7 MARINE ECOLOGICAL IMPACT ASSESSMENT

7.1 Introduction

7.1.1 This Chapter presents the marine ecological baseline condition within and in the vicinity of Po Toi O through literature review and surveys. Potential construction and operational impacts on the marine ecology caused by this Project have been identified and evaluated. Mitigation measures have been proposed to minimize the potential impacts where necessary.

7.2 Relevant Legislations, Standards & Guidelines

7.2.1 Reference has been made to the Technical Memorandum on Environmental Impact Assessment Process of the Environmental Impact Assessment Ordinance (Cap. 499) (EIAO TM) for the criteria for evaluating ecological impacts, i.e.:

- Annex 8 stipulates the criteria for evaluating ecological impacts
- Annex 16 sets out the general approach and methodology for the assessment of ecological impacts arising from a project or proposal. It also defines Recognized Sites of Conservation Importance and Species of Conservation Importance.

7.2.2 The following EIAO guidance notes detail the temporal considerations in arranging surveys, survey methodology at different habitat types, data collection and requirements of impact assessment:

- GN 6/2010 “Some Observations on Ecological Assessment from the Environmental Impact Assessment Ordinance Perspective”
- GN 7/2010 “Ecological Baseline Survey for Ecological Assessment”
- GN 11/2010 “Methodologies for Marine Ecological Baseline Surveys”

7.2.3 Other Hong Kong ordinances and guidelines relevant to this study for reference include:

- Wild Animals Protection Ordinance (Cap. 170), which protects wild mammals, avifauna, reptiles, amphibians and insects under column 2 from hunting, possession, trading and disturbance;
- Marine Parks Ordinance (Cap. 476), which designates, controls and manages marine parks and marine reserves;
- Protection of Endangered Species of Animals and Plants Ordinance (Cap. 586), which regulates trading and possession of endangered species in response to Convention on the International Trade in Endangered Species of Wild Fauna

and Flora (CITES);

- Town Planning Ordinance (Cap. 131), which stipulates the planning use of an area. Land uses related to this chapter are coastal protection areas, sites of special scientific interest and other specified uses that promote conservation or protection of the environment;
- Hong Kong Planning Standard and Guidelines (Chapter 10), which provides principles of conservation, policies to identify and conserve natural landscape and habitats through legislation and administrative controls and planning.

7.2.4 This assessment made also reference to the following international conventions where appropriate:

- Convention on the International Trade in Endangered Species of Wild Fauna and Flora (CITES);
- IUCN Red List;
- United Nations Conventions on Biological Diversity (1992).

7.3 Study Area

7.3.1 The Study Area for marine ecological impact assessment shares the same Study Area as the water quality impact assessment (covering Po Toi O bay, Clearwater Bay and waters surrounding Steep Island), as shown in **Figure 5-3**.

7.3.2 No site of conservation importance as defined in Annex 16 of the EIAO-TM was identified.

7.4 Literature Review

7.4.1 Baseline ecological information had been obtained through collection and review of past findings from relevant studies/surveys regarding the ecological characters of the Study Area described in **Section 7.3.1**. Examples of published reference and other environmental studies carried out in vicinity of the Study Area include:

- AFCD Hong Kong Biodiversity Database
- AFCD Monitoring of Marine Mammals in Hong Kong Waters
- AFCD Newsletters
- Approved Clear Water Bay Peninsula South OZP S/SK-CWBS/2 from Town Planning Board
- Past EIA studies, e.g. Hong Kong Offshore Wind Farm in Southeastern Waters
- Porcupine! by the University of Hong Kong
- Other related field books

Coral communities

7.4.2 Coral communities are more abundant in the eastern part of Hong Kong for the calm and clear oceanic waters. According to the approved EIA Hong Kong Offshore Wind Farm in Southeastern Waters (BMT 2009), coral communities were recorded at Shek Mei Tau and Clear Water Bay near Po Toi O. The coastal region of Po Toi O is lined with rocky shore, which is favorable for coral growth.

Marine mammal

7.4.3 Finless Porpoise (*Neophocaena phocaenoides*) resides in southern and eastern waters of Hong Kong. Although no Finless Porpoise was found near Po Toi O, historical records show that the nearest record was made between Steep Island and Ninepin Group, which is about 4 km away from Po Toi O (BMT 2009). The latest marine mammal study (i.e. from April 2013 – March 2014) conducted by Hung (2014) also pointed out that Finless Porpoise was found near Ninepin Group.

Amphioxus

7.4.4 Although no study has recorded amphioxus *Branchiostoma belcheri* (a species of conservation importance) near Po Toi O, the nearest record was made around Ninepin Group (BMT 2009).

7.5 Evaluation of Past Information & Identification of Data Gap

7.5.1 Information collected from literature review was evaluated to identify any data gap. Since the literature was only able to provide limited baseline ecological information, detailed ecological surveys were required to obtain a comprehensive and updated baseline ecological condition of the Study Area described in **Section 7.3.1**.

7.6 Methodology for Intertidal Survey

7.6.1 Intertidal surveys were conducted in accordance with the Environmental Impact Assessment Ordinance, Cap.499, GN 11/2010 Methodologies for Marine Ecological Baseline Surveys.

7.6.2 Intertidal surveys had been carried out near shores and vertical seawall that are likely to be affected by this Project. A walkthrough survey was carried out along the shoreline to identify habitat types. Representative sites of each habitat were selected for detailed study by carrying out transect surveys where possible. Observation was conducted on vertical seawall as transect cannot be laid. Transect surveys on rocky shore, sandy shore and mudflat had been carried out during low tide (maximum lowest tide at 0.7 m) when the shore is more exposed. 2 transects on rocky shore (R1 & R2),

1 transect on sandy shore (S1) and 1 transect on mudflat (M1) were surveyed. Locations of transect surveyed are presented in **Figure 7-1**.

7.6.3 Transects were laid perpendicular to shore line, starting from high water mark to low water mark. Along each transect, standard ecological sampling quadrats (0.5 m x 0.5 m) were laid at regular intervals (1 m for rocky shore and sandy shore, 2 m for mudflat). Intertidal epifauna and flora within each quadrat were identified. Mobile organisms including snails and limpets were counted in terms of abundance, while sessile organisms including macroalgae and lichens were estimated in terms of percentage coverage per quadrat.

7.6.4 Crevices were searched for hiding fauna on rocky shore. On sandy shore and mudflat, the surface 5 cm sediment was sieved (1 mm mash size) to search for hiding fauna. A core with 10 cm diameter and 20 cm depth was also collected in each quadrat, and was sieved (1 mm mash size) to search for benthos.

7.6.5 All intertidal organisms were identified to species level as far as possible.

7.6.6 Opportunistic observations of any intertidal organisms outside systematic surveys were also recorded.

7.6.7 Exact dates and the weather condition of each systematic survey day are shown in **Table 7-1**.

Table 7-1: Weather Condition during Each Intertidal Survey

Survey	Habitat	Date	Weather condition
Line transect R1	Rocky Shore	02/03/2014	Drizzle with wind Lowest tide: 0.7 m
Line transect R2	Rocky Shore	30/05/2014	Sunny Lowest tide: 0.4 m
Line transect M1	Mudflat	27/08/2014	Cloudy & Windy Lowest tide: 0.7 m
Line transect S1	Sandy Shore	08/09/2014	Partly cloudy Lowest tide: 0.6 m
Observation	Vertical Seawall	08/09/2014	Partly cloudy Lowest tide: 0.6 m

7.7 Methodology for Fish Survey

7.7.1 Fish surveys were conducted from April to June 2014 and April 2015. Active swimming fishes in marine water were counted by direct sighting (and by the aid with a pair of 8x binoculars if necessary) along the shore of Po Toi O bay.

7.8 Methodology for Benthic Survey (REA)

7.8.1 The benthic Rapid Ecological Assessment (REA) survey was conducted in accordance with the Environmental Impact Assessment Ordinance, Cap.499, GN 11/2010 Methodologies for Marine Ecological Baseline Surveys.

Field data collection

7.8.2 Assessment of substrate and ecological attributes had been conducted using a semi-quantitative REA method. All field data had been collected by marine ecologists using SCUBA (self-contained underwater breathing apparatus) dive. Surveys were conducted on 1st, 2nd, 8th & 9th March 2014.

7.8.3 In order to assess the substrate type and the taxonomic composition, surveys had been conducted at eleven subtidal sites (T1 to T11), which were selected because they are either near the proposed dredging site or near the alignment of the submarine outfall (**Figure 7-2**).

7.8.4 At each selected subtidal site, REA survey had been performed along a 50 m transect laid according to the contour of seabed at each subtidal site. Substrate type along the transect was recorded at 1 m intervals. The benthic cover, taxon abundance, and ecological attributes along the transect were recorded in a swathe of 2 m wide, 1 m either side of the transect.

7.8.5 Location, size and health status (including percentage cover of bleaching, mortality and sedimentation) of any corals and associated substrates found were recorded. Feasibility of translocation was also assessed.

7.8.6 Locations of the REA transects had been recorded on site by an handheld GPS unit. Pictures of representative taxa along the transects were taken during surveys.

Assessment Methodology

7.8.7 Assessment tables following the TM-EIAO guidance had been completed in order to assess ecological value for each subtidal site. Two types of information were recorded:

(1) Cover of the major benthic groups;

(2) Inventory of sessile benthic taxa.

These had been performed according to Tier I and Tier II levels of information.

7.8.8 Tier I: Categorization of ecological (benthic cover) and environmental variables.

- To describe the benthic cover, six substrates and seven ecological attributes (**Table 7-2a**) were assigned. Each attribute was ranked from 0 to 6 (**Table 7-2b**) based on the overall cover along the survey area.

7.8.9 Tier II: Taxonomic inventories to define types of benthic communities.

- An inventory of benthic taxa was compiled during each swim. Taxa were identified either in situ or with the aid of photos to confirm identification afterward.
- **Hard corals** (Order Scleractinia) – to genus and species level where possible;
- **Soft corals** (Subclass Octocorallia) – to genus level where possible;
- **Other benthos** (such as sponges zoanthids, bryozoans, macroalgae etc) – to genus level where possible or phylum with growth form;
- Each taxon in the inventory was ranked (from 0 to 5) on the basis of its abundance in the community at the subtidal site (**Table 7-2c**). These broad categories ranked the taxa in terms of the relative abundance of individuals, rather than the contribution to benthic cover, at each subtidal site.

Table 7-2: Categories of (a) Benthic Attributes, (b) Ordinal Ranks of Percentage Cover, and (c) Ordinal Ranks of Taxa Abundance of Substrate

a) Benthic attributes		b) Percentage Cover		c) Taxon abundance	
Substrate	**Ecological**	**Rank**	**Percentage Cover**	**Rank**	**Abundance**
Bedrock	Hard Corals	0	Not recorded	0	Absent
Boulders (diameter >50cm)	Dead Coral Skeleton	1	1-5%	1	Sparse
Cobbles (diameter < 50cm)	Soft Corals	2	6-10%	2	Uncommon
Rubble (dead corals)	Sea anemone beds	3	11-30%	3	Common
Sand with gravel	Encrusting Algae	4	31-50%	4	Abundant
Mud & Silt	Coralline Algae	5	51-75%	5	Dominant
	Erect Macroalgae	6	76-100%		

7.9 Methodology for Benthic Survey (Grab Sampling)

7.9.1 The benthic grab sampling survey was conducted in accordance with the Environmental Impact Assessment Ordinance, Cap. 499, GN 11/2010 Methodologies for Marine Ecological Baseline Surveys.

Sampling

7.9.2 Benthic surveys using grab sampling had been carried out on 24th July 2014 and on 6th October 2014 at seven stations (three stations B1 – B3 on 24th July 2014, four stations A1 – A4 on 6th October 2014, see **Figure 7-1**). Station B2 was the proposed location of the diffuser in Option 2 (see **Table 2-2** & **Figure 2-2** in **Chapter 2 – Project Descriptions**), while stations B1 and B3 were 150 m south and 150 m north from station B2 respectively. Nevertheless, since a species of conservation importance (Amphioxus *Branchiostoma belcheri*) was recorded in station B2, additional stations (stations A1 – A4) were sampled for investigating an alternative diffuser location (see Option 3 in **Table 2-2** & **Figure 2-2** in **Chapter 2 – Project Descriptions**) to mitigate impacts on *B. belcheri*.

7.9.3 3 samples were collected at each station (i.e. three replicates for each station). A hand held differential Global Positioning System (GPS) was used to ensure the correct sampling location.

7.9.4 For each sample, about 0.1 m^2 sediment was sampled by a modified Van Veen grab sampler (dimensions 0.3 m x 0.32 m x 0.16 m).

7.9.5 The sampler was lowered slowly through the water column, preventing any disturbance to the seabed. After sampled from the seabed, the sampler was raised, carefully retrieved and examined to determine acceptability of the sample. A sample was accepted only if it has minimal disturbance and adequate penetration depth.

7.9.6 The sample was then transferred into a large plastic bucket. Subsequently, the sample was mixed gently with seawater to suspend fine silt/clay and release benthic organisms. The sample was then washed through a sieve table, which comprised 1 mm and 500µm meshes. Sample was rinsed carefully with seawater to remove as much mud as possible. Materials left on screens were washed into large, labelled zip-lock bags. Excess seawater was drained from the bag. Then, 4% buffered formalin solution mixed with rose bengal stain was added to the sample. The formalin solution was used to fix and preserve sample while the rose bengal stain was used to stain organic tissue which aids sample sorting in the laboratory. The bag was placed inside another labelled zip-lock bag, and placed upright into robust

plastic containers before sending to the laboratory.

7.9.7 The sampler and all other utensils were rinsed with seawater after each sample had been collected to avoid cross contamination between samples.

Sample Sorting

7.9.8 Benthic samples were soaked in the fixing solution for a minimum 24 hours to ensure adequate fixation. Samples were then washed through a 500µm sieve with fresh water in order to remove the formalin. After re-sieving, benthic organisms, which were stained pink, were picked out and placed into a labelled wide mouth plastic jar, which contained 70% ethanol for preservation. Initial sorting of material was undertaken by eyes, while assisted by hand held lens and dissecting microscope.

7.9.9 After rinsing with clean alcohol, small amount of aliquots of the sample was placed in glass dishes. All organisms found, including anterior fragments of polychaetes, were removed from sample, and sorted to major taxonomic categories such as polychaetes, arthropods, and mollusks by the aid with a dissecting microscope.

7.9.10 Organisms were then identified to the lowest practicable level by the aid with dissecting microscope, published keys and reference materials (e.g. Day (1967); Fauchald (1977); Arnold and Birtles (1989), Lim (2000), Shin (1996), Chan (2000), Ma (undated)). In case of many benthic organisms, particularly the polychaetes, family level was often the lowest practicable level due to the sample condition. Where possible, specimens were identified down to genus or species level.

7.9.11 After identification, abundance of each taxa was counted and recorded. For specimens that had become fragmented, only the anterior end of the organism was counted.

7.9.12 After identification and counting, specimens were transferred to vials and preserved with 70% ethanol. Station number, replicate number and taxonomic category were labelled on each vial.

Data Analysis

7.9.13 Collected benthic sediment samples were analyzed for the following parameters for each of the sampling location:

- Faunal abundance; &
- Species composition.

7.9.14 Raw abundance data were calculated for each species. Abundance summaries of the combined dataset are given for:

- percent contribution of each taxonomy to the overall dataset; and
- percent contribution of each taxonomy to the station dataset.

7.10 Results of Intertidal Survey

7.10.1 Four habitats – rocky shore, mudflat, sandy shore, and vertical seawall – were identified in Po Toi O. Rocky shore dominated headlands, mudflat distributed in the bay, sandy shore was found between rocky shore and mudflat, and vertical seawalls were found on pier and jetty besides human settlement. Representative photos of habitats are presented in **Appendix 7.1**.

7.10.2 In general, taxa recorded outside systematic survey (e.g. birds *Egretta* spp.) have a higher mobility than taxa recorded in systematic survey (e.g. snails *Cerithidea* spp.). A detail list with the taxa recorded in these habitats is presented in **Appendix 7.2**.

Vertical Seawall

7.10.3 On vertical seawall, 13 taxa were recorded in total. In terms of the taxa composition, no distinct pattern was found. Nevertheless, taxa found in the high tidal zone had a lower density and a smaller body size (or coverage for algae) than those occupied the low tidal zone. Commonly found species included *Acanthopleura japonica* (Chiton) and *Saccostrea cucullata* (Rock Oyster).

7.10.4 No species of conservation importance was recorded on vertical seawall.

7.10.5 No breeding behaviour, egg, or immature individual was recorded on vertical seawall.

Rocky Shore

7.10.6 On rocky shore, 37 taxa were recorded in total. 32 of them were recorded during systematic surveys (12 taxa in R1 and 26 taxa in R2), while 5 extra taxa were recorded in walk-through survey. The most abundant taxon found in systematic surveys R1 and R2 were *Cellana toreuma* (Limpet) and *Monodonta labio* (Toothed top shell) respectively.

7.10.7 Zonation can be found from the high tidal zone to the low tidal zone. Some taxa (e.g. *Echinolittorina* spp.) were only recorded in high tidal zone, while some taxa (e.g. *Cellana* spp., *Clibanarius* sp. & *Petrolishthes japonicus*) were only found from mid to low tidal zones. Nevertheless, some taxa (e.g. *Ligia exotica* & *Monodonta labio*) were recorded from high to low tidal zones.

7.10.8 4 species with conservation statuses were recorded in rocky shore. All of them (Eastern Cattle Egret *Bubulcus coromandus*, Little Egret *Egretta garzetta*, Blue Rock-thrush *Monticola solitarius* & White Wagtail *Motacilla alba*) were avifauna species and were recorded outside systematic surveys. Nevertheless, although all wild birds in Hong Kong are protected under the Wild Animals Protection Ordinance (Cap. 170) (AFCD 2014), only Eastern Cattle Egret and Little Egret which have conservation status other than Cap. 170 are considered having conservation importance. Their conservation statuses are presented in **Table 7-3**.

Table 7-3: Conservation Statuses of Taxa with Conservation Importance Recorded on Rocky Shore (AFCD 2014)

Common Name (Species Name)	Conservation Status
Eastern Cattle Egret (*Bubulcus coromandus*)	1. Listed as "Local Concern" by Fellowes et al. (2002)
Little Egret (*Egretta garzetta*)	1. Listed as "Regional Concern" by Fellowes et al. (2002)
* All wild birds are protected under the Wild Animals Protection Ordinance (Cap. 170)	

7.10.9 No breeding behaviour, egg, or immature individual was recorded on rocky shore.

Sandy shore

7.10.10 On sandy shore, 4 taxa were recorded in total. All of them were recorded during systematic survey. The recorded taxa comprised 3 sessile taxa (Chlorophyta, Cyanobacteria & Rhodophyta) and 1 mobile taxon (*Ligia exotica*). All sessile taxa were having a low coverage (from 2.5% to 15% coverage), as they were only found on rocks scattered on the shore. Only 1 mobile taxon (*Ligia exotica*) with low abundance was recorded.

7.10.11 No species of conservation importance was recorded on sandy shore.

7.10.12 No breeding behaviour, egg, or immature individual was recorded on sandy shore.

Mudflat

7.10.13 On mudflat, 25 taxa were recorded in total. 17 of them were recorded during systematic survey, while 8 extra taxa were recorded in walk-through survey. No flora taxon (e.g. algae) was recorded in both systematic and walk-through surveys. The most abundant taxon found in systematic survey was *Saccostrea cucullata*, which attached on scattered rocks throughout the intertidal zone.

7.10.14 Similar to rocky shore, a different taxa composition can be found from the high tidal zone to the low tidal zone. Some taxa (e.g. *Grafrarium* sp. & *Batillaria* spp.) were recorded from high to low tidal zones, while some taxa (e.g. *Anomalocardia flexuosa* & *Cerithidea* spp.) were only found in low tidal zone.

7.10.15 3 species of conservation importance were recorded on mudflat. All 3 species (Little Egret *Egretta garzetta*, Intermediate Egret *E. intermedia* & Black-crowned Night Heron *Nycticorax nycticorax*) were avifauna species and were recorded outside systematic survey. Their conservation statuses are presented in **Table 7-4**.

Table 7-4: Conservation Statuses of Taxa with Conservation Importance Recorded on Mudflat (AFCD 2014)

Common Name (Species Name)	Conservation Status
Little Egret (*Egretta garzetta*)	1. Listed as "Regional Concern" by Fellowes et al. (2002)
Intermediate Egret (*E. intermedia*)	1. Listed as "Regional Concern" by Fellowes et al. (2002)
Black-crowned Night Heron (*Nycticorax nycticorax*)	1. Listed as "Local Concern" by Fellowes et al. (2002)
* All wild birds are protected under the Wild Animals Protection Ordinance (Cap. 170)	

7.10.16 Patches of eggs were found in high and mid tidal zones during systematic survey. Immature individuals of Black-crowned Night Heron *Nycticorax nycticorax* were also recorded in walk-through survey. These suggested that mudflat is a spawning and a nursery ground.

7.11 Results of Fish Survey

7.11.1 11 fish species were recorded in the Study Area described in **Section 7.3.1**. Except 3 species – Stripey (*Microcanthus strigatus*), Chinese demoiselle (*Neopomacentrus bankieri*) & Toothed blenny (*Petroscirtes breviceps*) – have no rarity information in Hong Kong, all of the species recorded are common in Hong Kong (AFCD 2014). Except the Grass puffer (*Takifugu niphobles*) is listed as "Data Deficient" by the IUCN Red List, no fish species recorded has conservation status. However, the Grass puffer is one of the commonest puffer fish in Hong Kong (Shao et. al. 2014).

7.11.2 Most fishes recorded, including Yellowfin seabream (*Acanthopagrus latus*), Mangrove snapper (*Lutjanus argentimaculatus*) & Grey mullet (*Mugil cephalus*), were immature individuals. This suggested that Po Toi O Bay is a nursery ground of

fish.

7.11.3 A detailed list of the species recorded in fish survey is presented in **Appendix 7.3**.

7.12 Results of Benthic Survey (REA)

7.12.1 Two substrate types – hard substrate and soft substrate – were identified. Hard substrate including bedrock, boulders and rubbles were found in shallow water (i.e. about 2.5 m below Chart Datum), while soft substrate such as coarse sand and fine sand dominated deeper water (i.e. deeper than 3.0 m below Chart Datum).

7.12.2 Hard substrates were dominated by sessile plants (e.g. erect macroalgae, encrusting algae and coralline algae) and suspension feeding sessile animals (e.g. barnacles and tube worms). Corals communities were also found on hard substrates but only with a low percentage cover.

7.12.3 A total of 69 hard coral colonies were found along all 7 transects (T1-T7) on hard (i.e. rocky) substrates (see **Figure 7-2**). Although coral colonies were small to medium in size (i.e. ranged from 100 to 4800 cm^2), colonies were generally in good and healthy condition with low levels of sedimentation, bleaching and partial mortality. Most of them were associated with rubbles and boulders.

7.12.4 No coral was found on soft substrates (transects T8-T11).

7.12.5 The species diversity of coral recorded was considered as low to moderate. In total, 19 hard coral species of 6 families including *Favites pentagona* (Family: Faviidae) and *Goniopora columna* (Poritidae) were recorded. All species have been recorded in Hong Kong waters.

7.12.6 No soft coral and no other sessile taxon of conservation importance was recorded.

7.12.7 Detail results are presented in a detailed coral survey report, which is attached in **Appendix 7.4**.

7.13 Results of Benthic Survey (Grab Sampling)

7.13.1 Samples in all 7 stations showed different substrate types: rocks with sand in A1, coarse sand in B1, fine sand in B2 & A3, and mud in B3, A2 & A4.

7.13.2 In total, 535 individuals which comprised of 35 taxa were recorded in the benthic survey by grab sampling. Station B1 had the highest population (274 individuals, consisted of 12 taxa), while station B3 had the highest diversity (18 taxa, 48 individuals in total). Nevertheless, due to the specimens' conditions, some specimens were not able to be identified to species level. Specimens were identified down to the

lowest level (e.g. family level) as possible. A detailed list with the taxa recorded in each station is presented in **Appendix 7.5**.

7.13.3 The species (taxa) composition varied from habitat to habitat. In terms of population, Syllidae and *Branchiostoma belcheri* dominated the seabed with coarse sand (i.e. station B1) and fine sand (i.e. stations B2 & A3) respectively, while the muddy seabed (i.e. stations B3, A2 & A4) and seabed with rocks and sand (i.e. station A1) were not dominated by any single taxon.

7.13.4 Amphioxus *Branchiostoma belcheri*, a taxon of conservation importance, was found in stations B1, B2 and A3 which had either coarse or fine sand seabed. No *B. belcheri* was recorded in stations with rocky and muddy seabeds (i.e. station A1 and stations B3, A2 & A4 respectively). All recorded *B. belcheri* were about 25 – 35 mm in length, which suggested that all individuals were in one to two years old (Chen 2007). In addition, since gonads (i.e. reproductive organ) were found in some *B. belcheri*, recorded individuals were in reproductive stage.

7.13.5 The density of *B. belcheri* individuals varied from stations to stations. Station B2 (average 236.7 ind/m^2) had the highest density, following by A3 (average 33.3 ind/m^2), and B1 (average 13.3 ind/m^2) had the lowest. As a significant amphioxus population has a density higher than 100 ind/m^2 (Chen 2007), station B2 (i.e. fine sand seabed) is considered as a major amphioxus habitat.

7.13.6 Berried females of *Typhlocarcinops denticarpes* were recorded in station A4 (i.e. muddy seabed), which suggested that the muddy seabed is a breeding ground of *T. denticarpes*.

7.14 Evaluation of Habitat

7.14.1 The ecological value of the habitats have been evaluated in accordance with EIAO-TM Annex 8 Table 2.

Table 7-5: Ecological Value of Intertidal Zones within 500 m from the Project

Criteria	Rocky Shore	Sandy Shore	Mudflat	Vertical Seawall
Naturalness	Natural	Natural	Natural	Artificial
Size	≈ 2.3 km	≈ 0.02 km	≈ 0.7 km	≈ 0.5 km
Diversity	Low	Low	Low	Low
Rarity	Common habitat in Hong Kong, Although no marine species of conservation importance recorded, 2 and 3 avifauna species of conservation importance were recorded in Rocky Shore and Mudflat respectively			
Recreatability	Not recreatable	Not recreatable	Not recreatable	Recreatable

Criteria	Rocky Shore	Sandy Shore	Mudflat	Vertical Seawall
Fragmentation	Low		Un-fragmented	Low
Ecological linkage	Linked with marine water with different coastal habitats			
Potential value	Low			
Breeding / Nursery ground	No breeding or nursery ground identified		Spawning and nursery ground identified	No breading or nursery ground identified
Age	N.A.	N.A.	N.A.	15-52 years
Abundance/ Richness of Wildlife	Low	Low	Low	Low
Ecological value	**Low**	**Low**	**Low**	**Low**

Table 7-6: Ecological Value of Subtidal Habitats

Criteria	Rocky Seabed	Sandy Seabed (Coarse sand)	Sandy Seabed (Fine sand)	Muddy Seabed
Naturalness	Natural	Natural	Natural	Natural
Size	N.A.			
Diversity	Low	Low	Low	Low
Rarity	Low - moderate diversity (19 species) of healthy hard coral colonies recorded	Amphioxus *B. belcheri* recorded	Significant population of amphioxus *B. belcheri* recorded	N.A.
Recreatability	Difficult to recreate	Recreatable	Recreatable	Recreatable
Fragmentation	N.A.			
Ecological linkage	Linked with adjacent seabed habitats			
Potential value	Low			
Breeding / Nursery ground	No breeding or nursery ground identified			Breeding ground of 1 crustacean species
Age	N.A.			
Abundance/ Richness of Wildlife	Low	Low – Moderate	Low	Low
Ecological value	**Moderate**	**Moderate**	**Moderate – High**	**Low**

7.15 Impact Identification and Assessment

7.15.1 The pipeline of the submarine outfall will be drilled underground by horizontal directional drilling without damaging the intertidal area. At the end of the 385 m pipeline, the diffuser will emerge from the seabed and the area will be dredged.

Direct Impact – Habitat loss

7.15.2 Although about 750 m^2 of rocky shore above high water mark will be temporarily occupied for the installation of submarine outfall by horizontal directional drilling (HDD), it will not encroach any intertidal zone. Therefore, no intertidal habitat will be lost. After completion of the submarine outfall, the rocky shore will be reinstated.

7.15.3 A fully-enclosed sheet pile cofferdam with an area of 10 m x 50 m (i.e. 500 m^2) will be installed on muddy seabed for the diffuser installation. Seabed within the cofferdam will be dredged to ensure the seabed stability for installing a diffuser with 5 m^2 in size. Therefore, about 500 m^2 of muddy seabed will be lost during construction phase.

7.15.4 However, except the area occupied by the diffuser, all dredged seabed will be backfilled to the original seabed level with rockfill. The cofferdam will also be removed after the completion of backfilling. Therefore, the installation of diffuser will lose 5 m^2 seabed permanently, and 495 m^2 seabed temporarily.

7.15.5 As the direct impacts identified are expected to be localized, largely temporary and reversible, and not directly affecting any species of conservation importance, the overall direct impact on marine ecology will be insignificant.

Indirect Impact – Water Quality Deterioration

Construction phase

7.15.6 Both land based and marine based construction activities are expected to deteriorate the water quality via surface runoff, waste water generated, accidental leakage of chemicals, and release of suspended solids (SS) during installing and extracting the sheet pile cofferdam.

7.15.7 Increased in SS, hence sedimentation rate, could bring negative impact on marine ecology. Past studies verified that certain levels of SS and sedimentation rates would depress both health and survival rate of fish (Binnie 1994), coral communities (Pastorok & Bilyard 1985; Hawker & Connell 1992; Erftemeijer et al. 2012) and amphioxus (Chen 2007).

7.15.8 Nevertheless, according to the assessment in **Chapter 5 – Water Quality Impact Assessment**, the water quality impact due to land-based construction works would be minimized to acceptable level if mitigation measures were implemented properly (e.g. placement of sandbag along watercourse near Fairway Vista and rocky shore where excavation will be carried out).

7.15.9 **Chapter 5 – Water Quality Impact Assessment** also pointed out that the marine-based construction works (i.e. installation & extraction of sheeting pile cofferdam by vibratory action) would only cause minor displacement of marine sediment. With erection and maintenance of silt curtain, the displaced sediment will settle quickly and will not significantly increase the SS level in water column. In addition, dredging and backfilling works will be confined within fully enclosed cofferdam (see **Section 7.15.3**). The dredger barge will be anchored outside the cofferdam for dredging and backfilling operation as well as storage of marine sediment in sealed compartment. No opening of cofferdam will be required and thus there will be no release of sediment into water bodies. Therefore, these works are not expected to impact on the water quality.

7.15.10 The overall indirect impact on marine ecology is expected to be insignificant.

Operational Phase – Normal operation

7.15.11 In addition to SS and sedimentation rate, change in concentrations of total inorganic nitrogen (TIN), unionized ammonia (UIA) and dissolved oxygen (DO) can affect health and survival of marine wildlife. TIN is a plant nutrient that encourages algal growth. High UIA concentration is toxic to fish. DO is essential for survival of marine organisms. During normal operation, the sewage collected will be treated before being discharged at the diffuser. Referring to **Chapter 5 – Water Quality Impact Assessment**, the water quality model predicted no substantial change in concentrations of water quality parameters listed above in the Study Area described in **Section 7.3.1**.

7.15.12 Both coral and amphioxus are sensitive to salinity. The diffuser will be installed at a location with more than 10 m water depth and is far from the major Amphioxus habitat and the rocky shore where coral grows (>100 m). The peak flow rate of the effluent discharge during normal operation is only at about 7 L/s. The change in salinity at these habitats arising from discharge of low salinity effluent is expected to be negligible.

7.15.13 Therefore, no adverse indirect impact on marine ecology is expected during normal operation.

Operational Phase – Emergency Plant Breakdown

7.15.14 The Po Toi O Sewage Treatment Plant (PTO STP) cannot operate in case of power or equipment failure. The Supervisory Control and Data Acquisition (SCADA) system in the PTO STP will signal to the operation and maintenance personnel for emergency attendance. Standby pump and screen will be provided at the PTO STP. According to the performance pledge of CLP, electricity provision will be restored within 2 hours after fault outage. Also, emergency generator will be delivered to PTO STP within 4 hours by future term contractor in case of plant failure where necessary.

7.15.15 As the average dry weather flow (ADWF) of PTO STP would be small (about 139 m^3/day), it would be possible to deploy tankers to transport away the sewage to Tseung Kwan O Preliminary Treatment Works (TKO PTW) (or other nearby sewage treatment works (STW)) for treatment in case the PTO STP cannot be recovered in a short period of time.

7.15.16 Emergency storage of 4-hour ADWF (23.19 m^3) will be provided in the PTO STP. In case of plant failure, three 12 m^3 sewage tankers will be called in to transport the sewage from PTO STP to TKO PTW. Tankers will take different travel routes to reduce the risk of delay due to traffic jam. The tanker arrangement is as follows:

Table 7-7: Tanker Away Arrangement

Tanker	Source	Potential Route	Arrival Time	Duty
A	DSD's tanker which stationed at Sai Kung Sewage Treatment Works	Sai Kung STW → Hiram's Highway → Clearwater Bay Road → Tai Au Mun Road → Po Toi O STP	1.5 hours from plant failure	Transport sewage from PTO STP to TKO PTW
B	DSD Sewage Treatment Division Term Contractor, required to arrive in 2 hours in contract	Shatin STW* → Route 9 → Tate's Cairn Tunnel → Clearwater Bay Road → Tai Au Mun Road → Po Toi O STP	2.5 hours from plant failure	Transport sewage from PTO STP to TKO PTW
C	DSD District Term Contractors (any 1 of the 3 districts), required to arrive in 1.5 hours in contract	Kwun Tong Preliminary Treatment Works* → Tseung Kwan O Road → Clearwater Bay Road → Tai Au Mun Road → Po Toi O STP	2.5 hours from plant failure	Standby at PTO STP, to be on duty if Tanker A/B breaks down or encounters traffic delay

* Typical location where term contractor's tankers are stationed

7.15.17 The distance between PTO STP and TKO PTW is about 12.1 km or 18-minute travel distance. Including sewage loading and unloading time, each tanker is assumed to take 2 hours round trip. Tankers A and B will work in shift to continuously remove sewage from PTO STP. If one of the tankers fails to arrive at PTO STP on time, Tanker C will come in to ensure that at least two tankers will be operating. An operation drill prior to future operation will be conducted to confirm the time estimates achievable at peak hours.

7.15.18 **Appendix 5.5** shows the fluctuation of sewage volume in PTO STP in case plant failure occurs during peak sewage flow (6pm). With continuous removal of sewage by tankers in rotation, the highest quantity stored in the plant will be 17.24 m^3, which is well below the emergency storage capacity (23.19 m^3). With about additional 6 m^3 storage buffer, the chance of having sewage volume exceeding the storage capacity is very low. No overflow of sewage from the PTO STP is anticipated.

7.15.19 Each tanker will deliver 12 m^3 sewage from PTO STP to TKO PTW. Based on DSD's past experience, it takes 15 minutes to unload all sewage. The average flow rate will be 12 m^3/15 minutes/60 seconds = 0.013 m^3/s, which is far below the design capacity of TKO PTW (5.55 m^3/s [1]). No overloading of TKO PTW is anticipated.

7.15.20 Considering the project scale, risk of emergency condition, construction difficulties and cost, the following provisions are the most appropriate and practical mitigation measures in case of plant/power failure:

- Delivery of an emergency generator to the PTO STP within 4 hours from plant failure;
- Provision of dual power by CLP;
- Provision of a supervisory control and data acquisition system (SCADA), which signals to the operation and maintenance personnel for emergency attendance in case of plant failure;
- Provision of a standby pump and screen at the PTO STP;
- Provision of emergency storage of 4-hr ADWF sewage retention time;
- Arrangement of tankers for continuous removal of incoming sewage to other sewage treatment plants for treatment to ensure a sufficient buffer for emergency storage.

1 Maunsell Consultants Asia Ltd. 2005. Further Development of Tseung Kwan O Feasibility Study (Application No. EIA-111/2015) Ch. 6 Sewerage and Sewage Treatment. [online] Available at: http://www.epd.gov.hk/eia/register/report/eiareport/eia_1112005/HTML/EIA/HTML/Volume%201/Sec_6%20Sewerage.htm. Last Accessed: 23 March 2016.

Cumulative Impact

7.15.21 Currently, there is one planned project, maintenance dredging of Po Toi O Fish Culture Zone, located within the Study Area. However, there is no solid plan on when the works will be carried out. Therefore, it is assumed that it will not be carried out concurrently with the construction work of the Project, and hence, no cumulative impact is expected.

7.16 Evaluation of Ecological Impacts

7.16.1 The significance of ecological impacts have been evaluated in accordance with EIAO-TM Annex 8 Table 1.

Table 7-8: Evaluation of the Significance of Ecological Impact on Intertidal Zones within 500 m from the Project

Criteria	Rocky Shore	Sandy Shore	Mudflat	Vertical Seawall
Habitat quality	Low	Low	Low	Low
Species	2 avifauna species of conservation importance	No species of conservation importance	3 avifauna species of conservation importance	No species of conservation importance
Impact Size /Abundance	Impacted indirectly (water quality deterioration) Low number of fauna			
Impact Duration	- Short term construction impact - Long term operational impact during normal operation			
Impact Reversibility	Reversible			
Impact Magnitude	Minor	Insignificant		
Overall Impact	**Minor**	**Insignificant**		

Table 7-9: Evaluation of the Significance of Ecological Impact on Subtidal Habitats

Criteria	Rocky Seabed	Sandy Seabed (Coarse sand)	Sandy Seabed (Fine sand)	Muddy Seabed
Habitat quality	Moderate	Moderate	Moderate – High	Low
Species	Coral communities (19 hard coral species)	Amphioxus *B. belcheri*	Significant population of amphioxus *B. belcheri*	No species of conservation importance
Impact Size /Abundance	Impacted indirectly (water quality deterioration) Moderate number of fauna.			5 m^2 lost permanently, 495 m^2 will be backfilled. Low number of fauna.
Impact Duration	- Short term construction impact - Long term operational impact during normal operation			
Impact Reversibility	Reversible			Irreversible for the diffuser footprint, reversible for remaining area
Impact Magnitude	Insignificant			Small
Overall Impact	**Insignificant**			**Minor**

7.17 Recommendations & Mitigation Measures

7.17.1 The location of the diffuser has undergone several rounds of site selection (as detailed in **Chapter 2**) to minimize the ecological impacts. Recommendations and mitigation measures have been proposed to minimize the ecological impacts to acceptable levels based on the following hierarchy: avoidance, minimization and compensation.

7.17.2 Avoidance

- To avoid impact on habitat with high ecological value and/or where species of conservation importance inhabits, the location of diffuser has been moved to muddy seabed (A4) to avoid disturbance on subtidal rocky shore and sandy seabed (B2), where coral and amphioxus inhabits respectively.
- Avoiding impact on intertidal habitats, Horizontal Directional Drilling (HDD) will be adopted above high water mark to install the submarine outfall underground.

- Avoid discharging any raw or partly treated sewage into waterbodies when the STP cannot operate normally due to power or equipment failure.

7.17.3 Minimization

- To minimize the disturbance on benthic habitats by dredging, HDD will be adopted for the installation of submarine outfall.
- Backfill the dredged seabed, except where the diffuser is located, to original seabed level
- Minimizing the water quality impact by implementing mitigation measures such as dredging within sheet pile cofferdam. Details of mitigation measures for water quality impact were presented in **Chapter 5 – Water Quality Impact Assessment**.

7.18 Evaluation of Residual Impacts

7.18.1 With proper implementation of mitigation measures on water quality, the impact on marine ecology is anticipated to be acceptable during construction and operational phases.

7.19 Environmental Monitoring and Audit Programme

7.19.1 Since the impact on marine ecology will be depended on water quality, regular water quality monitoring and audit programme proposed in the **EM&A Manual** will be sufficient. No specific monitoring and audit programme on marine ecology is required.

7.20 Conclusion

7.20.1. Coral communities were recorded in past study, while 4 avifauna, 1 amphioxus and 19 hard coral species of conservation importance were found in recent surveys. Besides, a major amphioxus habitat was recorded in recent surveys.

7.20.2. Although the muddy seabed where the diffuser will be located on will be lost during construction phase, no species of conservation importance will be directly affected. There will be a permanent loss of 5 m^2 in area at the diffuser location. However, impact on the remaining works area (495 m^2) would be reversible. Indirect impact due to water deterioration will be minimal as dredging works will be confined within fully enclosed cofferdam. No sediment release into water bodies is anticipated. No cumulative impact is expected as no project is known to be carried out concurrently with this Project. The overall construction phase impact is considered as low and acceptable.

7.20.3. As sewage will be collected and treated before discharge, modelling results predicted that no significant change in water quality is expected for normal operation of the Project.

7.20.4. Considering the project scale, risk of emergency condition, construction difficulties and cost, the following provisions are the most appropriate and practical mitigation measures in case of emergency plant breakdown:

- Delivery of an emergency generator to the PTO STP within 4 hours from plant failure;
- Provision of dual power by CLP;
- Provision of a supervisory control and data acquisition system (SCADA), which signals to the operation and maintenance personnel for emergency attendance in case of plant failure;
- Provision of a standby pump and screen at the PTO STP;
- Provision of emergency storage of 4-hr ADWF sewage retention time;
- Arrangement of tankers for continuous removal of incoming sewage to other sewage treatment plants for treatment to ensure a sufficient buffer for emergency storage.

7.20.5. With these provisions, emergency discharge of untreated sewage will not be required, and thus no adverse impact on water quality and marine ecology due to emergency plant breakdown is anticipated.

7.20.6. In summary, no adverse impact on marine ecology is expected in operational phase.

7.20.7. With proper implementation of mitigation measures on water quality, the residual impact on marine ecology is expected to be acceptable. No specific monitoring and audit programme is required for marine ecology.

7.21 References

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