5. Marine Ecological Impact Assessment

5.1 Introduction

In accordance with the EIA Study Brief No.ESB-171/2007, the potential marine ecological impacts arising from the dredging, laying of pipe and backfilling works for the construction and operation of the submarine gas pipelines and the associated works were assessed.

This Chapter evaluates the marine ecological resource found within the Study Area for the proposed submarine gas pipelines. Literature reviews as well as ecological field surveys were conducted to verify the ecological baseline conditions in the Study Area. The potential impacts on the existing ecological resources arising from the Project was assessed and evaluated according to the criteria stipulated in EIAO-TM Annexes 8 and 16. Mitigation measure specific for the marine ecology are recommended with an aim to protect, maintain and rehabilitate the natural environment.

5.2 Environmental Legislation, Standards, Guidelines and Criteria

A number of international conventions, local legislations and guidelines provide the framework for the protection of species and habitats of ecological importance. Those related to the Project are:

- *Wild Animals Protection Ordinance (Cap 170);*
- *Protection of Endangered Species of Animals and Plants (Ordinance (Cap 586);*
- *Town Planning Ordinance (Cap 131);*
- *Hong Kong Planning Standards and Guidelines Chapter 10 (HKPSG);*
- *The Technical Memorandum on Environmental Impact Assessment Process under the Environmental Impact Assessment Ordinance (EIAO-TM);*
- *EIAO Guidance Note No. 11/2004 Methodologies for Marine Ecological Baseline Surveys;*
- *United Nations Convention on Biodiversity (1992);*
- *Convention on International Trade in Endangered Species of Wild Flora and Fauna (CITES);*
- *Convention on the Conservation of Migratory Species of Wild Animals (the Bonn Convention);*
- *IUCN Red Data Books; and*
- *PRC Regulations and Guidelines.*

Under the ***Wild Animals Protection Ordinance (Cap.170)***, designated wild animals are protected from being hunted, whilst their nests and eggs are protected from destruction and removal. Most mammals

including all cetaceans are protected under this Ordinance. The Second Schedule of the Ordinance that lists all the animals protected was last revised in June 1992.

The ***Protection of Endangered Species of Animals and Plants Ordinance (Cap. 586)*** was gazetted on 10 March 2006 to replace the Animals and Plants (Protection of Endangered Species) Ordinance. The Ordinance was effective on 1 December 2006, which aims at regulating the import, introduction from the sea, export, re-export and possession or control of certain endangered species of animals and plants and parts and derivatives of those species; and to provide for incidental and connected matters.

The ***Town Planning Ordinance (Cap. 131)*** aim at promoting the health, safety, convenience and general welfare of the community by guiding and controlling development and the use of land. From conservation perspective, it provides designation of areas such as “Coastal Protection Areas”, “Sites of Special Scientific Interest (SSSIs)”, “Green Belt” and "Conservation Area” to promote conservation or protection or protect significant habitat.

Chapter 10* of the *Hong Kong Planning Standards and Guidelines covers planning considerations relevant to conservation. This chapter details the principles of conservation, the conservation of natural landscape and habitats, historic buildings, archaeological sites and other antiquities. It also addresses the issue of enforcement. The appendices list the legislation and administrative controls for conservation, other conservation related measures in Hong Kong, and government departments involved in conservation.

Annex 16* of the *EIAO-TM sets out the general approach and methodology for assessment of ecological impacts arising from a project or proposal, to allow a complete and objective identification, prediction and evaluation of the potential ecological impacts. *Annex 8* recommends the criteria that can be used for evaluating ecological impacts.

EIAO Guidance Note No. 11/2004 Methodologies for Marine Ecological Baseline Surveys elaborates on Annex 16 of the TM to provide information on the requirements of marine ecological baseline study. The note provides general guidelines for conducting a marine ecological baseline survey in order to fulfil the requirements stipulated in the TM in respect of marine ecological assessment for a designated project.

The Peoples’ Republic of China (PRC) is a Contracting Party to the ***United Nations Convention on Biological Diversity*** of 1992. The Convention requires signatories to make active efforts to protect and manage their biodiversity resources. The Government of the Hong Kong Special Administrative Region has stated that it will be “committed to meeting the environmental objectives” of the Convention (PELB 1996).

CITES (the Convention on International Trade in Endangered Species of Wild Fauna and Flora) is an international agreement between Governments. Its aim is to ensure that international trade in specimens of wild animals and plants does not threaten their survival.

The Convention on Migratory Species of Wild Animals (Bonn Convention) aims at developing international cooperation with a view to the conservation of migratory species of wild animals. This includes the conserve of terrestrial, marine and avian migratory species throughout their range. Migratory species threatened with extinction are listed as Appendix I of the Convention. Migratory species that needs or would significantly benefit from international cooperation are listed in Appendix II of the Convention. Hong Kong was a Party of this Convention since 1985.

The PRC in 1988 ratified the ***Wild Animal Protection Law*** of the PRC, which lays down basic principles for protecting wild animals. The Law prohibits killing of protecting animals, controls hunting, and protects the habitats of wild animals, both protected and non-protected. The Law also provides for the creation of lists of animals protected at the state level, under Class I and Class II. There are 96 animal species in Class I and 156 in Class II. Class I provides a higher level of protection for animals considered to be more threatened.

5.3 Assessment Methodology

In order to identify the ecological characters of the Study Area for subsequent impact assessment, a combination of desktop literature reviews and ecological field surveys were undertaken. The baseline condition of the physical environment within the Study Area was also examined through literature review. The result from the water quality impact assessment in Section 3 for this EIA study was used to prediction the implication on marine ecology due to the changes in water quality.

The Study Area for marine ecological impact assessment is defined as the same assessment area for Water Quality Impact Assessment, which cover the Victoria Harbour Water Control Zone (WCZ), the Western Buffer WCZ and the Eastern Buffer WCZ. Sensitive area likely to be impacted by the Project including sensitive coral sites in the above WCZs was also included in this assessment.

Literature Review

Extensive information on the marine ecological resource within the Study Area was reported by various studies. Relevant baseline information was gathered in order to establish an ecological profile of the Study Area through reviewing the best relevant literatures including previously approved Environmental Impact Assessment reports, scientific publications and environmental studies.

Field Survey

In addition to general review of marine ecological information in the study area, more specific information is needed, in particular to the area likely to be subjected to direct loss or direct impact. For this purpose, inter-tidal field surveys and sub-tidal dive surveys were conducted to fill the information gap on ecological baseline information.

Ecological surveys for the inter-tidal community were conducted in June and October 2009 at the pipeline landing points of both To Kwa Wan and North Point where direct and indirect impact on the coastal habitat potentially occur. Three survey points were selected on both landing areas to conduct the walk through and quantitative quadrate surveys to investigate the inter-tidal coastal communities. During walk through survey the community attributes were recorded through direct sighting by qualified ecologists with an aid of binoculars (locations refer to **Figure 5.3**). All flora and fauna within the area were recorded with their relative abundance to establish an ecological profile of the inter-tidal community of the Project Area. The surveys were conducted at a considerable low tide period (<1m CD) when a larger area of inter-tidal habitat are exposed to the air at low tide.

Quantitative quadrate method was used at the rocky shore in Hoi Sham Park. At the survey site, the high, middle and low tide levels were determined through observing the upper and lower tide marks. On each horizontal tidal level, 5 quadrates (0.5m x 0.5m) were placed randomly. All flora and fauna observed within the quadrate were identified and counted to determine the species density. For sessile organisms such as

oysters and barnacles, the percentage cover within the quadrate was estimated. Other inter-tidal fauna found outside the quadrate were recorded qualitatively to establish a species checklist for the habitat.

For the coral communities, sub-tidal dive survey was conducted in July 2009 at the pipeline landing points at both To Kwa Wan and North Point and at the breakwater of To Kwa Wan Typhoon Shelters. Both quantitative Rapid Ecological Assessment (REA) and qualitative spot dive were carried out during the survey. Details of the dive survey methodology are described in **Appendix D2: Marine Ecological Dive Survey Report**.

5.4 Baseline Conditions & Marine Ecological Sensitive Receivers

The Study Area for the purpose of this ecological impact assessment is same as those for Water Quality Impact Assessment covering the Victoria Harbour, Western Buffer and Eastern Buffer Water Control Zones (WCZs) in accordance with Clauses 3.4.1.2 and 3.4.3.2 in EIA Study Brief No.ESB-171/2007. It also includes any other area likely to be impacted by the Project and has potential ecological value such as the coral sites in Junk Bay.

The aquatic environment comprises several types of habitat, namely inter-tidal communities, sub-tidal communities, marine benthos and marine water, which need to be investigated to determine the ecological value. No ecological sensitive area, such as Site of Special Scientific Interest (SSSI), Marine Parks or Reserves or other sites of conservation importance are identified within and in vicinity of Study Area. The Study Area for the marine ecological impact assessment is shown in **Figure 5.1**, a habitat map showing the coastal habitat is presented in **Figure 5.4** and a representative inter-tidal habitat map with photos is presented in **Figure 5.5**.

5.4.1 Existing Condition of Victoria Harbour

5.4.1.1 Water Quality

The proposed submarine gas pipelines alignment runs from To Kau Wan, crosses through the Kowloon Bay and eastern Victoria Harbour, and lands at North Point, within the gazetted Victoria Harbour WCZ. The central waters of Hong Kong including the Victoria Harbour, Eastern Buffer and Western Buffer WCZs are important navigation channels and port areas.

The landing point at To Kwa Wan is in proximity to To Kwa Wan Typhoon Shelter, which is used by small to medium vessels as shelter against strong winds and rough sea conditions particularly during typhoon seasons. For this purpose, the typhoon shelter is semi-enclosed water bodies and vulnerable to pollution for both land and sea. The typhoon shelters in Victoria Harbour generally had poorer water quality (EPD, 2009).

The recent marine water quality monitoring results from Environmental Protection Department (EPD, 2009) showed that the water quality of the Victoria Harbour has been improved significantly after the implementation of the Harbour Area Treatment Scheme (HATS) Stage 1 in 2002, in which about 75% of the sewage around the Victoria Harbour underwent chemically enhanced primary treatment.

From the water quality monitoring result in 2008, the total inorganic nitrogen (TIN) and dissolved oxygen (DO) have showed non-compliance to the Water Quality Objectives (WQO) in some monitoring stations. The water quality monitoring station to the north of North Point (VM2) showed compliance to TIN but non-compliance to DO (EPD, 2009). Although water quality has been improved in recent years notably a

decrease in the levels of *E. coli* and an increase in the level of DO, in general, the Victoria Harbour provides a relatively poor quality and disturbed marine habitat compared to other waters in Hong Kong.

5.4.1.2 Sediment Quality

The sea bed sediment of Victoria Harbour was described as grey, clayey, very silty and very gravelly sand with shell fragments in 2002 sediment testing (Mouchel, 2002), which is similar to the sediment testing results conducted for the *Laying of Western Cross Harbour Main and Associated Land Mains from West Kowloon to Sai Ying Pun* in September 2006 (Mott Connell, 2007). According to the *Consultancy Study on Marine Benthic Communities in Hong Kong*, there were minimal seasonal changes in sediment characteristics for both summer and winter recorded around Victoria Harbour (CPSL, 2002). Review on the benthos survey for the Kai Tak Development Engineering Study (Maunsell, 2007a) sharing common Study Area with this Project showed that the sediment at Kowloon Bay, Victoria Harbour and the region close to North Point was typical sediment along the Victoria Harbour Channel.

From 2004 to 2008, elevated levels of heavy metals, in particular copper and silver could often be detected in the sediments of Victoria Harbour, Junk Bay and Tsuen Wan Bay. This was attributed to previous industrial pollution sources in the 60s to 80s before pollution control legislation was introduced. The sediment sample in typhoon shelters in Victoria Harbour are often contaminated by heavy metals due to historical discharges from industries. During 2004-08, the Kwun Tong TS's sediment recorded high level of heavy metals, (e.g. cadmium, chromium and copper) as well as total PCBs. In 2008, the copper level in To Kwa Wan TS is the second high amongst the typhoon shelters in Hong Kong. For polyaromatic hydrocarbons (PAHs), the level in the To Kaw Wan TS was higher than the levels in other typhoon shelters. High PAHs level could be attributed to contamination from the old industrial areas in San Po Kong and perhaps the old Kai Tak Airport (EPD, 2009).

Recent vibrocore samples for the proposed submarine gas pipelines alignment were collected in 38 locations (locations refer to **Figure 4.1**). The records indicated that the material along the proposed alignment of the submarine gas pipelines consist mainly of marine deposits which are very soft, grey, sandy, silty clay with some gravel size shell fragments. Sediments collected close to the central and southern fairway indicated that the surface deposit at around 1m depth from the seabed were anthropogenic, black sediment which oxidize to brown, slightly silty, fine to coarse sand with little sub-angular, fine to medium gravel of rocks were recorded (Mott Connell, 2007). The different in sediments composition was the result of continuous seabed perturbation by the marine traffic at the Victoria Harbour.

5.4.1.3 Inter-tidal Communities

Artificial Seawalls

Victoria Harbour WCZ (Victoria Harbour and Kowloon Bay)

The inter-tidal zone at the landing points of the proposed works area consists of artificial seawalls and concrete embanked wharf piles at the To Kwa Wan and North Point shorelines. Along the former Kai Tak Airport runway and To Kwa Wan typhoon shelter, the inter-tidal habitats are man-made sloping seawalls with embankment formed by large boulders and rock armour. Spot dive survey conducted close to seawalls inside Victoria Harbour (including Hung Hom, North Point and off Kai Tak) for the Harbour Area Treatment Scheme (HATS) Study in January 2003 recorded bryozoans (*Schizoporella errata*), barnacles, mussels (*Perna viridis*) and sponges (ENSR, 2008). Other study suggested that fouling organisms were regarded as common on artificial seawalls and wharfs in Hong Kong (Morton & Morton, 1983). These include barnacles

(*Tetraclita squamosa, Capitelum mitella* and *Balanus amphitrite*), polychaete tube-worms (*Hydroides elegans, Spirobis foraminosus* and *Pomatoceros triqueter*), mussels and oysters (*Perna viridis, Septifer virgatus, Saccostrea cucullata*), bryozoans (*Bugula neritina*), ascidians (*Ascidia sydneiensis*, *Ciona intestinalis, Styela plicata*) and various macro-algae that are either organic or nutrient enrichment indicators (*Ulva fasciata, Entromorpha prolifera, Codium cylindricum, Colpomenia sinuosa*) (Morton & Morton, 1983).

For the sloping seawalls and rockfills, fouling organisms are also commonly found. They include rock oysters, periwinkles and barnacles as well as algae, coelenterates, ascidians, bryozoans, sponges, crustaceans, other molluscs and polychaetes, which were tolerant to pollution (Morton & Morton, 1983). Inter-tidal fauna of low ecological value including isopod and grapsid crabs were recorded on the rubble-mount seawalls (Maunsell, 2007a).

Recent inter-tidal surveys conducted on the vertical seawall and sloping boulder-mounted seawall at the Kai Tak runway along the coast of Kowloon Bay for the study on *Decommissioning of the Former Kai Tak Airport other than the North Apron EIA* (Maunsell, 2007a) were reviewed. The habitat was generally inhabited densely by sessile encrusting fauna such as periwinkle (*Echinolittorina radiata*), topshell (*Monodonta labio*), limpet (*Cellana grata, C. Toreuma* and *Patelloida saccharina*), bivalve (*Saccostrea cucullata*) and barnacle (*Balanus amphitrite, Tetraclita japonica* and *T. squamosa*). Mobile species such as common Sea Slater (*Ligia exotica*) and crab were recorded. The flora species recorded on the surface of artificial seawalls include the encrusting algae (*Pseudulvella applanata* and *Hildenbrandia rubra*) and erect algae (*Hincksia mitchelliae*). All inter-tidal fauna and flora recorded in the Kai Tak area at Kowloon Bay were common with low conservation interest. The records of inter-tidal communities in Kowloon Bay and Victoria Harbour from various studies are summarised in **Table D-1** of **Appendix D1**.

Vertical Seawall at To Kwa Wan and North Point

Inter-tidal community surveys were conducted at the pipeline landing points in both To Kwa Wan and North Point in current EIA study (representative photos refer to **Figure 5.5**). At the survey sites, the coastline is dominated by artificial vertical seawall. The coastal shore are mostly homogeneous concreted seawall with reduced number of niches and restricts the diversity of the flora and fauna that colonize the habitat. The surfaces of the fauna species, in particular at To Kwa Wan area, are covered with grease and polluted substance therefore appears darker in colour. Vertical zonation pattern can be seen in the eulittoral zone in the seawall. From the higher to low tidal level, the littoral fringe is dominated by *Echinolittorina spp.*, followed by barnacle *Balanus amphitrite*, limpet *Cellana grata* and rock oyster *Saccostrea cucullata* at upper part of the eulittoral zone. At lower eulittoral and upper fringe of sub-littoral zone, *Haliplanella luciae* and Ascidiaea *Atyela plicata* were recorded. The results of the inter-tidal survey are listed in **Table D-2** and **D-3** in **Appendix D1**. All of the species recorded are common and typical to the wharves and embankments at Victoria Harbour area. Among the 6 surveyed sites (Locations refer to **Figure 5.3**), Site 6 is highest in species diversity, probably because of the less polluted water and the presence of wood piles, which provide more micro-habitats.

Natural Rocky Shores

Victoria Harbour WCZ

Owing to the coastal development along Victoria Harbour coastline, most of the natural habitat have been transformed into varied typed of artificial seawall. Natural inter-tidal habitat is rare in Victoria Harbour except a few locations in which rocky shores with hard substratum were retained. The coastal communities,

even on a relative natural habitat, are subjected to pollution from heavy marine traffic, water runoff or sewage discharge.

One of the remaining natural rocky shore in Victoria Harbour WCZ is the Green Island on the western side in which a large portion of natural rocky shore was retained. The coastline is dominated by granitic rocky shore interspersed with boulder shore. Findings from literature review recorded that the species diversity at the inter-tidal zone of Green Island was similar on both northern and southern shores, but different assemblages of inter-tidal fauna were recorded. Species recorded in Green Island include the commonly found barnacle *Tetraclita squamosa,* topshells *Monodonta labio,* littorinidae *Echinolittorina malaccana,* chitons *Acanthopleura japonica,* the limpets *Cellana grata* and a rare species of nerite *Nerita undata* (ERM, 1998). The mid-tidal zone of the rocky shores have an extensive bed of macroalgae *Porphyra* sp., *Ulva* sp., *Gelidium* sp. and encrusting cyanobacteria *Kyrtuthrix maculans.* The sea-lettuce *Ulva* sp. was commonly occur nearly all shores in Hong Kong (Morton & Morton, 1983).

Baseline surveys findings of the inter-tidal communities of Green Island, Little Green Island and a reference site in Hong Kong Island have been conducted by ERM in 1997 (ERM, 1998). A total of 22 species of fauna and 8 species of algae were recorded, abstract of the most abundant species are listed in **Table D-4** of **Appendix D1**.

The dominant species in the inter-tidal zone around the above study area were grazing gastropods such as chiton *Acanthopleura japonica* and limpets *Cellana grata, C. toreuma, Patelloida pygmaea* and *P. saccharina* recorded at the lower eulittoral zone, and periwinkles *Echinolittorina malaccana, E. radiata* and *E. vidua* recorded at the higher eulittoral zone. Predatory gastropods such as the dogwhelks *Thais clavigera* and *T. luteostoma* were also recorded in low density at the lower eulittoral zone. Sessile organisms including Stalked Barnacles and Acorn Barnacles were recorded in high abundances. Algae were sparsely distributed along the shore during summer, with cyanobacteria (*Pseudoulvella* spp.) having the highest percentage cover (ERM, 1998).

By comparing the three survey locations, the overall species abundance and species diversity were highest at the reference Hong Kong sites, followed by the Little Green Island and Green Island. The findings displayed the inter-tidal community to be of typical semi-exposed rocky shores. No rare species or species of conservation importance were recorded in this study.

Rocky Shore at Hoi Sham Park

At about 300m to north of the pipeline landing point at To Kwa Wan, a small rocky shore area on sandy base was preserved at Hoi Sham Park (representative photos refer to **Figure 5.5**). The inter-tidal communities on the rocky shore were surveyed in current EIA study on 8 June 09 and 12 October 09. The shore is deposited with garbage and the inter-tidal community are darker than its normal appearance as they are covered by grease and polluted substance. Despite of the relative natural landform, the diversity and abundance of the inter-tidal fauna species are of similar type to those at adjacent artificial seawall. Quadrate surveys were conducted in high, middle and low tide levels to record the inter-tidal community at different tidal zone. From the field observation and survey data, graduated zoning can be seen. At the littoral zone, periwinkles *Echinolittorina* spp. is common at the splashed area. The eulittoral zone is dominated by *Balanus amphitrite* and *Saccostrea cucullata* while *Cellana grata* and *Perna viridis* commonly occur. The results of the quadrate surveys are presented in **Tables D-5** and **D-6** in **Appendix D1**.

5.4.1.4 Marine Benthic Communities

Victoria Harbour WCZ (Eastern Victoria Harbour and Kowloon Bay)

Benthic infauna can be studied by grab sampling, vibrocore survey and the use of sediment profile photography method named Remote Ecological Monitoring of the Seafloor (REMOTS). Grab sampling with photographic record of the color of the sediment surface were conducted by Maunsell at Kowloon Bay and Victoria Harbour near the former Kai Tak airport runway (Maunsell, 2007a) (location refers to **Figure 5.2a**). All species found in the survey were widely distributed along the coast of China, including 37 species of polychaete species, 1 nemertean, 13 crustaceans, 3 mollusca and 1 fish species. The two abundant taxa are amphipods and polychaeta (e.g. *Eunice indica*, *Mediomastus* sp., *Cirriformia* sp., *Glycinde gurjanovae, Glycera chirori*). These species are considered as the indicators of the presence of high organic loading in sediment. The benthic condition in Kowloon Bay was considered of low in ecological value with the present of indicators species showing disturbed condition. The marine benthos recorded abstracted from various studies in vicinity to the proposed gas pipelines alignment are summarised in **Table D-7** of **Appendix D1**.

Study for the *Revised Scheme of South East Kowloon Development EIA* (Ove Arup, 2001) reported that benthic organisms recorded in Victoria Harbour near Kai Tak Airport (Kowloon Bay) with no more than 3 species. The polychaete *Capitella capitata,* accounted for 98% and 99% of the specimens for two sampling locations, were the dominant species. The biomass and density were also very low at the two sampling stations in Kowloon Bay (location refers to **Figure 5.2a**). The *Capitella capitata* able to tolerate very low oxygen tensions and enormous numbers were found in polluted areas including the harbour basins (Ma, 1999). It is an organic pollution indictor dominates in polluted water in sewage discharge.

In the benthic communities study conducted by CPSL (2002), the Victoria Harbour was included in the sampling stations 53 and 54. These stations were on coarser sediment than other locations. Based on the results of hierarchical classification of the summer survey data, stations 53 and 54 are classified as Group A. It was represented by the polychaetes *Cirratulus sp.*, *Schistomeringos rudolphi*, *Dodecaceria* sp. and *Naineris* sp., and bivalve *Ruditpaes philippinarum*. The relatively strong current and organically enriched environment in the harbour would favour the growth of bivalve *Ruditpaes philippinarum*. Although the number of individual was relatively high in both stations, the species diversity and richness are of no special conservation interest (CPSL, 2002).

Victoria Harbour WCZ and Western Buffer WCZ (Western Victoria Harbour and Sulphur Channel)

The content of marine sediments in the Western Buffer WCZ between the Stonecutters Island and Kenny Town are mainly silt (77%) and with minor composition of organic content (ERM, 1998). The most abundant benthic fauna recorded is Polychaetes, which comprised of approximately 80% of the total infauna recorded. Other species include molluscs, crustaceans and echinoderms with abundance less than 10% of the total species recorded for each species group. The assemblages of the Victoria Harbour benthic infauna was characterised by low species diversity, evenness and low individual biomass (CPSL, 2002; ERM, 1998). The most abundant polychaete species recorded in the Western Harbour Area include the *Aglaophamus lyrochaeta*, *Nephtys* sp., *Paraprionospio pinnata, Tharys* sp., *Marphysa stragulum*, *Notomastus latericeus* and *Glycera chiori* (ERM, 1998). *Paraprionospio pinnata* is known to be well adapted to organic pollution and is an indicator of the increase in TOM in sediments (CPSL, 2002).

Grab sampling along the Sulphur Channel between Green Island and Kennedy Town conducted in 1993 recorded that 92 macrobenthic organisms of 32 taxa, in which 69% of the total number of individuals were polychaetes, others include the molluscs and crustaceans (Binnie, 1994, cited in ERM, 1998). The most

abundant polychaetes comprised *Prionospio saccifera*, *Tharyx multifilis, Nephtys polybranchia, Sternespis sculata* and *Sigambra hanaokai*.

Sediment sampling results in 1995 around the Central waterfront recorded that no live benthic invertebrates were sampled (ERM, 1998). Only empty gastropod shells were collected. The malodorous and anoxic sediment suggested that the marine lives were subjected to pollution stress by the long term sewage discharge into the region.

Remote Ecological Monitoring of the Seafloor Studies (REMOTS) showed that benthic eutrophication occurs as a result of organic enrichment from the harbour (ERM, 1998) (sampling locations refer to **Figure 5.2**). Only the pollution tolerant polychaetes species (Spionidae and Capitellidae) and crustaceans (crab larvae and small amphipods) in small size and low density were recorded on the near surface sediment. CPSL (2002) also indicated that the benthic fauna recorded in Victoria Harbour is characterized by species which can adapt to eutrophic environment. The sediments in the study area appeared dark grey to black, reflecting the anoxic condition with high organic loading of the local region.

Trawl surveys were conducted by ERM in 1995 (sampling location refers to **Figure 5.2**). There are total 15 species and 44 individuals recorded close to the Green Island. The species diversity of the benthic epifauna was diverse, but low in abundance. The dominant species was anemones, which comprises of approximately 36% of the total number of organisms recorded in the region. Apart from the gorgonian soft corals and sea pen *Pteroides esperi*, the species recorded were considered to be of low ecological value, the fish diversity and macro-invertebrate communities around the Green Island were considered to be low compared with other areas in Hong Kong (ERM, 1995, cited in ERM, 1998). The benthic epifauna recorded around Green Island is summarised in **Table D-8** of **Appendix D1**.

5.4.1.5 Sub-tidal Coral Assemblages

Victoria Harbour WCZ and Western Buffer WCZ (Western Victoria Harbour, Green Island, Little Green, Sandy Bay and Sulphur Channel)

The coral communities at far field in the Western Victoria and Western Buffer WCZ were reviewed. Remotely Operated Vehicle (ROV) was used to conduct coral survey around Green Island, Little Green Island and the Sulphur Channel close to the western Hong Kong Island (reference site) by ERM as part of the ecological surveys for the Green Island Development Studies in 1997 (Babtie BMT, 1997, cited in ERM, 1998). Video were taken along three 10m wide belt transects at depths of -5, -10 and -15 mPD. Four species of soft coral and gorgonians were recorded in this study at Green Island and Little Green Island, including the Pink Soft Coral *Dendronnephthya* sp., Orange Sea Fan *Echinogorgia complexa*, White Sea Whip *Euplexaura curvata* and Purple Sea Whip *Ellisella gracilis*. No other soft coral and gorgonian colonies was recorded in the western Hong Kong Island waters in this study. **Table D-9** of **Appendix D1** shows the frequency of soft coral and gorgonian colonies encountered during the study.

The seabed in Green Island is quite varied with patches of sand and rubble in the shallower areas and mud with silt or sand in deeper area. Rocks and boulders of assorted sizes scattered throughout the area with some area of exposed pavement. Considerable amount of rubbish, including ghost nets, were scattered around the area. There were seven species of hard hermatypic coral recorded, along with five species of gorgonian from the genera *Echinogorgia* sp., *Echinomuricea* sp., one species of ahermatypic coral *Paracycathus rotundatus* and one species of soft coral from the genera *Dendronephthya* sp. recorded in the area (MMHK, 2010).

Sandy Bay is highly disturbed with artificially formed shoreline. The spot check dive for HATS study recorded 14 taxa of hard coral and 5 taxa of soft coral at a depth around 12m (ENSR, 2008). Soft corals *Echinomuricea* sp. and bryozoans *Schizoporella errata* were the most ubiquitous taxa recorded. Low coverage of soft corals and 9 hard corals were observed in east Sandy Bay, only small isolated *Echinomuricea* colonies and the more abundant *Psammocora superficialis* and *Porites lobaa* were recorded. For the west Sandy Bay, the soft coral coverage is moderate (10-50%) at deep and middle transects. Seven genera were recorded. Eleven hard corals with low coverage were also reported. The most abundant species recorded were Faviids.

Victoria Harbour WCZ (Eastern Victoria Harbour and Kowloon Bay)

Dive survey was conducted in the central Victoria Harbour under the Wan Chai Development Phase II recorded one species of hard coral *Oulastrea crispata* in low coverage and one species of octocoral *Echinomuricea* sp. at the central harbour area (Maunsell, 2007a). No other coral was identified in the region.

Recent dive survey for the Kai Tak Development Project conducted around the Kai Tak area in 2007 close to the proposed alignment of this Study was reviewed (Maunsell, 2007a) (sampling locations refer to **Figure 5.2**). The substrates in this area are composed of big boulders and rocks in shallow water and sandy with muddy substrates in deeper region. Isolated colonies of one hard coral species *Oulastrea crispata* were observed in low coverage of around 1-5% adjacent to the former Kai Tak Airport runway (the side at Kowloon Bay) and around the rubble mount embankment of the To Kwa Wan Typhoon Shelter. The isolated colonies were attached on boulders and rocks of size around 1cm to 30cm in diameter and in fair condition. Most of the coral colonies were found covered by layer of sediment.

Oulastrea crispata is an opportunist with a wide range of reproductive strategies that able to colonize a variety of substrata and to flourish as a pioneer colonizer of newly immersed structures (Lam, 2000). This coral is common, tolerant to harsh environment and may survive even under thin layers of sediment (Chan et al., 2005). This coral usually appear independently on rock surfaces in the sub-tidal area and may appear in large number on rocks in very shallow water.

Sub-tidal dive surveys were conducted at the proposed pipeline landing points in To Kwa Wan, North Point and the breakwaters at To Kwa Wan. At the landing points in North Point, only 2 small colonies of pioneering coral *Oulastrea crispata* was found. At the breakwaters at To Kwa Wan, *Oulastrea crispata* were commonly found attaching on artificial boulder breakwater but in low density and coverage. They are generally in good condition with colony size ranging from <1cm^2 to over 150cm^2. No other hard coral (scleractinian) species were found in the dive survey. Survey result refers to **Appendix D2**.

Eastern Buffer WCZ (near Cape Collinson and Tung Lung Chau)

The dominant coral species recorded near Cape Collinson is octocoral *Echinomuricea* sp. (ENSR, 2008). The soft coral community was more developed and diverse in shallow depth zone. Seafans, gorgonians and other soft corals composed of 25-50%. Seven species of hard coral were also recorded in shallow transects with the most abundant species *Goniopora stuchburyi*. Other hard corals were scattered with low percentage coverage (<5%) (ENSR, 2008).

Soft coral cover in south Tung Lung Chau was low (<5%) with only 4 genera recorded (ENSR, 2008). *Echinomuricea* sp. was abundant in this region. Four species of hard corals were recorded scattered at shallow depth zone with low percentage cover and very low numbers of soft corals were observed. In north

Tung Lung Chau, low percentage cover of soft coral was recorded in both middle and shallow depth zones. Seven hard coral species were recorded with the dominant species Favites. No rare or protected species were recorded in the Eastern Buffer WCZ.

Junk Bay

The whole sub-tidal zone in Junk Bay has been extensively surveyed in various EIA studies (ERM, 2007; Maunsell, 2005). In the EIA study for the further development of Tseung Kwan O (Maunsell, 2005), the area around Chiu Keng Wan, southwest coast of Junk Bay and Junk Island were surveyed, which resulted a total of 19 species of hard coral and 5 species of soft coral. The hard coral species recorded include *Acropora solitaryensis*, *Coscinaraean* sp., *Cyphastrea serailia, Favia favus*, *Favia lizardensis*, *Favia rotumana*, *Favia speciosa*, *Favites abdita*, *Goniastrea aspera*, *Goniopora stutchburyi*, *Hydnophora exesa*, *Leptastrea purpurea*, *Oulastrea crispata*, *Pavona decussata*, *Platygyra acuta*, *Plesiastrea versipora*, *Porites* sp., *Psammocora haimeana*, *Psammocora superficialis*, *Turbinaria* sp. and *Turbinaria peltata*. All of them are common in Hong Kong except *Acropora solitaryensis* and *Psammocora haimeana*, both are uncommon and usually found in northeastern waters. The study also recorded 2 species of soft corals, one species of black coral and 9 species of Gorgonian seawhips/ seafans. The hard coral cover are generally in low cover (<1%), small and of encrusting growth form attaching to bedrock.

In the EIA study for the South East New Territories (SENT) Landfill Extension (ERM, 2007), the Junk Island, Joss House Bay, Kwun Tsai and Tit Cham Chau were surveyed and recorded with 19 species of hard coral and 5 species of soft coral, which include hard (scleratinains) coral species *Acropora solitaryensis, Coscinaraea n* sp.*, Cyphastrea serailia, Favia favus, Favia lizardensis, Favia rotumana, Favia speciosa, Favites abdita, Goniastrea aspera, Goniopora stutchburyi, Hydnophora exesa, Leptastrea purpurea, Oulastrea crispata, Pavona decussate, Platygyra acuta, Plesiastrea versipora, Porites* sp.*, Psammocora superficialis* and *Turbinaria peltata.* All are common in Hong Kong except the *Acropora solitaryensis* which is uncommon and generally restricted to the oceanic offshore islands of southern Hong Kong and the coastline of exposed eastern mainland bays (Chan et al., 2005). The hard corals at the sub-tidal habitat were generally in low abundance and diversity, and dominated by species commonly found in Hong Kong.

5.4.1.6 Marine Waters

The Assessment Area covers three WCZs including the Eastern Buffer, Western Buffer and Victoria Harbour Water Control Zones. The inshore hydrography is affected by fresh water arriving from two sources, namely, heavy rainfalls and the Pearl River. The Pearl River also carries heavy loads of SS and nitrates. The effect of the Pearl River progressively reduces towards the southeast. The Victoria Harbour and Western Buffer WCZs are situated in a transition zone in which, in summer, surface waters of reduced salinity, higher temperature and rich in dissolved oxygen flow over the more saline and cooler oceanic waters which are low in dissolved oxygen. In winter, with a reduced flow from the Pearl River, the water of this region is vertically more uniform. The Western Buffer Water Control Zone covers the Ma Wan Channel, Kap Shui Mun Channel and other major navigation channels and anchorages in the Western Harbour. It has strong tidal flushing capacity and is used for disposal of effluent from the Stonecutters Island Sewage Treatment Works. The major marine animals of conservation concern inhabiting the Hong Kong marine waters are cetaceans, and in particular, two dolphin species.

5.4.1.7 Marine Mammals

All the marine mammals in Hong Kong are protected under the Wild Animals Protection Ordinance (Cap. 170) and the Protection of Endangered Species of Animals and Plants Ordinance (Cap. 586). Two

cetacean species namely Chinese White Dolphin *Sousa chinensis* and Finless Porpoise *Neophocaena phocaenoides* are found regularly in Hong Kong waters. A Humpback Whale *Megaptera novaeangliae* was reported in March 2009 in Eastern Buffer WCZ but it is only a vagrant but not regular visitor to Hong Kong.

Chinese White Dolphin (CWD) is listed as "Near Threatened" in IUCN Red Data List (IUCN 2009) on account of its decreasing trend in population. They have limited distribution in Hong Kong waters, due to their preference for shallow, coastal estuarine habitats (Clarke et al. 2000). They mainly occur at western and northwestern Lantau where the marine waters receive a large inflow of fresh water from the Pearl River. Several hotspots with consistent dolphin usage include the waters around Lung Kwu Chau, along Urmston Road, around the Brothers Island, and the stretch of waters from Tai O Pennisula to Fan Lau (AFCD 2009). Usage of the Victoria Harbour, in which the Study Area of this project covers, by Chinese White Dolphin is rare.

Finless Porpoise is listed as "Vulnerable" in IUCN Red Data List (IUCN 2009) on account of its decreasing trend in population. This species is rather cryptic and is therefore difficult to survey. In Hong Kong, it generally occurs in southern waters, from Soko Islands to Po Toi Islands but not in Victoria Harbour. The occurrence of Finless Porpoise displayed distinct seasonal variation in their distribution in Hong Kong. In winter and spring, porpoises mostly occur in South Lantau and Lamma waters but almost absent in these waters in summer and autumn (AFCD 2009).

5.4.1.8 Recognized Sites of Conservation Importance

There are no SSSIs, Marine Parks or Marine Reserves in the Study Area. The monitoring programme on marine mammals in local waters indicated that Chinese White Dolphin and Finless Porpoise have not been recorded in Victoria Harbour in last decade (Hung 2009). Such that, the Project Area in Victoria Harbour is not regarded as an natural habitat for Chinese White Dolphin and Finless Porpoise.

5.5 Ecological Importance

Based on the result of literature review and field survey listed above, the ecological value of the Study Area is evaluated in accordance with Clause 3.4.3.4 (iv)(c) in EIA Study Brief No. ESB-171-2007. For a general account of Victoria Harbour WCZ, the ecological value is relatively low given the low species diversity of inter-tidal and sub-tidal communities in the highly disturbed artificial coastal and aquatic environment. Except for the sub-tidal and inter-tidal zone at Green Island, which are considered to be of moderate low ecological value with the presence of hard coral (scleractinian), soft corals, gorgonian species and the more diverse coastal communities compared with the species present on the artificial seawalls along the Victoria Harbour. The coral communities in Sandy Bay are of moderate-low ecological value due to the disturbed environment and uneven distribution of soft and hard corals assemblages. The coral communities in Cape Collinson is of moderate-low ecological value due to the present of 10-50% of soft coral but <5% of hard coral coverage. The sub-tidal region of the north Tung Lung Chau coral communities support a moderate coverage of common hard coral (10-25%), thus the ecological value for this region is also considered to be of moderate-low. Marine mammals are rare in the marine waters in Western Buffer, Victoria Harbour and Eastern Buffer WCZs. The evaluation of the ecological importance of each habitat was determined on the basis of the criteria stated in the EIAO-TM *Annex 8* Table 2. The ecological importance of inter-tidal, marine benthic, sub-tidal habitats and marine waters are evaluated in **Tables 5.1** to **5.4** respectively whilst **Table 5.5** presents the result of hard coral species evaluation.

Table 5.1: Evaluation of the Ecological Importance of the Inter-tidal Habitats in Victoria Harbour WCZ

Criteria	Victoria Harbour (artificial seawall)	Green Island (natural rocky shore)
Naturalness	Mainly composed of vertical artificial seawall or sloping boulder-mounted seawall. The shoreline at To Kwa Wan received extensive disturbance through high pollution load from previous industrial area at San Po Kong, former Kai Tak airport and To Kwa Wan Typhoon Shelter.	Natural rocky shores with little human disturbance.
Size	The artificial seawall is continuous along the Victoria Harbour.	The natural inter-tidal shoreline is approximately 2,000m.
Diversity	The species diversity is low.	The species diversity is moderate-low.
Rarity	The species recorded are common fouling organisms found on artificial seawalls in Hong Kong waters.	The species recorded are typical of other semi-exposed rocky shores in Hong Kong.
Re-creatability	The artificial seawall is recreatable.	The natural rocky shores cannot be recreated.
Fragmentation	Not applicable.	Not applicable.
Ecological Linkage	The existing habitats are not functionally linked to high ecological value habitats.	Not functionally linked to high ecological value habitats.
Potential Value	Unlikely to develop a nature conservation interest habitat.	Unlikely to develop a nature conservation interest habitat.
Nursery/Breeding Ground	Not identified.	Not identified.
Age	Not applicable.	Not applicable.
Abundance/Richness of Wildlife	The species abundance was low at vertical smooth structures, wharf piles and boulder-mounted seawall.	The species richness of inter-tidal communities is moderate-low but all are common in similar habitat in Hong Kong
Summary	The inter-tidal assemblages along shoreline of Victoria Harbour are of low ecological value.	The inter-tidal assemblages along the natural rocky shores at Green Island are of moderate low ecological value.

Table 5.2: Evaluation of the Ecological Importance of the Marine Benthic Habitat in Victoria Harbour WCZ

Criteria	Victoria Harbour WCZ
Naturalness	Benthic sediment composed of mud and mix of mud and sand experienced frequent anthropogenic disturbance.
Size	Large.
Diversity	Low diversity of benthic organism.
Rarity	No rare benthos recorded
Re-creatability	Can be re-created easily.
Fragmentation	Not fragmented.
Ecological Linkage	No linkage to marine habitat with high ecological value.
Potential Value	Low potential to become site of conservation concern.
Nursery/Breeding Ground	No significant.
Age	Not applicable.
Abundance/Richness of Wildlife	High number of benthos owing to the organically enriched environment.
Summary	The marine benthic environment in this WCZ is a highly disturbed marine habitat. The marine benthos are of high number of individual but of low diversity and species richness.

Table 5.3: Evaluation of the Ecological Importance of the Sub-tidal Habitats

Criteria	Green Island / Sandy Bay (Western WCZ)	Victoria Harbour/ Kowloon Bay (Victoria Harbour WCZ)	Cape Collinson /Tung Lung Chau (Eastern WCZ)	Junk Bay (Junk Bay WCZ)
Naturalness	The sub-tidal zone is composed of natural rocky seabed with scattered boulders and become sandy offshore at Green Island. The sub-tidal zone at Sandy Bay is highly disturbed with re-created shoreline habitats.	The sub-tidal zone in the shallow region is composed of big boulders and rocks, while in the deeper region is composed of marine sediments with silt and muddy substrates receiving continuous disturbances.	The sub-tidal zone is natural	The sub-tidal zone is natural
Size	The study area of the sub-tidal zone is small.	The study area of the sub-tidal zone is large, covering the Victoria Harbour and the Kowloon Bay.	The study area of the sub-tidal zone is small.	The sub-tidal zone within Junk Bay is moderate in size
Diversity	The species diversity of coral communities is moderate-low for Green Island and moderate-low coral communities at Sandy Bay.	The species diversity of coral communities is very low.	The species diversity of coral communities is low.	The species diversity of coral communities within the region is moderate.
Rarity	The species recorded are not rare to Hong Kong.	The coral species *Oulastrea crispata* is very common in Hong Kong.	The species recorded are common in Hong Kong.	The hard coral species recorded in the region are mostly common, but also include at least two uncommon species.
Re-creatability	The natural seabed can hardly be recreated.	The disturbed seabed is recreatable.	The natural rocky shore can hardly be recreated.	The natural seabed can hardly be recreated.
Fragmentation	Not applicable.	Not applicable.	Not applicable.	Not applicable
Ecological Linkage	The sub-tidal habitats are not functionally linked to high ecological value habitat.	The existing habitats are not functionally linked to high ecological value habitats.	The sub-tidal habitats are ecologically link with the inter-tidal habitats in the surrounding waters.	The sub-tidal communities are ecologically link with those in eastern waters.
Potential Value	Low potential to develop nature conservation interest habitat.	Low potential to develop a nature conservation interest habitat.	Low potential to develop nature conservation interest habitat.	Low potential to develop nature conservation interest habitat.
Nursery/Breeding Ground	Not identified.	Not identified.	Not identified.	Not identified.
Age	Not applicable.	Not applicable.	Not applicable.	Not applicable.
Abundance/ Richness of Wildlife	The species abundance is moderate-low in Green Island.	Hard coral species abundance is very low.	Moderate soft coral abundance at Cape Collinson; moderate hard coral abundance at north Tung Lung Chau.	The coral communities in the region are generally in low coverage.
Summary	The sub-tidal assemblages at Green Island and Sandy Bay are of moderate low	The sub-tidal assemblages in Victoria Harbour are of low ecological value.	The sub-tidal assemblages at Cape Collinson and Tung Lung Chau are	The coral assemblage in the sub-tidal zone is in moderate diversity but low coverage.

Criteria	Green Island / Sandy Bay (Western WCZ)	Victoria Harbour/ Kowloon Bay (Victoria Harbour WCZ)	Cape Collinson /Tung Lung Chau (Eastern WCZ)	Junk Bay (Junk Bay WCZ)
	ecological value.		of moderate-low ecological value.	Moderate-low ecological value.

Table 5.4: Evaluation of the Ecological Importance of the Marine Waters

Criteria	Western Buffer WCZ	Victoria Harbour WCZ	Eastern Buffer WCZ
Naturalness	Disturbed by busy shipping lanes and fishery operation.	Disturbed by busy shipping lanes and pollution.	Disturbed by busy shipping lanes and fishery operation.
Size	Large, covers the Ma Wan Channel, Kap Shui Mun Channel and other major netvigation channel and anchorages in the Western Harbour	Large	Large
Diversity	Low densities of CWD were recorded.	No recent dolphin record.	No recent dolphin record.
Rarity	CWD is a species of conservation concern and protected under Hong Kong ordinances.	No rare species recorded.	No rare species, except a vagrant Humpack Whale *Megaptera novaeangliae* reported in March 2009.
Re-creatability	This habitat cannot be easily recreated.	This habitat cannot be easily recreated.	This habitat cannot be easily recreated.
Fragmentation	Marine waters are not fragmented.	Marine waters are not fragmented.	Marine waters are not fragmented.
Ecological Linkage	No ecological linage habitat of conservation importance.	No ecological linkage to habitat of conservation importance.	No ecological linkage to habitat of conservation importance.
Potential Value	Low	Low	Low
Nursery/Breeding Ground	Not significant	Not significant	Not significant
Age	Not applicable	Not applicable	Not applicable
Abundance/ Richness of Wildlife	Low abundance of marine mammals.	Low abundance	Low abundance of marine mammals.
Summary	Low ecological value	Low ecological value	Low ecological value

Table 5.5: Evaluating hard coral species found in the Study Area

Criteria	Remarks
Species	*Alveopora* sp ,*Achanthastrea echinata, Acropora solitaryensis, Alveopora* sp., *Coscinaraea n* sp., *Cyphastrea serailia, Favia favus, Favia speciosa, Favites pentagona, Favia lizardensis, Favia rotumana, Favia speciosa, Favites abdita, Favia cf. favus, Goniastrea aspera, Goniopora stuchburyi,Goniopora stutchburyi, Hydnophora exesa, Leptastrea purpurea, Oulastrea crispata, Montipora* sp., *Pavona decussata, Platygyra acuta, Plesiastrea versipora, Porites sp., Psammocora superficialis, Psammocora haimeana, Turbinaria*

Criteria	Remarks
	peltata, Turbinaria sp.*, Dendrophyllia* sp. and *Tubastrea* sp.
Protection Status	Some taxa of coral are protected under Cap. (187)
Distribution	They mainly grow along the northeastern and eastern shores, where the waters are both sheltered and free from the influence of Pearl River (Chan et al., 2005).
Rarity	*Acropora solitaryensis* and *Psammocora haimeana* are uncommon whilst others are common in Hong Kong.

5.6 Identification, Prediction and Evaluation of Environmental Impacts

The Installation of submarine gas pipelines require dredging and backfilling at Victoria Harbour and demolition of seawall at both landing points affect coastal and aquatic ecology through direct habitat loss and indirect changes to water flow regime and perturbations of the surrounding water quality. Identification and prediction of the potential impact was undertaken in accordance with the criteria stipulated in Annexes 3 and 8 in EIA-TM with reference of the baseline information collected in literature review and field survey. The significance of the identified potential impact, including any direct, indirect, on-site and off-site ecological impacts, was evaluated in accordance with Clause 3.4.3.4 (ix) in EIA Study Brief No.ESB-171/2007. Impact levels were ranked using the 6 point range “severe”, “severe-moderate”, “moderate”, “moderate-minor”, “minor” and “negligible”.

5.6.1 Construction Phase

5.6.1.1 Habitat Loss

The direct impacts arising from construction activities include a temporary loss of approximate 8.99ha seabed resulting from dredging of 3.1km trench with a width of approximately 29m and temporary loss of about 940m^2 and 650m² of vertical artificial shore at Ma Tau Kok and North Point respectively at the landing points of the pipeline. Both habitat loss in seabed and artificial seawall are regarded as temporary since the dredged area will be backfilled and the seawall will be reinstated.

Dredging on seabed would cause loss of sediment for benthic communities and direct removal of benthos. The seabed substrates are composed of soft mud or a mixture of mud and sand that experienced frequent disturbance from anthropogenic activities. As reviewed from previous report, the benthic communities inhabiting the seabed sediment are of no special conservation interest although the recorded number of individuals is relatively high.

Also, benthic fauna is expected to recolonize the seabed after the backfilling works and the deposition of sediment by natural process. The empty niche on the bed sediment will be rapidly colonized by benthic communities similar to adjacent area. The rapid recolonization of macrobenthic community has been demonstrated in local experiment (Lu & Wu, 1998, 2000) such that the loss of benthos due to the dredging works will be replenished soon after backfilling. Given the high commonness of the marine benthos and their capability of recolonization, the ecological impact in respect of the loss of marine benthic community and their habitat is considered as minor.

In respect of the demolishment of the artificial seawalls at both landing points, the inter-tidal habitat for marine organism would be lost temporarily. As evaluated in the above section, the inter-tidal communities inhabiting the artificial seawalls are mostly fouling organisms in low diversity and subjected to high pollution

level. Given the low ecological value of the marine organisms on the inter-tidal habitat, the potential impact of loss of inter-tidal communities is regarded as minor. Further, as found from the marine dive survey, two small colonies of hard coral (scleractinains) species *Oulastrea crispata* were found in the North Point seawall which are very close to the potential landing points and potentially subjected to direct impact. Given the high commonness of the species and very small size of the colonies, the impact of direct loss of the two small colonies of hard coral is regarded as minor.

5.6.1.2 Indirect Impact

The dredging activities would potentially affect the marine wildlife through causing turbulence on seabed. Degradation of water quality would be resulted from increase in suspended solids (SS) concentration, decrease in dissolved oxygen (DO) level and increase in nutrient levels in water columns.

Increase in SS concentration would cause high turbidity and reduce the sunlight penetrating the water column which would eventually reduce the food production ability of the photosynthesizing animals, as well as behaviour changing due to stress. Direct deposition of sediment on filter-feeding marine organism would have adverse impact on survival, growth and reproduction potential. Induced nutrient level from dredging activities would cause rapid boom in phytoplankton which lead to high oxygen demand in the marine water and eventually a sharp decrease in the DO level. Prolonged oxygen deprivation cause high mortality rate to marine organisms. Indirect impact to marine mammals is considered as negligible given the very low abundance of dolphin species within the Assessment Area. The Humpback Whale recorded in 2009 is a vagrant but not regular visitor to Hong Kong so that no impact to this species is expected.

The loss of sediment to suspension during dredging may have chemical effects on the receiving waters, if the sediment contains organic and chemical pollutants. Release of previously bound organic and inorganic constituents such as heavy metals, PAHs and polychlorinated biphenyls (PCBs) into the water column via suspension or disturbance of seabed (dredging or back filling) may cause lethal or sub-lethal effect to the marine fauna.

For the purpose of predicting potential impact on water quality, water quality modelling was employed to simulate the change on water quality parameters associated with the dredging activities in different scenarios. The water quality modelling setting has taken in account several key water quality parameters including SS elevation and dissolved oxygen level. The results of the simulation of SS elevation at marine ecology sensitive receivers at different scenarios are presented in **Tables 3.18** to **3.21**. The simulation results at scenario 2 have taken into account the cumulative effect of SS elevation due to the concurrent projects.

Potential Impact to the Coral Communities in Victoria Harbour WCZ

During the marine dive survey for this Project, low coverage of pioneering hard coral species *Oulastrea crispata* were found at the hard boulder in To Kwa Wan breakwaters. The coral species is common in Hong Kong because of their special tolerance to extreme environment. It may survive even under thin layers of sediment (Chan et al., 2005). Direct removal of the coral communities from the substratum is not expected as the muddy seabed is not a natural habitat for hard coral to colonize. However, given the close proximity to the dredging area, the *Oulastrea crispata* colonies attaching on the breakwaters hard boulder will be subjected to adverse impact. If without mitigation measure, the hard coral colonies will be affected by the high suspended solids concentration caused by the dredging activities. High level of sediment deposition on the coral would cause suffocation and may adversely affect the coral growth, recruitment and resilience

which lead to mortality. Therefore, the dredging activities may affect the health condition and lead to high mortality of the scattered coral colonies at To Kwa Wan breakwaters if without proper mitigation measure.

The hard coral species *Oulastrea crispata* recorded in scattered colonies in the sub-tidal zone along the former Kai Tak Airport runway and around the boulder-mounted embankment of To Kwa Wan Typhoon Shelter is common in Hong Kong and tolerant to harsh environment. Increased sedimentation level in the water column arising from the dredging works may further cover the corals with sediments. It is anticipated that moderate-minor impact on the remaining coral colonies will be resulted from the construction of the proposed gas pipeline.

Indirect Impact to Western Buffer WCZ and Eastern Buffer WCZ

As resulted in the water quality modelling in the **Chapter 3 - Water Quality Impact Assessment**, the coral site sensitive receivers in Cape Collision in Eastern Buffer WCZ, Green Island and Sandy Bay in Western Buffer WCZ and Junk Bay are all within acceptable level in all scenarios. The simulation results of dissolved oxygen level presented in **Tables 3.26** to **3.29** shows that the dissolved oxygen level would be within acceptable level in Eastern Buffer WCZ, Western Buffer WCZ and Junk Bay. The simulation results at scenario 2 have taken into account the cumulative effect of DO due to the concurrent projects.

The predicted SS elevations and concentrations for all scenarios in dry and wet seasons (presented in **Tables 3.16** to **3.21**) indicated no exceedance of suspended solids criterion for fish culture zone and marine ecology sensitive receivers. The contours presented in **Appendices B2** to **B5** also showed the predicted net sedimentation per meter square per day during dry and wet seasons, respectively. Both tables and figures indicated highest sedimentation rates at waters along the coasts of To Kwa Wan and North Point. Whilst the sedimentation rate at Cape Collinson at Eastern Buffer WCZ, Green Island and Sandy Bay at Western Buffer WCZ, where coral communities are located, will be much lower than 0.1 kg m^{-2} per day. Thus, dredging works near To Kwa Wan and North Point will have negligible impact upon the coral communities at the waters near Cape Collinson, Green Island and Sandy Bay.

Potential impact of Contaminant Release during Dredging

The concentrations of heavy metal and organic matters released from dredging were predicted by the water quality modelling. The results presented in **Table 3.30** indicates high concentration of arsenic, copper and silver in 3 sampling stations. All exceedance of the heavy metal concentrations are found at samples locating in the north portion of the proposed pipeline, except a marginally exceedence of silver concentration is found at Station VC-35. The marginal exceedance is expected to cause minimal water quality impacts since the potential release of silver from sediment will be rapidly diluted by large volume of marine water within the dredging site. After further simulation by water quality modelling, it is found that the mixing zone for arsenic, copper and silver is within 200m, 1500m and 250m respectively. Given the relative low abundance and diversity of marine organisms found in the northern portion of the proposed pipeline, i.e. To Kwa Wan, the potential impact to the marine ecology due to high concentration of heavy metal in released contaminant is minor.

Potential Impacts on Marine Ecology due to Changes in hydrology, Hydrodynamics Properties and Flow Regimes

The free surface hydrology of sea is a complex of physical processes involving mainly surface runoff, subsurface flow, evapotranspiration and hydraulics. Prediction of future behaviour of hydrologic systems is based on calculation of various hydrodynamic properties of fluid, such as velocity, pressure, density and

temperature. No effect on surface runoff, subsurface flow and evapotranspiration would be resulted since the construction works mainly involve dredging works and installation of gas pipeline.

Given that no effect on water density and temperature would be resulted, the only concern on the hydrologic systems would be the change of sea water velocity and pressure. Impact on water velocity and pressure would be resulted if the construction works significantly affect the width of harbour, depth of water and nature of the substrate. Since there will be no reclamation works and large scale seawall modification works involved, the potential for change of harbour width and substratum nature is negligible.

The dredging works to create a temporary trench of 29m in width and 3.1km in length at a seabed level of approximately -12.0mP.D. is considered as rather small in scale which would unlikely constitute significant effect on the water velocity and pressure of the Victoria Harbour. After installation of the pipeline, the trench would be backfilled and the seabed would recover to normal level. Given that no marine species of conservation concern were identified inhabiting the marine water in Victoria Harbour, the potential ecological impact due to changes in hydrology, hydrodynamics properties and flow regimes in Victoria Harbour is also considered as negligible.

Evaluation of the predicted potential impact to marine ecology of different water zones is presented in **Table 5.6.**

Table 5.6: Evaluation of the Significance of Ecological Impact

Criteria	Victoria Harbour/ Kowloon Bay	Cape Collinson/ Tung Lung Chau	Green Island/ Sandy Bay	Junk Bay
Habitat Quality	The coastlines are mostly artificially modified, e.g. vertical seawall and breakwaters. The sub-tidal zone and inter-tidal zone in this region are of low ecological values.	No significant impact is anticipated to the moderate-low ecological value of hard bottom substratum in sub-tidal zone.	No significant impact is anticipated to the moderate low ecological value natural rocky shores, soft bottom seabed and sub-tidal zone at Green Island. No significant impact to the moderate-low ecological value of sub-tidal zone habitats at Sandy Bay.	No significant impact is anticipated to the moderate-low ecological value of coral communities in sub-tidal zone.
Species	The species recorded in the dredging area are common and pollution tolerant. Only small and isolated colonies of one hard coral species *Oulastrea crispata* would be affected.	The species recorded are common. No protected or rare species recorded. The coral communities are not expected to be impacted by the dredging works.	No rare species were recorded within the study area, and coral communities of moderate conservation interest are not expected to be impacted by the dredging works.	The hard coral species recorded are mostly common but also include 2 uncommon species. The coral communities are not expected to be impacted by the dredging works.

Criteria	Victoria Harbour/ Kowloon Bay	Cape Collinson/ Tung Lung Chau	Green Island/ Sandy Bay	Junk Bay
Size/ Abundance	Approx. 8.99ha seabed will be temporary lost. Temporary loss of around 940m² and 650m² of artificial seawall at Ma Tau Kok and North Point landing points respectively. The species diversity of the soft benthos and inter-tidal fouling organisms at vertical seawall is low. The species abundance for the hard coral around Kai Tak and To Kwa Wan breakwaters are also low.	No direct impact and indirect disturbance are anticipated on the moderate abundance of soft corals at Cape Collinson and hard corals at north Tung Lung Chau.	No disturbance impact is anticipated on inter-tidal and sub-tidal region at Green Island and moderate-low abundance of soft and hard corals at Sandy Bay.	No direct impact. Indirect disturbance is insignificant.
Duration	The loss of seabed and artificial seawall are temporary (2 years). The change in water quality in the water column around the dredging area is temporary and within environmental acceptable level. Benthic communities within the dredging area are expected to recolonize after the backfilling of the seabed. The hard coral in Kai Tak will be translocated to other region by other projects prior to the construction. The impact to the coral at To Kwa Wan breakwaters will be temporary –mainly during the trench dredging period (8 months in maximum).	No change in water quality around the coral assemblages are expected.	No change in water quality around the soft coral and hard coral assemblages are expected.	Change in water quality around the coral assemblages are expected to be temporary, short term and insignificant.
Reversibility	The seabed within the working area will be backfilled with rock armour and by natural sedimentation. Benthic fauna is expected to recolonize the seabed after construction when the sediment accumulates.	Impact to coral assemblages are reversible if the stress is short term and in low magnitude. The change in water quality in the vicinity is anticipated to be in very low magnitude.	Impact to coral assemblages are reversible if the stress is short term and in low magnitude. The change in water quality in the vicinity is anticipated to be in very low magnitude.	Impact to coral assemblages are reversible if the stress is short term and in low magnitude. The change in water quality in the vicinity is anticipated to be in very low magnitude.
Magnitude	Impact to the hard coral communities on To Kwa Wan breakwaters will be in moderate-low magnitude.	The impact to the habitats identified is very low magnitude.	The impact to the habitats identified is very low magnitude.	The impact to the habitats identified is very low magnitude.
Summary	The impacts to the low ecological value marine benthos and artificial	The impacts to the coral communities at sub-tidal zone are predicted to be	The impacts to the coral communities and coastal communities at inter-	The impacts to the coral communities at sub-tidal zone are predicted to be

Criteria	Victoria Harbour/ Kowloon Bay	Cape Collinson/ Tung Lung Chau	Green Island/ Sandy Bay	Junk Bay
	inter-tidal habitats within the dredging and works area are predicted to be minor. Indirect disturbance to the remaining hard corals around Kai Tak area is of low significance. Impact to the hard coral *Oulastrea crispata* colonies in To Kwa Wan breakwaters is moderate-minor.	negligible due to the far distance, remote from the works boundary and the prediction of low elevation of SS concentration in the region.	tidal zone are predicted to be negligible due to no works will be constructed in the vicinity, remote from the works boundary and the prediction of low elevation of SS concentration at the region.	negligible due to the far distance, remote from the works boundary and the prediction of low elevation of SS concentration in the region.

5.6.2 Operational Phase

The design of the proposed submarine gas pipelines will minimize the frequency for maintenance or repair due to accidental breakage. The potential impacts in operational phase are mainly the change in seabed substrates along the 29m width trench. The existing soft marine deposit with mud or mixture of mud and sand will change to rock armour backfill with marine sediment naturally.

No maintenance dredging is required for the future operation of the proposed submarine gas pipelines. There would be no hydrodynamic impact as the operation of the submarine gas pipelines would not involve reclamation or filling that would affect the flow volume within Victoria Harbour. There would be no water quality impact during the operation of the submarine gas pipelines as no effluent would be discharged due to the operation of the submarine gas pipelines. Therefore, no impact on marine organism is expected in operation phase.

5.7 Mitigation of Adverse Environmental Impact

The proposed dredging works will be confined in the works area within 25m at either side of the proposed alignment. The trench will be backfilled with rock armour and allow natural sedimentation on the substrates to provide protection of the pipelines from damage by ship anchors.

In order to control the water quality level during construction period, general mitigation measures listed below are proposed in **Chapter 3 Water Quality Impact Assessment**.

- The maximum production rate for dredging from the seabed for installation of the submarine gas pipeline should not be more than 4,000m^3 per day (and no more than 1 closed grab dredger).
- Frame type silt curtain should be deployed to fully enclose the grab while dredging works are in progress. The frame type silt curtain should be extended to the seabed to cover the entire water column to minimize the potential SS impact.
- Good site practices to avoid silt runoff from construction works associated with the construction of the submarine gas pipelines could also further reduce the impact on the marine ecology.

As resulted from impact evaluation in **Table 5.5**, potential impact to the ecological sensitive receivers in Eastern Buffer WCZ and Western Buffer WCZ are minor. No specific mitigation measure for these two WCZs is required. However for the Victoria Harbour WCZ, the potential impact to the coral community on

the To Kwa Wan breakwater is evaluated as moderate-minor significant, which require a more specific measures to mitigate. In order to minimize the potential impact to acceptable level, specific sediment curtains should be deployed to protect the identified coral colonies. Aside from the general frame type silt curtain, a second silt curtain shall be installed between the dredger and the breakwater for protection of hard coral communities. The proposed alignment of the moving second silt curtain and the location of the coral are indicated in **Figure 5.6**. The silt curtain should be fabricated from permeable, durable, abrasion resistant membrane like geotextiles and be mounted on a floating boom structure surrounding the grab and should extend to the sea bottom. Detailed design of the silt curtain shall be submitted to EPD and AFCD for agreement at least two weeks prior to project commencement. This curtain shall be 75m long. This curtain shall be moved along with the dredger as the works progresses. The curtain shall be arranged so that at least 15m of the curtain shall extend past the dredger in each direction. This curtain shall remain in a suitable position between the dredger and the corals until the dredger is 250m from the corals.

In general, cage type silt curtain could reduce 80% of the SS elevation. For the floating silt curtain, it was reviewed in Tuen Mun – Check Lap Kok Link EIA Study that a loss reduction factor of 75% could be achieved. The combination of both cage type and single floating silt curtain would achieve a loss reduction factor of 95% (AECOM 2009). Water quality monitoring station VM 1,2 and 4 (locations depicted in **Figure 3.2**) are regarded as relevant reference points for determining the ambient level and the 30% increase above the ambient level. As listed in **Table 3.14**, the 30% increase above the ambient level in VM 1, 2 and 4 for depth average value in dry and wet season are 1.5mg/L and 2.9mg/L respectively. As indicated in **Appendix B2**, the SS elevations in the To Kwa Wan breakwaters are predicted to be 20mg/L at maximum if without mitigation measure. Since the combination of cage type and single floating silt curtain is expected to reduce the SS elevation by 95%, the SS elevation at the To Kwa Wan breakwaters is predicted to be 1mg/L at maximum level. This SS elevation level is regarded as compliant to the WQO criteria in term of 30% increase above the ambient levels. Therefore, the potential impact to the coral communities colonizing the To Kwa Wan breakwaters is regarded to be minor after installation of both cage type and single floating silt curtain.

Table 5.7 provides details of potential impacts of the construction without mitigation, proposed mitigation measures to reduce the significance of those impacts (where required) and significance of impact after those mitigation measures have been instigated.

Table 5.7: Summary of Potential Ecological Impacts on Coral Communities after Mitigation

Criteria	Disturbance impact to the ecological sensitive receivers in Western Buffer WCZ	Disturbance impact to the ecological sensitive receivers in Victoria Harbour WCZ	Disturbance impact to the ecological sensitive receivers in Eastern Buffer WCZ	Disturbance impact to the ecological sensitive receivers in Junk Bay
Receivers	Coral communities at Green Island and Sandy Bay	Coral communities at To Kwa Wan breakwaters	Coral communities at Cape Collinson and Tung Lung Chau	Coral communities at Junk Bay
Size/ Abundance	Small size and low abundance	Small size and low abundance	Small size and low abundance	Small size and low abundance
Duration	During the construction period; no impact during operational period	During the construction period; no impact during operational period	During the construction period; no impact during operational period	During the construction period; no impact during operational period
Reversibility	Reversible, if the stress is short term and in low magnitude.	Reversible, if the stress is short term and in low magnitude.	Reversible, if the stress is short term and in low magnitude.	Reversible, if the stress is short term and in low magnitude.
Impact Severity before Mitigation	Negligible	Moderate-minor	Negligible	Negligible

Criteria	Disturbance impact to the ecological sensitive receivers in Western Buffer WCZ	Disturbance impact to the ecological sensitive receivers in Victoria Harbour WCZ	Disturbance impact to the ecological sensitive receivers in Eastern Buffer WCZ	Disturbance impact to the ecological sensitive receivers in Junk Bay
Recommended Mitigation Measure	No specific mitigation measure required	Deployment of sediment curtains to protect the coral communities.	No specific mitigation measure required	No specific mitigation measure required
Impact Severity after Mitigation	-	Minor	-	-

5.8 Cumulative Impact

The major marine works include trench dredging is scheduled to take place from April 2012. Referring to the latest construction programme of other project within the Study Area, it is noted that construction period of other projects listed below might overlap with this Project.

- Stage 1 dredging within existing seawall for berth construction for Proposed Cruise Terminal at Kai Tak
- Stage 1 dredging for manoeuvre basin for Phase I Berth for Proposed Cruise Terminal at Kai Tak
- Dredging for seawall foundation at the former Kai Tak Airport runway for the new public landing steps cum fireboat berth for Proposed Cruise Terminal at Kai Tak
- Dredging for Temporary Causeway Bay Reclamation, Wan Chai Reclamation and Hong Kong Convention and Exhibition Centre Reclamation for Wan Chai Development Phase II and Central-Wan Chai Bypass
- Dredging for providing mooring space at south-east corner of Causeway Bay Typhoon Shelter deepening the seabed level at Kai Tak Barging Point for Shatin-Central Link
- Dredging and sand filling for construction of immersed tube sections of Trunk Road T2
- Dredging for providing Sufficient Water Depth for Kwai Tsing Container Basin and its Approach Channel

With reference to the construction programme and likely concurrent projects, representative worst case scenario has been adopted for water quality modelling (refer to **Chapter 3 - Water Quality Impact Assessment**), including all the potentially concurrent dredging activities envisaged during the proposed dredging works for installation of submarine gas pipelines.

The ecological impact assessment carried out in this chapter has already adopted the result of the water modelling in worst case scenario, i.e. cumulative effect of various concurrent projects. Therefore, the cumulative impact of concurrent projects has been taken in account when reaching the conclusion in **Section 5.8**. No additional ecological cumulative impact is expected in addition to those identified in **Section 5.8**.

5.9 Evaluation of Residual Impacts

The temporary loss of approximate 8.99ha seabed would be backfilled and recolonization of benthic fauna is expected. After instigation of mitigation measures, the potential impact in construction phase would be brought down to acceptable level. Since no maintenance dredging is required for the submarine gas pipelines, no unacceptable residual impact is expected.

5.10 Environmental Monitoring and Audit

The implementation of the water quality mitigation measures stated in **Section 3.8** should be checked as part of the environmental monitoring and audit procedures during the construction period as presented in the stand-alone Environmental Monitoring and Audit Manual. The placement of the second silt curtain described in **Section 5.7** should be subject to regular audit. For the coral communities on To Kwa Wan breakwaters, coral impact monitoring shall be carried out once a week during the period that a dredger is within 250 metre of the breakwaters. The health condition of the coral communities should be monitored by using CoralWatch method. It is a standardized method to evaluate bleaching by comparing colours of the corals with colours on the Coral Health Chart and record matching codes. The monitoring programme should include analysis and interpretation of mortality, evidence of siltation, comparisons with previous surveys and photographs. Assessment should also be conducted to determine any significant change to coral mortality and abundance. Details of the coral monitoring programme and the subsequent Event Action Plan are presented in the stand-alone Environmental Monitoring and Audit Manual.

5.11 Summary

The ecological value of the marine ecological resource was evaluated based on the results of literatures review and field surveys. It was found that the marine benthic organisms found within the dredging area consist of pollution tolerant soft benthos which are in low diversity and typical to benthos recorded in poor quality sediments. The inter-tidal survey confirmed that the Inter-tidal communities colonizing the artificial seawall at To Kwa Wan and North Point landing points are common fouling organisms. For the hard coral communities, low coverage of species *Oulastrea crispata* was found on sub-tidal habitat of To Kwa Wan breakwaters. Coral communities of varied coverage and species diversity were recorded in the coral sites Green Island, Sandy Bay, Cape Collinson, Tung Lung Chau and Junk Bay.

The temporary loss of marine benthic and inter-tidal communities is regarded as of low significance owing to the low diversity and abundance of marine fauna species found in the project area. The potential impact on water quality was predicted by using water quality modelling. The results indicated that the elevation of SS concentration and sedimentation rate are all within acceptable level around the identified marine ecological sensitive receivers.

It is concerned that the dredging activities would bring a certain level of adverse impact on the coral communities colonizing the To Kwa Wan breakwaters. But the adverse impact, mainly induced by SS, would be minimized by deployment of a second silt curtain. Therefore, the potential impact to the hard coral colonies would be minimized to an acceptable level. The health condition of the coral communities would be monitored regularly through dive survey in order to validate the effectiveness of the mitigation measures. In conclusion, the potential ecological impact arising from construction of the proposed submarine gas pipelines in Victoria Harbour and Kowloon Bay between To Kwa Wan and North Point is predicted to be minor.

5.12 References

AFCD. (2006). *Chinese White Dolphin – Distribution*. Retrieved October 11, 2006 from http://www.afcd.gov.hk/english/conservation/con_mar/con_mar_chi/con_mar_chi_chi/con_mar_chi_chi_dis_hk.html

AFCD (2009). *Monitoring of Marine Mammals in Hong Kong Waters – Data Collection (2008-09) – Final Report.* Agriculture, Fisheries and Conservation Department.

Chan, A. L. K., Chan, K. K., Choi, C. L. S., McCorry, D., Lee, M. W., & Ang, P. O. (2005). *Field Guide to Hard Corals of Hong Kong*. Hong Kong: Friends of the Country Parks & Cosmos Books Ltd.

CPSL. (2002). *Consultancy Study on Marine Benthic Communities in Hong Kong*. Submitted to Agriculture, Fisheries and Conservation Department of HKSAR Government.

Clarke, S.C., Jackson, A.P., & Neff, J. (2000). Development of a Risk Assessment Methodology for Evaluating Potential Impacts Associated with Contaminated Mud Disposal in the Marine Environment. *Chemosphere*, *41*, 69-76.

ENSR. (2008). *Harbour Area Treatment Scheme (HATS) Stage 2A Environmental Impact Assessment Study – Investigation: Final EIA Report*. Prepared for Drainage Services Department of HKSAR Government.

EPD. (2009). *Marine Water Quality in Hong Kong in 2008*. Hong Kong: Environmental Protection Department of HKSAR Government.

ERM. (1998). *Dredging an Area of Kellett Bank for Reprovisioning of Six Government Mooring Buoys: EIA Report*. Prepared for Port Works Division, Civil Engineering Department of HKSAR Government.

ERM. (2007). *South East New Territories (SENT) Landfill Extension – Feasibility Study: Environmental Impact Assessment Report.* Prepared for Environmental Protection Department of HKSAR Government.

Hung, S. K. Y. (2009). *Monitoring of Marine Mammals in Hong Kong Waters – Data Collection (2008-09): Final Report.* Submitted to the Agriculture, Fisheries and Conservation Department of the Hong Kong SAR Government.

IUCN. (2009). *IUCN Red List of Threatened Species. Version 2009.2*. Retrieved January 14, 2010, from www.iucnredlist.org

Lam, K. K. Y. (2000). Early Growth of a Pioneer Recruited Coral *Oulastrea crispata* (Scleractinia, Faviidae) on PFA-Concrete Blocks in a Marine Park of Hong Kong, China. *Marine Ecology Progress Series, 205*, 113-121.

Lu, L., & Wu, R. S. S. (1998). Recolonization and succession of marine macrobenthos in organic-enriched sediment deposited from fish farms. *Environmental Pollution*, *101*, 241-251.

Lu, L., & Wu, R. S. S. (2000). An experimental study on recolonization and succession of marine macrobenthos in defaunated sediment. *Marine Biology, 136*, 291-302.

Ma, C. H. (1999). *Marine Sedentary Polychaetes in Hong Kong*. Retrieved January 14, 2010, from http://personal.cityu.edu.hk/~bhworm/sedentary

Manusell. (2005). *Further Development of Tseung Kwan O – Feasibility Study: Environmental Impact Assessment Report*. Prepared for Civil Engineering and Development Department of HKSAR Government.

Maunsell. (2007a). *Decommissioning of the Former Kai Tak Airport other than the North Apron: Environmental Impact Assessment Report*. Prepared for Civil Engineering and Development Department of HKSAR Government.

Maunsell. (2007b). *Dredging works for Proposed Cruise Terminal at Kai Tak: Environmental Impact Assessment Report*. Prepared for Civil Engineering and Development Department of HKSAR Government.

Morton, B., & Morton, J. E. (1983). *The Sea Shore Ecology of Hong Kong*. Hong Kong: Hong Kong University Press.

Mott Connell Ltd. (2007). *Laying of Western Cross Harbour Main and Associated Land Mains from West Kowloon to Sai Ying Pun – Investigation: Environmental Impact Assessment Report*. Prepared for Water Supplies Department of HKSAR Government.

MMHK. (2010). *Providing Sufficient Water Depth For Kwai Tsing Container Basin and Its Approach Channel – Environmental Impact Assessment Report.* Prepared for Civil Engineering and Development Department of HKSAR Government.

Mouchel. (2002). *Maintenance Dredging for Central Fairway Phases 1, 2 & 3 Sediment Quality Report*. Prepared for Geotechnical Engineering Office, Civil Engineering Department of HKSAR Government.

Ove Arup. (2001). *Comprehensive Feasibility Study for the Revised Scheme of South East Kowloon Development: Environmental Impact Assessment Report*. Prepared for Kowloon Development Office, Territory Development Department of HKSAR Government.