of impulsive sound sources on fishes are thought to be transitory, mainly evoking a startle response and changes in schooling behaviour (McCauley et al. 2003). Habituation of fish to underwater sound has been shown to occur, with adverse behavioural changes ceasing during the exposure period, sometimes within minutes of the initial exposure (Pearson et al. 1992).

In general, subtle behavioural changes in fish may be expected to occur at received peak pressures of 160 dB re 1μPa, and peak pressures of 180 dB or higher may cause noticeable changes in behaviour or auditory trauma (Chapman and Hawkins 1969; Pearson et al. 1992; Skalski et al. 1992; McCauley et al. 2003).

At close range to the source, fish kills in the wild have been reported from impulsive noise sources such as pile driving and underwater blasting (Caltrans 2001; Vagle 2003; Hastings and Popper 2005; Popper and Hastings 2009). Pile driving and the use of explosives in water can produce compressive shock waves (overpressure) characterized by a rapid rise to a high peak pressure followed by a rapid decay to below ambient hydrostatic pressure (Wright and Hopky 1998). These shock waves can result in physical damage and occasionally direct mortality to nearby fish (Caltrans 2001; Vagle 2003). In finfish, the swim bladder is the primary site of damage although the kidney, liver and spleen may also be ruptured. There is evidence that smaller fish appear to be more vulnerable to overpressure impacts than larger fish and fish near the surface are more vulnerable than deep fish

(Mitson 1995; Baxter et al. 1982; Keevin and Hempen 1997; Popper and Hastings 2009; ICF Jones, Stokes, Illingworth and Rodkin Inc. 2009).

During a pile installation project in San Francisco, Caltrans (2001) identified fish mortalities within 50 m of the piles; postmortem examination indicated that the mortality was due to barotraumatic injuries. During the same pile driving project, all caged shiner perch at 150 m distance from pile strikes suffered injuries, with 40% seriously injured. Sound levels measured during pile driving were 207 re 1 uPa (SPL_{peak}) and 196 re 1 uPa (SPL_{rms}) at 103 m from the pile. Another study demonstrated auditory damage in fish exposed to impulsive noise sources at received SEL of 230 dB re 1 μPa^{2}s (Falk and Lawrence 1973). However, studies conducted by Weinwold and Weaver (1972) demonstrated no auditory damage in coho salmon (*Oncorynchus kisutch*) exposed to pulses at estimated received SEL of 214 to 216 dB re 1 μPa^{2}s. Experiments were also conducted by Nedwell and Turnpenny (2003) with wild brown trout (*Salmo trutta*), that were captured, caged, and then exposed to impact pile driving (hammering) noise at a distance of 400 m from the source. Results demonstrated that no physiological damage occurred at received exposure levels of 194 dB re 1 uPa (metric undisclosed).

High sound pressure levels transmitted through the water column can also potentially prevent fish from reaching breeding or spawning sites, finding food, and acoustically locating mates. This could result in long-term effects on reproduction and population parameters; however this effect pathway has not been studied in great detail. Further, avoidance reactions might result in displacement away from potential fishing grounds, leading to reduced catches (Popper and Hastings 2009). Pearson et al. (1992) suggested that a general threshold for alarm response in various caged rockfish species when exposed to seismic pulses is 180 dB re 1μPa (undisclosed metric) from a single air gun. In a companion study using the same air gun, Skalski et al. (1992) suggest that the reduced catchability (catch-per-unit-effort) of various rockfish in the wild derived from behavioral changes to the noise levels received from the airgun. Habituation of rockfish to underwater sound has also been shown to occur, with behavioural changes ending after the exposure period (Pearson et al. 1992).

For juvenile fish, the literature suggests that the effects of pile driving noise are variable. Ruggerone et al. (2008) examined the effects of pile driving exposure on caged yearling coho salmon. Individuals were exposed to cumulative SEL of ~207 dB re 1 uPa^{2}s during a 4-h period. Fish were sampled at 10 and 19 days post-exposure with zero mortality observed. An examination of the external and internal anatomy showed no differences between exposed and control fish. In another study, Halvorsen et al. (2012) defined the thresholds for onset of injury in juvenile Chinook salmon exposed to impulsive sounds that simulated an impact hammer striking a steel pile, with a reported SPL_{peak} of 215 dB re 1μPa at the source. Juvenile salmon exhibited tissue damage and adverse physiological effects at received SEL of 177 dB re 1 μPa^{2}s (for 1920 strikes) and 180 dB re 1 μPa^{2}s (for 920 strikes). Vagle (2003) reported mortality of herring, chum and chinook smolts during impact pile driving in Vancouver Harbour when peak pressures from hammer strikes approached 150 kPa[10] in the lower frequency range, although the range of this impact was not reported. At another pile driving site, Vagle (2003) reported no injury but some startle response in caged juvenile chinook salmon (at 3, 6, and 9 m from the pile) in response to hammer strikes of 44 kPa[11] (measured at pile). Received sound levels were not reported for the caged salmon at the various distances from the pile.

[10] 150kPa is equivalent to 224 dB re 1 uPa (SPL_{peak})

[11] 44kPa is equivalent to 213 dB re 1 uPa (SPL_{peak})

Studies have shown that fish eggs and larvae also may be killed or damaged from overpressure, especially as they are often stationary or directed by oceanic currents, and can thus not swim away from the sound source (Popper and Hastings 2009; ICF Jones, Stokes, Illingworth and Rodkin Inc. 2009). Kostyvchenko (1973) exposed fish eggs (European anchovy, *Engraulis encrasicholus,* and striped red mullet, *Mullus surmuletus*) to a calibrated noise source at variable distances. Received SPLs were 236 dB re 1 uPa at 0.5 m, 230 dB re 1 uPa at 1 m, and 210 dB re 1 uPa at 10 m, assuming a noise concentric dispersion. Egg survival for the combined species increased at increasing distance from the airgun, which were 75.4, 87.7, 90.2, and 92.3, for the 0.5, 5.0, 10 m and control exposures. Booman et al. (1996) exposed several Norwegian species of fish eggs and larvae (i.e., cod and turbot) to seismic airgun exposure at a SPL range between 242 and 220 dB re 1 μPa (metric undisclosed), at a distance ranging from 0.75 to 6 m from the airgun, respectively. Highest mortality rates were found at 1.4 m distance, with low and no mortality rates in the 5 meter range.

The present assessment recognizes that marine fish species occurring in the Project Area have different patterns of habitat use, life-history strategies, behavior and hearing ability, which result in varying susceptibility to underwater noise impacts. Highly mobile species such as salmon, herring, eulachon, capelin, smelts, and perch are able to leave an area when pile driving or blasting is occurring and return when activities cease. Because migration timing for salmon, eulachon and herring are well known in the Project Area, this information can be taken into account when planning pile driving activities. Other species like rockfish are less mobile and less able to leave an area upon disturbance; consequently, individuals of these species may be subject to longer exposure periods and at higher levels.

Underwater noise levels were not available for the exact size of piles being considered for the Proposed Project. Surrogate values were obtained from the California Department of Transport (CDOT) (ICF Jones and Stokes and Illingworth and Rodkin Inc. 2009) and the Washington State Department of Transport (WSDOT) (WSDOT 2009), including reference noise source levels for various pile sizes and types as outlined in Table 5.2-13. Representative source levels were selected form these data sources as surrogates for acoustic modeling and subsequent assessment of underwater noise impacts on marine fish.

Table 5.2-13: Reference Underwater Sound Levels for Impact Pile Driving (Single Strike)

Proposed Project Activity	Sound Levels (Single Strike)			
	Reference Distance from Pile (m)	SPL_{peak} (dB)	SPL_{rms} (dB)	kPa
0.41 m diameter steel pile (single strike)	20	200	187	10
0.61 m diameter steel pile (single strike)	10	207	194	22

Source: ICF Jones and Stokes and Illingworth and Rodkin, Inc. (2009); WSDOT (2009); Richardson et al. 1995; Urick 1975
Notes: dB – decibel (data as presented in source); kPa – kilo Pascal (converted from source values).

Underwater noise from impact pile driving was modeled using the Practical Spreading Loss Model, a two-dimensional noise model designed by NMFS specifically for pile driving/drilling activities (WSDOT 2009). Underwater noise levels were calculated on the basis of methods described in WSDOT's Advanced Training Manual: Biological Assessment Preparation for Transportation Proposed Projects Version 2014 (WSDOT 2009).

The Practical Spreading Loss Model is based on the following formula for geometric spreading:

$$TL = 15 \text{ X } \text{Log}(R1/R2) + \alpha R$$

Where:

TL: is the transmission loss in dB.

R1: is range in meters of the sound pressure level.

R2: is the distance from the source of the initial measurement.

αR: linear absorption and scattering loss

Solving for TL will provide the underwater sound pressure level at a given distance. To determine at what distance or range a known sound pressure level will occur, the equation must be solved for R1:

$$R1= (10(TL/15)) \bullet R2$$

The NMFS model was used to estimate the distance from the source at which point pile driving noise would attenuate to the injury threshold for fish. Underwater noise modeling results are presented in Table 5.2-14. Using the more conservative pile size (0.61 m diameter) as the reference source level in the model, acoustic modeling results indicate that underwater sound from impact pile driving will exceed the injury threshold for fish at distances up to 12 m from the source(as boundary conditions allow).

Bubble curtains are commonly used to reduce acoustic energy emissions from pile driving to reduce the sound exposures of nearby fauna. Bubble curtains are available in a variety of configurations, but all variations release compressed air into the water through multiple small holes drilled in a hose or manifold deployed underwater, usually close to the seabed. The resulting curtain of air bubbles absorbs sound energy and provides significant attenuation of sound pressure through the curtain. The reported effectiveness of bubble curtains is highly variable and depends on many factors: the thickness of the bubble layer, the total volume of injected air, the size of the bubbles relative to the sound wavelength, and whether the curtain is completely closed. Optimal results are obtained when using a double bubble curtain installed approximately 5 m from the source and an air volume flow rate of 20 m^{3}-min^{-1}, where a mean attenuation of approximately 15 dB can be achieved (Koschinski and Kock 2009). Typical attenuation values are closer to 10 dB.

Table 5.2-14: Distances to Fish Acoustic Thresholds for Impact Pile Driving and Vessel Noise (No Mitigation)

Acoustic Threshold Criteria for Fish	Distance to Threshold	
	Impact Pile Driving Noise (207 dB re 1 µPa at 10 m - SPL_{peak})[c]	Tug Vessel Noise (170 dB re 1 µPa at 1 m - SPL_{rms})[d]
DFO threshold[a] for injury (30 kPa / 210 dB - SPL_{peak})	6 m	N/A
NFMS interim threshold[b] for injury (206 dB - SPL_{peak})	12 m	N/A

Notes: Unless otherwise noted, all sound pressure levels are referenced to 1 micro Pascal (uPa)

a) Source: DFO 2003.

b) Source: Stadler and Woodbury 2009.

c) Based on practical spreading loss of a 0.61 m diameter steel pile (single strike) with source level of 207 dB re 1 uPa SPL_{peak} / 194 dB re 1 uPa SPL_{rms} @ 10m (ICF Jones and Stokes and Illingworth and Rodkin Inc. 2009).

d) Based on standard cylindrical spreading loss. Reference source level (170 dB re 1 µPa at 1 m SPL_{rms}) based on measurements of the Arctic Fox tug vessel – now the Island Fox tug (1,700BHP @ 1,225RPM, 85' x 30' x 11') (Richardson et al. 1995) - surrogate for actual Project tug Seaspan Commander (1700 Hp @ 1,225 RPM, 84' X 24.6' X 13') (Seaspan Marine 2010)

Confidence in the underwater noise model was considered to be moderate based on the following factors:

- The activities associated with construction of the marine facilities were modeled using conservation values and measured values from similar materials, equipment, and operations;
- The NMFS model is designed specifically for pile driving activities;
- There are no other significant noise sources in the Proposed Project Area that would need to be considered in the model;
- The short duration of all noise sources minimizes potential effects;
- Quality assurance was accomplished by implementing quality control checks on all model runs to ensure that model input parameters were correct, model output was plotted correctly and any calculations were checked; and
- It is acknowledged that there are limitations of using a two-dimensional model with respect to sound attenuation in a three-dimensional environment. The spreading loss model used for the underwater noise assessment only provides a rough approximation to the actual spreading loss in the marine environment. The model assumes that sound travels in a homogeneous environment. It does not take into account potential propagation effects related to absorption / reflection that may occur as a result of sound interacting with local marine topographical features, nor effects related to refraction that may occur as a result of boundary layer effects / water column stratification. For example, physical aspects of the receiving environment (e.g., freshwater surface lens, in-field gradients in temperature, bottom topography) could cause sound levels to attenuate at different rates than predicted by this geometric spreading-based model. More advanced sound field models do exist which account for these factors; however, these require detailed site-specific inputs for the model with respect to existing oceanographic, bathymetric and substrate conditions, which were not available for the specific Proposed Project Area. Nonetheless, the practical spreading loss model is commonly used to obtain an estimate of sound levels around a source when more complex models are not achievable.

The potential effects of underwater noise from impact pile driving on marine fish, including potential injury and disturbance effects have been carried forward in the assessment.

Vessel Noise

Vessel noise sources during the construction phase will include water taxis (crew transport vessels) and tug-assisted barge movements. In general, vessel noise increases with ship size, power/speed, propeller blade size, number of blades and rotations per minute, with the majority of underwater noise generated by propeller cavitation and singing (Gray and Greeley 1980; Mitson 1995; JASCO 2011).

Underwater noise levels generated by continuous Project noise sources such as vessel noise and barge loading are not high enough to result in injury to fish. Noise disturbance may cause fish to temporarily school in larger groups, move away from suitable habitat (displacement), or alter their natural movements (avoidance or diversion from a foraging area or migratory path). This could, in turn, reduce foraging efficiency and fecundity, and increase energy expenditure. Fish can detect noise from ships at long distances when ambient noise is low but are unlikely to move away until the noise is relatively high (i.e., when the distance is a few hundred metres) (Mitson 1995). A review of the literature indicates that most fish species typically show a response to vessel noise when their hearing threshold is exceeded by 30 dB or more (Mitson 1995).

Schwarz and Greer (1984) demonstrated in a laboratory setting that Pacific herring display startle behaviour and directional avoidance (movement away from the sound source) when exposed to recordings of vessel noise and electronically synthesized sound. Herring responded to increased amplitude (louder noise level), and their response increased in intensity and duration with increasing loudness. Also, herring responded more effectively to lower frequency sounds, indicating that they have a lower hearing threshold at lower frequencies (200 Hz) than at higher (1,000 Hz). Response to electronically synthesized sound corresponded with vessel noise, in which responses were more effective for larger vessels emitting noise at lower frequencies than smaller vessels emitting the same noise level at higher frequencies. Instantaneous noises provoked alarm response and to a lesser degree startle response.

There are no source level data available for the specific vessels identified for the Proposed Project. Tug-assisted barges similar in size and horsepower to that proposed by Seaspan[12] for the Proposed Project, with a reported SPL_{rms} value of 170 dB re 1 uPa at 1 m, typically emit underwater noise in the 1 kHz to 5 kHz bandwidth range (Richardson et al. 1995). These levels are below the injury threshold for fish.

Based on modeling results and a review of available literature, underwater noise generated from Project vessels will not occur at levels that cause injury or mortality to fish in the LSA, and therefore this effect is not carried forward in the assessment.

5.2.5.2.3.2 Operations

5.2.5.2.3.2.1 Loss of Habitat

Direct loss of marine benthic habitat due to the physical footprint of the Proposed Project facilities was assessed under the construction phase in Section 5.2.5.2.3.1.1.

5.2.5.2.3.2.2 Change in Habitat Quality

5.2.5.2.3.2.2.1 Groundwater Seepage

Groundwater seepage from the pit lake to the marine environment will meet applicable water quality guidelines or background levels, with the exception of phosphorus (Volume 2, Part B - Section 5.6: Groundwater Resources). Elevated concentrations of phosphorus naturally occur in existing groundwater. Although high levels of phosphorus are of potential concern for the freshwater environment due to potential nutrient over-enrichment

[12] Seaspan Commander to be used in the Project 1700 Hp @ 1,225 RPM, 84' X 24.6' X 13' (Seaspan Marine 2010); compared to Arctic Fox – now the Island Fox tug 1,700BHP @ 1,225RPM, 85' x 30' x 11' (Marcon International, Inc. 2014; Miles et al. 1987; Richardson et al. 1995)

issues, they are not of concern for the marine environment as phosphorus is not a limiting nutrient in the marine ecosystem (CCME 2007). Given the existing marine environment is already nitrogen-poor and subject to dilution by freshwater runoff events in Howe Sound, any increase of phosphorus concentrations in seawater are not likely to result in an increase of phytoplankton growth resulting in harmful effects on the marine ecosystem (e.g., hypoxia/anoxia). Therefore, the potential effect of groundwater seepage on marine fish habitat quality is considered negligible, and is not carried forward in the assessment.

5.2.5.2.3.2.2.2 Vessel Wake

Potential effects from Project generated vessel wakes on marine fish habitat quality are similar to those described in Section 5.2.5.2.3.1.2.2 for construction.

5.2.5.2.3.2.2.3 Propeller Scour

Potential effects from propeller scour on marine fish habitat quality are similar to those described in Section 5.2.5.2.3.1.2.3 for construction.

5.2.5.2.3.2.3 Effects of Underwater Noise

The main sources of Project-generated underwater noise during the operations phase are Project vessels and barge loading. Vessel noise was assessed as part of the construction phase (Section 5.2.5.2.3.1.3). This section assesses underwater noise generated during loading of the barges.

Underwater sound generated during loading of the barge is dependent on the volume of material in the barge at the time the loading is occurring. Materials loaded onto an empty barge would likely transmit sound through the barge hull into the marine environment, whereas material placed upon previously piled material may or may not produce detectable underwater sounds due to buffering provided by the “softer” receiving surface.

There are no source level data available for the specific barge loading activities identified for the Proposed Project. Surrogate data were obtained from the literature based on measurements of similar barge loading activities, with a reported broadband SPL_{rms} value of 139.5 dB re 1 uPa at 1 m (Reine et al. 2012). These levels are below the injury thresholds for fish; therefore this effect is not carried forward in the assessment.

5.2.5.2.3.3 Reclamation and Closure

5.2.5.2.3.3.1 Loss of Habitat

Support piles for the barge load-out jetty and conveyor system will serve as hard substrate habitat in the subtidal environment that may serve as vertical fish habitat and provide shelter for juvenile forage fish. Removal of the pile infrastructure following Project completion will result in a loss of this vertical fish habitat. Given the low number of piles to be removed during closure and the anticipated negligible impacts on fish habitat productivity in the LSA, this effect is not carried forward in the assessment.

5.2.5.2.3.3.2 Change in Habitat Quality

5.2.5.2.3.3.2.1 Removal of Marine Infrastructure

During reclamation and closure, marine fish habitat may be affected by sediment disturbance / re-suspension and potential release of creosote during removal of marine structures and remnant piles. These effects were assessed as part of the construction phase, as described in Section 5.2.5.2.2.1.2.

5.2.5.2.3.3.2.2 Vessel Wake

Potential effects from Project generated vessel wakes on marine fish habitat quality are similar to those described in Section 5.2.5.2.3.1.2.2 for construction.

5.2.5.2.3.3.2.3 Propeller Scour

Potential effects from propeller scour on marine fish habitat quality are similar to those described in Section 5.2.5.2.3.1.2.3 for construction.

5.2.5.2.3.3.3 Effects of Underwater Noise

The main sources of Project-generated underwater noise during the closure phase are Project vessels. Vessel noise was assessed as part of the construction phase (Section 5.2.5.2.3.1.3).

5.2.5.2.3.4 Accidents and Malfunctions

Accidents and malfunctions potentially resulting in release of toxic/hazardous and non-toxic (aggregate) materials in the marine environment are described in Section 5.2.5.2.1.4.1. The following section described how these events may result in adverse effects on marine fish and fish habitats.

5.2.5.2.3.4.1 Toxic and Hazardous Material spills

Hydrocarbon spills in the marine environment can result in adverse effects on fish habitat in the pelagic zone and fish spawning and rearing habitats in coastal areas. The effects can be both direct (e.g., toxic and smothering effect of hydrocarbons) and indirect (e.g., reduction of prey resources and/or degradation of vegetative spawning substrate such as sea grasses and macroalgae assemblages). The effects of a diesel fuel spill would be more severe in coastal areas as much of the fuel will remain near the surface of the water. Sinking or sorption of fuel may have acute (short term, lethal) or chronic (long term) toxic effects on benthic (demersal) fish species and may also alter fish behaviour (NOAA 1992) by means of avoidance of the impacted area.

Release of sewage and other domestic wastes into the marine environment during shipping can cause a wide range of adverse environmental effects. Decomposing sewage depletes dissolved oxygen in the water increasing biochemical oxygen demand which may result in hypoxic or anoxic conditions. Sewage and other domestic waste discharges may contain toxins. Nutrient enrichment in the marine environment by sewage and domestic waste can lead to algal blooms and reduced light penetration through the water column.

Given the dependency of many fish species on nearshore marine habitats, the potential effect of a toxic or hazardous material spill on marine fish and fish habitat is carried forward in the assessment.

5.2.5.2.3.4.2 Aggregate spills

Dispersion of aggregate during and after release from the barge could directly and indirectly affect nearby fish and fish habitat including potential spawning and rearing grounds. Direct mortality of adult fish caused by increased levels of turbidity and TSS is considered unlikely as adult fish are generally able to actively avoid the descending plume (Clarke et al. 2000). Juvenile fish are more susceptible to increased levels of sedimentation in the water column and may be subject to health effects and /or mortality if sustained levels of high turbidity and TSS persist. Larval hatching may also be delayed by increased sedimentation effects. However, extended periods of elevated turbidity and TSS as a result of an aggregate spill are considered unlikely given the nature/composition of the materials that will be loaded and transported on the barge.

The load-out jetty would be the most likely site of an aggregate spill. The seafloor in this area is presently covered with extensive woody/bark debris from historical log sort operations and is considered relatively low value fish habitat. No sensitive fish habitat areas (e.g., spawning grounds, RCAs) or suitable herring spawn habitat (e.g., eelgrass) occur in this area.

Given the above factors in combination with the limited footprint of a potential aggregate spill, the potential adverse effects of an aggregate spill on fish and fish habitat are considered negligible and are not carried forward in the assessment.

5.2.5.2.4 Marine Mammals

Marine mammals contribute to the overall ecosystem health in the region and provide social, cultural and economic benefits to communities in the Project Area. Potential environmental effects of the Project on marine mammals and their habitats during construction, operations and reclamation/closure include:

- Change in habitat quality / decreased prey availability due to sediment disturbance and re-suspension as a result of in-water works, vessel wakes and propeller scour (all phases);
- Potential injury or mortality from underwater noise generated during impact pile driving (construction);
- Behavioral disturbance from underwater noise generated during pile driving, vessel activities, and barge loading (all phases);
- Potential injury or mortality from vessel strikes (all phases); and
- Release of deleterious substances due to accidental spills of hazardous, toxic or aggregate material (all phases).

5.2.5.2.4.1 Construction

5.2.5.2.4.1.1 Changes in Habitat Quality

The proposed marine structures will have a minimal physical footprint and will not result in direct loss of marine mammal habitats. Potential indirect effects of construction activities (e.g., in-water works, vessel wakes, propeller scour) on marine mammal habitat quality include the reduced availability of their prey (e.g., forage fish, benthic invertebrates) due to Project-induced changes on water quality (increased levels of turbidity, TSS, metals, PAHs) from sediment disturbance events and subsequent changes in the abundance and distribution of marine mammal prey species. However, elevated levels of turbidity and TSS resulting from construction and vessel activities would be localized and limited to subtidal areas presently associated with low value fish habitat. In addition, marine mammals are highly mobile and have extensive foraging ranges. The potential effects of the Project on marine mammal prey habitat and prey availability are therefore considered negligible and are not carried forward in the assessment.

5.2.5.2.4.1.2 Effects of Underwater Noise

The main sources of Project-generated underwater noise considered in the marine mammal assessment include:

- Impact pile driving (construction);
- Vessel traffic (all Project phases); and
- Loading of aggregate onto barges (operations)

The potential impacts of underwater sound on marine mammals generated during the construction phase are assessed in this section. This includes underwater noise impacts related to impact pile driving and vessel traffic. Potential underwater noise effects from loading of aggregate onto barges is discussed under Project operations (Section 5.2.5.2.4.2.1). To frame this assessment, a brief overview is first provided below on hearing sensitivity and underwater noise thresholds for injury and disturbance in marine mammals.

Marine Mammal Hearing Sensitivity

The efficiency of underwater sound propagation allows marine mammals to use underwater sound as a primary method of communication, navigation, and prey detection. Underwater anthropogenic noise has gained recognition as an important stressor for marine mammals because of their reliance on underwater hearing for maintenance of these critical biological functions (Richardson et al. 1995; Ketten 1998). The potential effects of underwater noise on marine mammals depends, to a degree, on the type of marine mammal involved as well as the characteristics of the sound emitted including the received sound level and the frequency content of the received sound signal relative to the hearing abilities of the animal. The potential zone of effect of anthropogenic sound is also influenced strongly by the properties of natural background (ambient) sound present in the area of exposure (Richardson et al. 1995) and local sound transmission properties which are determined by site-specific environmental factors such as seafloor bathymetry, substrate composition and water column characteristics.

Marine mammals are acoustically diverse, with wide variations in ear anatomy, frequency and hearing range and amplitude sensitivity (Ketten 1991). Response to sound likely depends strongly on the presence of and level of sounds in the frequency bands or range of frequencies to which the animal is most sensitive (Richardson et al. 1995). The general trend for marine mammals is that larger species, such as humpback and grey whale, are better able to hear at lower frequency ranges than smaller species, such as Dall's porpoise. Hearing abilities are generally only well understood in certain captive species where audiograms (plots of hearing threshold at different sound frequencies) have been developed based on behavioural response studies (reactions to sound) and electrophysiological experiments (measuring auditory evoked potentials) (Erbe 2002).

Audible frequencies for toothed whales (e.g., killer whale, white-sided dolphin and porpoise) range from 0.08 to 150 kHz, but they are most sensitive to sounds in the mid-frequency range of 8 to 90 kHz (Richardson et al. 1995; Southall et al. 2007). Toothed whales use echolocation (biological sonar) to detect the presence and location of objects, other whales of the same species, and prey. Echolocation clicks are produced in the 0.5 to 25 kHz with dominant frequencies from 1 to 6 kHz range, with source levels reported at 160 dB re 1 μPa at 1 m (Richardson et. al.1995). Non echolocation calls (e.g., social calls such as whistles) are centered on frequencies below 12 kHz, but attain frequencies up to 18 kHz (Richardson et al. 1995), with dominant frequencies ranging between 6 kHz to 12 kHz. Killer whales are considered 'mid-frequency cetaceans' (Southall et al. 2007), meaning their most sensitive hearing range occurs in the mid-frequency range. This species has been shown to detect sounds as low as 15 kHz based on a signal of 30 dB re 1 μPa. Killer whales are a highly vocal species with call types consisting of pulsed sounds and whistles used for foraging, navigation and social purposes (Richardson et al. 1995). They use complex pulsed sounds (0.5 to 25 kHz) for echolocation with pulse repetition rates of up to 5,000 per second. Dall's porpoise communicate with low-frequency clicks emitted between 0.04 and 12 kHz with source levels reported at 120 to 148 dB re 1 μPa at 1 m. Harbour porpoise emit clicks at ~2 kHz with source levels reported at 100 dB re 1 μPa at 1 m (Richardson et al. 1995), and are considered one of the most sensitive marine mammal species to acoustic disturbance (Tougaard et al. 2014). The most sensitive hearing threshold for the harbour porpoise is approximately 33 dB re 1 μPa between 100 and 140 kHz (Kastelein et al. 2002).

The auditory system in baleen whales (e.g., humpback whales) does not appear to be as specialized as that of toothed whales (Ketten 1997). However, audiograms are generally not available for baleen whales due to the difficulties of implementing controlled behavioural or electrophysiological hearing studies on large animals under a captive experimental setting. Hearing thresholds and frequency sensitivities in baleen whales are thus inferred from anatomical ear structure, vocalizations, and behavioural studies in the wild (Richardson et al. 1995). In general, most baleen whale species emit low-frequency sounds and have been shown to be most sensitive to sounds in the low frequency range (below 1 kHz), overlapping with the low frequency noise typically emitted by shipping (0.05 to 0.5 kHz) (Richardson et al. 1995). They have an estimated auditory bandwidth of 0.007 to 22 kHz (Southall et al. 2007). Singing behaviour is considered to be an advanced form of vocalization in baleen whales (Clark 1991). Songs are composed of units, phrases, and themes; units sung in a sequence form phrases, a repetition of a phrase is a theme, and several themes combined create a song that can last several minutes (Payne and McVay 1971). Songs have been documented to change within and between seasons (Clark and Johnson 1984; Würsig and Clark 1993; Tervo et al. 2007).

Underwater hearing sensitivity in pinnipeds (seals and sea lions) falls in between that of baleen and toothed whales with an estimated auditory bandwidth between 75 Hz and 75 kHz. Phocinid seals (phocids), such as the harbour seal, have underwater hearing thresholds between 60 and 85 dB re 1 μPa, with flat audiograms between 1 kHz and 30 to 50 kHz (Mohl 1968; Terhune and Ronald 1972, 1975; Terhune 1981). Some phocids are able to detect high frequency sounds up to 180 kHz, although their sensitivity to sounds above 60 kHz is poor and frequencies cannot be discriminated (Mohl 1968). Phocids have an extended frequency range of hearing compared to otariids (sea lions), particularly at higher frequencies (Hemila et al. 2006; Kastelein et al. 2009).

Marine Mammal Acoustic Impact Thresholds

Effects of underwater sound on marine mammals are generally measured through observations of behavioral responses to sounds used as a surrogate measure for sensitivity or susceptibility (McCauley 1994, Richardson et al. 1995). Potential effects range from subtle changes in behaviour at low received levels to strong disturbance effects or temporary/permanent hearing impairment at high received levels. Direct lethal effects attributable to acoustic emissions are not represented in available literature, though military sonar trials have been implicated in mass stranding events (Southall et al. 2007; OSPAR 2009). Several metrics are commonly used to characterize sound pressure levels (SPL) from impulsive noise sources such as impact pile driving and non-pulsed (continuous) noise sources such as shipping.

Assessment of the potential effects of underwater anthropogenic noise on marine mammals requires acoustic thresholds against which received sound levels can be compared. Currently, under Canadian legislation, there are no defined standard threshold criteria for assessing acoustic injury or disturbance effects on marine mammals. In absence of specific legislated underwater noise criteria in Canada, DFO bases its assessment for potential 'serious harm' to marine mammals from anthropogenic noise on best currently-available science including underwater noise threshold criteria employed by the National Marine Fisheries Service (NMFS) (NOAA 2014). The current NMFS acoustic threshold criteria (for injury and disturbance) consist of a single threshold for cetaceans and a single threshold for pinnipeds regardless of sound source. These thresholds represent broadband values based on the primary sound level metric of SPL_{rms} as adapted for pulsive and non-pulsive sound sources, which involves averaging the sound pressure level over a period of time to determine the energy produced by the sound pressure wave. The current thresholds do not take into account the hearing ability of different marine mammal groups (no weighting is applied) or the differences among sound sources in terms of auditory impacts.

The current NMFS injury threshold for cetaceans and pinnipeds is 180 dB re 1 µPa (SPL_{rms}) and 190 dB re 1µPa (SPL_{rms}), respectively. Two types of auditory injury are considered in NMFS's injury threshold criteria, referred to as temporary threshold shifts (TTS) and permanent threshold shifts (PTS). TTS is a relatively short-term reversible loss of hearing following noise exposure, often resulting from cellular fatigue and metabolic changes (Saunders et al. 1985; Yost 2000). PTS is an irreversible loss of hearing (permanent damage) following noise exposure that commonly results from inner ear hair cell loss and/or severe damage or other structural damage to auditory tissues (Saunders et al., 1985; Henderson et al. 2008). While there is no direct evidence of PTS occurring in marine mammals, TTS has been demonstrated in both odontocetes and pinnipeds in response to exposure to impulsive and non-pulsive continuous tones, including mid-frequency odontocetes (bottlenose dolphin and beluga), high-frequency odontocetes (harbour porpoise), and pinnipeds (harbour seal, California sea lion) (a full review is provided in Southall et all. 2007 and NOAA 2013). There is no direct evidence of either PTS or TTS occurring in marine mammals as a consequence of exposure to vessel-generated sound (Southall et al. 2007).

The current NMFS disturbance (behavioral response) threshold for all marine mammals is 160 dB re 1µPa (SPL_{rms}) for impulsive noise (e.g., impact pile driving) and 120 dB re 1 µPa (SPL_{rms}) for non-pulsive noise (e.g., shipping) (NOAA 2014). Richardson et al. (1995) postulated that it is doubtful that many marine mammals would remain in areas for extended periods where received levels of continuous underwater noise were >140 dB re 1µPa at frequencies to which the animals are most sensitive. While elevated underwater noise could startle or displace animals, behavioural responses are not necessarily predictable from the sound source level (loudness) and may vary depending on factors such as age and status of the animal, type of activity it is engaged in, and social context (McCauley et al. 2003).

In summary, the injury and behavioural disturbance noise thresholds for marine mammals that have been employed in the present assessment are as follows:

- Injury thresholds for both pulsive and non-pulsive noise sources:
  - 180 dB re 1 µPa (SPL_{rms}) for cetaceans (baleen and toothed whales)
  - 190 dB re 1µPa (SPL_{rms}) for pinnipeds (seals and sea lions); and
- Disturbance (behavioural response) threshold:
  - 160 dB re 1µPa (SPL_{rms}) for pulsive noise (e.g., impact pile-driving); and
  - 120 dB re 1 µPa (SPL_{rms}) for non-pulsive noise (e.g., shipping).

The SPL_{rms} noise threshold criteria are understood to be conservative in terms of avoiding auditory injury to marine mammals, but they do not account for exposure to high peak pressures that may be expected from activities such as impact pile driving (NOAA 2014). They also do not take into account certain important attributes of the exposure such as duration, frequency, or repetition rate; nor do they account for the frequency-dependent hearing sensitivity of specific species. Sounds are less likely to disturb or injure animals if they are emitted at frequencies at which the animal has low hearing sensitivity. Southall et al. (2007) suggest that frequency dependence of hearing ability should be considered when establishing safety and disturbance thresholds and corresponding safety radii. NMFS has recently proposed new draft criteria (NOAA 2013) that suggest using an assessment approach based on different weighting functions and thresholds, as reported in Southall et al. (2007). Although these criteria are intended to reflect 'best available science', they are currently still in public review and are likely to be further revised prior to being finalized (noting that once finalized, they will likely replace those currently in use by NOAA Fisheries). Therefore, the present assessment is based on current NMFS acoustic thresholds, as these are the presently accepted standards.

Impact Pile Driving Noise

Elevated underwater noise levels will occur during construction as a result of impact pile driving. Installation of the barge load-out jetty and conveyor system will require impact driving of 8 steel piles (0.42 m diameter) in the intertidal, and 10 equivalent piles in the subtidal. Impact pile driving produces a loud, impulse sound that can propagate through the water and substrate. The underwater sound pressure levels caused by pile driving can be harmful to marine animals (Casper et al. 2012; Halvorsen et al. 2011; Halvorsen et al. 2012). The generation of underwater noise during pile driving and the probability of impact are dependent on the type of pile being driven, the type of hammer, substrate type, water depth and the species auditory capabilities (ICF Jones and Stokes and Illingworth and Rodkin Inc. 2009).

The threshold SPL_{peak} for direct physical trauma in marine mammals from impulsive noise is generally considered to be >200 dB re 1 µPa (Gordon et al. 2003). This being the case, marine mammals would not be expected to experience permanent hearing impairment from sound pressures generated by pile driving activity, except when very close to the source. Effects on behavior are more likely. In addition to masking of communication and echolocation signals, pile driving noise could interfere with environmental sounds that animals listen to, for example the sound of surf or prey species. In addition, underwater noise could startle or displace animals.

Brandt et al. (2011) measured harbour porpoise acoustic activity during impact pile driving of 91 monopile foundations in the offshore North Sea at a wind farm construction site. One pile driving event measured 196 dB re 1 µPa (SPL_{peak}), 176 dB re 1 $µPa^2s$ (SEL), and 170 dB re 1 $µPa^2s$ (M-weighted SEL). Porpoise vocal activity was demonstrated to completely cease up to one hour after pile driving, and remained below average levels for between 24 to 72 hours at distances up to 2.6 km from the pile driving site. Evidence of reduced vocal activity was evident up to 17.8 km from the site, although increased vocal activity was shown to temporarily increase at 22 km distance during pile driving, which could be explained by animals moving to this area to avoid the area of potential noise disturbance. Results from Brandt et al. (2011) indicate an overall reduced abundance of harbour porpoise during the 5-month installation period of the piles, with the authors postulating that this was either a direct (e.g., sensory disturbance, communication masking) or indirect (reduced prey availability) effect of pile driving noise. Würsig *et al.* (2000) studied the response of Indo-Pacific hump-backed dolphins (*Sousa chinensis*) to impact pile driving in the seabed, in water depths of 6 to 8 m. No overt behavioral changes were observed in response to the pile driving activities, but the animals' speed of travel increased and some dolphins remained within the vicinity while others temporarily abandoned the area. Dolphin numbers returned close to normal once pile driving had ceased.

Underwater noise levels were not available for the exact size of pile being considered for the Proposed Project. Surrogate values were obtained from the CDOT (ICF Jones and Stokes and Illingworth and Rodkin Inc. 2009) and the WSDOT (WSDOT 2009); which include reference noise source levels for various pile sizes and types; as outlined in Table 5.2-13. Representative source levels were selected form these data sources for acoustic modeling and subsequent assessment of underwater noise impacts on marine mammals.

Acoustic modeling was conducting using the Practical Spreading Loss Model, a two-dimensional noise model designed by NMFS specifically for pile driving/drilling activities as described in Section 5.2.5.2.3.1 (WSDOT 2009). The NMFS model was used to estimate the distance from the source at which point pile driving noise would attenuate to the injury and behavioral thresholds for marine mammals. Underwater noise modeling results are presented in Table 5.2-15. Using the more conservative pile size (0.61 m) as the reference source level in the model, results indicate that underwater sound from impact pile driving will exceed the most conservative injury threshold for marine mammals (180 dB re 1 µPa SPL_{rms}) at distances up to 86 m from the source, and will exceed the behavioral disturbance threshold for marine mammals (160 dB re 1 µPa SPL_{rms}) at distances up to 1.9 km from the source. Based on these results, potential hearing impairment effects are not expected unless a marine mammal is located <100 m from the source during active impact pile driving. Noise modeling results suggest that behavioral effects are likely to occur, although these would be limited to a maximum 2 km radius from the source (as boundary conditions allow). Behavioural effects on marine mammals from impact pile driving noise are therefore carried forward in the assessment.

Prediction confidence in the underwater noise model was considered to be moderate based on factors described in Section 5.2.5.2.3.1.3.

Table 5.2-15: Distances to Marine Mammal Acoustic Injury and Behavioral Thresholds from Unmitigated Impact Pile Driving

Proposed Project Activity	Predicted Noise Level (dB)[(a)]	Injury Threshold (dB) (Pinnipeds / Cetaceans)	Distance to Injury Threshold (m)	Behavioral Threshold (dB)	Distance to Behavioral Threshold (m)
Impact Pile Driving	207 Peak/ 194 rms SPL @ 10 m	190/180	18/86	160	1,848

Note: Unless otherwise noted, all sound pressure levels are referenced to 1 micro Pascal (uPa)

a) Source: Based on pile sizes reported in ICF Jones and Stokes and Illingworth and Rodkin Inc. (2009).

Vessel Noise

Vessel noise sources during the construction phase will include water taxis (crew transport vessels) and tug-assisted barge movements. In general, vessel noise increases with ship size, power/speed, propeller blade size, number of blades and rotations per minute, with the majority of underwater noise generated by propeller cavitation and singing (Gray and Greeley 1980; Mitson 1995; JASCO 2011).

A comprehensive review of the literature indicates no direct evidence of hearing impairment (either PTS or TTS) occurring in marine mammals as a consequence of exposure to vessel-generated sound. Adverse effects are more likely to be linked to behavior and acoustic communication. Research has demonstrated that vessel sound can elicit behavioural reactions in marine mammals and potentially result in masking of their communication space (Richardson et al. 1995). Acoustic responses to vessel sound include alteration of the composition of call types, the rates and duration of call production, and the actual acoustic structure of the calls. Observed behavioural responses include changes in respiration rates, dive patterns, and swim velocities. These responses have, in certain cases, been correlated with numbers of vessels and their proximity, speed, and directional changes. Responses have been shown to vary by gender and by individual.

Many toothed whales show considerable tolerance of ship traffic (Richardson et al. 1995). There is no available evidence of toothed whales permanently abandoning parts of their historical range because of vessel traffic (full review in Richardson et al. 1995 and Gordon et al. 2004).

Reactions of baleen whales to vessels also vary considerably (Richardson et al. 1995). Lower frequency (10 to 100 Hz) sounds have been shown to be more influential on behaviour (Frankel and Clark 1998, 2000, 2002). When receiving low-level sounds from distant or stationary ships, baleen whales both ignore and approach the sounds. If ships approach baleen whales slowly, baleen whales often exhibit slow and inconspicuous avoidance manoeuvres. In response to strong or rapidly changing ship sound, baleen whales often interrupt their normal behaviour and swim rapidly away. Avoidance is especially strong when a boat heads directly toward a whale (Richardson et al. 1995). Several cases of apparent tolerance and habituation to vessels have been reported in baleen whales (Norris et al. 1983, Withrow 1983, Dahlheim et al. 1984, Richardson et al. 1995). Low-level sounds from distant or stationary vessels often seem to be ignored by animals, particularly when feeding (Richardson et al. 1995). Baleen whales use shipping lanes in the St. Lawrence estuary and off Cape Cod each year despite frequent exposure to vessels (Mitchell and Ghanime 1982, Beach and Winrich 1989) Vessels in grey whale breeding lagoons have been shown to cause short-term escape reactions, particularly when boats move fast or erratically; however, the proportional incidence of escape / avoidance behaviour has been shown to decrease over the course of the winter, suggesting habituation (Reeves 1977; Swartz and Cummings 1978; Swartz and Jones 1981). Jones and Swartz (1984, 1986) found no evidence of grey whales leaving a lagoon despite of increased vessel presence. Shipping and evaporative salt works in Guerrero Negro Lagoon reportedly caused grey whales to abandon the lagoon for several years, although the whales returned after shipping decreased (Reeves 1977; Bryant et al. 1984). Hatler and Darling (1974) reported that grey whales in British Columbia return annually to traditional summer feeding areas despite co-occurrence of high vessel traffic in these regions. Individually recognizable bowhead whales have been shown to return to feeding locations within one day after being displaced by vessels and associated sound (Koski and Johnson 1987), although it was unknown if they would return after repeated disturbance. A radio-tagged bowhead whale exhibited reduced dive times when approached by a small ship on each of three days when the ship was within 500 m of the whale. However, dive patterns were shown to revert back to normal in the days following ship disturbance, and the whale remained in the same area for several days while the ship continued operating (Wartzok et al. 1989). Some humpback whales in Alaska show little or no reaction of approaching vessels (Watkins et al. 1981), with animals less likely to react overtly when actively feeding than when resting or engaged in other activities (Krieger and Wing 1984; 1986). In southeastern Alaska, vessel activity was observed to elicit short-term avoidance behaviour, although some humpback whales still remained for several weeks in areas of heavy vessel traffic, and returned to the same area in subsequent years (Baker et al. 1988; 1992). The most extensive data are from summer feeding grounds off Cape Cod, where humpback whales have been shown to spend extended periods in high traffic areas, and return there annually despite frequent exposure to vessel activity (Watkins 1986; Beach and Weinrick 1989; Clapham et al. 1993).

In general, evidence on reactions of seals to vessel sound is scarce; the limited data suggest that seals are fairly tolerant of vessel sound / vessel activity, and are known to return to areas of previous disturbance (full review in Richardson et al. 1995). Harbour seals hauled out on land have been shown to move into the water in response to vessel sounds, particularly during the pupping period (Reijnders 1981; Brasseur 1993 in Richardson et al. 1995). This species has also been observed returning to haul out sites within an hour of being displaced into the water as a result of vessel disturbance (Bowles and Stewart 1980; Osborn 1985). Several other studies report habituation of harbour seals and gray seals to repeated vessel approaches in high traffic areas (Bonner 1982; Johnson et al. 1989).

There are no noise source level data available for the specific vessels identified for the Proposed Project. Tug-assisted barges, similar in size and horsepower to those proposed by Seaspan to use for the Proposed Project, are reported to emit underwater noise of 170 dB re 1 µPa at 1 m (SPL_{rms}) and typically emit noise in the 1 kHz to 5 kHz bandwidth range (Richardson et al. 1995). These levels are below the NMFS injury thresholds for marine mammals, although still have the potential to result in behavioral responses and/or acoustic masking. Based on standard cylindrical spreading loss of sound in water, underwater noise levels of a tug-assisted barge are estimated to exceed the NMFS behavioral disturbance threshold for marine mammals (180 dB re 1 µPa SPL_{rms}) at distances up to 2,154 m from the source. Expected frequencies from Project vessel sound are more likely to overlap with the functional hearing range of baleen whales and pinnipeds than with toothed whales. Marine mammals that occur in proximity to the LSA likely have prior experience with vessel presence and associated underwater noise from existing traffic given the volume of shipping that presently occurs in the area (Volume 2, Part B - Section 7.2: Marine Transportation) and natural acoustic sources (e.g., surface agitation, such as wind and waves). In the extreme case, vessel noise could lead to displacement or a change in movement patterns, but these effects would likely be temporary with marine mammals returning to the area following the disturbance.

Table 5.2-16: Distances to Marine Mammal Acoustic Injury and Behavioral Thresholds from Vessel Noise

Proposed Project Activity	Predicted Noise Level (dB)[(a)]	Injury Threshold (dB) (Pinnipeds / Cetaceans)	Distance to Injury Threshold (m)	Behavioral Threshold (dB)	Distance to Behavioral Threshold (m)
Vessel Noise	170 rms @ 1m	190/180	0/0	120	2,154

Notes: Unless otherwise noted, all sound pressure levels are referenced to 1 micro Pascal (uPa)
a) Sources: Richardson et al. 1995

Based on the available literature, noise generated from tug-assisted barge movements will not occur at levels sufficient to cause injury to pinnipeds or cetaceans in the RSA. The potential for injury or mortality of a marine mammal as a result of underwater noise exposure from Project vessels is therefore considered negligible and is not considered further in the assessment. Vessel noise may affect the behaviour of marine mammals in close proximity (<3 km) of the active vessels while berthing or transiting in the LSA. Behavioural effects on marine mammals from vessel noise are therefore carried forward in the assessment.

5.2.5.2.4.1.3 Vessel Strikes

It is possible that ship strikes on marine mammals may increase in Howe Sound as a result of increased vessel traffic from the Project including tug-assisted barge and water taxi movements. Studies indicate that maritime activity may have adverse effects on marine mammals due to ship strikes (Moore and Clarke 2002; Laist et al. 2001). Baleen whales are more susceptible than other marine mammals due to their large size, slower travel and maneuvering speeds, and lower avoidance capability (Laist et al. 2001). Vessel speed and size are an important factor for determining the probability and severity of ship strikes involving marine mammals. Lethal and severe injuries are caused by ships 80 m or longer travelling at speeds greater than 13 to 15 knots. These speeds are considered to be a critical threshold, below which ship strikes and mortality are less likely to occur (Dolman et al. 2006; Jensen and Silber 2003). While there have been reports of toothed whales being struck by some types of ships (Wells and Scott 1997; Van Waerebeek et al. 2007), these animals are at relatively low risk due to their speed and agility (Richardson et al. 1995). Toothed whales and pinnipeds are fast and maneuverable in the water, and have sensitive underwater hearing, enabling them to avoid being struck by approaching vessels (Laist et al. 2001; Jensen and Silber 2003). There are very few documented cases of seal mortality as a result of a vessel strike (Richardson et al. 1995).

A vessel strike on a marine mammal may result in either injury or direct mortality. Injuries are typically the result of two mechanisms; either blunt force trauma from impact with the vessel or from lacerations from contact with the propellers. Depending on the severity of the strike and the injuries inflicted, the mammal may or may not recover. Recent research shows that vessel speed is positively correlated with the probability of a vessel strike (Kite-Powell et al. 2007; Vanderlaan and Taggart 2007). Mathematical models from current vessel-strike probability research support the reduced probability of a vessel strike with reduced speeds (Kite-Powell et al. 2007; Vanderlaan and Taggart 2007). Serious or lethal strikes to whales are infrequent at vessel speeds of less than 14 knots, and are rare at speeds of less than 10 knots (Laist et al. 2001).

Baleen whales that spend a considerable amount of time at or near the surface are at increased risk of vessel strikes. Research has shown that sound levels are lower near the surface, potentially explaining why baleen whales are often unresponsive to approaching vessels (Richardson et al. 1995). Acoustic modeling around the hull of a ship further shows that underwater sound levels may be lowest directly off the bow ahead of an oncoming vessel, compared to the sides and behind stern (Terhune and Verboom 1999). Baleen whales are therefore more likely susceptible to potential ship strikes when occurring in the direct path of a vessel.

The length of the Proposed Project tug and barge vessels are approximately 26 m and 80 m, respectively and will travel at approximately 6 knots when in the LSA and RSA. Proposed Project water taxis are < 10 m in length. The potential for a collision between a marine mammal and a Proposed Project vessel is considered rare given the overall size of the vessels (all < 80 m) given that the literature indicates that lethal and severe injuries are caused by ships 80 m or longer travelling at speeds greater than 13 to 15 knots. In addition, the speeds at which the vessels will travel in the LSA and RSA will provide ample time for animals to actively avoid the vessels and for vessel operators and crew to actively detect and avoid marine mammals during transits.

As the possibility for a vessel-marine mammal collision remains, this effect is carried forward in the assessment with additional measures identified to further reduce the likelihood of this effect from occurring.

5.2.5.2.4.2 Operations

5.2.5.2.4.2.1 Effects of Underwater Noise

Vessel Noise

Similar to the construction phase, an increase in the number of vessels operating in the RSA will increase underwater noise levels in the marine environment and may cause marine mammals to avoid affected areas. Marine mammals that occur in the vicinity of the RSA are likely have prior experience of noise exposure from large vessels (e.g., deep sea cargo and BC ferries) that contribute to existing background (ambient) noise levels.

Proposed Project activities will lead to a 3% annual increase in large vessel traffic (tug and barge) in Howe Sound and a 45% increase in large vessel traffic in Ramillies Channel (assuming this route is used exclusively over Thornbrough Channel). As described during the construction phase, there will be two water taxi movements per day (one round-trip), or approximately 520 water taxi movements per year (260 round-trips). Water taxis would transit in Thornbrough Channel once per day to the site in the morning and return at the end of the day. The exact departure location for water taxis in Thornbrough Channel is yet to be determined. Water taxis during operations would represent 11% of current water taxi movements, however current water taxi traffic to the site is expected to decline following the end of several forestry contracts in the McNab Valley.

Increase in marine noise resulting from vessel traffic associated with Proposed Project operations activities is not expected to exceed injury thresholds for marine mammals (Table 5.2-19); therefore this effect is considered negligible and is not carried forward in the assessment. Vessel noise may produce a localized behavioral response including potential avoidance of active vessels and the marine facility in the RSA, as described for the construction phase. Behavioural effects on marine mammals are therefore carried forward in the assessment.

Barge Loading

Underwater sounds associated with barge loading are dependent on the volume of material in the barge at the time the loading is occurring. Materials loaded onto an empty barge would likely transmit sound through the barge hull into the underwater environment, whereas material placed upon previously piled material may or may not produce detectable underwater sounds due to buffering provided by the "softer" receiving surface.

There are no noise source level data available for the specific barge loading activities identified for the Proposed Project. Similar barge loading activities produced a reported SPLrms of 139.5 rms SPL @ 60 m (Reine et al. 2012). This sound level is below the injury threshold for marine mammals, although still has the potential to result in behavioral responses and/or acoustic masking. Based on standard cylindrical spreading loss of sound in water, underwater noise levels from barge loading are estimated to exceed the NMFS behavioral disturbance threshold (120 dB re 1 μPa SPL_{rms}) at distances up to 1,200 m from the source (Table 5.2-17). Behavioral reactions may include avoidance, or a change in movement patterns, although these effects would likely be temporary with animals returning to the area following the disturbance.

Table 5.2-17: Distances to Marine Mammal Acoustic Injury and Behavioral Thresholds from Barge Loading

Proposed Project Activity	Predicted Noise (dB)[(a)]	Injury Threshold (dB) (Pinnipeds / Cetaceans)	Distance to Injury Threshold (m)	Behavioral Threshold (dB)	Distance to Behavioral Threshold (m)
Barge Loading	139.5 rms SPL @ 60 m	190/180	0/0	120	1,197

Notes: Unless otherwise noted, all sound pressure levels are referenced to 1 micro Pascal (uPa)
a) Source: Reine et al. 2012

Based on the available literature and noise modeling results, noise generated during barge loading will not occur at levels sufficient to cause injury to pinnipeds or cetaceans in the RSA. Potential injury or mortality of marine mammals as a result of underwater noise exposure from barge loading is therefore not considered further in the assessment. Barge loading noise may affect the behaviour of marine mammals in close proximity (<1.2 km) of the proposed terminal. Behavioural effects on marine mammals are therefore carried forward in the assessment.

5.2.5.2.4.2.2 Vessel Strikes

The potential effect of a marine mammal-vessel collision during the operations phase is the same as that described for the construction phase in Section 5.2.5.2.4.1.

5.2.5.2.4.3 Reclamation and Closure

5.2.5.2.4.3.1 Effects of Underwater Noise

Underwater noise generated during reclamation/closure activities and potential effects on marine mammals are the same as those described for the construction phase in Section 5.2.5.2.4.1.

5.2.5.2.4.3.2 Vessel Strikes

The potential effect of a marine mammal-vessel collision during the operations phase is the same as that described for the construction phase in Section 5.2.5.2.4.1.

5.2.5.2.4.4 Accidents and Malfunctions

Accidents and malfunctions potentially resulting in release of toxic/hazardous and non-toxic (aggregate) materials in the marine environment are described in Section 5.2.5.2.1.4. The following section described how these events may result in adverse effects on mammals.

5.2.5.2.4.4.1 Toxic and Hazardous Material Spills

This section addresses potential impacts to marine mammals as a result of accidental fuel spills. A number of marine mammal species potentially overlap with the RSA and could be affected by an accidental fuel spill along the shipping corridor. Potential effects of hydrocarbon exposure on marine mammals include the following:

- Direct contact of oil/fuel with marine mammal eyes may cause eye irritation / inflammation;
- Direct contact of oil/fuel with marine mammal skin or coat may reduce thermoregulation abilities and/or cause skin irritation / inflammation;
- Inhalation of hydrocarbon vapours could result in inflammation of mucous membranes, pneumonia, and neurological damage;
- Ingestion of oil or oil contaminated prey may result in toxicological effects, gastrointestinal inflammation, ulcers, bleeding, diarrhea, or maldigestion;
- Oil in the water could foul the baleen of baleen whales, leading to reduced filtering / feeding efficiency;
- Oil/fuel in the water could cause marine mammals to avoid the area, thus potentially resulting in temporary displacement from some feeding or migratory areas; and
- Reduced prey availability through prey displacement.

Toothed and Baleen Whales

There are a range of potential effects presented in the literature regarding impacts of spills on toothed and baleen whales, with some reports indicating that there is no conclusive evidence of acute or chronic impacts following hydrocarbon exposure while other post-spill studies suggest causal relationships between crude oil spills and whale mortalities (Short 2003; Engelhardt 1983). Geraci (1990) reviewed a number of studies on the physiological and toxic effects of oil on whales and concluded there was no conclusive evidence of oil contamination being responsible for the death of a cetacean. Matkin et al. (2008) suggest that certain cetaceans do not avoid oil spills, which increases their risk of exposure during an accidental event.

Whales are generally not considered to be at great risk for adverse effects of oiling on thermoregulation, as they rely on blubber for insulation (Geraci 1990). Studies have shown the effectiveness of cetacean epidermis as a barrier to the noxious substances found in petroleum. Whereas these substances normally damage the skin by permeating intercellular spaces and dissolving protective lipids, penetration in cetacean skin is impeded by tight intercellular bridges, and the extraordinary thickness of the epidermis. Intercellular and intracellular lipids, which are abundant in cetacean epidermal cells, and which are assumed to be a vulnerable target for petroleum, are shown to remain largely unaffected. A cetacean is most likely to contact weathered oil, because it is far more persistent but contains little of the more toxic light hydrocarbon fractions than freshly spilled oil. Cetaceans with large ranges may contact some oil as they move quickly through a fouled area, but with little potential for long-term exposure. To date, no published data prove oil-fouling of the skin of any free-living whale. This suggests that 1) oil may not stick to the smooth skin surface; or 2) contact with oil is rare because whales avoid oil slicks.

Heavy oil may coat the baleen of baleen whales, such as humpback and grey whales, reducing their feeding ability and efficiency (Geraci and St Aubin 1988). Hydrocarbons can also cause severe irritation to the eyes and other mucous membranes, which may reduce hunting and foraging abilities in these species (Short 2003; Geraci and St. Aubin 1988).

Pinnipeds

Hydrocarbons can adhere to the epidermal coat of pinnipeds, thus reducing its natural insulation properties and resulting in adverse thermoregulation effects on the individual (Geraci 1990). Seal mortality has been recorded as a result of oil spills, although large scale deaths have rarely been observed even when spill events occur close to breeding colonies (McLaren 1990). As with cetaceans, hydrocarbon exposure can result in severe irritation to the eyes and other mucous membranes, which may reduce hunting and foraging abilities in these species (Short 2003; Geraci and St. Aubin 1988).

Summary

Potential effects of hydrocarbon spills on marine mammals may be direct (e.g., contact with oil) or indirect (e.g., degradation of habitat, reduced prey availability, reduced health due to ingestion of oiled prey). Individuals directly overlapping with the plume would be at risk of direct impacts from hydrocarbon exposure (e.g., oiling effects) for a set period of time until the spill dissipates due to weathering effects. Effects would depend on the number of individuals coming into contact with the spill, the duration of contact, and the degree of weathering of the spilled fuel. The number of marine mammals contacting spilled fuel would depend on the location, size, timing, and duration of the spill and the animal's ability or inclination to avoid contact. Prolonged exposure to freshly spilled fuel could adversely affect some individuals, but the number would likely be small and limited to the Proposed Project Area or just beyond the Proposed Project Area. Marine mammals exposed to spilled diesel are likely to experience temporary, nonlethal effects.

Inhalation of light hydrocarbon compounds in sufficient levels may cause toxic effects in all marine mammals, such as central nervous system disorders, brain degeneration, liver damage, and reproductive failure (Engelhardt 1983; Geraci and St. Aubin 1980; Geraci 1990, Geraci and St Aubin 1988; Matkin et al. 2008). However, light compounds generally dissipate within the first few days of a spill. Marine mammals may also be indirectly affected by changes in water quality and, in turn, reduced prey availability and/or adverse health effects due to ingestion of oiled prey; these effects would persist for an undetermined period following the spill. Effects of hydrocarbon spills on marine fish and benthic invertebrates potentially serving as prey for marine mammals are discussed in Sections 5.2.5.2.2.4 and 5.2.5.2.3.4 respectively.

All effects are initially manifested at the individual level, and may lower an individual's probability of survival or reproduction, which could potentially have population-level effects if the species impacted was already compromised in population size. Given known and uncertain effects of hydrocarbon exposure on marine mammals and the potential presence of listed marine mammal species in the RSA, the potential effect of an accidental fuel spill on marine mammals is carried forward in the assessment.

5.2.5.2.4.4.1.1 Aggregate Spills

Direct mortality of marine mammals as a result of an aggregate spill is considered unlikely as animals would be able to actively avoid the descending plume (Clarke et al. 2000). Further, indirect effects on marine mammals as a result of elevated turbidity/TSS (e.g., reduced prey availability) are considered unlikely, given the ability of marine mammals to actively avoid impacted areas, the nature/composition of the aggregate materials that will be loaded and transported on the barge, as well as the nature of the receiving environment at the barge load-out jetty (most likely site of an aggregate spill) which supports relatively low value fish habitat.

Given the above factors in combination with the limited footprint of a potential aggregate spill, the potential adverse effects of an aggregate spill on marine mammals and marine mammal foraging habitat are considered negligible and are not carried forward in the assessment.

5.2.5.2.5 Marine Birds

Marine birds contribute to the overall ecosystem health in the region and provide social, cultural and economic benefits to communities in the Project Area. This section considers potential adverse effects of the Proposed Project on marine bird VCs with specific reference to the marine environment. For environmental effects of the Project on marine birds in their terrestrial environment (e.g., marbled murrelet when occupying old growth nesting habitat), refer to Volume 2, Part B - Section 5.3 (Terrestrial Wildlife and Vegetation). Potential environmental effects of the Project on marine birds and their marine habitats during construction, operations and reclamation/closure include:

- Change in habitat quality / decreased prey availability due to sediment disturbance and re-suspension as a result of in-water construction works, vessel wakes and propeller scour (all phases);
- Behavioral disturbance from in-air noise generated during site clearing, construction and operational activities (all phases); and
- Release of deleterious substances due to accidental spills of hazardous, toxic or aggregate material (all phases).

5.2.5.2.5.1 Construction

5.2.5.2.5.1.1 Changes in Habitat Quality

The proposed marine structures will have a minimal physical footprint and will not result in direct habitat loss of marine bird habitats. Potential indirect effects of construction activities (e.g., in-water works, vessel wakes, propeller scour) on marine bird habitat quality include the reduced availability of their prey (e.g., forage fish, benthic invertebrates) due to Project-induced changes on water quality (increased levels of turbidity/TSS/metals/hydrocarbons) from sediment disturbance and subsequent changes in the abundance and distribution of marine bird prey species. However, elevated levels of turbidity and TSS resulting from construction and vessel activities would be localized and limited to subtidal areas presently associated with low value fish habitat. Given the highly mobile nature of marine birds and their extensive foraging range, any adverse effects of the Project on marine bird prey availability are considered negligible and are not carried forward in the assessment.

5.2.5.2.5.1.2 Behavioral Disturbance from In-Air Noise

In-air noise and vibration generated by construction activities have the potential to disturb marine birds in the Proposed Project Area including eliciting avoidance behaviour that may lead to a change in distribution of marine birds in this area. Maximum in-air noise levels measured in the Proposed Project Area during baseline sampling was 44 decibels (dBA) during the day. Awbrey and Bowles (1990) suggest that disturbance in birds is typically initiated at 80 to 85 dBA with flight response elicited at 95 dBA. Operation of a tug boat would generate a noise level of 111 dBA at the source. Operation of a vibratory or impact hammer would generate a noise level of 129 dBA at the source. In-air noise levels exceeding 80 dBA are predicted to be limited to the immediate area of the loading facility, therefore potential avoidance effects are likely to be limited to birds in close proximity to the barge-load out jetty during the noise event. No effects are anticipated on marine bird distribution or behavior outside of this area, including in McNab Creek estuary where seasonal aggregations of birds are known to occur. Refer to Volume 2, Part B - Section 5.4 (In-air Sound) for further information related to in-air noise emissions.

Behavioural effects on marine birds from in-air construction noise have been carried forward in the assessment.

5.2.5.2.5.2 Operations

5.2.5.2.5.2.1 Behavioral Disturbance from In-air Noise

The in-air noise level generated by the conveyor motor in the barge loading area is estimated to be 96 dBA at the source. The in-air noise level generated by sand falling onto a barge is estimated to be 108 dBA at the source. These noise levels exceed bird disturbance threshold levels of 80 dBA (Awbrey and Bowles 1990) and may therefore result in behavioral responses including avoidance of the affected area. In-air noise levels above 80 dBA are predicted to be limited to the immediate area of the loading facility, therefore potential avoidance effects are likely to be limited to birds in close proximity to the barge-load out jetty. No effects are anticipated on marine bird distribution or behavior outside of this area, including in McNab Creek estuary where seasonal aggregations of birds are known to occur. Refer to Volume 2, Part B - Section 5.4 (In-air Sound) for further information related to in-air noise emissions.

Behavioural effects on marine birds from in-air operational noise have been carried forward in the assessment.

5.2.5.2.5.3 Reclamation and Closure

5.2.5.2.5.3.1 Behavioral Disturbance from In-air Noise

In-air noise generated during reclamation/closure activities and potential effects on marine birds are the same as those described for the construction phase in Section 5.2.5.2.5.1.2.

5.2.5.2.5.4 Accidents and Malfunctions

5.2.5.2.5.4.1 Toxic and Hazardous Material Spills

Marine birds are particularly sensitive to spills of hydrocarbons and may be directly or indirectly affected by a major accident resulting in a fuel spill. The Howe Sound and Strait of Georgia coast line is an environmentally sensitive area, particularly in the summer time, as it provides important habitat for breeding, feeding and molting colonies of seabirds, which are particularly vulnerable to oil spills (Schreiber and Burger 2002). Oil can be ingested by birds causing toxic effects and can smother bird plumage, causing death by starvation, drowning and loss of body heat (Fry and Lowenstine 1985; Islam and Tanaka 2004). Fouling of plumage is the primary concern for marine birds during an oil spill as it may take only a very small quantity to create enough fouling in some bird species to cause death (Fry and Lowenstine 1985). A hydrocarbon spill may also result in effects on the nervous and reproductive systems in marine birds and limit their growth rates and egg hatching success (Smith 1970; HELCOM 1996). Birds which spend more time within the water and nearshore will typically be more affected than birds which spend more time flying. An exception to this is the bald eagle (*Haliaeetus leucocephalus*) which is particularly susceptible to oil spills due to long recovery rates of individuals exposed to spills or who ingest prey exposed to oil spills (NOAA 1992). Despite spending limited time in direct contact with water, bald eagles' ingestion of exposed prey exposed can result in indirect toxic effects and death. Cleanup responses to hydrocarbon spills may also cause further disturbance to marine bird breeding and behavioural patterns (NOAA 1992).

Marine birds may also be indirectly affected by hydrocarbon spills through changes to water quality or food availability. Effects of releases of deleterious substances on marine bird prey such as marine benthic organisms and marine fish are discussed in Sections 5.2.5.2.2.4 and 5.2.5.2.3.4 respectively.

Given the known effects of hydrocarbon exposure on marine birds, the presence of important marine bird habitats in the RSA, and the potential presence of migratory bird species in the RSA, the potential effects of an accidental fuel spill on marine birds are carried forward in the assessment.

5.2.5.2.5.4.2 Aggregate Spills

Direct mortality of marine birds as a result of an aggregate spill is considered unlikely as individuals would be able to actively avoid the immediate spill area. Further, indirect effects on marine birds as a result of elevated turbidity/TSS (e.g., reduced prey availability) are considered unlikely, given the nature/composition of the materials that will be loaded and transported on the barge, as well as the nature of the receiving environment at the barge load-out jetty (most likely site of an aggregate spill) which supports relatively low value fish habitat.

Given the above factors in combination with the limited footprint of a potential aggregate spill, the potential adverse effects of an aggregate spill on marine birds and marine bird foraging habitat are considered negligible and are not carried forward in the assessment.

5.2.5.3 Mitigation

This section provides a description of the mitigation measures which will be applied to minimize the Proposed Project effects on Marine Resource VCs. The suite of measures proposed to mitigate effects on the marine environment is presented in Table 5.2-18.

The mitigation strategy outlined below forms the basis for the commitments that the Proposed Project is making with respect to marine resources. A detailed list of all commitments of the Proposed Project are provided in Volume 3, Part F – Section 19.

5.2.5.3.1 Construction

The following mitigation measures will be implemented during the construction phase of the Proposed Project to reduce Project-related effects to various Marine Resource VCs. Construction Environmental Management Plans (CEMP) will be developed prior to the initiation of Project construction to provide details on marine resource mitigation measures, implementation methods, and schedule. In-water works will take place during the Marine / Estuarine fisheries work windows for the Howe Sound area, when practicable. These timing windows are the periods when in-water work poses the least risk to fish and fish habitat. The fisheries work window for Howe Sound is August 16 - January 31 (DFO 2014). Subject to agreement by applicable regulatory agencies and the implementation of appropriate controls, some work will need to occur outside of these windows to accommodate the construction schedule and sequencing of construction activities. For in-water works taking place outside the fisheries work windows, additional mitigation will be considered including those identified in DFO's Measures to Avoid Causing Harm to Fish and Fish Habitat (DFO 2013c).

5.2.5.3.1.1 Alteration or Loss of Habitat

- No construction activities will be conducted in the foreshore or intertidal/subtidal areas except for installation/construction of the barge load-out jetty, walkway and conveyor system, upgrade of the barge ramp, removal of the old access dock and other debris, and removal of old dolphins (as necessary).
- The barge load-out jetty and its support piles will be installed in the existing log dump area, an area historically affected by log sort operations where the substrate is presently covered with extensive woody/bark debris and associated with relatively low value benthic habitat. The use of piles rather than fill to support marine structures will reduce the overall marine footprint and associated habitat losses. Where possible, the jetty and walkway will be grated to allow ambient light to reach the benthic communities below.
- The walkway / conveyor system has been designed to result in minimal shading effects on the marine environment. The conveyor platform will be approximately +5 m above ground in the intertidal zone, thus allowing ambient light to penetrate beneath the structure to the underlying substrate. In addition, the south facing orientation of the platform will further minimize potential shading effects to the underlying benthic habitat. Any potential shading effect is expected to be minimal and limited to the subtidal zone directly impacted by historical log sort operations and associated with low value habitat and a low production capacity for fish.
- A Fish Habitat Offset Plan will be developed and implemented to offset unavoidable permanent alteration or destruction of fish habitat from Project activities and works in accordance with a DFOs Fisheries Productivity Investment Policy: A Proponent's Guide to Offsetting (2013c and 2013d). The objective of the offsetting plan is to maintain or enhance the ongoing productivity and sustainability of commercial, recreational and Aboriginal fisheries in the Project Area. The Plan will be developed in consultation with DFO and key stakeholders. To address the residual effects in the marine foreshore area, BURNCO is proposing to

construct approximately 10 m^2 of hard substrate intertidal habitat attached to the pilings supporting the conveyer system across the foreshore. A draft offsetting plan is provided in Volume 4, Part G – Section 22.0: Appendix 5.1-B.

- All construction operations will be monitored by a qualified environmental monitor (EM) who will be onsite during all construction activities to brief contractors on the environmental sensitivities in the Project Area and requirements of the proposed work and the CEMP, to assess conformance with the CEMP, to evaluate whether in-water works are resulting in adverse effects on marine resources and effectiveness of mitigation measures being implemented, to report all non-conformances with the CEMP in the form of Environmental Incident Reports, and to describe how non-conformance issues will be managed/resolved.
- All works will be adequately contained to prevent the release of construction and/or demolition debris and materials and deleterious substances into the marine environment. All debris and other construction wastes will be contained and disposed of in an appropriate landfill facility.
- All works will be conducted in a manner to prevent the discharge or introduction, either direct or indirect, of soil, sediment or sediment laden water, turbid water or any other deleterious substance into the marine environment. Any water that came in contact with construction materials (cement, uncured concrete, lime containing material), including water used to wash equipment, will be prevented from entering directly or indirectly into the marine environment.
- The contractor shall adhere to the Best Management Practices for Pile Driving and Related Operations (DFO 2003).
- The existing treed buffer will be maintained between the Property and foreshore to limit noise and emission effects on the marine environment.
- Dust and noise suppression measures will be fully applied and maintained.
- Best management practices will be employed for erosion control during road and other facilities construction, maintenance and upgrade.
- Trench drains, catch-basins and manholes will be constructed to direct surface runoff into a retention pond, treatment facility or recycling plant.
- When reasonable, pre-cast concrete will be used for construction and installation of facilities within the intertidal and subtidal zones. A temporary concrete batch plant will be operating onsite during the Construction Phase.
- When constructing cast-in place concrete structures in the intertidal zone or over water, the following measures will be followed:
    - Concrete will be poured during suitable tides. Pours will be planned to take advantage of longer duration low tides in order to maximise curing time when the intertidal is exposed. Concrete is not to be poured directly into tidal waters;
    - Pumping hoses will be equipped with a shut-off valve to stop flow should a spill occur. Short term portable concrete batch plant will be constructed onsite, so no concrete pumping will be conducted by barge;

- Use tight-fitting formwork that is lined (e.g., with polyethylene) and that has gasket joints to prevent contact between concrete and tidal water. Curing concrete will also be covered as appropriate (i.e., above the high tide level, concrete will be covered with 'lids' or geotextile fabric/polyethylene; below the high tide level, concrete will be covered with tight fitting 'lids');
- Barriers will be used as appropriate to prevent splashing of the concrete over the forms and into the water or intertidal area during pouring;
- Fast curing concrete intended/formulated for marine applications will be used;
- Following placement of concrete, forms will be left in place isolating the concrete from tidal waters for a minimum of 24 hours or time required for the particular material used such that the concrete is cured before it is exposed to tidal waters;
- Wash down of equipment and tools that have come into contact with concrete will be conducted in a designated area away from the intertidal and drainages (e.g., streams and municipal drains) so that concrete products are prevented from entering watercourses (tidal waters, streams, drains);
- Excess or spilled concrete will be immediately cleaned up and removed from the intertidal area.

■ During removal and storage of creosote pilings, best management practices outlined in DFO's "Guidelines to Protect Fish and Fish Habitat from Treated Wood Used in Aquatic Environments in the Pacific Region" will be followed (Hutton and Samis 2000). These practices will include the following:

  - Every effort will be made to extract the entire length of the pile from the ground or seabed;
  - Methods such as pile vibrating, jetting or other appropriate technique will be utilized to remove the pile intact;
  - If it is not feasible to remove the pile intact or if the pile has broken off, every effort will be made to remove the stub in a way that is consistent with the safety and protection of Fisheries and Aquatic Habitat;
  - All debris from pile removal will be disposed of at an appropriate on-land facility.

■ Vessels, barges and barge support vessels involved in pile driving and construction activities will be positioned in a manner that will prevent disturbance to benthic communities on the seafloor. Contractors will position their vessels in a manner that will prevent damage to fish habitat and, particularly, to areas supporting known marine vegetation. The EM will advise the contractor on the location of sensitive submerged marine vegetation based on preliminary baseline surveys completed in the area, such that these areas can be actively avoided.

■ Work crews will constantly monitor the position of the barge platform in relation to the shoreline and take into consideration the height of tidal waters, magnitude of prevailing winds, direction of tidal currents or other factors that may influence vessel positioning.

■ Manoeuvring of work vessels in shallow areas should be minimized in order to avoid propeller scour and potential re-suspension of sediments or physical disturbance to shallow submerged marine vegetation.

- All equipment will be maintained in proper conditions to prevent leaking or spilling of hydrocarbons and other potentially toxic substances in the marine environment.
- All hydrocarbon products (fuel, oil, lubricants, hydraulic fluid, etc.), fuelling equipment and other chemical substances will be stored and handled in accordance with all applicable legislation, guidelines and BMP's to prevent their release and toxic effect in the marine environment.
- A Spill Prevention and Emergency Response Plan as well as a Material Storage, Handling and Waste Management Plan will be developed and implemented for hydrocarbons and other chemicals during the construction activities. The plan will include use of appropriate resources such as a dedicated and competent emergency response crew and spill containment and cleanup equipment. Draft contents of these plans are provided Volume 3, Part E - Section 16.0.
- During in-water works with potential to result in increased turbidity or suspended sediment in the marine environment, specific water quality performance objectives will be applied at specific distances from in-water works. These criteria will be based on BC water quality guidelines (WQGs) (BC MoE 2006) with respect to discharge or introduction of sediment or sediment-laden water in the marine environment, as follows:
  - Turbidity:
    - Change from background of 2 NTU when background is less than 8 NTU;
    - Change from background of 5 NTU when background is 8 to 50 NTU; or
    - Change from background of 10% when background is more than 50 NTU.

    i) TSS:
    - Change from background of 5 mg/L when background is less than 25 mg/L;
    - Change from background of 10 mg/L when background is 25 to 100 mg/L; or
    - Change from background of 10% when background is more than 100 mg/L.
  - If the guidelines outlined above are exceeded as a result of Proposed Project activities, in-water works or activities will be halted until measures are put in place to meet these water quality objectives; and
  - Where above guidelines cannot be practically met, the work areas and activities contributing to these conditions will be isolated from tidal and flowing waters. This may include use of silt curtains and other silt control measures.

5.2.5.3.1.2 Injury / Disturbance from Underwater Noise

The following measures will be implemented to mitigate effects from underwater noise on marine fish and marine mammals during the construction phase:

- Most acoustically sensitive fish and marine mammals (MM) will avoid the immediate impact area once impact pile driving is underway. Operators are encouraged to take advantage of this behaviour by adopting a ramp-up / soft-start procedure where this is technically feasible. A ramp-up procedure consists of initial activation of the equipment using the lowest energy source / pulse and gradually increasing the intensity of the sound until it reaches the required intensity, thus allowing time and incentive for acoustically sensitive marine fish and MM to leave the area prior to operating the impact driver at full power.

- Concurrent multiple underwater noise generating activities will be minimized when practicable (e.g., avoiding multiple pile driving activities at the same time). Where multiple underwater noise generating activities are planned, they will be sequenced where possible to minimize construction duration.
- For avoiding noise/pressure-related injuries to marine fish, the following measures will be undertaken during impact pile driving:
  - Underwater noise generated during impact pile driving will not exceed 30 kPa[13] at a distance of 10 m from the source.
  - If the sound level exceeds 30 kPa at a distance of 10 m from the source, measures will be undertaken to reduce either the intensity of the sound generated or the level of sound propagation through the water column. The appropriate measure will be chosen based on practicality and effectiveness and may include:
    - The placement of bubble curtains around the wetted pile during impact driving.
    - The use of a vibratory hammer in place of an impact hammer for pile driving.
  - Impact pile driving activities will be temporarily suspended if aggregations of fish (e.g., herring or salmonids) are spotted within the immediate work area or if any herring spawn is observed attached to equipment or structures in the water.
  - Impact pile driving will be scheduled to avoid sensitive fish periods such as spawning and migration timing for salmon, herring and capelin.
  - Impact driving will take place during the Marine / Estuarine fisheries work windows for the Howe Sound area, when in-water work poses the least risk to fish and fish habitat. The fisheries work window for Howe Sound is August 16 - January 31 (DFO 2014). Subject to agreement by applicable regulatory agencies and the implementation of additional appropriate controls (e.g., bubble curtains), some work may need to occur outside of these windows to accommodate the construction schedule and sequencing of construction activities.
- For avoiding underwater noise injuries to MM, the following measures will be undertaken during impact pile driving:
  - Monitoring for MM during all impact pile driving activities by a qualified and experienced marine mammal observer (MMO) with presence/absence communicated to the contractor.
  - Implementation of a Marine Mammal Safety Zone – defined as the zone within which MM may be potentially exposed to sound levels above the injury threshold criteria (180 dB re 1 µPa SPL_{rms} for cetaceans and 190 dB re 1 µPa SPL_{rms} for pinnipeds). The occurrence of MM within the safety zone will

[13] 30 kPa is the value typically specified in authorizations issued by DFO. 30 kPa of sound pressure is equivalent to a sound pressure level (SPL) of 210 dB (re 1 µPa) (Richardson *et al*. 1995; Urick 1975).

trigger specific mitigation actions (e.g., shut-downs) such to avoid potential for physical injury to MM from impact pile driving noise.

- Shut-down procedures – impact pile driving will be temporarily suspended when a MM is located within the safety zone until which time it moves outside the safety zone.
- Implementation of a pre-operational search for MM prior to start-up of active impact pile driving. This would consist of a visual scan of the water by an on-board observer to determine that no MMs are present within the safety zone. If a MM is spotted within the safety zone during the pre-ops search, the ramp-up procedure will be delayed 20 minutes from the time the MM left the safety zone, or was last sighted in the safety zone
- The EM / MMO will periodically verify underwater sound levels in the field using a hydrophone and a real-time sound monitor to confirm that sound levels at the modeled safety zone radius are below the established injury thresholds for MM. If sound levels are shown to exceed the injury thresholds at the safety zone radius, the safety zone distance will be adjusted accordingly.
- Plan operations during daylight hours to maximize detection ability of MM in Project Area.
- Avoid peak seasonal timing when MMs are most likely to be in or adjacent to the Project Area.

5.2.5.3.1.3 Disturbance from In-air Noise

Mitigation measures for in-air noise effects during the construction phase are addressed in Volume 2, Part B - Section 9.2 (Noise) of this EA report. No additional mitigation is proposed.

5.2.5.3.1.4 Mortality/Injury from Vessel Strikes

- All Project tug-assisted barge movements will occur at reduced speeds (<12 knots) when operating in LSA and RSA. Typically tug and barge vessels are expected to travel at approximately 6 knots when in the LSA and RSA.
- All Project vessels will follow established shipping lanes/navigational routes typically used in the area.
- All Project vessels will maintain a constant course and constant speed, to the extent practical, when operating in the RSA.
- To the extent practical, Project vessels will not approach within 100 m of any marine mammal.
- To the extent practical, if marine mammals approach within 100 m of a Project vessel, the vessel will reduce its speed and, if possible, cautiously move away from the animal. If it is not possible for a vessel to move away from or detour around a stationary marine mammal or group of marine mammals, the vessel will reduce its speed and wait until the animal(s) moves at least 100 m from the vessel prior to resuming speed.

5.2.5.3.2 Operations

The following mitigation measures will be implemented during the operations phase of the Proposed Project to reduce Project-related effects to various Marine Resource VCs.

5.2.5.3.2.1 Alteration or Loss of Habitat

- The barge load-out jetty will be situated in an area characterized by low value habitat (existing log dump/sort).
- The barge load-out jetty and conveyor/walkway will be supported by piles in lieu of fill such to minimize the area of seabed / foreshore disturbance.
- Dust and small aggregate particles in the air from the marine conveyor will be prevented through facility design configurations (covered conveyor, enclosed transfer points and water spray over the conveyor).
- The height and orientation of the walkway/conveyor system has been designed to maximize ambient light penetration to the underlying substrate.
- A tree buffer will be maintained along the foreshore to limit noise and dust emissions to the marine environment.
- No debris or debris will be released into the marine environment during operations.
- Groundwater seepage from the facility to the marine environment will meet BC WQG.
- Adherence to BMP for erosion control during road and facilities maintenance and upgrade.
- Vessels involved in in-water works will be positioned in a manner to prevent disturbance to benthic communities and benthic habitats.
- Work crews will monitor the position of barges and account for height of tidal waters, magnitude of prevailing winds, and direction of tidal currents or other factors that may influence vessel positioning.
- Manoeuvring of vessels in shallow areas will be minimized in order to avoid propeller scour and potential re-suspension of sediments or physical disturbance to shallow submerged marine vegetation.
- All equipment will be maintained in proper conditions to prevent leaking or spilling of hydrocarbons and other potentially toxic substances in the marine environment.
- All hydrocarbon products, fuelling equipment and other chemical substances will be stored and handled in accordance with all applicable legislation, guidelines and BMP's to prevent their release and toxic effect in the marine environment.
- A Spill Prevention and Emergency Response Plan will be developed and implemented for managing hydrocarbons and other chemicals during all operational activities.

5.2.5.3.2.2 Disturbance from Underwater Noise

No additional measures are proposed to mitigate for potential behavioral disturbance of marine mammals and fish due to underwater noise from Project vessels and barge loading activities during the operations phase.

5.2.5.3.2.3 Disturbance from in-air Noise

Mitigation measures for in-air noise effects during the Construction Phase are addressed in Volume 2, Part B - Section 9.2 (Noise) of this EA report. No additional mitigation is proposed.

5.2.5.3.2.4 Mortality/Injury from Vessel Strikes

Measures to mitigate for potential vessel strikes on marine mammals during the operational phase are the same as those described for the construction phase in Section 5.2.5.3.1.4.

5.2.5.3.3 Reclamation and Closure

5.2.5.3.3.1 Alteration or Loss of Habitat

In general, since the activities during the reclamation/closure phase are similar to those identified for the construction phase (with the exception of no pile driving during closure), the mitigation measures identified for the construction phase are also applicable during the reclamation/closure phase.

5.2.5.3.3.2 Disturbance from Underwater Noise

No additional measures are proposed to mitigate for potential behavioral disturbance of marine mammals and fish due to underwater noise from vessel and pile removal activities during the closure phase.

5.2.5.3.3.3 Disturbance from in-air Noise

Mitigation measures for in-air noise effects during the Construction Phase are addressed in Volume 2, Part B - Section 9.2 (Noise) of this EA report. No additional mitigation is proposed.

5.2.5.3.3.4 Mortality/Injury from Vessel Strikes

Measures to mitigate for potential vessel strikes on marine mammals during the operational phase are the same as those described for the construction phase in Section 5.2.5.3.1.4.

5.2.5.3.4 Accidents and Malfunctions

An integrated Spill Prevention and Emergency Response Plan (SERP) will be developed and implemented by the Proposed Project proponent. The plan will encompass and coordinate applicable plans prepared by construction and marine transportation contractors and will include accidents and Spill Prevention and Response Plan and measures. The plan will be developed and implemented in accordance with the requirements and provisions of the applicable regulations including the *BC Environmental Management Act* (2003), *Navigation Protection Act* (R.S.C. 1985), *Fisheries Act* (R.S.C. 1985) and *Canada Shipping Act* (2001) and regulations and orders pursuant to the acts. The management plans will set measures and controls in place to (i) prevent release of toxic or deleterious substances in the marine environment as a result of unplanned (accidental) events and (ii) contain and clean up spills and leaks in a case the release (accidental event) has taken place. The measures and practices include, but are not limited to, as follows:

- Marine contractors will comply with regulations of *Canada Shipping Act* (2001) governing navigation safety. This includes provisions for collision-prevention devices (e.g., lights, sound signals, radar reflectors), navigation safety aids, ships' structural conditions, personnel training and competence, documentation, radio equipment and communications, emergency systems, fire safety and lifesaving equipment, pollution prevention measures and alarms.
- All operations and that include handling and storage of hazardous materials will comply with the Workplace Hazardous Materials Information Systems (WHMIS), as established under the *Hazardous Products Act* (R.S.C. 1985) and associated regulations.
- Transport and handling of any hazardous material will be in compliance with the *Transportation of Dangerous Goods Act* (*1992*).
- The proponent will ensure that the vessels and machinery will arrive on site in a clean/good condition and are to be maintained free of fluid leaks and invasive species. Fuel tanks, lubricants and chemical storage containers and components will meet relevant safety standards for preventing uncontrolled release of stored materials during normal operation and during exposure to natural hazards and to prevent fires and explosions. Vessels and equipment will be inspected daily. The logged records of inspections will be maintained.
- No refuelling and washing of machinery or equipment will take place at the marine foreshore.
- All fuel, lubricant and other chemicals use, handling and transfer activities will be conducted by properly trained personnel according to pre-established formal procedures to prevent accidental releases and fire and explosion hazards. Documented procedures will include all aspects of the delivery or loading operation from arrival to departure, including connection of grounding systems, verification of proper hose connection and disconnection, and adherence to no-smoking and no-naked light policies.
- Appropriate spill control equipment (spill kits) will be kept on site during the work. Operating personnel will be familiar with the contents and use of spill response equipment and the location and operation of emergency 'shut-offs'.
- Spill prevention plan and emergency response procedures will be developed and posted on-site.
- There will be an emergency response team onsite during work hours consisting of competent and trained personnel responsible to deal with emergency situations including fire and explosions and oil spills. The teams will be trained in using the fire-fighting equipment and spill kits and will undergo regular drills and practices.

- Tide tables, current tables and weather reports will be consulted prior to commencing work to avoid adverse environmental interactions such as vessel grounding. Works at the foreshore will not take place during times when adverse environmental conditions are present. Marine weather and sea conditions may change rapidly; forecasts will be consulted as necessary.
- The contractor may decide to stop work due to Health and Safety concerns based on weather or other conditions. The determination regarding whether to work based on weather or other conditions will be made by the contractor in coordination with the Proposed Project Proponent. The Proponent will direct the contractor to stop work if deemed necessary.
- General waste materials are to be contained on-site for appropriate off-site disposal. Garbage bins with appropriate lids are to be used on-site. Materials and debris are not allowed to become waterborne. During periods of wind and waves, the barge and work areas are to be inspected to make sure garbage containers and materials are secured.
- Implementation of the Proposed Project Environmental Policy and management plans will be enforced through a company representative onsite. The measures will include regular toolbox meetings, trainings and inductions, inspections and audits of the contractors as necessary.
- All accidents, spills, and near-misses will be reported and recorded in the Proposed Project database. A formal investigation will be conducted, if necessary, to determine causes of an accident and adequate resources will be allocated to conduct the investigation.
- In a case of a spill of a toxic or deleterious material, all efforts will be made to contain and recover the substance and act according to the Spill Prevention and Emergency Response Plan and procedures that will encompass different scenarios of potential spills. The level of response will depend on the circumstances of the spill.
- In a case of reportable spill, the closest Canadian Coast Guard Station (1-800-889-8852) or Emergency Coordination Centre (1-800-OILS-911) will be contacted. The Spill Prevention and Emergency Response Plan will list the amounts and types of reportable substances.

5.2.5.3.5 Monitoring

Environment monitoring plans will be developed and implemented to support effect mitigation measures. Monitoring will consist of compliance monitoring.

Compliance monitoring will occur during all phases of Proposed Project activities as a part of the Proposed Project mitigation plans and practices. Compliance monitoring will include monitoring of Proposed Project emissions, water quality, and assessment of Proponent's and contractor(s') environmental performance using specifically developed performance indicators and benchmark. Where possible, an adaptive management approach will be used to modify management plans as needed based on the results of the monitoring program.

Table 5.2-18: Identified Mitigation Measures: Marine Resources

Potential Effect	Mitigation	Anticipated Effectiveness
Construction		
Habitat Loss / Change in Habitat Quality (VC: Marine Water and Sediment Quality, Benthic Communities, Marine Fish, Marine Mammals, Marine Birds)	▪ Mitigation through design: - Utilize existing disturbed features - installation of barge load-out jetty in low value habitat (existing log dump) - Use of piles instead of fill to reduce seabed disturbance - Height and orientation of walkway/conveyor designed to maximize ambient light penetration - Maintain tree buffer on foreshore to limit noise and dust emissions to marine environment. ▪ Develop a Fish Habitat Offset Plan to offset unavoidable permanent alteration or destruction of fish habitat from Project works (Volume 4, Part G – Section 22.0: Appendix 5.1-B). ▪ Develop and adherence to Construction Environmental Management Plan (CEMP; Volume 3, Part E – Section 16.0). ▪ Develop and adherence to Pile Construction Management Plan (Volume 3, Part E – Section 16.0). ▪ Environmental monitoring by a qualified EM. ▪ Prevent release of construction debris and deleterious substances into the marine environment. ▪ Adherence to BMP for Pile Driving and Related Operations (DFO 2003). ▪ Adherence to Erosion and Sediment Control Plan (Volume 4, Part G – Section 22.0: Appendix 3) during road and other facilities construction, maintenance and upgrade. ▪ Optimal use of pre-cast concrete for construction and installation of facilities within the intertidal and subtidal zones. ▪ Concrete will be poured during suitable tides. ▪ Concrete is not to be poured directly into tidal waters. ▪ Pumping hoses will be equipped with a shut-off valve to stop flow should a spill occur. ▪ Short term portable concrete batch plant will be constructed onsite, so no concrete pumping will be conducted by barge. ▪ Use of tight-fitting formwork that is lined (e.g., with polyethylene) and that has gasket joints to prevent contact between concrete and tidal water. ▪ Barriers will be used as appropriate to prevent splashing of the concrete over the forms and into the water or intertidal area during pouring. ▪ Fast curing concrete intended/formulated for marine applications will be used. ▪ Following placement of concrete, forms will be left in place isolating the concrete from tidal waters for a minimum of 24 h or time required for the particular material used such that the concrete is cured before it is exposed to tidal waters. ▪ Wash down of equipment and tools that have come into contact with concrete will be conducted in a designated area away from intertidal drainages so that concrete products are prevented from entering watercourses. ▪ Excess or spilled concrete will be immediately cleaned up / removed from the intertidal area. ▪ During removal and storage of creosote pilings, adherence to DFO BMP “Guidelines to Protect Fish and Fish Habitat from Treated Wood Used in Aquatic Environments in the Pacific Region”. ▪ Vessels involved in in-water works will be positioned in a manner to prevent disturbance to benthic communities and benthic habitats. ▪ Work crews will monitor the position of barges and account for height of tidal waters, magnitude of prevailing winds, and direction of tidal currents or other factors that may influence vessel positioning.	High

Potential Effect	Mitigation	Anticipated Effectiveness
	▪ Manoeuvring of vessels in shallow areas will be minimized in order to avoid propeller scour and potential re-suspension of sediments or physical disturbance to shallow submerged marine vegetation. ▪ All equipment will be maintained in proper conditions to prevent leaking or spilling of hydrocarbons and other potentially toxic substances in the marine environment. ▪ All hydrocarbon products, fuelling equipment and other chemical substances will be stored and handled in accordance with all applicable legislation, guidelines and BMP's to prevent their release and toxic effect in the marine environment. ▪ A Spill Prevention and Emergency Response Plan will be developed and implemented for managing hydrocarbons and other chemicals during the construction activities (Volume 3, Part E – Section 16.0). ▪ During in-water works with potential to result in increased turbidity or suspended sediment, specific water quality performance objectives (based on BC WQG) will be applied at set distances from in-water works. In-water works will be halted if objectives are not achieved. Where objectives cannot be practically met, work areas will be isolated from tidal waters with silt curtains or other silt control measures.	

<table>
<tr><th>Potential Effect</th><th>Mitigation</th><th>Anticipated Effectiveness</th></tr>
<tr><td>Injury / Disturbance from Underwater Noise (VC: Marine Fish, Marine Mammals)</td><td>▪ Implementation of ramp-up / soft-start procedure during impact pile driving
▪ Avoid concurrent multiple underwater noise generating activities (sequence where possible).
Noise mitigation for fish:
▪ Impact pile driving should not exceed 30 kPa at 10 m from pile. Otherwise, additional mitigation will be implemented such as the use of a vibratory hammer in place of an impact hammer or installation of bubble curtains around the wetted pile.
▪ Impact pile driving activities will be temporarily suspended if aggregations of fish (e.g., herring or salmonids) are spotted within the immediate work area or if any herring spawn is observed attached to equipment or structures in the water.
Noise mitigation for MM:
▪ Monitoring for MM during all impact pile driving activities by a qualified and experienced MMO.
▪ Implementation of a MM Safety Zone based on injury threshold criteria (180 dB re 1 μPa SPLrms for cetaceans and 190 dB re 1 μPa SPLrms for pinnipeds). The occurrence of MM within the safety zone will trigger specific mitigation actions (e.g., shut-downs).
▪ Shut-down procedures – impact pile driving will be temporarily suspended when a MM is located within the safety zone until which time it moves outside the safety zone.
▪ Conduct a pre-operational search for MM prior to start-up of active impact pile driving. If a MM is spotted within the safety zone during the pre-ops search, the ramp-up procedure will be delayed 20 minutes from the time the MM left the safety zone, or was last sighted in the safety zone
▪ MMO will periodically verify underwater sound levels in the field using a hydrophone and a real-time sound monitor to confirm that sound levels at the modeled safety zone radius are below the established injury thresholds for MM. If necessary, the safety zone distance will be adjusted accordingly.
▪ Plan operations during daylight hours to maximize detection ability of MM in Project Area.
▪ Avoid peak seasonal timing when MMs are most likely to be in or adjacent to the Project Area.</td><td>High for mitigation against injury.

Moderate for mitigation against behavioral disturbance</td></tr>
<tr><td>Disturbance from In-Air Noise (VC: Marine Birds)</td><td>▪ Refer to Volume 2, Part B - Section 9.2 (Noise).</td><td>Moderate</td></tr>
<tr><td>Mortality/Injury from Vessel Strikes (VC: Marine Mammals)</td><td>▪ Speed restrictions for tug-assisted barges in RSA (<12 knots).
▪ Vessels will follow established shipping lanes/navigational routes in RSA.
▪ Vessels will maintain a constant course and constant speed in RSA.
▪ Project vessels will not approach within 100 m of any MM.
▪ If MMs approach within 100 m of a Project vessel, the vessel will reduce its speed and, if possible, cautiously move away from the animal. If it is not possible for a vessel to move away from or detour around a stationary MM or group of MM, the vessel will reduce its speed and wait until the animal(s) moves at least 100 m from the vessel prior to resuming speed.</td><td>High</td></tr>
</table>

Potential Effect	Mitigation	Anticipated Effectiveness
	Operations	
Habitat Loss / Change in Habitat Quality (VC: Marine Water and Sediment Quality, Benthic Communities, Marine Fish, Marine Mammals, Marine Birds)	▪ Mitigation through design: - Utilize existing disturbed features - installation of barge load-out jetty in low value habitat (existing log dump) - Use of piles instead of fill to reduce seabed disturbance - Height and orientation of walkway/conveyor designed to maximize ambient light penetration - Maintain tree buffer on foreshore to limit noise and dust emissions to marine environment. ▪ Prevent release of debris and deleterious substances into the marine environment. ▪ Adherence to BMP for Erosion and Sediment Control Plan (Volume 4, Part G – Section 22.0: Appendix 3) during road and facilities maintenance and upgrade. ▪ Vessels involved in in-water works will be positioned in a manner to prevent disturbance to benthic communities and benthic habitats. ▪ Work crews will monitor the position of barges and account for height of tidal waters, magnitude of prevailing winds, and direction of tidal currents or other factors that may influence vessel positioning. ▪ Manoeuvring of vessels in shallow areas will be minimized in order to avoid propeller scour and potential re-suspension of sediments or physical disturbance to shallow submerged marine vegetation. ▪ All equipment will be maintained in proper conditions to prevent leaking or spilling of hydrocarbons and other potentially toxic substances in the marine environment. ▪ All hydrocarbon products, fuelling equipment and other chemical substances will be stored and handled in accordance with all applicable legislation, guidelines and BMP's to prevent their release and toxic effect in the marine environment. ▪ A Spill Prevention and Emergency Response Plan will be developed and implemented for managing hydrocarbons and other chemicals during operational activities.	High
Disturbance from Underwater Noise (VC: Marine Fish, Marine Mammals)	▪ No additional measures are proposed.	Moderate
Behavioral Disturbance from In-Air Noise (VC: Marine Birds)	▪ Refer to Volume 2, Part B - Section 9.2 (Noise).	Moderate
Mortality/Injury from Vessel Strikes (VC: Marine Mammals)	▪ Maintain mitigation measures implemented during construction.	High

Potential Effect	Mitigation	Anticipated Effectiveness
Reclamation and Closure		
Habitat Loss / Change in Habitat Quality (VC: Marine Water and Sediment Quality, Benthic Communities, Marine Fish, Marine Mammals, Marine Birds)	▪ Maintain mitigation measures implemented during construction.	
Disturbance from Underwater Noise (VC: Marine Fish, Marine Mammals)	▪ No additional measures are proposed.	
Disturbance from In-Air Noise (VC: Marine Birds)	▪ Refer to Volume 2, Part B - Section 9.2 (Noise).	
Mortality/Injury from Vessel Strikes (VC: Marine Mammals)	▪ Maintain mitigation measures implemented during construction.	High
Accidents and Malfunctions		
Toxic and Hazardous Material Spills	▪ Adherence to Spill Prevention and Emergency Response Plan (SERP)	High
Aggregate Spills	▪ Adherence to SERP	High

5.2.5.4 *Residual Effects Assessment*

Potential Project-related residual effects have been characterized using the criteria identified in Table 5.2-5. For each Marine Resource VC (excluding pathway VCs), the characterization of potential residual effects following the implementation of mitigation is described below and presented in Table 5.2-19 through Table 5.2-23. Residual effects have been characterized at the regional scale (RSA), as this scale provides a regional, ecologically relevant context for the distribution of VCs, and the ecosystems they depend on.

5.2.5.4.1 Construction, Operations and Reclamation/closure

5.2.5.4.1.1 Marine Water and Sediment Quality

5.2.5.4.1.1.1 Change in Water and Sediment Quality

The mitigation measures proposed to avoid or minimize changes in water and sediment quality as a result of pile installation/removal and other in-water works (construction and reclamation and closure) and propeller scour from tug activity (all phases) described in Section 5.2.5.3.1.1 are expected to be effective. The Proposed Project in the marine environment will occur in pre-disturbed areas associated with historical log sort operations. Given the unfavourable conditions presently available in the proposed marine Project footprint, the system is considered to have a low susceptibility to potential changes caused by the Proposed Project (context is resilient). Adherence to pile driving BMPs, the use of pre-cast concrete where possible and the implementation of a CEMP and environmental monitors during construction activities will minimize adverse effects to water and sediment quality from the Proposed Project activities (in-water works and propeller scour). With the application of mitigation, potential changes to marine sediment and water quality from in-water works and/or propeller scour are not anticipated to exceed CCME SQG or BC WQG for the protection of aquatic life; the magnitude of the effect is therefore considered low. The geographic extent is local since the effects will be restricted to the LSA. The duration is considered medium-term over the course of the Project as potential residual effects related to changes in water and sediment quality could result from activities throughout the lifetime of the Project. The frequency of the residual effect is considered low (rare) for in-water works and medium (intermittent) for propeller scour. In the event that in-water works or propeller scour did result in changes to marine water or sediment quality, the residual effect is considered fully reversible with water and sediment quality returning to pre-activity conditions shortly after the disturbance event (Table 5.2-19). The likelihood of these activities resulting in changes to marine sediment or water quality in excess of CCME SQG or provincial WQG is considered low given the application of known and effective mitigation measures and best practices. The level of confidence that the effect will not be greater than predicted is high due to the predicted effectiveness of the proposed mitigation.

5.2.5.4.1.2 Marine Benthic Communities

5.2.5.4.1.2.1 Loss in Habitat

The mitigation measures proposed to reduce loss of potential habitat for marine benthic communities are expected to be effective. The Proposed Project will result in the direct loss of 2.5 m^2 of marine benthic habitat from installation of 18 piles to support the barge load-out jetty and conveyor/walkway. The majority of this habitat loss corresponds with areas of low productive habitat value due to wood waste accumulation. Habitat losses will be addressed through fish habitat offsetting in the freshwater environment as described in Volume 2, Part B - Section 5.1. Furthermore, the barge load-out jetty and walkway/conveyor system may result in minimal shading on intertidal and subtidal vegetation underlying these structures, although the overall height of the conveyor/walkway system (~5 m above grade) and its north-south orientation will substantially reduce shading effects with no loss of production capacity anticipated.

Given the unfavorable habitat conditions presently available in the proposed marine Project footprint, the system is considered to have a low susceptibility to potential changes caused by the Proposed Project (context is resilient) and the magnitude of the direct habitat loss is predicted to be medium (measurable change but no population level effects). The residual effect is local in extent (restricted to the LSA) and medium-term in duration as the loss in habitat will persist until the piles are removed following completion of the Project. The frequency of occurrence is considered low as the habitat loss will occur only once during the construction phase. The residual effect is considered fully reversible as the area of direct habitat disturbance will be recolonized by benthic organisms from adjacent communities once piles are removed during the reclamation and closure phase (Table 5.2-20). The likelihood of this effect occurring is considered high, given it is known that benthic habitat will be lost within the physical footprint of the installed piles. The level of confidence that the effect will not be greater than predicted is high due to conservative assumptions regarding the amount of habitat loss that may occur due to the Proposed Project and the predicted effectiveness of the proposed habitat offsetting measures.

5.2.5.4.1.2.2 Changes in Habitat Quality

5.2.5.4.1.2.2.1 Removal, Upgrade and Installation of Marine Structures

The mitigation measures proposed to avoid or minimize changes to benthic habitat quality are expected to be effective. The Proposed Project in the marine environment will occur in pre-disturbed areas associated with historical log sort operations.

Given the unfavorable habitat conditions presently available in the proposed marine Project footprint, the existing system is considered to have a low susceptibility to potential changes caused by the Proposed Project (context is resilient). Given the application of known and effective mitigation, the magnitude of any habitat alteration is predicted to be low (within the scope of natural variability). The geographic extent is local since the residual effect will be restricted to the LSA. The duration is considered medium-term (construction and closure phases only) and the frequency is considered low (rare) as potential for the effect to occur will be limited to specific Project activities during each phase (in-water works). The residual effect is considered fully reversible with benthic habitat quality returning to pre-activity conditions shortly after the disturbance event (Table 5.2-20). The likelihood of this effect occurring is considered low given the application of known and effective mitigation measures and best practices. The level of confidence that the effect will not be greater than predicted is high due to the predicted effectiveness of the proposed mitigation.

5.2.5.4.1.2.2.2 Propeller Scour

Propeller scour effects on the seabed were determined to be limited to the immediate area of the barge offloading facility during active tug berthing activities. No propeller scour effects are anticipated on potential glass sponge communities in the LSA because propeller wash velocities at the depths at which glass sponges occur (> -20 m chart datum) are predicted to be within the same magnitude as tidal currents present at this depth, and below the velocity threshold (0.25 m/s) required for seabed particle mobilization (USACE 1989).Given the unfavorable benthic habitat conditions presently available in the subtidal footprint of the barge offloading facility, the existing system is considered to have a low susceptibility to potential changes caused by the Proposed Project (context is resilient). The magnitude of the residual effect is considered to be low (within the scope of natural variability. The geographic extent is considered local as propeller scour effects from tugs will be localized in the immediate area around the terminal (within the LSA). No propeller scour effects along the proposed barging route are anticipated due to the depth of the water in this area. The frequency is considered medium (occurring intermittently with active tug movements at the barge offloading facility). The residual effect is considered fully reversible as the area of potential seabed disturbance from propeller scour would be recolonized by benthic organisms from adjacent communities once the Project is completed. The duration of the effect is considered medium-term as the potential for the effect to occur will cease after Project closure. The likelihood that propeller scour will result in adverse changes to benthic habitat quality is considered low due to the low value benthic habitat already present in this area. The level of confidence that the effect will not be greater than predicted is considered high given conservative estimates incorporated in the propeller wash model.

5.2.5.4.1.2.3 Potential Mortality

5.2.5.4.1.2.3.1 Removal, Upgrade and Installation of Marine Structures

The removal, upgrade and installation of marine infrastructure (in-water works) may result in the direct mortality of marine benthic organisms within the immediate area of these activities by means of direct burial or crushing from physical interactions with infrastructure or equipment, as well as smothering or chronic/toxic effects from sediment re-suspension and/or release of cementitious materials or creosote to the marine environment during in-water works. Given the unfavorable habitat conditions presently available in the proposed marine Project footprint, the system is considered to have a low susceptibility to potential changes caused by the Proposed Project (context is resilient) and the magnitude of this effect (mortality from in-water works) is predicted to be medium (measurable change but no population level effects). The geographic extent is considered local since the effects will be restricted to the LSA. The duration is considered medium-term (limited to the construction and closure phases) and the frequency is considered low (rare) as the effect would only occur during in-water work periods. The residual effect is considered fully reversible (Table 5.2-20) because the effects from in-water works, while potentially lethal to individual organisms, are generally temporary in terms of the overall abundance and diversity of benthic populations in the larger surrounding area (Cruz-Motta and Collins 2004). Benthic communities physically disturbed by marine construction activities are typically recolonized by adult organisms from surrounding areas and from larvae of benthic invertebrates that occupy the water column near the disposal site (Newell et al. 1998). The likelihood of this effect occurring is considered high, given it is known that some loss of individuals will occur within the physical footprint of the installed piles. The level of confidence that the effect will not be greater than predicted is high due to the predicted effectiveness of the proposed mitigation.

5.2.5.4.1.2.3.2 Propeller Scour

Tug propeller wash in the vicinity of the barge offloading facility may result in the direct mortality of marine benthic organisms as a result of physical forces from the propeller jet plume, as well as from smothering, burial or chronic/toxic effects associated with sediment re-suspension. Given the unfavorable habitat conditions presently available in the proposed marine Project footprint, the system is considered to have a low susceptibility to potential changes caused by the Proposed Project (context is resilient) and the magnitude of this effect (mortality from in-water works) is predicted to be medium (measurable change but no population level effects). The geographic extent is considered local since the effects will be restricted to the LSA. The duration is considered medium-term (present throughout the life of the Project) and the frequency is considered medium (occurring intermittently with active tug movements at the barge offloading facility). The residual effect is considered fully reversible (Table 5.2-20) because the effects from propeller scour, while potentially lethal to individual organisms, are generally temporary in terms of the overall abundance and diversity of benthic populations in the larger surrounding area (Cruz-Motta and Collins 2004). The likelihood of this effect occurring is considered moderate, given it is possible that some mortality of individuals will occur near the barge offloading facility. The level of confidence that the effect will not be greater than predicted is considered high given conservative estimates incorporated in the propeller wash model.

5.2.5.4.1.3 Marine Fish

5.2.5.4.1.3.1 Loss in Habitat

The mitigation measures proposed to reduce loss of potential marine fish habitat are expected to be effective. The Proposed Project will result in the direct loss of 2.5 m^2 of marine fish habitat from installation of 18 piles to support the barge load-out jetty and conveyor/walkway. The majority of this habitat loss corresponds with areas of low productive fish habitat value due to wood waste accumulation. Habitat losses will be addressed through fish habitat offsetting in the freshwater environment as described in Volume 2, Part B - Section 5.1 (Fisheries and Freshwater Habitat). Furthermore, the barge load-out jetty and walkway/conveyor system may result in minimal shading on intertidal and subtidal vegetation (potential fish habitat) underlying these structures, although the overall height of the conveyor/walkway system (~5 m above grade) and its north-south orientation will substantially reduce shading effects with no loss of production capacity for marine fish habitat anticipated.

Given the unfavorable habitat conditions presently available in the marine Proposed Project footprint and the fact that no sensitive fish habitat areas (e.g., spawning grounds, RCAs) or suitable fish spawning areas (e.g., eelgrass) occur in this area, the existing system is considered to have a low susceptibility to potential changes caused by the Proposed Project (context is resilient) and the magnitude of the direct habitat loss is predicted to be low (potential measurable change but within the scope of natural variability with no population level effects anticipated). The residual effect is local in extent (restricted to the LSA) and medium-term in duration as the loss in fish habitat will persist until the piles are removed following completion of the Project. The frequency of occurrence is considered low as the habitat loss will occur only once during the construction phase. The habitat removed may be replaced at the end of the life of the Project be restoring the Proposed Project Area; the effect is therefore considered fully reversible (Table 5.2-21). The likelihood of this effect occurring is considered high, given it is known that some marine fish habitat will be lost within the physical footprint of the installed piles. The level of confidence that the effect will not be greater than predicted is high due to conservative assumptions regarding the amount of habitat loss that may occur due to the Proposed Project and the predicted effectiveness of the proposed habitat offsetting measures.

5.2.5.4.1.3.2 Changes in Habitat Quality

5.2.5.4.1.3.2.1 Removal, Upgrade and Installation of Marine Structures

The mitigation measures proposed to avoid or minimize changes to marine fish habitat quality are expected to be effective. The Proposed Project in the marine environment will occur in pre-disturbed areas associated with historical log sort operations. Given the unfavorable habitat conditions presently available in the proposed marine Project footprint, the existing system is considered to have a low susceptibility to potential changes caused by the Proposed Project (context is resilient). Given the application of known and effective mitigation, the magnitude of any habitat alteration is predicted to be low (potential measurable change but within the scope of natural variability with no population level effects anticipated). The geographic extent is local since the residual effect will be restricted to the LSA. The duration is considered medium-term (construction and closure phases only) and the frequency is considered low (rare) as potential for the effect to occur will be limited to specific Project activities during each phase (in-water works). The residual effect is considered fully reversible with marine fish habitat quality returning to pre-activity conditions shortly after the disturbance event (Table 5.2-21). The likelihood of this effect occurring is considered low given the application of known and effective mitigation measures and best practices, and in consideration of the low value fish habitat in the area potentially affected. The level of confidence that the effect will not be greater than predicted is high due to the predicted effectiveness of the proposed mitigation.

5.2.5.4.1.3.2.2 Propeller Scour

Propeller scour effects on the seabed were determined to be limited to the immediate area of the barge offloading facility during active tug berthing activities. No propeller scour effects are anticipated on fish habitat in the proposed barging route because propeller wash velocities at the water depths along the route are predicted to be within the same magnitude as tidal currents present at this depth and below the velocity threshold (0.25 m/s) required for seabed particle mobilization (USACE 1989). Given the unfavorable benthic habitat conditions presently available in the subtidal footprint of the barge offloading facility, the existing system is considered to have a low susceptibility to potential changes caused by the Proposed Project (context is resilient). The magnitude of the residual effect is considered to be low (potential measurable change but within the scope of natural variability with no population level effects anticipated). The geographic extent is considered local as propeller scour effects from tugs will be localized in the immediate area around the terminal (within the LSA) with no anticipated effects along the proposed barging route due to the depth of the water in this area.. The frequency is considered medium (occurring intermittently with active tug movements at the barge offloading facility). The residual effect is considered fully reversible as the area of potential fish habitat disturbance from propeller scour would be recolonized by fish from adjacent areas once the Project is completed. The duration of the effect is considered medium-term as the potential for the effect to occur will cease after Project closure. The likelihood that propeller scour will result in adverse changes to marine fish habitat quality is considered low due to the low value fish habitat already present in this area. The level of confidence that the effect will not be greater than predicted is considered high given conservative estimates incorporated in the propeller wash model.

5.2.5.4.1.3.3 Injury/Mortality from Underwater Noise (Pile Driving)

The mitigation measures proposed to reduce fish mortality or injury from Project-related underwater noise are expected to be effective.

With no mitigation applied and using the more conservative pile size (0.61 m diameter) as the reference source level in the model, acoustic modeling results indicate that underwater sound from impact pile driving will exceed the NMFS injury threshold for fish (206 dB re 1 uPa - SPL_{peak}) at distances up to 12 m from the source (as boundary conditions allow). With the implementation of noise-reduction measures (e.g., bubble curtains around the wetted pile) in combination with active mitigation measures as described in Section 5.2.5.3 (e.g., implementation of ramp-up procedures, sound verification monitoring), the potential for Project-generated underwater noise to result in serious harm (e.g., injury) to marine fish is considered unlikely.

Given the low value fish habitat presently available in the subtidal footprint of pile driving activities (extensive woody debris cover with low fish diversity and abundance) in combination with the lack of sensitive fish habitat areas (e.g., spawning grounds, RCAs) or suitable fish spawning areas (e.g., eelgrass) in the marine Proposed Project footprint , the system is considered to have a low susceptibility to potential changes caused by the Proposed Project (context is resilient) and the magnitude of this effect (mortality from in-water works) is predicted to be medium (potential measurable change but within the scope of natural variability with no population level effects anticipated). The predicted effect is considered local in extent, short-term (construction phase only), and low in frequency (occurs only during a specified period). The reversibility of the effect is considered to be high in the case of mortality (permanent at the level of the individual) and low in the case of injury, as the effect may be partially or fully reversible depending on the trauma incurred (e.g., ranging from stress effects to ruptured swim bladders). The likelihood of a mortality event is considered low due to the implementation of widely used and effective mitigation such the preferential use of vibratory hammers where possible, and the implementation of ramp-up procedures during active pile driving and underwater sound verification / monitoring. The level of confidence that the effect will not be greater than predicted is considered high due to the predicted effectiveness of the proposed mitigation.

5.2.5.4.1.4 Marine Mammals

5.2.5.4.1.4.1 Injury/Mortality from Underwater Noise (Pile Driving)

The mitigation measures proposed to reduce marine mammal mortality or injury from Project-related underwater noise are expected to be effective.

With no mitigation applied and using the more conservative pile size (0.61 m diameter) as the reference source level in the model, acoustic modeling results indicate that underwater sound from impact pile driving will exceed the NMFS injury threshold for marine mammals (180 dB re 1 uPa – SPL_{rms}) at distances up to 86 m from the source (as boundary conditions allow). With the implementation of noise-reduction measures (e.g., bubble curtains around the wetted pile) in combination with real-time monitoring and active mitigation measures as described in Section 5.2.5.3 (e.g., marine mammal monitoring in defined safety zone, pre-operations surveillance, implementation of ramp-up / shut-down procedures, sound verification monitoring), the potential for Project-generated underwater noise to result in serious harm (e.g., injury) to marine mammals is considered unlikely (negligible impact).

The magnitude of this effect is considered low given no marine mammal mortality or injury is anticipated with the proposed mitigation in place (although localized changes in behavior are possible). The predicted effect is local in extent, short-term (construction phase only), low in frequency (occurs only during a specified period) (Table 5.2-22). Injury to marine mammals may be irreversible or fully reversible depending on the trauma incurred. The effect is considered fully reversible if the injury consists of a temporary threshold shift (TTS), as this type of auditory injury is temporary with the individual's hearing sensitivity returning to near normal (pre-exposure) levels over time. The effect is considered irreversible if the injury consists of a permanent threshold shift (PTS), as this type of auditory injury is lasting (hearing levels will not return to pre-exposure levels). The context is considered sensitive for listed marine mammal species and resilient for all other marine mammal species. With the proposed mitigation in place, the likelihood of an injury to marine mammals from underwater noise as a result of pile driving is considered to have a low likelihood of occurrence. The level of confidence that the effect will not be greater than predicted is considered high due to the predicted effectiveness of the proposed mitigation.

5.2.5.4.1.4.2 Behavioral Disturbance from Underwater Noise (Pile Driving, Vessel Noise and Barge Loading)

Potential behavioral disturbance in marine mammals may occur as a result of underwater noise generated during impact pile driving, vessel operations, and barge loading activities.

With no mitigation applied and using the more conservative pile size (0.61 m diameter) as the reference source level in the model, acoustic modeling results indicate that underwater sound from impulsive Project noise sources such as impact pile driving will exceed the NMFS marine mammal behavioral disturbance threshold for pulsive noise (160 dB re 1 μPa SPL_{rms}) at distances up to 1.9 km from the source (as boundary conditions allow). With the implementation of noise-reduction measures (e.g., bubble curtains around the wetted pile), this zone of disturbance may be further reduced. Acoustic modeling results further indicate that underwater sound from continuous Project noise sources such as vessel noise and barge loading will exceed the NMFS marine mammal disturbance threshold for non-pulsive noise (120 dB re 1 μPa SPL_{rms}) at distances up to 2.2 km and 1.2 km from the source, respectively (as boundary conditions allow).

The magnitude of this predicted effect is considered medium as noise levels from impact pile driving, vessel operations and barge loading are expected to exceed established disturbance criteria for marine mammals. The geographic extent is considered regional for barge loading, impact pile driving and vessel noise (restricted to the RSA). The duration of the effect is considered to be short-term for pile driving and medium-term for vessel activities and barge loading. The frequency is considered low (rare) for pile driving and medium (intermittent) for vessel activities (Table 5.2-22). The reversibility of the effect is considered fully reversible as behavioural effects are likely to be temporary with individuals either habituating to the noise sources over time or returning to the area following the disturbance and displaying pre-activity behaviours. The context of the effect is considered resilient for all marine mammal species. Marine mammals occurring in the RSA likely have a natural resilience to imposed stresses of underwater noise due to their prior experience with existing marine traffic given the current volume of shipping that occurs in the area (Volume 2, Part B - Section 7.2: Marine Transportation). In addition, the literature suggests that marine mammals are unlikely to be deterred from preferred feeding grounds when exposed to noise levels exceeding known disturbance thresholds. The likelihood of the effect occurring is considered medium as it is possible that some marine mammals will demonstrate behavioral responses to Project-related pile driving, vessel noise and barge loading.

5.2.5.4.1.4.3 Injury/Mortality from Vessel Strikes

The mitigation measures proposed to reduce marine mammal mortality or injury from potential Project-related vessel strikes are expected to be effective. Baleen whales such as humpback and grey whales would be most susceptible to vessel strikes, due to their large size, slower travel and maneuvering speeds, and lower avoidance capability. Toothed whales (e.g., killer whales) and pinnipeds (seals and sea lions) are considered to be at a low risk due to their swimming speed and agility in the water. The proposed barge route does not pass through critical habitat of any marine mammal species. Critical habitat for resident killer whales is located outside the RSA; thereby further limiting the potential for vessel strikes with this population. In the rare event of a marine mammal strike at the proposed vessel speeds identified for the Project, the consequence would likely be a non-lethal injury (laceration from propeller and/or blunt force injury) rather than direct mortality.

The potential effect of a vessel strike on marine mammal populations is considered high in magnitude because potential receptors include federally and/or provincially listed species and the Proposed Project Area seasonally supports baleen whales (e.g., humpback and grey whales) which have a higher susceptibility to vessel-strikes compared to toothed whales and pinnipeds, although the effect is more likely to result in injury than death. The geographic extent would be local (restricted to the LSA), medium-term in duration (tug and barges are conservatively assumed to be used through reclamation and closure) and considered to have a high frequency

(Table 5.2-22). Possible outcomes from a ship strike includes death (however considered unlikely) and injury therefore the reversibility of this effect is considered high (permanent) to low (effect can be reversed) and will depend on the level of injury from the strike. The context is considered sensitive for listed marine mammal species and resilient for all other marine mammal species. The potential for a collision between a marine mammal and a Proposed Project vessel is considered to have a low likelihood of occurrence given the size and speeds of the vessels. Confidence that the effect will not be greater than predicted is high due to adherence to vessel size and speed restrictions known to reduce the likelihood of vessel-marine mammal collisions as presented in the scientific literature.

5.2.5.4.1.5 Marine Birds

5.2.5.4.1.5.1 Behavioral Disturbance from In-Air Noise

In-air noise emitted during Project construction and operational activities may result in adverse behavioral responses in marine birds including temporary avoidance of the affected area(s). Marine birds are considered to have a low susceptibility to potential behaviour disturbances from Project generated in-air noise (context is resilient); no detectable changes are anticipated in marine bird populations compared to baseline conditions. The magnitude of the residual effect is considered low, since the area with noise levels exceeding bird disturbance thresholds is limited to the Proposed Project footprint and does not extend into McNab Creek estuary where most congregations of marine birds in the region are known to occur. The geographic extent is local for in-air noise generated by pile driving, barge loading and vessels (restricted to the LSA). The duration is short-term for pile driving and medium-term for vessel operations and barge loading as these activities would occur over the life of the Proposed Project. The frequency is considered low (rare) for pile driving, medium for barge loading and high (continuous) for vessel operations (Table 5.2-23). The reversibility of the effect is considered fully reversible as marine birds will likely return to the area and display pre-activity behaviors once the Project in-air noise sources of concern are complete. The likelihood of the effect occurring is considered medium as it is possible that some marine birds will demonstrate temporary behavioral responses to Project-related construction and operational noise.

5.2.5.4.2 Accidents and Malfunctions

5.2.5.4.2.1 Toxic and Hazardous Material Spills

The mitigation measures proposed to prevent, reduce and control releases of deleterious substances (e.g., hydrocarbon spills) in the marine environment as a result of accidental events are expected to be effective.

In the unlikely event of a collision of a Proposed Project vessel with another vessel, shore feature or man-made structure, effects may include rupturing of the vessel's fuel tank. In the worst case scenario, the maximum amount of fuel that can be released into the marine environment is 81 m^3 of diesel fuel (total tank volume of Seaspan Commander). Most of the released fuel would undergo rapid weathering and evaporation processes and would be contained and cleaned by emergency response crews. Concentrations of hydrocarbons in water and potentially sediment (if the spill reached shore) would likely exceed established guidelines (CCME 2013; BC MoE 2006) by more than 10 times and subsequently result in adverse toxic effects on marine benthic invertebrates, and potentially fish, marine mammals and marine birds.

The context of all marine resource VCs is considered sensitive to change caused by potential toxic spills as a result of the Proposed Project, as a spill could impact sensitive resources outside the RSA depending on the location of the release. The magnitude of effect of a potential hydrocarbon spill on Marine Resource VCs is assessed as high. The predicted effect is regional in extent and medium-term in duration since spilled hydrocarbons would likely biodegrade within one or two months of an event (NOAA 1992), however chronic (long term) toxic effects from contamination may persist longer. The frequency of this potential effect is considered is low (occurs rarely) and fully reversible. With the proposed mitigation in place, the likelihood of a major hydrocarbon spill is considered low. Confidence that the effect will not be greater than predicted is moderate as scientific evidence regarding species-specific responses to spills is limited, however, the mitigation is expected to be effective in limiting the effects.

5.2.5.4.2.2 Aggregate Spills

The mitigation measures proposed to prevent, reduce and control releases of deleterious substances (e.g., aggregate spills) into the marine environment as a result of accidental events are expected to be effective.

The context for marine water and sediment quality and marine benthic communities in general is considered resilient to impacts caused by potential aggregate spills as a result of the Proposed Project as the potential location of an aggregate spill at the terminal does not directly overlap with sensitive marine benthic resources (e.g., eelgrass, glass sponge). The barging route overlaps with glass sponge reef at the mouth of Ramillies Channel (Volume 4, Part G – Section 22.0: Appendix 5.2-A, Figure 3). If an aggregate spill were to occur here, glass sponges would experience increased levels of sedimentation which can result in smothering and reduce filtering capabilities and limit feeding and growing (Leys et al. 2004). Therefore, the context for glass sponges is considered sensitive to aggregate spills. The magnitude of the potential effect from a major aggregate spill is assessed as low for marine water and sediment quality and marine benthic communities, and moderate for glass sponge reefs. The predicted effect is considered local in geographic extent and short-term in duration (plume would settle out fairly rapidly given the aggregate particle size). The frequency of this potential effect is considered low (occurs rarely) with a low reversibility (effect can be reversed). With the proposed mitigation in place, the likelihood of a major aggregate spill is considered low. Confidence that the effect will not be greater than predicted is high due to the predicted effectiveness of the proposed mitigation.

Table 5.2-19: Characterization of Potential Adverse Residual Effects: Marine Water and Sediment Quality

Proposed Project-Related Effect	Residual Effect Assessment Criteria					
	Context	Magnitude	Extent	Duration	Reversibility	Frequency
Construction						
Changes in Marine Water and Sediment Quality	R	L	L	MT	FR	L to M
Operations						
Changes in Marine Water and Sediment Quality	R	L	L	MT	FR	L to M
Reclamation and Closure						
Changes in Marine Water and Sediment Quality	R	L	L	MT	FR	L to M
Accidents and Malfunctions						
Toxic and Hazardous Material Spills	S	H	R to BR	MT	FR	L
Aggregate Spills	R	L	L	ST	FR	L

Assessment Criteria:
Context: R – Resilient, MR – Moderately Resilient, S - Sensitive;
Magnitude: N – Negligible, L – Low, M – Medium, H – High;
Extent: L – Local, R – Regional, BR – Beyond Regional;
Duration: ST – Short-term, MT – Medium-term, LT – Long-term;
Reversibility: FR – Fully Reversible, PR - Partially Reversible, IR - Irreversible;
Frequency: L – Low, M – Medium, H – High

Table 5.2-20: Characterization of Potential Adverse Residual Effects: Marine Benthic Communities

Proposed Project-Related Effect	Residual Effect Assessment Criteria					
	Context	Magnitude	Extent	Duration	Reversibility	Frequency
Construction						
Loss in Habitat	R	M	L	MT	FR	L
Changes in Habitat Quality – In-water Works	R	L	L	MT	FR	L
Changes in Habitat Quality – Propeller Scour	R	L	L	MT	FR	M
Potential Mortality - In-water Works	R	L	L	MT	FR	L
Potential Mortality – Propeller Scour	R	M	L	MT	FR	M
Operations						
Changes in Habitat Quality – Propeller Scour	R	L	L	MT	FR	M
Potential Mortality – Propeller Scour	R	M	L	MT	FR	M
Reclamation and Closure						
Changes in Habitat Quality – In-water Works	R	L	L	MT	FR	L
Changes in Habitat Quality – Propeller Scour	R	L	L	MT	FR	M
Potential Mortality - In-water Works	R	M	L	MT	FR	L
Potential Mortality – Propeller Scour	R	M	L	MT	FR	M
Accidents and Malfunctions						
Toxic and Hazardous Material Spills	S	H	R to BR	MT	FR	L
Aggregate Spills	R to S	L to M	L	ST	FR	L

Assessment Criteria:
Context: R – Resilient, MR – Moderately Resilient, S - Sensitive;
Magnitude: N – Negligible, L – Low, M – Medium, H – High;
Geographic Extent: L – Local, R – Regional, BR – Beyond Regional;
Duration: ST – Short-tern, MT – Medium-term, LT – Long-term;
Reversibility: FR – Fully Reversible, PR - Partially Reversible, IR - Irreversible;
Frequency: L – Low, M – Medium, H – High

Table 5.2-21: Characterization of Potential Adverse Residual Effects: Marine Fish

Proposed Project-Related Effect	Residual Effect Assessment Criteria					
	Context	Magnitude	Extent	Duration	Reversibility	Frequency
Construction						
Loss in Habitat	R	L	L	MT	FR	L
Changes in Habitat Quality – In-water Works	R	L	L	MT	FR	L
Changes in Habitat Quality – Propeller Scour	R	L	L	MT	FR	M
Mortality/Injury - UW Noise (Pile Driving)	R	M	L	ST	FR to IR	L
Operations						
Changes in Habitat Quality – Propeller Scour	R	N	L	MT	FR	L
Reclamation and Closure						
Changes in Habitat Quality – In-water Works	R	N	L	MT	FR	L
Changes in Habitat Quality – Propeller Scour	R	N	L	MT	FR	L
Accidents and Malfunctions						
Toxic and Hazardous Material Spills	S	H	R to BR	MT	FR	L

Assessment Criteria:
Context: R – Resilient, MR – Moderately Resilient, S - Sensitive;
Magnitude: N – Negligible, L – Low, M – Medium, H – High;
Geographic Extent: L – Local, R – Regional, BR – Beyond Regional;
Duration: ST – Short-tern, MT – Medium-term, LT – Long-term;
Reversibility: FR – Fully Reversible, PR - Partially Reversible, IR - Irreversible;
Frequency: L – Low, M – Medium, H – High.

Table 5.2-22: Characterization of Potential Adverse Residual Effects: Marine Mammals

Proposed Project-Related Effect	Residual Effect Assessment Criteria					
	Context	Magnitude	Extent	Duration	Reversibility	Frequency
Construction						
Mortality/Injury - Vessel strikes	S/R	H	L	MT	FR to IR	H
Mortality/Injury - UW Noise (Pile Driving)	S/R	L	L	ST	FR to IR	L
Behavioral Disturbance - UW Noise (Pile Driving, Vessels)	R	M	R	ST to MT	FR	L to M
Operations						
Mortality/Injury - Vessel strikes	S/R	H	R	MT	FR to IR	H
Behavioral Disturbance - UW Noise (Vessels, Barge Loading)	R	M	R	MT	FR	L to M
Reclamation and Closure						
Mortality/Injury - Vessel strikes	S/R	H	L	MT	FR to IR	H
Behavioral Disturbance - UW Noise (Vessels)	R	M	R	MT	FR	L to M
Accidents and Malfunctions						
Toxic and Hazardous Material Spills	S	H	R to BR	MT	FR	L

Assessment Criteria:
Context: R – Resilient, MR – Moderately Resilient, S - Sensitive;
Magnitude: N – Negligible, L – Low, M – Medium, H – High;
Geographic Extent: L – Local, R – Regional, BR – Beyond Regional;
Duration: ST – Short-tern, MT – Medium-term, LT – Long-term;
Reversibility: FR – Fully Reversible, PR - Partially Reversible, IR - Irreversible;
Frequency: L – Low, M – Medium, H – High.

Table 5.2-23: Characterization of Potential Adverse Residual Effects: Marine Birds

Proposed Project-Related Effect	Residual Effect Assessment Criteria					
	Context	Magnitude	Extent	Duration	Reversibility	Frequency
Construction						
Behavioral Disturbance - In-air Noise (Pile Driving, Vessels)	R	L	L	ST to MT	FR	L to H
Operations						
Behavioral Disturbance - In-air Noise (Barge Loading, Vessels)	R	L	L	MT	FR	M to H
Reclamation and Closure						
Behavioral Disturbance - In-air Noise (Vessels)	R	L	L	MT	FR	H
Accidents and Malfunctions						
Toxic and Hazardous Material Spills	S	H	R to BR	MT	FR	L

Assessment Criteria:
Context: R – Resilient, MR – Moderately Resilient; S - Sensitive;
Magnitude: N – Negligible, L – Low, M – Medium, H – High;
Geographic Extent: L – Local, R – Regional, BR – Beyond Regional;
Duration: ST – Short-tern, MT – Medium-term, LT – Long-term;
Reversibility: FR – Fully Reversible, PR - Partially Reversible, IR - Irreversible;
Frequency: L – Low, M – Medium, H – High.

Table 5.2-24: Likelihood of Occurrence of Potential Residual Effects: Marine Resources

VC	Residual Effect	Likelihood	Rationale
Construction			
Marine Water and sediment Quality	Change in Marine Water and sediment Quality - In-water Works	L	Mitigation measures are predicted to be effective.
	Change in Marine Water and sediment Quality – Propeller Scour	L	Area potentially affected is currently associated with historical log sort operations.
Marine Benthic Communities	Loss in Habitat	H	Benthic habitat will be directly lost from physical footprint of installed piles.
	Change in Habitat Quality - In-water Works	L	Mitigation measures are predicted to be effective. Proposed in-water works area supports low value benthic habitat.
	Change in Habitat Quality – Propeller Scour	L	Mitigation measures are predicted to be effective. Proposed in-water works area supports low value benthic habitat.
	Potential Mortality - In-water Works	H	Proposed in-water works area supports low value benthic habitat.
	Potential Mortality - Propeller Scour	M	Area potentially affected supports low value benthic habitat.
Marine Fish	Loss in Habitat	H	Benthic habitat will be directly lost from physical footprint of installed piles.
	Change in Habitat Quality- In-water Works	L	Mitigation measures are predicted to be effective. Proposed in-water works area supports low value fish habitat.
	Change in Habitat Quality - Propeller Scour	L	Area potentially affected supports low value fish habitat.
	Injury/Mortality from UW Noise (Pile Driving)	L	Area in which the potential effect will occur is localized. Mitigation measures and monitoring are predicted to be highly effective. Proposed in-water works area supports low value fish habitat.
Marine Mammals	Injury/Mortality from Vessel Strikes	L	Vessel size and speeds are predicted greatly reduce the likelihood for vessel strikes.
	Injury/Mortality from UW Noise (Pile Driving)	L	Local area in which the potential effect will occur. Mitigation measures and monitoring are predicted to be highly effective.
	Behavioral Disturbance from UW Noise (Pile Driving / Vessels)	M	Some marine mammals are likely to demonstrate behavioral responses to UW noise, including temporary avoidance or habituation.
Marine Birds	Behavioral Disturbance from In-Air Noise (Pile Driving / Vessels)	M	Some marine birds are likely to demonstrate behavioral responses to UW noise, including temporary avoidance or habituation.
Operations			
Marine Water and Sediment Quality	Change in Marine Water and sediment Quality - In-water Works	L	Mitigation measures are predicted to be effective.
	Change in Marine Water and sediment Quality – Propeller Scour	L	Area potentially affected is currently associated with historical log sort operations.

VC	Residual Effect	Likelihood	Rationale
Marine Benthic Communities	Change in Habitat Quality – Propeller Scour	L	Area potentially affected supports low value benthic habitat.
	Potential Mortality - Propeller Scour	L	Area potentially affected supports low value benthic habitat.
Marine Fish	Change in Habitat Quality – Propeller Scour	L	Area potentially affected supports low value fish habitat.
Marine Mammals	Injury/Mortality from Vessel Strikes	L	Vessel size and speeds are predicted greatly reduce the likelihood for vessel strikes.
	Behavioral Disturbance from UW Noise (Vessels / Barge Loading)	M	Some marine mammals are likely to demonstrate behavioral responses to UW noise, including temporary avoidance or habituation.
Marine Birds	Behavioral Disturbance from In-Air Noise (Vessels / Barge Loading	M	Some marine birds are likely to demonstrate behavioral responses to UW noise, including temporary avoidance or habituation.
Reclamation and Closure			
Marine Water and sediment Quality	Change in Marine Water and sediment Quality - In-water Works	L	Mitigation measures are predicted to be effective.
	Change in Marine Water and sediment Quality – Propeller Scour	L	Area potentially affected is currently associated with historical log sort operations.
Marine Benthic Communities	Change in Habitat Quality - In-water Works	L	Mitigation measures are predicted to be effective. Proposed in-water works area supports low value benthic habitat.
	Change in Habitat Quality – Propeller Scour	L	Area potentially affected is currently associated with historical log sort.
	Potential Mortality – Propeller Scour	L	Area potentially affected supports low value benthic habitat.
Marine Fish	Change in Habitat Quality- In-water Works	L	Mitigation measures are predicted to be effective. Proposed in-water works area supports low value fish habitat.
	Change in Habitat Quality – Propeller Scour	L	Area potentially affected supports low value fish habitat
Marine Mammals	Injury/Mortality from Vessel Strikes	L	Vessel size and speeds are predicted greatly reduce the likelihood for vessel strikes.
	Behavioral Disturbance from UW Noise (Vessels)	M	Some marine mammals are likely to demonstrate behavioral responses to UW noise, including temporary avoidance or habituation.
Marine Birds	Behavioral Disturbance from In-Air Noise (Vessels)	M	Some marine birds are likely to demonstrate behavioral responses to UW noise, including temporary avoidance or habituation.
Accidents and Malfunctions			
All Marine Resource VCs	Toxic and hazardous (hydrocarbon) spills	L	Fuel spills are unlikely to occur after mitigation applied.
Marine Benthic Communities	Aggregate spills	L	Aggregate spills are unlikely to occur after mitigation applied.
Marine Water and Sediment Quality	Aggregate spills	L	Aggregate spills are unlikely to occur after mitigation applied.

Assessment Criteria: Likelihood: L – Low, M – Medium, H – High

5.2.5.5 Significance of Residual Effects

The significance of potential residual adverse effects will be determined for each VC based on the residual effects criteria and the likelihood of a potential residual effect occurring, a review of background information and available field study results, consultation with government agencies, First Nations, and other experts, and professional judgement. A summary of significance determinations is presented in Table 5.2-25.

The determination of significance of residual adverse effects is rated as negligible-not-significant, not significant, or significant, which are generally defined as follows:

- Negligible-Not Significant: The basis for determining that effects are negligible will be provided in the Application for each VC. Negligible effects will not be carried forward to the cumulative effects assessment
- Not significant: Effects determined to be not significant are residual effects greater than negligible that do not meet the definition of significant. Residual effects that are not significant will be carried forward to the cumulative effects assessment.
- Significant: The basis for determining that a residual effect is significant will be provided in the Application for each VC. Significant residual effects will be carried forward to the cumulative effects assessment.

Detailed rationale for significance determinations is provided below.

5.2.5.5.1 Construction, Operations, Reclamation and Closure

5.2.5.5.1.1 Marine Water and Sediment Quality

5.2.5.5.1.1.1 Change in Water and sediment Quality

The effects of changes in marine water and sediment quality due to in-water works during construction and closure/reclamation are expected to be controlled with mitigation. Any residual effects would be restricted to areas associated with unfavourable marine environments with low value habitat due to wood waste accumulation from historical log dump operations. With the application of known and effective mitigation (i.e., application of DFO's guidelines, environmental monitoring by a qualified EM, and implementation of a CEMP), the significance of this residual effect is considered to be negligible – not significant (Table 5.2-25).

5.2.5.5.1.2 Marine Benthic Communities

5.2.5.5.1.2.1 Habitat Loss

A total of 2.5 m^2 of marine benthic habitat will be directly lost due to installation of 18 piles in the marine environment. The majority of this habitat loss corresponds with areas of low value habitat due to wood waste accumulation from historical log dump operations. The barge load-out jetty and walkway/conveyor system will result in minimal shading effects on underlying benthic vegetative habitat. The overall height and orientation of these structures will minimize shading with no anticipated loss of productive capacity. Following pile removal during closure/reclamation, marine benthic communities are predicted to recolonize the area of physical disturbance. The Project marine footprint does not overlap with any sensitive benthic resources (i.e., glass sponges, eelgrass, kelp beds, and northern abalone habitat). With the application of known and effective mitigation (i.e., pile installation during fisheries work windows), in combination with habitat offsetting, the significance of this residual effect is considered to be negligible – not significant (Table 5.2-25).

5.2.5.5.1.2.2 Change in Habitat

5.2.5.5.1.2.2.1 Removal, Upgrade and Installation of Marine Structures

Potential changes to benthic habitat quality as a result of in-water works during construction and closure/reclamation are expected to be controlled with mitigation. Any residual effects would be restricted to areas associated with low productive habitat value due to wood waste accumulation from historical log dump operations. The Project marine footprint does not overlap with any sensitive benthic resources (i.e., glass sponges, eelgrass, kelp beds, and northern abalone habitat). With the application of known and effective mitigation (i.e., in-water works during fisheries work windows, environmental monitoring by a qualified EM, and implementation of a CEMP), the significance of this residual effect is considered to be negligible – not significant (Table 5.2-25).

5.2.5.5.1.2.2.2 Propeller Scour

Any residual effects on benthic habitat quality from propeller scour would be restricted to subtidal benthic habitat in the vicinity of the barge offloading facility. This area is associated with low productive benthic habitat value due to wood waste accumulation from historical log dump operations. Given existing habitat conditions and the lack of sensitive benthic resources in this area (i.e., glass sponges, eelgrass, kelp beds, and northern abalone habitat), the significance of this effect is considered to be negligible – not significant.

5.2.5.5.1.2.3 Potential Mortality

5.2.5.5.1.2.3.1 Removal, Upgrade and Installation of Marine Structures

Potential mortality of benthic organisms due to in-water works during construction and closure/reclamation is expected to be controlled with mitigation. Any residual effects would be restricted to areas associated with low productive habitat value due to wood waste accumulation from historical log dump operations. The Project marine footprint does not overlap with any sensitive benthic resources (i.e., glass sponges, eelgrass, kelp beds, and northern abalone habitat). With the application of known and effective mitigation (i.e., in-water works during fisheries work windows, environmental monitoring by a qualified EM, and implementation of a CEMP), the significance of this effect is considered to be negligible – not significant (Table 5.2-25).

5.2.5.5.1.2.3.2 Propeller Scour

Potential mortality of benthic organisms due to propeller scour effects would be restricted to subtidal benthic habitat in the vicinity of the barge offloading facility. This area is associated with low productivity benthic habitat due to wood waste accumulation from historical log dump operations. Given existing habitat conditions and the lack of sensitive benthic resources in this area (i.e., glass sponges, eelgrass, kelp beds, and northern abalone habitat), the significance of this effect is considered to be negligible – not significant.

5.2.5.5.1.2.4 Significance of Net Residual Effect on Marine Benthic Communities

Collectively, the Project is not anticipated to result in serious harm to benthic resources that are part of a CRA fishery, or to benthic resources that support such a fishery. The net residual effects of the Proposed Project are not expected to exceed ecological thresholds or compromise the maintenance of self-sustaining CRA-associated benthic species populations in the marine environment, on either a local or a regional scale, and are therefore determined to be negligible – not significant.

5.2.5.5.1.3 Marine Fish

5.2.5.5.1.3.1 Habitat Loss

A total of 1.4 m^2 of marine fish habitat will be directly lost due to installation of 10 piles in the subtidal environment. The majority of this habitat loss corresponds with areas of low productivity habitat due to wood waste accumulation from historical log dump operations. Following pile removal during closure/reclamation, marine fish are predicted to recolonize the area of physical disturbance. The Project marine footprint does not overlap with any sensitive fish habitat areas (i.e., fish spawning grounds). With the application of known and effective mitigation (i.e., pile installation during fisheries work windows), in combination with habitat offsetting, the significance of this residual effect is considered to be negligible – not significant (Table 5.2-25).

5.2.5.5.1.3.2 Change in Habitat

5.2.5.5.1.3.2.1 Removal, Upgrade and Installation of Marine Structures

Potential changes to marine fish habitat quality as a result of in-water works during construction and closure/reclamation are expected to be controlled with mitigation. Any residual effects would be restricted to areas associated with low value fish habitat due to wood waste accumulation from historical log dump operations. The Project marine footprint does not overlap with any sensitive fish habitats (i.e., fish spawning grounds). With the application of known and effective mitigation (i.e., in-water works during fisheries work windows, environmental monitoring by a qualified EM, and implementation of a CEMP), the significance of this residual effect is considered to be negligible – not significant (Table 5.2-25).

5.2.5.5.1.3.2.2 Propeller Scour

Any residual effects on marine fish habitat quality from propeller scour would be restricted to subtidal benthic habitat in the vicinity of the barge offloading facility. This area is associated with low productive fish habitat due to wood waste accumulation from historical log dump operations. Given existing habitat conditions and the lack of sensitive fish resources in this area (i.e., fish spawning or rearing grounds), the significance of this residual effect is considered to be negligible – not significant.

5.2.5.5.1.3.3 Injury/Mortality from Underwater Noise

Impact pile driving has the potential to result in injury or mortality of marine fish occurring in the RSA. The zone of potential injury was modeled and quantified based on conservative acoustic injury criteria (NMFS thresholds). No overlap of this zone occurs with sensitive fish habitat areas (spawning habitats). With the application of known and effective mitigation measures and monitoring (i.e., bubble curtains around the wetted pile, pile driving during fisheries work windows, ramp-up procedures, sound verification monitoring), the significance of this residual effect is considered negligible – not significant (Table 5.2-25).

5.2.5.5.1.3.4 Significance of Net Residual Effect on Marine Fish

Collectively, the Project is not anticipated to result in serious harm to fish that are part of a CRA fishery, or to fish that support such a fishery. The net residual effects of the Proposed Project are not expected to exceed ecological thresholds or compromise the maintenance of self-sustaining CRA-associated fish populations in the marine environment on both the local or regional scale, and are therefore determined to be negligible – not significant (Table 5.2-25).

5.2.5.5.1.4 Marine Mammals

5.2.5.5.1.4.1 Injury/Mortality from Underwater Noise

Impact pile driving has the potential to result in injury or mortality of marine mammals occurring in the LSA. The zone of potential injury was modeled and quantified based on conservative acoustic injury criteria (NMFS thresholds). This zone does not overlap with sensitive marine mammal habitat areas (i.e., breeding grounds, critical habitat areas). Given the availability of accepted mitigation and monitoring measures and their known effectiveness (i.e., bubble curtains around the wetted pile, marine mammal monitoring of a defined safety zone, shut-down and ramp-up procedures, sound verification monitoring), the significance of this residual effect is considered to be negligible – not significant (Table 5.2-25).

5.2.5.5.1.4.2 Behavioral Disturbance from Underwater Noise

Project-related noise sources (i.e., pile driving, vessel operations and barge loading) may result in behavioral disturbance of marine mammals occurring in the RSA. The zone of behavioral disturbance was modeled and quantified based on conservative acoustic disturbance criteria (NMFS thresholds). No overlap of this zone occurs with sensitive marine mammal habitat areas (i.e., breeding grounds, critical habitat areas). Behavioral reactions to underwater noise emissions are considered likely, however any residual effect would be localized, temporary and fully reversible, with no effects at the population level anticipated. Based on the literature, marine mammals will either habituate to the noise and remain in the area, or leave temporarily and return once the noise has subsided. With the application of known and effective mitigation measures (i.e., bubble curtains around the wetted pile), the significance of this residual effect is considered to be not significant (Table 5.2-25).

5.2.5.5.1.4.3 Vessel Strikes

Project vessel movements have the potential to result in marine mammal strikes. The potential effect of a vessel strike on marine mammal populations is considered high in magnitude because potential receptors include federally and/or provincially listed species and the Proposed Project Area seasonally supports baleen whales (e.g., humpback and grey whales) which have a higher susceptibility to vessel-strikes compared to toothed whales and pinnipeds, although the effect is more likely to result in injury than death. Reduced vessel speeds and the use of small vessel sizes will greatly reduce the likelihood of ship strikes on marine mammals and provide time for these animals to avoid oncoming vessels, as well as time for crew on Proposed Project vessels to detect and avoid marine mammals. With the implementation of known and effective mitigation measures such as ships maintaining minimum distances from marine mammals, the significance of this residual effect is considered to be negligible – not significant (Table 5.2-25).

5.2.5.5.1.4.4 Significance of Net Residual Effect on Marine Mammals

The net residual effects of the Proposed Project are not expected to exceed ecological thresholds or compromise the maintenance of self-sustaining marine mammal populations in the marine environment on both the local or regional scale, and are therefore determined to be negligible – not significant.

5.2.5.5.1.5 Marine Birds

5.2.5.5.1.5.1 Behavioral Disturbance from In-Air Noise

Project-related noise sources (i.e., pile driving, vessel operations and barge loading) may result in behavioral disturbance of marine birds occurring in the LSA, although this would be limited to the immediate jetty area. Any residual effects would be temporary and fully reversible, with no effects at the population level anticipated. Based on the literature, marine birds will either habituate to the noise and remain in the area, or leave temporarily and return once the noise has subsided. Given the in-air noise disturbance will not exceed established bird disturbance acoustic thresholds in the McNab Creek Estuary where aggregations of marine birds are known to occur on a seasonal basis, the significance of this residual effect is considered to be negligible (Table 5.2-25).

The net residual effects of the Proposed Project are not expected to exceed ecological thresholds or compromise the maintenance of self-sustaining marine bird populations, on both a local or regional scale, and are therefore determined to be negligible – not significant.

5.2.5.5.2 Accidents and Malfunctions

5.2.5.5.2.1 Toxic and Hazardous Material Spills

The magnitude of a potential hydrocarbon spill was assessed as high for all Marine Resource VCs. However, adherence to the Proponent's SERP and compliance with the applicable safety regulations (*Navigation Protection Act* and *Canada Shipping Act*) will result in a low likelihood of occurrence. With the application of mitigation measures (i.e., SERP) and adherence to maritime safety regulations, the potential effect of a major hydrocarbon spill is considered to be not significant (Table 5.2-25).

5.2.5.5.2.2 Aggregate Spills

The magnitude of a potential aggregate spill was assessed as negligible for marine water and sediment quality and marine benthic communities, given the non-toxic nature of the spilled materials, the limited spatial extent of a potential spill, and the nature of the receiving environment (i.e., low value habitat) near the load-out jetty. Adherence to the Proponent's SERP and compliance with the applicable safety regulations (*Navigation Protection*

Act and *Canada Shipping Act*) will result in a low likelihood of occurrence. With the application of mitigation measures and adherence to maritime safety regulations, the potential effect of a major aggregate spill is considered to be negligible – not significant (Table 5.2-25).

Table 5.2-25: Significance of Potential Residual Effects: Marine Resources

VC	Residual Effect	Significance	Rationale
Construction, Operations and Closure / Reclamation			
Marine Water and Sediment Quality	Change in Water and sediment Quality (In-water Works and Propeller Scour)	Negligible-Not Significant	Any residual effects would be restricted to areas with low habitat value due to wood waste accumulation from historical log dump operations. Mitigation and monitoring during in-water works are expected to be effective.
Marine Benthic Communities	Loss of Habitat	Negligible-Not Significant	Footprint of marine infrastructure is minimal in size and situated in low value benthic habitat. Negligible shading effects due to design of structure. Proposed Project marine footprint does not overlap with sensitive benthic resources (i.e., glass sponges, eelgrass, kelp beds, and northern abalone habitat). Implementation of Fish Habitat Offset Plan to offset direct losses from pile installation.
	Change in Habitat Quality (In-water Works Propeller Scour)	Negligible-Not Significant	Footprint of marine infrastructure is minimal in size and situated in low productivity benthic habitat. Project marine footprint does not overlap with sensitive benthic resources (i.e., glass sponges, eelgrass, kelp beds, and northern abalone habitat). Mitigation and monitoring during in-water works are expected to be effective.
	Potential Mortality (In-water Works and Propeller Scour)	Negligible-Not Significant	Footprint of marine infrastructure is minimal in size and situated in low productivity benthic habitat. Project marine footprint does not overlap with sensitive benthic resources (i.e., glass sponges, eelgrass, kelp beds, and northern abalone habitat). Mitigation and monitoring during in-water works are expected to be effective.

VC	Residual Effect	Significance	Rationale
Marine Fish	Loss of Habitat	Negligible-Not Significant	Footprint of marine infrastructure is minimal in size and situated in low productivity fish habitat. Negligible shading effects due to design of structure. Project marine footprint does not overlap with sensitive fish habitat areas (i.e., spawning habitats). Implementation of Fish Habitat Offset Plan to offset direct habitat losses from pile installation.
	Change in Habitat Quality (In-water Works and Propeller Scour)	Negligible-Not Significant	Footprint of marine infrastructure is minimal in size and situated in low productivity fish habitat. Marine terminal footprint does not overlap with sensitive fish habitat areas (i.e., spawning habitats). Mitigation and monitoring during in-water works are expected to be effective.
	Injury/Mortality from UW Noise (Pile Driving)	Negligible-Not Significant	Application of known and effective mitigation and monitoring measures (i.e., bubble curtains, ramp up procedures, sound verification monitoring) will mitigate this effect. Marine terminal footprint does not overlap with sensitive fish habitat areas (i.e., spawning habitats).
	Behavioral Disturbance from UW Noise (Pile Driving / Vessels)	Negligible-Not Significant	Application of known and effective mitigation and monitoring measures (i.e., bubble curtains) will help to mitigate this effect. Marine terminal footprint does not overlap with sensitive fish habitat areas (i.e., spawning habitats). Behavioral responses to underwater noise emissions are possible but any residual effect would be localized and fully reversible - individuals are likely to temporarily avoid the affected area but return following completion of the activity.
Marine Mammals	Injury/Mortality from UW Noise (Pile Driving)	Negligible-Not Significant	Application of known and effective mitigation and monitoring measures (i.e., bubble curtains, marine mammal monitoring in defined safety zones, shut-down and ramp-up procedures, sound verification monitoring) will mitigate this effect. No sensitive marine mammal breeding, foraging or critical habitat areas in LSA or RSA.
	Behavioral Disturbance from UW Noise (Pile Driving / Vessels / Barge Loading)	Not significant	Application of known and effective mitigation and monitoring measures (i.e., bubble curtains) will help to mitigate this effect. No sensitive marine mammal breeding, foraging or critical habitat areas in the LSA or RSA. Behavioral responses to underwater noise emissions are possible but any residual effect would be localized and fully reversible - individuals are likely to temporarily avoid the affected area but return following completion of the activity.

VC	Residual Effect	Significance	Rationale
	Injury/Mortality from Vessel Strikes	Negligible-Not Significant	Application of known and effective mitigation measures (i.e., speed restrictions, avoidance of marine mammals) will mitigate this effect. No sensitive marine mammal breeding, foraging or critical habitat areas in LSA or RSA.
Marine Birds	Behavioral Disturbance from In-Air Noise (Pile Driving / Vessels / Barge Loading)	Negligible-Not Significant	Behavioral responses to in-air noise emissions are possible but any residual effect would be localized and fully reversible – individuals are likely to temporarily avoid the affected area but return following completion of the activity. Noise disturbance effects unlikely to extend to McNab Creek where seasonal aggregations of marine birds are known to occur.
Accidents and Malfunctions			
All Marine Resource VCs	Toxic and hazardous material spills	Not Significant	The implementation of mitigation including the SERP reduces the likelihood of this effect as well as the magnitude in the unlikely event of an accidental spill.
Marine Benthic Communities	Aggregate spills	Negligible-Not Significant	Plume footprint of potential aggregate spill would be minimal in size and would mostly impact low productivity benthic habitat around the marine terminal during loading activities. Project marine footprint does not overlap with sensitive benthic of fisheries resources (i.e., glass sponges, eelgrass, kelp beds, and northern abalone habitat).
Marine Water and Sediment Quality	Aggregate spills	Negligible-Not Significant	Plume footprint of potential aggregate spill would be minimal in size and would mostly impact low productivity benthic habitat. Project marine footprint does not overlap with sensitive benthic of fisheries resources (i.e., glass sponges, eelgrass, kelp beds, and northern abalone habitat).

5.2.5.6 Level of Confidence

The level of confidence of predicted residual effects is provided in Table 5.2-26. The prediction confidence of the assessment on each VC is based on scientific information and statistical analysis, professional judgement and effectiveness of mitigation (rated as high, moderate, and low).

Table 5.2-26: Level of Confidence in Potential Residual Effect Predictions: Marine Resources

Residual Effect	Level of Confidence (LOC) in Residual Effect Prediction	LOC Rationale
Construction, Operations and Closure / Reclamation		
Change in Water and Sediment Quality - In-water Works	High	Predicted effectiveness of proposed mitigation. Environmental monitoring during in-water works by qualified EM. Adherence to the Environmental Management Program during construction and decommissioning.
Change in Water and Sediment Quality – Propeller Scour	High	Baseline surveys indicate that the area potentially affected will occur in pre-disturbed areas associated with historical log sort operations. Conservative estimates incorporated in the propeller wash model.
Loss of Habitat (Marine Benthic Communities and Marine Fish)	High	Assessment of habitat losses are based on detailed field studies (Volume 4, Part G - Section 22.0: Appendix 5.2-A). Predicted effectiveness of proposed mitigation. A Fish Habitat Offset Plan will be developed and implemented to offset unavoidable permanent alteration to or destruction of fish habitat from Project activities and works. In-water works restricted to periods of least risk to fisheries.
Change in Habitat Quality (Marine Benthic Communities and Marine Fish) - In-water Works	High	Predicted effectiveness of proposed mitigation. Environmental monitoring during in-water works by qualified EM. Adherence to the Environmental Management Program during construction and decommissioning. In-water works restricted to periods of least risk to fisheries.
Change in Habitat Quality (Marine Benthic Communities and Marine Fish) – Propeller Scour	High	Baseline surveys indicate that the area potentially affected (around the terminal) is presently associated with extensive woody/bark debris cover and unfavorable habitat conditions. Conservative estimates incorporated in the propeller wash model.
Potential Mortality (Marine Benthic Communities) - In-water Works	High	Predicted effectiveness of proposed mitigation. Environmental monitoring during in-water works by qualified EM. Adherence to the Environmental Management Program during construction and decommissioning. In-water works restricted to periods of least risk to fisheries.
Potential Mortality (Marine Benthic Communities) – Propeller Scour	High	Baseline surveys indicate that the area potentially affected (around the terminal) is presently associated with extensive woody/bark debris cover and unfavorable habitat conditions. Conservative estimates incorporated in the propeller wash model.

Residual Effect	Level of Confidence (LOC) in Residual Effect Prediction	LOC Rationale
Injury/Mortality from Underwater Noise (Marine Fish and Marine Mammals)	High	Injury zones modeled were based on conservative acoustic injury criteria (NMFS thresholds). Implementation of known and effective mitigation measures. Active marine mammal and underwater noise monitoring during pile installation. Pile driving restricted to periods of least risk to fisheries.
Behavioural Disturbance from Underwater Noise (Marine Fish and Marine Mammals)	Moderate	Disturbance zones modeled are based on conservative acoustic disturbance criteria (NMFS thresholds). Lack of species-specific information regarding the long-term effects of increased vessel traffic on behaviour.
Injury/Mortality from Vessel Strikes (Marine Mammals)	High	Based on literature, vessel-marine mammal collisions unlikely given size of vessels and restricted travelling speeds in LSA. Implementation of known and effective mitigation measures.
Behavioral Disturbance from In-Air Noise (Marine Birds)	High	Based on computer model predictions (refer to Volume 2, Part B - Section 9.2 Noise).
Accidents and Malfunctions		
Toxic and hazardous material spills (All Marine VCs)	Moderate	Adherence to SERP. Scientific information regarding species-specific responses to hydrocarbon spills are lacking.
Aggregate Spills (Marine Water and Sediment Quality and Marine Benthic Communities)	High	Adherence to SERP.

5.2.5.7 Cumulative Effects Assessment

Cumulative effects result from interactions between Proposed Project-related residual effects and incremental effects of past, present and reasonably foreseeable projects and activities. Potential effects from past and present projects were assessed as part of the baseline conditions. Cumulative effects assessment methodology is described in Volume 2, Part B - Section 4.5.

5.2.5.7.1 Cumulative Effects Assessment Boundaries

This section describes the assessment of potential cumulative effects associated with the Marine Resources VC. Cumulative effects result from interactions between Project-related adverse residual effects and incremental effects of all other past, present and reasonably foreseeable projects and activities. The effects of the Project in combination with the effects of other Projects and activities that have been carried out (past and present projects) are considered through the documentation of the existing conditions as reported in Section 5.2.4. The combination of the residual Proposed Project effects with the effects of all other past, present and reasonably foreseeable projects and activities that will be carried out comprise the total future cumulative effects.

Cumulative effects assessment follows the same method for assessing residual adverse effects following the identification of interactions described in Section 5.2.5.1. Essentially, the only difference in the outcome of assessment criteria between cumulative and incremental effects from the Project is in the magnitude and geographic extent of adverse residual effects. Determining the magnitude of potential cumulative effects involves comparing changes from existing conditions to conditions with the future case, in terms of incremental adverse effects relative to baseline values (i.e., existing conditions). Cumulative effects from the Project in combination with all other past, present and reasonably foreseeable projects and activities can influence a population throughout its entire annual range (including migratory movements, where applicable). In contrast, the geographic extent of incremental adverse residual effects from the Project alone may have a local or regional influence on a specific population.

5.2.5.7.2 Residual Effects Included in Cumulative Effects Assessment

Project-related residual effects considered in the cumulative effects assessment for Marine Resources are provided in Table 5.2-27**.** Rationale has been provided if residual effects were excluded from the cumulative effects assessment. Negligible residual effects were not carried through to the cumulative effects assessment as they were considered unmeasurable or within the range of natural variability and therefore unlikely to interact cumulatively with other past, present and reasonably foreseeable projects in the region.

Table 5.2-27: Residual Effects Included in Cumulative Effects Assessment for Marine Resources

Residual Effect	Included in Cumulative Effects Assessment	Rationale
Behavioral disturbance of marine mammals from Project-generated underwater noise (i.e., pile driving / vessel operations / barge loading)	Yes	Yes – potential for the Project effect to interact cumulatively with other past, present and past, present and reasonably foreseeable projects and activities and potentially result in cumulative effects to marine mammal populations.

5.2.5.7.3 Spatial and Temporal Boundaries

As described in Section 5.2.3.2.1, the spatial boundary of the cumulative effects assessment for Marine Resources is defined as the RSA (e.g., Howe Sound), as shown in Figure 5.2-1.

Projects that overlap with the cumulative effects assessment boundary are shown in Volume 2, Part B – Section 4.0, Figure 4-5.

5.2.5.7.4 Effects of Other Projects and Activities

A list of past, present and past, present and reasonably foreseeable projects and activities with potential effects that could interact temporally and/or spatially with Proposed Project-related residual effect are provided in Volume 2, Part B - Section 4.0. Those Projects identified as having the potential to result in cumulative adverse effects on marine mammals related to underwater noise behavioral disturbance are outlined in Table 5.2-28. Several existing and proposed Projects were not considered in the cumulative assessment of underwater noise disturbance effects on marine mammals for the following reasons:

- No marine shipping component identified;
- No marine terminal construction component identified;

- Marine construction component identified in development plans; although insufficient project information currently available to assess potential effects;
- Some in-water works identified (waterfront and pier)' although insufficient project information currently available to assess potential effects;
- The project is considered part of the baseline environmental conditions for the VCs assessed; and
- With respect to potential forestry and mineral activities in Howe Sound, there is insufficient information currently available to undertake a cumulative effects assessment on marine resources in the region. This includes a lack of detailed information on the location of future log handling/sorting/shipping activities in forest tenures, exploration activities in mineral tenures, frequency of these activities, vessel types involved, and proposed vessel routes to support these activities.

Table 5.2-28: Potential Incremental Effects of Other Project and Activities on Marine Resources

Project	Timeline	Phase of the project overlaps with the Proposed Project[14]	Project Description	Rationale
Reasonably Foreseeable Future Projects				
Woodfibre LNG	Construction to start in 2015 Operations in the second quarter of 2017 Assumes permit issuance in 2015/early 2016	Operations	An LNG marine export facility has been proposed at the former Western Forest Products Woodfibre Mill site in Howe Sound. A single LNG carrier (tug-assisted) will travel to the Woodfibre LNG terminal along existing shipping lanes at a frequency of three to four times per month. The LNG carrier will travel at 8 to 10 knots in Howe Sound and will be accompanied by a minimum of three tugs, at least one of which will be tethered to the carrier. Two BC Coast Pilots will travel on board the carrier during transits in Howe Sound. http://a100.gov.bc.ca/appsdata/epic/html/deploy/epic_project_home_408.html	Potential for cumulative increases in vessel traffic in the RSA. Cumulative ship noise in Howe Sound has the potential to result in increased behavioral disturbance of marine mammals in this region. . Effect carried forward in cumulative effects assessment.

5.2.5.7.5 Potential Interactions with Other Projects

Interactions between adverse effects from certain or reasonably foreseeable project activities and Proposed Project residual adverse effects that could result in cumulative adverse effects to marine resources are summarized in Table 5.2-29.

[14] When timelines are uncertain it was assumed that the Proposed Project would overlap with both construction and operations.

Table 5.2-29: Other Projects or Activities and Potential Adverse Cumulative Interactions and Effects for Marine Resources

Other Project/Activity	Potential Incremental Effect	Potential for Interaction Resulting in Cumulative Effect	Rationale for Potential Cumulative Effect
Behavioral Disturbance of Marine Mammals from Project-generated UW Noise			
Woodfibre LNG Project	Changes in behaviour of marine mammal populations in the RSA as a result of vessel and pile driving noise.	Y	The proposed Woodfibre vessel routes overlap with the Project RSA. Underwater noise generated by pile driving and shipping components of the Woodfibre LNG Project has the potential to interact in a cumulative fashion with underwater noise effects of the Project with respect to potential changes in behaviour of marine mammals. Marine mammals in Howe Sound have the potential to be affected by cumulative noise disturbance effects from both Projects.

No interaction or not likely to interact cumulatively (N), Yes, Potential cumulative effect (Y),

5.2.5.7.6 Cumulative Effects Related to Behavioral Disturbance to Marine Mammals from UW Noise

Underwater noise generated by the Woodfibre LNG Project activities (i.e., pile driving, tug assisted LNG carrier movements, barges and crew transport vessel movements) has the potential to interact in a cumulative fashion with underwater noise generated by the Project (i.e., vessels, pile driving and barge loading) with respect to marine mammal behavioural disturbance effects. The maximum potential injury and disturbance zone radii associated with Project noise sources from both projects are presented in Figure 5.2-7 and Figure 5.2-8, for pinnipeds and cetaceans respectively.

For Project activities originating at the terminals (pile driving, berthing activities, vessel operations at terminal), no aggregate acoustic effects are predicted (i.e., no overlap of injury and disturbance noise fields between the Projects) due to the distance between the two terminals.

With respect to shipping activities in Howe Sound, the Woodfibre LNG Project will include 40 LNG carrier visits per year during operations and the BURNCO Project will include 190 barge transits per year during operations. Underwater noise generated during each LNG carrier movement will result in a maximum potential disturbance zone radius of 4.6 km around the vessel (Woodfibre LNG 2015). Underwater noise generated during each barge transit will result in a maximum potential disturbance zone radius of 2.2 km around the barge (Figure 5.2-7 and Figure 5.2-8). Given the combined shipping volume anticipated for both projects, no concurrent vessel movements are expected and therefore no aggregate acoustic effects are predicted to occur (i.e., no direct overlap of disturbance noise fields) between the Projects.

Potential behavioural effects on marine mammals from Project noise sources are anticipated to be similar for both projects. Based on available literature, marine mammals are likely to tolerate/habituate to the short-term increased levels of underwater noise and remain in the area, or leave temporarily and return once the noise subsides.

The number of marine mammal individuals potentially affected by underwater noise in the RSA is likely to increase as a result of the cumulative increases in activities generating underwater noise as a result of both projects.

5.2.5.7.7 Mitigation

Mitigation measures that will assist in minimizing interactions between Proposed Project effects and those from other reasonably foreseeable project activities are described in Table 5.2-30. Shipping activities associated with the Woodfibre LNG Project will be subject to the same regulatory requirements (e.g., *Canada Shipping Act)* and oversight by CCG Marine Communications and Traffic Services. In addition, mitigation measures described in Section 5.2.5.3 to reduce or otherwise mitigate the potential adverse effect of underwater noise on marine mammals are also considered relevant to the mitigation of cumulative effects.

Long-term, comprehensive monitoring studies documenting the resilience of marine mammals to development, the effectiveness of mitigation and the time required to reverse these impacts are lacking, particularly with respect to potential long-term impacts of behavioural changes due to elevations in underwater noise. Uncertainty remains regarding the degree to which behavioral effects may occur in marine mammals and in the effectiveness of some of the proposed mitigative measures. As a result, the anticipated effectiveness of mitigation measures with respect to behavioural disturbance from cumulative underwater noise is considered medium.

Table 5.2-30: Identified Mitigation Measures: Cumulative Effects - Marine Resources

Potential Effect	Mitigation	Anticipated Effectiveness (low, med, high)
Behavioral Disturbance of Marine Mammals from Project-generated UW Noise	▪ Most acoustically sensitive marine mammals will avoid the immediate impact area once impact pile driving is underway. Operators are encouraged to take advantage of this behaviour by adopting a ramp-up / soft-start procedure where this is technically feasible. A ramp-up procedure consists of initial activation of the equipment using the lowest energy source / pulse and gradually increasing the intensity of the sound until it reaches the required intensity, thus allowing time and incentive for acoustically sensitive marine mammals to leave the area prior to operating the impact driver at full power. ▪ Concurrent multiple underwater noise generating activities will be minimized when practicable (e.g., avoiding multiple pile driving activities at the same time). Where multiple underwater noise generating activities are planned, they will be sequenced where possible to minimize construction duration. ▪ All Project vessels will follow established shipping lanes/ navigational routes typically used in the area.	Medium – Uncertainty remains regarding the degree to which some effects may occur and in the effectiveness of some marine mammal mitigative techniques due to a lack of long-term, comprehensive monitoring studies.

5.2.5.7.8 Residual Cumulative Effects and their Significance

Potential residual cumulative effects and their significance were characterized using the same methodology used to characterize residual effects and is summarized in Table 5.2-31.

The magnitude of the residual adverse effect of marine mammal behavioural disturbance from cumulative underwater noise exposure is considered to be the same as the incremental effect (medium), as activities are expected to exceed established behavioural criteria for marine mammals within a localized area on a temporary basis. In addition, there are no designated critical habitat areas for marine mammals in the RSA, therefore, marine mammals will not be deterred or displaced from critical foraging or breeding areas as a result of cumulative underwater noise effects in the RSA. The geographic extent is considered regional, as potential behavioural effects associated with the Woodfibre project will extend into the Project RSA. The duration is considered to be long-term for vessel and barge loading noise (all phases of the Project) and short-term for pile driving (construction phase only). The frequency is considered medium for vessel and barge loading noise, as underwater noise from these activities will exceed behavioural thresholds on an intermittent basis (based on estimated vessel call volumes) throughout the Proposed Project, and low for pile driving noise as the behavioural threshold will only be exceeded periodically during the construction phase (e.g., pile-driving will not occur continuously during this period). The potential cumulative effect is considered fully reversible as marine mammals will either habituate to underwater sounds and remain in the area, or leave temporarily and return once the noise has subsided. The context of the effect is considered resilient for all marine mammal species, as animals in the RSA are already exposed on a regular basis to underwater shipping noise given the current volume of vessel traffic occurring in the region in addition to other naturally occurring noise sources (e.g., surface agitation from wind and wave action, see Section 5.2.5.2.3.1.3).

The likelihood of behavioural disturbance effects to occur as a result of cumulative underwater noise produced by the Woodfibre and BURNCO Projects is considered moderate (medium). No effects at the population level are likely; therefore, the cumulative adverse effect is considered not significant. The level of confidence that the effect will not be greater than predicted is considered moderate. This is due to the conclusive information regarding long-term behavioral effects of underwater noise on marine mammals as a result of increased exposure to industrial noise.

Table 5.2-31: Summary of Residual Cumulative Effects Characterization for Marine Resources

Proposed Project-Related Effect	Residual Cumulative Effect Assessment Criteria								
	Context	Magnitude	Extent	Duration	Reversibility	Frequency	Significance	Likelihood (low, med, high)	Level of Confidence
Construction									
Behavioral Disturbance to Marine Mammals from UW Noise (Pile Driving / Vessels)	R	M	R	LT	FR	M to H	NS	M	M
Operations									
Behavioral Disturbance to Marine Mammals from UW Noise (Vessels / Barge Loading)	R	M	R	LT	FR	H	NS	M	M
Reclamation and Closure									
Behavioral Disturbance to Marine Mammals from UW Noise (Vessels)	R	M	R	LT	FR	H	NS	M	M

Assessment Criteria:
Context: R – Resilient, MR - Moderately Resilient, S - Sensitive;
Magnitude: N – Negligible, L – Low, M – Medium, H – High;
Geographic Extent: L – Local, R – Regional, BR – Beyond Regional;
Duration: ST – Short-tern, MT – Medium-term, LT – Long-term;
Reversibility: FR – Fully Reversible, PR - Partially Reversible, IR – Irreversible;
Frequency: L – Low, M – Medium, H – High
Significance: N – Negligible, NS – Not Significant, S – Significant
Level of Confidence: L – Low, M – Moderate, H – High

5.2.6 Conclusions

The proposed Project is expected to interact with the following Marine Resource VCs:

- Marine Water and Sediment Quality (Pathway VC)[15]
- Marine Benthic Communities
- Marine Fish
- Marine Mammals
- Marine Birds

Potential Project-related residual effects include:

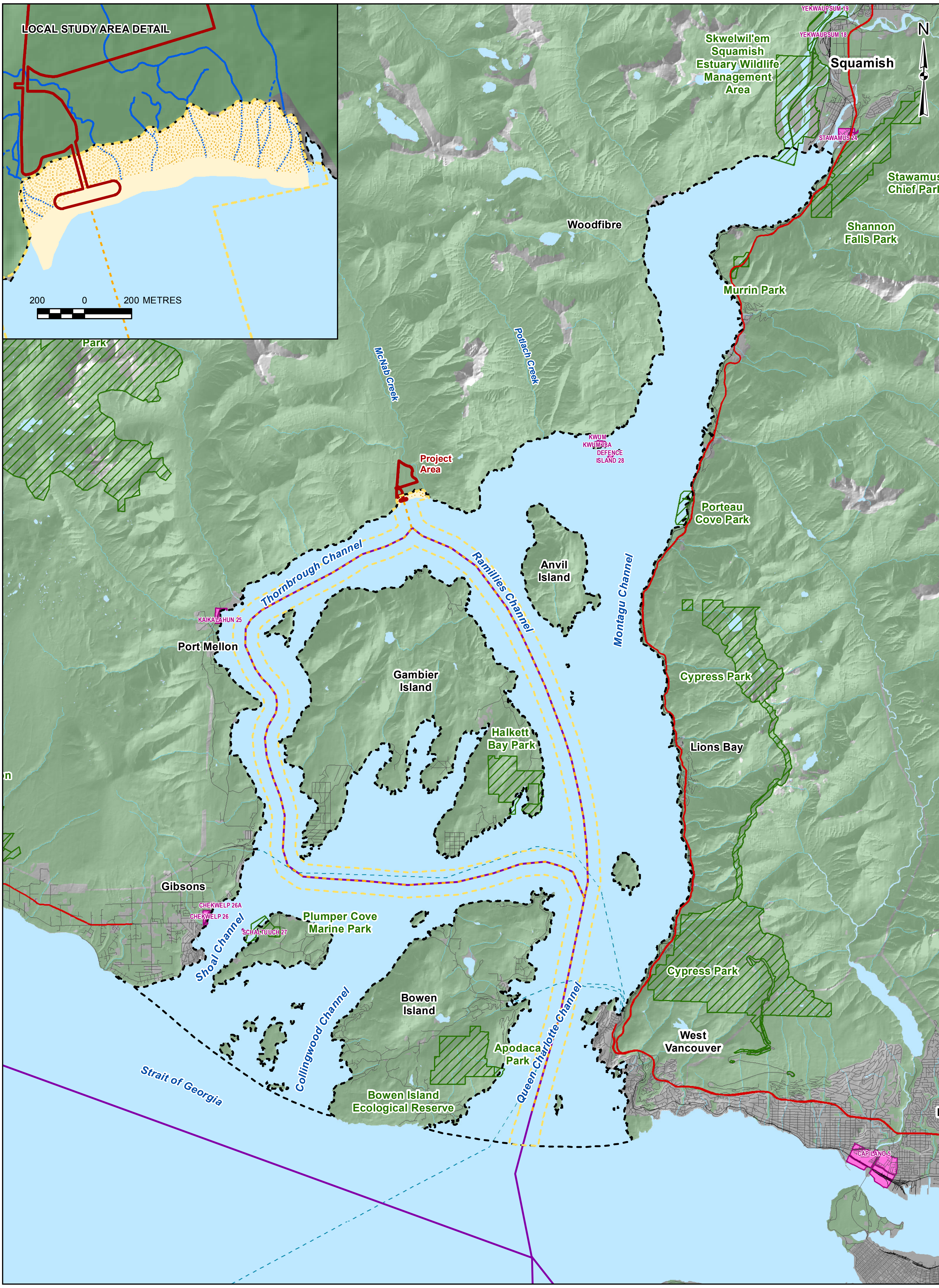
- Direct loss of marine benthic/fish habitat due to installation of 18 support piles and shading effects from marine infrastructure;
- Changes in benthic and fish habitat quality associated with reduced water quality as a result of:
  - Sediment disturbance and re-suspension due to placement and removal of marine structures (construction and reclamation/closure phases);
  - Release of creosote during removal of old piles (construction and reclamation/closure phases);
  - Release of cementitious material during concrete works (construction phase);
  - Sediment disturbance and re-suspension due to propeller scour (all phases); and
  - Release of deleterious substances due to accidental spills of hazardous / toxic materials (all phases).
- Potential mortality of benthic organisms as a result of:
  - Direct physical disturbance from pile installation (construction);
  - Direct physical disturbance from propeller scour (all phases);
  - Smothering and toxic effects from sediment re-suspension due to in-water works (construction and reclamation/closure phases) and propeller scour (all phases);
  - Release of creosote during removal of old piles (construction and reclamation/closure phases);
  - Release of cementitious material during concrete works (construction phase); and
  - Release of deleterious substances due to accidental spills of hazardous / toxic materials (all phases).

[15] Pathway components are identified when the component does not represent an assessment endpoint but a pathway through which other VCs may be affected.

- Potential injury or mortality of fish and marine mammals from underwater pile driving noise (construction phase);
- Potential behavioural disturbance to marine mammals due to underwater noise from pile driving noise (construction), Project vessels (all phases) and barge loading activities (operations);
- Potential injury or mortality of marine mammals from vessel strikes (all phases);
- Potential behavioral disturbance to marine birds due to in-air noise from pile driving (construction), Proposed Project vessels (all phases) and barge loading (operations);
- Potential effects of accidental spills of toxic materials (e.g., fuel spills) on all marine VCs (all phases); and
- Potential effects of accidental spills of non-toxic aggregate spills on marine benthic communities (operations).

The majority of the Proposed Project-related residual effects can be mitigated through planning and implementation of known and effective mitigation measures, including comprehensive Operational and Construction Environmental Management Plans, Spill Prevention and Emergency Response Plan, Erosion and Sediment Control Plan and a Fish Habitat Offset Plan.

Net residual effects for the VCs identified above (with the exception of Marine Water and Sediment Quality) are predicted to be negligible – not significant or not significant given the magnitude, ecological context and likelihood of occurrence.



LEGEND

- Project Area
- Local Study Area
- Regional Study Area
- Park / Protected Area
- Indian Reserve
- McNab Creek Estuary
- Intertidal Zone
- Proposed Barging Route
- Existing Barging Route
- Permanent / Perennial Watercourse
- Intermittent Watercourse
- Intertidal Watercourse

5,000 0 5,000

SCALE 1:150,000 METRES

REFERENCE

Elevation and indian reserves from Geobase. Watercourses from the Province of British Columbia and field data. Parks/protected areas and base data from the Province of British Columbia. All rights reserved. McNab Creek Estuary digitized from Province of BC, 1999. Projection: UTM Zone 10 Datum: NAD 83

PROJECT

BURNCO ROCK PRODUCTS LTD.
BURNCO AGGREGATE PROJECT, HOWE SOUND, B.C.

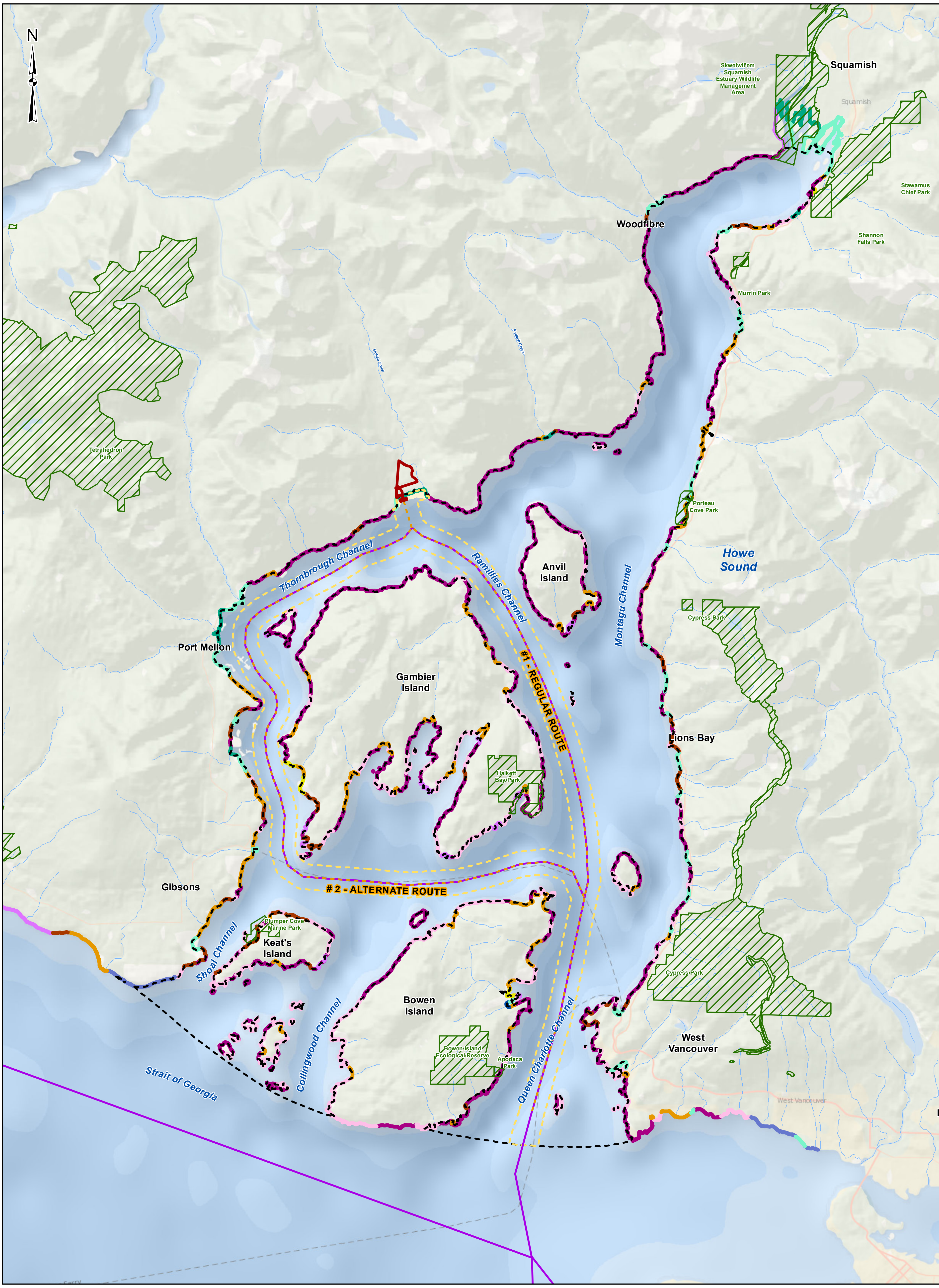
TITLE

MARINE RESOURCES
LOCAL AND REGIONAL STUDY AREAS

Golder Associates

PROJECT NO. 11-1422-0046			PHASE No.	
DESIGN	MD	14 May 2014	SCALE AS SHOWN	REV. 1
GIS	DL	17 May 2016		
CHECK	KZ	04 Mar 2016	FIGURE 5.2-1	
REVIEW	PO	04 Mar 2016		

Path: X:\Project Data\BC\McNab\Figures\MXD\Marine Figures\Marine_EA\Final\BURNCO_MARINE_Figure_5_2-1_Marine_Resources_Local_Regional_Study_Areas.mxd



LEGEND

- Project Area
- Local Study Area
- Regional Study Area
- Park / Protected Area
- McNab Creek Estuary
- Proposed Barging Route
- Existing Barging Route

Physical Coastal Classes

- Estuary (Organics/Fines)
- Sand Beach
- Sand and Gravel Beach
- Gravel Beach
- Gravel Flat
- Mud Flat
- Rock Ramp
- Rock Platform
- Rock Cliff
- Man Made

5,000 0 5,000

SCALE 1:150,000 METRES

REFERENCE

Base data from the province of British Columbia. All rights reserved. Coastal class data based on Province of British Columbia Shorezone Mapping System, obtained from BCMCA and email communication, Living Oceans Society, Feb 21, 2014, kbodtker@livingoceans.org. Ocean base map obtained from ESRI and its data suppliers, Redmond, WA, 2009. McNab Creek Estuary digitized from Province of BC, 1999. Projection: UTM Zone 10 Datum: NAD 83

PROJECT

BURNCO ROCK PRODUCTS LTD.
BURNCO AGGREGATE PROJECT, HOWE SOUND, B.C.

TITLE

PROJECT VESSEL ROUTES AND SHORELINE CLASSES

Golder Associates

PROJECT NO. 11-1422-0046			PHASE No.	
DESIGN	AK	23 Oct. 2014	SCALE AS SHOWN	REV. 1
GIS	DL	17 May 2016	FIGURE 5.2-2	
CHECK	KZ	04 Mar 2016		
REVIEW	PO	04 Mar 2016		

Path: X:\Project Data\BC\McNab\Figures\MXD\Marine Figures\Marine_EA\Final\BURNCO_MARINE_Figure_5_2-2_Project_Vessel_Routes_and_Shoreline_Classes.mxd

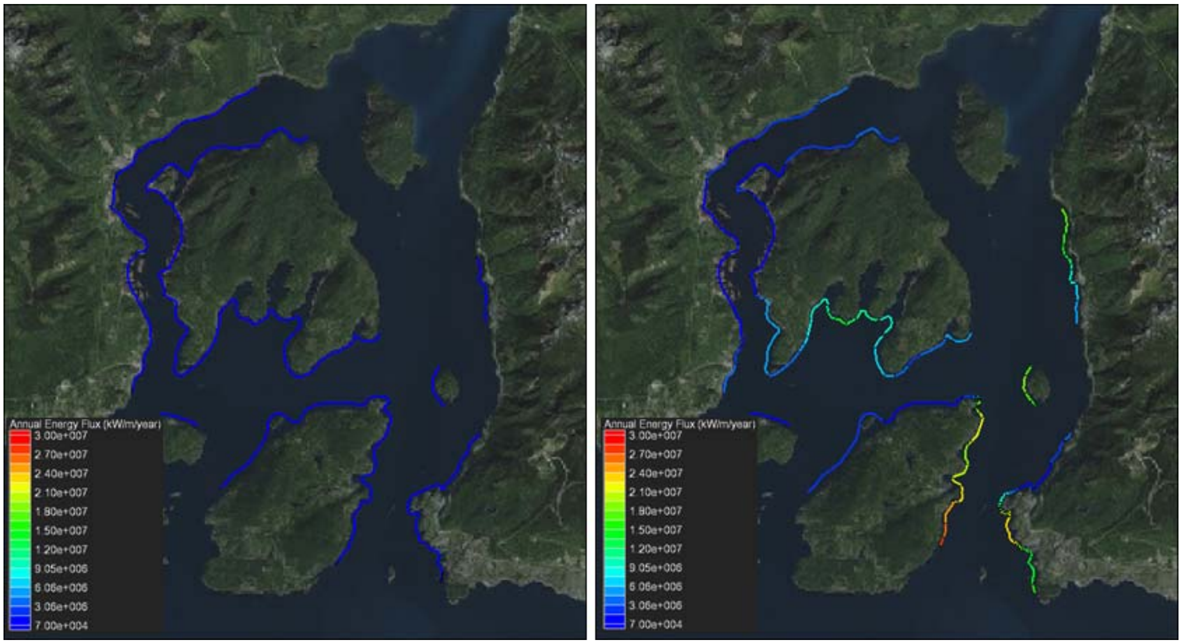


Figure 5.2-3: Annual Energy Flux for Water Taxi (left) and Wind-waves (right) along Route 1

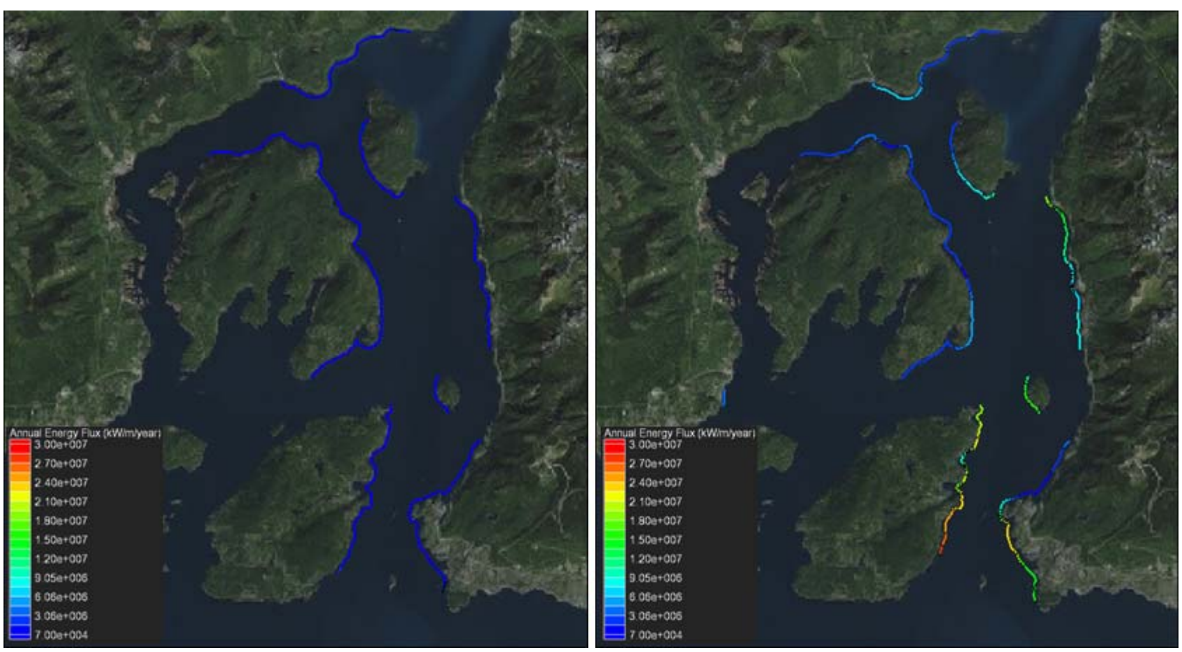


Figure 5.2-4: Annual Energy Flux for Water Taxi (left) and Wind-waves (right) along Route 2

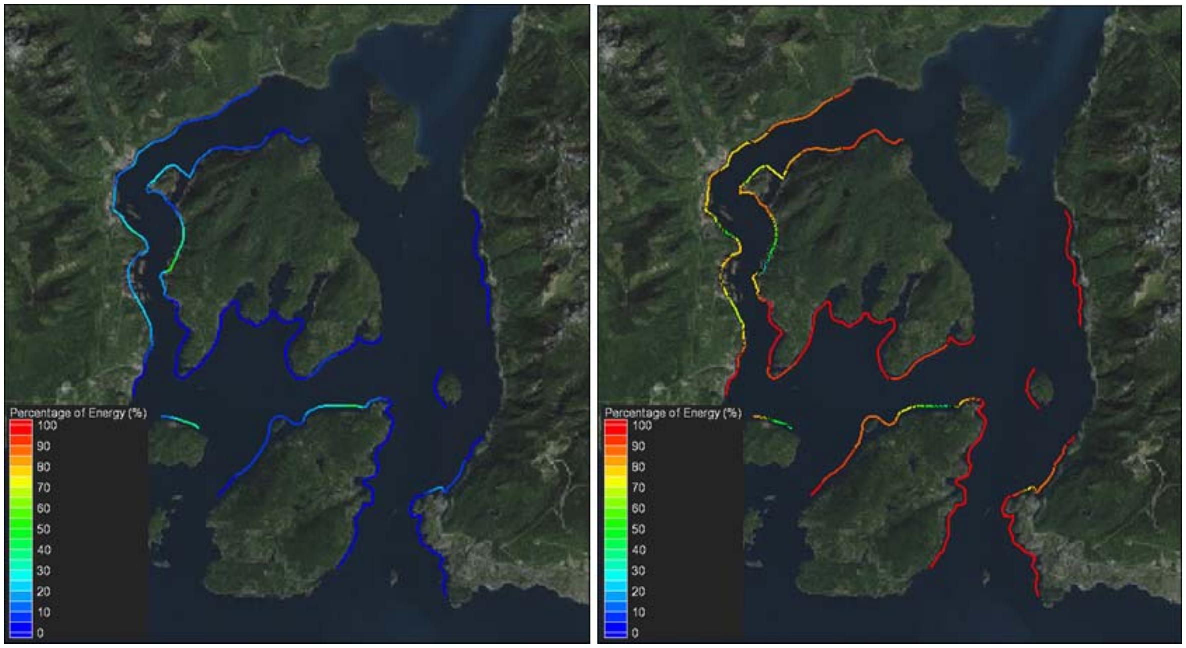


Figure 5.2-5: Contribution of Annual Energy Flux Percentage for Water Taxi Wake (left) and Wind-waves (right) along Route 1

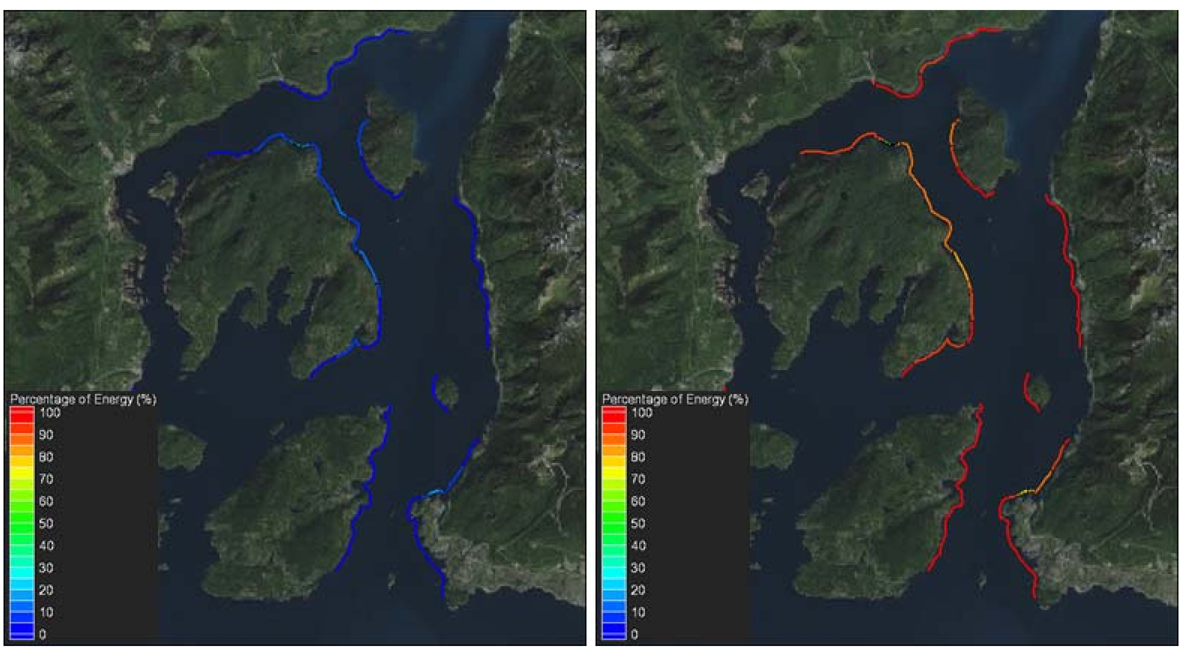
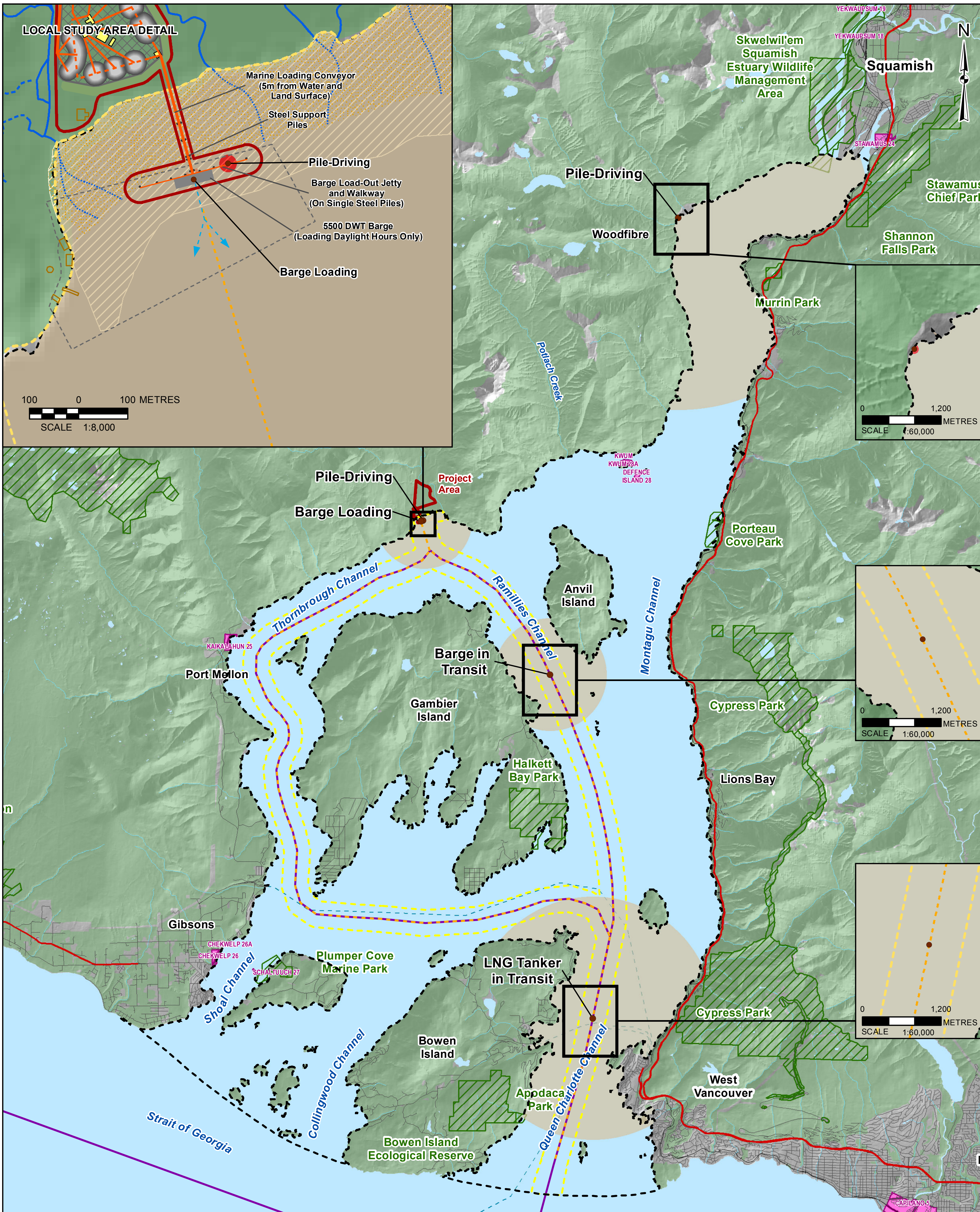


Figure 5.2-6: Contribution of Annual Energy Flux Percentage for Water Taxi Wake (left) and Wind-waves (right) along Route 2



Injury thresholds for both pulsive and non -pulsive noise sources:

- 190 dB re 1μPa (SPL_{rms}) for pinnipeds (seals and sea lions)

Disturbance (behavioural response for all marine mammals) threshold :

- 160 dB re 1μPa (SPL_{rms}) for pulsive noise (e.g., impact pile-driving)
- 120 dB re 1 μPa (SPL_{rms}) for non-pulsive noise (e.g., shipping, barge loading)

LEGEND

- Underwater Noise Feature
- Distance to Injury Threshold for Pinnipeds
- Distance to Disturbance Threshold for Pinnipeds
- Project Area
- Local Study Area
- Regional Study Area
- Park / Protected Area
- Indian Reserve
- McNab Creek Estuary
- Intertidal Zone
- Barge
- Dock
- Processing Area
- Existing Feature
- Existing Log Tenure Area
- Processing Area Berm
- Product Stockpiles
- Possible Processing Plant Configuration
- Elevated Conveyor
- Underground Conveyor
- Barge Load-out
- Proposed Barging Route
- Existing Barging Route
- Permanent / Perennial Watercourse
- Intermittent Watercourse
- Intertidal Watercourse
- Transmission Line
- Barge Route
- Pile

5,000 0 5,000

SCALE 1:150,000 METRES

REFERENCE

Injury and disturbance thresholds from NOAA, 2014. Elevation and indian reserves from Geobase. Watercourses from the Province of British Columbia and field data.Base data from the province of British Columbia. McNab Creek Estuary digitized from Province of BC, 1999. Projection: UTM Zone 10 Datum: NAD 83

PROJECT

BURNCO ROCK PRODUCTS LTD.
BURNCO AGGREGATE PROJECT, HOWE SOUND, B.C.

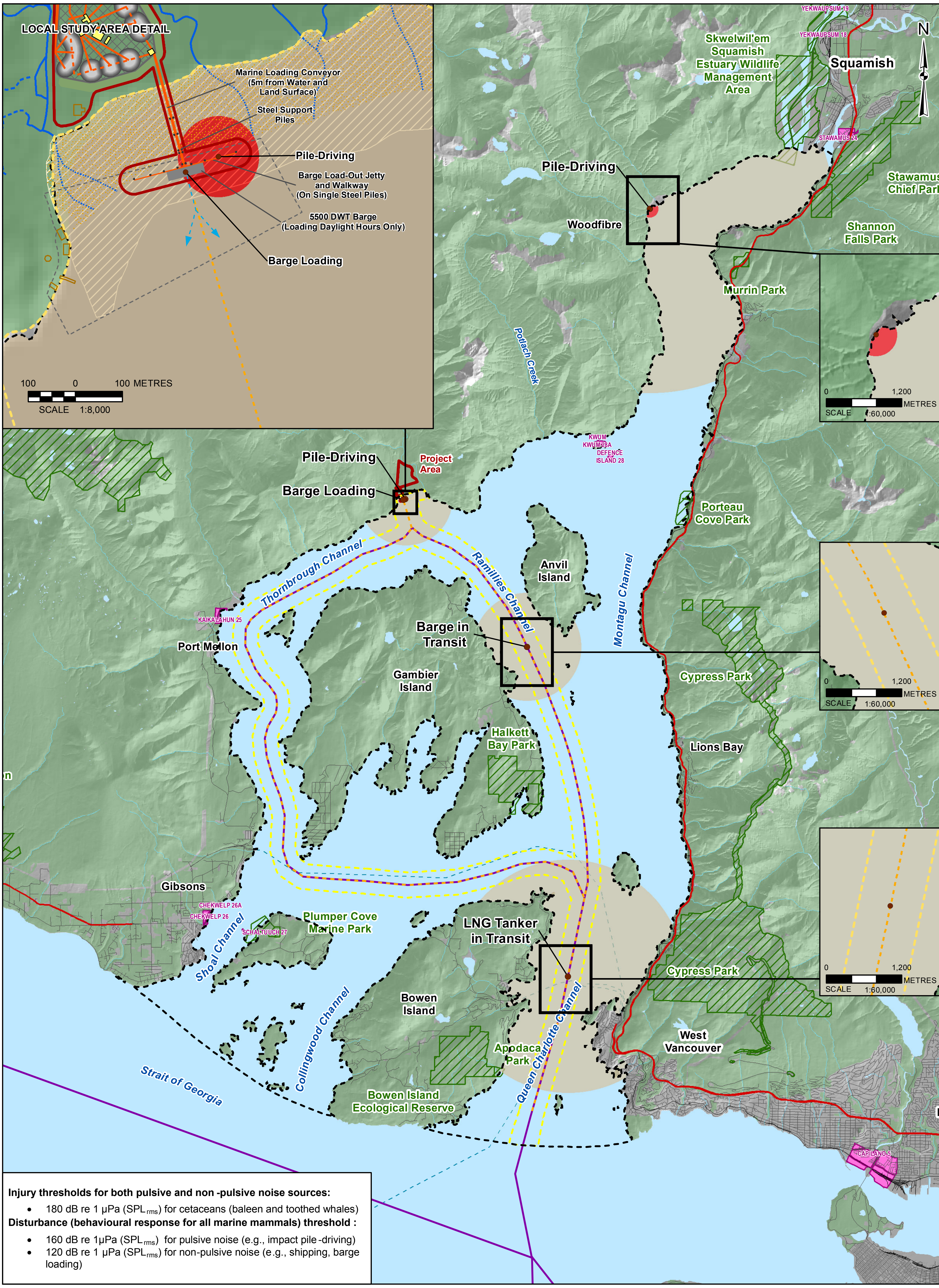
TITLE

ACOUSTIC INJURY AND DISTURBANCE THRESHOLDS FOR PINNIPEDS

Golder Associates

PROJECT NO. 11-1422-0046			PHASE No.	
DESIGN	KZ	02 Oct 2015	SCALE AS SHOWN	REV. 1
GIS	DL	17 May 2016		
CHECK	KZ	04 Mar 2016	**FIGURE 5.2-7**	
REVIEW	PO	04 Mar 2016		

Path: X:\Project Data\BC\McNab\Figures\MXD\Marine Figures\Marine_EA\Final\BURNCO_MARINE_Figure_5_2-7_Underwater_Noise_Thresholds_Pinnipeds.mxd



Injury thresholds for both pulsive and non-pulsive noise sources:

- 180 dB re 1 μPa (SPL_{rms}) for cetaceans (baleen and toothed whales)

Disturbance (behavioural response for all marine mammals) threshold:

- 160 dB re 1μPa (SPL_{rms}) for pulsive noise (e.g., impact pile-driving)
- 120 dB re 1 μPa (SPL_{rms}) for non-pulsive noise (e.g., shipping, barge loading)

LEGEND

- Underwater Noise Feature
- Distance to Injury Threshold for Cetaceans
- Distance to Disturbance Threshold for Cetaceans
- Project Area
- Local Study Area
- Regional Study Area
- Park / Protected Area
- Indian Reserve
- McNab Creek Estuary
- Intertidal Zone
- Barge
- Dock
- Processing Area
- Existing Feature
- Existing Log Tenure Area
- Processing Area Berm
- Product Stockpiles
- Possible Processing Plant Configuration
- Elevated Conveyor
- Underground Conveyor
- Barge Load-out
- Proposed Barging Route
- Existing Barging Route
- Permanent / Perennial Watercourse
- Intermittent Watercourse
- Intertidal Watercourse
- Transmission Line
- Barge Route
- Pile

5,000 0 5,000

SCALE 1:150,000 METRES

REFERENCE

Injury and disturbance thresholds from NOAA, 2014. Elevation and indian reserves from Geobase. Watercourses from the Province of British Columbia and field data.Base data from the province of British Columbia. McNab Creek Estuary digitized from Province of BC, 1999. Projection: UTM Zone 10 Datum: NAD 83

PROJECT

BURNCO ROCK PRODUCTS LTD.
BURNCO AGGREGATE PROJECT, HOWE SOUND, B.C.

TITLE

ACOUSTIC INJURY AND DISTURBANCE THRESHOLDS FOR CETACEAN

Golder Associates

PROJECT NO. 11-1422-0046			PHASE No.	
DESIGN	KZ	02 Oct 2015	SCALE AS SHOWN	REV. 1
GIS	DL	17 May 2016		
CHECK	KZ	04 Mar 2016	FIGURE 5.2-8	
REVIEW	PO	04 Mar 2016		

Path: X:\Project Data\BC\McNab\Figures\MXD\Marine Figures\Marine_EA\Final\BURNCO_MARINE_Figure_5_2-8_Underwater_Noise_Thresholds_Cetacean.mxd