Conceptual Fish Habitat Offsetting Plan

Proposed Aurora LNG Project

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Prepared for:
Aurora LNG
Calgary, Alberta

AUTHORSHIP

Philip Molloy, Ph.D., CBiol (UK) .... Author (Marine)
Stefan Dick, M.Sc. .... Quality Review (Marine)
Sean Mitchell, Ph.D., R.P.Bio. .... Author (Freshwater)
Michael Browne, M.Sc., R.P.Bio. .... Quality Review (Freshwater)
Karen Munro, R.P.Bio. .... Independent Review

EXECUTIVE SUMMARY

Nexen Energy ULC ("Nexen") proposes to construct and operate the Aurora LNG Project (the Project) for and on behalf of Aurora LNG, a joint venture between Nexen and INPEX Gas British Columbia Ltd. (Aurora LNG). The Project comprises the construction and operation of a liquefied natural gas (LNG) facility and marine terminal on the southeast corner of Digby Island near Prince Rupert, British Columbia (BC). Natural gas will be converted to LNG for shipment via LNG carriers to markets overseas.

The Project includes activities that have the potential to harm fish or fish habitat. In accordance with paragraph 35(2) of the federal *Fisheries Act*, Aurora LNG must obtain an authorization from Fisheries and Oceans Canada (DFO) to carry out such activities and offset any associated residual *serious harm to fish* (as defined by DFO). This Conceptual Fish Habitat Offsetting Plan marks the first step along the path to developing a Habitat Offsetting Plan in support of an application for a *Fisheries Act* Authorization. More immediately, this Plan is intended to support Aurora LNG's Application for an Environmental Assessment Certificate (the Application) by demonstrating their commitment to counterbalancing Project impacts on fish and fish habitats and presenting initial concepts to offset preliminary estimates of residual *serious harm to fish*. Consultation with Aboriginal Groups will play an important role as Aurora LNG progresses through this permitting process. This consultation will occur throughout the development of the Fish Habitat Offsetting Plan and will ultimately contribute towards Aurora LNG's selection and design of offsetting features.

Determining residual *serious harm to fish* and associated offsetting requirements involves a stepwise process that integrates the Project description, biophysical conditions, mechanisms of effect, measures to avoid and mitigate these effects, and DFO's definition of *serious harm to fish*. This Plan follows that sequence by identifying Project mechanisms that could harm fish, describing existing freshwater and marine fish and fish habitat, and identifying the pathways through which the Project mechanisms could harm those resources. Within that context, Aurora LNG's avoidance and mitigation measures are considered before characterising residual effects on fish or fish habitat that remain after the implementation of those measures. Finally, the extent and/or magnitude of disruptions resulting in death of fish or permanent alteration or destruction of fish habitat that could impair the ability of a commercial, recreational or Aboriginal (CRA) fishery species to complete one or more life process are characterised to inform a determination of residual *serious harm to fish*. It is this residual *serious harm to fish* that Aurora LNG is required to offset.

Key Project elements comprise terrestrial and marine infrastructure. The main terrestrial components are: the LNG processing plant and storage facilities, a seawater desalination system, a camp, roads, a control room, a boil-off-gas system, laydown areas, and a flare system. Key marine components are an LNG jetty with two berths for LNG carriers off south Digby Island, a pioneer facility and material offloading facility (MOF) in Casey Cove, an intake pipe for the seawater desalination system, and two outfall locations Two designs are being considered for the MOF: a pile-and-deck option and a concrete caisson option. Both options are considered within this plan.

Project components that interact with the freshwater and marine environments have potential to cause *serious harm to fish* owing to the presence of freshwater and marine CRA fishery species and associated habitats. Field surveys identified the following notable features of freshwater and marine environments:

- Freshwater Environment
    - The freshwater watercourses and lakes of Digby Island are typically of low pH, conductivity, and nutrient concentrations. Watercourses in the south of the island, close to or within the Project development area (PDA), are typically short and narrow, draining wetlands and small ponds. Each watercourse has been subdivided into reaches, and each reach has been assigned a unique alpha-numeric code to facilitate identification. There are 19 watercourses within the PDA itself, the largest of which is Watercourse J. Ten of these watercourses are considered fish bearing, though barriers to movement and distribution are common.
    - Five freshwater CRA fishery species occur within the watercourses of the PDA: Dolly Varden (*Salvelinus malma*), cutthroat trout (*Oncornhynchus clarkii*), coho salmon (*O. kisutch*), Chinook salmon (*O. tshawytscha*), and pink salmon (*O. gorbuscha*). Of these, the most commonly captured species was coho salmon. Presence of various life stages of CRA fishery species in the PDA indicates the potential use of watercourses for spawning, egg incubation, and rearing.
- Marine Environment
    - Marine habitats differ between south Digby Island and Casey Cove. South Digby Island habitats comprise a mix of intertidal mud, sand, and gravel, broken by rocky areas supporting rich seaweed communities. Subtidally, the seafloor constitutes a mix of soft and hard substrates, the latter often supporting stands of canopy-forming bull kelp (*Nereocystis leutkeana*) and various species of understory kelps. Eelgrass (*Zostera marina*) occurs in a non-continuous bed between Frederick Point and the mouth of Delusion Bay while, across the same area, salt marsh fringes the upper intertidal. Casey Cove is dominated by relatively fine substrate (typically mud, sand, and gravel with some cobble) intertidally and subtidally. Eelgrass is common in sandy and muddy low-intertidal substrates, especially in the western part of the cove. Marine riparian vegetation at both locations is typical of BC north coast temperate rainforest, i.e., dominated by western hemlock (*Tsuga heterophylla*), Sitka spruce (*Picea sitchensis*) and western red cedar (*Thuja plicata*).
    - A wide range of marine CRA fishery species use these marine habitats, representing a suite of functional groups. Benthic/demersal fish occurring over soft substrates include several species of flatfish (family Pleuronectidae) and big skate (*Raja binoculata*), while those inhabiting hard substrate include various rockfishes (*Sebastes* spp.), kelp greenling (*Hexagrammos decagrammus*), and lingcod (*Ophiodon elongates*). Pelagic fish occurring in the waters around the island include surf smelt (*Hypomesus pretiosus*) and Pacific herring (*Clupea pallasii*). All five species of Pacific salmon are found around the southern waters of Digby Island and Casey Cove, as are numerous epibenthic invertebrates such as Dungeness crab (*Metacarcinus magister*), red rock crab (*Cancer productus*), Tanner crab (*Chionoecetes bairdi*), various scallops (*Chlamys* spp.), and *Pandalus* shrimps. Sediment-dwelling invertebrates also thrive in the muddy intertidal and subtidal sediments around the island, including soft shell clam (*Mya arenaria*), saltwater clam (*Saxidomus* spp.), *Macoma* clam, and cockles (*Clinocardium* spp.).

It is anticipated that the Project will cause *serious harm to fish* in both freshwater and marine systems. There are several mechanisms through which *serious harm to fish* could be incurred. In the freshwater environment, Project construction could cause *serious harm to fish* either via death of fish or habitat effects. Specifically, death of fish could be caused via:

- Crushing, burial, entrainment or impingement.

Freshwater habitat change or loss could occur through:

- Change in habitat structure and cover
- Change in water quantity or quality
- Change in access to habitats

In the marine environment, Project construction and operations could cause *serious harm to fish* either via death of fish or habitat effects. Specifically, death of fish could be caused via:

- Crushing, burial, entrainment or impingement
- Exposure to underwater noise or pressure waves

Marine habitat change or loss could occur through:

- Removal of marine vegetation, including marine riparian vegetation, eelgrass and macroalgae
- Change in substrate shape, height or type
- Removal of substrate

Aurora LNG proposes to implement a suite of avoidance and mitigation measures to reduce the amount and severity of *serious harm to fish* in both marine and freshwater systems. The avoidance of sensitive habitats and timing restrictions for specific construction activities will contribute towards reduced interaction with fish. In addition to such site-specific measures, more general avoidance steps have been implemented, which include aspects of Project location selection, Project design, and placement of Project components. Mitigation measures to be applied in freshwater systems include: avoiding sensitive periods for fish species, reducing disturbance to riparian areas where possible; having environmental monitors on site during instream works; obtaining relevant permits for all instream works; isolating watercourses to prevent harm to fish and conducting fish salvage when necessary; meeting water quality guidelines when discharging effluent, including erosion and sediment control measures; keeping the construction site clean; maintaining spill kits; containment of concrete works; and restricting recreational fishing by workers in the PDA. Marine-based mitigation measures include: the use of bio-friendly materials; silt curtains; bubble curtains; adherence to blasting guidelines; the use of BMPs; and sediment and erosion control.

Following the implementation of avoidance and mitigation measures, residual *serious harm to fish* in the freshwater environment is expected to cause a localized effect for a total of 10,857 m^2 of in-channel habitat and 218,830 m^2 of riparian habitat. This effect is expected due to clearing and infilling of channels in the PDA. Project activities are not expected to result in death of fish that would reduce the productivity of any local population or stock of a CRA fishery species, and therefore is not expected to constitute residual *serious harm to fish*.

Residual *serious harm to fish* in the marine environment is also expected to occur as a result of habitat change or loss. Specifically, it is anticipated that the Project will remove or change up to 264,976 m^2 of marine vegetation and substrate at south Digby Island and Casey Cove, of which up to 70,720 m^2 is deemed to constitute residual *serious harm to fish*, and will require offsetting. This area considers the amount of eelgrass and rocky habitat expected to be permanently altered or destroyed. Although some fish mortality may occur in the marine environment, this effect is not expected to reduce the productivity of any local populations of CRA fishery species, and is not expected to constitute residual *serious harm to fish*. As such, offsetting is not expected to be required for the death of fish.

Several conceptual offsetting approaches are presented to counterbalance Project-related residual *serious harm to fish.* These offsets are based on the four guiding principles set out by DFO in their Fisheries Protection Investment Policy (DFO 2013a). Specifically:

- Offsetting measures must support fisheries management objectives or local restoration priorities
- Benefits from offsetting must balance Project impacts
- Offsetting measures must provide additional benefits to the fishery
- Offsetting measures must generate self-sustaining benefits over the long term

These principles have been used to develop conceptual offsetting measures that fall within four categories: habitat restoration and enhancement; habitat creation; chemical or biological manipulations; and complementary measures (investments in data collection and scientific research). Freshwater offsetting concepts include:

- Habitat restoration: increasing connectivity, barrier removal, riparian planting, connected salt-marsh and rocky habitat at the mouth of an offsetting watercourse
- Habitat creation: creation of new constructed channels
- Complementary measures: research on the effect of low pH systems on coho salmon production and possibilities for restoration

Conceptual marine offsetting measures include:

- Habitat restoration and enhancement: enhancement of soft-substrates in Casey Cove and south Digby Island, expansion of eelgrass beds in Casey Cove and Delusion Bay
- Habitat creation: development of a wide range of intertidal and subtidal rocky habitats
- Complementary measures: research into drivers of nearshore mortality in Pacific salmon; availability of spawning beaches to surf smelt and potential implications of climate change and coastal development; and drivers behind spatial fluxes in herring spawning across years and implications for CRA fishery predators

Ultimately, sufficient offsetting will be implemented to counterbalance Project impacts. This will be achieved through the selection of appropriate offset ratios that will take into consideration a suite of factors that influence the expected extent of *serious harm to fish* and offsetting benefits. Objective approaches will be used to translate the value of different habitats when calculating appropriate ratios for out-of-kind offsets, such as habitat equivalency analysis.

Offsets implementation will be scheduled to reduce productivity lag effects, after which two levels of monitoring will be conducted, with the over-arching objective to promote effective offsetting. Compliance monitoring will be conducted during the creation of offsets to confirm they have been built as designed and fulfil any *Fisheries Act* Authorization design requirements. Once built, the effectiveness of the offsets will be monitored to confirm they are performing as designed. Effectiveness monitoring will be based on requirements identified in the *Fisheries Act* Authorization but are expected to focus on habitat function and the use of that habitat by the CRA fishery species the offsets were designed to benefit.

The offsetting concepts presented herein constitute early ideas based on current predictions of Project effects, existing biophysical environment, and possible strategies to counterbalance Project residual *serious harm to fish*. Aurora LNG looks forward to discussing concepts with DFO and Aboriginal Groups, and refining the concepts towards effective, practicable, locally relevant measures.

ACRONYMS AND ABBREVIATIONS

ACBM	articulated concrete ballast mat
BC	British Columbia
bcf/d	billion cubic feet per day
BMPs	best management practices
CD	chart datum
CFHOP	Conceptual Fish Habitat Offsetting Plan
COSEWIC	Committee on the Status of Endangered Wildlife in Canada
CRA	commercial, recreational or Aboriginal
DFO	Fisheries and Oceans Canada
DWT	dead weight tonnage
EA	environmental assessment
EBM	ecosystems-based management
EM	environmental monitor
EM	environmental monitor
FEED	front-end engineering design
FFHOP	Final Fish Habitat Offsetting Plan
FPIP	Fisheries Productivity Investment Policy
FPPS	Fisheries Protection Policy Statement
H:V	horizontal:vertical
HDPE	high density polyethylene
HEA	habitat equivalency analysis
HWM	high water mark
IFMPs	Integrated Fisheries Management Plans
km	kilometre
kPa	kilopascal
LAA	local assessment area
LNG	liquefied natural gas
LUMP	land use management plan
LWD	large woody debris
m	metre
mm	millimetre
MOF	materials-offloading facility
OD	outside diameter
PDA	Project development area

PNCIMA .... Pacific North Coast Integrated Management Area initiative

Project .... Aurora LNG Project

PRPA .... Prince Rupert Port Authority

SARA .... *Species at Risk Act*

YOY .... young of the year

GLOSSARY

Alkalinity	The amount of alkali in a substance, such as water (as alkalinity increases the pH value increases).
Bog	Soft wetland, usually with moss growing on it, which does not decompose, but forms a thick layer of acid peat.
Benthic	Associated with the bottom of the sea or a lake.
Cascade	A small waterfall, typically one of several that fall in stages down a steep rocky slope.
Conductivity	The amount of electricity water can conduct.
Commercial, Recreational, or Aboriginal (CRA) fishery species	Fish that are part of commercial, recreational or Aboriginal fisheries are interpreted to be those fish that fall within the scope of applicable federal or provincial fisheries regulations, as well as those that can be fished by Aboriginal organizations or their members for food, social or ceremonial purposes or for purposes set out in a land claims agreement. Fish that support these fisheries are those that contribute to the productivity of a fishery (often, but not exclusively, as prey species). The “fish that support” may reside in water bodies that contain the commercial, recreational or Aboriginal fisheries or in water bodies that are connected by a watercourse to such water bodies.
Demersal	Dwelling at or near the bottom of a body of water.
Echinoderm	Marine invertebrates of the phylum Echinodermata, such as a starfish, sea urchin, or sea cucumber.
Estuary (estuarine)	The area where a river empties into an ocean; a bay, influenced by the ocean tides, resulting in a mixture of salt and fresh water.
Finfish	A true fish, either bony (e.g., salmon and eulachon) or cartilaginous (e.g., sharks and rays). Term is used to differentiate between true fish and shellfish or other aquatic animals (e.g., marine mammals).
Fish	Use of the word *fish* is intended to include all of the species captured under Fisheries and Ocean Canada’s definition of fish, as provided in the *Fisheries Act*: i.e., “a) parts of fish, b) shellfish, crustaceans, marine animals and any parts of shellfish, crustaceans or marine animals; and c) the eggs, sperm, spawn, larvae, spat and juvenile stages of fish, shellfish, crustaceans and marine animals”.
Forage fish	Small fish that breed prolifically and serve as food for predatory fish within either freshwater or marine environments.
Fry	A recently hatched or very young fish.
Glide	A section of watercourse that has little or no turbulence.
Intertidal	The area between the higher high water and the lower low water, which is at some point exposed to air.
Mainstem	The primary downstream segment of a river or stream as contrasted to its tributaries. The tributaries, which are smaller than the mainstem, feed into and increase the size of the mainstem.

Parr	A young salmon or trout between the stages of fry and smolt, distinguished by dark rounded patches evenly spaced along its sides.
Pelagic	Referring to the top and middle layers of sea water.
Pool	A part of the watercourse where the water depth is above average and water velocity is below average. Natural watercourses often consist of a succession of pools and riffles.
Riffle	Shallow rapids in an open watercourse, where the water surface is broken into waves by obstructions such as shoals or sandbars wholly or partly submerged beneath the water surface. Also, a stretch of choppy water caused by such a shoal or sandbar; a rapid.
Riparian	Marine riparian habitat is considered to be the zone 10 m landward from the higher high water level. Within freshwater systems the riparian area is typically considered the area on either side of the top of banks of a watercourse or high water mark of a lake that can extend up to 50 m.
Serious harm to fish	*"Serious harm to fish"* is defined by the *Fisheries Act* as: ▪ "the death of fish; ▪ a permanent alteration to fish habitat of a spatial scale, duration or 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; ▪ the destruction of fish habitat of a spatial scale, duration, or intensity that fish can no longer rely upon such habitats for use 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."
Smolt	A young salmon at the stage of development when it becomes covered with silvery scales and is ready to migrate from fresh water to the sea.
Subtidal	The area below the lower low water level that is never exposed to air.
Substrate	The material (e.g. sediment, rocks, sand, gravel) in the bottom of a marine habitat, or one that forms the bed of a watercourse.
Turnaround	Scheduled events during which all aspects of an industrial processing plant temporarily shut down to allow equipment renovations, maintenance, replacements, or upgrades to occur.
Tributary	A watercourse or river that flows into a larger river or lake.
Young-of-the-year	Age-0 fish, or those animals born within the past year, from transformation to juvenile until January 1, which have not yet reached one year of age.

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1 INTRODUCTION

Nexen Energy ULC (“Nexen”) proposes to construct and operate the Aurora LNG Project (the Project) for and on behalf of Aurora LNG, a joint venture between Nexen and INPEX Gas British Columbia Ltd. (Aurora LNG). The Project comprises the construction and operation of a liquefied natural gas (LNG) facility and LNG jetty on the southeast corner of Digby Island near Prince Rupert, British Columbia (BC) (see Figure 1). Natural gas will be converted to LNG for shipment via LNG carriers to support markets overseas.

The Project includes construction and operation of LNG processing units (or ‘trains’), up to three LNG storage tanks, an LNG jetty, a material offloading facility (MOF) and a pioneer facility (see Figure 2). The land-based supporting facilities will include an onsite power generation facility, a camp for accommodations, administration buildings, cleared areas for storage, and roads throughout the area.

The LNG jetty, located off the south end of Digby Island, will be capable of accommodating a range of sizes of LNG carriers, up to Q-flex (345 m long with a ~12 m draught). The jetty will provide access for vehicles and will support LNG piping, vapour return lines, process piping and utilities. A MOF will be constructed in Casey Cove to facilitate safe berthing and mooring of heavy-lift ships and barges delivering materials and construction equipment. Two MOF design options are currently being contemplated: a pile-and-deck structure, and a concrete caisson structure. A pioneer facility will also be constructed in Casey Cove to facilitate the early stages of site development. This facility will consist of a passenger boat landing and barge landing.

Aurora LNG will implement measures to avoid and mitigate potential Project effects on freshwater and marine fish and fish habitat during construction and operations. Despite the implementation of these measures, not all Project-related effects can be fully avoided or mitigated; some Project activities may result in residual *serious harm to fish* as defined under the federal *Fisheries Act*. Any such activities would require an authorization pursuant to paragraph 35(2)(b) of the *Fisheries Act*.

Aurora LNG is committed to counterbalancing residual serious harm to fish by implementing offsetting measures for fish and fish habitat. These offsets would benefit commercial, recreational, and Aboriginal (CRA) fishery species around Digby Island. Proposed offsetting measures contained in this document are based on professional experience and Fisheries and Oceans Canada’s (DFO’s) policy statements (DFO 2013a, 2013b), which are themselves founded on the principles of productivity, habitat utilization, and dependency. This Conceptual Fish Habitat Offsetting Plan (CFHOP) marks the first step along the path to developing a Final Fish Habitat Offsetting Plan in support of an application for a *Fisheries Act* Authorization. More immediately, this Plan is intended to support Aurora LNG’s Application for an Environmental Assessment Certificate (the Application) by demonstrating Aurora LNG’s commitment to counterbalancing Project impacts on fish and fish habitats. The offsets proposed herein serve as ideas to fuel discussion during consultation with DFO and Aboriginal Groups. They will be further refined following recommendations gathered during this consultation process.

2 REGULATORY CONTEXT

2.1 Fisheries Act

The federal *Fisheries Act*, implemented by DFO, is the legislative authority for the management and conservation of freshwater and marine fish and fish habitat in Canada. *The Fisheries Act* and associated regulations and policies outline protection rules and provide direction for decision making in Canadian fisheries management. This protection emphasizes the sustainability and continued productivity of CRA fisheries. Fish and fish habitat that are part of, or support, a CRA fishery are protected by the prohibition of *serious harm to fish* under subsection 35(1) of *the Fisheries Act*. *Serious harm to fish,* defined in Section 2 of *the Fisheries Act*, is “the death of fish or any permanent alteration to, or destruction of, fish habitat”. Proponents of projects that would result in *serious harm to fish* that form part of a CRA fishery must apply for, and receive, a *Fisheries Act* Authorization under paragraph 35(2)(b) prior to commencing Project construction.

DFO’s Fisheries Protection Policy Statement (FPPS; DFO 2013b) further clarifies this definition of *serious harm to fish* by defining permanent alteration to, and destruction of fish habitat. Specifically, these terms comprise the alteration or elimination of fish habitat at “a spatial scale, duration or 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”. Therefore, it is important to distinguish between changes to fish habitat that do and those that do not fulfil this definition of “permanent alteration” or “destruction”. The FPPS further advises that avoidance of *serious harm to fish* includes ensuring the free passage of fish (Section 20) and prohibiting the taking, catching, or killing of fish (Section 23). The FPPS also provides guidance to proponents on key factors to consider when evaluating Project impacts and associated avoidance, mitigation and offsetting measures. These are specifically:

- The contribution of relevant fish to the ongoing productivity of CRA fisheries
- Fisheries management objectives
- Whether there are measures or standards to avoid, mitigate or offset *serious harm to fish* that are part of, or support, a CRA fishery
- Public interest

The FPPS also provides guidance on limiting Project impacts to fish and fish habitat and designing habitat offsets. Proponents are instructed to demonstrate that measures have been applied to avoid and mitigate Project impacts to fish or fish habitat. Avoidance measures “completely prevent *serious harm to fish*”, for example, timing activities to completely avoid overlap with sensitive fish life stages. If complete avoidance of *serious harm to fish* is not possible, mitigation measures should be implemented that “reduce the spatial scale, duration or intensity of *serious harm to fish*”. When such harm cannot be fully avoided or mitigated, any residual *serious harm to fish* must be counterbalanced by offset measures. These measures are actions that “are intended to provide tangible conservation outcomes for fish and fish habitat that may reasonably be expected to counterbalance the loss of fish habitat and fisheries productivity as a result of the negative impacts of projects”. Proponents are required to submit an offsetting plan to DFO that details the avoidance, mitigation and offsetting measures.

DFO's Fisheries Productivity Investment Policy (FPIP; DFO 2013a) provides guidance to proponents on undertaking effective measures to offset residual *serious harm to fish*. The FPIP details guiding principles for offsetting, and types of offsetting measures. Proponents are directed to design offsetting measures that meet the following principles:

- Support fisheries management objectives or local restoration policies
- Benefits must balance project impacts
- Provide additional benefits to the fishery
- Generate self-sustaining benefits over the long term

These principles can be met through four types of offsetting:

- Habitat restoration and enhancement
- Habitat creation
- Chemical or biological manipulation
- Complementary measures

Offsets can either be developed as needed on a Project specific basis, or through a habitat 'banking' system, whereby proponents create offsets in advance of Project impacts; however, since the Project currently has no such habitat bank, this approach is not considered further.

2.2 British Columbia Water Sustainability Act

In addition to federal legislation for protection of fish and fish habitat, the provincial *Water Sustainability Act* also contains provisions for the protection of fish and fish habitat in freshwater. This legislation is primarily focussed upon protection of water resources during water extraction activities or during "changes in and about a stream". In particular, Section 15 requires the maintenance of environmental flow needs within a channel during water extraction and Section 16 requires mitigation measures when activities are likely to have a significant adverse impact on the water quality, water quantity, or aquatic ecosystem of a stream or aquifer, a stream channel, or other users of water from the stream or aquifer. The *Water Sustainability Act* is consistent with, and complementary to, the *Fisheries Act*.

In keeping with this regulatory context, Aurora LNG is committed to avoiding and mitigating effects to fish and fish habitat, and offsetting any residual serious harm to fish. Details of these avoidance, mitigation and offset measures will be provided in a Final Fish Habitat Offsetting Plan. This Plan will be based on the definitions and guidance detailed in DFO's FPPS (DFO 2013b), and will follow the principles provided in DFO's FPIP (DFO 2013a), consistent with fisheries protection provisions of the *Fisheries Act*. This CFHOP provides an early indication of Aurora LNG's approach to navigate this regulatory context and, consequently, counter-balance Project-related impacts[1] to fish and fish habitat.

[1] To align with DFO's use of the term, "impact", this term is interpreted herein as *the outcome of a Project component or activity in which fish and/or fish habitat are harmed*. Note that this interpretation differs from that used in the environmental assessment for the Project.

3 CONSULTATION AND ENGAGEMENT

The Project is located within the asserted traditional territories of several Aboriginal Groups in the Digby Island area, including: Lax Kw'alaams Band, Metlakatla First Nation, Gitxaala Nation, Kitsumkalum First Nation, Kitselas First Nation, and Gitga'at First Nation. The Métis Nation BC has also indicated that their members exercise traditional practices around the Digby Island area.

Aurora LNG recognises the importance to Aboriginal Groups of the proposed Project area and the resources within it. Traditional knowledge accumulated over generations and an understanding of traditional land-use practices hold great value in characterising local fish and fish habitat, potential Project interactions (including those causing *serious harm to fish*), and the identification of effective, locally relevant and practicable offsetting solutions. As such, Aurora LNG intends to work with Aboriginal Groups through the offsetting process and use information shared during this consultation process to identify a widely accepted Habitat Offsetting Plan. This document marks a key tool to guide detailed, focussed conversations about ways to counter-balance the Project's residual *serious harm to fish*.

Aurora LNG has worked and consulted with Aboriginal Groups and will continue to request further information and recommendations regarding proposed offsetting measures from Aboriginal Groups throughout the development of the offsetting plan, the implementation of offsets, and subsequent monitoring. To date, Aurora LNG has worked with Lax Kw'alaams Band and Metlakatla First Nation during the collection of field data used to inform this offsetting plan. As part of a series of technical workshops with Aboriginal Groups, Aurora LNG solicited recommendations regarding suitable offsetting options (see Appendix A of the Application for details regarding consultation with Aboriginal Groups). Several key points emerged during these workshops:

- A desire for habitat to be considered in the quantification of *serious harm to fish* and not just "number of fish present"
- A preference for "like-for-like" offsetting options over "out-of-kind" options
- A preference for offsetting to occur in or near to the location of residual *serious harm to fish*
- A recognition that while DFO does not prefer the use of salmon hatchery programs as part of habitat offsetting, the Oldfield Creek fish hatchery is an option to consider for offsetting

Future consultation with Aboriginal Groups is expected to occur through several forums and media. In particular, Aurora LNG anticipates participating in focused meetings with the Nations individually or collectively in the form of group workshops, small in-person meetings and teleconferences. Aurora LNG also hopes that Aboriginal Groups will provide feedback on drafts of the Habitat Offsetting Plan (such as this) either directly or through the Environmental Assessment Application Review process.

The overarching goal of Aurora LNG's offsetting consultation strategy is to develop a widely agreeable and beneficial offsetting plan. This strategy will be guided by a series of clear consultation objectives, specifically:

- Confirm Aboriginal Groups interested in the offsetting process
- Seek alignment on:
  - Offsetting objectives
  - Offsetting concepts (kind, locations and amount)
  - Offsetting monitoring protocols, success criteria and duration
  - Future involvement of Nations in offsetting work

Finally, it should be reiterated that this CFHOP marks a key step in the consultation process. The concepts presented in this plan should not be considered final; rather, they constitute initial ideas based on current understanding of the Project, existing biophysical environment, and possible strategies to counter-balance Project *serious harm to fish*. Aurora LNG looks forward to discussing and developing these concepts with Aboriginal Groups.

4 PROJECT COMPONENTS AND ACTIVITIES

4.1 Project Location

The Project is proposed for southeastern Digby Island and an adjacent water lot, approximately three kilometres (km) southwest of Prince Rupert, on the northwest coast of BC (see Figure 1). The LNG facility is to be located on provincial Crown land within the Skeena-Queen Charlotte Regional District and the North Coast Forest District. The marine terminal, MOF and pioneer facility, and a portion of the shipping route are within the jurisdiction and administration of the Prince Rupert Port Authority (PRPA). The project development area (PDA) is approximately 785 ha. For further details on Project location, please see Proposed Project Overview, Section 1.0, of the Application.

4.2 Project Components

The Project will consist of the following major components: an LNG production and storage facility, LNG jetty (including dredge areas around each berth), supporting infrastructure and facilities (including a MOF and associated dredge areas, a water treatment system, and a seawater intake/outfall system), temporary infrastructure and facilities (including a pioneer facility), and operation of LNG carriers and other supporting marine traffic during construction and operations. Through front end engineering and design (FEED), Aurora LNG will seek to optimize the design of in-water Project components, with the goal of reducing the total area of affected marine fish habitat to the extent practicable. The proposed layout of the Project components is illustrated in Figure 2. For further details on the Project components, please see Section 1.0 of the Application.

4.2.1 LNG Facility

The LNG production and storage facility will require, at full build-out, approximately 104 million cubic metres per day (Mm^3/d) (3.7 billion standard cubic feet per day [Bcf/d] or 3.9 Peta Joules per day [PJ/d]) of natural gas, of which approximately 96 Mm^3/d (3.4 Bcf/d or 3.6 PJ/d) will be processed into 24 MTPA of LNG and approximately 8 Mm^3/d (0.3 Bcf/d or 0.3 PJ/d) will be required for facility operation. There will be three LNG storage tanks at the LNG facility with total storage capacity of up to 585,000 m^3.

The LNG facility will include natural gas receiving and treatment facilities, natural gas processing facilities, LNG storage tanks, and office and maintenance facilities. The facility will be constructed in phases, with two LNG trains constructed during the first phase and two additional LNG trains constructed as required by market conditions (for a total of four liquefaction trains). The exact phasing and optimization of the train size and layout will be established during FEED. The natural gas supply (also known as feed gas) pipeline will enter the property via a dedicated pipeline delivery station.

4.2.2 LNG Jetty

It is anticipated that the LNG jetty will be comprised of the following components (see Figure 3):

- A main access trestle running north-south off Fredrick Point
- Two east-west oriented trestles connecting the main access trestle to LNG loading platforms
- Two loading platforms, including loading arms
- Two east-facing LNG carrier berths (and associated dredge areas)

The main access trestle will be approximately 1.25 km long, and will extend due south from Frederick Point, across the western edge of Spire Island to a point approximately 300 m south-southwest of Tuck Island. This trestle will be comprised of two infill causeways and two pile-supported segments. Installation of piles in shallow water (above -3 m chart datum [CD]) from standard floating structures is challenging from technical and safety perspectives; consequently, earth-fill causeways will be installed across shallow zones abutting Digby Island and Spire Island. The footprint for the Digby Island section of the causeway will be approximately 140 m long and 50 to 60 m wide and will cover an area of approximately 7,580 m^2. The footprint for the Spire Island section will be 492 m long by 45 to 70 m wide and will cover an area of approximately 26,600 m^2. Causeway structures will have protective riprap sides, sloping at approximately 2:1 (horizontal:vertical [H:V]). The elevated segments of the main access trestle will be supported by piles, which will likely be 1.5 m (60 inch) diameter tubular steel pipe. Installation of piles will involve impact pile driving through the overburden substrate and rock-socket drilling into the underlying bedrock. Rock anchors will be used to secure the piles; the type of anchor will depend on the likely force exerted on each pile. The trestle will cross substrate ranging in elevation from +10 m (on Digby Island) to -8 m CD.

Two east-west oriented piled trestles will connect the main access trestle to loading platforms at the LNG carrier berths. The berths will be capable of accommodating up to Q-flex LNG carriers (315 m length, 50 m beam and 107,000 dead weight tonnage [DWT]), with an LNG cargo capacity of up to 217,000 m^3. These berths will be east-facing, oriented to allow carrier approach, and providing moorage and departure with the bow into the prevailing wind and wave direction. The first berth will be located close to Frederick Point, north-northeast of Spire Island; the second will be located approximately 1 km south of the first berth, just south of Tuck Island. Loading arms at each berth will transfer the LNG onto the carriers, and a vapour return arm will transfer boil-off-gas back to the liquefaction trains. LNG carriers are expected to be at berth for approximately 24 hours and concurrent loading of carriers at adjacent berths may occur. The LNG berths will include discrete breasting and mooring dolphins, likely built from 1.5 m (60 inch) diameter piles, and connected via elevated catwalks. Water depths at the loading berths currently range from approximately -5 m to -30 m CD.

To accommodate LNG carriers, it is anticipated that blasting and dredging will be required at both berths. Resulting dredge pockets will extend to -15 m CD, with sides sloping at an angle of approximately 3:1 (H:V). The first berth will require two dredge pockets to be excavated over a total area of approximately 38,976 m^2 (including slope sides). The second berth will require only one pocket to be dredged off the south side of Tuck Island, covering an area of approximately 15,340 m^2. In total, it is anticipated that approximately 187,200 m^3 of material (sediment and rock) will be removed.

Construction of the LNG jetty is expected to require the installation of a total of 293 piles, all of which will be seated on subtidal substrate.

4.2.3 Supporting Infrastructure and Facilities

Supporting infrastructure will include a MOF (and associated dredge areas), laydown areas, an organic soil storage area, a seawater intake and outfall system, a water treatment system, administrative buildings, storage facilities and a medical centre, a camp for operations, maintenance, and turnaround personnel, access road, and haul roads. A description of key supporting infrastructure and facilities is provided below. See Proposed Project Overview, Section 1.0, of the Application for additional details.

4.2.3.1 Material Offloading Facility

A MOF is proposed on the south shore of Casey Cove to facilitate safe berthing and transportation of large loads, including modules from heavy lift and roll-on/roll-off vessels to land transportation units. The MOF will accommodate offloading modules up to 7,000 tonnes by self-propelled modular transporters, which typically have load capacities between 900 and 1000 kilopascals (kPa). The MOF will also contain crawler cranes or outrigger pads, with point-load capacities in excess of 100 kPa. The MOF areas may continue to be used over the life of the Project to receive or dispatch shipments such as refrigerant, containers, rotating equipment, and rotor transport canisters from roll-on/roll-off vessels.

Two MOF designs are being considered: pile and deck, and concrete caisson. Both designs are assessed herein and described in further detail below. Both design options would require the excavation of a dredge pocket to accommodate access by vessels. The pockets will be dredged to -15 m CD, with sides sloping at an angle of approximately 5:1 (H:V), which will provide adequate draught for a fully loaded break bulk vessel and also accommodate a fully loaded roll-on/roll-of cargo ship. The area and volume of sediment required to be dredged differs between the two designs. The dredge pocket for the concrete caisson MOF option will cover an area of 96,767 m^2 and will require the removal of 314,000 m^3 of sediment. The pile-and-deck MOF option will cover an area of 102,196 m^2 and will require the removal of 365,000 m^3 of sediment.

Both MOF designs include berthing dolphins to help secure vessels docked at the facility. Each dolphin will likely comprise four 1.5 m (60 inch) diameter steel pipes, installed at the western edge of the dredge basin at the bottom of the side slope. The pile-and-deck design would require three such dolphins, while only two are proposed for the concrete caisson option. These dolphins will be connected to one another and the main wharf by means of a raised catwalk.

PILE AND DECK OPTION

The pile-and-deck design involves a wharf structure running east to west, parallel to the shoreline, measuring approximately 400 m x 35 m (see Figure 4). The wharf would be connected to land by an unloading access trestle that would join the shore approximately 330 m west of Charles Point. This access point falls immediately west of an existing, derelict domicile and associated wharf, overgrown lawn, and garden (all of which will be removed prior to Project construction). The trestle would be approximately 185 m x 35 m. A secondary, smaller (115 m x 35 m) access trestle may be installed on the north shore of Charles Point to further facilitate and expedite vessel loading and unloading.

The wharf, access trestle(s), and dolphins would be supported by 523 piles, likely 1.5 m (60 inch) diameter steel pipe. Of these, 418 would be subtidal, 78 would be intertidal, and the remaining piles would be equally spilt over marine riparian and terrestrial habitat. Piles are likely to be installed by impact driving through soft sediment overburden and rock socket drilling into the underlying till.

CONCRETE CAISSON OPTION

The concrete caisson design involves a solid-structure wharf, composed of 11 to 12 precast concrete open box-like caissons (approximately 15 m x 45 m x 18 m [width x length x height]) installed on the seafloor and backfilled with ballast or rock fill (see Figure 5). Prior to installation, the seafloor would be prepared by installing a levelling pad, likely of crushed rock. The open structure would be backfilled with a similar kind of crushed rock before the topside platform is installed at the desired height (+10.5 m CD), formed of precast cover slabs. The resulting wharf would be approximately 455 m long and 35 m deep. The wharf may be connected to land by a concrete-deck access, measuring 115 m long and 35 m wide, oriented perpendicular to the wharf face. The wharf and access deck would border a laydown area, founded on infill.

The concrete caisson option would require the installation of approximately 15 piles, likely 1.5 m (60 inch) diameter steel pipe, following the same methods as the pile-and-deck option.

4.2.3.2 Seawater Intake and Outfall System

A seawater water intake and outflow system will be built to collect and desalinate seawater for several uses, including power-plant cooling, potable water during construction and operations, and ultra-pure process water (see Figure 2). These processes will create wastewater that will be discharged to the sea. Seawater supply will come through an intake pipe, located 2 m above the seafloor at a seabed bathymetry of -27 m (CD, that is, the intake itself will be at -25 m CD) at the mouth of Casey Cove. The pipe will follow a curvilinear route from shore within the footprint of the proposed MOF. The pipe will be buried across intertidal sections to provide at least 0.5 m cover. In subtidal stretches deeper than -1 m CD, the pipe will be laid on the seafloor until its terminus, where it will be elevated from the seafloor. The intake pipe will have a minimum outside diameter of 760 mm, be made of high-density polyethylene (HDPE), glass-reinforced plastic, or concrete, and, if needed, at least partially concrete-weight coated to provide negative buoyancy. Where needed, the pipe will be covered in articulated concrete ballast mats (ACBMs) to protect shallow areas of the pipe from potential hazards. Pipes will be installed through a combination of trenching through riparian and intertidal reaches, and surface lay in subtidal waters.

The outfall, which is expected to be located at Charles Point, will constitute a 232 m long, 300 mm outside diameter, HDPE pipe running perpendicular to the shoreline to a water depth of -30 m CD (see Figure 2). The pipe will be trenched through the foreshore to a minimum substrate cover of 1 m above the top of the pipe. Subtidal sections of the pipe will be laid upon the seafloor and, in waters shallower than -5 m CD, protected by ACBMs. The pipe will be weighted by ballast to help it rest securely on the seabed. Discharges will comply with local regulations and specifications of the discharge permit.

4.2.3.3 Water Treatment System

During site preparation, a temporary drainage and stormwater system will be established to collect and control storm flows and runoff into the sea. The system will include internal and perimeter ditches, and erosion and sediment controls. A sanitary wastewater treatment facility will be established for use during construction and operations within the camp system to treat wastewater prior to discharge through the outfall pipe located at Charles Point. Sewage sludge from the water treatment process will be transported off site for disposal at an approved landfill. Prior to establishing sewage facilities, portable toilets will be used, with disposal to a licensed facility.

Liquid wastes generated during operation of the facility will include treated sanitary wastewater, stormwater runoff, contact water from the LNG process, plant process drains, blown down water from power plant cooling, and reject water from the demineralized water unit. Treated water will be monitored prior to discharge to ensure that it meets all applicable federal and provincial regulatory requirements. Runoff from roads and buildings will drain into a ditch system and be discharged via stormwater outfalls. Runoff from the processing areas, process equipment, and firewater system testing will be directed to an oil separator where oily residues will be skimmed off to a collection sump and the effluent will be directed to the stormwater outfalls.

4.2.4 Temporary Infrastructure and Facilities

4.2.4.1 Pioneer Facility

A pioneer facility will be constructed to facilitate the early stages of site development by allowing for the transport of initial equipment, supplies, and workforce to the Project. This facility will consist of two structures: a barge landing and a passenger boat landing (see Figure 6). The two structures will be located within Casey Cove, to the west of the proposed MOF.

BARGE LANDING

A barge landing will be installed to allow barge (approximately 1,200-1,500 DWT) access for equipment transfer. The barge landing will be surfaced with crushed rock durable enough to support most heavy-duty, off-road equipment (e.g. bulldozers and front-end loaders). The initial loads of crushed rock will be delivered by a grounded barge and a front-end loader will push this material onto the beach to form an initial ramp. This ramp will then be used to transfer the bulldozer and other equipment and material onto the beach. The remaining work will be conducted from shore.

If the existing beach material is too weak to support the proposed structure and equipment, a crushed-rock foundation (itself mounted upon geotextile fabric) will be constructed prior to placement of crushed rock by excavating down to an approximate depth of 2 m. This detail will be finalized based on FEED-stage geotechnical investigations. Barges will be secured to three mooring piles, which will be driven into the seafloor using a conventional floating pile driving derrick. The final footprint of the ramp will be approximately 4,000 m^2 and range in width from approximately 13 m to 52 m. The ramp toe will sit at -0.2 m CD and extend approximately 90 m shoreward, where it will transition into a rock-filled causeway before reaching the shoreline.

PASSENGER BOAT LANDING

A passenger boat landing will be constructed to accommodate crew boats. This structure will constitute a floating crew (pontoon) dock with an articulated gangway and fixed trestle walkway connected to an earth-filled causeway. The causeway for the boat landing will be constructed from shore in a similar manner to the barge landing and have a final footprint of approximately 940 m^2, ranging in width from 5 m to 23 m. The toe of the causeway will be located at approximately +2 m CD and extend approximately 65 m inland. The floating 30 m long pontoons will be secured in place by guide piles (two on each side), which will be installed using a conventional floating pile-driving derrick barge. The floating pontoon will be connected to the causeway by a 30-m long articulated gangway and a 50-m long walkway, supported by two fixed pile trestles. Floating pontoons, gangway, and fixed trestles will be constructed offsite and delivered on a barge.

4.3 Project Activities

A variety of activities will occur during construction, operations and decommissioning of the proposed Project. All anticipated activities with the potential to interact with freshwater or marine fish and fish habitats are identified in Table 1.

Table 1 Project Phase and Associated Activities with the Potential to Interact with Freshwater and Marine Fish and Fish Habitat

Project Phase	Project Activity	Description of Relevant Activities
Construction	Site preparation	▪ Vegetation clearing and grubbing ▪ Grading ▪ Excavation ▪ Use of industrial equipment
	Onshore construction	▪ Vegetation clearing and grubbing ▪ Grading ▪ Excavation ▪ Use of industrial equipment ▪ Dewatering of channels ▪ Infilling
	Dredging and disposal at sea	▪ Dredging ▪ Disposal of dredgeate at sea at the previously-used Brown Passage disposal site
	Marine construction	▪ Infilling ▪ Pile installation ▪ Underwater blasting ▪ Installation of seawater intake and outfall pipes ▪ Vessel movements
	Waste management	▪ Stormwater/wastewater management
Operations	LNG production	▪ Presence of marine infrastructure
	LNG shipping	▪ Vessel movements
	Waste management	▪ Stormwater/wastewater management ▪ Seawater withdrawal
Decommissioning	Dismantling of land-based and marine infrastructure	▪ Removal of land-based and marine infrastructure ▪ Reclamation according to applicable legislation at time of decommissioning

4.4 Schedule

A tentative schedule for major Project activities is presented in Table 2. These dates are current time estimates but are based on preliminary Project design and engineering and are subject to change.

Table 2 Anticipated Project Schedule

Project Phase	Project Activity	Duration	Anticipated Schedule
Construction	Site preparation	2 years	2020-2022
	Onshore construction	3 years	2022-2025
	Dredging, including disposal at sea	3 years	2020-2023
	Marine construction	MOF: 1-2 years LNG jetty: 2-3 years	MOF: 2020-2022 LNG jetty: 2021-2024
	Commissioning and start-up	1 year	2025
Operations	LNG shipping, LNG production and waste management	25 years minimum	2026-2051+
Decommissioning	Dismantling of land-based and marine infrastructure	2-5 years	2052+ (will start approx. 12 months after the end of operations)

5 BIOPHYSICAL ENVIRONMENT

5.1 Freshwater Environment

5.1.1 Watercourses within the PDA

Watercourses within the PDA are typically short and narrow, draining wetlands and small ponds. All watercourses in the PDA and Digby Island are unnamed (non-Gazetted) and were therefore assigned alpha-numeric codes to distinguish them for the purpose of this Project (see Appendix H of the Application) (see Figure 7, Table 3). During four field programs conducted in 2014 and 2015, 60 of the 106 watercourse reaches were surveyed within or connected to the PDA. The longest watercourse within the PDA, watercourse J, has a mainstem length of 4.07 km, but the majority (80%) of watercourses in this area are less than 650 m long. Channels are narrow, as is typical of short watercourses, with a median width of 2.1 m Thirty-four of the watercourse reaches in the PDA were identified as fish bearing for at least part of their length (see Table 3), despite frequently containing suspected barriers to fish distribution. Glide/run habitat was the most prevalent habitat type surveyed, with approximately 22,300 m^2 delineated within the PDA. Also, within the PDA, important rearing and spawning habitat, along with critical migratory habitat, was found in 63%, 31%, and 22% of reaches surveyed, respectively. Cobble, gravel and fines were the most common dominant substrates within the watercourses in the PDA; organics were also the dominant substrate in a lesser number of watercourses in the PDA (see Appendix H of the Application).

Within the fish bearing watercourse reaches in the PDA, the habitat types are comprised of 12% pool, 62% glide, and 26% riffle/cascade.

The watercourses and lakes of Digby Island are typically of low pH (3.95-6.26 pH units), conductivity (17-74.8 µS/cm), alkalinity (<1.0-3.8 mg/L), and nutrient concentrations (nitrogen <0.43 mg/L) (see Section 4.5 of the Application). Three water quality stations within the PDA had pH from 3.52 to 3.96 and conductivity 30 to 37 µS/cm (see Table 8.2 in Appendix 2 of Appendix P of the Application) on the date sampled.

Table 3 Summary of Watercourses within the Project Development Area (Data from Appendix H of the Application)

Watercourse name	Total mainstem length (m)	Total tributary length (m)	Channel width (m) [1]	Habitat surveyed	Fish surveyed	Fish bearing	Stream class [1]	Barriers to fish distribution
A	592	181	1.70	Y	Y	Y	S3	Falls
B	423	0	1.60	Y	Y	N	S6	-
C	290	0	1.50	Y	Y	N	S6	Falls
D	74	0	0.90	Y	Y	N	S6	Falls
E	915	216	1.70	Y	Y	Y	S3	-
F	127	0	1.00	Y	Y	Y	S4	Cascades
G	1,012	215	2.50	Y	Y	Y	S3	Falls/Cascades
H	47	0	0.76	Y	Y	N	S6	-
I	39	0	-	Y	N	-	-	-
J	4,073	8,302	8.30	Y	Y	Y	S2	Cascades/ Beaver Dams
K	1,405	165	2.30	Y	Y	Y	S3	Cascades
L	739	0	1.20	Y	Y	Y	S4	-
T	478	0	-	-	-	-	-	-
V	40	0	-	Y	Y	-	-	Falls
W	266	0	5.42	Y	Y	Y	S3	-
Y	223	249	1.34	Y	Y	Y	S4	Cascades
Z	338	0	1.43	Y	Y	N	S6	Cascades
AA	340	0	-	Y	Y	-	-	Falls
AB	390	0	-	N	N	-	-	-
TT [2]	1,144	0	2.46	Y	Y	Y	S3	-

NOTES:
[1] = Channel width and stream class are based upon classification of the lowest reach of the watercourse system.
[2] = Watercourse TT was mapped as being infringed upon by the access road to the north (see Appendix H of the Application). More recent mapping has moved the watercourse outside of the PDA. For purposes of this CFHOP, this watercourse is considered to fall within the PDA unless future field surveys confirm it outside.

5.1.2 Fish Habitat and Species

Seven taxa of freshwater fish are reported within the watercourses of the PDA (see Figure 7): Dolly Varden (*Salvelinus malma*), cutthroat trout (*Oncornhynchus clarkii*), coho salmon (*O. kisutch*), Chinook salmon (*O. tshawytscha*), pink salmon (*O. gorbuscha*), threespine stickleback (*Gasterosteus aculeatus*), and sculpin sp. (likely either coastrange sculpin [*Cottus aleuticus*] or prickly sculpin [*C. asper*]). The cutthroat trout subspecies indicated to occur, based on Project location, is most likely to be the coastal cutthroat trout (*O. clarkii clarkii*), a blue-listed species in BC. Although pink salmon were not reported in freshwater watercourses, marine surveys observed several (5-10) spent pink salmon carcasses near the outflow of Watercourse J at the head of Delusion Bay on September 10, 2014. Further, in August, 2014, two adult pink salmon were captured by tangle net; the first at Spire Island and the second in Delusion Bay (see Appendix H of the Application). The sculpin species within the PDA were not identified, but upon review of Scott and Crossman (1973) and Klinkenberg (2015) only the two freshwater species, coastrange sculpin and prickly sculpin, are potentially within this area, and are typically found together (Brown et al. 1995).

Five of the seven freshwater fish species (Dolly Varden, cutthroat trout, coho salmon, Chinook salmon, and pink salmon) are CRA fishery species (see Table 4).

Table 4 Conservation Status of Freshwater Fish Species on Digby Island

Common Name	Scientific Name	Provincial Status[1,2]	Federal Status[3,4]
Dolly Varden	*Salvelinus malma*	Yellow (S4)	Not listed
Coastal cutthroat trout	*Oncorhynchus clarkii*	Blue (S3S4)	Not listed
Coho salmon	*Oncorhynchus kisutch*	Yellow (S4)	Not listed
Chinook salmon	*Oncorhynchus tshawytscha*	Yellow (S4)	Not listed
Pink salmon	*Oncorhynchus gorbuscha*	Yellow (S5)	Not assessed
Threespine stickleback	*Gasterosteus aculeatus*	Yellow (S5)	Not listed
Sculpin sp.	*Cottus aleuticus / Cottus asper*	Yellow (S5) [5]	*C. aleuticus*: Not listed *C. asper*: Not assessed

NOTES:

1 Yellow = Includes species that are apparently secure and not at risk of extinction. Blue = Includes any indigenous species or subspecies considered to be of Special Concern (formerly Vulnerable) in British Columbia. Taxa of Special Concern have characteristics that make them particularly sensitive or vulnerable to human activities or natural events.

2 S3=special concern, vulnerable to extirpation or extinction; S4=apparently secure; S5=Demonstrably widespread, abundant and secure.

3 Federal listing by Committee on the Status of Endangered Wildlife in Canada (COSEWIC)

4 None of these species are listed in the federal Species at Risk Public Registry under the *Species at Risk Act* (SARA)

5 Both sculpin species are Yellow listed (S5)

Fish sampling occurred in the PDA in May, August-September and October of 2014, as well as March-April 2015. The most commonly captured species in the PDA was threespine stickleback, representing 55% of the total 792 fish collected. Second in abundance was coho salmon (25%), followed, in order, by sculpin sp. (12%), Dolly Varden (5%), Chinook salmon (2%), and cutthroat trout (0.4%). No pink salmon fry were captured in freshwater the surveys, although they were expected to be present during the March / April surveys; their relative abundance and distribution is unknown (see Appendix H of the Application).

Presence of life stages indicates use of these watercourses for spawning, egg incubation, and rearing; that is, the full life cycle for most of these species. Specifically:

- Dolly Varden: The range of body sizes captured indicate that Dolly Varden are present at all life stages from young-of-the-year (YOY) to sexually mature (reproducing) adults (see Table 5). Thus, these watercourses are inferred to be used for spawning, incubation, emergence, and rearing by Dolly Varden.
- Cutthroat trout: Only two trout were measured, but these two fish represented the two extremes of the life history of YOY and sexually mature adults. Thus, these watercourses are inferred to be used for spawning, incubation, emergence, and rearing by coastal cutthroat trout.
- Coho salmon: Coho salmon were captured over a range of sizes indicative of YOY and parr. Thus, these watercourses are inferred to be used for spawning, incubation, emergence, and rearing by coho salmon.
- Chinook salmon: Only relatively large juveniles (>55 mm) of Chinook salmon were captured. In conjunction with the inappropriate spawning habitat for Chinook provided by the small watercourses (low gradient, small substrate, low velocity), watercourses are inferred to be used transiently by Chinook for rearing. Juveniles are potentially from nearby watercourses (e.g., Skeena River or Nass River) known to support spawning adults. Chinook spawning and rearing by YOY appear unlikely in the small watercourses of Digby Island.
- Threespine stickleback: The watercourses, ponds, and lakes of Digby Island support the full life cycle of this species.
- Sculpin sp.: The watercourses, ponds and lakes of Digby Island support the full life cycle of these species.

Table 5 Occurrence and sizes of fish reported on Digby Island, 2014-2015, and length of YOY and sexual maturity from the literature (see Appendix H of the Application)

Species	Range of body lengths (mm)	Number captured	Occurrence location (watercourse)s	Reported length of YOY	Reported length at sexual maturity
Dolly Varden	37-180	38	E, G, J, S[1], TT,W,Y	<50 mm [3] <60 mm [4]	≥ approx. 200 mm (anadromous southern Alaska form) [4]
Cutthroat trout	35-245	3	J, S[1]	<60 mm [5,6]	175-200 mm [7]
Coho salmon	29-127	201	E, F, G, J, K, L, S[1], TT, Y	40-54 mm [3]	>250 mm [8]
Chinook salmon	59-118 [2]	16	J	37-44 mm (spring fry) [9]	>500 mm
Threespine stickleback	23-70	439	J, S[1]		Highly variable by site and population
Sculpin sp.	23-151	96	E, F, G, J, K, S[1], W, Y	25-30 mm (*C. aleuticus*) [10] 35-40 mm (*C. asper*) [10]	Not documented Not documented

NOTES:

[1] Watercourse S is not within the PDA, but is on Digby Island immediately west of the Project area.
[2] all Chinook were captured in spring sampling.
[3] Dolloff and Reeves (1990).
[4] Armstrong and Morrow (1980).
[5] Moore and Gregory (1988).
[6] Rosenfeld and Boss (2001).
[7] Foster (2003).
[8] Scott and Crossman (1973).
[9] Peacock et al. (1996).
[10] Brown et al. (1995)

5.2 Marine Environment

5.2.1 Fish Habitat and Species

In-water infrastructure will be located off the south end of Digby Island (LNG jetty) and in Casey Cove (MOF and pioneer facility) (see Figure 2). Information on existing marine fish and fish habitats in these areas was collected through a desktop study and the following site-specific field studies:

- Intertidal surveys completed in July and September 2014, and August 2015
- Subtidal remotely operated vehicle (ROV) surveys completed in July and September 2014, and October 2015
- Eelgrass survey completed in August 2015
- Marine fish surveys completed in April and August 2014, March and October 2015, and February and May 2016

Marine fish habitats identified at south Digby Island and in Casey Cove include marine riparian habitat, intertidal habitats (e.g., soft sediment habitat supporting eelgrass beds), and subtidal habitats (e.g., rocky habitat supporting kelp species). Marine fish species, including CRA fishery species and species that support CRA fishery species (e.g., Pacific salmon and Pacific herring), are known to occur in both areas. A description of marine fish and fish habitat specific to the waters of south Digby Island and Casey Cove is provided below. See the Marine Fish and Fish Habitat Technical Data Report (see Appendix K of the Application) for additional details.

5.2.1.1 South Digby Island

MARINE RIPARIAN HABITAT

Marine riparian vegetation recorded along the southern shore of Digby Island is dominated by western hemlock (*Tsuga heterophylla*), Sitka spruce (*Picea sitchensis*), and western red cedar (*Thuja plicata*), interspersed with red alder (*Alnus rubra*) and Pacific crabapple (*Malus fusca*). Beneath this canopy is an understory composed of shrubs such as salal (*Gaultheria shallon*), salmonberry (*Rubus spectabilis*), and false lily-of-the-valley (*Maianthemum dilatatum*), as well as a variety of ferns, shrubs, wildflowers, sedges, grasses, and mosses.

INTERTIDAL HABITATS

Intertidal habitats around the south shore of Digby Island are rich and diverse, and underpinned by a range of substrate types. Mid- and high-intertidal zones are composed primarily of hard substrate (bedrock) with lesser amounts of gravel, cobble and boulder, transitioning to a mix of sand, gravel, and/or boulder in the low intertidal. This area is topographically complex, featuring several small, rocky islands and outcrops with some fine substrates in low-intertidal areas. The prevalence of hard substrate and physical complexity in this area supports a rich community of macroalgae. Green (primarily *Ulva* spp.), brown (primarily *Fucus* sp.), and red algae (largely *Mastocarpus* blade and crust) are common in mid and low intertidal zones, while kelp (*Alaria* spp., *Saccharina* spp., *Nereocystis* sp., *Costeria* sp.) are widespread in mid to low intertidal zones. Bull kelp (*Nereocystis leutkeana*) is also common in the waters around Spire, Tuck, and Metford Islands.

Eelgrass (primarily *Zostera marina*) occurs around the southern waters of Digby Island, particularly in low-intertidal, soft substrate (see Figure 8). These patches are, at times, interspersed with toothed surfgrass (*Phyllospadix serrulatus*), particularly in higher intertidal areas. Eelgrass beds are generally located west of the proposed LNG jetty. Between Frederick Point and Miller Point, sparse eelgrass is located inshore, whereas a number of larger, denser beds are located seaward in the low-intertidal.

Salt marsh is found around the south of Digby Island and is located west of Frederick Point (~500 m^2; Triton 2014) and near Miller Point. At Miller Point, the salt marsh extends from the upper limit of the intertidal zone back to the tree line in an area approximately 30 m long by 20 to 40 m wide. This salt marsh habitat transitions into an estuarine meadow at the mouth of Delusion Bay (Triton 2014).

SUBTIDAL HABITATS

Subtidal substrates observed at south Digby Island transition from rocky (boulder/bedrock, cobble/gravel) nearshore areas (pocketed with soft and shell substrates) to expansive reaches of soft bottom in deeper waters. Reflecting this depth-linked shift, more diversity is found in the rocky shallows than over deep soft substrates. A varied marine flora community thrives on the solid, sunlit substrates down to 5 m depth. At least eight kelp taxa were observed in the area: bull kelp, ribbon kelp (*Alaria marginata*), split kelp (*Saccharina groenlandica*), sugar kelp (*Laminaria saccharina*), *Agarum* spp., *Alaria* spp., *Laminaria* spp., and *Saccharina* spp. Bull kelp is particularly conspicuous in this highly dynamic area, but generally occurs at low abundance, in contrast to *Laminaria* and *Saccharina* kelps, which are abundant, particularly on boulder, bedrock, and soft bottom with shell or cobble near Spire and Tuck islands. At least seven red algae species also inhabit shallow rocky substrate in this area, particularly around Lima Point, Fredrick Point, and Spire and Tuck islands.

MARINE FISH SPECIES

All five species of Pacific salmon (juveniles) were observed within the southern waters of Digby Island, as well as surf smelt (*Hypomesus pretiosus*), Pacific sand lance (*Ammodytes hexapterus*), and Pacific herring (*Clupea pallasii*). Other CRA fishery species observed typically over varied soft bottom substrate include Pacific cod, whitespotted greenling (*Hexagrammos stelleri*), kelp greenling (*Hexagrammos decagrammus)*, rock sole (*Lepidopsetta bilineata*), slender sole (*Lyposetta exilis*), Dover sole (*Microstomus Pacificus*), yellowfin sole (*Limanda aspera*), starry flounder (*Platichthys stellatus*), big skate (*Raja binoculata*), cabezon (*Scorpaenichthys marmoratus*), copper rockfish (*Sebastes caurinus*), black rockfish (*S. melanops*), and quillback rockfish (*S. maliger*). Larval fish that could not be identified without genetic analysis (herein referred to as unidentified larval fish, and is a grouping that could possibly include eulachon, as well as other Osmerids) were also observed within the waters of south Digby Island.

CRA invertebrates observed within the southern waters of Digby Island include crustaceans such as Dungeness crab (*Metacarcinus magister*), tanner crab (*Chionoecetes bairdi*), red rock crab (*Cancer productus*), brown box crab (*Lopholithodes foraminatus*), spot prawn (*Pandalus platyceros*), humpback shrimp (*Pandalus hypsinotus*), and coonstripe shrimp (*Pandalus danae*). Dungeness crab and tanner crab were typically observed on soft bottom substrates, whereas red rock crab and the single brown box crab were observed over various substrate types (i.e., soft bottom, boulder, cobble, shell). Echinoderms, including giant California sea cucumber (*Parastichopus californicus*), and red urchin (*Strongylocentrotus franciscanus*), green urchin (*S. droebachiensis*), white urchin (*S. pallidus*), and purple urchin (*S. purpuratus)* were observed in areas with mixed rock substrates. Spiny scallop (*Chlamys hastata)* and smooth pink scallops (*Chlamys rubida*) were generally observed in deeper waters in the southern portion of the study area, and a giant Pacific octopus (*Enteroctopus dofleini*) was recorded over soft bottom substrate at a depth of approximately 30 m. Sediment-dwelling bivalves of CRA importance documented within south Digby Island include cockles (*Clinocardium sp.*), soft shell clam (*Mya arenaria*), and *Macoma* clams.

See Appendix 1, Table 1-1, of this report for a complete list of marine fish and invertebrate species observed at south Digby Island. For each species observed, the table identifies its conservation status, contribution to a CRA fishery, and the habitat zones and substrate types on which it is typically found.

5.2.1.2 Casey Cove

MARINE RIPARIAN HABITAT

Marine riparian vegetation observed within Casey Cove is similar to that observed along the southern shoreline of Digby Island. The dominant tree species are western hemlock, Sitka spruce, and western red cedar, interspersed with red alder and Pacific crab apple, which is typically covered in old man's beard (*Usnea* spp.). The understory is composed of shrubs (e.g., salmonberry), ferns, wildflowers, as well as sedges, terrestrial grasses, and mosses.

INTERTIDAL HABITATS

The high- and mid-intertidal zones in Casey Cove are composed primarily of gravel, cobble, and sand, with mud dominating the low intertidal. Salt-tolerant vegetation (e.g., sedge species and some terrestrial grasses and lichen) dominate the high intertidal zone. Green algae (primarily *Ulva* spp.), brown algae (primarily *Fucus* spp.) and some red algae (primarily *Mastocarpus* blade) are typically observed throughout the mid intertidal zone. Kelps (*Laminaria* spp., *Saccharina* spp., *Alaria* spp.) occur in the low intertidal, while eelgrass is common in sandy and muddy low intertidal substrates (see Figure 9). In particular, a relatively dense, continuous eelgrass bed occupies the shallow subtidal of western Casey Cove, with a fringe of sparse coverage extending to the head of the cove. A narrow patch also runs along the south shore of the cove. There are no salt marshes or estuarine meadows within Casey Cove (see Figure 9).

SUBTIDAL HABITATS

Subtidal substrate consists primarily of soft bottom with mixed substrates (soft bottom, shell, and cobble/gravel). Areas offshore from Charles Point are primarily bedrock/boulder with cobble/gravel, and mixed substrate. Subtidal areas are also littered with debris such as glass bottles, cables, and scrap metal. A mixed community of subtidal marine vegetation is found in the area. *Laminaria* kelps and bull kelp were identified on cobble/gravel or bedrock/boulder as well as on soft substrate, where shells act as anchor points. Sea lettuce (*Ulva* spp.), rockweed (*Fucus* spp.), ribbon kelp, and pink rock crust (*Lithomanion* spp.), and eelgrass are also present subtidally (see Figure 9).

MARINE FISH SPECIES

CRA fishery species observed within Casey Cove include juveniles belonging to all five species of Pacific salmon, in addition to a variety of other forage fish species (e.g., Pacific herring and surf smelt). Benthic/demersal species such as red Irish lord (*Hemilepidotus hemilepidotus),* whitespotted greenling, kelp greenling, lingcod *(Ophiodon elongates),* yellowtail rockfish (*Sebastes flavidus*), copper rockfish, rock sole, English sole, starry flounder, and Pacific tomcod *(Microgadus proximus)* were observed. Unidentified larval fish and unidentified larval smelt were also documented within Casey Cove.

CRA marine invertebrates observed within Casey Cove study include spiny scallop, red sea urchin, Dungeness crab, red rock crab and a number of sediment-dwelling bivalves: soft shell clam, *Macoma* clam, and cockles.

See Appendix 1, Table 1-1, of this report for a complete list of marine fish and invertebrate species observed in Casey Cove. For each species observed, the table identifies its conservation status, contribution to a CRA fishery, and the habitat zones and substrate types on which it is typically found.

6 ASSESSMENT METHODS

A stepwise approach is used to first identify potential *serious harm to fish*; then account for reductions in effects afforded by avoidance and mitigation measures; and ultimately, identify, quantify and characterise residual *serious harm to fish*. Having described the proposed Project works and activities (see Section 4) and existing biophysical conditions (see Section 5), the next step is to identify potential mechanisms of effects to fish arising through direct or habitat-mediated interactions between the Project and fish (see Section 7). Identification of these pathways provides insight into the potential (i.e., if completely unmitigated) *serious harm to fish* that could be caused by the Project. Avoidance and mitigation measures, which will collectively reduce the severity of harm caused to fish by the Project, are reviewed (see Section 8) and their beneficial influence taken into consideration before residual *serious harm to fish* is characterized (see Section 9). Throughout, effects to fish in marine and freshwater environments are separated but assessment of both systems follows the same methodology. The characterization of Project-associated residual *serious harm to fish* guides the development, design, and placement of offsetting features (see Section 10). Each step in this assessment methodology, and the ultimate determination of serious harm, will be updated to reflect the refinement of Project design, engineering plans, mitigation measures, and environmental data, and finalised in a Final Fish Habitat Offsetting Plan.

The first step is to identify the mechanisms of *serious harm to fish*. These mechanisms are the ways in which Project works or activities interact with fish or their habitats either directly (i.e., causing mortality) or indirectly through habitat effects. These interactions are such that the resulting effect could be of a duration, extent or magnitude that could impair the ability of a CRA fishery species to perform one or more life processes. Identification of these mechanisms therefore involves an analysis of the nature of overlap between the proposed Project works and activities (see Section 4) and the existing biophysical environment (see Section 5). At this part of the assessment, the effects arising through these mechanisms are considered in the absence of mitigation. Consequently, the objective of this step of the methodology is to simply identify the possible pathways through which fish could be seriously harmed.

Having identified mechanisms for *serious harm to fish*, the second step of the assessment methodology is to review best management practices (BMPs) and Project specific measures that would result in the avoidance or mitigation of *serious harm to fish* that are part of a CRA fishery. The measures considered follow the hierarchy of fisheries protection outlined in DFO's FPIP (DFO 2013a). First, efforts are considered that entirely avoid *serious harm to fish* during all Project phases. Such avoidance measures include Project location and design considerations, adoption of standard practices, and strategic timing of construction activities that have the potential to interact harmfully with fish during certain times of the year. Subsequently, mitigation measures are considered that reduce the extent, intensity and duration of impacts to fish that remain following the implementation of avoidance measures. Such mitigative considerations include the use of construction methods or equipment that, compared to standard options, reduce harmful effects on fish.

The third step of the assessment methodology is to characterize any remaining, unavoidable effects to fish following the implementation of avoidance and mitigation measures. Effects are characterized according to the following metrics or criteria: likelihood of an effect; duration; geographic extent; habitat availability; habitat dependency; magnitude; and whether or not the effect is likely to cause a localized effect on CRA fishery species (see Table 6). In each case, characterizations are ranked, based on criteria defined in Table 6, to capture the nature of this specific aspect of the effect. Collectively, these characterizations are assimilated to inform a justification of whether or not the effects to fish remaining after the implementation of avoidance and mitigation measures constitutes residual *serious harm to fish.* Any residual *serious harm to fish* typically requires a Section 35(2)(b) *Fisheries Act* Authorization and needs to be counterbalanced through offsetting (DFO 2013b).

To avoid repetition of information contained in the EA, a detailed assessment of potential Project-related change in mortality risk and change in habitat for freshwater and marine fish and fish habitats is not included in this Plan. Rather, the assessment of potential residual *serious harm to fish* (see Section 9) takes the conclusions of the Application (i.e., residual Project effects) and characterizes them in terms of residual *serious harm to fish*, using the criteria presented in Table 6. The characterization, description, and measures or categories used here (see Table 6) differ slightly to those presented in the Application. The reason for this discrepancy is that the measures used here focus both freshwater and marine assessments of Project residual effects with the metrics described in DFO's FPIP (DFO 2013a). Nevertheless, the characterisations of residual effects here are consistent with those presented in the Application.

Having determined those aspects of the Project expected to cause a localized effect on CRA fishery species, offsets are proposed that would counterbalance these effects. At this stage, proposed offsets are presented as conceptual options. These concepts are developed in keeping with the objectives, guiding principles and offsetting measures detailed in DFO's FPIP (DFO 2013a). Given their conceptual nature, these proposed measures are intended to serve as a starting point for discussion with DFO and during consultation with Aboriginal Groups (see Section 3). It is anticipated that offsets will be refined to incorporate recommendations received during consultation.

Table 6 Characterization of Residual Effects on Fish and Fish Habitat

Characterization	Description	Quantitative Measure or Definition of Qualitative Categories	
Likelihood	The probability of an adverse residual effect occurring following implementation of avoidance and mitigation measures. Likelihood is based upon confidence in the available relevant scientific literature, available engineering information and/or the effectiveness of avoidance and mitigation measures.	Low	Adverse interactions between the Project and fish and fish habitat can largely be avoided, and adverse residual effects are unlikely
		Medium	Adverse interactions between the Project and fish and fish habitat may be difficult to avoid, and adverse residual effects are likely
		High	Adverse interactions between the Project and fish and fish habitat cannot be practically avoided, and adverse residual effects are highly likely
Duration	The period of time required until the effect can no longer be measured or otherwise perceived.	Short-term	Residual effect is measurable for a few hours to a few months
		Medium-term	Residual effect is measurable for many months to a few years
		Long-term	Residual effect is measurable for many years
		Permanent	Residual effect continues indefinitely
Geographic Scale	Whether the spatial extent of an effect is expected to displace fish that would otherwise be occupying the affected habitat.	Small	The geographic scale of the disturbance will not displace fish that would otherwise be occupying the affected habitat.
		Large	The geographic scale of the disturbance will displace fish that would otherwise be occupying the affected habitat.
Habitat Availability	The availability and condition of nearby habitat. Effects to a fish population or stock from the permanent alteration or destruction of habitat may be greater if the availability and condition of nearby habitat is low.	Low	The habitat that is being permanently altered or destroyed is the only habitat of its type and quality in the immediate vicinity of the Project.
		Moderate	The same type and quality of habitat that is being permanently altered or destroyed is present but not abundant in the area of the Project.
		High	The same type and quality of fish habitat that is being permanently altered or destroyed is highly abundant in the area of the Project.
Habitat Dependency	Dependency on habitats by fish populations is a function of both the life processes they support and the relative abundance of alternative habitat of the same type and quality available for use nearby (i.e., within a distance reasonably accessible by the species in question).	Negligible	Species are not expected to use affected habitat to carry out one or more of their life processes.
		Low	Species use affected habitat to carry out life processes, but similar habitat is available in the local area that provides the same ecological function(s).
		Medium	Species use affected habitat to carry out life processes, but some similar habitat is available in the local area that provides the same ecological function(s) albeit not in abundance.
		High	Species rely entirely on affected habitat to carry out one or more of their life processes, and these processes cannot be derived from other habitats nearby.

Table 6 Characterization of Residual Effects on Fish and Fish Habitat

Characterization	Description	Quantitative Measure or Definition of Qualitative Categories	
Magnitude	The amount of change relative to existing conditions.	Low	No measurable change to existing fish or fish habitat.
		Moderate	A measurable change to existing fish or fish habitat that does not have potential to adversely affect the ongoing productivity or sustainability of fish populations or stocks.
		High	A measurable change to existing fish or fish habitat that has potential to adversely affect the ongoing productivity or sustainability of fish populations or stocks.
Localized Effect	Whether the Project impacts are expected to have an effect on fish or fish habitat that could reduce the productivity of fish populations or stocks that utilize the Project area.	No	A localized effect is not expected after application of avoidance and mitigation measures.
		Yes	A localized effect is expected after application of avoidance and mitigation measures.
Residual *Serious Harm to Fish*	Whether *serious harm to fish* is expected after efforts have been made to avoid and mitigate potential Project effects.	No	No residual *serious harm to fish* from Project activity or work is expected.
		Yes	Residual *serious harm to fish* from Project activity or work is expected.

7 MECHANISMS FOR SERIOUS HARM TO FISH

The following sections provide a summary of the mechanisms by which the Project could result in *serious harm* to freshwater and marine fish, through the death of fish and the permanent alteration or destruction of fish habitat. For a more detailed discussion of effect mechanisms, please refer to Section 4.8.5 (freshwater fish and fish habitat) and Section 4.9.5 (marine fish and fish habitat) of the Application.

7.1 Freshwater

For purposes of offsetting, all watercourses and associated riparian areas within the PDA are assumed to be permanently removed, with the exception of watercourse reaches J1 to J5 and J1.1 (see Figure 7). The Project requires the area in and around the watercourses in the PDA for facility development, as well as non-vegetated, 'no-grow' zones around the Project facilities for safety (i.e., fire risk reduction).

Project activities that are considered to have the potential to cause *serious harm* to freshwater fish through the death of fish or the permanent alteration or destruction of fish habitat are indicated by check marks in Table 7. The mechanisms by which these activities could cause *serious harm* are described in the following sections. Other effect mechanisms that may adversely affect freshwater fish, but that are not expected to cause *serious harm* following the implementation of avoidance and mitigation measures, are as follows:

- Change in water temperature, dissolved oxygen, nutrients, or food supply.
- Change in sediment or contaminant concentrations
- Change in access to habitats or migration patterns

These mechanisms and the corresponding residual Project effects are discussed in detail in Section 4.8.5 of the Application, but are not considered further in this plan.

Table 7 Mechanisms for *Serious Harm to Fish* in the Freshwater Environment

Phase	Activity	Mechanisms for Death of Fish	Mechanisms for Permanent Alteration or Destruction of Fish Habitat
		Crushing, burial, entrainment or impingement	Change in habitat structure and cover
Construction	Site preparation	✓	✓
	Onshore construction	✓	✓
	Dredging and disposal at sea	-	-
	Marine construction	-	-
	Waste management	-	-
Operations	LNG production	-	-
	LNG shipping	-	-
	Waste management	-	-
Decommissioning	Dismantling of land-based and marine infrastructure	*Serious harm to fish* occurring during decommissioning will be assessed at that time and in accordance with best practices and legislation in place at that time.	

7.1.1 Mechanisms for Death of Fish

7.1.1.1 Crushing, Burial, Entrainment or Impingement

During construction, fish (all life stages from gametes to adults, as defined in the *Fisheries Act*) have the potential to be buried beneath deposited material; crushed by construction equipment, machinery, or material; or removed from the watercourse by excavation and deposited on land. The extent to which this mechanism could affect fish depends on the species of fish present in the affected area, their ability to avoid the disturbance, and the nature of connectivity to downstream reaches during construction.

Extraction of water from watercourses during watercourse dewatering processes prior to watercourse infilling may cause fish mortality due to entrainment in intakes or impingement on screens around intakes.

7.1.2 Mechanisms for Permanent Alteration or Destruction of Fish Habitat

7.1.2.1 Change in Habitat Structure and Cover

Infilling of watercourses and removal of riparian vegetation will remove fish habitat within the PDA. For infilled watercourses, this habitat will no longer support fish. The infilling of habitat within all watercourses of the PDA, with the exception of Watercourse J, is anticipated to result in loss of fish productivity.

7.2 Marine

Project activities that are considered to have the potential to cause *serious harm* to marine fish through the death of fish or the permanent alteration or destruction of fish habitat are indicated by check marks in Table 8. The mechanisms by which these activities could cause *serious harm* are described in the following sections. Other effect mechanisms that may adversely affect marine fish, but that are not expected to cause *serious harm* following the implementation of avoidance and mitigation measures, are as follows:

- Change in behaviour of marine fish due to exposure to underwater noise and changes in lighting conditions
- Change in health of marine fish due to exposure to elevated levels of total suspended solids
- Change in habitat at the Brown Passage disposal at sea site due to deposition of sediment.

These mechanisms and the corresponding residual Project effects are discussed in detail in Section 4.9.5 of the Application, but are not considered further in this plan

Table 8 Mechanisms for *Serious Harm to Fish* in the Marine Environment

Phase	Activity	Mechanisms for Death of Fish		Mechanisms for Permanent Alteration or Destruction of Fish Habitat		
		Crushing, burial, entrainment, or impingement	Exposure to underwater noise or pressure waves	Removal of vegetation[1] (e.g. riparian, eelgrass)	Change in substrate height, shape, or type	Removal of substrate
Construction	Site preparation	-	-	✓	-	-
	Onshore construction	-	-	-	-	-
	Dredging	✓	-	✓	✓	-
	Disposal at sea	✓	-	-	-	-
	Marine construction	✓	✓	✓	✓	✓
	Waste management	-	-	-	-	-
Operations	LNG production	-	-	-	-	-
	LNG shipping	-	-	-	-	-
	Waste management	✓	-	-	-	-
Decommissioning	Dismantling of land-based and marine infrastructure	*Serious harm to fish* occurring during decommissioning will be assessed at that time and in accordance with best practices and legislation in place at that time.				

NOTE:
[1] Marine macroalgae are considered via change in, or removal of, substrate.

7.2.1 Mechanisms for Death of Fish

7.2.1.1 Crushing, Burial, Entrainment, or Impingement

Dredging at the LNG jetty berths and at the MOF will physically remove sediment and rock from within the footprint of the dredge pockets, which will result in the mortality of associated organisms (e.g., invertebrates attached to rocky substrates and infaunal organisms inhabiting soft substrates). Disposal of sediment at sea will result in the deposition of sediment on the seafloor, which could potentially bury or crush sessile or slow moving organisms.

Infilling will be required for construction of the LNG jetty, concrete caisson MOF, and pioneer facility. In these areas, sessile or slow moving organisms, as well as eggs and planktonic larvae, may be crushed or buried during placement of fill material. Pile installation at the LNG jetty and MOF may also crush epibenthic and infaunal organisms present within the footprint of each pile. Trenching through intertidal and shallow subtidal habitats for installation of the seawater intake and outflow pipes, and laying the pipes on the seafloor, also have the potential to cause injury or mortality to marine organisms.

During operations, larval or juvenile fish and invertebrates may become entrained in the seawater intake pipe located off Charles Point, or impinged on the fine screens at the pump station, resulting in mortality.

7.2.1.2 Exposure to Underwater Noise or Pressure Waves

Marine fish are at risk of injury or mortality from exposure to underwater noise impulses generated during pile driving and blasting activities. Underwater noise can cause barotrauma injuries to fish as a result of sudden changes in pressure, which can damage major organs and surrounding tissues. Barotrauma injuries can lead to immediate or delayed mortality (e.g., rupture of the swim bladder), or cause injuries that are potentially recoverable (e.g., loss of sensory hair cells). The severity of effects depends on the intensity of the underwater noise, the life stage, and the physiology of the fish (e.g., presence and function of swim bladder).

7.2.2 Mechanisms for Permanent Alteration or Destruction of Fish Habitat

7.2.2.1 Loss of Marine Vegetation

Site preparation will require the removal of marine riparian vegetation in areas where Project infrastructure abuts the marine environment. This includes shoreline areas at the MOF and pioneer facility in Casey Cove, and at northern end of the LNG jetty at Frederick Point.

Dredging and infilling for the MOF and installation of the seawater intake and outfall pipes will result in the loss of eelgrass in Casey Cove.

7.2.2.2 Change in Substrate Height, Shape, or Type

Dredging, infilling, and installation of the seawater intake and outfall pipes will affect the height (depth or elevation), shape (topography: aspect, complexity, rugosity) and type (e.g. bedrock, boulder, cobble, gravel, sand, and mud) of marine substrate. Substrates form the physical underpinnings of fish habitat. As such, changes to marine substrate can translate into shifts in marine communities and productivity, in some cases impairing the ability of marine species to perform one or more life process.

7.2.2.3 Loss of Substrate

Infilling and pile installation associated with construction of the MOF, pioneer facility, and LNG jetty will result in the removal of intertidal and subtidal substrates.

8 AVOIDANCE AND MITIGATION OF *SERIOUS HARM TO FISH*

8.1 General Approach

Fisheries and Oceans Canada has a clearly defined hierarchy of preference as part of its mandate to protect fish and fish habitat (DFO 2013b). This hierarchy emphasizes that impacts should first be avoided wherever possible to prevent their occurrence. Where avoidance is not possible, mitigation measures must be implemented to minimize potential impacts caused by Project activities. Finally, where impacts cannot be avoided or fully mitigated (a residual effect remains), offsetting is likely required. Avoidance measures employed as part of the Project design are listed in Section 8.2. Mitigation measures that will be implemented during Project construction and operations are summarized in Table 9 (freshwater) and Table 10 (marine).

8.2 Avoidance Measures

Aurora LNG has incorporated the following avoidance measures into the design of the Project to reduce effects to fish freshwater and marine fish and fish habitat, and, in so doing, *serious harm to fish*:

- The current LNG jetty position was moved from a previous location farther east near Miller Point, which has resulted in reduced impact on fish habitat.
- Previous designs of the LNG jetty included three berths, while current designs include only two, a change that is expected to reduce effects on marine fish.
- The original location of Project infrastructure has been reconfigured to avoid removal of Watercourse J and associated riparian areas.

8.3 Mitigation Measures

8.3.1 Freshwater

Aurora LNG will implement a suite of mitigation measures designed to reduce potential Project effects on freshwater fish and fish habitat and, consequently, *serious harm to fish*. These measures are listed in Table 9.

8.3.1 Marine

Aurora LNG will implement a suite of mitigation measures designed to reduce Project effects on marine fish and fish habitat and, consequently, *serious harm to fish*. These measures are listed in Table 10.

Table 9 Measures to Mitigate *Serious Harm to Fish* in the Freshwater Environment

Mitigation No.[1]	Mitigation Measure	Applicable to	
		Mitigating Potential Death of Fish	Mitigating Potential Permanent Alteration or Destruction of Fish Habitat
4.8-1	Aurora LNG will avoid sensitive periods (e.g. spawning, rearing, and emergence) during construction, where possible, or isolate areas and conduct a fish salvage prior to construction. Any salvaged fish will be relocated to suitable habitat downstream or a nearby watercourse.	✓	-
4.8-3	Aurora LNG will reduce disturbance to riparian areas, to the extent possible, and will avoid watercourses and riparian areas not within the footprint of the Project. Exclusion fencing will be installed to delineate the protected areas.	-	✓
4.8-5	A disturbance buffer defined as riparian reserve zone (RRZ; BC Environmental Protection and Management Regulation) will be applied to the two freshwater watercourses (J1 – J5 and J1.1 – Figure 4.8-2) which surround the proposed camp location. Where possible, the riparian management area (RMA) will also be protected.	✓	-
4.8-6	An environmental monitor will be on-site during all instream works to monitor for potential harm to fish.	✓	✓
4.8-7	Aurora LNG will obtain all relevant environmental permits to conduct instream works or extract water, and will adhere to BMPs and Guidelines indicated in the conditions of the permit.	✓	✓
4.8-9	Prior to construction or salvage, Aurora LNG will block fish access to affected watercourses, to prevent harm to fish.	✓	
4.8-10	Discharged water quality (e.g., TSS and turbidity) will meet guidelines for the protection of aquatic life. Erosion and Sediment Control facilities will receive diverted site run-off prior to discharge into existing watercourses/marine environment.	✓	✓
4.8-12	Concrete works on site will be contained so that no untreated concrete water runoff or wash-water will enter the nearby freshwater or marine environment. Equipment to contain, and neutralize the pH (e.g. CO_2) will be kept on site at all times during these works.	✓	-
4.8-13	All construction equipment on site will be kept clean, free of leaks, and will have spill kits. Where possible, fueling of construction vehicles will take place at least 30 m away from any watercourse or waterbody.	✓	-
4.8-14	While on site, workers will be prohibited from recreational or commercial fishing within the LAA during all stages of the Project.	✓	-

NOTE:
[1] Mitigation number corresponds to numbering in Section 4.8 of the Application.

Table 10 Measures to Mitigate *Serious Harm to Fish* in the Marine Environment

Mitigation No.[1]	Mitigation Measure	Applicable to	
		Mitigating Potential Death of Fish	Mitigating Potential Permanent Alteration or Destruction of Fish Habitat
4.5-1	A 30 m marine riparian disturbance buffer will be applied, except where infrastructure access to the marine environment is required (e.g. Marine Terminal, Material Offloading Facility), or for safety or security considerations. On the east side of Digby Island this buffer will be of variable width, extending beyond the 30 m minimum in some areas.	-	✓
4.5-2	Erosion and sediment control measures will be implemented during on-land construction activities.	-	✓
4.5-3	A water quality monitoring program will measure turbidity during dredging to identify exceedances of predicted TSS values outside the work area.	-	✓
4.5-5	Dredging will employ suitable methods to reduce sediment spill and dispersion.	-	✓
4.5-6	Silt curtains will be used, where practicable, to reduce the spatial extent of suspended sediments in the marine water column during dredging activities.	-	✓
4.9-1	Materials that promote colonization of algae and invertebrates will be used during construction of in-water infrastructure (e.g., rocky substrate along the LNG jetty trestle).	✓	✓
4.9-3	Guidelines for underwater blasting outlined in Wright and Hopky (1998) and DFO (2013c) will be followed during blasting activities.	✓	✓
4.9-4	Pile installation procedures will follow the Best Management Practices for Pile Driving and Related Operations (BC Marine and Pile Driving Contractors Association 2003)	✓	✓
4.9-5	Rock or sediment removed from the dredge area will be salvaged and used for construction or habitat offsetting (if feasible).	✓	✓
4.9-6	Intertidal construction areas will be delineated using flagging to limit the area affected by construction.	✓	✓
4.9-7	Following trenching/backfilling for installation of the seawater intake and outflow pipes, intertidal and subtidal substrates will be returned to conditions similar to those prior to construction.	✓	✓
4.9-8	Dredging and disposal activities will be conducted during DFO's least risk timing window (November 30 to February 15) (DFO 2014)	✓	-

Table 10 Measures to Mitigate *Serious Harm to Fish* in the Marine Environment

Mitigation No.[1]	Mitigation Measure	Applicable to	
		Mitigating Potential Death of Fish	Mitigating Potential Permanent Alteration or Destruction of Fish Habitat
4.9-9	Underwater blasting will be conducted during DFO's least risk timing window (November 30 to February 15) (DFO 2014).	✓	-
4.9-10	Bubble curtains will be installed around the blast area to provide noise attenuation and reduce underwater sound levels emitted into the marine environment.	✓	-
4.9-11	During impact pile driving, enclosed bubble curtains will be installed around piles to provide noise attenuation and reduce underwater sound levels emitted into the marine environment.	✓	-
4.9-12	A ramp-up procedure will be used for impact pile driving that will involve the steady and gradual build-up of underwater acoustic energy output from a lower energy level to full output.	✓	-
4.9-15	An Environmental Monitor will be onsite at all times during active in-water impact pile driving and underwater blasting to monitor for fish kills. If a fish kill is observed, the activity will be temporarily suspended, and additional mitigation measures will be discussed with DFO.	✓	-
4.9-16	Siting and design of the seawater intake pipe will follow DFO guidelines for minimizing entrainment and impingement of aquatic organisms at marine intakes (Fedorenko 1991)	✓	-

NOTE:

[1] Mitigation number corresponds to numbering in Sections 4.5 and 4.9 of the Application

9 DETERMINATION OF RESIDUAL *SERIOUS HARM TO FISH*

This section characterizes residual *serious harm to fish* resulting from Project activities and provides a determination on the expected requirements for offsetting. To avoid repetition of information contained in the Application, a detailed assessment of potential Project-related change in mortality risk and change in habitat for freshwater and marine fish and fish habitats is not included here. Rather, the assessment takes the conclusions of the Application (i.e., residual Project effects) and summarizes them in terms of residual *serious harm to fish*, using the criteria presented in Table 6. For a detailed assessment of Project-related change in mortality risk and change in habitat, please refer to Section 4.8.5 (freshwater fish and fish habitat) and Section 4.9.5 (marine fish and fish habitat) of the Application.

9.1 Freshwater

9.1.1 Death of Fish

Mortality caused by crushing, burial, entrainment or impingement is expected to be greatly reduced through the implementation of mitigation measures described in Table 9. Nevertheless, it is anticipated there may be some unavoidable death of fish but that, in all cases, this mortality will not affect the productivity of local populations or stocks of CRA fishery species. Residual effects on fish caused by mortality and conclusions regarding associated residual *serious harm to fish* are summarised in Table 11.

9.1.1.1 Crushing, Burial, Entrainment or Impingement

Mortality through crushing or burial as a result of site preparation or onshore construction may cause some mortality if fish are prevented from freely leaving the area in a downstream direction, or incomplete salvage of fish occurs due to their cryptic behaviour or turbid water preventing visibility. Mortality through entrainment into pumps or impingement on pump fish screens during channel dewatering may occur if pumps are improperly screened or screens lose integrity during operation.

With the implementation of fish salvage prior to construction and the exclusion of immigration by maintenance of barrier nets, the residual effect of fish mortality is considered to have a low likelihood of occurrence and is predicted to be low in magnitude. Appropriate screening of water intakes during dewatering is also expected to result in a low magnitude effect with a low likelihood of occurrence. Although unlikely, should a small number of fish be killed during Project construction works (e.g. creek infilling), it is not expected to have a population level effect, based on existing knowledge and data from freshwater fish surveys of Digby Island in 2014 and 2015. It is anticipated that these individuals, of the affected species, will be replaced within one to two generations, as appropriate fish habitat (e.g. spawning, rearing, migratory) for all life stages of the identified species in the PDA, will remain accessible on Digby Island and within the PDA. Therefore, the duration of the effect is considered to be medium-term. With the implementation of avoidance and mitigation measures, the potential mortality of a limited number of fish is not expected to affect the productivity of local populations or stocks of CRA fishery species. Consequently, no residual *serious harm to fish* is anticipated as a result of crushing, burial, entrainment or impingement during Project construction (see Table 11).

Table 11 Characterization of Residual Effects and Summary of Residual *Serious Harm to Fish* resulting from Death of Fish in the Freshwater Environment

Mechanism	Phase: Activity	Mitigation Measures	Summary of Effect	Characterization of Residual Effect			Localized Effect	Residual *Serious Harm to Fish*	Habitat Offsets Proposed?
				Likelihood	Duration	Magnitude			
Crushing, burial, entrainment or impingement	Construction: Site preparation	Fish salvage; maintain barrier to upstream movement; infill upstream to downstream	Crushing or burial beneath equipment, machinery, or fill; excavation and deposition on land	L	MT	L	N	N	N
	Construction: Onshore construction	Fish salvage; maintain barrier to upstream movement; infill upstream to downstream; water intake screening	Crushing or burial beneath equipment, machinery, or fill; excavation and deposition on land; entrainment or impingement on screen during dewatering	L	MT	L	N	N	N

KEY
See Table 6 for detailed definitions

LIKELIHOOD:
L: Low
M: Medium
H: High

DURATION:
ST: Short-term;
MT: Medium-term
LT: Long-term
P: Permanent

MAGNITUDE:
L: Low
M: Moderate
H: High

LOCALIZED EFFECT:
Y: Yes
N: No

RESIDUAL SERIOUS HARM TO FISH:
Y: Yes
N: No

HABITAT OFFSETS PROPOSED?
Y: Yes
N: No

9.1.2 Permanent Alteration or Destruction of Fish Habitat

9.1.2.1 Change in Habitat Structure and Cover

The infilling of watercourses and removal of riparian vegetation within the PDA, to the extent of 10,857 m^2 and 218,830 m^2, respectively, is expected to result in residual *serious harm to fish* through the permanent removal of functioning fish habitat (see Table 12). Loss of instream habitat and riparian vegetation is expected to occur during site preparation and onshore construction. These losses are likely to occur, since the instream and riparian vegetation areas to be removed fall within the footprints of facility infrastructure or access zones, which will be cleared or infilled. The removal of riparian vegetation is expected to be measurable, but will occur mainly in areas where the watercourse will be removed, and will have no impact on the productivity or sustainability of remaining watercourses and fish populations. Avoidance measures (see Section 8.2) have reduced the habitat area to potentially be infringed by the Project, and mitigation measures (see Table 9) will be implemented to reduce harm to fish. However, the residual effect is expected to be permanent in duration, large in geographic scale, moderate in magnitude, and affect a habitat that has moderate availability. Consequently, the loss of instream and riparian habitats is expected to constitute residual *serious harm to fish*, and offsetting is expected to be required (see Table 12).

Table 12 Characterization of Residual Effects and Summary of Residual *Serious Harm to Fish* Resulting from Permanent Alteration or Destruction of Freshwater Fish Habitat

Mechanism	Phase: Activity	Mitigation Measures	Summary of Effect	Characterization of Residual Effect							Localized Effect	Residual *Serious Harm to Fish*	Habitat Offsets Proposed?
				Spatial Extent (m^2)	Likelihood	Duration	Geographic Scale	Habitat Availability	Habitat Dependency	Magnitude			
Change in habitat structure and cover	Construction: Site preparation	Avoidance of sensitive habitats; sediment and erosion control measures; adherence to BMPs	Loss of instream and riparian habitats	10,857 (instream) 218,830 (riparian)	H	P	L	M	L	M	Y	Y	Y
	Construction: Onshore construction	Avoidance of sensitive habitats; sediment and erosion control measures; adherence to BMPs	Loss of instream and riparian habitats		H	P	L	M	L	M	Y	Y	Y

KEY
See Table 6 for detailed definitions

LIKELIHOOD
L: Low
M: Medium
H: High

DURATION:
ST: Short-term;
MT: Medium-term
LT: Long-term
P: Permanent

HABITAT DEPENDENCY
N: Negligible
L: Low
M: Medium
H: High

MAGNITUDE:
L: Low
M: Moderate
H: High

GEOGRAPHIC SCALE
S: Small
L: Large

HABITAT AVAILABILITY
L: Low
M: Moderate
H: High

LOCALIZED EFFECT
Y: Yes
N: No

RESIDUAL SERIOUS HARM TO FISH
Y: Yes
N: No

HABITAT OFFSET PROPOSED?
Y: Yes
N: No

9.2 Marine

9.2.1 Death of Fish

Mortality caused by crushing, burial, entrainment, or impingement, and exposure to underwater noise or pressure waves is expected to be greatly reduced through the implementation of avoidance and mitigation measures described in Table 10. Nevertheless, it is anticipated there will be some unavoidable death of fish but that, in all cases, this mortality will not affect the productivity of local populations or stocks of CRA fishery species. All mortality arising as a result of Project activities is anticipated to be accounted for in the proposed offsetting through the implementation of precautionary offset ratios (see Section 10.5). Residual effects on fish caused by mortality and conclusions regarding associated residual *serious harm to fish* are summarised in Table 13.

9.2.1.1 Crushing, Burial, Entrainment or Impingement

Some mortality of marine fish and invertebrates is expected to occur through crushing or burial during all Project activities that involve physical contact with the seafloor. This includes dredging, disposal at sea, infilling, pile installation, and installation of the seawater intake and outflow pipes. In all cases, the most susceptible organisms are those that lack the ability to move away from or avoid the active work area. In rocky habitats, this includes sessile or slow-moving invertebrates (e.g., mussels, barnacles, limpets, snails, small crabs, seastars, urchins, sea cucumbers) and finfish that take refuge in rocky crevices or macroalgal habitats (e.g., gunnels, pricklebacks, sculpins). In soft sediment habitats, susceptible species include sessile or slow-moving epibenthic invertebrates (e.g., sea pens, seastars, small crabs, shrimps), infaunal organisms (e.g., clams, worms), and some small benthic finfish (e.g., gobies, poachers, eelpouts). More mobile fish and invertebrates (e.g., juvenile salmon, Pacific herring, surf smelt, flatfish, Dungeness crabs) are less susceptible to crushing and burial because they are considered more likely to avoid areas of active in-water construction. However, the mobility of these species does not preclude the possibility that a relatively small number may be killed during construction.

With the implementation of avoidance and mitigation measures described in Section 8, mortality of marine fish and invertebrates through crushing or burial will be limited to the in-water footprint of Project works. While the loss of individual organisms will be permanent, recolonization of available habitats (e.g., dredge pockets, Brown Passage disposal site, rip-rap revetments around infill areas) is expected to occur rapidly via larval dispersal and immigration from nearby habitats. Most of the affected species have high intrinsic population growth rates, and individuals killed during construction are expected to be replaced within one to two generations. Therefore, mortality from crushing or burial during Project construction is considered to be moderate in magnitude, with no measurable effect on the productivity of local populations or stocks of CRA fishery species. No residual *serious harm to fish* is expected as a result of crushing or burial during Project construction (see Table 13).

Table 13 Characterization of Residual Effects and Summary of Residual *Serious Harm to Fish* resulting from Death of Fish in the Marine Environment

Mechanism	Phase: Activity	Mitigation Measures	Summary of Effect	Characterization of Residual Effect			Localized Effect	Residual *Serious Harm to Fish*	Habitat Offsets Proposed?
				Likelihood	Duration	Magnitude			
Crushing, burial, entrainment or impingement	Construction: Dredging and disposal at sea	Timing restrictions	Mortality caused by crushing or burial during dredging and disposal at sea	H	MT-LT	M	N	N	N
	Construction: Marine construction	Demarcation of intertidal construction areas	Mortality caused by crushing or burial during infilling, pile installation, and trenching to install seawater system intake and outflow pipes	H	MT-LT	M	N	N	N
	Operations: Waste management	DFO guidelines on the siting and design of seawater intakes	Mortality caused by entrainment in seawater intake pipe or impingement on intake screens	H	MT-LT	M	N	N	N
Exposure to underwater noise or pressure waves	Construction: Marine construction	Timing restrictions; enclosed bubble curtains; pile installation BMP; onsite QEM	Mortality caused by exposure to intense underwater noise or pressure waves produced during impact pile driving and underwater blasting	H	MT-LT	M	N	N	N

KEY
See Table 6 for detailed definitions

LIKELIHOOD:
L: Low
M: Medium
H: High

DURATION:
ST: Short-term;
MT: Medium-term
LT: Long-term
P: Permanent

MAGNITUDE:
L: Low
M: Moderate
H: High

LOCALIZED EFFECT:
Y: Yes
N: No

RESIDUAL SERIOUS HARM TO FISH:
Y: Yes
N: No

HABITAT OFFSET PROPOSED?
Y: Yes
N: No

During operations, some marine organisms are expected to be killed as a result of entrainment in the seawater intake pipe and impingement on the fine screens at the shore-based pump station. However, through adherence to DFO's guidelines on the siting and design of seawater intakes (Fedorenko 1991), mortality of marine organisms is expected to be limited to the larvae and juveniles of fish and invertebrates that have depth distributions that overlap with the intake terminus (-25 m CD). This includes larval crabs, echinoderms (e.g., urchins, sea cucumbers), and the larvae and juveniles of demersal fish (e.g., flatfish, Pacific cod, pollock). Fish species with larval and juvenile stages that are distributed in near-surface waters (e.g., juvenile salmon, larval eulachon, larval and juvenile surf smelt, larval and juvenile Pacific herring) are considered unlikely to become impinged or entrained in the seawater intake.

The magnitude of mortality resulting from entrainment or impingement during Project operations is considered moderate. While this mortality is, by definition, permanent, individuals killed are expected to be replaced within one to two generations of the affected species. Therefore, the duration of this effect is considered to be medium-term to long-term. With adherence to DFO's guidelines for seawater intakes, the residual effect is not expected to affect the productivity of local populations or stocks of CRA fishery species. Consequently, no residual *serious harm to fish* is anticipated as a result of entrainment or impingement during Project operations (see Table 13).

9.2.1.2 Exposure to Underwater Noise or Pressure Waves

Death of fish as a result of exposure to underwater noise or pressure waves generated by impact pile driving and underwater blasting is expected to be greatly reduced following the implementation of avoidance and mitigation measures described in Section 8. For underwater blasting, adherence to DFO's least-risk work window (November 30 – February 15) will avoid overlap with sensitive species and life stages, including outmigrating juvenile salmon and larval eulachon. For impact pile driving, enclosed bubble curtains will be installed around the full wetted length of each pile to attenuate underwater noise and reduce the distances within which fish could be injured or killed. Both activities will be conducted following DFO guidelines and BMPs (Wright and Hopky 1998, BC Marine and Pile Driving Contractors Association and DFO 2003, DFO 2013c), which are designed to reduce potential mortality of fish.

Despite the implementation of avoidance and mitigation measures, some marine fish occurring close to the sites of impact pile driving and underwater blasting may be killed as a result of pressure waves produced by these activities. For this reason, an environmental monitor (EM) will be onsite during all periods of active impact pile driving and underwater blasting to observe for potential fish kills. In the event a fish kill is observed, the activity will be temporarily suspended and additional mitigation measures will be discussed with DFO. While the presence of a EM will not necessarily prevent fish from being killed, it will allow for the assessment of mitigation performance effectiveness.

With the implementation of mitigation measures, mortality resulting from exposure to underwater noise or pressure waves is considered to be moderate in magnitude. While any mortality that does occur will be permanent, individuals killed are expected to be replaced within one to two generations of the affected species. Therefore, the duration of this effect is expected to be medium-term to long-term. The loss of a relatively small number of individuals is not expected to affect the productivity of local populations or stocks of CRA fishery species. Consequently, no residual *serious harm to fish* is anticipated as a result of exposure to underwater noise or pressure waves during Project construction (see Table 13).

9.2.2 Permanent Alteration or Destruction of Fish Habitat

9.2.2.1 Loss of Marine Vegetation

Following the implementation of avoidance and mitigation measures, loss of marine vegetation (i.e., marine riparian vegetation and eelgrass) is expected to occur during site preparation and marine construction (see Figure 10, Figure 11 and Figure 12). In all cases, these losses are likely to occur, since marine vegetation falls within footprints of marine infrastructure or access zones, which will be cleared or infilled. The estimated areas of marine riparian vegetation and eelgrass loss are summarised in Table 14. The area lost depends on the MOF option selected; more vegetation is expected to be lost as a result of the concrete caisson MOF option owing to the need for infilling over vegetated areas.

Table 14 Estimated Area of Marine Vegetation Loss

Activity	Location	Project Feature	Area of Marine Riparian Lost (m^2)	Area of Eelgrass Lost (m^2)
Site preparation (land based)	South Digby	LNG jetty	1,323	0
	Casey Cove	MOF option: Pile-and-deck Concrete caisson	973 1,545	0 0
		Pioneer facility	669	0
Activity Total		**Pile-and-deck MOF** **Concrete caisson MOF**	**2,965** **3,537**	**0** **0**
Dredging	South Digby	LNG jetty	0	0
	Casey Cove	MOF option: Pile-and-deck Concrete caisson	0 0	3,719 1,630
Activity Total		**Pile-and-deck MOF** **Concrete caisson MOF**	 **0**	**3,719** **1,630**
Marine Construction (infilling, pile installation)	South Digby	LNG jetty	0	0
	Casey Cove	MOF option: Pile-and-deck Concrete caisson	0 0	0 4,550
Activity Total		**Pile-and-deck MOF** **Concrete caisson MOF**	**0** **0**	**0** **4,550**
Grand Total		**Pile-and-deck MOF** **Concrete caisson MOF**	**2,965** **3,537**	**3,719** **6,180**

Beyond the likelihood of occurrence, further characterization of residual effects of vegetation loss differs between marine riparian and eelgrass, reflecting their respective value to marine fish. Although the loss of marine riparian will last for the life of the Project, this duration is not expected to limit or diminish the ability of fish to carry out one or more life process. The geographic scale of riparian loss is small, since no marine species occupy this habitat and, hence, cannot be displaced from it. Further, dependence on marine riparian habitats by fish species is low as it is widely available, and similar services will be provided either through mitigation measures (e.g. sediment and erosion control) or by neighbouring areas of riparian vegetation, which is common throughout the Project area and broader region. The removal of marine riparian vegetation is expected to be measurable, but have no impact on the productivity or sustainability of fish populations and, hence the effect magnitude is considered moderate. The loss of marine riparian vegetation is not expected to have a localized effect and it is not expected to cause residual *serious harm to fish* (see Table 15). Consequently, habitat offsetting is not expected to be required for the loss of marine riparian vegetation.

The spatial extent of eelgrass loss will be greater if the concrete caisson MOF option is selected (see Table 14). In this scenario, up to 6,180 m^2 of eelgrass is estimated to be lost, causing an effect deemed to be permanent and of large geographic scale. Unlike marine riparian habitat, eelgrass is relatively scarce both in the Project area and the broader region. For this reason, eelgrass is considered to be of low availability; however, since there is additional eelgrass within the immediate vicinity of the areas being lost, dependency by fish on the sections being removed is considered to be moderate. The magnitude of the resulting effect is expected to be moderate to high; that is, measurable and, depending on the final amount of eelgrass lost, possibly with the potential to adversely affect the productivity of fish. Given the importance of eelgrass to fish and its relative scarcity in the region, the estimated loss is expected to cause a localized effect that constitutes residual *serious harm to fish*, requiring offsetting (see Table 15).

It is anticipated that some canopy-forming kelp stands (*Nereocystis luetkeana*) and areas of understory kelps (e.g., *Laminaria* spp., *Saccharina* spp.) will be lost as a result of dredging and infilling. These areas will be estimated based on detailed mapping prior to the completion of the Final Fish Habitat Offsetting Plan. Nevertheless, offsetting for these important habitat-generating kelps is accounted for in this Plan under the removal of hard substrate, described in Section 9.2.2.3.

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Table 15 Characterization of Residual Effects and Summary of Residual *Serious Harm to Fish* resulting from Permanent Alteration or Destruction of Marine Fish Habitat

Mechanism	Phase: Activity	Mitigation Measures	Summary of Effect	Characterization of Residual Effect							Localized Effect	Residual *Serious Harm to Fish*	Habitat Offsets Proposed?
				Spatial Extent (m^2)	Likelihood	Duration	Geographic Scale	Habitat Availability	Habitat Dependency	Magnitude			
Loss of marine vegetation	Construction: Site preparation	Delineation of intertidal construction area; maintenance of marine riparian vegetation buffer; sediment and erosion control	Loss of marine riparian for the pioneer facility, MOF and LNG jetty	Up to 3,537	H	P	S	H	L	M	N	N	N
	Construction: Dredging	Sediment and erosion control	Loss of eelgrass for the MOF	Up to 3,719	H	P	L	L	M	H	Y	Y	Y
	Construction: Marine construction	DFO guidelines on the siting and design of seawater intakes; bio-friendly materials	Loss of eelgrass for pile installation and infilling for the MOF	Up to 4,550	H	P	L	L	M	M-H	Y	Y	Y
Change in substrate height, shape or type	Construction: Dredging	Silt curtains; sediment and erosion control	Change in substrate conditions in dredge pockets	Up to 152,793	H	P	L	H	L	M	N	Y	Y
	Construction: Marine construction	Demarcation of intertidal construction area; bio-friendly materials; sediment and erosion control	Change in substrate due to installation of rip-rap around areas of infill and installation of seawater system pipes	Up to 27,131	H	P	L	H	L	M	N	Y	Y
Loss of substrate	Construction: Marine construction	Demarcation of intertidal construction area	Loss of marine substrate from infilling and pile installation	Up to 78,675	H	P	L	M	M	H	Y	Y	Y

KEY
See Table 6 for detailed definitions

LIKELIHOOD
L: Low
M: Medium
H: High

DURATION:
ST: Short-term;
MT: Medium-term
LT: Long-term
P: Permanent

HABITAT DEPENDENCY
N: Negligible
L: Low
M: Medium
H: High

MAGNITUDE:
L: Low
M: Moderate
H: High

GEOGRAPHIC SCALE
S: Small
L: Large

HABITAT AVAILABILITY
L: Low
M: Moderate
H: High

LOCALIZED EFFECT
Y: Yes
N: No

RESIDUAL SERIOUS HARM TO FISH
Y: Yes
N: No

HABITAT OFFSET PROPOSED?
Y: Yes
N: No

9.2.2.2 Change in Substrate Height, Shape or Type

Dredging associated with the LNG jetty and MOF will reduce the elevation of substrates, driving subtidal substrates to greater depths (‘subtidal to subtidal’), and either reducing the zone of intertidal substrates (‘intertidal to intertidal’) or converting them to subtidal substrates (‘intertidal to subtidal’; see Table 16). Dredging for the LNG jetty berths will result in substrate changes over an area of approximately 54,316 m^2 (see Figure 10 and Table 16). In Casey Cove, dredging associated with the MOF will result in changes to substrate of approximately 95,137 m^2 to 98,477 m^2, depending on the design (see Figure 11; Figure 12; Table 16).

Infilling associated with the LNG jetty, pioneer facility, and (concrete caisson) MOF will increase substrate elevation (rendering subtidal areas shallower subtidal or intertidal, and shifting some intertidal areas to a higher intertidal zone), increase complexity to hard and irregular rip-rap, and steepen substrate gradient to an estimated slope of 2:1 (horizontal:vertical [H:V]) (see Figure 10, Figure 11 and Figure 12). In total, approximately 17,498 m^2 of substrate is expected to be changed as a result of infilling for the LNG jetty, and 1,228 m^2 and 7,800 m^2 in Casey Cove for the pioneer facility and concrete caisson MOF, respectively (see Table 16). No infilling is expected to be required if the pile-and-deck MOF option is selected.

Trenching and backfilling during installation of the seawater outfall pipe will result in the alteration of substrate in the intertidal zone; installation of the seawater intake pipe is not expected to affect intertidal substrates because the pipe is assumed to connect to a pump station constructed as part of the MOF, and the point of connection will be located within the subtidal zone. Based on the current proposed alignment of the outfall pipe, approximately 100 m of the 230 m long pipe overlaps the intertidal zone, and therefore approximately 300 m^2 of intertidal substrate will be affected (assuming the trench is 3 m wide).

Installation of the seawater intake and outfall pipes will increase subtidal substrate elevation within the footprint of the pipes. Subtidal reaches of the pipes will be laid upon the seafloor, likely partially covered with coarse ballast material and/or ACBMs. This installation will introduce a hard feature over top of, and protruding from, soft substrate (in the case of the intake pipe) or a mix of substrates (in the case of the outflow pipe). Based on the current proposed alignment, approximately 350 m of the intake pipe and 130 m of the outfall pipe will overlap the subtidal zone, and therefore the introduction of these two pipes to the seafloor will result in the alteration of approximately 305 m^2 of soft or mixed subtidal substrate (assuming an outer pipe diameter of 0.76 m [intake] and 0.3 m [outfall]).

Table 16 Estimated Area (m^2) of Change in Marine Substrate Resulting from Dredging, Infilling, and Installation of Seawater System Pipes, and Approximate Area Requiring Offsetting

Activity	Type of change in substrate	Estimated area of change (m^2)					Approximate area requiring offsetting (m^2)				
		Seawater system pipes	Jetty	Pioneer facility	MOF – pile-and-deck option	MOF – concrete caisson option	Seawater system pipes	Jetty	Pioneer facility	MOF – pile-and-deck option	MOF – concrete caisson option
Dredging	Subtidal to subtidal	0	51,037	0	86,134	84,178	0	17,870	0	17,230	16,840
	Intertidal to subtidal	0	2,993	0	7,826	7,602	0	1,050	0	1,570	1,530
	Intertidal to intertidal	0	286	0	4,517	3,357	0	110	0	910	680
	Total	0	54,316	0	98,477	95,137	0	19,030	0	19,710	19,050
Infilling	Subtidal to subtidal	0	3,220	0	0	3,497	0	1,130	0	0	700
	Subtidal to intertidal	0	6,672	0	0	3,082	0	2,340	0	0	620
	Intertidal to intertidal	0	7,606	1,228	0	1,221	0	2,670	250	0	250
	Total	0	17,498	1,228	0	7,800	0	6,140	250	0	1,570
Installation of pipes	Subtidal to subtidal	305	0	0	0	0	70	0	0	0	0
	Intertidal to intertidal	300	0	0	0	0	60	0	0	0	0
	Total	605	0	0	0	0	130	0	0	0	0
All	Subtidal to subtidal	305	54,257	0	86,134	87,675	70	18,990	0	17,230	17,540
	Subtidal to intertidal	0	6,672	0	0	3,082	0	2,340	0	0	620
	Intertidal to subtidal	0	2,993	0	7,826	7,602	0	1,050	0	1,570	1,530
	Intertidal to intertidal	300	7,892	1,228	4,517	4,578	60	2,770	250	910	920
	Total	605	71,814	1,228	98,477	102,937	130	25,150	250	19,710	20,610
	Grand Total				**172,124**	**176,584**				**45,240**	**46,140**

Across all Project mechanisms and locations, changes in the height, shape, or type of substrate are expected over an area of approximately 172,124 m^2 to 176,584 m^2; however, not all of this area is expected to require offsetting. The potential for residual *serious harm to fish* resulting from a change in intertidal or subtidal substrates depends on the comparative value of the initial and final conditions:

- *Changes from soft to hard substrate.* Compared to hard substrates, soft sediments are relatively common and widely available in the Project area. While soft sediments support a range of infaunal and benthic CRA fishery species (e.g., clams, sea cucumbers, Dungeness crab, flatfish) they typically do not support rich vegetative assemblages (Peterson 2005) and as such have lower cover, habitat complexity, and species richness (Guidetti 2000, Giakoumi and Kokkoris 2013) than hard substrate habitats. Consequently, changes from soft to hard substrate (e.g. via the installation of the seawater system pipes in subtidal waters and placement of rip-rap) are expected to increase local productivity. This benefit occurs due to the introduction of hard, consolidated surface that can be colonized by marine algae and epibenthic organisms (Gass and Roberts 2006, Lindeyer and Gittenberger 2011). These substrates are expected to subsequently support rich communities similar to those of hard substrates nearby and more diverse and productive than neighbouring soft substrates (Love and York 2005). This change in substrate is not considered likely to reduce the ability of a CRA fishery species to perform one or more life process and, hence, no potential for residual *serious harm to fish* is anticipated and offsetting is not expected to be required for such changes (see Table 15).
- *Changes from hard to soft substrate*. Replacement of hard substrate by soft substrate constitutes the loss of a locally less abundant, productive area and the introduction of a comparatively abundant substrate with lower productivity. Such a change has the potential to impair the ability of CRA fishery species to complete one or more life processes and reduce local productivity. As such, changes from hard to soft substrate could cause residual *serious harm to fish* and offsetting for these changes is expected to be required (see Table 15).
- *Changes in height or shape of soft substrate*. Soft substrates are common across all intertidal and subtidal elevations likely to be affected by the Project. Changes in the elevation or shape of soft substrates may result in short-term reductions in productivity; however, soft substrates are expected to be rapidly recolonized either by immigration of mobile species, or recolonization via settlement of pelagic larvae, and resulting communities are expected to reach a climax state within approximately one to five years (Newell et al 1998). As such, dips in productivity are expected to be short-lived and buffered by the abundance of these species and substrates nearby. Changes in height or shape of soft substrates (with no change in substrate type) are not considered likely to reduce the ability of a CRA fishery species to complete one or more life process and, hence, no potential for residual *serious harm to fish* is anticipated and offsetting is not expected to be required for such changes (see Table 15).
- *Changes in height or shape of hard substrate*. Communities associated with newly introduced, bare rocky substrates pass through more complex phases of ecological succession and are slower to reach climax communities than soft sediments (Newell et al. 1998). This ecological dynamic creates a relatively long period of reduced productivity and habitat availability for associated communities. It is possible, therefore, that disturbances to rocky substrates can impair the ability of associated CRA fishery species to complete one or more life processes. As a result, such changes have the capacity to cause residual *serious harm to fish* and offsetting is expected to be required to counterbalance such effects (see Table 15).

Determining the amount of offsetting required to counterbalance residual *serious harm to fish* caused by changes in substrate height, shape, or type requires an understanding of the relative abundance of different substrate types. This understanding can be extrapolated from habitat data collected through existing detailed field programs. Subtidal and intertidal surveys in Casey Cove indicate that affected substrates are approximately 80% to 90% soft and 10% to 20% hard. Around south Digby Island, affected substrates are approximately 65% to 80% soft and 20% to 35% hard. Taking a precautionary stance, by assuming the highest of these ranges for percent cover of hard substrate in these areas (and rounding up to the nearest 10 m^2), the approximate area of substrate change expected to constitute residual *serious harm to fish* and require offsetting is (depending on the MOF option) 45,240 m^2 to 46,140 m^2 (see Table 15; Table 16).

9.2.2.3 Loss of Substrate

Up to 78,675 m^2 of marine substrate is expected to be lost as a result of infilling and pile installation during construction of the LNG jetty, MOF, and pioneer facility (see Figure 10, Figure 11 and Figure 12; Table 17). Infilling is expected to result in the loss of up to 15,750 m^2 at south Digby Island, for the LNG jetty causeways (approximately 64% intertidal and 36% subtidal), and up to 60,766 m^2 in Casey Cove, for the installation of the (concrete caisson) MOF and pioneer facility (approximately 38% intertidal and 62% subtidal). The loss of substrate as a result of pile installation for the LNG jetty is expected to amount to 2,127 m^2 (all subtidal), and for the installation of the (pile-and-deck) MOF and pioneer facility in Casey Cove is expected to amount to 879 m^2 (approximately 85% subtidal and 15% intertidal).

Applying the same rationale as described for Change in Substrate Height, Shape, or Type (see Section 9.2.2.2), it is not anticipated that all 78,675 m^2 will require offsetting. Using the same (precautionary) assumptions regarding the relative value of hard and soft substrate and availability in Casey Cove and south Digby Island, the approximate area of substrate loss that is expected to constitute residual *serious harm to fish* and require offsetting is (depending on the MOF option) 6,690 m^2 to 18,460 m^2 (see Table 15; Table 17).

Table 17 Estimated Area (m^2) of Marine Substrate Loss and Approximate Area Requiring Offsetting

Activity	Tidal Zone	Estimated area of change (m^2)				Approximate area requiring offsetting (m^2)			
		Jetty	Pioneer facility	MOF – pile-and-deck option	MOF – concrete caisson option	Jetty	Pioneer facility	MOF – pile-and-deck option	MOF – concrete caisson option
Infilling	Intertidal	10,131	1,127	0	22,575	3,550	230	0	4,520
	Subtidal	5,619	0	0	37,064	1,970	0	0	7,420
	Total	15,750	1,127	0	59,639	5,520	230	0	11,940
Pile installation	Intertidal	0	0	134	0	0	0	30	0
	Subtidal	2,127	5	740	27	750	10	150	10
	Total	2,127	5	874	27	750	10	180	10
All	Intertidal	10,131	1,127	131	22,575	3,550	230	30	4,520
	Subtidal	7,746	5	743	37,091	2,720	10	150	7,430
	Total	17,877	1,132	874	59,666	6,270	240	180	11,950
	Grand Total			**19,883**	**78,675**			**6,690**	**18,460**

9.2.2.4 Summary of Residual *Serious Harm to Fish*

In summary, the Project is expected to result in the permanent alteration or destruction of approximately up to 264,976 m^2 of marine vegetation and substrate at south Digby Island and in Casey Cove, 70,770 m^2 of which is deemed to constitute residual *serious harm to fish* and require offsetting (see Table 18). This area considers the amount of eelgrass and rocky habitat expected to be permanently altered or destroyed.

Table 18 Summary of Estimated Area (m^2) of Fish Habitat Affected by the Project and Area Requiring Offsetting

Mechanism	Location(s) of Alteration or Loss	Affected Area (m^2)	Estimate of Area Requiring Offsetting (m^2)
Loss of Marine Vegetation: Marine Riparian	South Digby Island, Casey Cove	Up to 3,537	0
Loss of Marine Vegetation: Eelgrass	Casey Cove	Up to 6,180	Up to 6,180
Change in Substrate Height, Shape or Type	South Digby Island, Casey Cove	Up to **176,584**	Up to **46,140**
Loss of Marine Substrate	South Digby Island, Casey Cove	Up to 78,675	Up to 18,460
Total	**South Digby Island, Casey Cove**	**Up to 264,976**	**Up to 70,780**

Many CRA fishery species use eelgrass and rocky habitats to complete one or more of their life processes, including spawning, rearing, foraging, and migrating (see Table 19). Rocky reefs are of importance to fish across a range of functional groups, including benthic species such as yellowtail, copper, black and quillback rockfish, anadromous Pacific salmon, forage fish (e.g. surf smelt and Pacific herring) and a wide range of sessile and epibenthic invertebrates. Eelgrass beds support fewer species than rocky habitats, but serve as important rearing areas for many species, including lingcod, rockfish, all Pacific salmon, surf smelt, and Pacific herring. Since the Project is most likely to cause residual *serious harm to fish* to these species through habitat effects, these will be the focal beneficiaries of habitat offsetting.

Table 19 List of CRA fishery species Using Habitats Expected to Incur Residual *Serious Harm to Fish* (based on Appendix 1 of this report)

Functional Group	Key CRA fishery species by Habitat Use	
	Rocky Habitat	**Eelgrass**
Benthic/ demersal fish	Whitespotted greenling; kelp greenling; lingcod; Pacific cod; yellowtail rockfish; black rockfish; copper rockfish; quillback rockfish	Juvenile lingcod; juvenile yellowtail, black, copper and quillback rockfish
Anadromous fish	Chum, pink, Chinook, coho, and sockeye salmon; Dolly Varden	Juvenile chum, pink, Chinook, coho and sockeye salmon; juvenile Dolly Varden
Forage fish	Surf smelt; Pacific herring	Juvenile surf smelt; juvenile Pacific herring
Epibenthic invertebrates	Dungeness crab; red rock crab; red, purple and green sea urchin; California sea cucumber; pink, spiny scallop, smooth white scallop; gumboot chiton; giant Pacific octopus; snails	Juvenile Dungeness crab; juvenile *Pandalus* shrimp
Sessile invertebrates	Mussels	N/A

10 CONCEPTUAL OFFSETTING MEASURES AND MONITORING

10.1 Guiding Principles

Residual *serious harm to fish* associated with both freshwater and marine Project effects will be counterbalanced through implementation (and subsequent monitoring, see Section 10.6) of habitat offsetting features. The development of these offsets will be grounded on DFO's four guiding principles (DFO 2013b).

10.1.1 Principle 1: Offsetting measures must support fisheries management objectives or local restoration priorities

Fisheries management objectives and local restoration priorities will be considered based on available government, non-government and Aboriginal reports.

- Federal government:
  - DFO develops Integrated Fisheries Management Plans (IFMPs) to guide the conservation and sustainable use of marine resources. Relevant IFMPs for the north coast Pacific Region will be considered during the creation and design of offset features. Particular consideration will be given to the salmon (north coast; DFO 2016a), Pacific herring (DFO 2013d), intertidal clams (DFO 2016b), red urchin (DFO 2016c), green urchin (DFO 2013e), Pacific oyster (DFO 2016d), crab by trap (DFO 2016e), prawn and shrimp by trap (DFO 2016f), shrimp by trawl (DFO 2016g), and groundfish (DFO 2016h). Relevant objectives within the IFMPs that are sufficiently specific to be tangibly addressed will be used to refine the development of habitat offsetting.
  - Canada's Oceans Strategy. The federal government of Canada has developed Canada's Ocean Strategy to outline its approach to fulfilling the *Ocean Act* (Government of Canada 2002). The strategy adopts an integrated management approach that connects provincial and national policies and programs. Three principles lie at the heart of this strategy: sustainable development, integrated management, and the precautionary approach. Collectively, these principles connect potentially competing marine user groups to develop low-risk management actions while engaging and educating the Canadian public about Canada's ocean resources and uses of them. The principles and objectives of Canada's Ocean Strategy will be used to help guide and refine final offsetting designs and locations.
  - PRPA, who have jurisdiction over the marine waters surrounding the Project area, has published a land use management plan (LUMP) (PRPA and AECOM 2010) that, among other aspects, outlines the PRPA's vision, environmental initiatives, relative environmental sensitivity of the shorelines, high-level plans for future development, and strategic actions. Where possible, the proposed offset design and locations will consider aspects of the PRPA LUMP.
  - The Government of Canada develops recovery strategies intended to stop or reverse a species' decline. Each document specifically outlines objectives to focus and guide subsequent detailed recovery planning. These strategies may be single-species, multi-species, or ecosystem focussed

as best befits the recovery objectives. Recovery strategies will be reviewed, relevant plans considered and offsetting objectives aligned with recovery objectives where possible.

- Collaborative Initiatives:
  - The Pacific North Coast Integrated Management Area initiative (PNCIMA 2013) was a partnership between the Government of Canada, the Province of British Columbia, and coastal First Nations. This initiative sought to implement an ecosystems-based management (EBM) approach to achieve sustainable resource use across BC's north coast; however, in 2011, the federal government withdrew funding and the PNCIMA process has remained largely dormant since that time. Nevertheless, where opportunities arise, offsetting will be refined to contribute towards PNCIMA goals.
  - The Province of British Columbia and the federal government have developed the Canada-British Columbia Marine Protected Area Network Strategy (Government of Canada and Government of British Columbia 2014), with the objective of protecting and conserving marine resources. As with PNCIMA, where opportunities arise, offsetting will be refined to contribute towards the goals of the Canada-BC strategy.
  - The Government of British Columbia has also collaborated with several First Nations and marine stakeholders to develop the North Coast Marine Plan (Marine Planning Partnership Initiative, 2015). This plan integrates community-level marine plans that have been separately developed by Metlakatla First Nation, Gitxaala Nation, Kitselas First Nation, Kitsumkalum First Nation, Gitga'at First Nation, and Haisla First Nation. As with the PNCIMA initiative, this plan adopts an EBM approach to promote ecosystem, social, cultural and economic benefits. Reflecting this integrative approach, the plan provides specific objectives, and associated strategies spanning a wide range of topics, including environmental monitoring, protection, pollution, tenured activities, and fisheries (among others). Offsetting will be designed to contribute to these strategies wherever appropriate and feasible.

Digby Island has relatively little freshwater resource and is isolated from the major nearby Skeena and Nass rivers. Thus there are no relevant island-specific freshwater fisheries management plans. Freshwater offsetting is to be consistent with local management plans and will be consistent with the intent and direction of the marine management plans to the greatest extent practicable.

10.1.2 Principle 2: Benefits from offsetting must balance Project impacts

Several steps will be taken to promote benefits that offset Project impacts. Consultation (see Section 3) will encourage input from local Aboriginal Groups and user groups on appropriate benefits and practicable offsetting designs. Former and current local and government biologists will also be consulted for suggestions on how to fine-tune offsetting concepts to promote their effectiveness. Offsets will be designed and located to target the same species and life stages expected to be impacted by the Project. Offset ratios (see Section 10.5) based on a precautionary approach, such that they err towards providing more benefits than needed, will be used. The ratios will also consider lag effects, such as the time taken for communities inhabiting offsets to shift towards climax states and for productivity to peak. Monitoring programs will be undertaken during and subsequent to implementation of offsetting (see Section 10.6) to confirm that offsets are built or enacted (for complementary measures) as designed and perform as expected. A contingency plan (see Section 10.7) will be included that provides a 'safety net' such that if the offsets do not perform as designed, they are either adapted or supplemented so that benefits are ultimately secured.

10.1.3 Principle 3: Offsetting measures must provide additional benefits to the fishery

Offsets will be designed to provide additional benefits to the fishery. According to DFO (2013a), "this means that benefits to the fishery are caused by offset actions and not by other factors." Benefits to fisheries will be facilitated by focussing the design and location on CRA fishery species expected to be affected by the Project. Benefits include the provision of habitat functions or other ecological processes, such as settlement or securement substrate; nursery, rearing and spawning areas; refugia; and feeding opportunities.

10.1.4 Principle 4: Offsetting measures must generate self-sustaining benefits over the long term

A long-term legacy effect will be promoted by selecting success criteria that focus on ecological components indicative of stable and sustainable benefits. Monitoring will continue until success criteria defined in the approved *Fisheries Act* Authorization have been achieved. Example criteria are provided in Section 10.6.2.2 and include indicators of well-established, self-sustaining communities, regular use by focal CRA fishery species, and stable species abundances.

10.2 Offsetting Categories

There are four broad categories of offsetting, which differ in their approach but share the common objective of providing a benefit to focal CRA fishery species (DFO 2013a):

- Habitat Restoration and Enhancement – "physical manipulation of existing habitat to improve habitat function and productivity"
- Habitat Creation – "the development" of aquatic habitat "or expansion of aquatic habitat into a terrestrial area"
- Chemical or Biological Manipulations – chemical or biological amelioration of aquatic habitats to improve ecological function or productivity, such as "chemical manipulation of water bodies, stocking of fish or shellfish, and management or control of aquatic invasive species"
- Complementary Measures – "investments in data collection and scientific research related to maintaining or enhancing the productivity of [CRA] fisheries".

The most appropriate category is context-specific, depending on considerations such as availability of appropriate locations for remedial offsetting or development of new habitat, the focal CRA fishery species and amount of offsetting required. Each category is considered separately below for freshwater and marine-related offsetting.

Offsetting concepts presented within the following sections are, at this stage, just that: conceptual. Their intention is twofold: 1) to demonstrate the capacity to counter-balance anticipated Project residual *serious harm to fish;* and, 2) as preliminary ideas to promote productive discussion and refinement during consultation. Offset types, designs, and locations are based on current understanding of the biophysical conditions within and around the Project footprint, and the Project team's understanding of the local area;

however, Aurora LNG recognises the importance and value of local and traditional knowledge in defining practicable, effective offsets.

10.3 Conceptual Freshwater Offsetting Measures

The proposed conceptual freshwater offsetting (see Figure 14) integrates three of the above categories – Habitat Restoration and Enhancement, Habitat Creation, and Complementary Measures – to provide a diversity of opportunities for increases in fish productivity. The approach is to use restoration and enhancement of existing poor quality or inaccessible habitat, creation of new habitat, and complementary measures to inform future offsetting efforts for small coastal watercourses. The following conceptual measures to offset lost freshwater fish productivity due to the Project are based upon the following fundamentals:

- Target species: coastal cutthroat trout; Dolly Varden; and Chinook, coho and pink salmon
- Life stages for which offsetting required: spawning (cutthroat trout, Dolly Varden, coho and pink salmon) and rearing (cutthroat trout, Dolly Varden, coho and Chinook salmon)
- Permanent loss of in-channel habitat requiring offsetting: 10,857 m^2 of instream fish habitat within the PDA (see Section 4.8 of the Application)
- Permanent loss of riparian vegetation: 218,830 m^2 (see Section 4.8 of the Application)
- Offsetting to occur outside of the PDA because, with the exception of Watercourse reaches J1-J5 and J1.1, the remaining watercourses within the PDA will be infilled
- Limited offsetting opportunities for some species and life stages on Digby Island (Dolly Varden which prefer high gradient, high velocity habitat; Chinook salmon which prefer large rivers, high velocity, large substrate for spawning), resulting in consideration of offsetting directed to these species/life stages in other areas.

10.3.1 Habitat Restoration and Enhancement

Habitat offsetting to restore or enhance existing watercourses includes two approaches: increasing connectivity and stability of discharge between channels to provide consistency of flow; and barrier removal to provide access to previously unavailable habitat.

10.3.1.1 Increasing Connectivity and Stability of Discharge

Increasing connectivity and stability of discharge in watercourses by connecting previously isolated ponds to increase flow in downstream channels will provide access to, and use of, currently existing habitat. The benefit would be increase in pond habitat for use by coho salmon and cutthroat trout. Conceptually, potential locations for this approach are at watercourses P, Q, and S, on Digby Island (see Figure 14). This will require field surveys to delineate ponds/wetlands, assess water chemistry, and ensure downstream channel capacity is not exceeded.

10.3.1.2 Barrier Removal

Several natural barriers for which removal would likely allow access to rearing habitat have been identified in Appendix H of the Application. Specifically:

- Watercourse A: Removal of a 1.9 m high falls located 83 m upstream of the confluence with the marine environment. This will allow access to 509 m (571 m^2) of habitat not currently available. This barrier removal is to be in conjunction with eelgrass and salt marsh development of the marine nearshore at this area (see Section 10.3.2.1) and development of new channel in the upstream area, including a detention pond to collect overland flow and provide stability of discharge through the year. Confirmation if this barrier is currently a complete barrier to fish movement is required. The linkage between the created pond, stable flow in the channel, and downstream saltmarsh habitat and supporting rocky wall create a 'connected aquatic system'. It is anticipated that this would be used by coho salmon (spawning and rearing in the pond and channel) and pink salmon (spawning in channel and rearing in the created marsh/rock wall area). The combination of improved access, greater area of in-stream habitat, stability of flow, and development of the marine nearshore and eelgrass beds is anticipated to increase productivity of this small system.
- Watercourse P: Modification of a 12.0 m high cascade would allow fish access to >800 m of habitat currently unavailable. This watercourse is suspected fish-bearing throughout its length (Appendix H of the Application) and thus confirmation that this is a barrier is required prior to modification. This watercourse is also a candidate for increasing connectivity and discharge, and the barrier removal would be done in conjunction with that to increase productivity. This will require field surveys to confirm the non-fish bearing status.
- Barrier removal from watercourses on other coastal islands, or the mainland, for which a barrier prevents access to a large area of high quality rearing and spawning habitat for cutthroat trout, Dolly Varden, pink, coho, or Chinook salmon. Potential systems may include McNichol Creek (Watershed code 910-807900), Wolf Creek (910-789500), and Kloiya River (910-791900)[2]. Identification and selection of watercourses for barrier removal requires a more detailed desktop analysis for candidate watercourses and field assessments for habitat quality to be accessed.

10.3.1.3 Riparian Offsetting

The requirement for riparian offsetting exceeds potential riparian offsets on Digby Island and, thus, some of this could occur on the mainland or Kaien Island. Coastal watercourses with the most highly disturbed riparian conditions (e.g., urban watercourses such as Hays Creek in Prince Rupert) may provide the greatest benefit from planting. To the extent practicable, for purposes of subsequent monitoring of efficacy of the offset, the planting should be confined to a small number of waterways, with each area including a large extent of planting. This will allow an assessment of fish productivity response to riparian offsets. At this conceptual stage, Hayes Creek within Prince Rupert is a candidate system to investigate feasibility of planting.

2 McNichol Creek has two barriers of falls/rock; Wolf Creek has two falls and a dam, and Kloyia River has two rock barriers and one falls. Fish species in these systems include cutthroat trout, rainbow trout/steelhead (*Oncorhynchus mykiss*), Dolly Varden, coho, Chinook, and pink salmon.

10.3.2 Habitat Creation

To offset the lost productivity from the infilled channels, creation of new habitat (channels) can be completed.

10.3.2.1 Salt Marsh and Foreshore Habitat Creation (Watercourse A)

At the mouth of Watercourse A, flowing into Casey Cove, a salt marsh may be constructed and riprap containment berm used to create nearshore rocky habitat. Salt marsh and rocky substrates are relatively scarce within the area. Consequently, the introduction of these features will contribute to the use and productivity of Watercourse A by anadromous salmonids, which will be able to take advantage of the increased cover and production as they transition between freshwater and marine systems. Finger-like projections from the berm will also capture and retain sediments being transported, creating soft bottom communities immediately adjacent to the rocky shoreline (see Section 10.4.2.1). This combination of offsetting in the marine and freshwater environment, integrated within this channel, is anticipated to increase CRA fish productivity within Watercourse A.

Such an integrated offsetting approach is anticipated to address a greater range of life cycle requirements for CRA fishery species than focusing on freshwater and marine separately. Identification during consultation of other opportunities to integrate freshwater and nearshore marine offsetting will likely increase the effectiveness and benefit of offsetting.

10.3.2.2 General Design Considerations

Channels should be designed to support the spawning and rearing, including overwintering, of the target species (see also Table 20 for habitat preferences for CRA salmonid species in PDA). A single large channel or small number (<4) of large channels are preferred over a larger number of small channels. Larger channels will support a greater richness of species and provide for a fuller range of community dynamics than will smaller channels. Meso-habitat abundance and distribution should mimic that of the channels being replaced (i.e., approximately 12% pool, 57% glide, 24% riffle, and 7% cascade). The distribution of meso-habitat types should reflect salmonid life history requirements (e.g., resting pools adjacent to spawning riffles, areas of backwater and shallow stream edge for YOY), in addition to engineering stability. Constructed channels should take advantage of connection to existing wetlands and ponds to increase availability of deep water for overwintering and also to stabilize discharge.

Design and construction of one or two large channels may be constrained by available space and water availability on Digby Island within which to construct channels. Construction of channels on the adjacent mainland may provide more effective opportunity to increase fish production and take advantage of water of more suitable water chemistry. Construction of artificial channels has a history of effectiveness and methods to create these habitats are established. These factors increase likelihood of success.

These channels, depending upon their width and length, may also contribute to the riparian offsetting due to the requirement to build riparian forest along the channel. To achieve greatest benefit, siting of these channels in disturbed landscapes, within currently altered, or non-existent riparian conditions (e.g., field, cutblock) would provide greatest benefit without having to alter existing functioning forest during construction.

Appropriate site selection for channel(s) construction will require local knowledge and participation of informed and experienced local personnel such as First Nations, stewardship societies, the angling community, and hatchery operators to increase success and efficacy of channels.

Table 20 Habitat Preferences by Species and Life History for Construction of Artificial Offsetting Channels

Species and life stage	Depth range (m)	Substrate	Velocity (m/s)	Habitat type	Comments	Sources
Cutthroat Trout						
Spawning	0.15-0.45	Gravel; small gravel (75% < 25.4 mm diameter; 40% < 6.35 mm diameter)		-	Cutthroat spawn in small streams (<3-4 m wide)	Magee et al. (1996); Roberge et al. (2002)
Rearing	0.15-0.60	-	0.0-0.7	Organic-boulder substrate, woody debris, pool-glide; Areas of reduced flow, primarily back eddies, sloughs, and small pools (YOY and juveniles); riffles (juveniles)	Cover (large woody debris [LWD], Boulder/cobble, overhanging banks, root wads) very important to rearing cutthroat trout	Bonneau and Scarnecchia (1998); Roberge et al. (2002)
Overwintering	0.05-0.60	-	0.0-0.4	-	Cover (LWD, Boulder/cobble, overhanging banks, root wads) very important to rearing cutthroat trout	Bonneau and Scarnecchia (1998);
Dolly Varden (anadromous)						
Spawning	0.2-0.7	Gravel-Cobble; Large gravel; dominated by 10-100 mm diameter material	Moderate; 0.3-0.7	Riffle-run; pool-tails or riffle crests contiguous to holding pools	-	Griffith (1979); Roberge et al. (2002); AMEC (2011)[3]
Rearing	0.05-0.40	Gravel substrate (young of year [YOY]); gravel-cobble, boulder (juveniles). 2->256 mm (juvenile)	0.0-0.2	Riffle, run, pool (YOY and juveniles); side channels	-	Roberge et al. (2002); AMEC (2011)
Overwintering	0.2-0.6	Gravel, cobble-boulder	-	deep pools; open areas with groundwater upwelling	-	AMEC (2011)

3 Values from the AMEC (2011) Habitat Suitability Index model reflect those values representing “above average” or “excellent” habitat conditions.

Table 20 Habitat Preferences by Species and Life History for Construction of Artificial Offsetting Channels

Species and life stage	Depth range (m)	Substrate	Velocity (m/s)	Habitat type	Comments	Sources
Coho salmon						
Spawning	Shallow; 0.10-0.20	Gravel; 39-139 mm diameter	0.3-0.91	Pool-riffle; Subgravel flow; tail-outs of pools immediately above riffles or upwelling sites; often in small streams ~ 1 to 2 m wide	-	Groot and Margolis (1991); Roberge et al. (2002); McPhail (2007)
Rearing	<1.0 ; shallow, stream edges (YOY)	Sand to cobble substrate	<0.78 (juveniles)	Woody debris, banks, overhead cover, pools, side-channels, backwater	-	Roberge et al. (2002)
Overwintering	-	-	-	Side channels, back channels, off channel pond, and other low velocity, off channel areas are the preferred overwintering habitats for juvenile coho salmon.	-	Swales et al. (1986)
Chinook salmon						
Spawning	0.05-0.70	Gravel, cobble	0.10–1.89	Pool–riffle	-	Groot and Margolis (1991); McPhail (2007)
Rearing	0.21 – 0.65	Gravel (48-70%) – cobble (20-25%)	0.06-0.30	-	-	Nechako River Project (1987)
Pink salmon						
Spawning	0.20-0.1.0	Sand, gravel, cobble	0.3-1.0	riffle	-	Roberge et al. (2002); Groot and Margolis (1991); McPhail (2007)
Rearing	-	-	-	Estuarine; emigrate to marine environment shortly after emergence.	-	Roberge et al. (2002)

10.3.3 Complementary Measures

The pH of the surface water on Digby Island, and other islands dominated by bog-fed systems is naturally in the low range for fish use (6.5 or less). Consistent with Section 4.8 of the Application, in which further study of the effect of acidification and fish mortality and health within these naturally low pH systems is recommended, the following Complementary Measure is proposed.

A research program should be undertaken with two objectives:

- Determine if the naturally low pH, not a result of acidification, is limiting the productivity of coho salmon within these bog-dominated systems. Coho are selected as the focal species as they are ubiquitous and use these systems to the greatest extent among the Pacific salmon species.
- If the naturally low pH is determined to be limiting use by coho (reducing survival or growth relative to control sites), evaluate and field trial methods of increasing pH to determine if this is a viable chemical offsetting measure.

Such a program should be a collaborative effort among industry, academia, and government. There is a large literature of acidification effects on salmonids in Atlantic Canada (brook trout [*Salvelinus fontinalis*] and Atlantic salmon [*Salmo salar*]) and this work should build upon that. The outcome of the research is to not only understand fish-pH interactions in coastal bog-dominated systems for the protection of the resource, but also to evaluate the feasibility of chemical offsetting (e.g., increasing pH) as a means to increase productivity within these systems.

10.4 Conceptual Marine Offsetting Measures

The objective of marine offsetting will be to counterbalance residual *serious harm to fish* caused by Project components and activities occurring in marine areas or otherwise affecting marine fish. As per DFO's guidance, these offsets would seek to benefit the species (and life stages) expected to be harmed by the Project (see Table 19).

10.4.1 Habitat Restoration and Enhancement

Several options for marine habitat restoration or enhancement have been identified in and around the proposed Project area (see Figure 15 and Figure 16). These are summarised below, with potential approaches to restoration and enhancement.

10.4.1.1 Enhancement of Soft Substrate

The unconsolidated nature of soft sediment precludes the establishment of highly productive seaweed communities that are found on shallow bedrock, cobbles, and boulders. Consequently, soft sediments are comparatively featureless, barren areas with lower fisheries productivity (with the exception of infaunal invertebrates, such as clams). Intertidal and subtidal observations over soft substrates in the Project area noted that low-story kelps grow on occasional shells dispersed across sand and mudflats (see Section 5.2.1.2). These rare occurrences of firm substrate and the associated vegetation add small pockets of complexity to the otherwise featureless, unvegetated substrates in those areas.

These observations of kelp on shells provide a 'proof of concept' that the relatively barren soft-substrate areas in Casey Cove and/or south Digby could be enhanced by the placement of sparsely distributed cobbles (see Figure 15 and Figure 16). It is anticipated that artificially placed cobbles would be colonised by kelps such as *Laminaria* and *Alaria*, creating a loose field of low-lying fronds. Kelp frond fields would serve as enhanced habitat for a suite of benthic CRA fishery species, such as Dungeness crab, rockfish, kelp greenling, and scallops. Migratory juvenile and adult salmon would benefit from this enhancement through the current-attenuating effects of kelp fronds, predator refuge, and prey availability. Existing CRA fishery species that use soft substrates (e.g. soles and flounders) would persist in interstitial areas and benefit from the increase in prey availability.

10.4.1.2 Eelgrass Expansion

Eelgrass beds are present in areas of Casey Cove and Delusion Bay (see Section 5.2.1.1). In general, eelgrass beds are highly productive (Phillips 1974) and support numerous CRA fishery species (notably juveniles), such as lingcod, Pacific salmon, rockfish, surf smelt, and Dungeness crab. As a result, eelgrass beds are considered high-value habitats (see Appendix K of the Application). The seaward extent of these beds is approximately -7 m CD (see Appendix K of the Application), likely limited by the extent of suitable conditions (primarily penetration of adequate light for photosynthesis).

One habitat enhancement option is to extend eelgrass beds in Delusion Bay and Casey Cove (see Figure 15 and Figure 16) by increasing the area of suitable conditions. This extension would involve the following steps:

1. Installation of a containment berm. A riprap berm (which would constitute new, highly productive fish habitat, see Section 10.4.2) would be needed to retain the fine sediment that would become substrate for eelgrass. The foot of this berm would sit below the depth range of eelgrass and the berm would extend up to approximately -5 to -7 m CD. Berm construction would follow best management practices (BC MELP 2000).
2. Backfilling with suitable sediment. The area behind the rip-rap berm would be filled with soft substrate, potentially including that obtained through nearby dredging. This would raise the mudline from its current depth, which does not support eelgrass, to depths that are favourable for eelgrass. If needed, this backfill could be topped with sediment suitable for eelgrass growth.
3. Eelgrass expansion. Although it would be expected that existing eelgrass would spread naturally to the expanded area, this expansion could be expedited by transplanting shoots from existing beds or seeding. Transplant success rates can be improved by carefully selecting (among other considerations) donor beds and donor plants from specific water depths and conditions. Using the existing eelgrass as donor beds would promote successful transplantation since the plants are already adapted to local conditions. Additional techniques may improve colonisation success, such as anchoring rhizomes to stones (Zhou et al. 2014) or shells (Lee and Park 2008), or seeding deeper waters (Eriander et al. 2016).

10.4.2 Habitat Creation

10.4.2.1 Heterogeneous Rocky Habitats

The bulk of marine-related residual *serious harm to fish* is expected to arise due to the removal of hard substrates, such as bedrock and boulder (see Section 9.2.2.3). The most relevant form of in-kind offsetting is, therefore, the development of habitats founded upon similarly hard substrate. A suite of rocky habitats are suggested below and depicted in Figure 16; the intention of this mix of concepts is to create a range of rocky habitats featuring a corresponding diverse set of ecological niches. It is expected that creating such a range of rocky habitats would offer wider benefits to CRA fishery species than would the creation of a more homogenous area of rocky habitat.

Currently, four rocky habitats are proposed to contribute towards Project impacts:

1. Intertidal rocky fields

   Naturally occurring intertidal rocky areas around Digby Island comprise a diverse mix of bedrock, dense and sparse boulders, and a patchwork of tidal pools and raised reef-like mounds with steep faces. These areas support a highly diverse mix of marine vegetation, invertebrates, and fish (see Section 5.2). One offsetting concept is to mimic this complexity by constructing intertidal rocky fields composed of a mix of rock reefs, fields of boulders or reef balls, and tidal pools formed in either natural topographic undulations or excavations to create artificial pockets.

2. Complex, rocky walls

   The ecological benefits of the proposed eelgrass expansions in Casey Cove and Delusion Bay would extend to the rocky berms proposed to support the soft sediment. These structures would offer an exposed, high-relief rocky matrix with regular flushing and currents that would likely promote the growth of bull kelp, which is known to occur around Digby Island. The matrix of holes and nooks within the rip-rap wall would provide refuge for a variety of CRA fishery species, including wolf eel (*Anarrhichthys ocellatus*), rockfish, and lingcod. The walls could be further enhanced by the addition of spur-and-grooves extending from the base into surrounding soft substrate (see below).

3. Rocky projections

   The rip-rap edge of the LNG jetty causeway will introduce a complex hard substrate into the shallow fringes around this structure. Although the basic engineering design of this structure is not considered offsetting, it is proposed that the structure be enhanced to increase the amount of habitat created for fish. This enhanced design would involve adding villi-like projections extending over a range of intertidal and subtidal zones to create spur-and-groove landscapes with an extensive interface of complex rocky substrate with neighbouring habitats. Spur and groove structures will also be added to the bottom of the rocky berm used to support the proposed eelgrass enhancements at the mouth of Delusion Bay and in Casey Cove. The resulting combination of hard substrate, a complex structural matrix, and proximity to mixed substrates is expected to support rich, diverse kelp communities, providing benefits to many CRA fishery species known to thrive in such conditions.

4. Subtidal rock reef arrays.

   Construction of arrays of rocky reefs in waters ranging from approximately 0 to -10 m CD. These arrays would constitute a mix of rip-rap mounds standing ~2 m above the seafloor and surrounded by a mix of sparsely scattered cobble, boulders, and/or concrete reef balls. As with the previous rocky habitats, the objective of this concept is to introduce a range of rocky habitats types that provide a suite of ecological niches. As such, it is anticipated that these arrays will support a rich and diverse group of CRA fishery species that use the various components of this offset for a range of life processes including egg incubation, rearing, feeding, and reproduction.

10.4.3 Chemical and Biological Manipulations

Currently, no chemical or biological manipulations are proposed as potential offsets for Project impacts to marine CRA fish. Manipulations of this nature are unusual in marine habitats due to their open, complex nature, which often renders offsetting of this kind relatively unreliable. If feasible, practicable, and low-risk manipulation forms of offsetting are identified during consultation, such options would be considered to counter-balance Project impacts.

10.4.4 Complementary Measures

At this stage, no explicit complementary marine measures have been proposed; however, Aurora LNG anticipates that possible research and data-gathering opportunities are likely to be discussed during consultation, which could constitute offsetting alternatives. Potential topics could include:

1. understanding the relative importance of bottom-up and top-down drivers of nearshore mortality, including predator-prey dynamics and food or habitat availability, for Skeena River Pacific salmon
2. testing hypotheses regarding the availability of spawning beaches to surf smelt and the potential implications of climate change and coastal development on (a) the availability of spawning habitats and, (b) population ramifications
3. drivers behind spatial fluxes in Pacific herring spawning across years and implications for CRA fisheries predators

10.5 Offset Ratios and Habitat Balance

Appropriate offset ratios (area of offset: area affected) will be used to calculate sufficient offsetting to counter-balance Project residual *serious harm to fish*. Offset ratios will be dictated by several considerations:

- A precautionary approach (decisions relating to offset ratios well err towards increasing the area of offsetting)
- Area, type and productivity of the habitat affected
- Area, type and expected productivity of the offset habitat
- Type of offset being implemented (e.g. in-kind vs out-of-kind offsetting)
- Uncertainty relating to the potential for residual *serious harm to fish*
- Uncertainty relating to the effectiveness of each offsetting measure
- The potential for lag effects

Objective approaches will be used to translate the value of different habitats when calculating appropriate ratios for out-of-kind offsets. For example, the Vancouver Fraser Port Authority has established relative habitat values to facilitate the expenditure of credits from their habitat bank as out-of-kind offsetting (Conlin 1987). Offsetting ratios can also be guided through habitat equivalency analysis (HEA), as described by Barrell et al. (2014). Conceptually, HEA involves balancing "negative impacts on ecological function and the positive effects of the restoration activity, while accounting for uncertainties in the success of restoration, variance in the quality of damaged and restored habitat, and time lag in service restoration" (Barrell et al. 2014). This concept is then formalized into a mathematical equation that pits negative "debts" on the left-hand side, which includes a term for area harmed, against positive "credits" on the right-hand side, which includes a term for area benefitted. The equation is then balanced, or skewed towards the credit side, by adjusting the ratio of the two area terms. In turn, this ratio informs the offset ratio. Such approaches can be developed independently for marine and freshwater systems.

10.6 Implementation and Monitoring

10.6.1 Implementation schedule

Offsets implementation will be scheduled to reduce productivity lag effects. A detailed implementation schedule will be developed in consultation with DFO and included in the Final Fish Habitat Offsetting Plan.

10.6.2 Monitoring

Two levels of monitoring will be conducted, the over-arching objective of which will be to promote effective offsetting. Compliance monitoring will be conducted during the creation of offsets to confirm they have been built as designed and fulfil any *Fisheries Act* Authorization design requirements. Once built, the effectiveness of the offsets will be monitored to confirm they are performing as designed. A detailed monitoring plan will be included in the Final Fish Habitat Offsetting Plan. Aurora LNG will seek to engage Aboriginal Groups throughout compliance and effectiveness monitoring as (for example) construction monitors, research technicians, field biologists, and wildlife monitors.

The following sections outline the components that will be included in this final monitoring plan.

10.6.2.1 Compliance Monitoring

Offsets will be designed to be ecologically effective and structurally sound. It is also anticipated that DFO may specify design conditions to promote specific ecological functions. The purpose of construction compliance monitoring is therefore to confirm the offsets have been constructed as designed and any conditions of the associated *Fisheries Act* Authorization have been met. Compliance monitoring will occur during start-up and critical periods of offset construction by a qualified professional (at least three years of experience with similar projects, graduate training in a relevant discipline, and a professional designation). Additional monitoring will also take place immediately following completion of construction, which will inform whether or not adjustments to the construction are required to conform to designs.

Construction compliance monitors will record (at least) the following information:

- Written summary of construction events
- Photos of key construction activities
- Changes in design needed to adapt to unexpected conditions
- Technical, personnel, environmental, and safety issues that arise during construction and how they were resolved
- Adjustments to construction required to meet design specifications
- Confirmation that offsetting components meet design requirements
- Confirmation that any design-related conditions specified in the *Fisheries Act* Authorization have been met

If any complementary measures are implemented, such as research programs, compliance monitoring will serve to confirm that these programs are being run according to plan.

An as-built report will be submitted to DFO following construction of all marine habitat offsets.

10.6.2.2 Effectiveness Monitoring

Effectiveness monitoring of all offsets will be conducted following construction (or implementation, in the case of complementary measures) to confirm that they are functioning as intended. Specific success criteria, monitoring methods, and measurable parameters will be tailored to the offsetting measures and specified in the Final Fish Habitat Offsetting Plan. Monitoring of offset features will focus on habitat function and the use of that habitat by the CRA fishery species the offsets were designed to benefit. Such criteria will be developed for each metric included in the monitoring program and will be approved by DFO.

All monitoring programs will be based on comparison to relevant reference areas. Wherever appropriate, Before-After-Control-Impact survey designs will be followed, with multiple control sites whenever such reference areas are available. Monitoring programs will be completed at appropriate time intervals (typically annually) and over adequate periods (typically five to ten years) to determine whether or not the success criteria have been met.

If complementary offsetting measures are implemented, success criteria would be specified to indicate that the proposed benefits are being achieved. For instance, if the objective of the research is to broaden our understanding of a CRA fishery species in a way that will improve the management of this species, success criteria would focus on the collection, transfer, and use of the information collected. Effectiveness monitoring would confirm that these success criteria are being met and, as such, the research agenda is yielding the expected benefits to fisheries.

Reports will be submitted to DFO following the completion of each monitoring survey. Each report will include introductory context, methods, results, an assessment of each monitoring-related condition of the *Fisheries Act* Authorization, and a conclusion regarding the success of each offset.

10.7 Contingency Plan

If monitoring reveals that the offsets have not been met, and are deemed unlikely to meet success criteria defined in the approved *Fisheries Act A*uthorization, a contingency plan will be developed in consultation with DFO and Aboriginal Groups. This plan would include, as appropriate:

- A program to determine why the success criteria have not been met, which would inform ways to resolve offset shortfalls
- Ways to alter the existing offsets to improve their ecological effectiveness, such as changing substrate composition or promoting ecological succession by seeding offsets with target organisms
- Alternative or additional offsets to counterbalance residual *serious harm to fish*; such measures might include extending existing offsets, developing “out of kind” offsets (with offset ratios adjusted accordingly), or implementing new complementary measures

11 CLOSURE

This Conceptual Fish Habitat Offsetting Plan marks the first step towards development of acceptable offsetting strategies required in support of the Application for an Environmental Assessment Certificate for the Project. This document will continue to be updated and modified as consultation continues with DFO and Aboriginal Groups. A more detailed Final Fish Habitat Offsetting Plan will be developed for the Project in the future in an application for Authorization under Section 35(2) of the *Fisheries Act*.

12 REFERENCES

AMEC. 2011. Habitat Suitability Index (HIS) model for Dolly Varden. Appendix 6.7-G in Kitsault Mine Project, Environmental Assessment. Avanti Mining Inc.

Armstrong, R.H. and J.E. Morrow. 1980. The Dolly Varden charr, *Salvelinus malma,* in *Charrs: salmonid fishes of the Genus Salvelinus,* edited by E.K. Balon, 100-136. The Hague, Netherlands: Dr. W. Junk bv Publishers.

Barrell, J.P., M.C. Wong and J. Grant. 2014. Evaluating Coastal Habitat Value Through Metrics of Ecosystem Function for use in Habitat Restoration. Canadian Technical Report of Fisheries and Aquatic Sciences. 3095: v + 21 p.

Bonneau, J.L. and D.L. Scarnecchia. 1998. Seasonal and diel changes in habitat use by juvenile bull trout (*Salvelinus confluentus*) and cutthroat trout (*Oncorhynchus clarkii*) in a mountain stream. *Canadian Journal of Zoology*. 76: 783-790.

BC Marine and Pile Driving Contractors Association (BC MPDCA) and DFO. 2003. Best Management Practices for Pile Driving and Related Operations. Available at https://a100.gov.bc.ca/appsdata/epic/documents/p351/d32211/1273516310337_a8f9af96262d9ff325e4452109b72a5c6e2c4828796e47dd8ed0c732bc322dfb.pdf Accessed: July, 2016

BC Ministry of Environment, Land and Parks (BC MELP). 2000. Riprap Design and Construction Guide. Available at: http://www.env.gov.bc.ca/wsd/public_safety/flood/pdfs_word/riprap_guide.pdf Accessed: July, 2016.

Brown, L.R., S.A. Matern and P.B. Moyle. 1995. Comparative ecology of prickly sculpin, *Cottus asper*, and coastrange sculpin, *C. aleuticus*, in the Eel River, California. *Environmental Biology of Fishes*, 42: 329-343.

Conlin, 1987. Habitat Classification and Approach to Compensation. A memorandum to Higgins, R.J. Senior Habitat Management Biologist, South Coast Division, Fisheries and Oceans Canada, Government of Canada.

Dolloff, C.A. and G.H. Reeves. 1990. Microhabitat partitioning among stream-dwelling juvenile coho salmon, *Oncorhynchus kisutch*, and Dolly Varden, *Salvelinus malma*. *Canadian Journal of Fisheries and Aquatic Sciences,* 47: 2297-2306.

Eriander L., E. Infantes, M. Olofsson, J.L. Olsen and P.-O. Moksnes. 2016. Assessing methods for restoration of eelgrass (*Zostera marina* L.) in a cold temperate region. *Journal of Experimental Marine Biology and Ecology,* 479: 76-88.

Fedorenko, A.Y. 1991. Guidelines for Minimizing Entrainment and Impingement of Aquatic Organisms at Marine Intakes in British Columbia. Canadian Manuscript Report of Fisheries and Aquatic Sciences 2098. pp 86.

Fisheries and Oceans Canada (DFO). 2013a. Fisheries Productivity Investment Policy: A Proponent's Guide to Offsetting. Available at: http://www.dfo-mpo.gc.ca/pnw-ppe/offsetting-guide-compensation/index-eng.html. Accessed: July, 2016.

Fisheries and Oceans Canada (DFO). 2013b. Fisheries Protection Policy Statement. Available at: http://www.dfo-mpo.gc.ca/pnw-ppe/pol/PolicyStatement-EnoncePolitique-eng.pdf. Accessed July, 2016.

Fisheries and Oceans Canada (DFO). 2013c. Measures to Avoid Causing Harm to Fish and Fish Habitat. Available at http://www.dfo-mpo.gc.ca/pnw-ppe/measures-mesures/measures-mesures-eng.html. Accessed: July 2016.

Fisheries and Oceans Canada (DFO). 2013d. Pacific Region Integrated Fisheries Marine Plan: Pacific Herring. November 7, 2013 – November 6, 2014.

Fisheries and Oceans Canada (DFO). 2013e. Pacific Region Integrated Fisheries Marine Plan: Green Sea Urchin. September 1, 2013 – August 31, 2016.

Fisheries and Oceans Canada (DFO). 2014. British Columbia Marine/Estuarine Timing Windows for the Protection of Fish and Fish Habitat – North Coast Area. Available at: http://www.dfo-mpo.gc.ca/pnw-ppe/timing-periodes/bc-n-eng.html. Accessed: August 2016.

Fisheries and Oceans Canada (DFO). 2016a. *Pacific Region Integrated Fisheries Management Plan Summary: Salmon – Northern BC. June 1, 2016 – May 31, 2017*. Available at: http://www.pac.dfo-mpo.gc.ca/fm-gp/mplans/2016/smon/smon-nc-cn-2016-sm-eng.pdf. Accessed: August 2016.

Fisheries and Oceans Canada (DFO). 2016b. *Pacific Region Integrated Fisheries Management Plan Summary: Intertidal Clams. January 1, 2016 – December 31, 2018*. Available at: http://www.pac.dfo-mpo.gc.ca/fm-gp/mplans/2016/intertidal_clam-palourde_intercotidale-2016-18-eng.pdf. Accessed: August 2016.

Fisheries and Oceans Canada (DFO). 2016c. *Pacific Region Integrated Fisheries Management Plan Summary: Red Sea Urchin. August 1, 2016 – July 31, 2017*. Available at: http://www.pac.dfo-mpo.gc.ca/fm-gp/mplans/2013/red_urchin-oursin_rouge-sm-2013-eng.pdf. Accessed: August 2016.

Fisheries and Oceans Canada (DFO). 2016d. *Pacific Region Integrated Fisheries Management Plan Summary: Pacific Oysters (Crassostrea gigas). March 1, 2016 – February 28, 2017*. Available at: http://www.pac.dfo-mpo.gc.ca/fm-gp/mplans/2016/oyster-huitre-sm-2016-eng.pdf. Accessed: August 2016.

Fisheries and Oceans Canada (DFO). 2016e. *Pacific Region Integrated Fisheries Management Plan Summary: Crab by Trap. January 1 – December 31, 2016*. Available at: http://www.pac.dfo-mpo.gc.ca/fm-gp/mplans/2016/crab-crabe-sm-2016-eng.pdf. Accessed: August 2016.

Fisheries and Oceans Canada (DFO). 2016f. *Pacific Region Integrated Fisheries Management Plan Summary: Prawn and Shrimp by Trap. May 1, 2016 – April 30, 2017*. Available at: http://www.pac.dfo-mpo.gc.ca/fm-gp/mplans/2016/prawnshrimp-trap-crevette-casier-sm-2016-eng.pdf. Accessed: August 2016.

Fisheries and Oceans Canada (DFO). 2016g*. Pacific Region Integrated Fisheries Management Plan Summary: Shrimp by Trawl. April 1, 2016 – March 31, 2017*. Available at: http://www.pac.dfo-mpo.gc.ca/fm-gp/mplans/2016/shrimp-trawl-crevette-chalut-sm-2016-17-eng.html. Accessed: August 2016.

Fisheries and Oceans Canada (DFO). 2016h. *Pacific Region Integrated Fisheries Management Plan: Groundfish. 2016 – 2017*. Available at: http://www.pac.dfo-mpo.gc.ca/fm-gp/mplans/2016/ground-fond-sm-2016-eng.pdf. Accessed: August 2016.

Foster, M.B. 2003. Maturity, fecundity, growth, and sustained yield of coastal cutthroat trout at Florence Lake, southeast Alaska. M.Sc. thesis, University of Alaska Fairbanks.

Gass, S.E. and J.M. Roberts. 2006. The occurrence of the cold-water coral *Lophelia pertusa* (Scleractinia) on oil and gas platforms in the North Sea: Colony growth, recruitment and environmental controls on distribution. *Marine Pollution Bulletin*, 52: 549–559

Giakoumi, S. and G.D. Kokkoris. 2013. Effects of habitat and substrate complexity on shallow sublittoral fish assemblages in the Cyclades Archipelago, North-eastern Mediterranean Sea. *Mediterranean Marine Science*, 14: 58-68.

Government of Canada. 2002. *Canada's Ocean Strategy*. Available at: http://www.dfo-mpo.gc.ca/oceans/documents/cos-soc/cos-soc-eng.pdf Accessed: July, 2016

Government of Canada and Government of British Columbia. 2014. *Canada—British Columbia Marine Protected Area Network Strategy*. Available at: https://www.for.gov.bc.ca/tasb/slrp/pdf/ENG_BC_MPA_LOWRES.pdf. Accessed: July, 2016.

Griffith, R.P. 1979. The spawning and rearing habitat of Dolly Varden char and Yellowstone cutthroat trout in allopatry and in sympatry with selected salmonids. Prepared for Fish and Wildlife Branch, Ministry of Environment. Victoria, BC. June 15, 1979.

Groot, C. and L. Margolis. 1991. *Pacific salmon life histories*. University of British Columbia Press. Vancouver, BC.

Guidetti, P. 2000. Differences among fish assemblages associated with nearshore *Posidonia oceanica* beds, rocky-algal reefs and unvegetated sand habitats in the Adriatic Sea. *Estuarine, Coastal & Shelf Science*, 50 (4): 515-529.

Khtada Environmental Services (Khtada). 2015. Aurora LNG freshwater fish and fish habitat final report, 2014-2015. Prepared for Nexen Energy ULC. July 7, 2015.

Klinkenberg, B. (Ed.) 2015. E-Fauna BC: Electronic Atlas of the Fauna of British Columbia [www.efauna.bc.ca]. Lab for Advanced Spatial Analysis, Department of Geography, University of British Columbia, Vancouver. Accessed: July, 2016

Lee, K.S. and J.I. Park. 2008. An effective transplanting technique using shells for restoration of Zostera marina habitats. *Marine Pollution Bulletin,* 56(5): 1015-1021

Lindeyer, F. and A. Gittenberger. 2011. Ascidians in the succession of marine fouling communities. *Aquatic Invasions,* 6(4): 421-434.

Love, M.S. and A. York. 2005. A comparison of the fish assemblages associated with an oil/gas pipeline and adjacent seafloor in the Santa Barbara Channel, Southern California Bight. Bulletin of Marine *Science*, 77(1): 101-117.

Magee, J.P., T.E. McMahon and R.F. Thurow. 1996. Spatial variation in spawning habitat of cutthroat trout in a sediment-rich stream basin. *Transactions of the American Fisheries Society*, 125: 768-779.

Marine Planning Partnership Initiative. 2015. *North Coast Marine Plan*. Available at: http://mappocean.org/wp-content/uploads/2016/07/MarinePlan_NorthCoast_WebVer_20151207_corrected.pdf. Accessed: July, 2016.

McPhail, J. D. 2007. *The Freshwater Fishes of British Columbia*. The University of Alberta Press. Edmonton, AB.

Moore, K.M.S. and S.V. Gregory. 1988. Response of young-of-year cutthroat trout to manipulation of habitat structure in a small stream. *Transactions of the American Fisheries Society*, 117: 162-170.

Nechako River Project. 1987. Studies of juvenile Chinook salmon in the Nechako River, British Columbia. – 1985 and 1986. Canadian Manuscript Report of Fisheries and Aquatic Sciences, No. 1954.

Newell, R.C., L.J. Seiderer and D.R. Hitchcock. 1998. The impact of dredging works in coastal waters: A review of the sensitivity to disturbance and subsequent recovery of biological resources of the sea bed. *Oceanography and Marine Biology: an Annual Review*, 36: 127-178.

Peacock, S.D., B. Spilsted and B. Snyder. 1996. *A review of stock assessment information for Skeena River Chinook*. Pacific Stock Assessment Review Committee Working Paper S96-7.

Peterson, C. 2005. *Nearshore Benthic Communities*. *In:* The Gulf of Alaska – Biology and Oceanography. Munday, P.R. (Ed). University of Alaska, Fairbanks.

Pacific North Coast Integrated Management Area Initiative (PNCIMA). 2013. *Draft Pacific North Coast Integrated Management Area Plan*. Available at http://www.pncima.org/media/documents/pdf/draft-pncima-plan-may-27--2013.pdf Accessed: July, 2016.

Phillips, R. C. 1984. *The ecology of eelgrass meadows in the Pacific Northwest: A community profile*. U.S. Fish and Wildlife Service. FWS/OBS-84/23. 85 pp.

Prince Rupert Port Authority (PRPA) and AECOM. 2010. Port of Prince Rupert 2020 Land Use Management Plan. Available at: http://www.rupertport.com/documents/prpa-land-use-management-plan/pdf. Accessed: July, 2016.

Roberge, M., J.M.B. Hume, C.K. Minns, and T. Slaney. 2002. Life history characteristics of freshwater fishes occurring in British Columbia and the Yukon, with major emphasis on stream habitat characteristics. Canadian Manuscript Report of Fisheries and Aquatic Sciences. 2611.

Rosenfeld, J.S. and S. Boss. 2001. Fitness consequences of habitat use for juvenile cutthroat trout: energetic costs and benefits in pools and riffles. *Canadian Journal of Fisheries and Aquatic Sciences*, 58: 585-593.

Scott, W.B. and E.J. Crossman. 1973. *Freshwater fishes of Canada*. Fisheries Research Board of Canada. Bulletin 184.

Swales, S., R.B. Lauzier and C.D. Levings. 1986. Winter habitat preferences of juvenile salmonids in two interior rivers in British Columbia. *Canadian Journal of Zoology*, 64: 1506-1514.

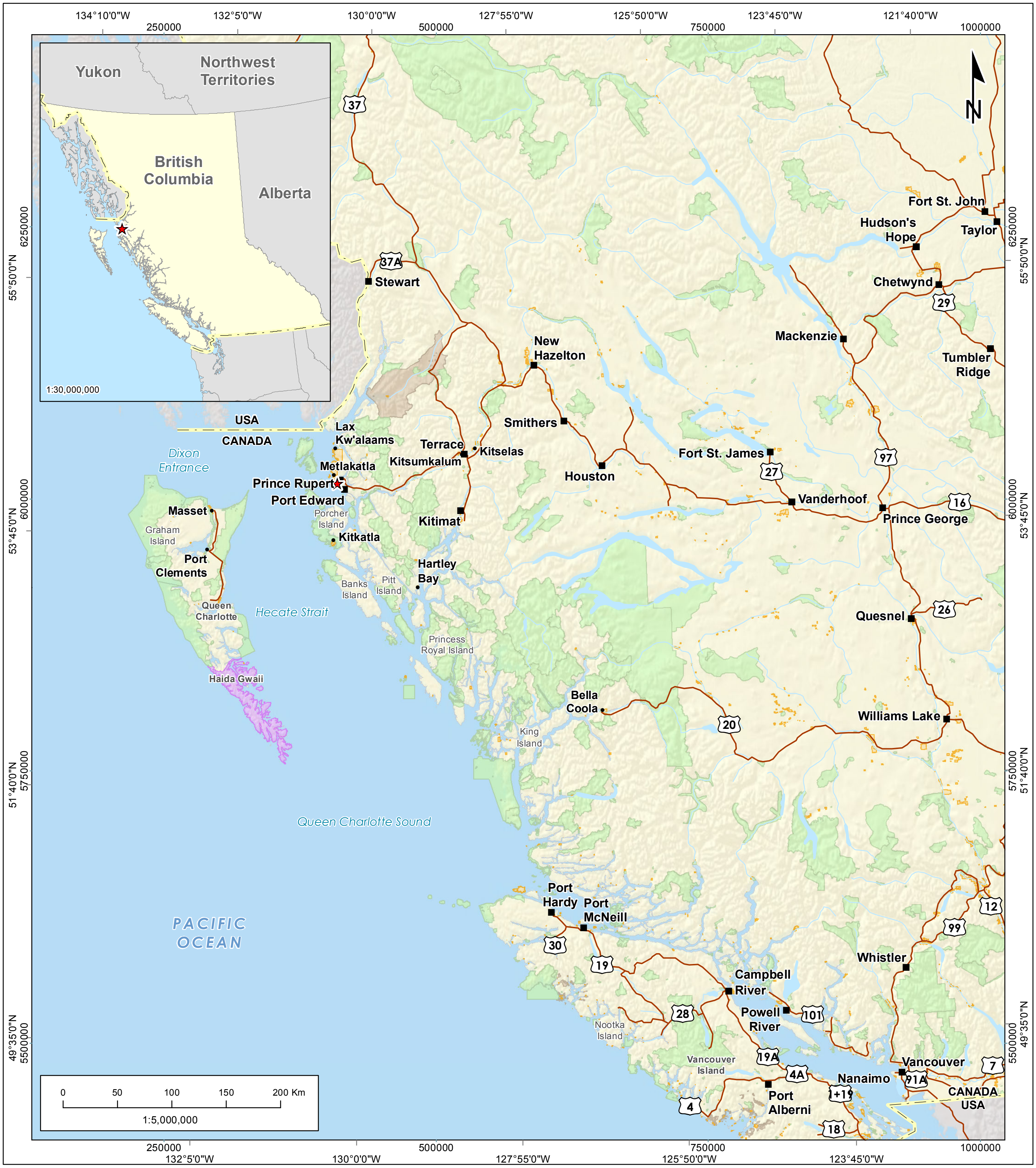
Triton Environmental Consultants Ltd. (Triton) 2014. Aurora LNG Marine Fish and Fish Habitat Reconnaissance 2014 Final Report - Draft. Prepared for Nexen Energy ULC. 66 pp. + appendices.

Wright D.G. and Hopky, G.E. 1998. Guidelines for the Use of Explosives In or Near Canadian Fisheries Waters. Canadian Technical Report of Fisheries and Aquatic Sciences 2107. Available at http://www.dfo-mpo.gc.ca/Library/232046.pdf. Accessed: July , 2016

Zhou Y., P. Liu, B. Liu, X. Liu, X. Zhang, F. Wang and H. Yang. 2014. Restoring eelgrass (*Zostera marina* L.) habitats using a simple and effective transplanting technique. *PLoS ONE*, 9(4): 1-7.

13 FIGURES

Please see the following pages.



City, Municipality, or Town

Community, Locality, or Village

Road

International Boundary

Watercourse

Waterbody

Park, Protected Area, Ecological Reserve, or Conservancy

National Park

First Nation Reserve

Treaty Lands

Project Location

aurora LNG

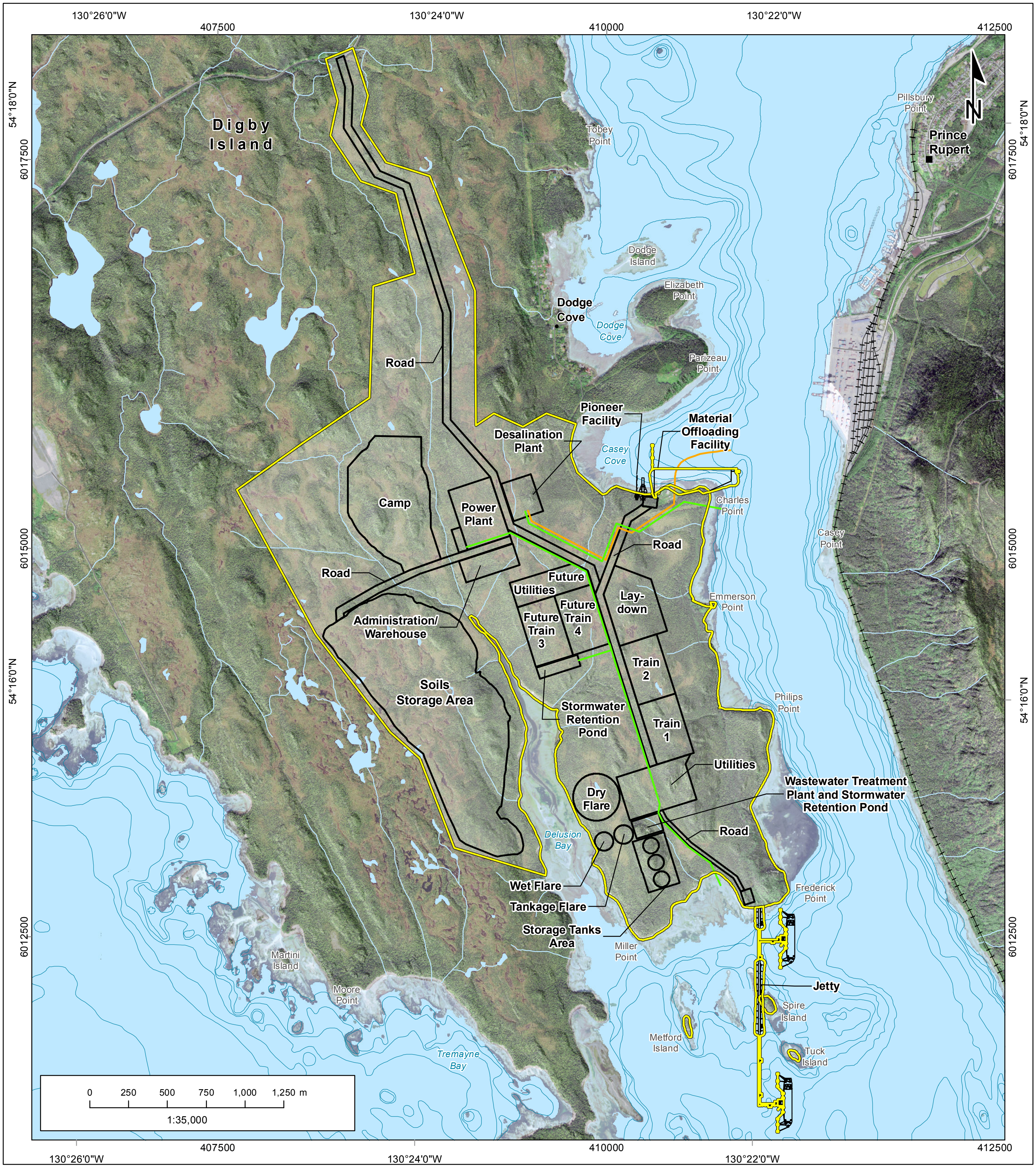
COMMUNITY COMMITMENT CONNECTION

CONCEPTUAL FISH HABITAT OFFSETTING PLAN

PROJECT LOCATION

Data Sources: Government of British Columbia: DataBC, Terrain Resource Information Management, National Topographic System, BC Stats, BC Oil & Gas Commission. Government of Canada: CanVec v12, National Hydrology Network, Atlas of Canada National Framework, Fisheries and Oceans Canada, Environment Canada, Natural Resources Canada. INPEX Gas British Columbia Ltd. Nexen Energy ULC.Service Layer Credits: Copyright:© 2014 Esri

Projection: UTM Zone 9 Datum: NAD 83	Fig. ID: 123220054 Date: Oct 27, 2016	Drawn By: RC Checked By: PM	FIGURE NO: 1



■ City, Municipality, or Town
• Community, Locality, or Village
Road
Railway
Watercourse
Bathymetric Contour
Waterbody
Water Outfall
Water Intake
Project Component
Project Development Area

aurora LNG

COMMUNITY COMMITMENT CONNECTION

CONCEPTUAL FISH HABITAT OFFSETTING PLAN

PROJECT COMPONENTS

Data Sources: Government of British Columbia: DataBC, Terrain Resource Information Management, National Topographic System, BC Stats, BC Oil & Gas Commission. Government of Canada: CanVec v12, National Hydrology Network, Atlas of Canada National Framework, Fisheries and Oceans Canada, Environment Canada, Natural Resources Canada. INPEX Gas British Columbia Ltd. Nexen Energy ULC.

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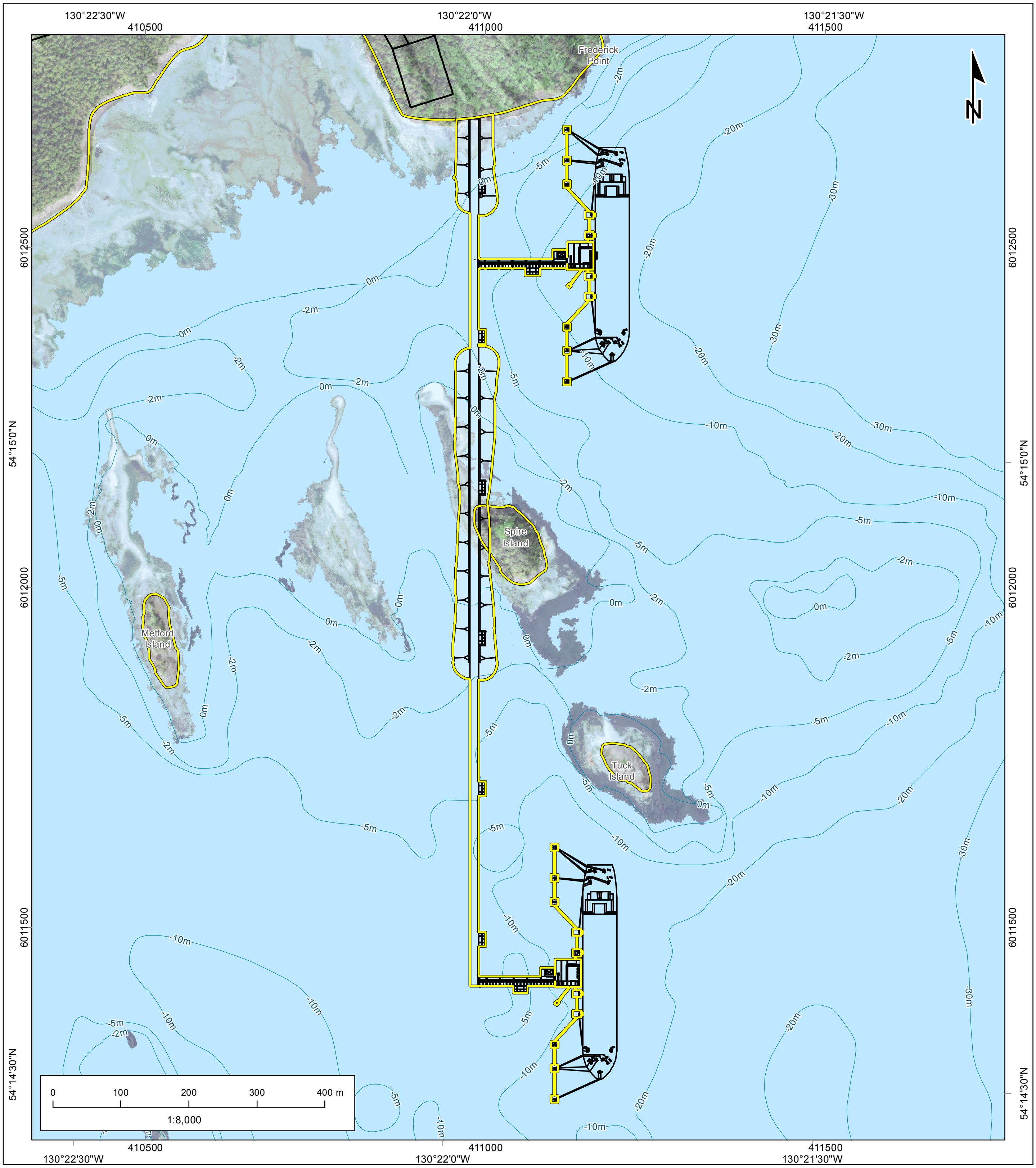
Projection: UTM Zone 9 Datum: NAD 83	Fig. ID:123220054 Date: Oct 28, 2016	Drawn By: RC Checked By: PM	FIGURE NO: 2



Bathymetric Contour

Project Component

Project Development Area

Data Sources: Government of British Columbia: DataBC, Terrain Resource Information Management, National Topographic System, BC Stats, BC Oil & Gas Commission. Government of Canada: CanVec v12, National Hydrology Network, Atlas of Canada National Framework, Fisheries and Oceans Canada, Environment Canada, Natural Resources Canada. INPEX Gas British Columbia Ltd. Nexen Energy ULC.

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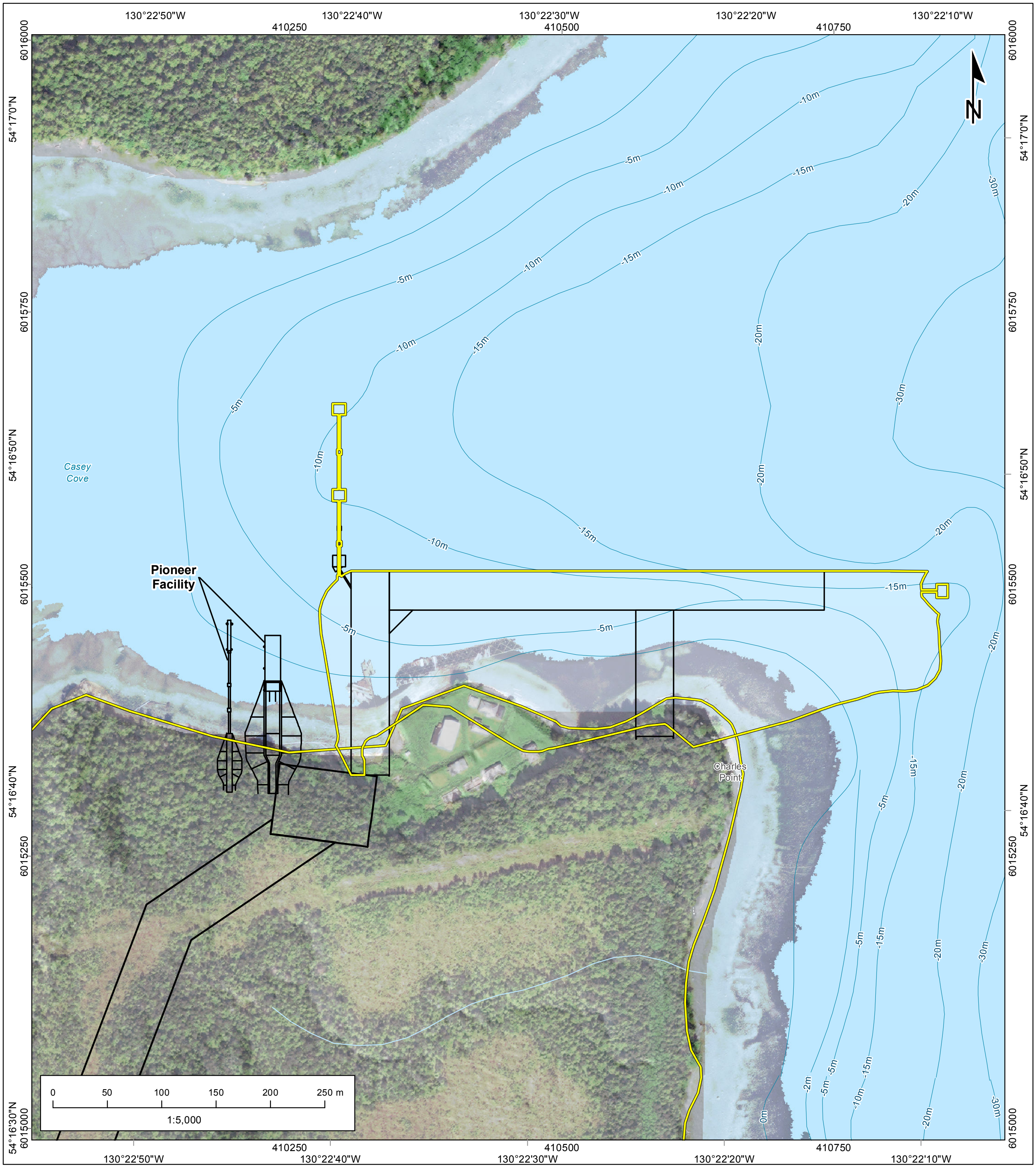
COMMUNITY COMMITMENT CONNECTION

CONCEPTUAL FISH HABITAT OFFSETTING PLAN

LNG JETTY

Projection: UTM Zone 9 Datum: NAD 83	Fig. ID:123220054 Date: Oct 27, 2016	Drawn By: RC Checked By: PM	FIGURE NO: 3



Watercourse

Bathymetric Contour

Project Component

Project Development Area

Data Sources: Government of British Columbia: DataBC, Terrain Resource Information Management, National Topographic System, BC Stats, BC Oil & Gas Commission. Government of Canada: CanVec v12, National Hydrology Network, Atlas of Canada National Framework, Fisheries and Oceans Canada, Environment Canada, Natural Resources Canada. INPEX Gas British Columbia Ltd. Nexen Energy ULC.

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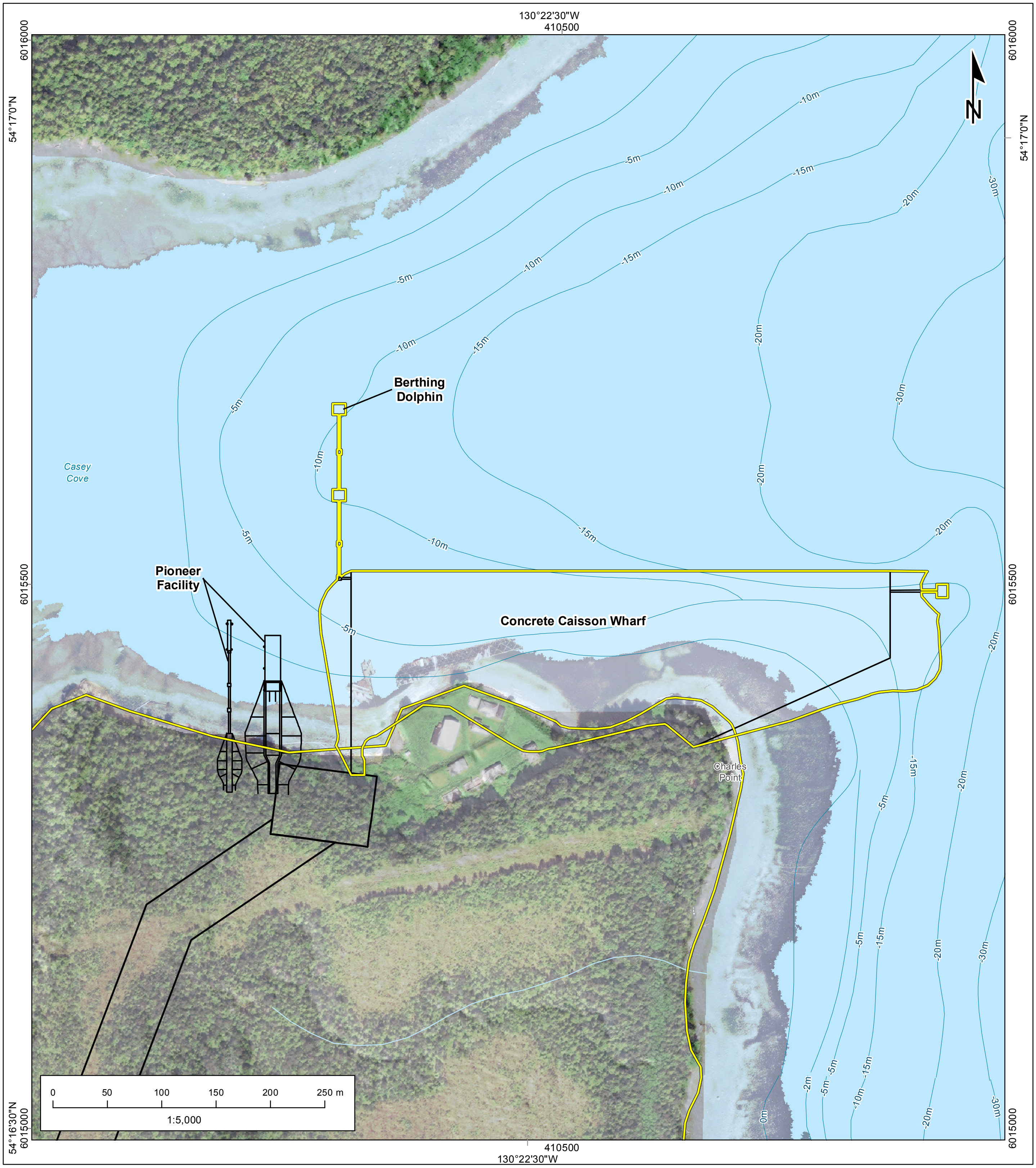
COMMUNITY COMMITMENT CONNECTION

CONCEPTUAL FISH HABITAT OFFSETTING PLAN

MATERIAL OFFLOADING FACILITY: PILE-AND-DECK OPTION

Projection: UTM Zone 9 Datum: NAD 83	Fig. ID:123220054 Date: Oct 27, 2016	Drawn By: RC Checked By: PM	FIGURE NO: 4



	Watercourse
	Bathymetric Contour
	Project Component
	Project Development Area

Data Sources: Government of British Columbia: DataBC, Terrain Resource Information Management, National Topographic System, BC Stats, BC Oil & Gas Commission. Government of Canada: CanVec v12, National Hydrology Network, Atlas of Canada National Framework, Fisheries and Oceans Canada, Environment Canada, Natural Resources Canada. INPEX Gas British Columbia Ltd. Nexen Energy ULC.

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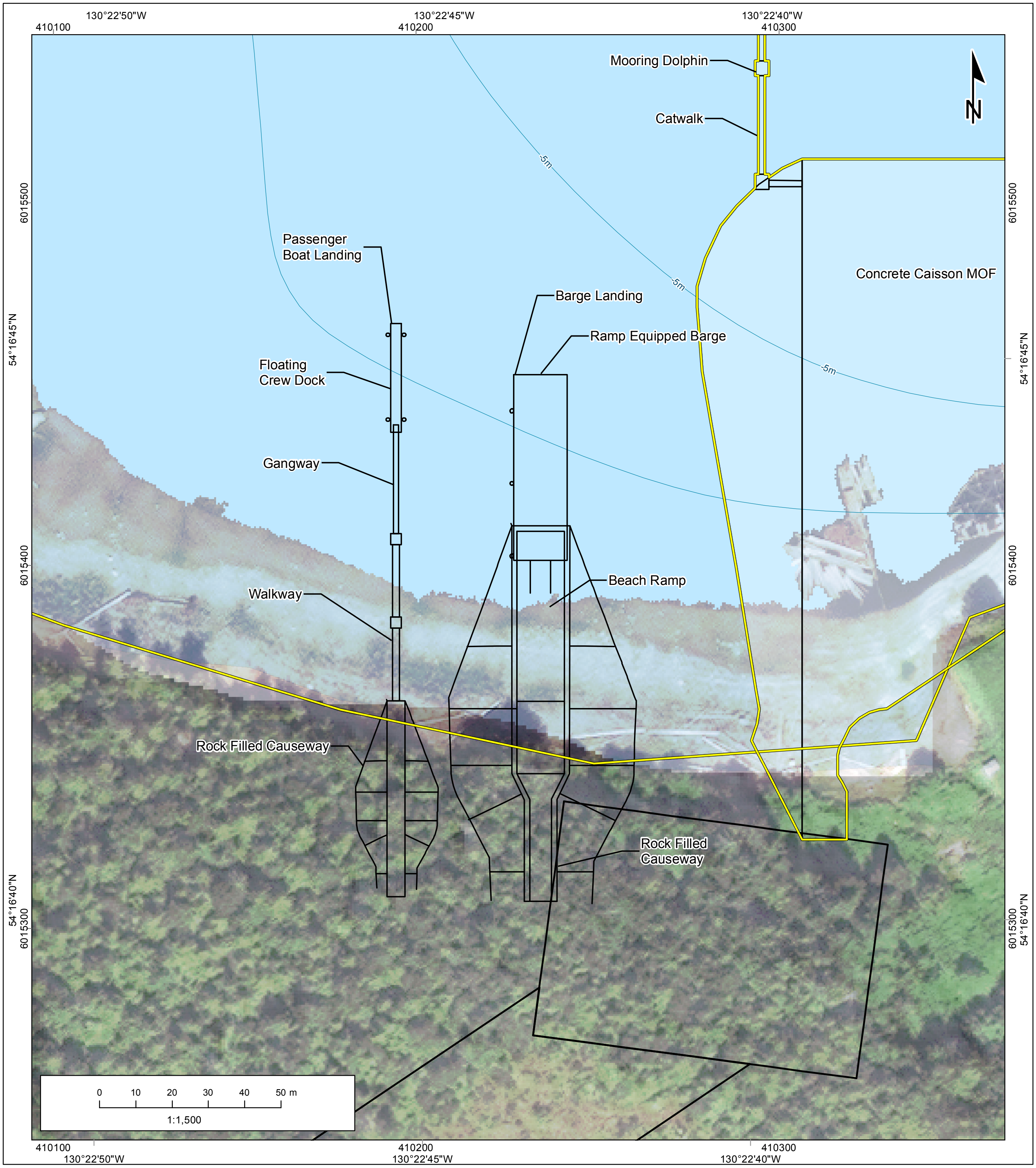
CONCEPTUAL FISH HABITAT OFFSETTING PLAN

MATERIAL OFFLOADING FACILITY: CONCRETE CAISSON OPTION

Projection: UTM Zone 9 Datum: NAD 83	Fig. ID:123220054 Date: Oct 27, 2016	Drawn By: RC Checked By: PM	FIGURE NO: 5



Bathymetric Contour
Project Component
Project Development Area

Note: Concrete-caisson MOF option is shown

Data Sources: Government of British Columbia: DataBC, Terrain Resource Information Management, National Topographic System, BC Stats, BC Oil & Gas Commission. Government of Canada: CanVec v12, National Hydrology Network, Atlas of Canada National Framework, Fisheries and Oceans Canada, Environment Canada, Natural Resources Canada. INPEX Gas British Columbia Ltd. Nexen Energy ULC.

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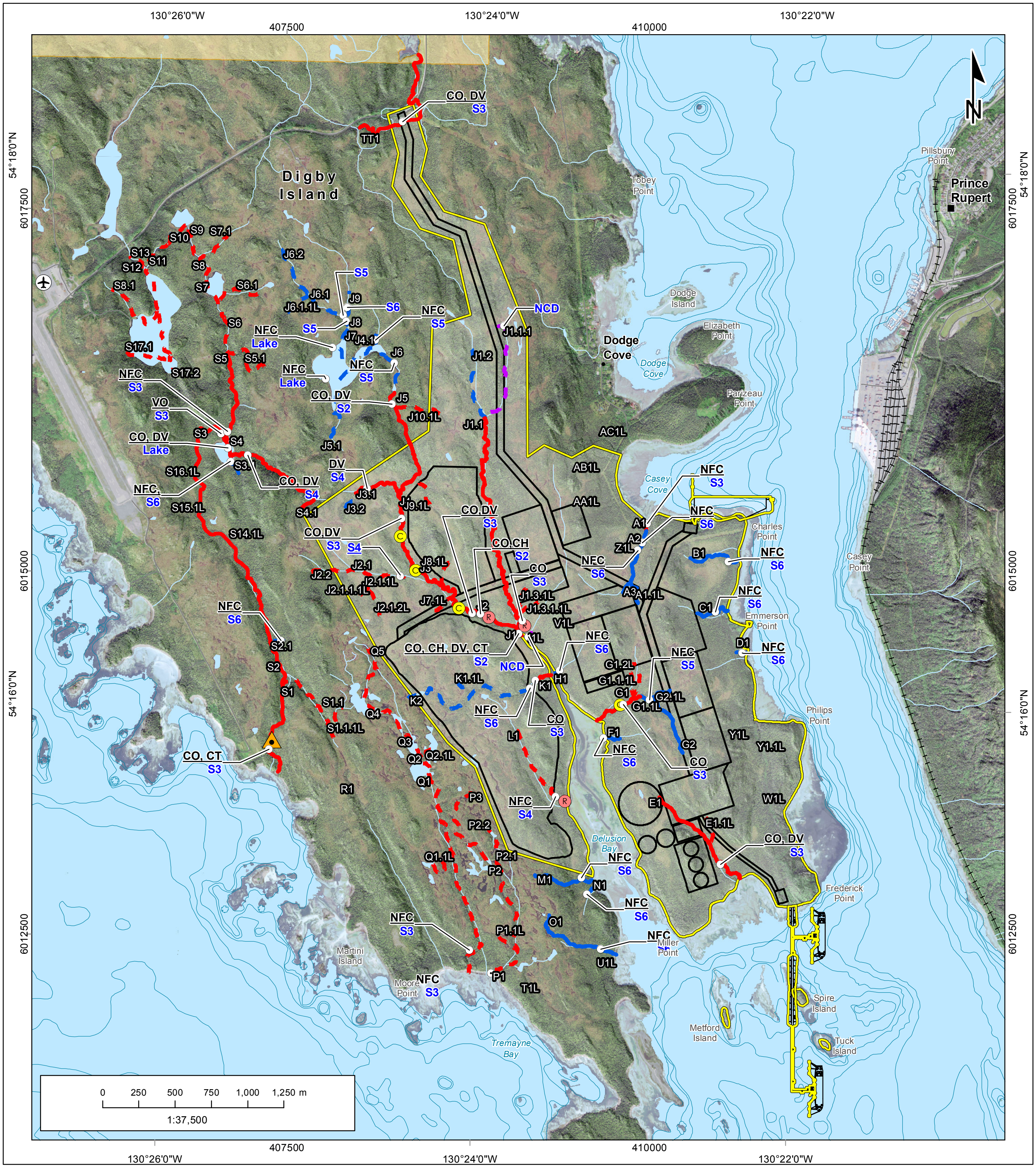
CONCEPTUAL FISH HABITAT OFFSETTING PLAN

PIONEER FACILITY

Projection: UTM Zone 9 Datum: NAD 83	Fig. ID:123220054 Date: Oct 27, 2016	Drawn By: RC Checked By: PM	FIGURE NO: 6



- City, Municipality, or Town
- Community, Locality, or Village
- Road
- Railway
- Watercourse
- Bathymetric Contour
- Project Component
- First Nation Reserve
- Waterbody
- Project Development Area
- Site Location
- Adult Coho Salmon Holding Pool
- Salmon Redds observed
- Reference Site
- Known CRA fish species present
- Suspected CRA fish species present
- Known non-fish bearing (CRA)
- Suspected non-fish bearing (CRA)
- Known NCD
- Suspected NCD

Data Sources: Government of British Columbia: DataBC, Terrain Resource Information Management, National Topographic System, BC Stats, BC Oil & Gas Commission. Government of Canada: CanVec v12, National Hydrology Network, Atlas of Canada National Framework, Fisheries and Oceans Canada, Environment Canada, Natural Resources Canada. INPEX Gas British Columbia Ltd. Nexen Energy ULC.

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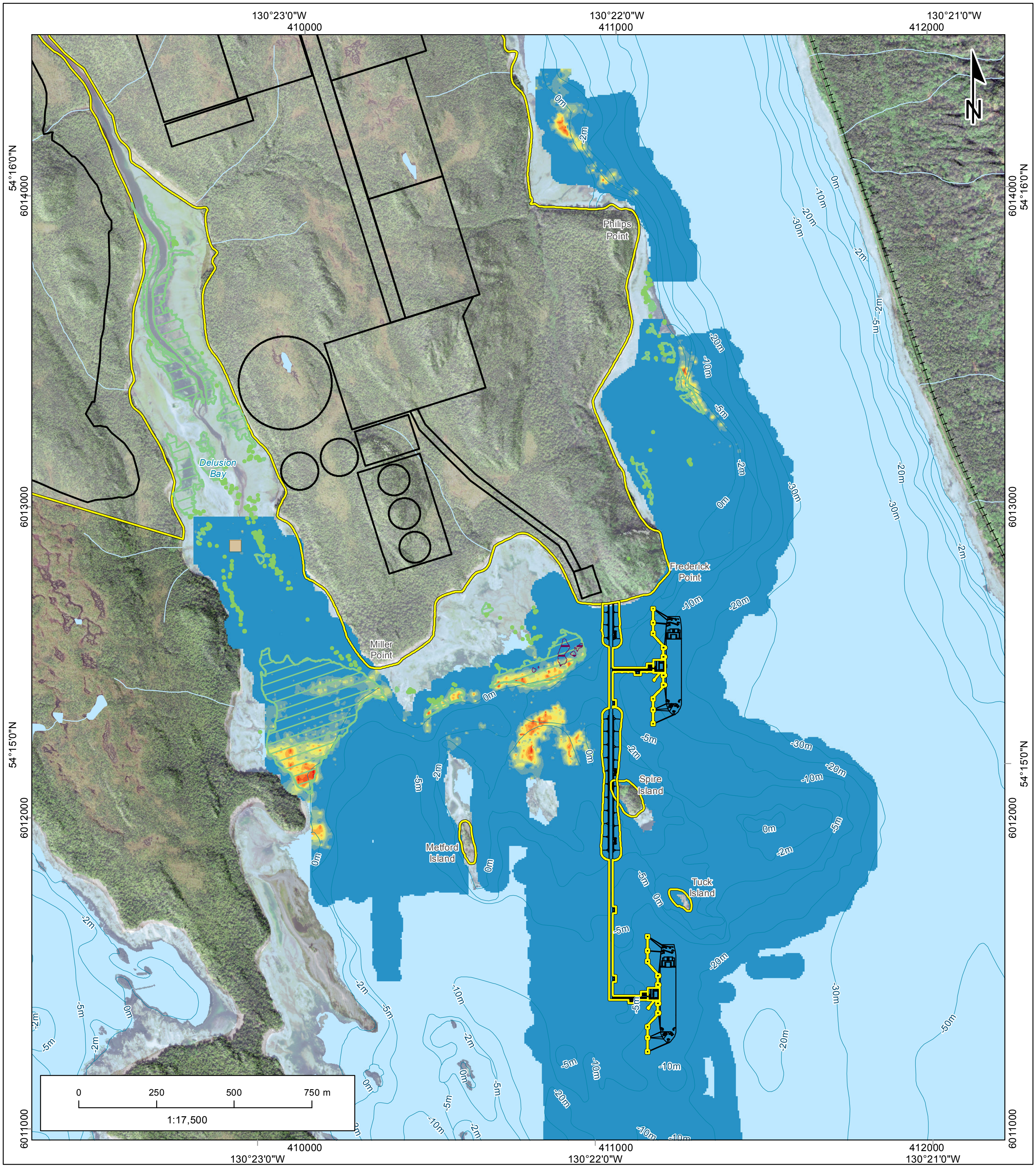
CONCEPTUAL FISH HABITAT OFFSETTING PLAN

DISTRIBUTION OF FISH-BEARING WATERCOURSES ON DIGBY ISLAND

Projection: UTM Zone 9 Datum: NAD 83	Fig. ID:123220054 Date: Oct 27, 2016	Drawn By: RC Checked By: PM	FIGURE NO: 7



- Road
- Railway
- Watercourse
- Bathymetric Contour
- Project Component
- Waterbody
- Project Development Area
- Eelgrass (*Z. marina*) Patch
- *Phyllospadix scouleri* Bed
- Eelgrass (*Z. marina*) Bed
- Mixed *Z. marina*/*P. serrulatus* Bed

Eelgrass Cover (%)

- 0 - <10
- 10 - < 20
- 20 - < 30
- 30 - < 40
- 40 - < 50
- 50 - < 60
- 60 - < 70
- 70 - < 80
- 80 - < 90
- 90 - 100

Data Sources: Government of British Columbia: DataBC, Terrain Resource Information Management, National Topographic System, BC Stats, BC Oil & Gas Commission. Government of Canada: CanVec v12, National Hydrology Network, Atlas of Canada National Framework, Fisheries and Oceans Canada, Environment Canada, Natural Resources Canada. INPEX Gas British Columbia Ltd. Nexen Energy ULC.

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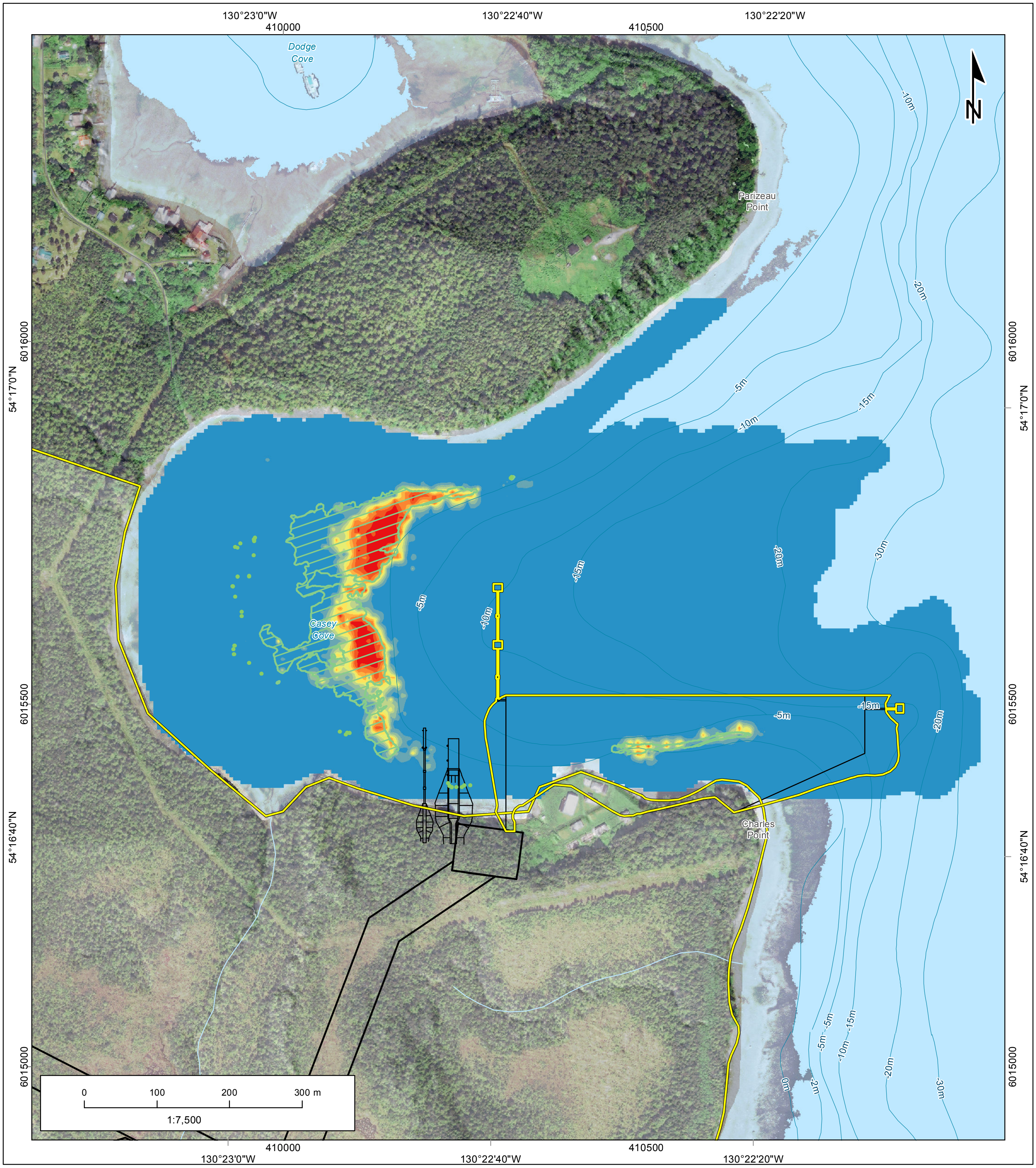
CONCEPTUAL FISH HABITAT OFFSETTING PLAN

DISTRIBUTION OF EELGRASS AT SOUTH DIGBY ISLAND

Projection: UTM Zone 9 Datum: NAD 83	Fig. ID:123220054 Date: Oct 27, 2016	Drawn By: RC Checked By: PM	FIGURE NO: 8



Road	
Watercourse	
Bathymetric Contour	
Project Component	
Project Development Area	
Eelgrass (*Z. marina*) Patch	
Eelgrass (*Z. marina*) Bed	

Eelgrass Cover (%)

- 0 - <10
- 10 - < 20
- 20 - < 30
- 30 - < 40
- 40 - < 50
- 50 - < 60
- 60 - < 70
- 70 - < 80
- 80 - < 90
- 90 - 100

Note: Concrete-caisson MOF option is shown

Data Sources: Government of British Columbia: DataBC, Terrain Resource Information Management, National Topographic System, BC Stats, BC Oil & Gas Commission. Government of Canada: CanVec v12, National Hydrology Network, Atlas of Canada National Framework, Fisheries and Oceans Canada, Environment Canada, Natural Resources Canada. INPEX Gas British Columbia Ltd. Nexen Energy ULC.

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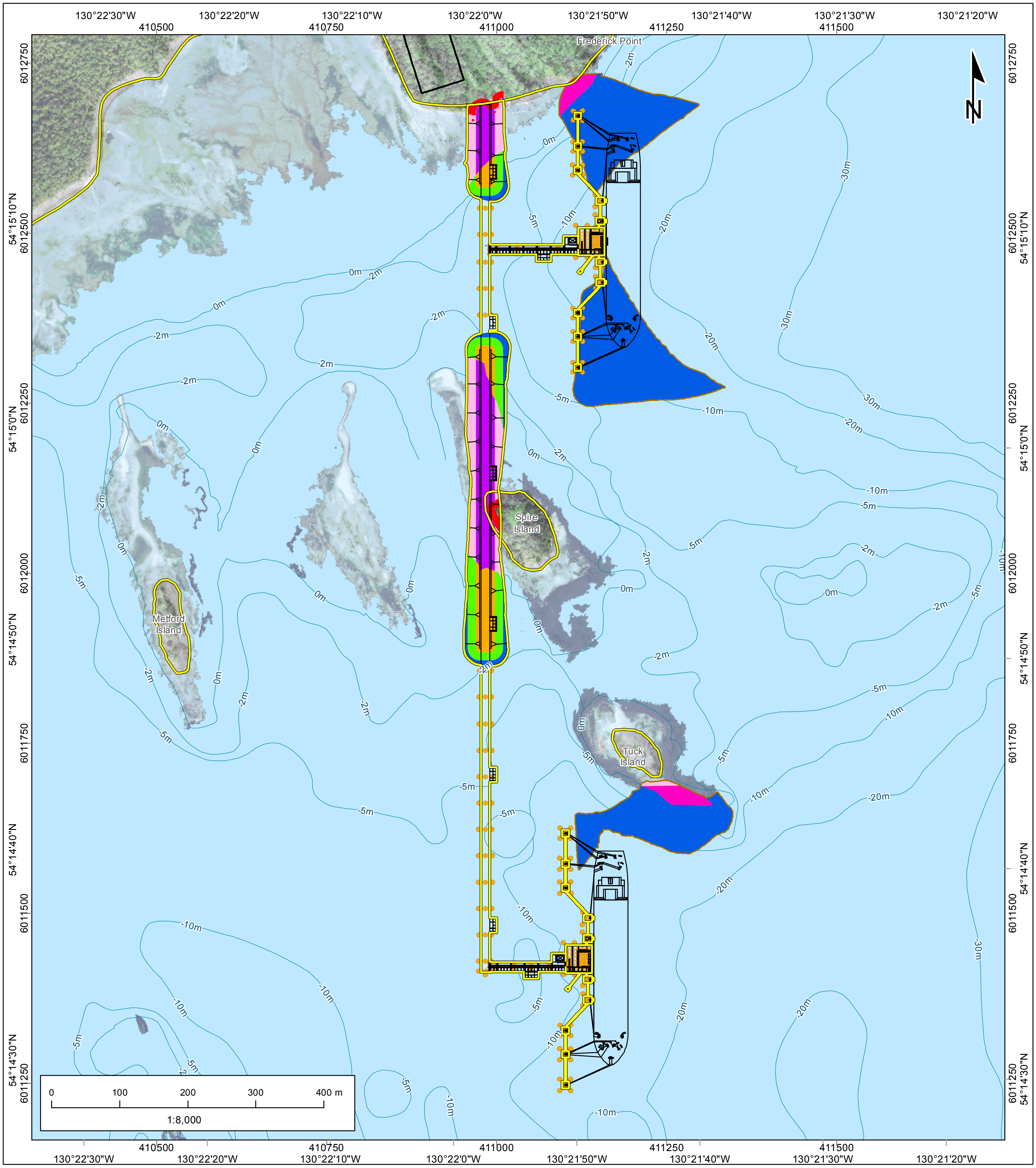
CONCEPTUAL FISH HABITAT OFFSETTING PLAN

DISTRIBUTION OF EELGRASS IN CASEY COVE

Projection: UTM Zone 9 Datum: NAD 83	Fig. ID:123220054 Date: Oct 27, 2016	Drawn By: RC Checked By: PM	FIGURE NO: 9



Bathymetric Contour
Project Component
Dredge Area
Project Development Area

Marine Habitat Loss Due to Piles*
Subtidal

Marine Habitat Loss
Marine Riparian
Eelgrass
Intertidal
Subtidal

Marine Habitat
Intertidal to Intertidal
Intertidal to Subtidal
Subtidal to Subtidal
Subtidal to Intertidal

* Not shown to scale. Represents 60 inch diameter piles.

Data Sources: Government of British Columbia: DataBC, Terrain Resource Information Management, National Topographic System, BC Stats, BC Oil & Gas Commission. Government of Canada: CanVec v12, National Hydrology Network, Atlas of Canada National Framework, Fisheries and Oceans Canada, Environment Canada, Natural Resources Canada. INPEX Gas British Columbia Ltd. Nexen Energy ULC.

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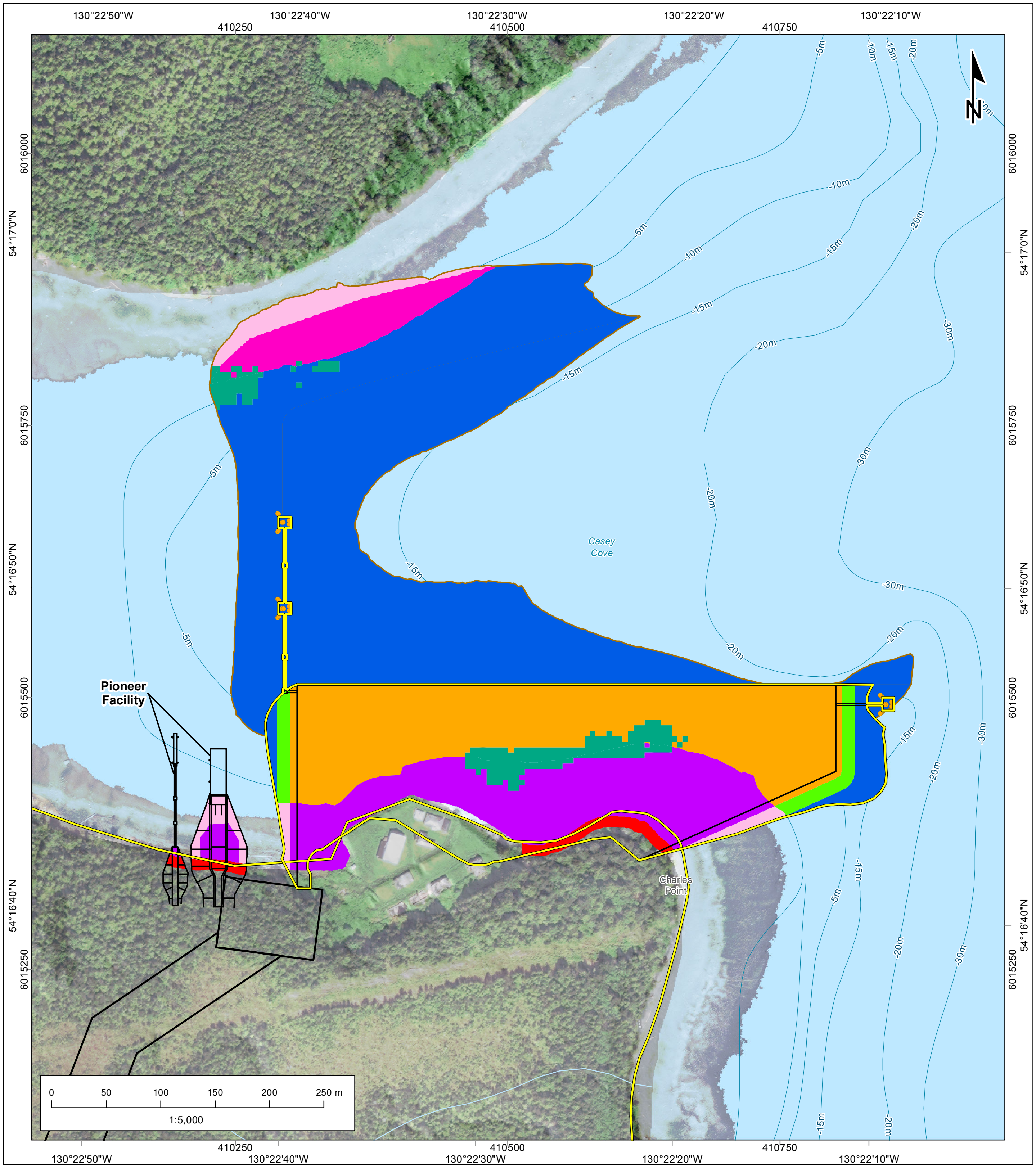
CONCEPTUAL FISH HABITAT OFFSETTING PLAN

ALTERATION OR LOSS OF MARINE SUBSTRATE AND VEGETATION: LNG JETTY

Projection: UTM Zone 9 Datum: NAD 83	Fig. ID:123220054 Date: Oct 28, 2016	Drawn By: RC Checked By: JM	FIGURE NO: 10



Watercourse	**Marine Habitat Loss Due to Piles***	**Marine Habitat Loss**	**Marine Habitat Alteration**
Bathymetric Contour	Subtidal	Marine Riparian	Intertidal to Intertidal
Project Component		Eelgrass	Intertidal to Subtidal
Dredge Area		Intertidal	Subtidal to Subtidal
Project Development Area		Subtidal	Subtidal to Intertidal

* Not shown to scale. Represents 60 inch diameter piles.

Data Sources: Government of British Columbia: DataBC, Terrain Resource Information Management, National Topographic System, BC Stats, BC Oil & Gas Commission. Government of Canada: CanVec v12, National Hydrology Network, Atlas of Canada National Framework, Fisheries and Oceans Canada, Environment Canada, Natural Resources Canada. INPEX Gas British Columbia Ltd. Nexen Energy ULC.

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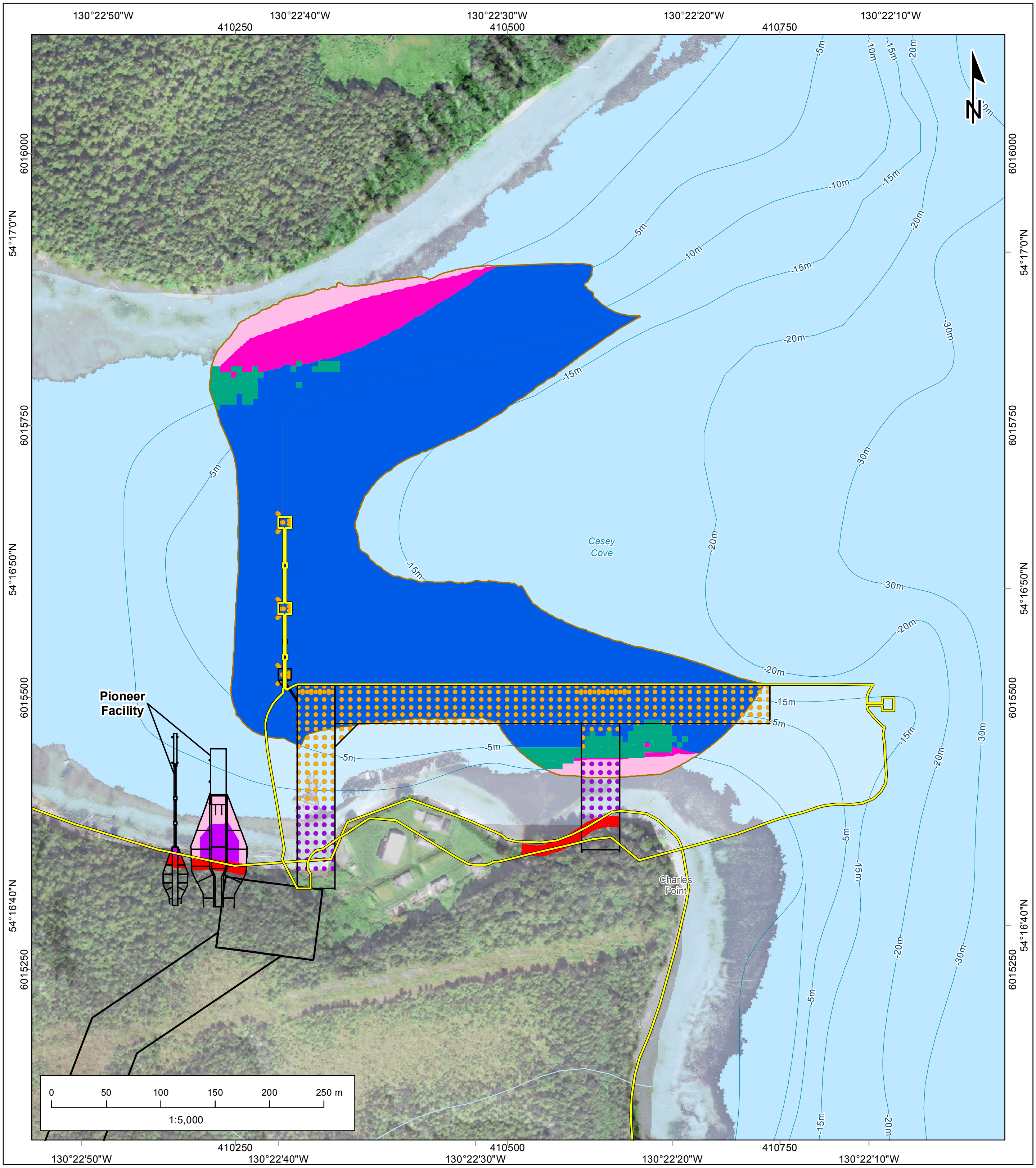
CONCEPTUAL FISH HABITAT OFFSETTING PLAN

ALTERATION OR LOSS OF MARINE SUBSTRATE AND VEGETATION: CONCRETE CAISSON MOF OPTION

Projection: UTM Zone 9 Datum: NAD 83	Fig. ID:123220054 Date: Oct 28, 2016	Drawn By: RC Checked By: JM	FIGURE NO: 11



Watercourse
Bathymetric Contour
Project Component
Dredge Area
Project Development Area

Marine Habitat Loss Due to Piles*
- Intertidal
- Subtidal

Marine Habitat Loss
- Marine Riparian
- Eelgrass
- Intertidal
- Subtidal

Marine Habitat Alteration
- Intertidal to Intertidal
- Intertidal to Subtidal
- Subtidal to Subtidal
- Subtidal to Intertidal

* Not shown to scale. Represents 60 inch diameter piles.

Data Sources: Government of British Columbia: DataBC, Terrain Resource Information Management, National Topographic System, BC Stats, BC Oil & Gas Commission. Government of Canada: CanVec v12, National Hydrology Network, Atlas of Canada National Framework, Fisheries and Oceans Canada, Environment Canada, Natural Resources Canada. INPEX Gas British Columbia Ltd. Nexen Energy ULC.

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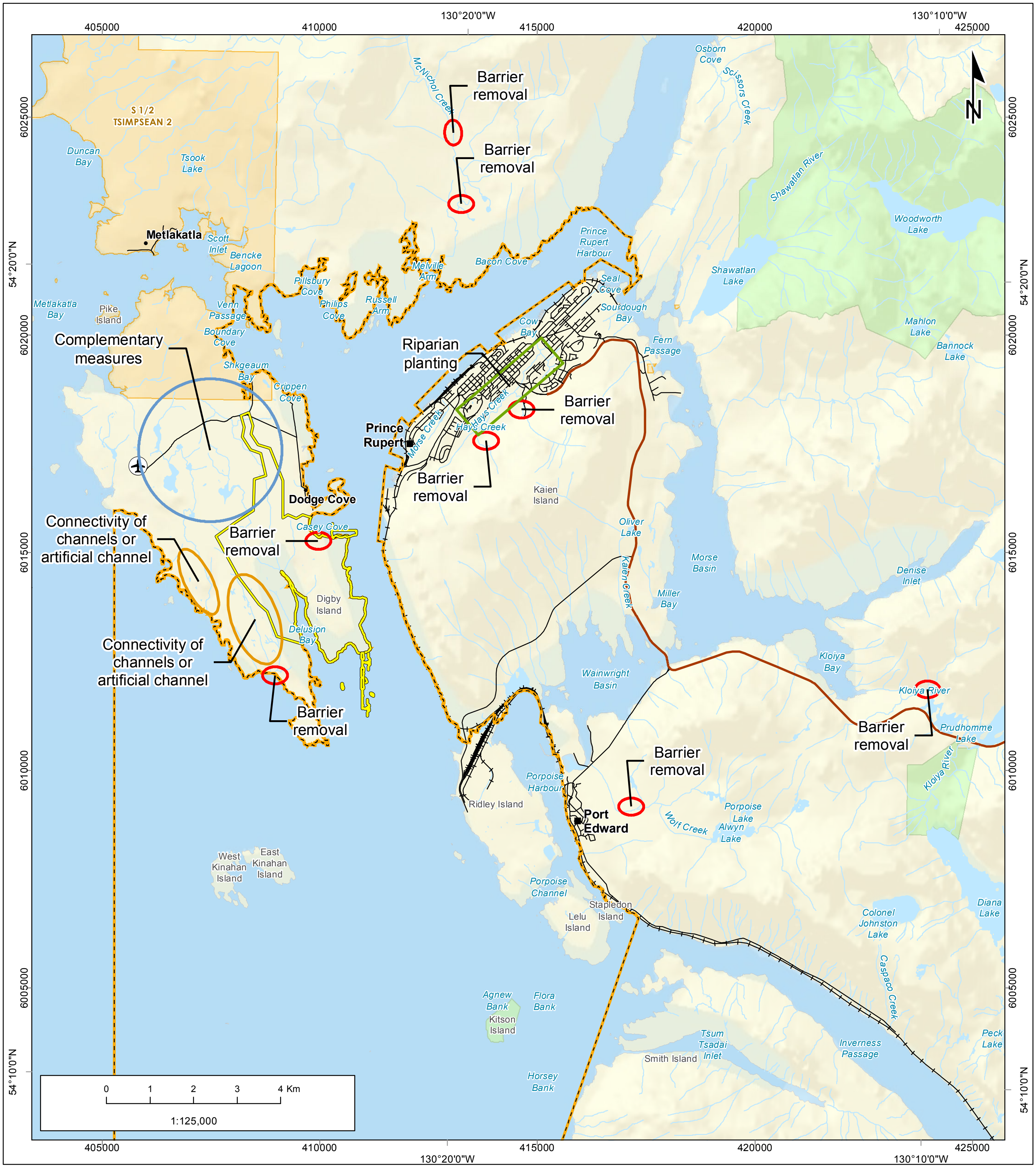
CONCEPTUAL FISH HABITAT OFFSETTING PLAN

ALTERATION OR LOSS OF MARINE SUBSTRATE AND VEGETATION: PILE-AND-DECK MOF OPTION

Projection: UTM Zone 9 Datum: NAD 83	Fig. ID:123220054 Date: Oct 28, 2016	Drawn By: RC Checked By: JM	FIGURE NO: 12



City, Municipality, or Town
Community, Locality, or Village
Airport
Highway
Road
Railway
Watercourse

Park, Protected Area, Ecological Reserve, or Conservancy
First Nation Reserve
Waterbody
Prince Rupert Port Authority Boundary
Project Development Area

Freshwater Feature:
Barrier removal
Complementary measures
Connectivity of channels or artificial channel
Riparian planting

Data Sources: Government of British Columbia: DataBC, Terrain Resource Information Management, National Topographic System, BC Stats, BC Oil & Gas Commission. Government of Canada: CanVec v12, National Hydrology Network, Atlas of Canada National Framework, Fisheries and Oceans Canada, Environment Canada, Natural Resources Canada. INPEX Gas British Columbia Ltd. Nexen Energy ULC.Service Layer Credits: Copyright:© 2014 Esri

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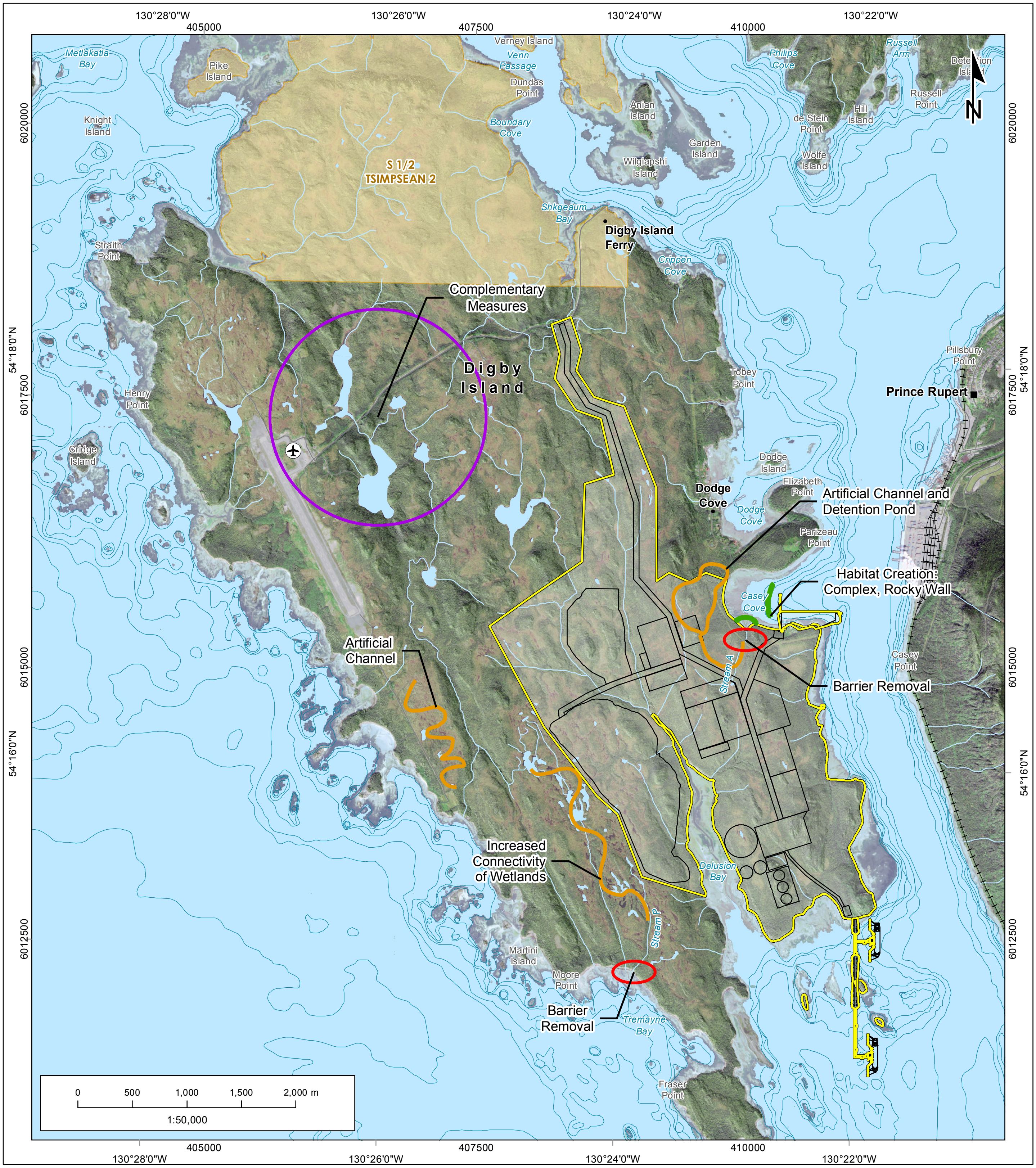
CONCEPTUAL FISH HABITAT OFFSETTING PLAN

CONCEPTUAL FRESHWATER OFFSETTING: REGION

Projection: UTM Zone 9 Datum: NAD 83	Fig. ID: 123220054 Date: Oct 27, 2016	Drawn By: LT Checked By: SM	FIGURE NO: 13



- City, Municipality, or Town
- Community, Locality, or Village
- Road
- Railway
- Watercourse
- Bathymetric Contour
- Park, Protected Area, Ecological Reserve, or Conservancy
- First Nation Reserve
- Waterbody
- Project Component
- Project Development Area

Freshwater Feature

- Artificial channel
- Complementary Measures
- Barrier Removal
- Proposed Rocky Wall

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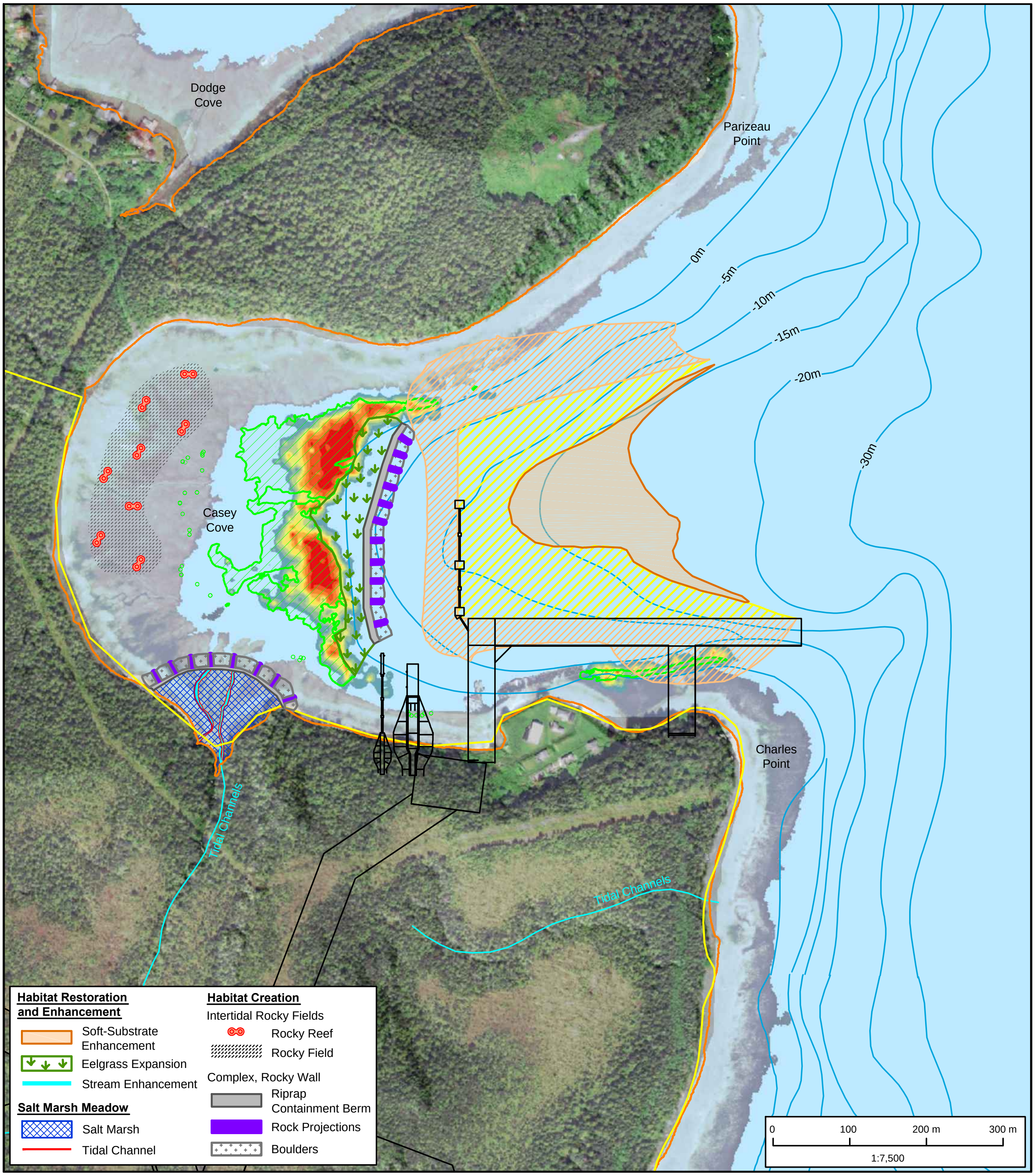
CONCEPTUAL FISH HABITAT OFFSETTING PLAN

CONCEPTUAL FRESHWATER OFFSETTING: DIGBY ISLAND

Data Sources: Government of British Columbia: DataBC, Terrain Resource Information Management, National Topographic System, BC Stats, BC Oil & Gas Commission. Government of Canada: CanVec v12, National Hydrology Network, Atlas of Canada National Framework, Fisheries and Oceans Canada, Environment Canada, Natural Resources Canada. INPEX Gas British Columbia Ltd. Nexen Energy ULC.

Projection: UTM Zone 9 Datum: NAD 83	Fig. ID:123220054 Date: Oct 27, 2016	Drawn By: LT Checked By: SM	FIGURE NO: 14



Road
Watercourse
MHHWL (6.1 m CD)
Bathymetric Contour

Project Component
Project Development Area
Dredge Basin
Dredge Side Slopes
Eelgrass *(Z. marina)* Patch
Eelgrass *(Z. marina)* Bed

Eelgrass Cover (%)

0 - <10
10 - <20
20 - < 30
30 - < 40
40 - < 50
50 - < 60
60 - < 70
70 - < 80
80 - < 90
90 - 100

Notes:
Pile-and-Deck MOF Option Shown

Data Sources: Government of British Columbia: DataBC, Terrain Resource Information Management, National Topographic System, BC Stats, BC Oil & Gas Commission. Government of Canada: CanVec v12, National Hydrology Network, Atlas of Canada National Framework, Fisheries and Oceans Canada, Environment Canada, Natural Resources Canada. INPEX Gas British Columbia Ltd. Nexen Energy ULC.

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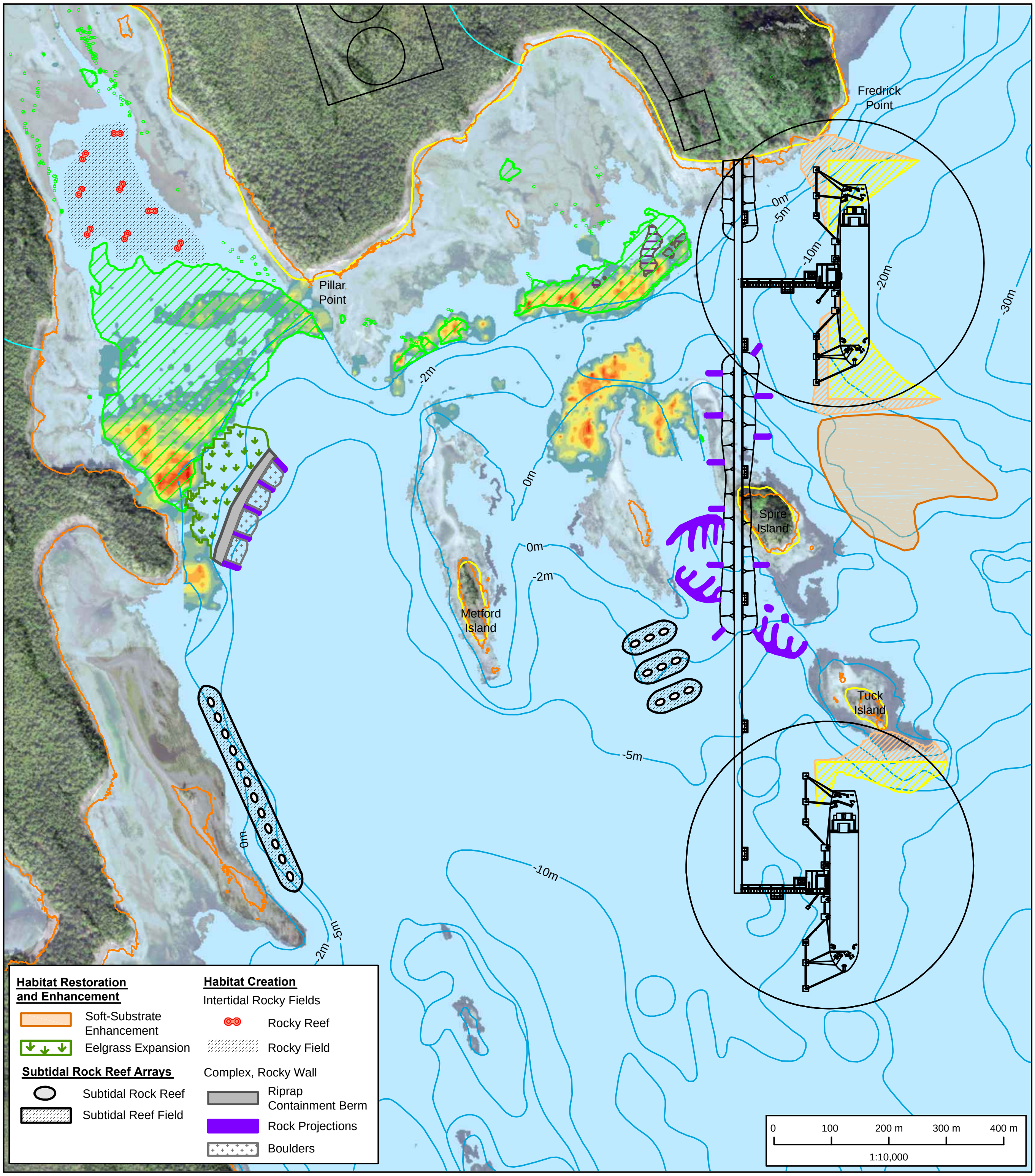
COMMUNITY COMMITMENT CONNECTION

CONCEPTUAL FISH HABITAT OFFSETTING PLAN

CONCEPTUAL MARINE OFFSETTING: CASEY COVE

Projection: UTM Zone 9 Datum: NAD 83	Fig. ID: 123220054 Date: Sept 02, 2016	Drawn By: SM Checked By: PM	FIGURE NO: 15



- Watercourse
- MHHWL (6.1 m CD)
- Bathymetric Contour
- Project Component

- Project Development Area
- Dredge Basin
- Dredge Side Slopes
- Eelgrass *(Z. marina)* Patch
- *Phyllospadix scouleri* Bed
- Eelgrass *(Z. marina)* Bed
- Mixed Z. *marina/P. serrulatus* Bed

Eelgrass Cover (%)

0 - <10	50 - < 60
10 - <20	60 - < 70
20 - < 30	70 - < 80
30 - < 40	80 - < 90
40 - < 50	90 - 100

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COMMUNITY COMMITMENT CONNECTION

CONCEPTUAL HABITAT OFFSETTING PLAN

CONCEPTUAL MARINE OFFSETTING: SOUTH DIGBY ISLAND

Data Sources: Government of British Columbia: DataBC, Terrain Resource Information Management, National Topographic System, BC Stats, BC Oil & Gas Commission. Government of Canada: CanVec v12, National Hydrology Network, Atlas of Canada National Framework, Fisheries and Oceans Canada, Environment Canada, Natural Resources Canada. INPEX Gas British Columbia Ltd. Nexen Energy ULC. Sub-bottom Profiling Data from Golder 2014 Geophysical Report, Dated December 17, 2014

Projection: UTM Zone 9 Datum: NAD 83	Fig. ID: 123220054 Date: Aug 05, 2016	Drawn By: SM Checked By: PM	FIGURE NO: 16

APPENDIX 1

Marine Fish Species Potentially Affected by the Project

Table 1-1 Marine Fish Species Potentially Affected by the Project

Functional Group	Common Name	Scientific Name	Habitat Zone	Habitat Substrate Type	Provincial Status[1,2]	Federal Status[3]	Key CRA Fishery Species	Fish Presence Documented[4]	
								Casey Cove	South Digby Island
Benthic/ Demersal Fish	Whitespotted greenling	*Hexagrammos stelleri*	Intertidal Subtidal	Rocky Varied soft sediment	No Status (SNR)	-	✓	✓	✓
	Kelp greenling	*Hexagrammos decagrammus*	Intertidal Subtidal	Rocky Varied soft sediment	No Status (SNR)	-	✓	✓	✓
	Lingcod	*Ophiodon elongatus*	Subtidal	Rocky Eelgrass (juveniles)	No Status (SNR)	-	✓	✓	×
	Pacific cod	*Gadus macrocephalus*	Subtidal	Soft sediment Rocky	No Status (SNR)	-	✓	×	✓
	Pacific tomcod	*Microgadus proximus*	Subtidal	Soft sediment	No Status (SNR)	-	✓	✓	×
	Rock sole	*Lepidopsetta spp*	Intertidal Subtidal	Soft sediment	No Status (SNR)	-	✓	✓	✓
	English sole	*Parophrys vetulus*	Intertidal Subtidal	Soft sediment	No Status (SNR)	-	✓	✓	×
	Butter Sole	*Isopsetta isolepis*	Intertidal Subtidal	Soft sediment	No Status (SNR)	-	✓	×	✓
	C-O sole	*Pleuronichthys coenosus*	Intertidal Subtidal	Soft sediment	No Status (SNR)	-	✓	×	×
	Slender sole	*Lyposetta exilis*	Intertidal Subtidal	Soft sediment	No Status (SNR)	-	✓	×	✓
	Dover sole	*Microstomus Pacificus*	Intertidal Subtidal	Soft sediment	No Status (SNR)	-	✓	×	✓

Table 1-1 Marine Fish Species Potentially Affected by the Project

Functional Group	Common Name	Scientific Name	Habitat Zone	Habitat Substrate Type	Provincial Status[1, 2]	Federal Status[3]	Key CRA Fishery Species	Fish Presence Documented[4]	
								Casey Cove	South Digby Island
Benthic/ Demersal Fish (cont'd)	Yellowfin sole	*Limanda aspera*	Intertidal Subtidal	Soft sediment	No Status (SNR)	-	✓	×	✓
	High cockscomb	*Anoplarchus purpurescens)*	Intertidal Subtidal	Rocky	No Status (SNR)	-	×	×	✓
	Pricklebacks	Family Stichaeidae	Intertidal Subtidal	Mixed	No Status (SNR)	-	×	×	✓
	Black prickleback	*Xiphister atropurpureus*	Intertidal	Mixed	No Status (SNR)	-	×	✓	×
	Pacific snake prickleback	*Lumpenus sagitta*	Intertidal Subtidal	Mixed	No Status (SNR)	-	×	×	✓
	Sturgeon poacher	*Podothecus accipenserinus*	Intertidal Subtidal	Soft sediment	No Status (SNR)	-	×	×	✓
	Speckled sanddab	*Citharichthys stigmaeus*	Intertidal Subtidal	Soft sediment	No Status (SNR)	-	×	×	✓
	Starry flounder	*Platichthys stellatus*	Intertidal Subtidal	Soft sediment	No Status (SNR)	-	✓	✓	✓
	Sandfish	Family *Trichodontidae*	Intertidal Subtidal	Soft sediment	No Status (SNR)	-	×	×	✓
	Snailfish	*Liparidae spp.*	Intertidal Subtidal	Soft sediment Kelp/Eelgrass	No Status (SNR)	-	×	×	✓
	Shiner perch	*Cymatogaster aggregate*	Intertidal Subtidal	Kelp/Eelgrass	No Status (SNR)	-	×	✓	✓

Table 1-1 Marine Fish Species Potentially Affected by the Project

Functional Group	Common Name	Scientific Name	Habitat Zone	Habitat Substrate Type	Provincial Status[1,2]	Federal Status[3]	Key CRA Fishery Species	Fish Presence Documented[4]	
								Casey Cove	South Digby Island
Benthic/ Demersal Fish (cont'd)	Kelp perch	*Brachyistius frenatus*	Intertidal Subtidal	Kelp/Eelgrass	No Status (SNR)	-	×	×	✓
	Pacific staghorn sculpin	*Leptocottus armatus*	Intertidal	Soft sediment	No Status (SNR)	-	×	✓	✓
	Buffalo sculpin	*Enophrys bison*	Intertidal Subtidal	Soft sediment Rocky Seaweed	No Status (SNR)	-	×	✓	✓
	Prickly sculpin	*Cottus asper*	Intertidal Subtidal	Gravel/ sand	No Status (SNR)	-	×	✓	✓
	Great sculpin	*Myoxocephalus polyacanthocephalus*	Intertidal Subtidal	Rocky	No Status (SNR)	-	×	×	✓
	Tadpole sculpin	*Psychrolutes paradoxus*	Intertidal Subtidal	Soft sediment	No Status (SNR)	-	×	×	✓
	Fluffy sculpin	*Oligocottus snyderi*	Intertidal	Rocky	No Status (SNR)	-	×	×	×
	Red Irish lord	*Hemilepidotus*	Subtidal	Soft sediment	No Status (SNR)	-	✓	✓	×
	Yellowtail rockfish	*Sebastes flavidus*	Intertidal Subtidal	Kelp, Eelgrass (juveniles) Rocky	No Status (SNR)	-	✓	✓	×
	Copper rockfish	*Sebastes caurinus*	Intertidal Subtidal	Kelp, Eelgrass (juveniles) Rocky	No Status (SNR)	-	✓	✓	✓

Table 1-1 Marine Fish Species Potentially Affected by the Project

Functional Group	Common Name	Scientific Name	Habitat Zone	Habitat Substrate Type	Provincial Status[1,2]	Federal Status[3]	Key CRA Fishery Species	Fish Presence Documented[4]	
								Casey Cove	South Digby Island
Benthic/ Demersal Fish (cont'd)	Black rockfish	*Sebastes melanops*	Intertidal Subtidal	Kelp, Eelgrass (juveniles) Rocky	No Status (SNR)	-	✓	×	✓
	Quillback rockfish	*Sebastes maliger*	Intertidal Subtidal	Soft sediment (juveniles) Kelp, Eelgrass (juveniles) Rocky	No Status (SNR)	T	✓	×	✓
	Cabezon	*Scorpaenichthys marmoratus*	Subtidal	Varied soft sediment Rocky	No Status (SNR)	-	✓	×	✓
	Juvenile gunnel	Family Pholidae	Intertidal	Rocky seaweed	No Status (SNR)	-	×	×	✓
	Crescent gunnel	*Pholis laeta*	Intertidal Subtidal	Soft sediment Rocky seaweed	No Status (SNR)	-	×	✓	✓
	Penpoint gunnel	*Apodichthys flavidus*	Intertidal Subtidal	Rocky seaweed	No Status (SNR)	-	×	×	✓
	Northern ronquil	*Ronquilus jordani*	Subtidal	Mixed	No Status (SNR)	-	×	✓	
	Big skate	*Raja binoculata*	Subtidal	Soft sediment	No Status (SNR)	NaR	×	×	✓
	Eelpouts	*Zoarcidae spp.*	Subtidal	Soft sediment	No Status (SNR)	-	×	×	✓

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Functional Group	Common Name	Scientific Name	Habitat Zone	Habitat Substrate Type	Provincial Status[1,2]	Federal Status[3]	Key CRA Fishery Species	Fish Presence Documented[4]	
								Casey Cove	South Digby Island
Anadromous Fish	Chum salmon	*Oncorhynchus keta*	Intertidal Subtidal	Eelgrass (juveniles) Soft sediment Rocky	Yellow-Listed (S5)	-	✓	✓	✓
	Pink salmon	*Oncorhynchus gorbuscha*	Intertidal Subtidal	Eelgrass (juveniles) Soft sediment Rocky	Yellow-Listed (S5)	-	✓	✓	✓
	Chinook salmon	*Oncorhynchus tshawytscha*	Intertidal Subtidal	Eelgrass (juveniles) Soft sediment Rocky	Yellow-Listed (S4)	T	✓	✓	✓
	Coho salmon	*Oncorhynchus kisutch*	Intertidal Subtidal	Eelgrass (juveniles) Soft sediment Rocky	Yellow-Listed (S4)	E	✓	✓	✓
	Sockeye salmon	*Oncorhynchus nerka*	Intertidal Subtidal	Eelgrass (juveniles) Soft sediment Rocky	Yellow-Listed (S4)	E	✓	✓	✓
	Dolly Varden	*Salvelinus malma*	Intertidal Subtidal	Soft sediment Rocky Eelgrass (juveniles)	Yellow-Listed (S4)	-	✓	×	✓
N/A	Unidentified larval fish	*N/A*	Intertidal Subtidal	N/A	-	-	-	✓	✓

Table 1-1 Marine Fish Species Potentially Affected by the Project

Functional Group	Common Name	Scientific Name	Habitat Zone	Habitat Substrate Type	Provincial Status[1,2]	Federal Status[3]	Key CRA Fishery Species	Fish Presence Documented[4]	
								Casey Cove	South Digby Island
Pelagic Forage Fish	Pacific sand lance	*Ammodytes hexapterus*	Intertidal Subtidal	Soft sediment	No Status (SNR)	-	✓	×	✓
	Surf smelt	*Hypomesus pretiosus*	Intertidal Subtidal	Soft sediment Rocky Eelgrass (juveniles)	No Status (SNR)	-	✓	✓	✓
	Unidentified larval smelt	Family Osmeridae	Intertidal Subtidal	Soft sediment Rocky Eelgrass (juveniles)	No Status (SNR)	-	✓	✓	×
	Pacific herring	*Clupea pallasii*	Intertidal Subtidal	Variable/ Pelagic Eelgrass/Kelp (juveniles) Soft sediment Rocky	No Status (SNR)	-	✓	✓	✓
	Tubesnout	*Aulorhynchus flavidus*	Intertidal Subtidal	Seaweed, kelp, eelgrass beds	-	-	×	✓	✓
	Bay Pipefish	*Syngnathus leptorhynchus*	Intertidal	Seaweed, kelp, eelgrass beds	No Status (SNR)	-	×	×	✓
Epifaunal Invertebrates	Dungeness crab	*Metacarcinus magister*	Intertidal Subtidal	Eelgrass (juveniles) Soft sediment Rocky	-	-	✓	✓	✓
	Tanner crab	*Chionoecetes bairdi*	Intertidal Subtidal	Soft sediment	-	-	✓	×	✓
	Red rock crab	*Cancer productus*	Intertidal Subtidal	Soft sediment with shell Cobble Boulder	-	-	✓	✓	✓

Table 1-1 Marine Fish Species Potentially Affected by the Project

Functional Group	Common Name	Scientific Name	Habitat Zone	Habitat Substrate Type	Provincial Status[1, 2]	Federal Status[3]	Key CRA Fishery Species	Fish Presence Documented[4]	
								Casey Cove	South Digby Island
Epifaunal Invertebrates (cont'd)	Brown box crab	*Lopholithodes foraminatus*	Intertidal Subtidal	Soft sediment Cobble Boulder	-	-	✓	×	✓
	Hermit crab	*Pagarus* spp	Intertidal Subtidal	Soft sediment	-	-	×	✓	✓
	Helmet crab	*Telmussus cheiragonus*	Intertidal	Soft sediment	-	-	×	×	✓
	Purple shore crab	*Hemigrapsus nudus*	Intertidal	Rocky	-	-	×	✓	×
	Shore crabs	*Hemigrapsus* spp.	Intertidal	Rocky	-	-	×	×	✓
	Pygmy rock crab	*Cancer oregonensis*	Intertidal	Rocky	-	-	×	×	×
	Squat lobster	*Munida quadrispina*	Subtidal	Soft sediment	-	-	×	×	✓
	Unidentified shrimp	*Pandalus spp.*	Subtidal	Soft sediment Eelgrass (juveniles)	-	-	✓	×	✓
	Spot prawns	*Pandalus platyceros*	Intertidal Subtidal	Soft sediment	-	-	✓	×	✓
	Smooth pink shrimp	*Pandalus jordani*	Intertidal Subtidal	Soft sediment	-	-	✓	×	×
	Spiny pink/northern shrimp	*Pandalus borealis*	Intertidal Subtidal	Soft sediment	-	-	✓	×	×
	Coonstripe shrimp	*Pandalus danae*	Subtidal	Soft sediment	-	-	✓	×	✓
	Humpback shrimp	*Pandalus hypsinotus*	Intertidal Subtidal	Soft sediment	-	-	✓	×	✓

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Functional Group	Common Name	Scientific Name	Habitat Zone	Habitat Substrate Type	Provincial Status[1, 2]	Federal Status[3]	Key CRA Fishery Species	Fish Presence Documented[4]	
								Casey Cove	South Digby Island
Epifaunal Invertebrates (cont'd)	Sunflower star	*Pycnopodia helianthoides*	Subtidal	Variable	-	-	×	✓	✓
	Vermillion star	*Mediaster aequalis*	Subtidal	Variable	-	-	×	✓	✓
	Leather star	*Dermasterias imbricata*	Intertidal Subtidal	Variable	-	-	×	×	✓
	Ochre star	*Pisaster ochraceus*	Intertidal	Variable	-	-	×		✓
	Brittle star	*Ophiura sarsii*	Subtidal	Variable	-	-	×	✓	✓
	Six-rayed star	*Leptasterias* spp.	Intertidal	Variable	-	-	×	✓	✓
	Sea squirt	Styelidae spp.	Intertidal	Rocky	-	-	×	✓	×
	Lewis's moonsnail	*Neverita lewisii*	Intertidal	Soft sediment	-	-	×	✓	×
	Giant plumose anemone	*Metridium farcimen*	Subtidal	Rocky	-	-	×	×	✓
	Painted anemone	*Urticina crassicornis*	Intertidal	Rocky	-	-	×	×	✓
	Crimson anemone	*Cribrinopsis fernaldi*	Subtidal	Rocky Sand/Gravel	-	-	×	×	×
	Swimming anemone	*Stomphia didemon*	Subtidal	Rocky	-	-	×	✓	✓
	White-spotted rose anemone	*Urticina lofotensis*	Intertidal	Rocky	-	-	×	×	✓
	Mottled anemone	*Umbonia crassicornis*	Intertidal	Rocky	-	-	×	×	✓
	Red sea urchin	*Strongylocentrotus franciscanus*	Intertidal Subtidal	Soft sediment Rocky Kelp beds	-	-	✓	✓	✓

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								Casey Cove	South Digby Island
Epifaunal Invertebrates (cont'd)	Green sea urchin	*Strongylocentrotus droebachiensis*	Intertidal Subtidal	Rocky Kelp beds	-	-	✓	×	×
	White sea urchin	*Strongylocentrotus pallidus*	Intertidal Subtidal	Soft sediment Rocky Kelp beds	-	-	✓	×	✓
	Purple sea urchin	*Strongylocentrotus purpuratus*	Intertidal Subtidal	Rocky Kelp beds	-	-	✓		✓
	California sea cucumber (also known as giant or red sea cucumber)	*Parastichopus californicus*	Intertidal Subtidal	Soft sediment Rocky	-	-	✓	✓	✓
	Leafy hornmouth	*Ceratostoma foliatum*	Intertidal	Rocky	-	-	×	×	✓
	Spiny scallop	*Chlamys hastate*	Intertidal Subtidal	Variable Rocky Soft Sediment Shells	-	-	✓	✓	✓
	Smooth white scallop	*Chlamys rubida*	Subtidal	Variable Rocky Soft Sediment Shells	-	-	✓	×	×
	Pink scallop	*Chlamys rubida*	Intertidal Subtidal	Variable Rocky Soft Sediment Shells	-	-	✓	×	✓

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								Casey Cove	South Digby Island
Epifaunal Invertebrates (cont'd)	Gumboot chiton	*Cryptochiton stelleri*	Intertidal Subtidal	Rocky	-	-	×	×	✓
	Giant Pacific octopus	*Enteroctopus dofleini*	Subtidal	Rocky Soft sediment	-	-	✓	×	✓
	Lion's mane jellyfish	*Cyanea capillata*	Intertidal Subtidal	Variable/ pelagic	-	-	×	×	✓
	Limpets	*Lottia* spp.	Intertidal Subtidal	Rocky	-	-	×	✓	✓
	Snails	*Littorina* spp.	Intertidal Subtidal	Rocky	-	-	×	✓	✓
Sessile Invertebrates	Barnacles	*Balanus glandula, Semibalanus cariosus, Cthamalus dalli*	Intertidal	Rocky	-	-	×	✓	×
	Mussels	*Mytilus edulis*	Intertidal	Rocky	-	-	✓	×	✓
	Cloud sponge	*Aphrocallistes vastus*	Subtidal	Rocky	-	-	×	✓	×
	Orange sea pen	*Ptilosarcus gurneyi*	Subtidal	Soft sediment	-	-	×	✓	×
Infaunal Invertebrates	Cockles	*Clinocardium* spp.	Benthic	Soft sediment	-	-	✓	✓	✓
	Soft shell clam	*Mya arenaria*	Benthic	Soft sediment	-	-	✓	✓	✓
	Salt water clam	*Saxidomus* spp.	Benthic	Soft sediment	-	-	✓	✓	×
	Macoma clam	*Macoma* spp.	Benthic	Soft sediment	-	-	✓	✓	✓
	Polychaete worms	*Nereis* spp., *Glycera* spp.	Benthic	Soft sediment	-	-	×	✓	✓
	Ribbon worms	*Nemertean* spp.	Benthic	Soft sediment	-	-	×	✓	✓
	Ghost shrimp	*Neotrypaea californiensis*	Benthic	Soft sediment	-	-	×	✓	×

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								Casey Cove	South Digby Island

NOTES:

"-" = not yet assessed.

1 BC Species and Ecosystem Explorer Database. Sub-national conservation status ranks are given in parentheses (S1 = critically imperilled; S2 = imperilled; S3 = special concern, vulnerable to extirpation or extinction; S4 = apparently secure; SNR = conservation status not yet assessed. Two conservation status ranks [e.g., S3S4] denote a range)

2 BC conservation status derived from: British Columbia Provincial Listed Species of Concern (Yellow-listed = Not at risk; Blue-listed = Special concern; Red-listed = Extirpated, endangered or threatened)

3 COSEWIC (Committee On the Status of Endangered Species In Canada) /SARA (*Species at Risk Act*) status listed on Government of Canada Species at Risk Public Registry (T = Threatened, E = Endangered; NaR = Not at Risk)

4 Documented fish presence determined through field surveys conducted from 2014-2016 (✓ = species captured or observed during field surveys; × = species not captured or observed, but may occur within the study area)