Viterra-Cascadia Terminal Capacity Expansion Project – Marine Habitat Offsetting Plan

Prepared for:

Canadian Pacific
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Project No. 104703-01

Prepared by:

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Pertains to:

VFPA file No.: 20-095
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LIST OF ACRONYMS AND ABBREVIATIONS

Acronym / Abbreviation	Definition
AEA	Aquatic Effects Assessment
BC	British Columbia
BMP	Best Management Practice
CEMP	Construction Environmental Management Plan
CP	Canadian Pacific Railway
DFO	Fisheries and Oceans Canada
FAA	*Fisheries Act* Authorization
FPIP	Fisheries Productivity Investment Policy
HADD	Harmful Alteration, Disruption or Destruction
Hemmera	Hemmera Envirochem Inc.
HHWLT	Higher high-water large tide
LLWLT	Lower low-water large tide
PER	Project Environmental Review Process
VFPA	Vancouver Fraser Port Authority

LIST OF SYMBOLS AND UNITS OF MEASURE

Symbol / Unit of Measure	Definition
%	percent
CD	chart Datum
cm	centimeter
km	kilometre
m	metre
m^2	square metre
m^3	cubic metre
mm	millimeter
>	greater than

1.0 INTRODUCTION

As part of the Vancouver Fraser Port Authority (VFPA) Burrard Inlet Road and Rail Improvement Project, Canadian Pacific (CP) is planning Phase 4 of the Viterra-Cascadia Terminal Capacity Expansion Project (the Project) along the south shore of Burrard Inlet, east of the Second Narrows Bridge in Burnaby, British Columbia (**Figure 1a** and **Figure 1b**). As part of the expansion activities for Phase 4, CP is proposing to construct 1,500 metres (m) of new track between CP mileage 122.93 and 124.96.

CP has retained Hemmera Envirochem Inc. (Hemmera) to:

- Determine whether the Project will result in Harmful Alteration, Disruption or Destruction (HADD) and/or killing of fish by means other than fishing pursuant to a *Fisheries Act* (RSC 1985, c. F-14), Section 35(2)(b) Authorization (FAA).
- Develop a marine habitat Offsetting Plan, with suitable measures and quantities to offset residual HADD caused by the Project.
- Prepare and apply for a FAA pursuant to Section 35(2)(b) of the *Fisheries Act.*
- Obtain project approval from the VFPA through their Project and Environmental Review (PER) process, and a lease with the VFPA for (i) the expanded track within their jurisdiction, and (ii) the offsetting habitats.

This document describes the Project's Offsetting Plan, which summarizes the area of residual HADD to fish and fish habitat that is anticipated to result from the Project (for related details, see the Aquatics Effects Assessment; Hemmera Envirochem Inc. 2021). The Offsetting Plan was prepared consistent with the *Fisheries Productivity Investment Policy: A Proponent's Guide to Offsetting* (Government of Canada 2013).

The Offsetting Plan was developed in accordance with a Supply of Services Agreement between Hemmera Envirochem Inc., a wholly owned subsidiary of Ausenco Engineering Canada Inc. (Ausenco), and Canadian Pacific (Client), dated May 24, 2017 (Contract). This report has been prepared by Hemmera, based on fieldwork conducted by Hemmera for sole benefit and use by Canadian Pacific. In performing this work, Hemmera has relied in good faith on information provided by others and has assumed the information provided by those individuals is both complete and accurate. This work was performed to current industry standard practice for similar environmental work, within the relevant regional jurisdiction. The findings presented herein should be considered within the context of the scope of work and Project terms of reference; further, the findings are time sensitive and are considered valid at the time the report was produced. The conclusions and recommendations contained in this report are based upon the applicable guidelines, regulations, and legislation existing at the time the report was produced; any changes in the regulatory regime may alter the conclusions and/or recommendations.

Cascadia Terminal Rail Extension Project
Burrard Inlet, Burnaby, BC

Project Location

Legend

- Habitat Assessment Area
- CP Mileage
- Existing CP Railway

Notes

1. All mapped features are approximate and should be used for discussion purposes only.
2. This map is not intended to be a "stand-alone" document, but a visual aid of the information contained within the referenced Report. It is intended to be used in conjunction with the scope of services and limitations described therein.

Sources

- Contains information licensed under the Open Government Licences - Province of British Columbia and City of Vancouver
- Proposed Project Features: AECOM, 2019
- Aerial Image: City of Vancouver, 2015; ESRI World Imagery
- Inset Basemap: ESRI World Topographic Map

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Metres

NAD 1983 CSRS UTM Zone 10N

Page Size: 11" x 17"

104703-01	Production Date: Mar 22, 2021	Figure 1a

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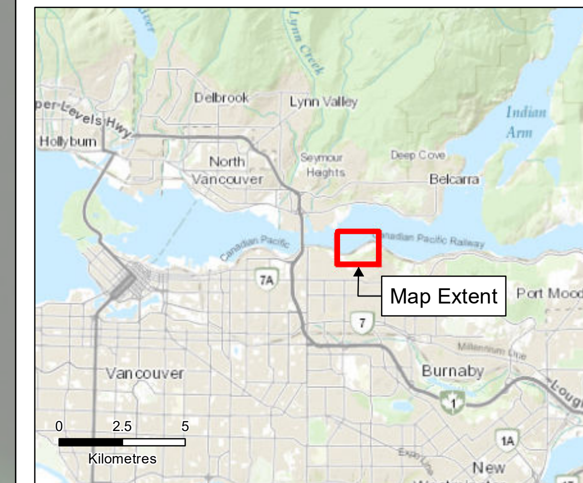
Cascadia Terminal Rail Extension Project
Burrard Inlet, Burnaby, BC

Project Location



Legend

- Area Assessed
- CP Mileage
- Existing CP Railway

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2.0 OFFSETTING OBJECTIVES

The objective of this Offsetting Plan is to counterbalance the 29,860 square metres (m^2) of residual HADD resulting from construction of the Project consistent with Fisheries and Oceans Canada's (DFO) guiding principles of maintaining or enhancing the ongoing productivity and sustainability of the aquatic ecosystem (Government of Canada 2019d). Projects that result in residual HADD to fish habitat must maintain or improve the productivity of affected fisheries resources. This offsetting philosophy has guided development of this Offsetting Plan. Relevant fisheries management objectives and local management priorities were also considered, as described briefly below.

2.1 Guiding Principles for Offsetting

Offsetting measures have been selected in accordance with DFO's guiding principles (Government of Canada 2019d):

1. "*Measures to offset must support fisheries management objectives or local restoration priorities and give priority to the restoration of degraded fish habitat.*"
2. "*Benefits from offsetting measures should balance the adverse the effects resulting from the works, undertakings, or activities.*"
3. "*Measures to offset should provide additional benefits to the ecosystem.*"
4. "*Offsetting measures must generate self-sustaining benefits over the long term.*"

DFO gives preference to in-kind measures (i.e., same quantity, quality, and habitat type) versus out-of-kind measures (i.e., differing quantity, quality, and habitat type). Further, when determining the location for offsetting, those occurring within the vicinity of the Project or within the same watershed are preferable (Government of Canada 2019d). Finally, preference is to construct offset habitats in advance of, or concurrent to, Project construction works to limit time lag between loss of habitat productivity from construction and the creation of new, fully functioning offset habitats.

Working with CP, Hemmera took the following steps in developing this Offsetting Plan to meet the offsetting objectives and align with DFO's guiding principles (Government of Canada 2019d):

- Determined the residual HADD to fish or fish habitat requiring offsetting by:
  - Characterizing residual effects using DFO's Pathways of Effects (Fisheries and Oceans Canada 2018).
  - Determining residual effects for each impact type and phase associated with the Project.
  - Quantifying the spatial extent of residual effects for each habitat type to be impacted by the Project.
- Established criteria for selecting offsetting measures, including measures that:
  - Are located within Burrard Inlet and in proximity to the Project.
  - Are consistent with DFO policy on fish and fish habitat (Government of Canada 2019a, 2019d).
  - Reflect fisheries management objectives and local habitat enhancement priorities (**Section 2.2**), most notably those identified by Indigenous Communities.
  - Are consistent with VFPA land use planning designations and considered acceptable to VFPA, if overlapping with VFPA jurisdiction.
  - Are communicated with VFPA Real Estate to discuss potential offsetting and ensure compatibility with VFPA objectives and operations (**Section 2.3**).

- Determined the amount of offsetting required, by estimating the:
  - Productivity of both the habitat affected by the Project and proposed offsetting habitats, based on productivity of similar habitat estimated through on-site observations, and based on review of scientific literature and technical reports.
  - Relative values of affected and potential offset habitat types, while also considering the estimated time lag between the harm occurring and the offset becoming fully functional, uncertainty, and underlying habitat values associated with offsetting measures.
- Identified local habitat creation and enhancement opportunities that could be appropriate for offsetting and implemented them into offsetting design.

The DFO Policy for Applying Measures to Offset Adverse Effects on Fish and Fish Habitat under the *Fisheries Act* also identifies that "out-of-kind" may be appropriate as the resulting habitat can have a greater capability to produce and sustain fish than the habitat located at the Project location (Government of Canada 2019d). An out-of-kind offsetting approach has been selected for the Project to align the offsetting habitat with the following objectives:

- Restoring degraded habitats.
- Alleviating pressure on juvenile salmon populations in Burrard Inlet.
- Creating habitat that is limited in Burrard Inlet (complex features in shallow coastal areas) and conducive of kelp recruitment and growth (i.e., stable rocky substrates at shallow depths and in proximity to existing kelp beds).

2.2 Fisheries Management Objectives and Local Management Priorities

Fisheries management objectives specific to the Project Area were considered where available and appropriate. The resources, plans, and strategies consulted were as follows:

- The Southern Pacific Salmon Integrated Fisheries Management Plan outlines fishery management objectives for stocks of concern along the BC coast between Cape Caution and the Washington border (Government of Canada 2019c).
- DFO's management goals and objectives for invertebrate fisheries are (Government of Canada 2020):
  - *To ensure conservation and protection of invertebrate stocks and their habitat through the application of scientific management principles applied in a risk-averse and precautionary manner based on the best scientific advice available*.
  - *To meet the federal Crown's obligations regarding Aboriginal fisheries for food, social, and ceremonial purposes*.
  - *To develop sustainable fisheries through partnership and co-management arrangements with client groups and stakeholders to share in decision making, responsibilities, costs, and benefits*.
  - *To develop fishing plans and co-operative research programs which will contribute to improving the knowledge base and understanding of the resource*.
  - *To consider the goals of stakeholders with respect to social, cultural, and economic value of the fishery*.
  - *To consider health and safety in the development and implementation of management plans and fishery openings and closures*.
- Priorities identified in the Burrard Inlet Action Plan (Tsleil-Waututh Nation 2017):
  - Conserve critical nearshore habitat complexes (e.g., "habitat islands" for rearing salmon, forage fish, and other marine biota).
  - Mapping and recovery of nearshore bull kelp beds.
  - "Net environmental gain" / "like-for-like" offsetting focus.

2.3 Meetings and Sessions with Indigenous Communities

Indigenous engagement commenced in April 2020, with 16 Indigenous communities identified as having potential overlapping interests with the Project. Engagement was initiated to identify Indigenous interests overlapping the project and to help appropriately mitigate or otherwise address those adverse impacts through collaboration and information sharing. From those nations, four requested to be involved in archaeological activities (Kwikwetlem First Nation, Musqueam Indian Band, Squamish Nation, and Tsleil-Waututh Nation), and three requested further involvement and planning around habitat offsetting (Kwikwetlem First Nation, Musqueam Indian Band, and Tsleil-Waututh Nation).

In August 2020, offsetting workshops were held with Kwikwetlem First Nation and Tsleil-Waututh Nation. CP met again with Kwikwetlem First Nation and Tsleil-Waututh Nation in October 2020 and November 2020, respectively, to discuss the proposed offsetting concept design. Offsetting plans and design were created using feedback generated during the August workshops, and were further refined from the workshops held later in the fall of 2020.

As of March 2021, CP continues to reach out to Musqueam Indian Band to organize offsetting workshops and share draft application documents with Kwikwetlem First Nation and Tsleil-Waututh Nation for review and feedback.

3.0 PROPOSED OFFSETTING MEASURES

3.1 Setting

Onsite offsetting measures within or adjacent to the Project footprint are not feasible, due to limitations from VFPA with respect to navigation. As such, offsite measures to offset are proposed to be constructed at nearby Berry Point, located on the south shore of Burrard Inlet approximately 2.36 kilometres (km) east of the Project Area (**Figure 2**). The Proposed Offsetting Area is bordered to the west by a vegetated rocky headland separating the Proposed Offsetting Area from the Island Tug and Barge docking and operational facility. A Shell fuel dock borders the Proposed Offsetting Area to the east. The southern border of the Proposed Offsetting Area runs along the south shore of Burrard Inlet and consists of a thin band of riparian vegetation on the seaward side of the existing CP rail line (**Appendix A: Photo 1** and **Photo 2**). The northern border of the Proposed Offsetting Area extends out into Burrard Inlet (**Appendix A: Photo 3**). Burrard Inlet extends east into the Port Moody Arm and west towards second narrows.

Burrard Inlet has, over the past century, become industrialized into what is now Canada's largest port (Port of Vancouver 2016). The current shoreline within the Inner Harbour is characterized by industrial terminals, private marinas, and seawalls. There is little natural habitat complexity remaining between First and Second Narrows and 95% of the shoreline is currently developed (Northwest Hydraulic Consultants 2019). East of the Second Narrows, several large terminals dominate the south shore including the Chevron Parkland Refinery, Westridge Terminal, and Suncor Terminal.

Historically, the Tsleil-Waututh lived around Burrard Inlet and harvested the abundant resources including salmon, herring, and shellfish for sustenance since time immemorial. Their use of salmon (*Oncorhynchus* spp.), Pacific herring (*Clupea pallasii*), bivalves, birds, and terrestrial resources from the area is confirmed in the fossil record (Tsleil-Waututh Nation 2017).

Hemmera's assessment of marine productivity gaps in Burrard Inlet indicated a general decline in fish abundance and structurally complex habitat. Specifically, limited refuge and foraging habitat to support juvenile salmon out-migration, loss of kelp habitat, and less diverse nearshore floral and faunal communities. To address these key habitat deficiencies, CP proposes to construct a large, contiguous and complex reef structure in the shallow subtidal zone (**Figure 3**), along with an area of enhanced intertidal sandflats and an intertidal marsh bench. The reef structure will be composed of three elements that provide habitat to a variety of focal species of flora and fauna, including: (i) deep rocky reefs of differing designs and materials to create a variety of interstitial spaces and substrate for kelp growth; (ii) a subtidal bench consisting of unconsolidated sand, gravel and cobble overlaid with sporadic large boulders and bundles of concrete rail ties; (iii) a shallow rocky reef.

Shoreward of the reef structure, edge habitat and enhanced intertidal sandflats, provide suitable substrate for colonization by a diversity of algae and invertebrates species and intertidal marsh provides rearing and feeding habitat for migrating fishes and contributes to local nutrient cycling through detrital matter inputs.

More detail on the design elements and their intended ecological values are described in the following sections below.

Cascadia Terminal Rail Expansion Project
Burrard Inlet, Burnaby, BC

Proposed Offsetting Location

Legend
- Study Area
- Minor Pile
- Navigational Feature
- Transect Line
- Rail Track
- High Water Mark
- Low Water Mark
- Parcel Boundary

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- Aerial Image: ESRI World Imagery
- Nautical Chart: Canadian Hydrographic Service

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Metres

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Page Size: 11" x 17"

104703-01	Production Date: Mar 16, 2022	Figure 2

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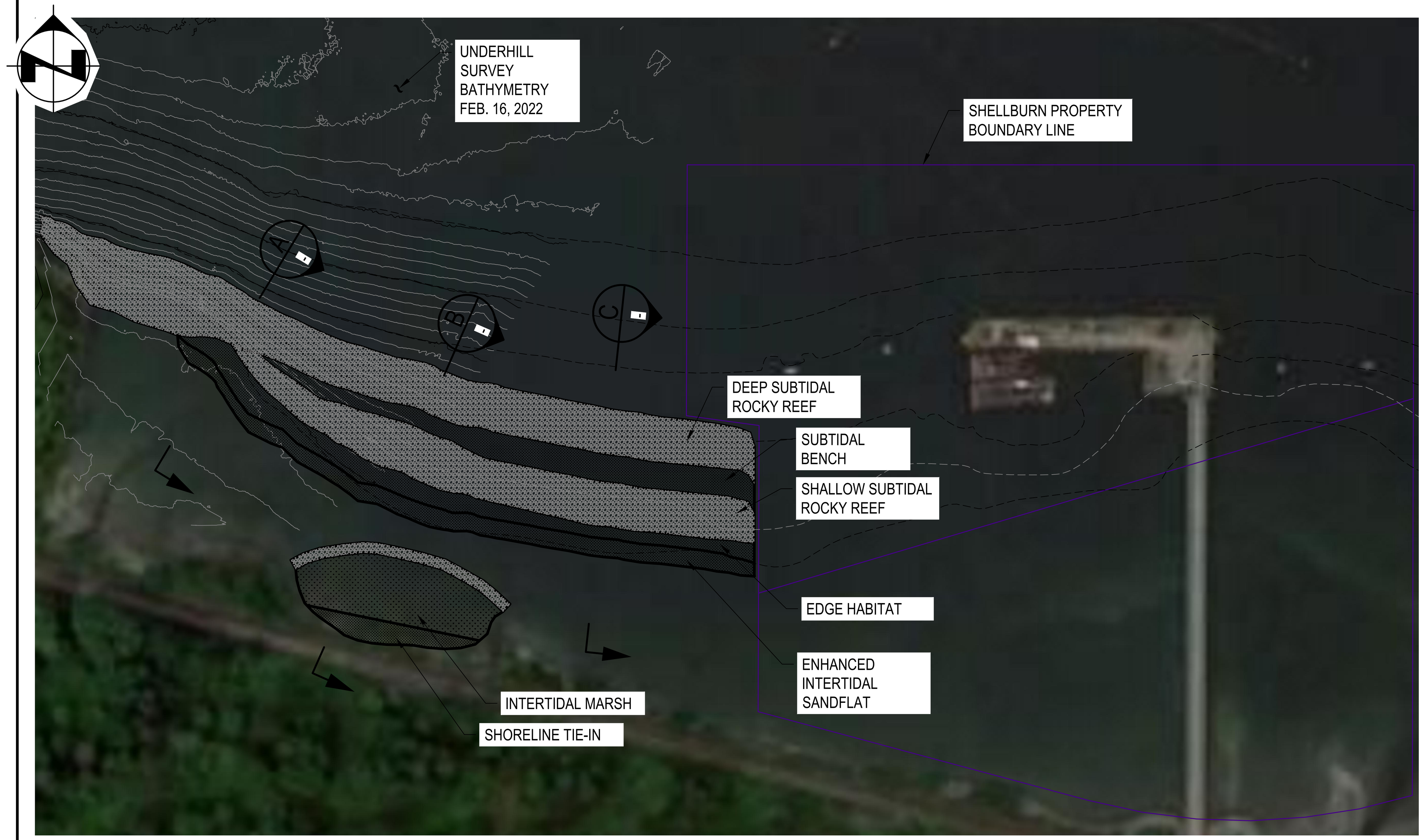

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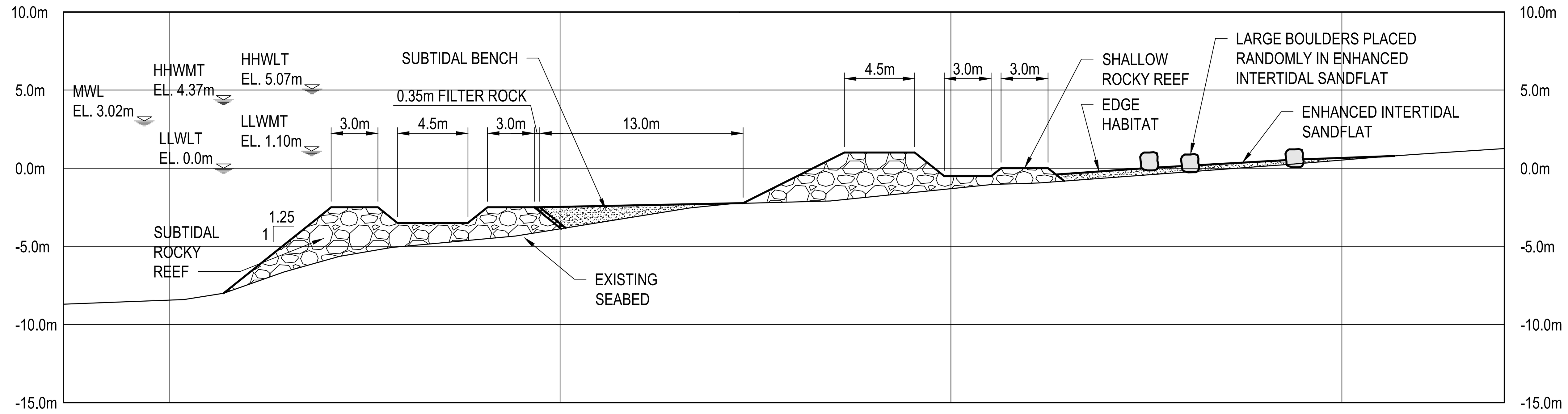
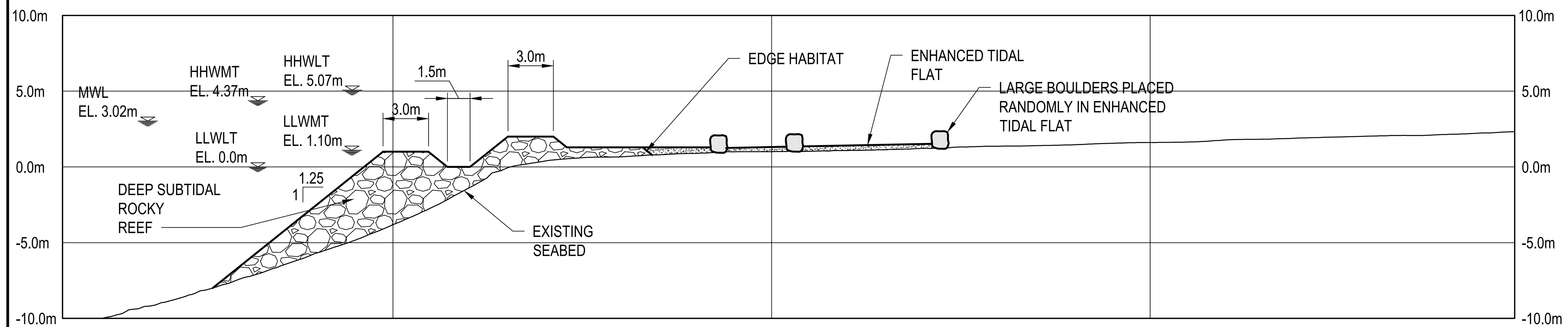


SECTION C
1:250



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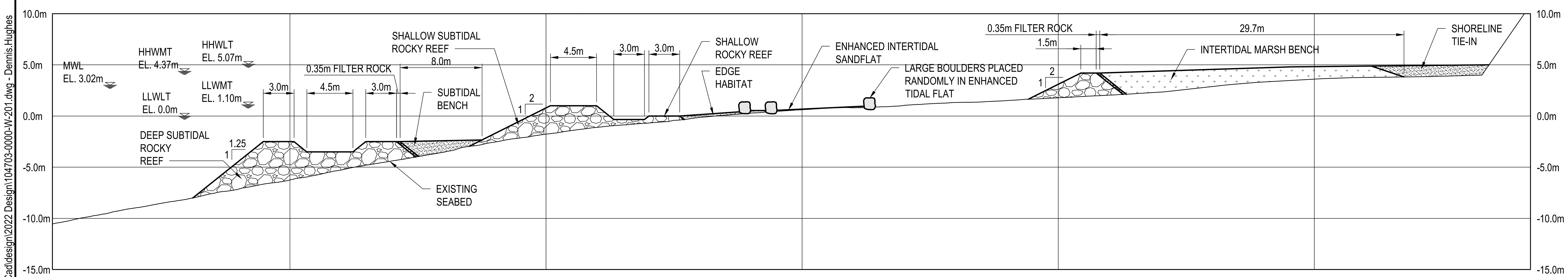
1:250



SECTION B
1:250

HABITAT OFFSETTING

	AREA (m^2)
DEEP SUBTIDAL ROCKY REEF	8150
SHALLOW SUBTIDAL ROCKY REEF	4600
SUBTIDAL BENCH	3500
EDGE HABITAT	2440
ENHANCED INTERTIDAL SANDFLAT	2250
INTERTIDAL MARSH BENCH	2400

10 0 10m
SCALE = 1:250

20 0 20 40 60 80 100m
SCALE = 1:1750

Safety in all we do

REF.	DRAWING No.	REFERENCE DRAWING	No.	BY	DATE	REVISION DETAILS	CHKD	ENG	APPR
			B	DH	16/MAR/2022	PRELIMINARY DESIGN	LA	OS	JW
			A	DH	04/MAR/2022	ISSUED FOR CLIENT REVIEW	LA	LA	JW

DRAWN	D. HUGHES	16/03/2022
DWG. CHECKED	O. SAYAO	
DESIGNED	L. ABSALONSEN	
DES. APPR.	O.SAYAO	
PROJ. APPR.	J. WALKER	

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CLIENT CANADIAN PACIFIC RAILWAY COMPANY

TITLE VITERRA CASCADIA TERMINAL
TRACK EXPANSION
ARTIFICIAL REEFS

PROJECT No. 104703-01
SCALE AS SHOWN
SIZE A1
DRAWING No. 104703-0000-W-201
REV B

3.2 Deep Rocky Reef

CP proposes to construct deep rocky reefs of differing design, ranging in depths from -5 m Chart Datum (CD) to -8 m CD. The depth ranges span those preferred by large kelps such as bull kelp (*Nereocystis luetkeana*), which grows in beds nearby and is anticipated to colonize the offsetting reefs. The deep rocky reefs will also provide structural support for the shallower habitat elements (i.e., subtidal bench and intertidal reef), contributing to long-term stability and sustainability of the offset features.

The deep rocky reefs will be constructed using a combination of large boulders (0.15 m – 0.75 m in diameter) and concrete rail ties. These materials are not meant to stack neatly, and will thus contribute to hard, rocky substrates for colonization of benthic invertebrates, encrusting algae, and kelps, and also create an abundance of interstitial spaces, cracks, and crevices for crevice-loving species such as rockfish (*Sebastes* spp.), lingcod (*Ophiodon elongatus*), and octopus (*Enteroctopus dofleini*) along with a diverse community of motile and sessile invertebrates including sea cucumbers, sea stars, urchins, and coralline algae (**Figure 4**).

Figure 4 An example of an artificial rocky reef offset built in northern BC. Source: Ryan Miller, Hemmera.

The abundance and size of the kelp bed habitats and their associated communities within the Inner and Central Harbours have declined over time (Tsleil-Waututh Nation 2017). The subtidal and intertidal (described below) reef components of the habitat units will promote attachment and growth of a diverse benthic algal layer and canopy kelps that are important to many invertebrate and fish species and provide habitat, refuge, and nursery areas (Ebeling and Laur 1985; Carr 1991; Miller et al. 2009). Subtidal rocky reefs will be constructed in such a way to provide physical complexity and structure, which has been shown to increase diversity of associated biological communities (Sheaves et al. 2006; Hunter and Sayer 2009; Legendre 1993).

Rocky marine habitats provide attachment substrate for kelps and benthic algae, promoting primary production and thereby supporting herbivore communities and the associated higher trophic levels (Bruno et al. 2008; Tallis 2009; Trebilco et al. 2015; Ebeling and Laur 1985). Subtidal kelp beds and benthic algal communities provide structure in the water column and refuge, spawning, and nursery habitats (Sheaves et al. 2015; Nagelkerken et al. 2015; Steneck et al. 2002). Kelp is eaten directly by organisms (Bustamante et al. 1997) and provides foraging habitat for kelp-associated fishes (Reisewitz et al. 2006; Norderhaug and Christie 2011). Additionally, they may reduce local current velocities and dampen wave action (Gaylord et al. 2007), which reduces shoreline impacts and may enhance local waters with retention of pelagic larvae and deposition of organic materials within the bed (Rosman et al. 2010).

The rail ties used for construction of subtidal reefs are approximately 2.5 m long, 0.3 m wide, and 0.2 m high. They will be stacked haphazardly to increase the three-dimensional rugosity and complexity of the reef habitat.

Artificial reefs and habitat complexes are an accepted and successful method for offsetting in British Columbia (Hunter and Sayer 2009). To date, numerous artificial reef structures have been successful in the promotion of macroalgal, benthic invertebrate, and fish recruitment and community establishment for projects across a broad geographic area including elsewhere in Burrard Inlet. This offsetting habitat has been designed to increase habitat complexity of the benthos and to provide a variety of habitat types and ecosystem functions in a discrete.

3.3 Subtidal Bench

The subtidal bench will consist of unconsolidated sands, gravel and cobble, with erratic boulders dispersed throughout. The bench will extend shoreward from a deep subtidal reef at their base. This bench will support some understory kelp (on the larger rocks) and a variety of infaunal invertebrates in the unconsolidated sediments; for example, sieve kelp (*Agarum clathratum*), Nuttall's cockle (*Clinocardium nuttallii*) and horse clams (*Tresus* spp.). Benthic algae and understory kelp colonizing the boulders and larger cobbles will provide cover for juvenile salmonids during their outmigration from natal streams out through Burrard Inlet, foraging habitat for a diversity of benthic and demersal fish and invertebrates (e.g., crab, gastropods grazers, flounder, sculpins, etc.), and is expected to become colonized by an interstitial community of invertebrates such as polychaete worms and mollusc bivalves (**Figure 5**). Additionally, the benthic algae and understory kelp could support herring spawning, which has declined massively since the industrialization of Burrard Inlet (Tsleil-Waututh Nation 2017).

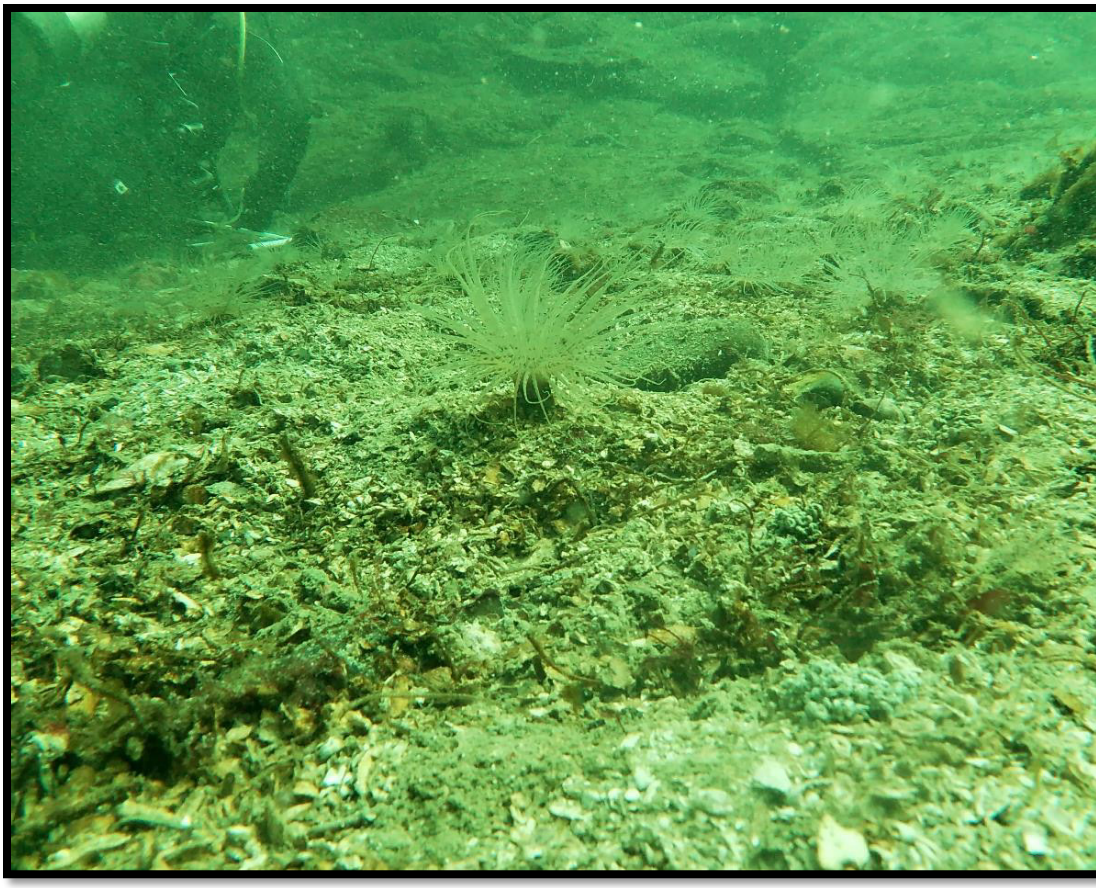


Figure 5 Illustration of a natural marine community associated with subtidal, unconsolidated cobble and sediments. Source: Joe Walker, Hemmera.

3.4 Shallow Rocky Reef

The shallow rocky reef will extend from the depth of the subtidal bench to approximately the Lower Low Water Large Tide (LLWLT). The shallow subtidal reef will provide rocky substrates suitable for colonization by a diversity of algae and invertebrates species. The hard substrate will promote attachment by shallow water kelps (e.g., *Saccharina and Costaria*) and sessile benthic invertebrates (calcareous tube worms, hydroids). This, in turn, will provide understory and habitat for a variety of motile invertebrates (*Pugettia spp.,* leather star [*Dermasterias imbricata*]) and small-bodied fish, such as gunnels (*Pholidae spp*.), pricklebacks (*Stichaeidae spp*.), and sculpins (*Cottidae spp*.) (**Figure 6**). The shallow rocky reef will consist of small boulders (0.5 m – 0.75 m in diameter) and cobbles (<0.5 m) with limited crevices and large interstitial spaces; the absence of crevices will preclude colonization by ambush predators, such as lingcod and rockfish, providing a safe area for juvenile salmon on both sides of the structure. The retaining wall will be constructed with a 1:1 slope.

Figure 6 Example of a marine community inhabiting shallow rocky habitat in coastal BC, where red macroalgae are common. Source: Joe Walker, Hemmera

Burrard Inlet provides migration and rearing habitat to five Pacific salmon species, steelhead (*O. mykiss*), and cutthroat trout (*O. clarkii*). Salmon populations have undergone significant reductions in Burrard Inlet due to a number of factors, including the damming of rivers, loss of nearshore habitat, pollution, and reduction in water quality (Tsleil-Waututh Nation 2017). Juvenile salmon out-migrate from natal streams and rivers through the heavily populated and developed central and inner harbours. The extensive development of the shoreline may be creating physical and behavioural barriers to salmonids as they out-migrate. For example, Chinook (*O. tshawytscha*), coho (*O. kisutch*), and steelhead smolts out-migrate from the Indian River and along the shoreline of North Vancouver.

Forage fish, including Pacific herring and surf smelt (*Hypomesus pretiosus*), are important food items for several marine species using nearshore habitats for spawning (e.g., beaches, kelp/algaes). Historically, large numbers of the forage fish spawns were recorded in Burrard Inlet; however, these have largely vanished from the Inner and Central Harbours, potentially a result of shoreline hardening and the overall loss of shallow-water habitat complexity (Tsleil-Waututh Nation 2017). Pacific herring are schooling forage fish that range from Alaska to California and spawn predominantly on substrates and vegetation in the lower intertidal and shallow subtidal zones, typically in sheltered inlets, sounds, and estuaries (Lassuy and Moran 1989). Federal herring spawning records do not include Burrard Inlet, and, while spawning in the behaviour has not been recently observed, there are reports of increasing numbers of herring being observed (Kwikwetlem First Nation 1/13/2021). Suitable substrate is lacking from the Inner Harbour, and what substrate is present is often toxic to developing larvae (i.e., creosote piles, vessel berths), although a recent collaboration between the Tsleil Waututh Nation and Seachange Marine Conservation Society has removed approximately 45 creosote timber piles from several locations in Indian Arm, many still remain throughout Burrard Inlet (Vines 2000; Anuradha 4/27/2021). While the Central Harbour offers more naturalized shoreline than the Inner Harbour, the existing terminals on the south shore reduce the overall amount of suitable substrates to support herring spawn. The combined efforts of the artificial reef substrate and cleanup efforts like the aforementioned pile removal project will promote benthic algae and provide clean spawning substrate and surfaces which, in turn, could aide population recovery and the return of spawning aggregations to Burrard Inlet.

3.5 Edge Habitat

Previous offsetting habitat projects have included “edge habitat” in the total area of influence of the reef habitat. This edge habitat has been shown to provide important feeding habitat to the species that occupy the reef (Stantec Consulting Ltd. 2013). The reef structures provide nutrient input, fringe habitat, and refuge habitat for numerous fish and invertebrates that feed on the edge habitat surrounding the reef. The edge habitat has been demonstrated to provide habitat to a more abundant and more diverse benthic community than native substrate located further from the reef. The area located behind the reef complexes are predicted to benefit from this effect and have been included in the overall design considerations. Past implementations of this “edge effect” have utilized buffers of up to 15 m beyond the reef edge (Stantec Consulting Ltd. 2013). In order to provide cover for finfish, attachment substrate for algae and kelp, encrusting algae, and substrate for encrusting and mobile invertebrates, erratic boulders will be placed throughout the gravel and cobble buffer zone to increase the benefits of this edge effect.

3.6 Enhanced Intertidal Sandflat

Existing intertidal sandflat located above the shallow rocky reef will be enhanced by the addition of habitat complexity elements while maintaining beach habitat that may be suitable for forage fish spawning. This will be done through the addition of small piles of bivalve shells and small erratic boulders (0.5 m – 0.75 m in diameter) and cobbles (<0.5 m).

Small piles of bivalve shells are intended to create settlement habitat for larval Dungeness crabs and other bivalve species (Dumbauld et al. 1993; Fernandez et al. 1993; Eggleston and Armstrong 1995; Dumbauld et al. 2000). Shell fragments are preferred settlement habitat over eelgrass and other marine vegetation, providing the best protection for settling crab larvae (Fernandez et al. 1993). Shell will be sourced from the aquaculture industry (e.g., oyster leases), cleaned, and placed in the sandflat areas by hand at low tide. Placement will occur following marsh bench and shallow rocky reef creation and planting, in order to minimize the amount of sediment that may settle out of the water and cover shell during construction.

Erratic boulders and cobble will be added to provide attachment substrate for rockweed (*Fucus distichus*) and barnacles (*Balanus glandula*), as well as motile invertebrates such as Dungeness crabs, shore crabs (*Hemigrapsus* sp.), isopods, amphipods, limpets, periwinkle snails, and polychaetes.

3.7 Intertidal Marsh Bench

An intertidal marsh bench (2,400 m^2) will be constructed above the enhanced intertidal sandflat. The marsh bench will be reinforced with a rock toe berm along the seaward edge to prevent erosion and sloughing of backfill material. Design for the marsh bench will mimic natural marsh conditions found at the Maplewood Marsh located east of second narrows, which represents the largest naturally occurring intertidal marsh near the Proposed Offsetting Area. Previous surveys of Maplewood Marsh have identified vegetation communities primarily consisting of salt resistant species including pickleweed (*Sarcocornia pacifica*), gumweed (*Grindelia latifolia*), saltgrass (*Distichlis spicata*) and saltwort (*Glaux maritima;* Moffat & Nichol 2016). In addition, brackish species such as arrowgrass (*Triglochin maritima*), Baltic rush (*Juncus balticus*), Pacific silverweed (*Potentilla anserina),* and Lyngbye's sedge (*Carex lyngbyei*) were surveyed in areas of the Maplewood Marsh which receive greater freshwater input from McCartney Creek (Moffat & Nichol 2016). Surveys at Maplewood Marsh also indicated that the densest marsh vegetation occurs between 4.2 m CD – 4.7 m CD. Additionally, within Port Moody Arm, salt tolerant species have previously been surveyed down to 3.8 m CD while other species such as dunegrass (*Leymus mollis*) have been recorded above HHWMT in the range of 4.62 m CD to above the HHWLT mark at 5.32 CD (Moffat & Nichol 2016).

Two main design considerations will impact the establishment and success of a brackish tidal marsh: the creation of adequate surface elevations for selected marsh species and the incorporation of adequate drainage. Substrate elevations govern the extent and duration of tidal inundation within the marsh, which in turn impacts the assemblage of vegetation species. Placement of fill shoreward of the rock berm will bring the bench up to elevations suitable for local marsh vegetation, the bench will be slightly sloped to incorporate and final elevation will range from approximately 4.2 m CD to 4.8 m CD) and to provide adequate drainage while still maintaining soils consistently near saturation. Three types of fill shall be used to achieve the final marsh bench elevation. The base shall be a coarse grade fill, with a medium grade fill material consisting of gravel and sand overlaid. The uppermost layer shall consist of sandy silt that will provide an anchoring material for plants to root, fertility for growth, and suitable characteristics that promote stability and drainage under intertidal conditions. Marsh soil may include dredged material or imported soil from an upland source. The material should be clean mineral soil, free from rocks, debris, and contamination. Use of manufactured soil is not recommended because sawdust and peat moss typically used in its fabrication increases the buoyancy and the soil may not remain in place when exposed to currents and waves.

At the base of the intertidal marsh bench, a rip rap berm will be constructed to a height of 4.0 m CD to contain the growing medium on the bench, particularly during a period of settlement before planting. A core of fractured gravel or similar will be used to construct the berm and rip rap will be used as a final substrate/armoring layer. Substrate classes and sizes are presented in **Table 4.1** below. The coarse material will simplify and speed up the construction process and remove the need for containment measures within the berm (i.e., filter cloth). The berm shall be constructed with a slope of 2 horizontal:1 vertical on both sides.

Upslope of the marsh bench, a shoreline tie-in area has been established from to act as a buffer between the marsh bench and CP's railway infrastructure. This area will be infilled from the top of the marsh bench (4.8 m CD) to tie-in with the existing shoreline at the HHWLT (5.07 m CD). The shoreline tie-in zone will be planted with native backshore species such as dunegrass, gumweed, Pacific Silverweed (*Potentilla anserina*) and silver burweed (*Ambrosia chamissonis)* to assist with backshore erosion and sediment control and colonize disturbed areas to minimize the encroachment of invasive species on the marsh bench. Because of planned future development in this region, the shoreline tie-in area is not included in our summary of offsetting habitat and will not be considered for the balance below. The intention of this area is to reduce the potential for erosion to the marsh bench at the lower elevation.

Following the construction of the marsh bench, a minimum 3-month settlement period will allow for substrate settlement before, nursery stock will be transplanted to the bench (refer to planting plan **Section 6.4** below) in March or April, timed with emergent marsh in the area. After planting, the marsh is expected to take three to five years to establish and become fully productive.

3.8 Summary

The proposed offsetting habitat will provide structural complexity and cover for juvenile salmonids in shallow coastal areas where juveniles are known to rear (Government of Canada 2000). Additionally, the invertebrates and algae colonizing the structures themselves will provide foraging opportunities for juvenile salmon as they out-migrate through the Central and Inner Harbours. The installation of a subtidal rocky reef, a subtidal bench consisting of unconsolidated sands and gravels, a shallow to intertidal rocky reef, and intertidal marsh will contribute to habitat complexity and the establishment of biological diversity and productivity in Burrard Inlet’s coastal water, benefitting salmon and several other ecologically important and harvestable species such as lingcod, crab, and bivalve shellfish. Intertidal marsh is expected to provide rearing and feeding habitat for migrating fishes and contribute to local nutrient cycling through detrital matter inputs. Finally, the installation of large, stable, rocky substrates across a range of water depths, from 0 to -8 m CD, will promote recruitment of kelp from local bull kelp beds, further contributing to habitat complexity and biological productivity of the offsetting location.

4.0 DESCRIPTION OF HABITAT TYPES AND RELATIVE VALUES

Creating a habitat balance requires (i) a detailed description of habitat types and distributions, including the habitats requiring compensation and the new habitats being considered to offset a Project's HADD, and (ii) an approach to converting two or more different habitat types into a common currency for direct comparison and summation.

To address the former, CP completed a detailed assessment of habitats underlying the Project Area as reported in the Aquatic Effects Assessment (Hemmera Envirochem Inc. 2021). More recently, the area underlying the proposed offsetting site was assessed during a field survey in October 2021. In both of these surveys, the areas of interest were segmented by distinct biophysical features or habitats, typically defined by physical substrates, dominant flora and fauna, elevation relative to CD, and the prevalence of anthropogenic disturbances to the natural state.

Because some habitats are inherently more productive than others and provide a broader suite of ecosystem services than others, it is reasonable to consider some habitats more value than others if placed on a common scale for relative comparison (as per Williams 2005).

The following section describes the approach used for characterizing the habitats underlying the Project and offsetting sites, including brief descriptions of physical substrates and the dominant flora and fauna inhabiting those sites. Those habitat types were then attributed a relative score based on principles of biological productivity developed and described by Williams (2005), leading to a common currency of relative values for which multiple habitat types could be compared for the purpose of balancing losses and gains caused by Project construction and habitat offsetting, respectively.

4.1 Methods

4.1.1 Field surveys

In order to assess the habitat underlying the offsetting area, a benthic habitat survey was conducted on October 28, 2021. The survey was undertaken by a team of WorkSafeBC certified SCUBA divers, both qualified marine biologists, following the DFO Marine Foreshore Environmental Assessment Procedure (Government of Canada 2004b). The study area at Berry Point was a 200 m x 300 m area approximately 2.36 km east of the Project Area.

One dive was conducted at Berry Point consisting of three transects. Transects were established within a predefined area running perpendicular to the shoreline. A total of 23 quadrats were sampled at regular intervals along the three transects between 0.8 m CD and -12 m CD.

Waypoints along each transect were collected with using Avenza Systems Inc. mapping software by an observer on the dive boat following the bubble trail left by the SCUBA divers. Underwater video was recorded by SCUBA divers using a high-definition GoPro camera. All fish observed were recorded by the lead diver during his seaward swim, laying out a measuring tape. Transect surveys consisted of assessing marine biota within a 1 x 1 m quadrat area every 5 m along the transect line. Within each 1.0 m^2 area, the diver recorded: transect position, depth, substrate type, vegetation cover, sessile invertebrate cover, mobile invertebrate density, and fish density. Substrate type and relative composition were described visually using a generalized Wentworth-based scale (Wentworth 1922; **Table 4.1**).

Table 4.1 Substrate Classification

Substrate Type	Size Range (Diameter)
Bedrock/ Boulder	>256 mm
Cobble	64 – 256 mm
Gravel	2 – 64 mm
Sand	0.06 – 2 mm
Silt/Clay/Mud	<0.06 mm
Other*	-

Note: *Substrates can also include anthropogenic structures, wood debris and shell hash etc., all of which were characterized under "substrate – other" during field sampling.

4.1.2 Habitat valuation

A common currency of fish habitat has not been developed, so to ensure that the appropriate quantity and quality of fish habitat is created to offset project impacts, relative values have been developed for each type of habitat that will be impacted by the Project and for each habitat to be built as part of the offset in accordance with industry accepted techniques and the specifics of habitat within the Project Area (Bradford 2017; Government of Canada 2014). The relative habitat values presented in Williams (2005) have been often used for the purposes of habitat creation and restoration and forms the baseline for the final habitat values (**Table 4.2**).

Table 4.2 Relative Habitat Values

Habitat Type	Relative Value
Sand/gravel beaches	1
Mudflat	2
Vegetated backshore (marine riparian)	3
Macroalgae	4
Salt marsh	5
Eelgrass	6

Source: (Williams 2005)

The relative values for existing habitats were determined by matching habitat types described by Williams (2005) to habitat types observed in the Project footprint and proposed offsetting site. The habitats described by Williams (2005) represent fully functional habitats that provide a full range of ecological services. When determining relative habitat values of existing habitats, local conditions were considered to modify the published values, where appropriate (e.g., existing riparian habitat values, which are low as the strip of riparian vegetation is often < 5 m wide).

Quantification of fish habitat productivity is expressed as a measure of habitat area by habitat type. In addition to the amount of space available for use by aquatic organisms, the productivity of fish and fish habitat is influenced by several physical and biological features, including habitat complexity, species diversity, primary production, prey availability, availability of refuge from predators, and environmental conditions (e.g., submergence, water flow, disturbance regimes, temperature, dissolved oxygen, pH).

4.2 Results

4.2.1 Habitat Underlying Project Area

Further description of the existing habitat types affected by the Project and rationale for the proposed relative value of these habitats is provided in the sub-sections below; descriptions are derived from the Aquatic Effects Assessment prepared for the Project (Hemmera Envirochem Inc. 2021).

4.2.1.1 Kelp Bed Habitat

Subtidal hard substrates within the Project Area are similar to intertidal habitats, consisting of bedrock shelves, and areas of gravel and sand with scattered boulder and cobble. Subtidal habitats within the study area overlap with multi-canopy macroalgae beds dominated by bull kelp with a diverse benthic algal understory and are therefore considered to provide a similar productivity to the macroalgae habitat described by Williams (2005). No adjustment to this habitat has been proposed and it remains a “4”.

4.2.1.2 Benthic Algal Habitat

Below approximately +0.5 m CD and above 0 m CD, the benthic algal layers and kelp beds are anticipated to have a similar potential productivity to the macroalgae habitat described by Williams (2005). The presence of abundant soft substrate areas and lack of extensive macroalgae coverage (including intertidal bull kelp) warrants a minor reduction in relative value of this existing habitat to “3.5” for the area as a whole.

4.2.1.3 Fucus Community

Below the rip rap slope, and above +0.5 m CD, intertidal areas are populated with the typical biobands of vegetation and invertebrates common to the mid and high intertidal areas in BC, specifically rockweed (*Fucus distichus*) and barnacles (*Balanus glandula*). These layers provide habitat to mobile invertebrates including shore crabs, limpets, periwinkle snails, and winkles that tolerate extended periods of desiccation as they often retreat to shaded areas beneath boulder and cobble substrates during low tide. The bedrock substate at this elevation was largely bare of invertebrate colonization, possibly due to the lack of the aforementioned shaded areas. The habitats provide limited foraging opportunities for more mobile species of invertebrates (e.g., crabs) and finfish when the tide levels permit. The relative habitat value of the *Fucus* and bedrock habitats observed in the Project Area was reduced to “2”.

4.2.1.4 Unvegetated Substrates

The highest intertidal zone is occupied largely by rip rap boulders armouring the slope of the existing rail bed. The substrate is largely bare, providing occasional foraging opportunities at the highest tidal levels and rare colonization by rockweed. The relative value of the rip rap habitat was determined to be “0.5”.

4.2.1.5 Marine Riparian Habitat

Existing marine riparian habitats within the Project Area consists of a narrow (approximately 5 m wide) band of sparse native shrubs and trees with abundant invasive plants confined between the crest of the rip rap slope and edge of rail ballast. The riparian vegetation present has naturally colonized this area following construction of the rail line. Given consideration towards the inherently modest value of riparian habitat within marine foreshore areas when compared to other more productive fish habitats (i.e., marine riparian vegetation typically provides reduced fish habitat function over estuarine or freshwater riparian areas), its sparse conditions and presence of invasive plant species, the relative value of this existing habitat is considered to be “1.5”.

4.2.2 Habitat Underlying Berry Point Offsetting Area

The results of the 2021 SCUBA survey provided confirmation that there is a suitable location upon which to build the offsetting habitat (i.e., currently consists of habitat with a low relative value and is located in an appropriate location and depth). The surveys also enabled determination of the habitat values underlying and surrounding the proposed offsetting location (see **Section 4.2**). These were subsequently used to inform amount of offsetting habitat required (**Section 5.0**).

Further description of the existing habitat type affected by the offsetting measure and rationale for the proposed relative value of this habitat is provided below. VFPA has requested that offsetting habitat be constructed above -8 m CD so as not to obstruct navigation within Burrard Inlet, as such only habitat above -8 m CD has been considered for the analysis below. Summary data tables for the Berry Point Study Area can be found in **Appendix B**.

4.2.2.1 Sandflat Habitats

The Berry Point Study Area has approximately 31,200 m^2 of marine habitat, with 21,800 m^2 in the subtidal zone down to -8 m CD and 9,400 m^2 in the intertidal zone to +1.9 m CD. The subtidal area at Berry Point can be divided into two distinct profiles. The southwest corner of the Study Area consists of an intertidal sandflat and alluvial fan. The top of the sandflat slope sits at approximately -1.5 m CD around 40-50 m from the shoreline. The slope then descends in the subtidal zone at a 1:4 (rise:run) gradient to a maximum surveyed depth of -12 m CD. The eastern extent of the Study Area, surveyed during Transect 3, consists of a longer shallow intertidal sandflat which gradually extends into the subtidal to a maximum surveyed depth of -4.1 m CD.

The Study Area receives freshwater input from one named (Squatter Creek; City of Burnaby 2016) and one unnamed watercourse (one storm drainage and one stream) connected via a culvert which runs underneath the CP rail line and outfalls above the highwater and flows down into the intertidal area. The marine habitat at Berry Point is characterised by high proportions of sand (91.8%; **Appendix A: Photo 4**) with some smaller patches of gravel in the intertidal (2.0%) and silt (6.3%) in the subtidal. Wood waste was observed covering approximately 4.8% of the substrate in both the intertidal and subtidal zones, while shell hash coverage was observed at 1.0% in both zones (**Appendix A: Photo 5**).

Algal coverage at Berry point was limited to sparse colonization of subtidal soft substrates by diatoms. No attached or wrack macroalgae was present within quadrats surveyed at Berry Point and presence is likely limited by the lack of hard substrate for attachment. Lack of hard substrate likely limits the colonization of the area by encrusting invertebrate species. The only species of encrusting invertebrates observed were acorn barnacles (*Balanus glandula;* 1% mean cover for quadrats where present) limited to 2 quadrats in which some gravels were present for attachment.

Mobile invertebrate communities were also low in abundance however showed higher species diversity with 5 identified species. Two species of infaunal bivalves were observed: nuttall’s cockle (*Clinocardium nuttallii*; 0.09/m^2) and horse clams (0.64/m^2). Infaunal community presence (likely polychaetes or infaunal bivalves) was also inferred through the observation of holes (0.09/m^2) in the sediment. Graceful rock crabs (*Metacarcinus gracilis*; 1.64/m^2) were the most abundant species observed at the Berry Point Study Area and also the most widely distributed being found in 8/11 quadrats (**Appendix A: Photo 6**) surveyed above

-8 m CD. The only other invertebrate species observed during surveys were juvenile ochre stars (*Pisaster ochraceus*; 0.09/m^2; Appendix A: Photo 7). Fish species observed during the outward swim for each transect were limited to 3 English sole (*Parophrys vetulus*) and a single unidentified sculpin (*Cottoidea* spp.).

4.2.2.2 Rationale

DFO prioritizes the restoration of degraded habitat when considering offsetting habitat, and in accordance with this policy, the offsetting habitat will be constructed in the Inner Harbour. The quality and productivity of the Inner Harbour fish habitat is reduced from lack of naturalized foreshore, high levels of contaminated sediments, and reduced water quality (Tsleil-Waututh Nation 2017). The proposed offsetting habitat will be installed overtop existing sandflat habitat at Berry Point. This habitat can be considered similar the sand/gravel beach habitat, to which Williams (2005) assigns a relative value of “1” (**Table 4.3**).

4.2.3 Offsetting Habitat Features

Each feature of the offsetting habitat (described below) is designed to provide a specific habitat type and function to a specific fish community, and balance the habitat that has been lost due to Project construction (as described in Hemmera Envirochem Inc. (2021) and summarized above). Therefore, each habitat component will provide a unique habitat value relative to the scoring scheme described by Williams (2005). A visual summary of the offsetting habitat is provided in **Figure 7** below.

4.2.3.1 Deep Rocky Reef

Subtidal rocky reef habitat consisting of large boulders and concrete rail ties is anticipated to provide similar habitat value to the macroalgae habitat described by Williams (2005) with a relative habitat value of 4. This resultant habitat value is based upon an expectation that the reefs will be colonized by understory and canopy forming kelps, and that the rugosity and crevices inherent in the design will support rock fish, octopus, lingcod, crab and a variety of other benthic and demersal species. These habitats will mimic the existing function provided by the kelp beds found towards the Second Narrows bridge, adding continuity to the macro-algal and canopy forming kelp communities of the Inner and Central Harbours. Habitat created through construction of these subtidal reefs is expected to achieve high productivity and be fully functional within three to five years of construction. A relative value of “3.5” is proposed for the subtidal bench habitat component.

4.2.3.2 Subtidal Bench

The unconsolidated habitats of the subtidal bench are designed to provide habitat to the epifaunal and infaunal communities found on similar unconsolidated benthos in BC waters. The surface of the sediment is expected to provide a habitat value similar to that of mudflat (2). Horse clams and other infaunal invertebrates will recolonize the subtidal bench substrates. Motile demersal vertebrates and invertebrates, particularly juveniles, will utilize the area for foraging and shelter. These include crabs and flatfish, and sea cucumbers. The erratic boulder and cobble substrates; however, will provide cover for fish and attachment substrate for benthic algae and sessile invertebrates not commonly found on soft substrates. This anticipated cover for juvenile salmonids and rockfishes improves the relative value beyond that of a typical mudflat. A relative value of “2.5” is proposed for the subtidal bench habitat component.

4.2.3.3 Shallow Rocky Reef

The shallow rocky reef habitat is anticipated to provide habitat value somewhat less than the macroalgae habitat described by Williams (2005). This is due to the planned lack of interstitial spaces in the reef structure. Nevertheless, the reef is predicted to promote the recruitment of an abundant benthic algal layer and the associated fish and invertebrate community. Additionally, the protection of the shoreward channel will provide protected, subtidal migration corridor for juvenile salmon and wave-sheltered habitat for a variety of benthic and demersal forage fish that tend to live in shallow waters. The shallow reef will have the added benefit of acting like a breakwater, contributing to shoreline security from storm-driven waves and sea level rise caused by climate change. Therefore, the proposed habitat value of the intertidal reef is “3”.

4.2.3.4 Edge Effect

The gravel and cobble substrate areas on the shoreward side of the Shallow Rocky Reef will have erratic boulders placed to mimic naturally occurring rocky intertidal habitat and to provide continuity and cover. The enhanced edge habitat will support foraging opportunities for fish while allowing them to remain near the relative safety of the structures. Additionally, the recruitment of larval and adult invertebrates to the habitat will lead to higher abundances of these species in the edge habitat, particularly those species like swimming scallops (*Chlamys hastata*), Dungeness crabs, and sea cucumbers. A relative value of “2.5” is proposed for the areas between the reef structures.

4.2.3.5 Enhanced Intertidal Sandflat

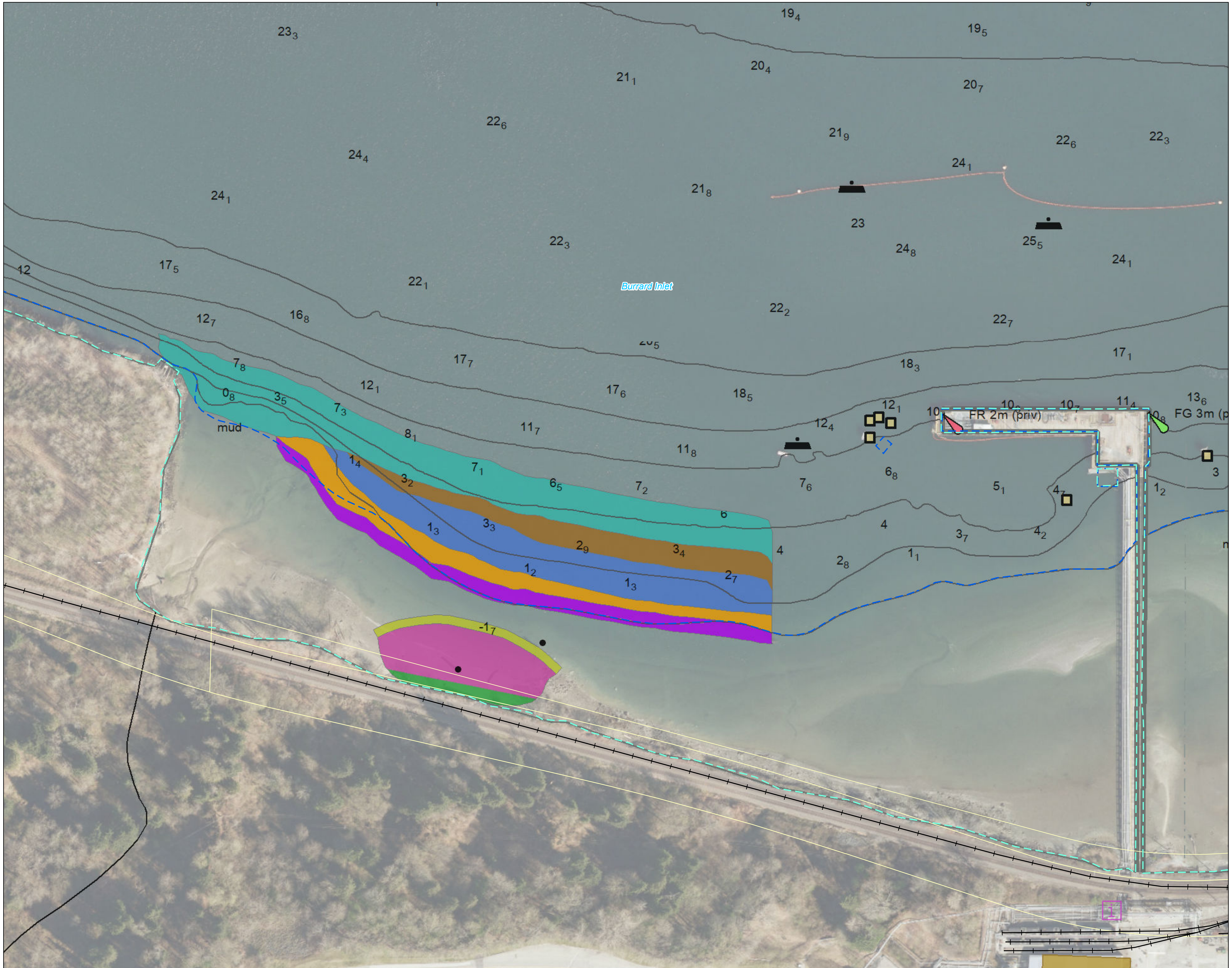
The sandflat areas between the habitat complex structures will have erratic boulders, cobble, and bivalve shells placed to mimic the naturally occurring rocky subtidal habitat and to provide continuity and cover. The enhanced intertidal sandflat habitat will support foraging opportunities for fish, such as juvenile salmonids, while allowing them to remain near the relative safety of the structures. Additionally, the recruitment of algae and invertebrates to the habitat complex structures will lead to higher abundances of these species in the enhanced intertidal sandflat habitat, particularly those species like Dungeness crabs, shore crabs (*Hemigrapsus* sp.), isopods, amphipods, and polychaetes. A relative value of “2.5” is proposed for the areas between the reef structures.

4.2.3.6 Intertidal Marsh

Intertidal marsh habitat in Burrard Inlet is extremely limited and discontinuous as a result of the industrialisation of the inner harbour. The proposed offsetting habitat involves the creation of a dense and continuous bench of native vegetation which is expected to contribute the productivity of Burrard Inlet. Intertidal marsh contributes to local nutrient cycling through detrital input, provide filtration and sediment trapping services, and habitat for potential drift insect which provide food for nearshore fishes. Intertidal marsh is also recognised as important refuge and feeding habitat for out migrating juvenile salmon as they progress to their marine life stage. The proposed offsetting is anticipated to provide similar ecosystem services as salt marsh which has a relative habitat value of “5” based on the ecological services they provide (Williams 2005).

Cascadia Terminal Rail Expansion Project
Burrard Inlet, Burnaby, BC

Offsetting Habitat



Legend

- Minor Pile
- Navigational Feature
- Rail Track
- High Water Mark
- Low Water Mark
- Parcel Boundary

Offsetting Habitat Feature

- Deep Subtidal Rocky Reef
- Edge Habitat
- Enhanced Intertidal Sandflat
- Filter Rock
- Intertidal Marsh
- Shallow Subtidal Rocky Reef
- Shoreline Tie-in
- Subsidal Bench

Notes

1. All mapped features are approximate and should be used for discussion purposes only.
2. This map is not intended to be a "stand-alone" document, but a visual aid of the information contained within the referenced Report. It is intended to be used in conjunction with the scope of services and limitations described therein.

Sources

- Contains information licensed under the Open Government Licences - Province of British Columbia
- Aerial Image: ESRI World Imagery
- Nautical Chart: Canadian Hydrographic Service

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4.2.4 Summary of Relative Habitat Values

Qualitative multipliers have been applied to the values proposed by Williams (2005) for each habitat type that are impacted by the Project (both by the Project directly and at the offsetting location). Because Williams (2005) generally assumed mature, fully functional habitats in his calculation, the relative values applied to CP's Project site are lower as they comprise industrialized coastal areas. These multipliers were determined based on habitat patch size, substrate size and distribution, depth of habitats, habitat patch connectivity, historical use and anthropogenic effects, and adjacent habitat types (**Table 4.3**).

Table 4.3 Relative Habitat Value of Habitats Underlying Project and Offsetting Areas

Existing Habitat	Relative Values (Williams 2005)	Relative Value of Existing Habitats
Underlying Project area		
Marine riparian	3	1.5
Fucus community	4	2
Benthic algal community	4	2
Kelp Bed	4	3.5
Unvegetated (bare) substrates	n/a	0.5
Underlying Offsetting area		
Sandflat	1	1

Similarly, relative habitat values are applied to the intended habitat creation or offset, which assumes each habitat components will function as intended for local marine life. Relative values for the habitat offset are reported in **Table 4.4**.

Table 4.4 Relative Habitat Value of Offsetting Habitats

Offsetting Habitat Features	Relative Values (Williams 2005)	Relative Value of Offsetting Habitats
Deep Rocky Reef	4	3.5
Subtidal Bench	2	2.5
Shallow Rocky Reef	3	3
Enhanced Edge Effect	2	2.5
Enhanced Intertidal Sandflat	2	2.5
Intertidal Marsh	5	5

5.0 OFFSETTING REQUIREMENTS

The offsetting requirements are based on the addition and subtraction of areas, informed by (i) the area of HADD as described in the Project's AEA (Hemmera Envirochem Inc. 2021), (ii) plus the habitat lost at the offsetting location caused by the physical footprint of the offsets, (iii) plus additional offsetting area to account for uncertainty related to the success of the intended habitat function, (iv) plus additional offsetting area to account for the time lag between offset construction and when the offsets are colonized by marine flora and fauna as intended. Each component of the habitat balance, (i) – (iv) is described below.

5.1 Physical Habitat Build

A comparison of relative habitat values allows the Project to replace impacted habitat with more productive habitat, achieving equivalency and counterbalancing Project-related effects. Relative habitat values used for this assessment are based on accepted relative habitat value approaches and habitat conditions within the Project Area, as described above and also see (Hemmera Envirochem Inc. 2021). Offsetting habitat requirements (e.g., the amount of habitat required to offset residual harm), where residual harm or HADD includes that caused by the combination of the Project and the offsetting footprint, are presented in **Table** 5.2. The area of HADD as described in the Project's AEA is 29,860 m^2 which is equivalent to a corrected habitat (HADD x Modifier Value [i.e., Relative habitat value]) of 47,479 m^2. To offset the Project HADD, 14,175 m^2 of offsetting habitat is proposed, which is equivalent to a corrected habitat area of 48,355 m^2 - resulting a net habitat gain of 877 m^2. The habitat lost at the Offsetting Area caused by the physical footprint of the offsets is 14,078 m^2, which is equivalent to a corrected habitat area of 14,078 m^2. This will be offset by 4,817 m^2 of habitat, which is equivalent to a corrected habitat area of 14,817 m^2 – resulting in a net habitat gain of 1,400 m^2. In total, there will be 18,922 m^2 of offsetting habitat built to offset the Project HADD and habitat lost to offsetting – resulting in an overall net corrected habitat gain 2,277 m^2.

5.2 Time Lag

Habitats described by Williams (2005) represent mature, high-quality habitats that provide a range of ecological services. For constructed habitats, there is a time lag between construction and when the habitat functions as intended, as the bare substrates will first be colonized by opportunistic species and, overtime, experience a series of successional stages before reaching a stable ecological state or stable ecological community (Rhoads and Germano 1986).

To account for a time lag prior to the offsetting measure functioning as intended, a 3% discount rate is used in this Offsetting Plan to determine additional offsetting requirements that will address the temporal delay in functionality. Furthermore, this 3% discount rate has been compounded by the number of years between construction and functioning habitat (Bradford 2017). The period of time for cleared or newly introduced rocky substrate to achieve species assemblage and abundance similar to undisturbed substrate is 3 to 4 years (Vance 1988). Construction of the offsetting habitat is scheduled concurrently with the construction of the Project, which will reduce the time lag between the loss of residual habitat associated with the Project and the habitat creation. The new habitats are, however, still expected to take approximately 3 to 5 years to become colonized by a stable ecological community of flora and fauna and function as intended, as calculated using the following equation:

$$M_{lag} = (1 + r)^{tlag}$$

M_{lag} = Multiplier that accounts for discounted loss of habitat value due to time lag (expressed as percentage of total habitat area)

r = discount rate (3% or 0.03)

^{tlag} = Time for habitat to achieve productivity (3 years)

M_{lag} is calculated as 1.0927, which is then rounded up to a multiplier of 1.1, or a 10% increase. Therefore, to account for time lag, a 10% multiplier has been applied to the offsetting habitat, i.e., 10% of 18,992 m^2 is 1,899 m^2 of additional offsetting habitat. This will be fulfilled through 1,548 m^2 of Enhanced edge habitat and 351 m^2 of Enhanced intertidal sandflat.

5.3 Uncertainty

Consistent with policy, the proposed offsetting habitat must account for the inherent uncertainty (Government of Canada 2019d). Sources of uncertainty are varied and can include uncertainty in the underlying predictions of HADD, in the measures to avoid and to mitigate adverse effects, or in the design and long-term viability of the proposed habitats.

The offsetting habitat has been designed according to commonly accepted standards and best practices and is anticipated to be highly successful in providing abundant, high-quality fish habitat. Creation of the offset habitat is considered a low-risk technique for offsetting, with high confidence in their success. As it is impossible to remove all uncertainty, an additional 10% (additional 1,899 m^2) has been added to the offsetting target to account for this. This will be fulfilled through 1,899 m^2 of Enhanced intertidal sandflat.

5.4 Habitat Balance Summary

The offsetting habitat referenced is the sum of the physical area of various reef habitats proposed for construction (18,992 m^2). Including time lag and uncertainty, the total offsetting requirement is 22,790 m^2. The habitats and areas that constitute the proposed offsetting are presented below in **Table 5.1**. A detailed summary of the total offsetting requirement calculations, including time-lag and uncertainty, is presented in **Table 5.2**.

Table 5.1 Summary of Offsetting Habitats and Area (m^2)

Offsetting Habitat Features	Area (m^2)
Deep Rocky Reef	8,150
Subtidal Bench	2,950
Shallow Rocky Reef	4,600
Enhanced Edge habitat	2,440
Enhanced Intertidal Sandflat	2,450
Intertidal Marsh	2,400
Total	**22,790**

Table 5.2 Summary of Habitat Offsetting Areas by Habitat Type relative to Areas of HADD caused by the Project

Habitat Type Experiencing HADD		Habitat Footprint of HADD (m^2)[1]	Habitat Value Modifier A (HADD)	Corrected Habitat Area of HADD(m^2) (HADD x Modifier Value A)	Proposed Habitat to Offset HADD	Offsetting Habitat Surface Area (m^2)[2]	Habitat Value Modifier B (Offset)	Corrected Habitat Area (m^2) (Offsetting Habitat Area x Modifier Value B)	Net Gain in Habitat (m^2)
Project Area	Kelp Bed	965	3.5	3,378	Deep reef	965	3.5	3,378	0
	Benthic Algal Community	8,502	2.5	21,255	Deep reef	6,135	3.5	21,473	+ 218
	Fucus Community	4,843	2	9,686	Deep reef	1,050	3.5	3,675	+ 52
					Subtidal bench	2,425	2.5	6,063	
	Unvegetated	10,165	0.5	5,083	Subtidal bench	525	2.5	1,131	+ 610
					Shallow reef	1,460	3	4,380	
	Marine riparian	5,385	1.5	8,078	Intertidal marsh	1,615	5	8,075	- 3
Project Subtotal		**29,860**		***47,479***		**14,175**		***48,355***	***+877***
Area Underlying Offsetting Location	Sandflat	14,175	1	14,175	Shallow reef	3,140	3	9,420	+ 1,400
					Edge habitat	892	2.5	2,230	
					Intertidal marsh	785	5	3,925	
Offsetting Subtotal		**14,078**		***14,078***		**4,817**		***15,575***	**+ *1,400***
Project and Offsetting Subtotal						**18,992**			**+ 2,277**
Additional Habitat to Offset "Time Lag[3]"						**1,899**			
Additional Habitat to Offset "Uncertainty[3]"						**1,899**			
Total Area of Habitat Offsetting Project						**22,790**			

Notes:

1. Habitat footprint refers to the 2-dimensional footprint viewed from above.
2. Habitat area refers to the surface area of the 3-dimensional offsetting habitat construction that is considered available to fish.
3. Additional Habitat to offset Time Lag and Uncertainty (total of 3,798 m^2) will be comprised of 1,548 m^2 of Edge habitat and 2,250 m^2 of Enhanced intertidal sandflat habitats.

6.0 OFFSETTING IMPLEMENTATION AND MONITORING

Construction equipment and activities associated with building the offsetting habitats has the potential to affect fish and fish habitat; therefore, the proposed offsetting must be constructed in such a way to avoid and/or mitigate potential adverse effects. As outlined in the Aquatic Effects Assessment, the Fish and Fish Habitat Protection Policy Statement outlines a hierarchy of measures and standards for fisheries protection that aim to: (1) Avoid, (2) Mitigate, and/or (3) Offset the HADD of fish habitat (2019a). The following measures are designed to avoid and minimize potential adverse effects from the offsetting habitat construction to avoid further HADD. Construction of offsetting habitats will be consistent with mitigation measures outlined within the Construction Environmental Management Plan and the Aquatic Effects Assessment for Project works within the marine aquatic environment and as summarized below, including implementation of BMPs and DFO's Measures to Avoid Causing Harm to Fish and Fish Habitat (2019d).

6.1 Offsetting Construction

Offsetting complex construction will consist of placement of railroad ties and rock in water by water-based equipment (derrick and crane with supply barge). The subtidal rocky reef will be a rip rap berm (300 to 900 mm diameter rip rap) supported on the seaward side by railroad ties. The shallow subtidal to intertidal rocky reef will, likewise, be small boulder and cobble berm (64 – 300 mm diameter). The two berms will be infilled subtidally by with sand and gravel to create the subtidal bench habitat. Heavy rip rap (300 to 900 diameter) will be placed irregularly on the subtidal bench to create complex topography.

6.2 Measures to Avoid

Avoidance (i.e., prevention) measures are considered prior to the development of mitigation strategies. Where avoidance of effects from shallow rock reef construction is not possible or practical, mitigation measures and BMPs have been identified to minimize any potential effects. Avoidance measures considered include site selection, design, and timing, while those considered for implementation during the construction phase include construction timing and other mitigation measures.

6.2.1 Construction Timing

Subject to obtaining key environmental permits and considering environmental timing windows and work restrictions, the Project and associated in-water offsetting will be timed to occur within DFO Burrard Inlet reduced risk work window of August 16 – February 28. It is anticipated that the entirety of the Project's in-water construction, including offsetting habitat, can be completed within this time period.

6.2.2 Offsetting Locations

The locations chosen for the proposed habitat offset was selected to avoid impacts to sensitive habitats or those that are critical to sensitive life stages of fish (e.g., eelgrass, reef, kelp beds).

6.3 Mitigation Measures

Where avoidance of effects is not possible or practical, mitigation measures and BMPs have been identified. The proposed guidelines and recommendations presented in this section are intended to address potential effects to fish and fish habitat that may result from the proposed Project construction.

Construction of offsetting habitats will be guided by mitigation measures outlined in a Construction Environmental Management Plan (CEMP), including implementation of Best Management Practices (BMPs) and DFO's Measures to Protect Fish and Fish Habitat (2019b). The CEMP clearly defines the procedures and controls to achieve mitigation of potential Project effects, and objectives to maintain environmental performance. The following elements are included within the CEMP:

- General Practices
- Site Access, Mobilisation, and Laydown Areas
- Air Quality
- Noise and Vibration
- Water Quality
    - Water Quality Monitoring Plan
    - Water Quality Contingency Plan
- Machinery and Equipment
- Erosion and Sediment Control
- Contaminated Soil and Groundwater Management
- Vegetation and Wildlife Management
- Marine and Foreshore Works
    - Marine Lifeform Salvage
    - Marine Mammal Monitoring Plan
- Freshwater Habitat Management
- Archaeological and Cultural Resources
- Sensitive Habitat Features and Species
- Emergency Response Plan
    - Emergency Communication
    - Environmental Emergency Plan
    - Spill Response Plan
- Fuel Management
- Waste Management
- Mitigation Contingency Measures

6.4 Intertidal Marsh Planting Plan

A list of intertidal marsh species has been included below (**Table 6.1**). Marsh transplants will be sourced from nursery stock where available.

Temporary fencing is recommended around the marsh until it is fully established. Fencing should be designed to prevent grazers, such as Canada geese, from accessing and damaging the area through overgrazing while allowing for fish passage and minimal entrapment of debris or wrack. Given the limited access to the location, trampling by members of the public is not expected to be an issue.

After a settlement period, and confirmation of the settled marsh bench elevation a total of 9,600 marsh plugs will be planted at 0.5 m spacing centre to centre (i.e., 4 plugs/m^2). Marsh plugs will be transplanted at appropriate elevations and so that the sediment surface of the plug matches the sediment surface of the constructed habitat bench. Resultant sediment plugs, removed prior to installation of the transplant plugs, will be sidecast and allowed to incorporate into the surface of the marsh.

Table 6.1 Intertidal Marsh Species

Stock Type	Reference Marsh Elevation (mCD)[1]	Scientific Name	Common Name
Plug	3.02 – 4.8	*Carex lyngbyei*	Lyngby's sedge
Plug	3.58 – 5.07	*Distichlis spicata*	saltgrass
Plug	4.23 – 5.20	*Sarcocornia pacifica*	Pickleweed
N/A	4.24 – 3.49	*Glaux maritimia*	Sea milkwort
Plug	3.02 – 5.07	*Grindelia integrigolia*	Gumweed
Plug	4.45 – 5.31	*Juncus balticus*	Baltic Rush
Plug	4.65 – 5.28	*Potentilla anserina*	Pacific Silverweed
Plug	4.65 – 4.74	*Triglochin maritima*	Arrowgrass

Notes:

1. As per Moffat & Nichol (2016)

7.0 HABITAT EFFECTIVENESS MONITORING AND REPORTING

A 5-year habitat effectiveness monitoring program will be implemented to determine whether the offsetting measure is functioning as intended and counterbalancing the Project's residual effects – success will be determined after year 5. Colonization of the constructed habitat will be monitored and discussed in annual summary reports. The monitoring will be designed using DFO's Monitoring and Assessment of Fish Habitat Compensation and Stewardship Projects: Study Design, Methodology and Example Case Studies as a guiding document (Pearson et al. 2005).

Detailed descriptions of the proposed methods are presented in the following subsections. Specific monitoring periods and success criteria are described for each of the offsetting habitat features, based on a variety of factors.

7.1 Measures of Success

The objectives of the habitat offsets is to establish productive and self-sustaining habitats contributing to productive fisheries values for Burrard Inlet within five years from completion of the Project works. Success criteria involve physical (structural) stability of the offsetting complex, the establishment of marine vegetation, and habitat use by fish and invertebrates. Measures of success are described in further detail below for each of the offsetting features.

7.1.1 Deep Rocky Reef Monitoring

The deep reef components of the offsetting complex will be monitored to verify the habitat is functioning as intended. The habitat is expected to develop understorey kelp communities and be physically stable. Monitoring will be assessed via diver-supported belt transect and quadrat surveys, and benthic sampling. Effectiveness monitoring will document the following:

- Density (average % cover) and number of species of benthic algal community (i.e., *Laminaria* spp., *Saccharina* spp., *Agarum* spp., etc.).
- Density (average % cover or individuals / m^2) and number of species of kelp community and benthic algae and sessile invertebrate and fish communities.
- The physical stability of the site and structures to ensure competent construction of the structure to prevent loss of material or material failure.

Deep rocky reef habitat will be considered successful following the post-construction monitoring program if the structures are determined to be physically stable and there is an increasing annual trend of density (average % cover or individuals / m^2) and number of species of kelp community, benthic algae, sessile invertebrate, and fish communities during the 5-year monitoring period.

Subtidal (SCUBA) assessments will follow the sampling methods outlined in the working draft, Marine Foreshore Environmental Assessment Procedure (Government of Canada 2004b). A stratified random sampling design will be developed with transects established evenly throughout the offsetting habitat.

7.1.2 Subtidal Bench Monitoring

The subtidal bench components of the offsetting complex will be monitored to verify the habitat is functioning as intended. Sampling methodology will include transect and quadrat-based surveys similar to those described in previous section. Effectiveness monitoring will include an evaluation of the following:

- Physical site stability of subtidal bench habitat.
- Occurrence of erosion or physical changes that may affect the stability of the bench substrates and benthic communities.
- Abundance (individuals/m^2) and number of species identified within the epifaunal and infaunal communities.

Subtidal bench habitat will be considered successful following the post-construction monitoring program if the structures are determined to be physically stable and there is an increasing annual trend of abundance and number of species within the epifaunal and infaunal communities during the 5-year monitoring period.

7.1.3 Shallow Rocky Reef Monitoring

The shallow rocky reef components of the offsetting complex will be monitored to verify the habitat is functioning as intended. Sampling methodology will be based on the working draft Marine Foreshore Environmental Assessment Procedure (Government of Canada 2004b) and include transect and quadrat-based surveys similar to those described in previous sections.

In order to survey the entire shallow rocky reef habitat and include the finfish and mobile invertebrate communities, surveys will be conducted using SCUBA assessments during high tides. Transects will be established evenly throughout the habitat, with adequate replication within the reefs and the reference sites.

Effectiveness monitoring of intertidal reef habitat will document the following:

- Density (average % cover) and number of species of understorey kelp community (i.e., *Laminaria* spp., *Saccharina* spp., *Agarum* spp., *Alaria* spp., *Costeria* spp., etc.) and canopy-forming kelp species
- Increasing annual trend of density (average % cover or individuals/m^2) and number of species of kelp community, benthic algae, sessile invertebrate, and fish communities during the 5-year monitoring period.
- The physical stability of the site and structures to ensure competent construction of the structure to prevent loss of material or material failure.

Shallow rocky reef habitat will be considered successful following the post-construction monitoring program if the structures are determined to be physically stable and there is an increasing annual trend of density (average % cover or individuals/m^2) and number of species of kelp community, benthic algae, sessile invertebrate, and fish communities during the 5-year monitoring period.

7.1.4 Edge Habitat Monitoring

The Edge habitat of the offsetting complex will be monitored to verify the habitat is functioning as intended. Sampling methodology will include transect and quadrat-based surveys similar to those described in previous section. Effectiveness monitoring will include an evaluation of the following:

- Physical site stability of Edge habitat.
- Occurrence of erosion or physical changes that may affect the stability of the Edge habitat substrates and benthic communities.
- Abundance (individuals/m^2) and number of species identified within the epifaunal and infaunal communities.

Edge habitat will be considered successful following the post-construction monitoring program if the structures are determined to be physically stable and there is an increasing annual trend of abundance and number of species within the epifaunal and infaunal communities during the 5-year monitoring period.

7.1.5 Enhanced Intertidal Sandflat Monitoring

The Enhanced Intertidal Sandflat habitat of the offsetting complex will be monitored to verify the habitat is functioning as intended. Sampling methodology will be based on the working draft Marine Foreshore Environmental Assessment Procedure (Government of Canada 2004b) and include transect and quadrat-based surveys similar to those described in previous sections. Transects will be established evenly throughout the habitat, with adequate replication within the reefs and the reference sites.

Effectiveness monitoring of intertidal reef habitat will document the following:

- Density (average % cover) and number of species of understorey kelp community (i.e., *Laminaria* spp., *Saccharina* spp., *Agarum* spp., *Alaria* spp., *Costeria* spp., etc.) and canopy-forming kelp species
- Increasing annual trend of density (average % cover or individuals/m^2) and number of species of kelp community, benthic algae, sessile invertebrate, and fish communities during the 5-year monitoring period.
- The physical stability of the site and structures to ensure competent construction of the structure to prevent loss of material or material failure.

Enhanced Intertidal Sandflat habitat will be considered successful following the post-construction monitoring program if the structures are determined to be physically stable and there is an increasing annual trend of density (average % cover or individuals/m^2) and number of species of kelp community, benthic algae, sessile invertebrate, and fish communities during the 5-year monitoring period.

7.1.6 Intertidal Marsh Bench Monitoring

Monitoring of the constructed intertidal marsh offsetting habitat will be conducted over a 5-year period, with monitoring events scheduled for years 1 through 3 and year 5. If the initial three-year periods show that the habitat is successful and functioning as intended, per the criteria below, DFO will be consulted to determine if year five monitoring is required. Tidal marshes are expected to be transplanted using nursery stock and thus monitoring of donor beds will not be required.

Sampling methodology will be based on the working draft *Marine Foreshore Environmental Assessment Procedure* (Government of Canada 2004a). Effectiveness monitoring will include an evaluation of:

- Physical site stability of intertidal marsh habitat and the associated rock berm.
  - Measures of physical site stability including the horizontal and vertical movement of the rock berm.
  - Measures of physical site stability including elevation and slope of the marsh substrate within the tidal marsh habitat.
- Occurrence of erosion or physical changes that may affect the stability of the marsh substrates and vegetation.
- The percent cover of invasive species in the tidal marsh planting area.
- The percent cover and species diversity of marsh vegetation in the offsetting habitat and reference sites.

The tidal marsh habitat will be deemed successful if, following the post-construction monitoring program, the following conditions have been met:

- The planted tidal marsh is not less than 2,400 m^2
- The intertidal marsh habitat and associated rock berm are physically stable.
  - Both the horizontal location and vertical height of the structure are within a 10% tolerance of the as-built measurements.
  - Final elevations are stable and within the range capable of supporting tidal brackish marsh habitat.
- Positive drainage on the ebbing tide limits the formation of extensive pools.
- Not more than 5% invasive species (by area).
- Support transplanted marsh vegetation at statistically similar percent areal coverage as the Maplewood reference tidal marsh.

The Maplewood tidal marsh was selected as a reference site based on its proximity to the proposed offsetting location (i.e., located east of second narrows bridge in Burrard Inlet) and matching of the offsetting habitat to the elevation, substrate, community assemblages of the marsh.

Marsh effectiveness monitoring will include an assessment of vegetation establishment and success, conducted earlier in the growing season (June) during suitable daytime low tides.

Each year of monitoring, both the overall marsh areal vegetation cover and marsh monitoring quadrat stations will be assessed using a modified Braun-Blanquet cover-abundance scale (modified from Braun-Blanquet 1964) consisting of five classes of cover (**Table 7.1**). The extent of invasive species, woody debris and wrack will also be estimated.

Table 7.1 Areal vegetation cover classes (adapted from Braun-Blanquet 1964)

Cover Classes	Range of Areal Coverage (%)
5	76-100
4	51-75
3	26-50
2	5-25
1/+	<5 and a few individuals
1/r	<5 and only one individual

Quadrat stations (1 m^2) will be established during Year 1 effectiveness monitoring using a stratified random sampling approach. A statistically relevant number of quadrats will be determined for each target habitat type (elevation often determines target habitat type). Quadrat stations will be marked by GPS and with the installation of a wood stake.

Additionally, biota or signs of biota within the plots or within the broader site (e.g., macrofauna, including invertebrates, invertebrate burrows, etc.) will be documented and anthropogenic features in the plots or within the broader site will also be noted.

Both the overall marsh and quadrats will be photographed from several viewpoints (consistent photo stations will be used from year to year) to provide a visual record of changes to the marsh over time.

In addition to the assessment of areal coverage, Year 1 monitoring will also assess the initial plant survivorship and establishment by observing each plant and its current health (e.g., healthy, stressed, damaged, dead).

Monitoring will also involve the identification of potential maintenance and/or remediation requirements (e.g., supplemental armouring, planting, etc.) and documentation of site physical features and conditions that may affect habitat success (e.g., stability or signs of erosion, presence of stressors such as wildlife grazing).

Each year of monitoring will compare results to the post-construction report and planting plan, along with any other years of effectiveness data collection. General descriptive statistics will be conducted on the data to provide graphical descriptions and to allow for comparisons of mean percent cover between the offsetting and reference locations.

7.2 Post-construction Monitoring Schedule

A five-year post-construction monitoring period is proposed to assess stability and habitat functioning of the offsetting habitats. Effectiveness monitoring will take place during the peak growing season for macroalgae (including bull kelp), between June 15 and September 15 during years 1 (2024), 2 (2025), 3 (2026) and 5 (2028). An assessment of whether the offset habitat is functioning as intended will be made after Year 5.

In the event that Pacific herring spawning is occurring in Burrard Inlet during any of the post-construction monitoring years, supplemental low tide surveys will occur during the anticipated peak spawning period (e.g., late March/early April). Methods to be applied will include additional transect/quadrat surveys, focusing on the evaluation of extent of herring spawn and characterization of microsite selection on the Project fill slope or artificial reefs.

7.3 Maintenance Program

An adaptive management strategy will be implemented to increase the likelihood that, following the five-year monitoring program, the habitats are deemed effective in providing suitable offsetting for the residual effects of the Project. If any habitat component of the proposed offsetting does not meet effectiveness measures by Year 3 (i.e., no colonization by macroalgae or marine invertebrates, and no presence of fish), additional monitoring will be conducted in Year 4, and mitigation measures will be conducted as needed to increase the effectiveness of the areas as offsetting habitat. Mitigation measures may include:

- Kelp seeding (green gravel, kelp infused ropes).
- Kelp & benthic algae transplantations.
- Watering or supplemental planting of marsh species.
- Physical adjustments to substrate quantity, quality, or design.

7.4 Reporting

7.4.1 Post-construction / As-built Reporting

A post-construction monitoring report will be drafted and delivered within 6 months of completion of the offsetting habitat works. Contents of the report will include:

- Dated photographs of works, undertakings and operations related to the successful implementation of mitigation measures.
- Dated photographs of completed offsetting measures.
- Construction monitoring and inspection and audit records.
- If mitigation does not function as described, details of changes to proposed mitigation, corrective actions or contingency measures that were implemented.
- As-built drawing of the completed offsetting habitats.
- Estimates of the post-construction footprint, based on as-built drawings, of the reef complex.

7.4.2 Habitat Effectiveness Reporting

An annual habitat effectiveness monitoring report will be prepared and provided to DFO by the end of each monitoring year and will include the results of the effectiveness monitoring program outlined above.

The annual habitat effectiveness monitoring report will include the following:

- Qualitative assessment of the physical condition and stability of each habitat component.
- Qualitative assessment of substrate composition at offset habitats.
- Quantitative assessment of fish, invertebrates, algae, kelp, and plants observed in the offset habitats.
- An assessment of success of the offsetting measures.
- Additional comments and observations on offset habitat performance.
- Photographic or video documentation of the areas monitored, as appropriate.
- Any maintenance or management recommendations.

The report prepared in Year 5 (2028) will function as a final monitoring report and will include the results of the offsetting works over the full five-year period.

8.0 CONTINGENCY PLANNING

The habitat effectiveness monitoring program will be used to assess and characterize the offsetting works and determine whether the success criteria have been met over a 5-year period. A contingency plan will be developed and implemented in the unlikely event that the offsetting habitats have not met the success criteria. The plan will be developed in consultation with DFO.

If a contingency plan is required, Hemmera anticipates it would include the following components:

- Assessment and description of why the offsetting works has not met the success criteria, to inform options to potentially resolve offset shortfalls and adapt these works as needed (maintenance or augmentation of previous works).
- Options to alter the offsetting habitats, to improve their effectiveness as fish habitat.
- Options for alternative or additional offsets to counterbalance residual HADD to fish.
- Description of additional effectiveness monitoring measures required to assess the success of the contingency plan.

9.0 COST ESTIMATE FOR OFFSETTING

A cost estimate for the offsetting measures proposed in this Fish Habitat Offsetting Plan is provided in **Table 9.1**. The cost estimate will be further refined following confirmation of material volume and gradation requirements. Once the Offsetting Plan has been accepted by DFO, CP will submit a Letter of Credit to DFO to cover the cost of implementing the Offsetting Plan.

Table 9.1 Proposed Cost Estimate for Offsetting

Item	Cost Estimate
Final engineering design (Issued for Tender)	TBD
Offsetting habitat construction - mobilization/demobilization	TBD
Offsetting habitat materials – boulders	TBD
Offsetting habitat materials – cobble	TBD
Offsetting habitat materials – gravel	TBD
Offsetting habitat materials – sand	TBD
Offsetting habitat materials – marsh / dunegrass plants	TBD
Offsetting habitat materials – growing medium	TBD
Offsetting habitat installation	TBD
Construction Contingency (25%)	TBD
Engineering construction supervision/inspection/survey	TBD
Post-construction monitoring report, as-built drawings (record drawings)	TBD
Habitat effectiveness monitoring and reporting (4 assessments over 5 years)	TBD
Contingency planning/implementation	TBD
Total	**TBD**

This cost estimate is based on the following assumptions:

- Material and installation costs for offsetting habitat are based on past experience on similar projects and further validated through consultation with the marine commercial industry.
- Post-construction monitoring reporting and as-built for the offsetting habitat will include side scan or bathymetric survey, SCUBA assessment, preparation of as-built drawings, and a memorandum of results.
- Habitat effectiveness monitoring will include yearly assessments in Years 1, 2, 3, and 5, post-construction. Offsetting habitat will be assessed via SCUBA with underwater video, transects and quadrats, with yearly reporting to DFO and a final wrap-up report in Year 5.
- The contingency planning/implementation cost is based on replacement of 25% of marsh plantings and 2 shallow rock reefs (including an additional monitoring event), with the understanding that the risk of offsetting failure (especially shallow rock reefs) is low.

9.1 Tenure

The area where offsetting will occur is within lands administered by the VFPA and will require a lease agreement in advance of construction. CP has advanced discussions with VFPA, and they are supportive of the proposed Offsetting Plan. CP will ensure that required leases are amended and/or obtained prior to proposed construction of the offsetting.

10.0 CLOSURE

This work was performed in accordance with the Contract (Number 5600015425) between Hemmera, a wholly owned subsidiary of Ausenco, and Canadian Pacific, dated December 1, 2018. This report has been prepared by Hemmera, based on fieldwork conducted by Hemmera, for sole benefit and use by Canadian Pacific. In performing this work, Hemmera has relied in good faith on information provided by others and has assumed that the information provided by those individuals is both complete and accurate. This work was performed to current industry standard practice for similar environmental work, within the relevant jurisdiction and same locale. The findings presented herein should be considered within the context of the scope of work and project terms of reference; further, the findings are time sensitive and are considered valid only at the time the report was produced. The conclusions and recommendations contained in this report are based upon the applicable guidelines, regulations, and legislation existing at the time the report was produced; any changes in the regulatory regime may alter the conclusions and/or recommendations.

If you have any questions, please do not hesitate to contact the undersigned by phone at 604.669.0424.

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APPENDIX A
Dive Photo Log

Photo 1 The Proposed Offsetting Area facing the south shore of Burrard Inlet. Photo taken October 28, 2021, facing south.

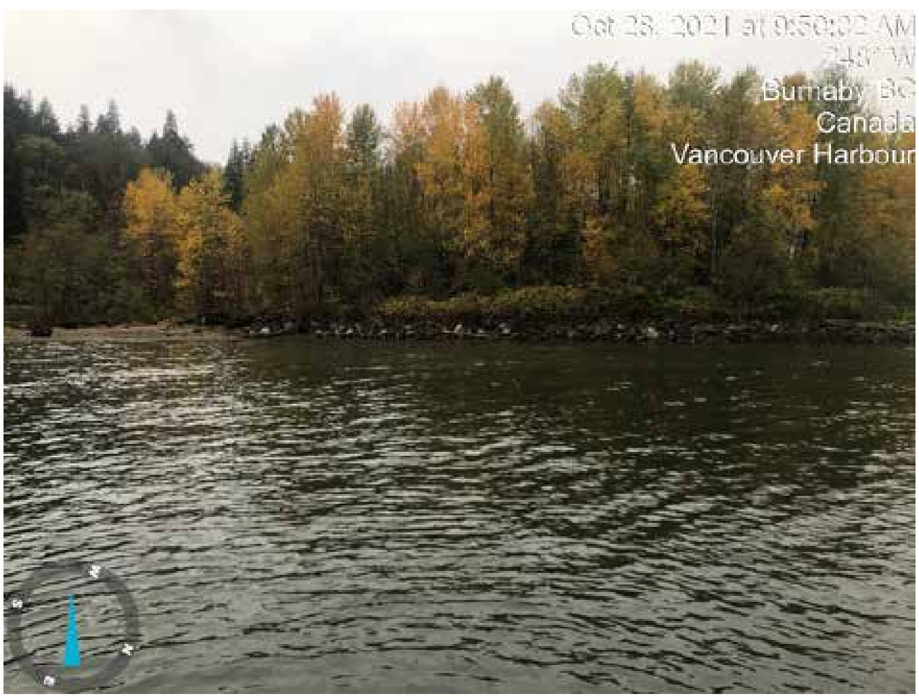

Photo 2 The Proposed Offsetting Area facing the southwest shore of Burrard Inlet towards the Island Tug and Barge facility. Photo taken October 28, 2021, facing southwest.

Photo 3 The Proposed Offsetting Area facing North into Burrard Inlet. Photo taken October 28, 2021, facing north.

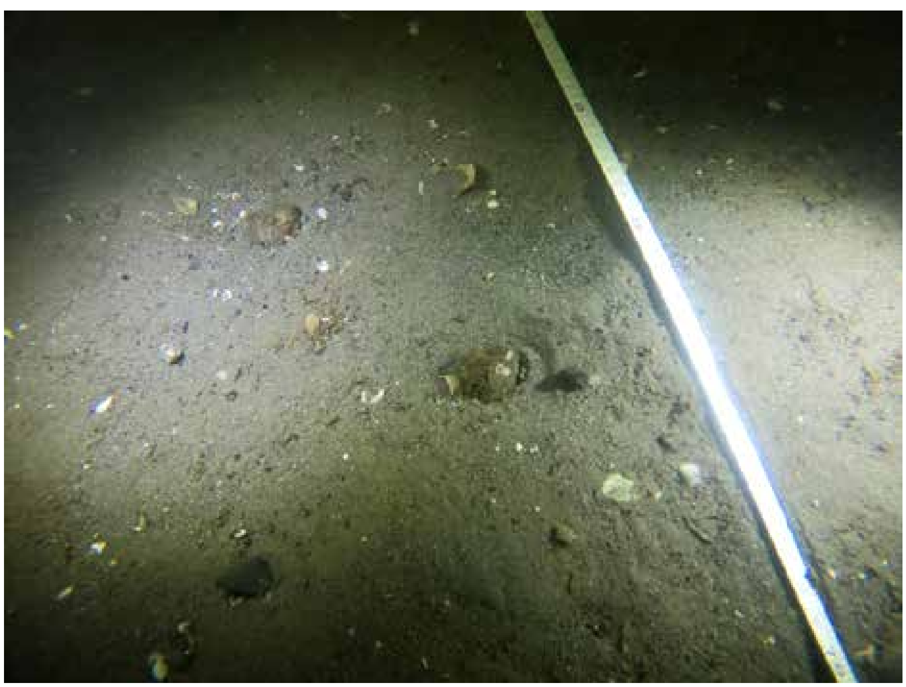

Photo 4 Representative image of substrates within the Proposed Offsetting Area. Photo taken October 28, 2021, using high-definition underwater camera.

Photo 5 Woodwaste and shell hash covering substrate within the Proposed Offsetting Area. Photo taken October 28, 2021, using high-definition underwater camera.

Photo 6 Graceful Rock Crabs (*Metacarcinus gracilis*) observed within the Proposed Offsetting Area. Photo taken October 28, 2021, using high-definition underwater camera.

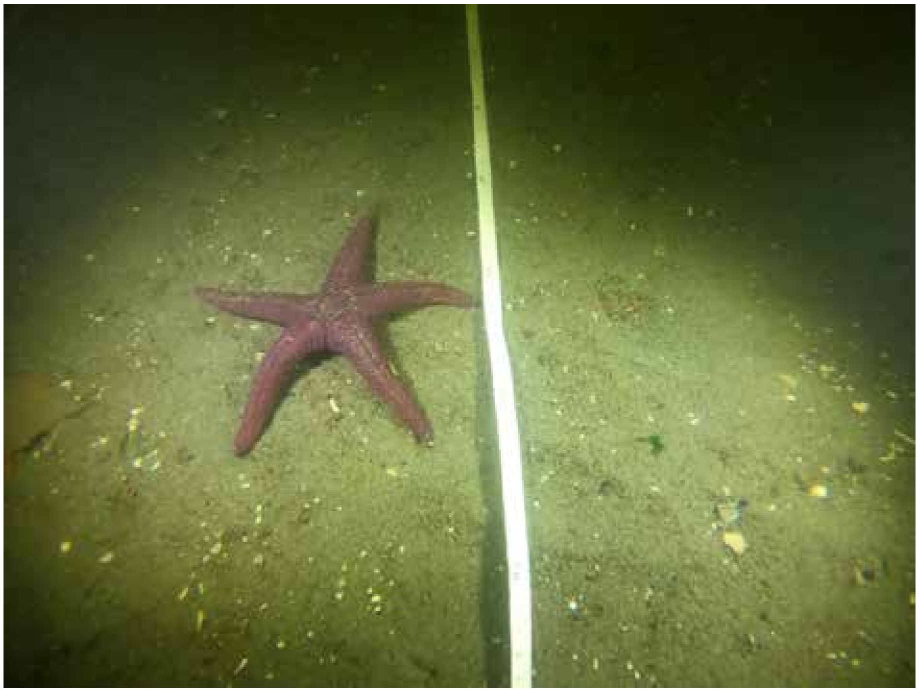

Photo 7 Ochre star (*Pisaster ochraceus*) observed within the Proposed Offsetting Area. Photo taken October 28, 2021, using high-definition underwater camera.

APPENDIX B
Dive Quadrat Summary Tables

Table B1 Substrate composition in the Project Area. Values are expressed as mean percentage cover within 1 m^2 quadrats surveyed by Hemmera divers in the Project area on October 28, 2021. Values are rounded to the nearest whole number. See Section 4.0 for detailed methodology.

Type	Subtidal occurrence
Rip rap	-
Bedrock	-
Boulder	-
Cobble	-
Gravel	2.0
Sand	91.8
Silt	6.3
Shell	1.0
Wood waste	4.8

Table B2 Algae occurrence in the Project Area. Values are expressed as mean percentage cover within 1 m^2 quadrats surveyed by Hemmera divers in the Project area on October 28, 2021. Values are rounded to the nearest whole number. See Section 4.0 for detailed methodology.

Type	Common Name	Scientific name	Subtidal occurrence
Silicified algae	Diatoms	*Bacillariophyceae* spp.	25%

Table B3 Invertebrate counts expressed in means across 1 m^2 quadrats and totals (in parentheses) in the Project Area, from Hemmera diver surveys conducted on October 28, 2021. Mean values are rounded to decimal places. See Section 4.0 for detailed methodology.

Type	Common Name	Scientific name	Subtidal occurrence
Sessile invertebrate	Horse clam	*Tresus* spp.	0.64 (7)
Sessile invertebrate	Nuttal's cockle	*Clinocardium nuttallii*	0.09 (1)
-	Hole	N/A	0.09 (1)
Mobile invertebrate	Graceful rock crab	*Metacarcinus gracilis*	1.64 (18)
Mobile invertebrate	Ochre star	*Pisaster ochraceus*	0.09 (1)

Table B4 Fish counts expressed as total per transect in the Project Area observed by Hemmera diver surveys conducted on October 28, 2021. Mean values are rounded to decimal places. See Section 4.0 for detailed methodology.

Common Name	Scientific name	Subtidal occurrence
English sole	*Parophrys vetulus*	3
Sculpin	*Cottoidea* spp.	1