

**APPENDIX 17-A**  
**Proposed Onsite Habitat Concepts**

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## **Appendix 17-A Proposed Onsite Habitat Concepts**

**Appendix 17-A** describes the onsite habitat concepts proposed for offsetting Project effects: tidal marsh, sandy gravel beach, mudflats, subtidal rock reef, and eelgrass beds.

### ***Concept 1: Intertidal (Salt) Marsh***

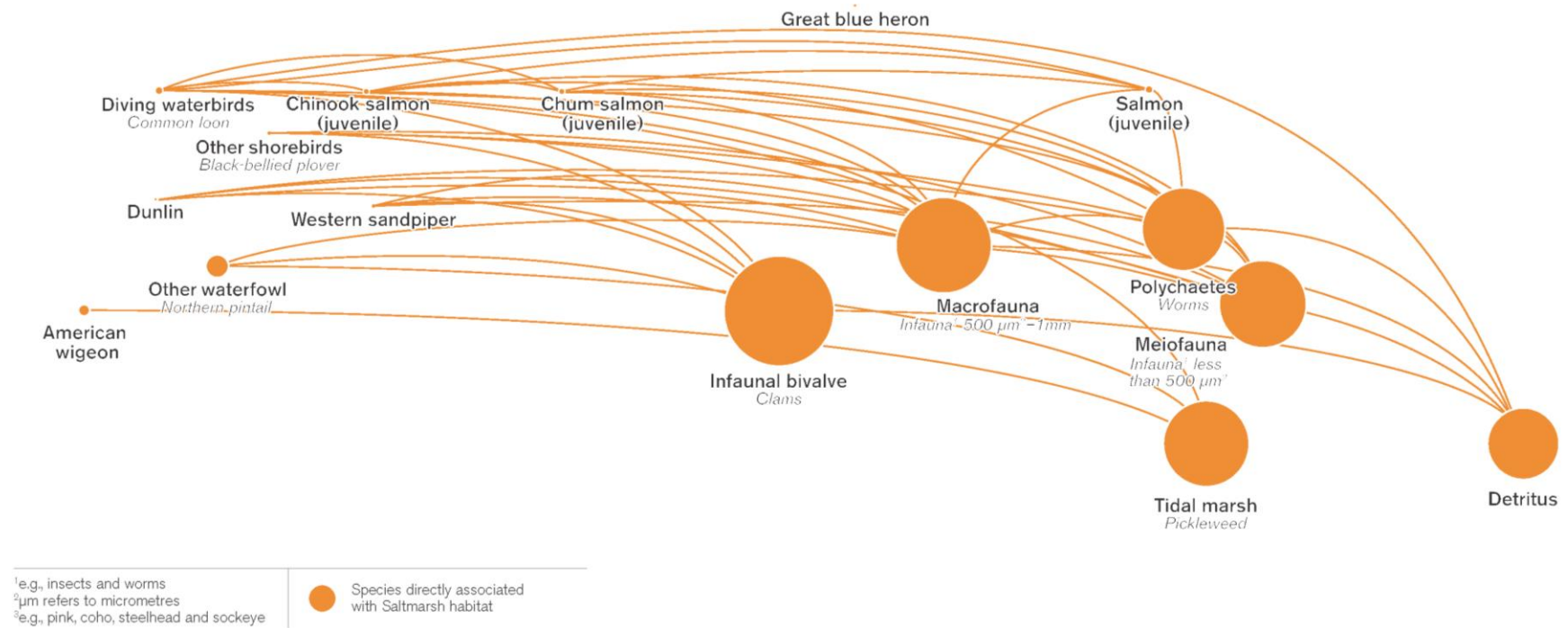
Intertidal marshes perform important ecological functions including shoreline stabilisation, gas and nutrient regulation, contaminant filtering, and nutrient supply (Adam 1993), as well as increasing biological diversity. They also provide complex, structural habitat used for shelter and food by organisms at a number of trophic levels. Intertidal marsh is generally defined as vegetated low-lying habitat for which the flooding characteristics are determined by the tidal movement of the adjacent water body.

In the Fraser River estuary, three types of intertidal marsh occur: salt, brackish, and tidal freshwater. Intertidal (salt) marsh is found in areas of predominantly marine influence, and is typically colonised by salt-tolerant emergent plants. It is the type that currently is present along the Roberts Bank causeway, and is therefore the type that is planned for the onsite offsetting concept.

The structure and function of intertidal (salt) marsh habitat is heavily influenced by hydrology, as well as salinity, substrate, and sediment supply (Roman and Burdick 2012). Intertidal marshes, also generally referred to as salt marshes, in the Fraser River estuary provide food and shelter for juvenile and adult invertebrates, fish, and birds (Adams and Whyte 1990, Williams et al. 2009). Intertidal (salt) marsh habitat at Roberts Bank typically includes species such as sedges (*Carex* spp.), saltgrass (*Distichlis spicata*), and succulents (*Sarcocornia virginica*, *Triglochin maritima*) (Williams et al. 2009). Approximately 12.3 ha of intertidal marsh would be directly lost due to Project construction (see **Section 11.6.3 Marine Vegetation, Potential Effect – Changes in Productivity**).

**Figure 17-A1** represents the food web for the Roberts Bank functional groups that will directly benefit (**Table 17-A1**) from the creation of intertidal (salt) marsh as predicted by the ecosystem model (see **Appendix 10-D Roberts Bank Spatial Ecosystem Model Sensitivity Analysis**). The habitat is intended for use by invertebrates, such as bivalves and macro and meiofauna, along with some of their predators (e.g., juvenile Chinook salmon, great blue heron, and American widgeon) that feed on some of these groups and will use the habitat as refuge. The ecosystem model predicts that the total or gross biomass gains range from 38.5 t/ha to 50.0 t/ha.

**Figure 17-A1 Onsite Intertidal (Salt) Marsh Food Web**



**Table 17-A1 Onsite Intertidal (Salt) Marsh Food Web**

<b>Directly Affected Functional Groups</b>	<b>Productivity (t/km<sup>2</sup>)<sup>1</sup></b>
American wigeon	0.218
Diving waterbirds	0.012
Dunlin	0.043
Great blue heron	0.008
Shorebirds	0.004
Waterfowl	5.636
Western sandpiper	0.007
Chum salmon (juvenile)	0.012
Chinook salmon (juvenile)	0.007
Salmon (juvenile)	0.001
Small demersal fish	0.013
Epifaunal grazers	0.254
Epifaunal omnivores	0.025
Macrofauna	66.009
Infaunal bivalves	7.440
Meiofauna	267.112
Polychaetes	278.389
Intertidal salt marsh vegetation	3,225.640
<b>Subtotal – directly affected functional groups</b>	<b>3,850.830</b>
Other	1,145.000
<b>Total for all functional groups</b>	<b>4,996.000</b>

<sup>1</sup> From **Appendix 10-D: Appendix D: Habitat Productivity Memo – Table D-6**; values are absolute biomass.

Between 2010 and 2013, effectiveness monitoring was conducted for intertidal (salt) marsh habitat constructed along the south side of the causeway<sup>1</sup> as compensation for the DP3 Project (Williams et al. 2014). Port Metro Vancouver constructed lagoon marshes at the shoreward end of the Roberts Bank causeway and open marsh benches in the mid-section of the causeway, and excavated upland and intertidal shoreline armouring to allow for natural colonisation of salt marsh plant species. Marsh vegetation has established on the open marsh benches, whereas the protected lagoon marshes and excavated mudflat have been less effective (G.L. Williams and Associates Ltd. 2013). The effectiveness monitoring concluded that the habitat is not fully functional, and the biological and physical processes have not yet stabilised due to exposure to a higher wind and wave energy environment than the habitat had been designed for. The wind and wave environment has been considered during the design of salt marsh habitats for RBT2.

<sup>1</sup> Note that the location is referred to as East Causeway (Williams et al. 2014).

Tidal marsh is a habitat-forming functional group. Review of existing and future physical and biological environments indicate that between 5 ha and 15 ha of intertidal (salt) marsh would be feasible in more quiescent areas along the widened causeway, such as within the bend of the northwest section of the existing terminals, and in an elbow of the proposed terminal (**Figure 17-1**). This area of salt marsh includes pioneering marsh that can be created along the existing mudflat on bars adjacent to the causeway and terminals, as shown in **Appendix 17-B: Drawing 17-B1**. This figure also shows the salt marsh's base elevation of +3.0 m CD rising to +5.0 m CD and typical native plantings. The backshore, above 5 m CD, will include wind- and salt-resistant shrub species.

### **Concept 2: Sandy Gravel Beach**

In the Pacific Northwest, sandy gravel beaches are an important spawning area for forage fish including surf smelt (*Hypomesus pretiosus*), Pacific herring (*Clupea pallasii*), and sand lance (*Ammodytes hexapterus*). Forage fish are small schooling types of fish that form important trophic links between marine zooplankton and larger predators including salmon, rockfish, marine mammals, and birds (Penttila 2007). Surf smelt and sand lance account for much of the forage fish biomass at Roberts Bank, making the development of sandy gravel beach integral to maintaining the ongoing productivity in the Project area. Construction of soft sediment beaches along the causeway and in association with the new terminal will provide habitat for forage fish spawning and is consistent with the predominance of soft substrates in the estuary.

Forage fish utilise exposed beaches between the tidal heights of +1.5 m CD to +4.8 m CD for spawning as follows:

- Surf smelt: spawn in coarse sand or pea-sized gravel (1 mm to 7 mm diameter) in the upper intertidal zone (Penttila 2007) between +2.2 m CD and +4.8 m CD.
- Sand lance: prefer sandy substrates between +1.5 m CD and +3.1 m CD at Roberts Bank.
- Pacific herring: use lower intertidal sites (below +1.0 m CD) within this habitat type for spawning. Cobble in the lower intertidal zone will provide attachment for marine algae to support herring spawning. It should be noted that forage fish surveys at Roberts Bank found little utilisation by spawning herring.

More information on forage fish is provided in **Section 13.5 Marine Fish, Existing Conditions**.

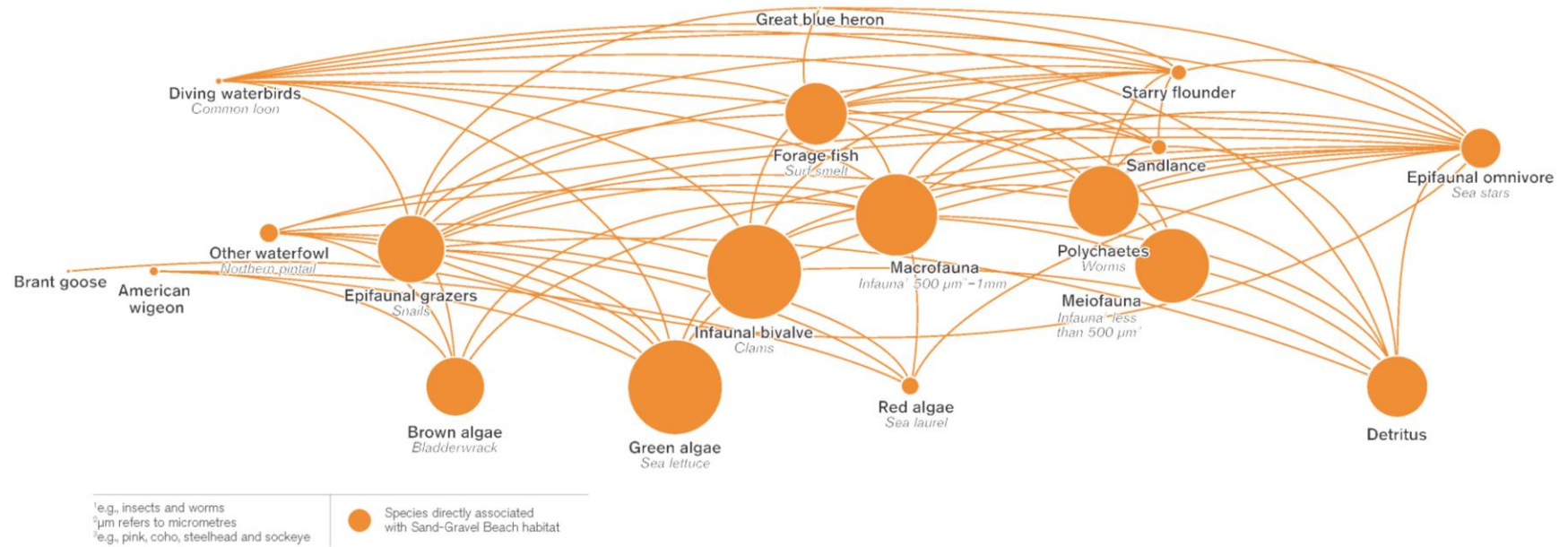
**Figure 17-A2** represents the food web for the Roberts Bank functional groups that will directly benefit (**Table 17-A2**) from the creation of sandy gravel beaches as onsite offsetting. The beaches are intended to provide attachment and substrate suitable for marine vegetation such as brown and green algae, and invertebrates, including bivalves, macrofauna, and polychaetes, and will also benefit some of their predators (e.g., forage fish, flatfish, and great blue heron). The ecosystem model predicts that the total or gross biomass gains range from 13.4 t/ha to 15.6 t/ha.

Effectiveness monitoring was conducted between 2010 and 2013 for sandy gravel beach habitat constructed along the south side of the causeway<sup>2</sup> as compensation for the DP3 Project (Williams et al. 2014). Port Metro Vancouver placed sand and gravel near the shoreward end of the Roberts Bank causeway to create spawning beaches for surf smelt and Pacific sand lance. Based on sediment grain size analysis, suitable substrate for Pacific sand lance and surf smelt spawn exists at several of the beach spawn and reference sites; however, spawning at Roberts Bank has not been confirmed (Thuringer et al. 2013a, b). The beach substrates have been transported higher on the beach and along the shore by wind and waves from storm events. This has resulted in a net transport of beach substrates toward the Delta dyke and creation of sand berms at the openings to the lagoon marshes, which in turn has limited the availability of functional sandy gravel beaches and delayed the formation of stable habitat. The wind and wave environment has been considered during concept development for sandy gravel beach habitats for RBT2 through use of the results of coastal geomorphology modelling. This modelling is described in **Section 9.5 Coastal Geomorphology**.

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<sup>2</sup> Note that this location is referred to as the East Causeway (Williams et al. 2014).

**Figure 17-A2 Onsite Sandy Gravel Beach Food Web**



**Table 17-A2 Onsite Sandy Gravel Beach Food Web**

<b>Directly Affected Functional Groups</b>	<b>Productivity (t/km<sup>2</sup>)<sup>1</sup></b>
American wigeon	0.142
Brant goose	0.031
Diving waterbirds	0.050
Great blue heron	0.021
Waterfowl	0.300
Flatfish	0.583
Forage fish	7.950
Herring	5.584
Sand lance	0.300
Starry flounder	0.595
Epifaunal grazer	41.250
Epifaunal omnivore	7.416
Infaunal bivalve	178.698
Macrofauna	124.836
Meiofauna	38.462
Polychaetes	39.522
Brown algae	519.260
Green algae	363.312
Red algae	15.841
<b>Subtotal – directly affected functional groups</b>	<b>1,344.153</b>
Other	216.000
<b>Total for all functional groups</b>	<b>1,560.000</b>

<sup>1</sup> From **Appendix 10-D: Appendix D: Habitat Productivity Memo – Table D-7**; values are absolute biomass.

Review of existing and future physical and biological environments indicate that between 4.5 ha and 10 ha of sandy gravel beach would be feasible in areas with higher wave energy along the widened causeway. Two sandy gravel spawning beaches consisting of sand, gravel, and cobble are proposed for the Project. Cross-sections for these concepts are shown in **Appendix 17-B**.

### **Concept 3: Mudflats**

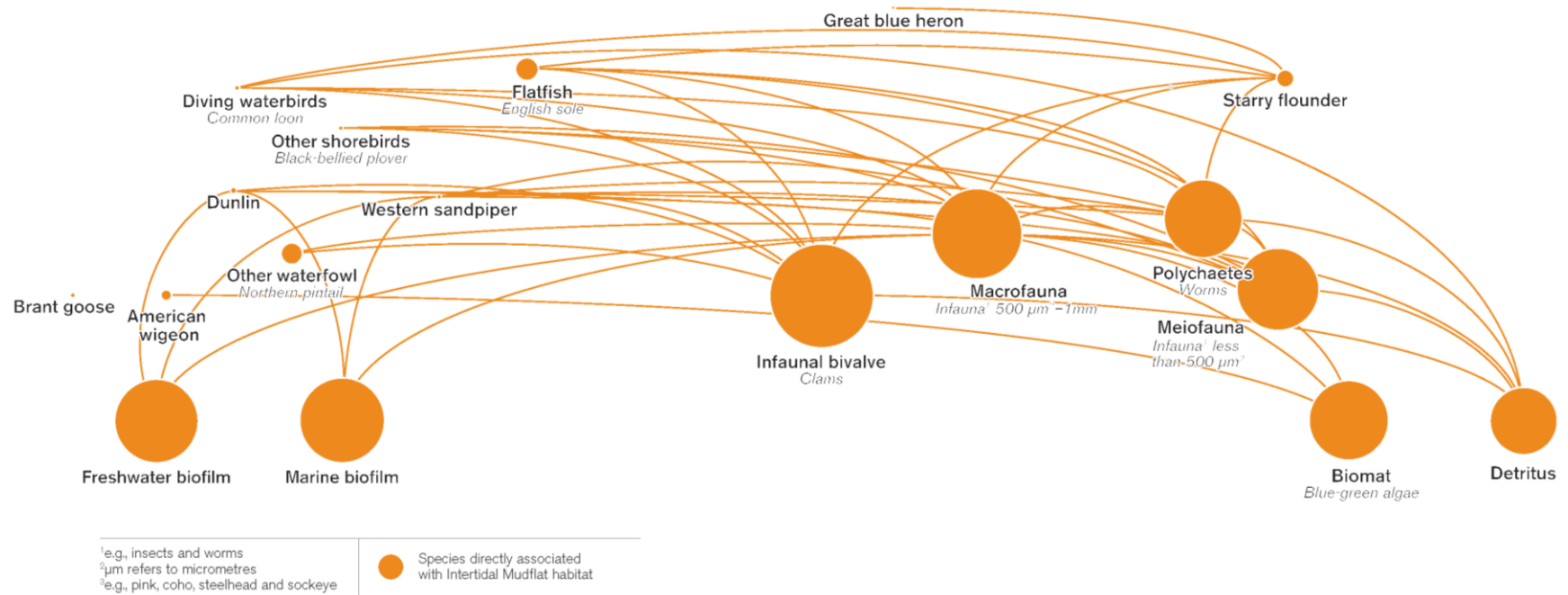
Deposits of mud, silt, and clay found in sheltered intertidal areas, mudflats play an important role in dissipating wave energy and support large numbers of birds and fish. At Roberts Bank, gently sloping tidal mudflats extend seaward from shore for a distance of up to 6 km. The width of the tidal flats is primarily governed by the vertical tidal range (approximately 5 m), the wave climate, and sediment characteristics.

Mudflats support biofilm, which is an important component of the benthic foodweb in estuarine and coastal ecosystems. As described in **Section 11.0 Marine Vegetation**, it is a thin (0.01 to 2 mm) yet dense layer of microphytobenthos, microbes, organic detritus, and sediment found on intertidal sediments.

Biofilm is an important primary producer, providing food for grazers, deposit feeders, and filter feeders (Cahoon 1999), and is the preferred diet of many invertebrate and fish species (Sullivan and Currin 2000). Within the Fraser River estuary, biofilm is an important food source for migratory shorebirds including the western sandpiper (*Calidris mauri*) (Elner et al. 2005, Kuwae et al. 2008, Coastal and Ocean Resources Inc. 2012). At Roberts Bank, biofilm presently occurs seaward of the tidal marshes and adjacent to the shoreward end of the causeway (see **Figure 11-6 Pre-2012 Map of Biofilm Distribution within the LAA**). Approximately 2.5 ha of intertidal mudflat with biofilm will be directly affected by the Project.

**Figure 17-A3** represents the food web for the Roberts Bank functional groups that will directly benefit (**Table 17-A3**) from the creation of intertidal mudflat as onsite offsetting. Invertebrates such as bivalves, macrofauna, and meiofauna, will benefit, along with some of their predators (e.g., diving waterbirds and dunlin). The ecosystem model predicts that the total or gross biomass gains range from 42.4 t/ha to 60.7 t/ha. Although habitat will be suitable for the species noted above, shorebirds such as Western sandpiper may not use it because the nearby terminal infrastructure provides cover and perches for raptors that are shorebird predators.

**Figure 17-A3 Onsite Mudflat Food Web**



**Table 17-A3 Onsite Mudflat Food Web**

<b>Directly Affected Functional Groups</b>	<b>Productivity (t/km<sup>2</sup>)<sup>1</sup></b>
American wigeon	0.332
Brant goose	0.009
Diving waterbirds	0.020
Dunlin	0.077
Great blue heron	0.015
Gulls and terns	0.089
Shorebirds	0.008
Waterfowl	2.153
Western sandpiper	0.013
Flatfish	0.091
Starry flounder	0.216
Infaunal bivalves	2.367
Macrofauna	98.639
Meiofauna	545.509
Polychaetes	462.097
Biofilm	3,127.889
<b>Subtotal – directly affected functional groups</b>	<b>4,239.524</b>
Other	1,833.000
<b>Total for all functional groups</b>	<b>6,073.000</b>

<sup>1</sup> From **Appendix 10-D: Appendix D: Habitat Productivity Memo – Table D-3**; values are absolute biomass.

As shown in **Figure 17-1** and **Figure 17-A2**, mudflat intended to be suitable for biofilm establishment is proposed for the zone seaward of the tidal marsh and in the lee of the pioneering salt marsh. Review of existing and future physical and biological environments indicate that up to 4.5 ha of mudflats would be feasible in more quiescent areas along the widened causeway, such as within the bend of the northwest section of the existing terminals, and in an elbow of the proposed terminal.

#### **Concept 4: Subtidal Rock Reef**

Artificial subtidal rock reef habitat promotes high productivity and was first successfully used for habitat compensation at Roberts Bank in 1983, which led to further rock reef placement in 1993 and 2005 for Deltaport Terminal projects. The crest of the existing reefs now range from -4.0 m CD to 0.0 m CD, with the deepest reefs supporting the highest fish densities (Archipelago 2014).

In B.C., lingcod (*Ophiodon elongatus*), copper rockfish (*Sebastes caurinus*), and kelp greenlings (*Hexagrammos decagrammus*) commonly colonise rocky reefs (including artificial reefs) at depths of 5.0 m to 10.0 m (Naito 2001). Since lingcod and rockfish populations in the southern Strait of Georgia have been severely depressed for several decades, Rockfish Conservation Areas have been established (DFO 2005, 2006). The new subtidal rock reef habitat will provide an additional source of recruitment for rockfish populations for the Strait of Georgia.

Subtidal rock reefs at Roberts Bank terminals provide a stable substrate for attachment of numerous large brown macroalgae, including bull kelp and sugar kelp (*Saccharina latissima*) (Archipelago 2014). These kelp beds provide:

- A direct food source for grazing invertebrates and large quantities of detritus to the foodweb;
- Shelter and food sources for lingcod, quillback (*Sebastes maliger*) and copper rockfish (*Sebastes caurinus*), shiner perch (*Cymatogaster aggregata*), Dungeness crab, and various sea stars (Archipelago 2014);
- Substrate for spawning fish species such as Pacific herring (*Clupea pallasii*); and
- Wave attenuation.

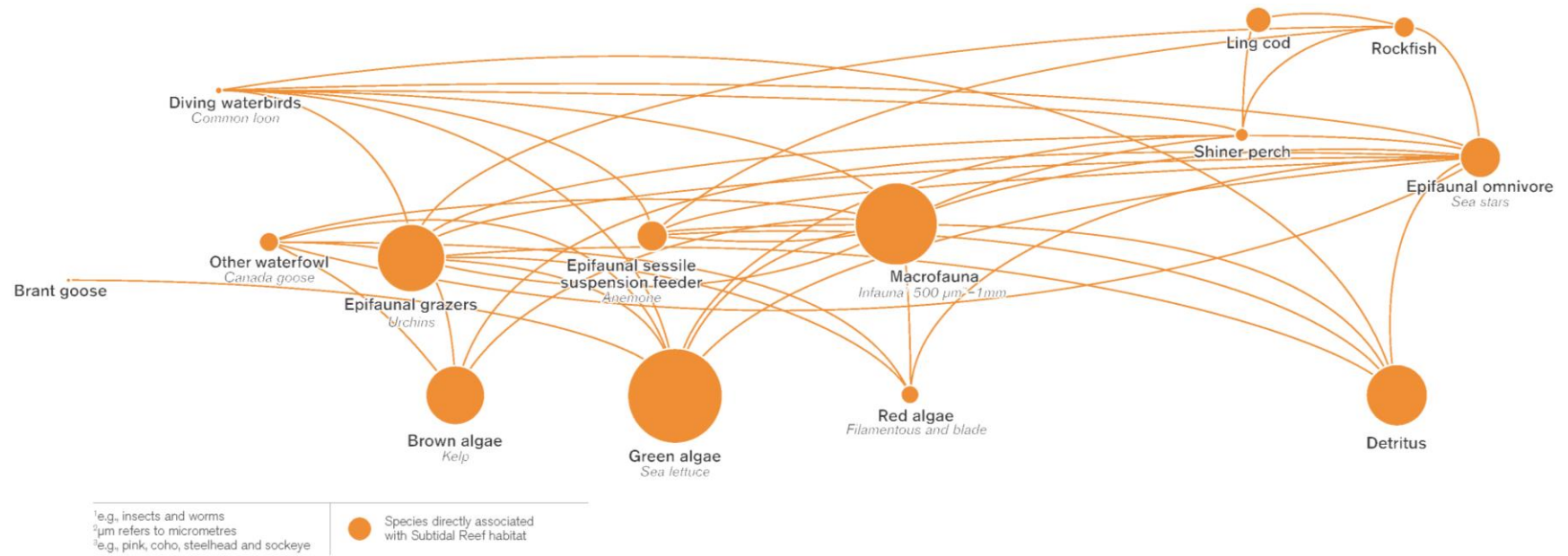
Additional information on rock reefs assessment at Roberts Bank is provided in **Section 13.5.2 Reef Fish**.

Effectiveness monitoring was conducted between 2009 and 2012 for reef habitat constructed as compensation for the DP3 Project and located south and west of the existing Deltaport Terminals (Fehr et al. 2010, 2012, Fehr 2012). When they were surveyed in 2009 and 2010, the oldest reference reefs contained a complex macro-algal community, and abundant and diverse fish communities, while the newly constructed expansion reefs were in the primary stages of colonisation and succession (Gartner Lee 1992, Golder 1996, Triton 2004, Archipelago 2009). Surveys in 2012 and 2013 indicated that the reefs are physically

stable and that the faunal community on the expansion reefs had reached a stable community composition, with fish species abundance and diversity on all artificial reefs comparable to typical rocky reefs in the Strait of Georgia (Archipelago 2014).

**Figure 17-A4** represents the food web for the Roberts Bank functional groups that will directly benefit (**Table 17-A4**) from the creation of subtidal rock reefs. Marine vegetation, such as brown, green, and red algae, will attach and grow on the rock reefs, providing refuge, feeding, and spawning habitat for invertebrates, fish, and birds. The ecosystem model predicts that the total or gross biomass gains range from 21.7 t/ha to 25.0 t/ha.

**Figure 17-A4 Onsite Subtidal Rock Reef Food Web**



**Table 17-A4 Onsite Subtidal Rock Reef Food Web**

<b>Directly Affected Functional Groups</b>	<b>Productivity (t/km<sup>2</sup>)<sup>1</sup></b>
Diving waterbirds	0.080
Herring	2.590
Large demersal fish	0.022
Small demersal fish	0.073
Lingcod	105.448
Rockfish	63.035
Shiner perch	0.019
Dungeness crab	15.378
Epifaunal grazers	49.317
Epifaunal omnivores	0.709
Epifaunal sessile suspension feeders	116.047
Macrofauna	9.690
Brown algae	1,753.383
Green algae	0.001
Red algae	68.192
<b>Subtotal – directly affected functional groups</b>	<b>2,183.984</b>
Other	316.000
<b>Total for all functional groups</b>	<b>2,500.000</b>

<sup>1</sup> From **Appendix 10-D: Appendix D: Habitat Productivity Memo – Table D-4**; values are absolute biomass.

The proposed design will create one new subtidal rock reef and enhance four of the existing reefs with small perpendicular arms, for up to 2 ha of new subtidal rock reef habitat (**Appendix 17-B: Drawing 17-B3**). The new reef is proposed near the east perimeter dyke of the new terminal, and adjacent to the existing reefs. To optimise productivity, the conceptual design of rock reef habitat considers the following:

- Waves, currents, and potential for scour/subsidence;
- Net productivity (relative value of reef productivity versus that of habitat being displaced); and
- Proximity to shorelines and passage for other species.

Detailed design of the subtidal rock reefs will consider the potential for subsidence and placement of the structure in relation to the terminal. Subsidence due to scour needs to be considered, typically through placement of a rock blanket (0.08 m to 0.15 m diameter) below the reef structure and extended several metres past the reef structure on the lee side of ebbing and flooding tides. Fish species associated with rocky reefs (such as lingcod, rockfish, and sculpin) prey on juvenile salmonids; therefore, proposed reefs will be placed along the terminal's east dyke or far enough away to allow a passage corridor; a distance estimated conservatively to be 50 m.

To optimise growth of green algae (for food) and brown algae (for structure) to support higher trophic levels, the conceptual design has been located in shallow subtidal areas so that the reef crest is in depths ranging from -5.0 m CD to 0.0 m CD. Reefs may extend through the intertidal to +2.0 m CD; however, due to the high-energy wave environment this is not recommended. Siting the reef crest at depths greater than -5.0 m CD at Roberts Bank would result in insufficient light through most of the algal growing season, due to the naturally high levels of turbidity.

Large angular rip-rap, 0.5 to 1.5 m diameter and randomly stacked, provides numerous crevices for fish and crab refugia and a large surface area for sessile organisms and kelp to attach. Further, large interstitial spaces allow water circulation through the reef to oxygenate adult fish and their egg masses (e.g., lingcod) during spawning season.

In summary, key structural design components that will influence the success of the proposed rocky reefs include the following:

- Elevation with relation to light exposure;
- Size and texture of substrate; and
- Reef complexity, including spacing between reefs, creation of void space, and topographic variability.

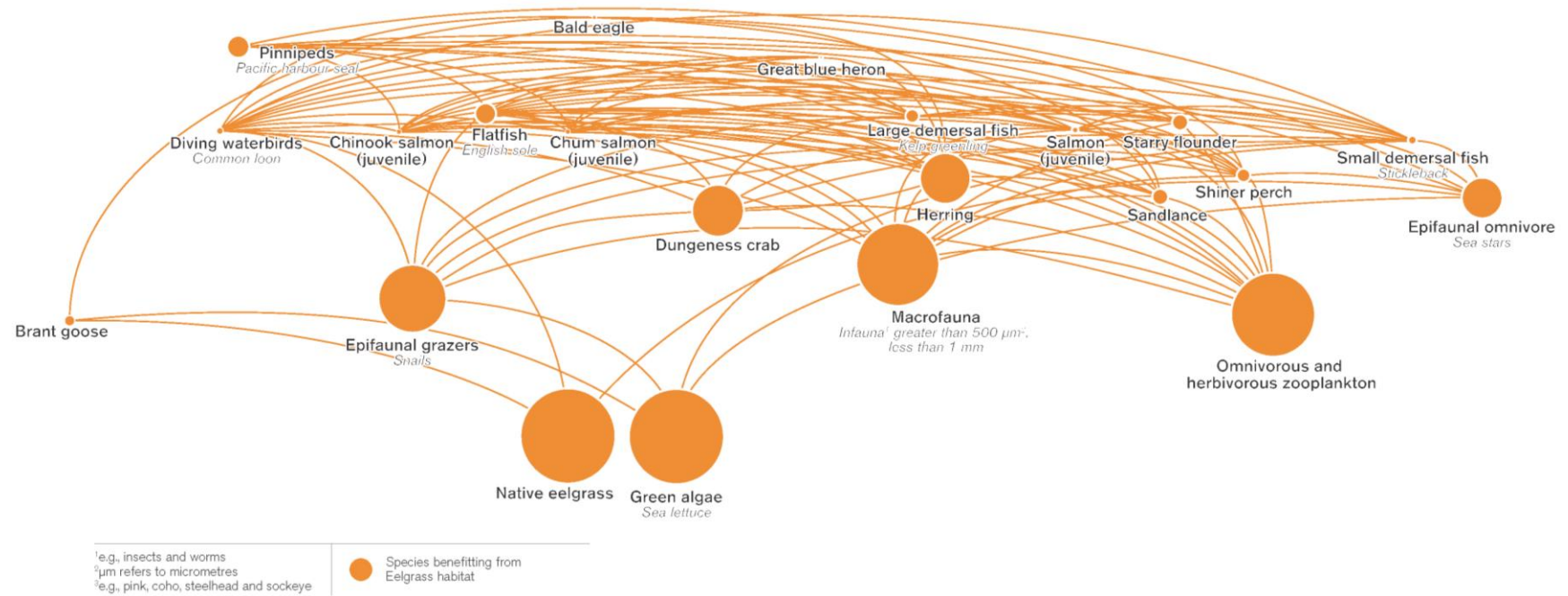
### ***Onsite Concept 5: Eelgrass Transplant***

An eelgrass transplant is proposed as an onsite offsetting concept. Eelgrass beds are highly productive habitats, serving numerous critical functions in estuarine communities such as:

- Providing direct and indirect food and shelter for invertebrates, fish, and birds;
- Acting as an important primary producer, and supporting the food web by providing detritus and encouraging epiphyte growth (e.g. diatoms and algae), that are grazed on by small invertebrates (Borum 1985);
- Providing spatially complex habitat that support many species (such as out-migrating juvenile Pacific salmon) and trophic levels, and promoting higher and different species' compositions than unstructured habitats like tidal flats (DFO 2009);
- Influencing sediment regimes and water flow interactions (e.g., eelgrass blades soften currents to allow sediment to settle out of the water column, while eelgrass root mass prevents erosion (Hasegawa et al. 2008, DFO 2009); and
- Positively influencing water quality by absorbing nutrients, mitigating effects of excessive nutrient inputs, and preventing algal blooms (Pellikaan and Nienhuis 1988, DFO 2009).

**Figure 17-A5** represents the food web for the Roberts Bank functional groups that will directly benefit from transplanting eelgrass to create eelgrass beds for onsite offsetting. As per **Table 17-A5**, the total (gross) biomass gain is approximately 8.0 t/ha. Invertebrates, such as bivalves, macrofauna, and meiofauna, will benefit along with some of their predators (e.g., juvenile Chinook salmon, diving waterbirds, gulls, and terns). Eelgrass indirectly also provides refuge and spawning habitat for many functional groups. In addition, eelgrass is a primary food source for Brant geese. At Roberts Bank, eelgrass also provides important juvenile crab rearing habitat in intertidal and shallow subtidal waters where they can seek refuge beneath or among plants. Juvenile crabs remain in lower intertidal or shallow subtidal waters and as they grow, tend to move into progressively deeper water. The ecosystem model predicts that the total, or gross biomass gains for an eelgrass transplant range from 4.8 t/ha to 8.0 t/ha.

**Figure 17-A5 Onsite Eelgrass Food Web**



Regional case studies have demonstrated that eelgrass transplants can meet or exceed the density of the donor bed within two to three years of transplanting (Precision Identification Biological Consultants 2002). An eelgrass transplant method developed in B.C. is considered to be greater than 90% effective (C. Durance, Precision Identification, personal communication, 2014).

Following terminal construction, there is an opportunity to transplant up to 3 ha of native eelgrass within the Roberts Bank study area. **Figure 17-1** shows the proposed onsite eelgrass transplant location. Potential donor areas include the eelgrass bed north of the existing terminal and areas south of the causeway within the inter-causeway area.

**Table 17-A5      Onsite Eelgrass Food Web**

<b>Directly Affected Functional Groups</b>	<b>Productivity (t/km<sup>2</sup>)<sup>1</sup></b>
American wigeon	0.085
Brant goose	0.099
Diving waterbirds	0.045
Great blue heron	0.020
Gulls and terns	0.040
Waterfowl	0.236
Chinook salmon (juvenile)	0.028
Chum salmon (juvenile)	0.027
Herring	8.579
Salmon (juvenile)	0.002
Shiner perch	0.281
Small demersal fish	0.261
Dungeness crab	12.492
Epifaunal grazers	42.614
Infaunal bivalves	169.517
Macrofauna	176.664
Meiofauna	2.006
Polychaetes	4.645
Native eelgrass	59.479
<b>Subtotal – directly affected functional groups</b>	<b>477.120</b>
Other	325.000
<b>Total for all functional groups</b>	<b>802.000</b>

1. From **Appendix 10-D: Appendix D: Habitat Productivity Memo – Table D-5**; values are absolute biomass

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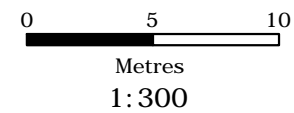
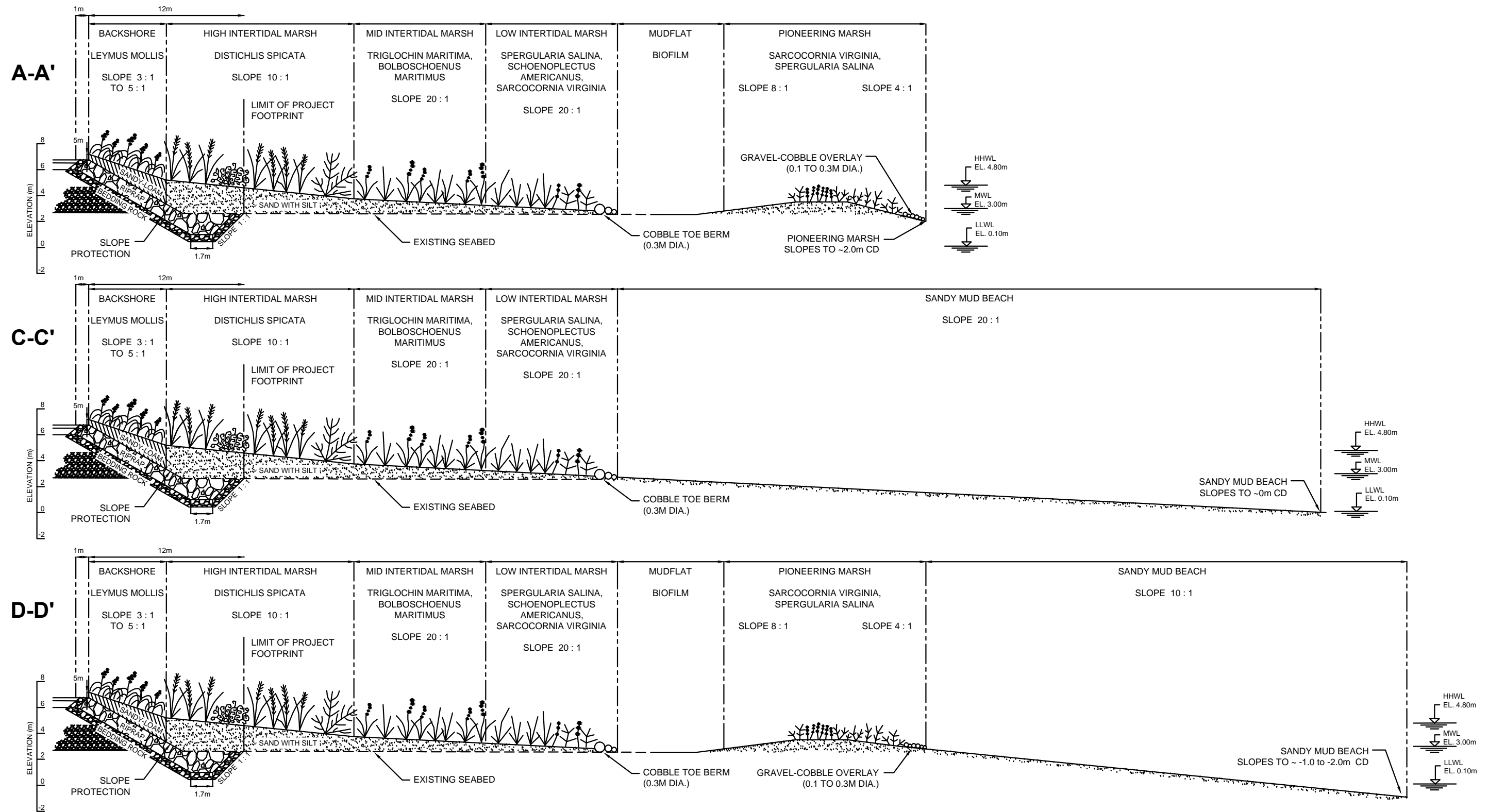
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**APPENDIX 17-B**  
**Habitat Concept Drawings**

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Notes:

- Scale is approximate and some drawing elements are not to scale
- Elevations in metres above chart datum



## ROBERTS BANK TERMINAL 2

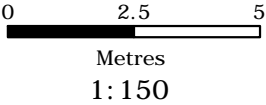
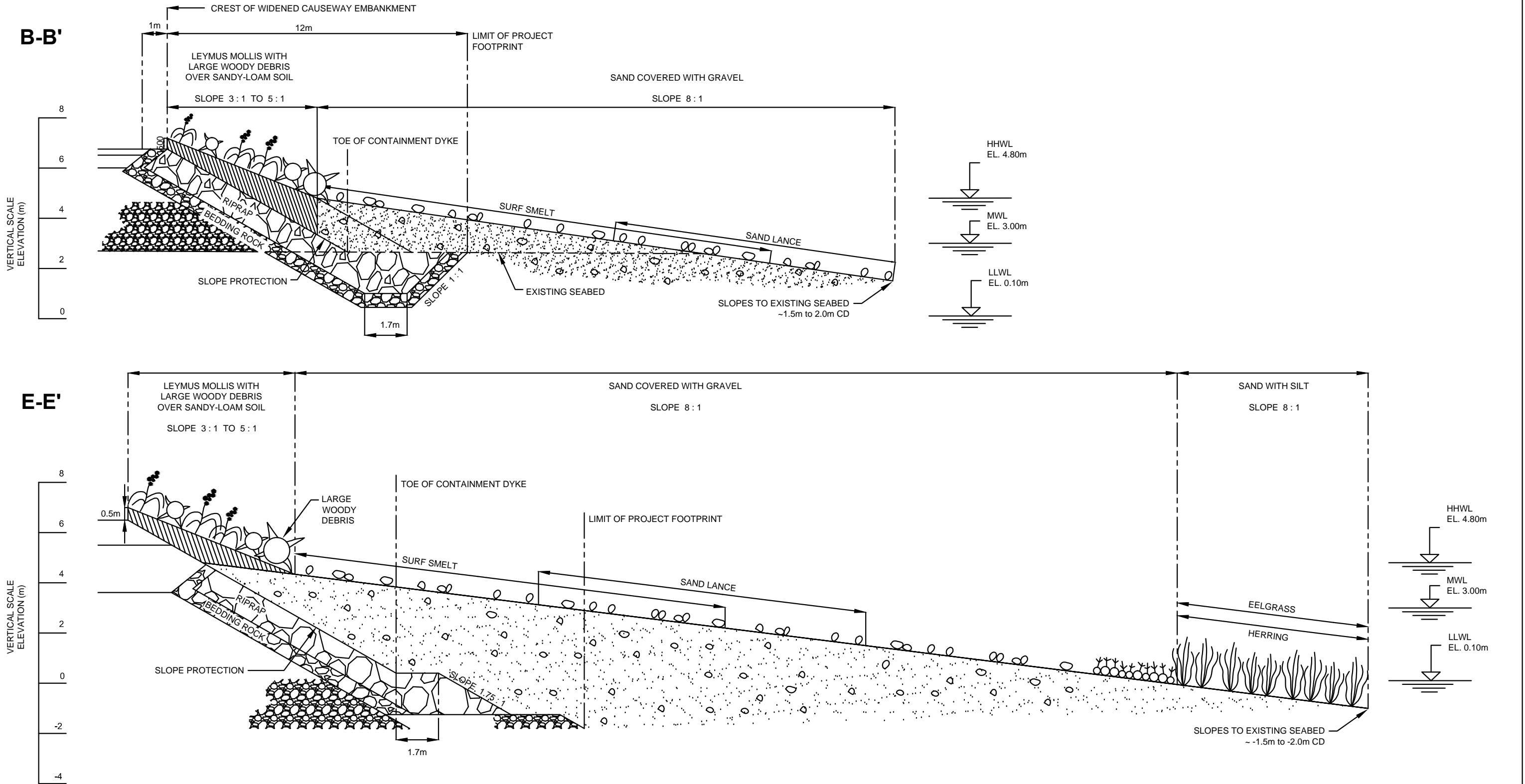
### ONSITE HABITAT CONCEPT, INTERTIDAL MARSH CROSS-SECTIONS

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17-B1

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Notes:

- Scale is approximate and some drawing elements are not to scale
- Elevations in metres above chart datum



ROBERTS BANK TERMINAL 2

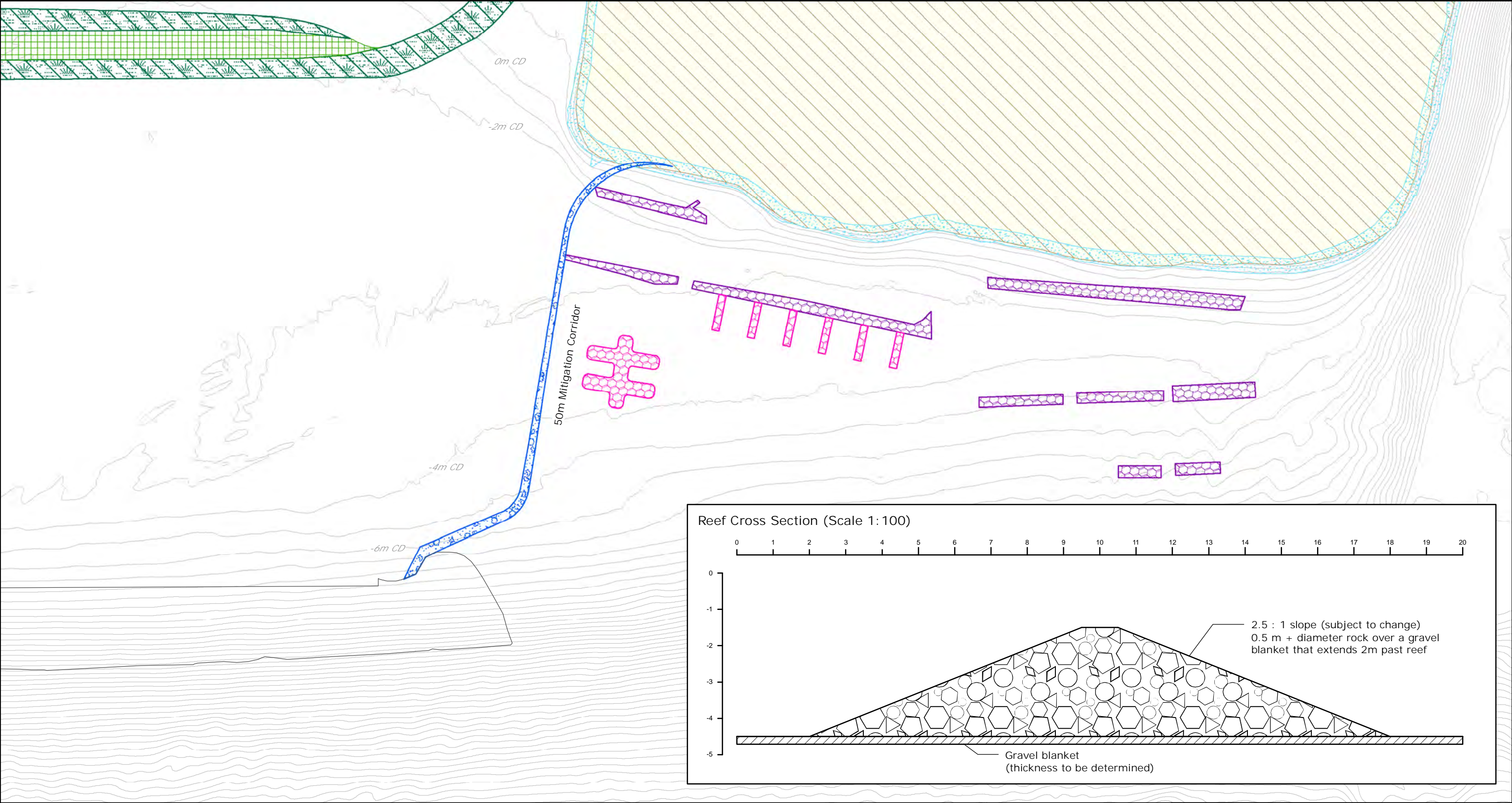
ONSITE HABITAT CONCEPT,  
SANDY GRAVEL BEACH CROSS-SECTIONS

DATE:









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17-B2

Path: O:\1200\1246\EIS\_FINAL\_FIGURES\Sec\_17\_0\_Conceptual\_Mitigation\_Strategy\mxd\17\_B3\_EIS\_MitigationStrategy\_OnsiteMitigation\_Concept\_SubtidalReef\_150204.mxd



Legend

- |   |   |
|---|---|
|  MUDFLAT            |  SUBTIDAL ROCK REEF          |
|  ROCKY SHORELINE    |  EXISTING SUBTIDAL ROCK REEF |
|  SANDY GRAVEL BEACH |  EXISTING RIP RAP            |
|  INTERTIDAL MARSH   |  EXISTING INFRASTRUCTURE     |

Notes:

- Scale is approximate and some drawing elements are not to scale
- Elevations in metres above chart datum

0 100 200  
Metres

1:5,000

NAD 1983 UTM Zone 10N



PORT METRO  
vancouver

ROBERTS BANK TERMINAL 2

ONSITE HABITAT CONCEPT,  
SUBTIDAL ROCK REEF

DATE:

02/04/2015

17-B3

**APPENDIX 17-C**  
**ONSITE OFFSETTING CONCEPTS –**  
**PRODUCTIVITY ASSESSMENT**

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**APPENDIX 17-C ONSITE OFFSETTING CONCEPTS - PRODUCTIVITY ASSESSMENT**

Port Metro Vancouver is planning an array of onsite offsetting concepts, to partially offset Project effects, which include intertidal marsh, sandy gravel beaches, mudflats, eelgrass transplants, and subtidal rock reefs (**Table 17-C1**). To quantify the net effect of the Project with the onsite offsetting concepts, the net gain in productivity from the onsite offsetting concepts (measured as biomass (t)) was estimated and then subtracted from the with-Project key run determined by an ecosystem model (presented in **Table 17-C2**).

**Table 17-C1 Proposed Areas for Onsite Habitat Offsetting Concepts**

Offsetting Concept	Area of Potential Habitat Constructed Onsite (ha)	Estimated Proportions of Underlying Habitat
Intertidal marsh	15	10% rock intertidal, 90% intertidal sandflat
Sandy gravel beach	4.5	10% rock intertidal, 90% intertidal sandflat
Eelgrass transplant	3	50% intertidal sandflat, 50% subtidal sandflat
Mudflat	4.5	100% intertidal sandflat
Subtidal rock reef	2	100% subtidal sandflat

To determine productivity of all functional groups associated with the onsite offsetting concepts, we used the following method:

$$\text{Productivity}_{(\text{net gain})} = \text{Productivity}_{(\text{onsite concepts})} - \text{Productivity}_{(\text{existing habitat})}$$

1.  $\text{Productivity}_{(\text{onsite concepts})}$ : Calculate the gross productivity for all functional groups associated with each onsite offsetting concept based on values determined by the ecosystem model described in **Appendix 10-D: Appendix D Habitat Productivity Memo**, and multiply by the area of potential habitat constructed onsite (**Table 17-C1**);
2.  $\text{Productivity}_{(\text{existing habitat})}$ : Calculate the gross productivity for all functional groups associated with habitats to be constructed over based on values determined by the ecosystem model (see Habitat Productivity memo) described in **Appendix 10-D** and multiply by the estimated area of the habitat; and,
3.  $\text{Productivity}_{(\text{net gain})}$ : Calculate the net gain in productivity for each onsite offsetting concept by subtracting the productivity of the existing underlying habitats ( $\text{Productivity}_{(\text{existing habitat})}$ ) from the predicted productivity of the proposed onsite offsetting concepts ( $\text{Productivity}_{(\text{onsite concepts})}$ ).

Note that rock intertidal (i.e., rip-rap that forms part of the Project's perimeter) could develop into productive habitat, but is unlikely to be productive at the time that the offsetting concepts would be constructed over it.

Results of the net change in biomass for each functional group are shown in **Table 17-C2**. The amount of each habitat type that can feasibly be constructed will be determined through further stages of design. The percent change in biomass can be used to compare the productive potential of onsite concepts to the with-Project key run.

**Table 17-C2 Change in Biomass for Functional Groups with the Project and with Proposed Onsite Offsetting**

Functional Groups	Biomass (t)			% Change in Biomass		
	Without Project	With Project	With Project & Onsite	With Project	With Project & Onsite	Difference with Onsite
American wigeon	4.765	4.365	4.359	-8.4	-8.5	-0.1
Bald eagle	0.120	0.112	0.113	-6.7	-6.2	+0.5
Brant	1.088	1.031	1.035	-5.2	-4.9	+0.4
Diving waterbirds	1.506	1.412	1.416	-6.2	-6.0	+0.2
Dunlin	0.471	0.531	0.542	+12.7	+15.1	+2.4
Great blue heron	0.671	0.669	0.671	-0.3	0.0	+0.3
Gull and terns	2.639	2.602	2.606	-1.4	-1.2	+0.2
Raptor	0.008	0.011	0.011	+37.5	+38.1	+0.6
Shorebirds	0.045	0.044	0.044	-2.2	-1.6	+0.6
Waterfowl	16.559	17.904	17.985	+8.1	+8.6	+0.5
Western sandpiper	0.058	0.066	0.068	+13.8	+16.8	+3.0
Chinook (adult)	187.099	177.595	177.447	-5.1	-5.2	-0.1
Chinook (juvenile)	0.655	0.759	0.763	+15.9	+16.5	+0.7
Chum (adult)	111.643	106.517	106.494	-4.6	-4.6	0.0
Chum (juvenile)	0.491	0.561	0.564	+14.3	+14.8	+0.6
Dogfish	35.953	35.142	35.124	-2.3	-2.3	-0.1
Flatfish	20.441	20.133	20.192	-1.5	-1.2	+0.3
Forage fish	573.086	564.989	565.333	-1.4	-1.4	+0.1
Herring	242.712	237.094	237.511	-2.3	-2.1	+0.2
Large demersal fish	8.386	8.285	8.321	-1.2	-0.8	+0.4
Lingcod	32.031	31.055	33.163	-3.1	+3.5	+6.6
Rockfish	18.475	16.844	18.105	-8.8	-2.0	+6.8
Salmon adult	55.454	53.173	53.188	-4.1	-4.1	0.0
Salmon juvenile	0.092	0.090	0.090	-2.2	-2.2	0.0
Sand lance	11.323	11.969	12.051	+5.7	+6.4	+0.7
Shiner perch	8.921	10.563	10.630	+18.4	+19.2	+0.8
Skate	12.584	11.565	11.575	-8.1	-8.0	+0.1

Functional Groups	Biomass (t)			% Change in Biomass		
	Without Project	With Project	With Project & Onsite	With Project	With Project & Onsite	Difference with Onsite
Small demersal fish	3.945	3.732	3.758	-5.4	-4.7	+0.7
Starry flounder	11.453	12.145	12.158	+6.0	+6.2	+0.1
Carnivorous zooplankton	1,623.743	1,449.794	1,451.469	-10.7	-10.6	+0.1
Dungeness crab	252.769	243.926	243.551	-3.5	-3.6	-0.1
Epifaunal grazer	835.674	769.722	772.843	-7.9	-7.5	+0.4
Epifaunal omnivore	105.284	102.864	103.295	-2.3	-1.9	+0.4
Epifaunal sessile suspension feeder	48.876	58.341	62.871	+19.4	+28.6	+9.3
Bivalves	6,590.176	6,071.293	6,050.637	-7.9	-8.2	-0.3
Jellyfish	599.746	550.586	551.085	-8.2	-8.1	+0.1
Macrofauna	2,743.430	3,476.688	3,511.405	+26.7	+28.0	+1.3
Meiofauna	1,588.644	1,763.839	1,783.814	+11.0	+12.3	+1.3
Omnivorous and herbivorous zooplankton	2,970.768	2,761.889	2,769.037	-7.0	-6.8	+0.2
Polychaetes	1,099.779	979.598	974.331	-10.9	-11.4	-0.5
Orange sea pen	7.692	3.463	3.467	-55.0	-54.9	+0.1
Shrimp	27.290	23.759	23.796	-12.9	-12.8	+0.1
Biofilm fresh	1,642.846	3,111.264	3,357.852	+89.4	+104.4	+15.0
Biofilm marine	1,819.684	1,399.847	1,398.601	-23.1	-23.1	-0.1
Brown algae (kelp / <i>Fucus</i> )	448.060	394.903	418.604	-11.9	-6.6	+5.3
Native eelgrass	304.576	316.065	317.835	+3.8	+4.4	+0.6
Green algae ( <i>Ulva</i> )	6,894.604	6,311.657	6,338.201	-8.5	-8.1	+0.4
Non-native eelgrass	6.855	6.807	6.917	-0.7	+0.9	+1.6
Red algae	15.168	13.596	15.176	-10.4	+0.1	+10.4
Phytoplankton	2,183.184	2,252.024	2,252.909	+3.2	+3.2	0.0
Intertidal marsh species	1,329.832	1,664.890	2,142.507	+25.2	+61.1	+35.9
Biomat	1,217.125	861.010	861.857	-29.3	-29.2	+0.1
<b>Net Gain / Loss (all functional groups)</b>		+200.30	+1,028.90			

	Increase in biomass with Project and onsite offsetting is greater than +5%
	Decrease in biomass with Project and onsite offsetting is greater than -5%