Development of an Offshore Wind Farm in Hong Kong

EIA Study

Executive Summary

January 2010

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1 INTRODUCTION

1.1 BACKGROUND

The Hongkong Electric Company Ltd (hereinafter referred to as HK Electric), is proposing the development of an offshore wind farm in the Hong Kong SAR. The project will produce around 100 MW of electricity, which will be supplied directly to the HK Electric grid network to help meet the HKSAR Government commitments to renewable energy generation and reduction in greenhouse gas emissions.

The EIA report for the project, which is covered by this *Executive Summary*, is prepared in accordance with *EIA Study Brief* (No. ESB-151/2006) and the *Technical Memorandum of the Environmental Impact Assessment Process (EIAO-TM)*.

1.2 PURPOSE OF THE EIA

This EIA Report addresses the key environmental issues associated with the construction and operation of the proposed wind farm and addresses the detailed requirements of the *EIA Study Brief*. This information will contribute to decisions by the Director of the Environmental Protection Department on:

- The overall acceptability of any adverse environmental consequences that could arise as a result of the Project;
- The conditions and requirements for the detailed design, construction and operation of the Project to mitigate against any adverse environmental consequences; and
- The acceptability of residual impacts after the proposed mitigation measures are implemented.

As specified by the *EIA Study Brief*, the EIA addresses the key environmental issues associated with the construction and operation of the wind farm.

1.3 PROJECT HISTORY

As a primary supplier of electricity in Hong Kong, HK Electric has committed to promoting the development of renewable sources of energy. As part of this commitment, HK Electric pioneered the development of wind power in Hong Kong with the development of the first grid-connected 800kW wind farm on Lamma Island "Lamma Winds" in February 2006.

In order to determine the feasibility for the development of an offshore wind farm in Hong Kong, a *Site Selection Study* was undertaken by ERM in 2008 to

inform the identification of a preferred site for development of an offshore wind farm. The main objective of the exercise was to identify the environmental, physical and planning/social constraints associated with siting the offshore wind farm and identify the most appropriate location for the wind farm. In particular, the exercise was undertaken to avoid and reduce the potential environmental impacts on sensitive areas in line with the Study Brief requirements.

1.4 SITE LOCATION

The wind farm and cable route are located in the waters between Lamma Island and Cheung Chau lying adjacent to the Southwest Lamma Channel. The closest distance of the site to land is approximately 3.5 km to Lamma Island. The water depth at the site ranges from -18 to -23mPD. The proposed area for development has been developed to avoid main shipping routes, key nature conservation sensitivities and existing pipeline infrastructure buried in the seabed. The proposed cable route will run from the north of the site and connect to the Lamma Power Station Extension as shown in *Figure 1.1*.

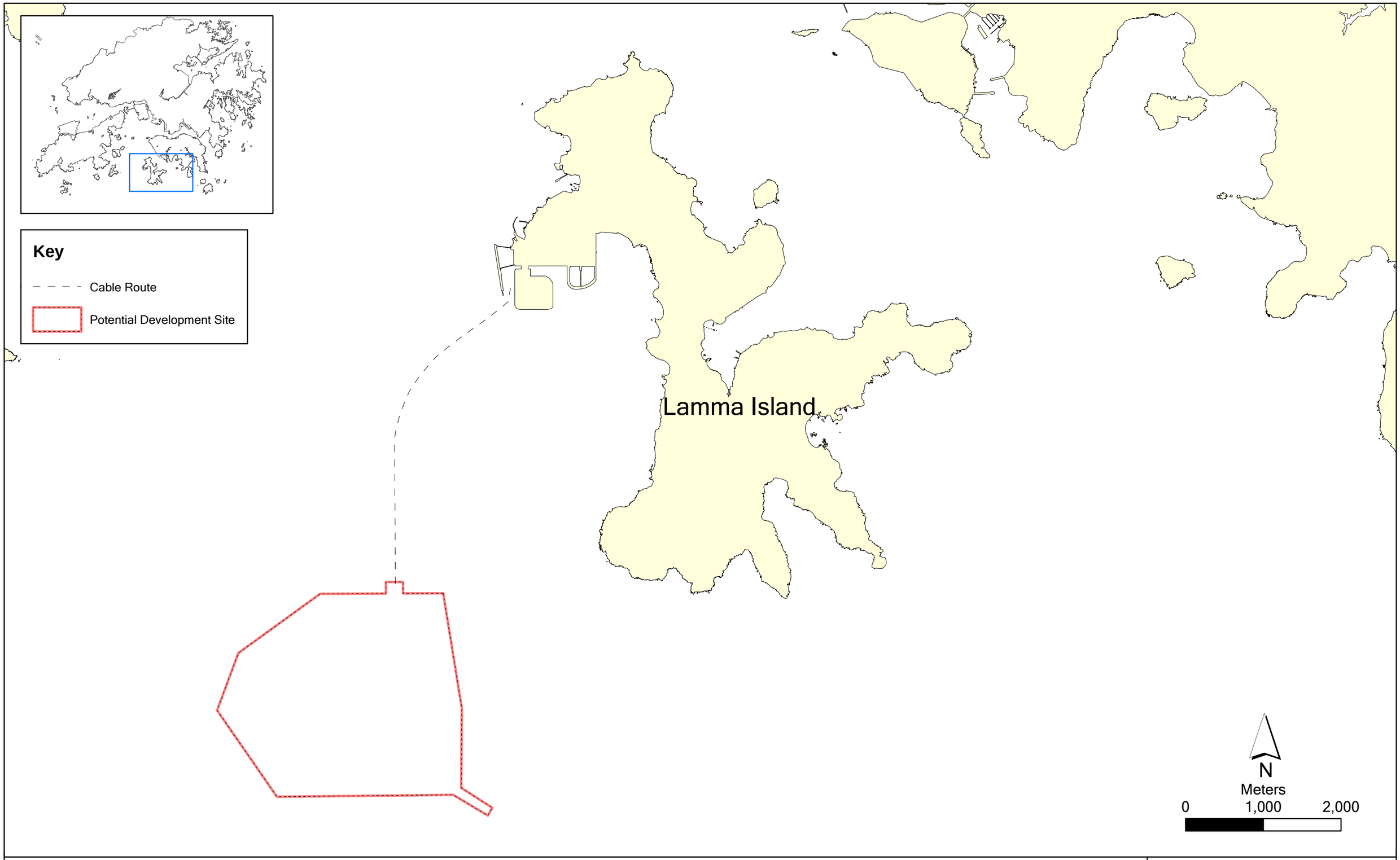

Figure 1.1

Location of the SW Lamma Offshore Windfarm and Cable Route

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Environmental Resources Management

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2 THE NEED FOR AN OFFSHORE WIND FARM IN HONG KONG AND THE KEY COMPONENTS OF DEVELOPMENT

The need for the development of renewable energy in Hong Kong derives from the need to reduce greenhouse emissions and other air pollutants, improve air quality and to move towards a sustainable means of energy production. Wind energy provides a means to generate electricity whilst not directly releasing emissions and is not dependent upon the finite reserves of more conventional fossil fuels. The need to consider alternative 'renewable' forms of energy is also becoming increasingly important to support increasing population sizes, mitigate the cost of higher fossil fuel prices, and provide increased security and diversity of energy supply.

2.1 THE BENEFITS OF DEVELOPMENT

Climate Change and Air Quality

Over the past decade, the fuel used for electricity generation in Hong Kong has evolved from being primarily coal to a diverse mix that is roughly 24% gas, 22% nuclear and 54% coal. The generation of electricity from fossil fuels can lead to the release of greenhouse gas emissions and other pollutants. Due partly to the introduction of natural gas into the fuel mix, HK Electric's air emissions from power generation have significantly improved, with sulphur dioxides (SO_2), nitrogen oxides (NO_x) and particulates reduced by 13%, 17% and 30%, respectively. Also, carbon dioxide emissions were reduced by 7.2% (1). Improving fuel diversity and security of supply, whilst improving emissions, is important for Hong Kong's quality of life, competitiveness and ability to attract investment.

The target for China is to develop 10% of its electricity generation from renewables by 2010 and 16% by 2020 in line with other countries who are party to the UN Framework Convention on Climate Change of 1992. The Hong Kong SAR is not a party to this Convention in its own right. However, the Hong Kong Government has indicated that its policy is 'to contribute to international efforts to stabilise greenhouse gas concentrations in the atmosphere' to help combat global climate change.

In 2005, the First Sustainable Energy Strategy for Hong Kong (2) set a target of 1-2% electricity consumption from renewable sources by 2012 in Hong Kong. The operation of the proposed wind farm would help to meet this target by offsetting approximately:

- The annual use of 62,000 Tonnes (T) of coal;

(1) HK Electric (2008). Social and Environment Report

(2) Sustainable Development Unit (2005). First Sustainable Energy Strategy.

- The annual emission of 150,000T of carbon dioxide;
- The annual emission of 520T of sulphur dioxide; and
- The annual emission of 240T of nitrogen oxide.

Security and Diversity of Supply

The electricity generated from the proposed wind farm would be adequate to meet the consumption for 50,000 households in Hong Kong and is roughly around 1.6% of HK Electric's total electricity sent out in 2008. The development therefore means that there would be a reduced dependency on imported fossil fuels and would help to secure supply from natural resources within Hong Kong.

Socio-economic

Employment

The opportunity to source materials and expertise for the construction and operation of the wind farm from Hong Kong suppliers provides opportunity to the local economy. Opportunities could also lead to spin-off effects in mainland China and also lead to Hong Kong being a hub of knowledge for the development of offshore wind farms across the Asia Pacific Region and beyond.

Detailed decisions on the management of the offshore wind farm have not been finalised. However, it is anticipated that a number of positions for the operation will be required, including maintenance staff and management staff. In addition, ongoing maintenance needs will need the supply of materials.

Tourism

Experience at other international wind farm indicates that a number of visitors will come to view the wind farm once constructed. This could have positive implications for the local economy.

2.2 BACKGROUND TO THE COMPONENTS OF AN OFFSHORE WIND FARM

Wind farm technology has advanced rapidly over the last 10 – 20 years with European countries acting as the technological hub of development. In general, a wind farm is comprised of the following main components:

- Wind turbine units, including foundations.
- Submarine electricity cables that connect turbine units to the offshore substation and an onshore grid network.
- An offshore substation.

- A meteorological monitoring mast to record atmospheric and sea conditions.

The following provides a summary of these components.

Wind Turbines

Wind turbines generally consist of rotor blades, a nacelle (the housing that sits at the top of the wind turbine tower that contains the gearbox, generator etc), tower and foundation. Large-scale modern turbines are usually designed with three blades, which rotate around a horizontal hub at the top of a steel tower. Wind turbines vary in size depending upon the level of energy output and the supplier.

Most wind turbines start generating electricity at wind speeds of around 3-4 metres per second (m/s); generate maximum 'rated' power at around 15 m/s; and shut down to prevent storm damage at 25 m/s or above. When the wind blows the blades rotate. This leads to the turning of a shaft located inside the turbine nacelle. This shaft goes into a gearbox, which increases the rotation speed for the generator also located in the nacelle.

Foundations are required to support the turbine mast, nacelle and blades and also to provide a platform above sea level for ongoing maintenance access.

Subsea Cables

Wind turbines will be inter-connected by subsea cables to provide both power and telemetry links. 22kV, 33kV or other voltage rating according to the proprietary design of wind turbine manufacturers will be used for the windfarm internal grid and connection to the offshore sub-station. 132kV cables will be used to connect the substation to the onshore grid.

Sub-station

An offshore sub-station will be required to transform the voltage of the electricity generated at the wind turbine to a high voltage suitable (132kV) for transmission of power within HK Electric's onshore grid network. As an alternative, an onshore sub-station may also be considered at a later stage subject to detailed engineering design.

Monitoring Mast

A monitoring mast will be required to measure wind, wave and current information for operational purpose. These structures generally consist of a steel lattice mast located on seabed foundations. Anemometry equipment is installed on the mast and wave and current sensors are installed on the seabed/foundation structure.

2.3 *IDENTIFICATION OF ALTERNATIVE SITE LOCATIONS*

The assessment of siting alternatives has been undertaken in accordance with *Clause 3.3.1* of the Study Brief and the *EIAO-TM*. The preferred site for the wind farm has been identified through a detailed and technical evaluation following similar methodologies applied in previously accepted EIA reports under the *EIAO*. The method has employed detailed mapping and a review of both the natural and man-made environment and the associated environment constraints. Eight alternative sites have been reviewed through a comparative assessment of wide-ranging environmental concerns, such as Landscape and Visual, Heritage, Marine Recreation and Amenity, Seabed Sediments, Water Quality, Noise, Nature Conservation and Fisheries. Physical aspects have also been examined and the potential environmental benefits / disbenefits that result as a consequence of those aspects are also considered. Taking into consideration the range of environmental and physical factors described in the previous sections, the Southwest Lamma (Site 1) is preferred.

3.1 PROJECT DESCRIPTION

The key components of the project are presented in *Figure 3.1* and include the following:

- The construction of around 35 nos. of 2.3 to 3.6MW class wind turbine units including seabed works required for foundation emplacement. Should 3.6MW class wind turbine be selected, the number of wind turbines would be reduced to around 28 to 30 in order to maintain the wind farm capacity of around 100MW.
- The installation of interconnecting submarine electricity cables between turbine units, to the offshore substation and to grid.
- Construction of an offshore substation. There may, however, be an option for the offshore substation to be replaced by an onshore one subject to detailed engineering design.
- Development of an onshore lay down area and quayside for material storage and pre-assembly works.
- Development of an offshore wind monitoring mast.

Table 3.1 presents the summary of the Project details.

Table 3.1 Summary of Project Description

Detail	Preliminary Design Information
Wind farm site area	600 ha
Submarine cable route trench (inter-array)	Approximately 13 km
Submarine cable route trench (offshore sub station to landing point)	Approximately 4.3 km
Submarine cable route length (inter-array loop)	Approximately 26 km
Submarine cable route length (offshore sub station to landing point loop)	Approximately 9 km
Grab dredging volume	3,000 m^3
Jetting area/volume	13,000 m^3
Turbine foundation footprint area	38.5 m^2
Scour protection footprint area	900 m^2

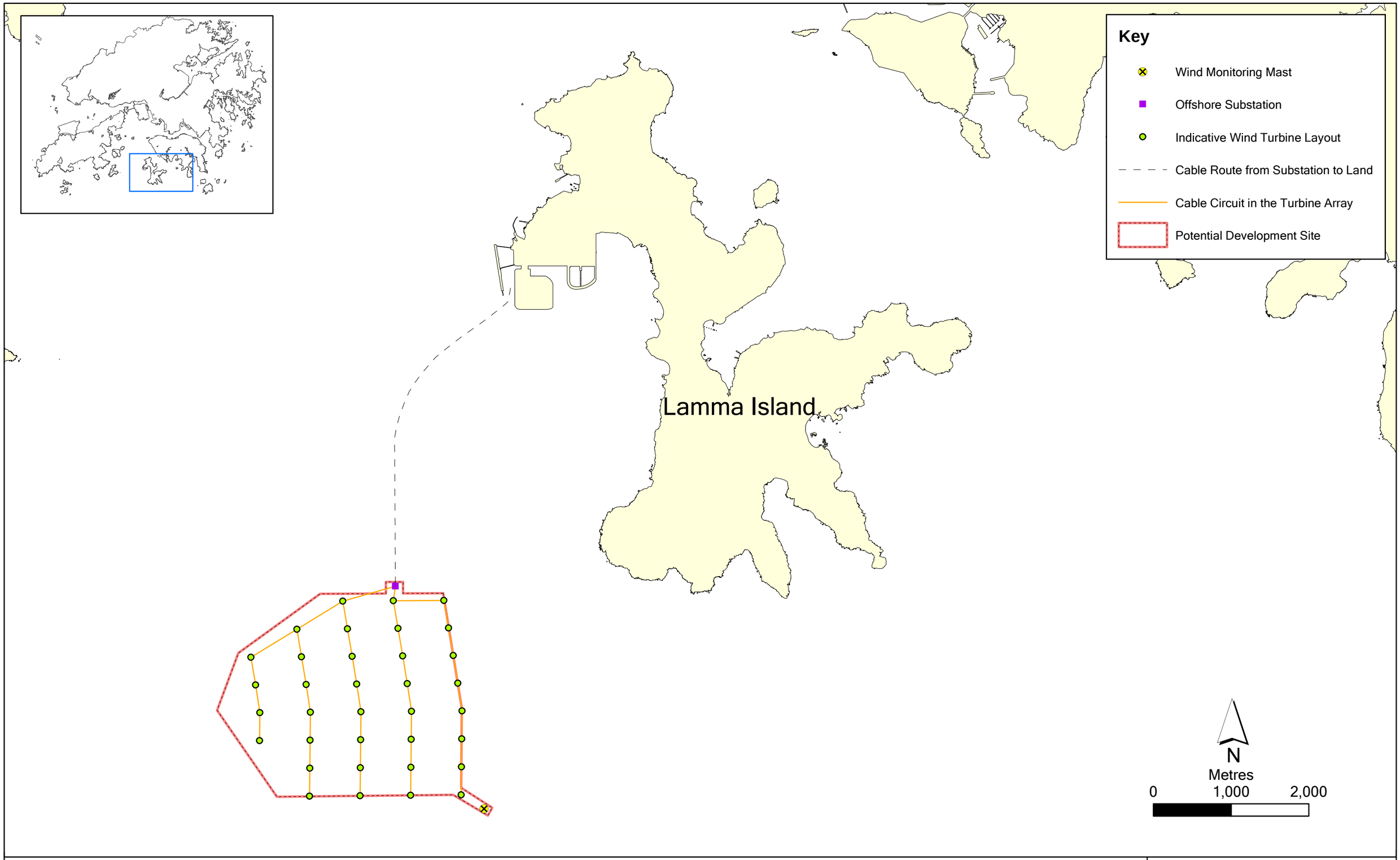

Figure 3.1

Location of Project Components

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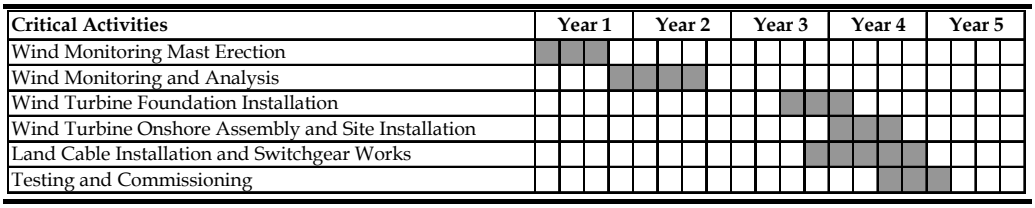
Detail	Preliminary Design Information
Volume of grab dredging arisings for disposal	3,000 m^3
Volume of excavated C& D material	Seawall = 2,145 m^3
	Onshore cable trench = 250 m^3
Volume of excavated C&D material for disposal	0 m^3
Volume of grout per turbine	70 m^3
Lay down area	2.73 ha

Project Programme

The preliminary programme for the Detailed Design and Construction Phases is presented in *Figure 3.2.*

Figure 3.2 Construction Programme



3.2 CONSIDERATION OF DESIGN AND ENGINEERING ALTERNATIVES

An assessment of different design options and construction methods was conducted to investigate not only the environmental considerations of each option, but also to include an examination of the engineering feasibility. Options ranged from alternative foundation design to siting of an offshore vs. onshore substation. Where appropriate, options were discounted on environmental grounds. However, in general, a worse case assessment approach has been taken forward to ensure a precautionary level of assessment and to allow flexibility for future design changes during the subsequent Detailed Design Phase. The options have been considered consistently throughout EIA chapters, which address the requirements of the Study Brief (*ESB-151/2006*) and *EIAO-TM*. The following provides a summary of alternative design options and construction methods that have been considered.

Design Options

Wind Farm Layout: The preliminary layout has considered the influence of site constraints and spacing requirements in order to avoid wake loss across the wind farm. A geometric design has been taken forward for the purpose of informing the assessment as this would help to reduce visual impacts and

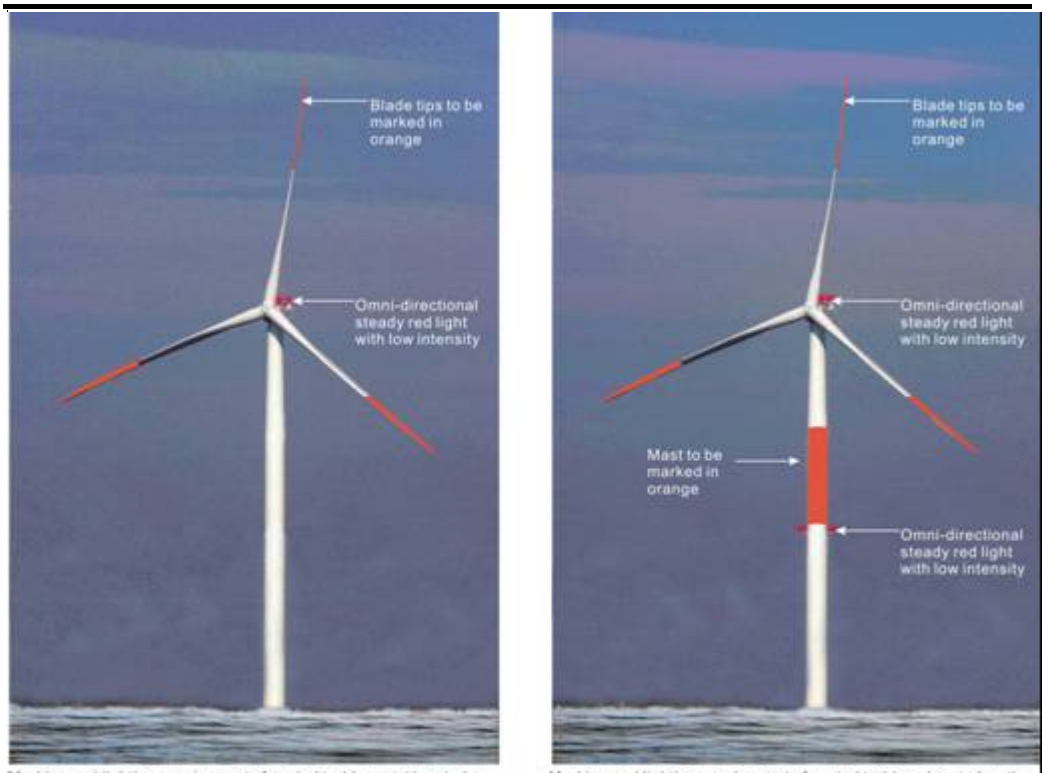
navigational risk. The preliminary layout will, however, potentially be subject to amendment during the Detailed Design Phase.

Wind Turbines: A range of turbines are available on the market with various dimensions for height and rotor diameter. Preliminary dimensions are not expected to exceed a tip height of +125mPD. In the event the wind turbine model with a maximum rotor diameter of 111m be adopted, the maximum tip height would be +136mPD. The turbines with greatest rotor diameter have been used for the assessment as part of a precautionary assessment of impacts. It is, however, possible that a smaller rotor diameter could be used for the size of turbines being considered as these are available on the market.

Foundation Design: Three types of foundation design were considered. It was concluded that a piled foundation (monopile or tripod pile) provided the best environmental and engineering option. Monopiles (with rock scour protection) are likely to occupy the larger seabed footprint and hence were taken forward to the EIA stage in order to produce a more conservative assessment of impacts.

Lighting and Marking: A number of options were considered and the preferred option was identified in accordance with the requirements of the Civil Aviation Department and Marine Department. The requirements for lighting and marking are not expected to give rise to unacceptable adverse environmental impacts (*Figure 3.3*).

Figure 3.3 Marking and Aviation Lighting Requirements for Offshore Wind Farms



Marking and lighting requirements for wind turbines not located on the periphery.

Marking and lighting requirements for wind turbines located on the periphery. Note the marking on the mast corresponds to the markings on the blade tips when pointing downwards.

Substation: A sub-station will be required to transform the voltage of the electricity generated at the wind turbine to a high voltage suitable for transmission of power ashore. A base case of an offshore substation has been taken forward for assessment; however, there may be an option for an onshore substation subject to detailed engineering design.

Monitoring Mast: A wind monitoring mast will be required to measure wind, wave and current information for operational purposes. The structure will consist of a steel lattice mast and foundation. Anemometry equipment will be installed on the mast and wave and current sensors installed on the foundation structure.

Construction Methods

Foundation Installation: Alternative different construction methodologies were considered for the installation of the wind turbines, wind monitoring mast and offshore substation. Percussive piling techniques have been selected as the most appropriate method of installation for the following reasons:

- **Environmental Impact -** As marine percussive piling has no waste generation associated with these activities compared with bored piling, this method is considered to have better environmental performance.

- **Proven Method -** The typical method to install piles in Hong Kong is through percussive means. Installation for wind turbines through percussive piling is also the most common industry method. Alternatives are considered to either still be in their development stage or in their infancy of testing and implementation. Suction can technology may be viable alternative for installation, however, considering it is yet to be a proven technology in Hong Kong, and has not been employed in other offshore wind farms internationally, the method is not preferred over the more common piled approach.

- **Proven Mitigation** - A series of mitigation measures have been adopted in marine piling works in Hong Kong related to the management of underwater sound impacts related to percussive piling, specifically related to protect marine mammals. Previous projects in Hong Kong have demonstrated that impacts to marine mammals can be avoided and percussive means of piling can be undertaken with favourable environmental performance.

- **Schedule –** Monopile installation using percussive piling methods typically take at most 4 days to install each pile. Subject to the final ground investigation works, it can thus be expected that the installation of the proposed wind farm would take around 4 to 5 months, weather dependent. Bored piling requires drilling of the foundation down to rock level depths to ensure adequate stability of the pile. Installation of each pile would thus take 1.5 to 2 months to install based on local experience, equating to an indicative estimate of 6 years of piling works using a single set of plant, or up to 10 years should restrictions be imposed on construction works, such as closed period during marine mammal peak seasons. Such an increase in duration would result in a prolonged exposure of increased levels of marine traffic and underwater sound generating works in these southern waters and would be deemed to be less preferred on environmental grounds than a construction period of shorter duration.

Subsea Cable Installation: Grab dredging and jetting techniques have been identified as being the preferred method for cable installation. The area of grab dredging is, however, restricted to the nearshore area to the Lamma Power Station Extension to allow for cable landing preparation works. This restriction will assist in reducing the amount of sediment that needs dredging and subsequent offsite disposal. It is also deemed necessary to install cable protection as appropriate where the proposed cable for the wind farm development crosses existing telecommunication cables.

3.3 WATER QUALITY

The potential impacts to water quality caused by construction and operational activities of the offshore wind farm and its components have been assessed in the *EIA Report*. The impacts have been identified and assessed to be in compliance with the criteria and guidelines stated in the *EIAO – TM Annexes 6*

and *14* respectively.

Sensitive receivers potentially affected by construction and operational activities of the proposed wind farm development have been identified and the potential impacts have been evaluated. The key sensitive receivers include finless porpoise, green turtles, the Potential South Lamma Marine Park, commercial fisheries spawning habitat, fish culture zones, ecologically sensitive areas (horseshoe crab habitat and coral communities), beaches (gazetted and non – gazetted) and sea water intakes. The assessment has included the potential impacts caused by marine works (i.e. foundation construction, dredging and jetting) on water quality due to the increases of suspended sediments concentrations, potential decreases of dissolved oxygen and increases of nutrient concentrations, as well as those caused by operational activities such as the alteration of the hydrodynamic regime.

Computational models have been used to simulate the variation in suspended sediments concentration during the construction phase and the impacts due to change in currents resulting from the presence of marine structures during the operation phase.

Potential impacts arising from the proposed dredging works are predicted to be largely confined to the specific works area adjacent to the Lamma Power Station Extension. Modelling results indicate that the SS elevations as a result of grab dredging, jetting and foundation construction are expected to be localised to the mixing zone and largely compliant with the WQO and tolerance criterion at the majority of sensitive receivers. The exception is for isolated colonies of low value coral communities at the Lamma Power Station Extension seawall where through the application of silt curtains during dredging works no unacceptable impacts would be expected to occur. The predicted elevations of suspended sediment concentrations during the construction phase are transient in nature and not predicted to cause significant adverse impacts to water quality at the sensitive receivers.

During the operation phase, unacceptable adverse impacts to water quality are not expected to occur. Hydrodynamic modelling has shown that the wind farm development will have negligible near-field and far-field impacts on current flow and direction as well as flushing capacity at key channels in Hong Kong. There will be little change to existing hydrodynamics, water quality and local erosion and sedimentation patterns.

Unacceptable impacts to water quality sensitive receivers have been further avoided through the adoption of mitigation measures including the siting of the proposed wind farm and submarine cable away from many water quality sensitive receivers, the selection of acceptable working rates for the marine works, construction operational mitigations (i.e. dredging operational measures) and appropriate on-site land based construction activities. No mitigation measures are required during the operational phase.

The identified potential concurrent projects that could lead to cumulative water quality impacts are the marine dumping activities at the South Cheung Chau uncontaminated mud disposal site. Modelling carried out for this Project showed that impacts of the wind farm and submarine cable construction activities are very localised and transient. Sediment does not disperse at appreciable concentrations beyond the works areas. A review of modelling of disposal activities at the South Cheung Chau Disposal Ground shows that sediment plumes would not reach the wind farm area and plumes would not overlap with those generated from the jetting works, should they coincide. It is therefore anticipated that the works proposed for this Project would not lead to potential for increasing the loading of sediments within the wider marine environment that is associated with the uncontaminated mud disposal ground. No significant cumulative impacts associated with water quality are therefore expected.

Unacceptable impacts to water quality sensitive receivers have largely been avoided through the adoption of the following measures:

- *Siting:* A number of locations were studied for the offshore wind farm and the associated cable route, with the principal aim of avoiding direct impacts to sensitive receivers;

- *Reduction in Indirect Impacts:* The offshore wind farm and cable route are located at a sufficient distance from a large number of water quality sensitive receivers so that the dispersion of sediments from the construction works does not affect the receivers at levels of concern (as defined by the WQO and tolerance criterion); and

- *Adoption of Acceptable Working Rates:* The modelling work has demonstrated that the working rates (i.e. 2,500 m^3 day^{-1} for grab dredging; 360 m hr^{-1} for jetting operations) for the operations will not cause unacceptable impacts to the receiving water quality.

Aside from these pro-active measures that have been adopted, a number of operational constraints and good site practice measures for dredging, jetting, construction run-off and other discharges are also recommended (e.g. deployment of silt curtain and closed grab dredgers during dredging, avoidance of spillage of oil, fuel and chemicals, bunding of storage devices on land etc) . No unacceptable residual impacts have been predicted to occur during the construction and operational phases.

Water quality monitoring and auditing is recommended for the construction phase and the specific monitoring requirements are detailed in the *Environmental Monitoring and Audit Manual* (*EM&A Manual*) associated with the *EIA Report*. As no unacceptable impacts have been predicted to occur during the operation of the wind farm, monitoring of impacts to marine water quality during the operational phase is not considered necessary.

3.4 *WASTE MANAGEMENT*

The potential impacts to waste management caused by construction and operational activities of the offshore wind farm have been assessed in the *EIA Report*. The impacts have been identified and assessed to be in compliance with the criteria and guidelines stated in the *EIAO – TM Annexes 7* and *15* respectively.

The key potential impacts during the construction phase are related to waste generated from dredging, seawall removal, site works at the laydown area and excavation/filling of onshore cable trenches. The storage, handling, collection, transport, disposal and/or re-utilisation of these materials and their associated environmental impacts have been the primary focus of the assessment.

It is estimated that a total of approximately 3,000 m^3 of marine sediment will be dredged. These sediments are considered to be uncontaminated and are suitable for Open Sea Disposal and this will be confirmed during the detailed engineering design phase. Up to 2,145 m^3 of existing seawall will be removed and reinstated as part of the works. All excavated material will be stored at the Laydown Area and reused to reinstate the seawall. As such, it is not anticipated that any waste will be generated.

Other wastes produced during the construction phase are of small quantity and will be disposed of according to their nature, avoiding potential adverse impacts. The potential environmental impacts associated with the storage, handling, collection, transport and disposal of waste produced during operational activities have been estimated to be insignificant and will therefore meet the criteria specified in the *EIAO-TM*.

Unacceptable impacts as a result of the waste produced during the construction phase have been avoided through the adoption of specific mitigation measures and in particular through the establishment and implementation of a Waste Management Plan (WMP).

In order to ensure that the construction Contractor(s) has implemented the recommendations of the EIA Report, regular site audits will be conducted of the waste streams, to determine if wastes are being managed in accordance with the approved procedures and the site WMP.

3.5 *TERRESTRIAL ECOLOGY*

The proposed wind farm was studied in detail through a site selection study in order to select a site that avoided to the extent practical, adverse impacts to terrestrial ecology and important habitats for birds, particularly migratory birds or bird species of high ecological value.

A total of 14 identified species were recorded in the Project Site including Aleutian Tern, Ancient Murrelet, Barn Swallow, Black Kite, Black-headed Gull, Black-naped Tern, Black-tailed Gull, Bridled Tern, Common Tern, Heuglin's Gull, Little Tern, Red-necked Phalarope, Whiskered Tern and White-winged Tern, two of which were considered bird species of conservation interest (Black Kite and Ancient Murrelet). In addition, in the wider Study Area a further three bird species of conservation interest were recorded, including White-bellied Sea Eagle, Common Buzzard and Pacific Reef Egret. Most of the birds that are of conservation interest are common and widespread in Hong Kong with the exception of Pacific Reef Egret (uncommon but widespread resident), White-bellied Sea Eagle (uncommon resident) and Ancient Murrelet (scarce winter visitor). The assessment revealed that the Project Site did not provide important foraging grounds for birds.

Potential construction phase impacts to birds may arise from the permanent loss of habitats due to the construction of wind turbine foundation, substation and monitoring mast; temporary disturbance and displacement of birds. The relatively small scale loss of approximately 0.16 ha of open waters within the Project Site is not expected to be significant for bird/migratory bird populations in view of similar habitats in the vicinity and the limited bird use in the area. The direct ecological impact due to the construction of the wind turbine is expected to be low, and will not contribute to any potential cumulative impact.

Barrier effect to bird movement and bird collisions during the operation of the wind farm were assessed. Aleutian Tern, Ancient Murrelet, Barn Swallow, Black Kite, Black-headed Gull, Black-naped Tern, Black-tailed Gull, Bridled Tern, Common Tern, Heuglin's Gull, Little Tern, Red-necked Phalarope, Whiskered Tern and White-winged Tern have utilised the Project Site and therefore are the species that may be affected by the operation of the wind farm. However, these species were recorded in relatively low numbers and most of them were flying below the rotor area. Since the wind farm is not located within important bird habitat or on the flight path of migratory birds, the potential risk of bird collision will be low. In addition, collision risk assessment using the worse case scenario also predicted low number of bird collision. Overall, no adverse residual impacts are envisaged.

A bird monitoring programme will be undertaken to confirm that the construction and operation of the wind turbines will not cause adverse impacts to birds. Monitoring for bird abundance and distribution will be undertaken for one year during the pre-construction phase, one year during the construction phase for the wind turbines and the first year of the operation of the turbines.

3.6 MARINE ECOLOGY

The potential impacts to marine ecology caused by construction and operational activities of the offshore wind farm and its components have been assessed in the *EIA Report*. The impacts have been identified and assessed to be in compliance with the criteria and guidelines stated in the *EIAO – TM Annexes 8* and *16* respectively. The potential direct and indirect impacts to marine ecology assessed include loss of habitats, disturbance to wildlife, disturbance to ecologically sensitive areas and pollution.

Ecologically sensitive receivers have been identified and the potential impacts arising from the construction and operation phases of the offshore wind farm to these have been evaluated. The sensitive receivers include finless porpoise (*Neophocaena phocaenoides*) habitat, green turtle (*Chelonia mydas*) inter-nesting habitat, the Potential South Lamma Marine Park and nearshore sensitive receivers, including coral communities.

Potential construction phase impacts to marine ecological resources, as well as impacts to marine mammals and sea turtles, may arise from the permanent loss of habitat in the footprint of marine structures, disturbances to benthic habitats as a result of jetting and dredging and impacts on intertidal and subtidal habitats during seawall removal.

As impacts arising from the proposed dredging works are predicted to be largely confined to the specific works areas and the predicted elevations of suspended sediment due to the Project are not predicted to cause exceedances of the water quality objectives outside of the mixing zones, adverse impacts to water quality, and hence marine ecological resources or marine mammals and sea turtles, are not anticipated.

Although the loss of 0.16 ha of water column habitat would be an inevitable and adverse consequence of the project, the residual impact is assessed to be acceptable after taking into consideration a number of factors, including the sizable ranges and mobility of affected animals and the fact that the habitat that would be lost is not be considered to be a critical habitat for marine mammal or sea turtles. The area is also subject to considerable disturbance by heavy marine traffic and trawling by fishing vessels.

The loss of 3.6 ha of soft bottom seabed habitat would also be an inevitable and adverse consequence of the project. However, this habitat is considered to be of low conservation value and is not significant in context to the amount of similar habitat available elsewhere in Hong Kong. In addition, the disturbance of approximately 0.99 ha of soft bottom habitat from dredging activities is considered to be of minor significance.

The removal of low ecological value artificial rocky shore as a result of seawall removal activities for cable landing (see *Section 5*) will not lead to unacceptable impacts for subtidal or intertidal ecology. The reinstatement of the seawall with materials that have been removed will mean that there will be no long

term change in the amount of available artificial intertidal and subtidal hard bottom habitat.

Percussive piling has the potential to cause impacts to marine mammals, and to a lesser extent, sea turtles through underwater sound generation. Impacts to noise sensitive species from percussive piling operations associated with wind turbine installations in offshore waters has been shown to be significantly reduced by avoidance of works during peak seasons of finless porpoise, adopting soft-starts procedures and strictly controlled exclusion zones. Through the adoption of such mitigation for the proposed wind farm, i.e. marine mammal / sea turtle exclusion zones, adoption of closed periods for piling works during peak marine mammal season and noting that the wind farm site is away from Sham Wan and not a preferred habitat for sea turtles, no unacceptable impacts on these species are expected to occur.

Operational phase adverse impacts to marine ecological resources are not expected to occur. In particular, unacceptable impacts to marine mammals and sea turtles from the generation of underwater sound levels are not predicted to be of concern. In addition, the wind farm structures, and in particular rock scour material may have the potential to create an artificial reef, which could have beneficial impacts related to food supply for marine mammals.

No unacceptable residual impacts are predicted to marine ecological resources.

During the construction phase of wind turbines, pre-, during and post-installation monitoring of marine mammal abundance, behaviour and distribution, including vessel-based surveys, passive acoustic monitoring and land-based theodolite tracking, will be undertaken. Periodic re-assessment of mitigation measures for marine mammals/ sea turtles and their effectiveness will also be undertaken during these periods.

3.7 FISHERIES

The potential impacts to commercial fisheries caused by construction and operational activities of the proposed offshore wind farm and its components have been assessed in the *EIA Report*. The impacts have been identified and assessed to be in compliance with the criteria and guidelines stated in the *EIAO – TM Annexes 9* and *17* respectively.

Fisheries sensitive receivers have been identified and the potential impacts arising from the construction and operation phases of the offshore wind farm and its components have been evaluated. Potential impacts to fisheries resources and fishing operations may arise from the short term disturbance of marine habitat due to foundation construction, dredging and jetting or through changes to key water quality parameters, as a result of marine works, underwater sound generation, and restriction of fishing activity in proximity

to the marine working areas. Water quality impacts arising from the proposed dredging, jetting and foundation construction works are predicted to be largely confined to the specific works areas and to be temporary in nature. The predicted elevations of suspended sediment concentrations due to the Project are not predicted to exceed the assessment criteria over large areas or at sensitive receivers and they are not expected to cause significant adverse impacts to water quality or to any fishing grounds or species of importance to the fishery. Restriction of access for fishing during construction consists of a small area (500 m from works) and should not significantly affect capture fisheries in the area in the context of similar or better fishing areas elsewhere. In addition, increase in vessel traffic is small in scale and should not pose a significant risk to fishing vessels, particularly given the high levels of marine traffic that currently exist in the area that fishing vessels contend with on a daily basis.

During the operation of the wind farm a total of 700 ha of habitat will be lost to fisheries operations within and adjacent to the turbine array. This represents 0.42% of Hong Kong's territorial waters. No unacceptable impacts associated with the loss of fisheries habitat and fishing ground during construction and operation of the wind farm is expected to be anticipated

Underwater sound generation from marine construction and operation works is not expected to have a significant impact on fisheries resources.

No fisheries-specific mitigation measures are required during the construction or operation activities.

The water quality monitoring programme will provide management actions and supplemental mitigation measures to be employed should impacts arise, thereby ensuring the environmental acceptability of the Project. As impacts to the fisheries resources and fishing operations are small and of short duration, the development and implementation of a monitoring and audit programme specifically designed to assess the effects on commercial fisheries resources is not deemed necessary. In addition, the adoption of appropriate mitigation measures to manage navigational risks will also mean that the risk to fishing vessels would be low.

A Fisheries Review and Consultation Programme will also be implemented prior to the commencement of construction of the wind turbines. The general intention of the FRCP will be to outline, in consultation with the fishery sector, whether there is scope for fishing operations to be conducted within the development area. The FCRP will also aim to explore the possibilities of additional measures/projects to be undertaken within the development area for the enhancement of fisheries resources. If deemed acceptable, a Fisheries Enhancement Plan (FNP) will be developed for the wind farm area.

3.8 *LANDSCAPE AND VISUAL IMPACT*

A Landscape and Visual Impact Assessment has been undertaken for the South West Lamma site in the *EIA Report*. The landscape impacts were identified and some mitigation measures proposed. The residual landscape impacts are:

1. There will be *negligible* residual construction impacts on LCAs 2 Inshore Waters Landscape and LCA 4 Coastal Upland and Hillside Landscape.

2. There will be *slight* un-mitigated construction impacts LCA 3 Industrial Urban Landscape. Approximately 2.78ha of this LCA will be affected during construction, however this area will be fully mitigated with the adoption of the mitigation measures proposed resulting in a *negligible* residual construction impact.

3. There will be *moderate* adverse residual construction impacts on LCA1 Offshore Waters Landscape. Approximately 700ha of this LCA will be lost and cannot be mitigated.

4. There will be *negligible* residual operational impacts on LCAs 2 Inshore Waters Landscape, 3 Industrial Urban Landscape and 4 Coastal Upland and Hillside Landscape. There will be *moderate* adverse residual operational impacts on LCA1 Offshore Waters Landscape.

5. There will be *negligible* residual construction and operation impacts on the following LRs:

    - LR 2 Man made rocky sea-wall. Approximately 0.001ha of this LR will be lost during construction; however this will be fully mitigated with the adoption of the mitigation measures proposed.

    - LR 3 Industrial Area. Approximately 0.02ha of this LR will be lost during construction; however this will be fully mitigated with the adoption of the mitigation measures proposed.

    - LR 4 Soft Landscape areas. Approximately 0.001ha of this LR will be lost during construction; however this will be fully mitigated with the adoption of the mitigation measures proposed.

    - LR 5 Mixed Shrubland. There will be no impacts on this LR.

    - LR 6 Pond. There will be no impacts on this LR.

There will be *slight* residual construction and operation impacts on LR1 Seascape as 0.16ha will be lost and can not be mitigated.

A Visual Impact Assessment was undertaken with several conservative assumptions:

1. Whilst the review of Hong Kong's climatic conditions shows that they will reduce the visibility of the wind farm, clear visibility has been assumed;

2. Based on the analysis of the parameters of human vision, the more conservative limit of view of 15.5km has been adopted, and;

3. Intervening vegetation and buildings have not been considered during the identification of VSRs.

Nineteen VSRs were identified and assessed based on their sensitivity and magnitude of change. Whilst visual mitigation of the wind turbine structures is difficult, four VMM's were proposed, however the ability of these mitigation in reducing the significance threshold of the impacts is limited. The residual impacts identified were as follows:

1. There will be *negligible* residual visual impacts from VSR3 Lamma Ferry Pier, VSR 14 Stanley Waterfront and VSR 15 Wong Nai Chung Gap and Violet Hill.

2. There will be slight residual visual impacts from VSR1 Lamma Island (Hung Shing Ye beach), VSR2 Lo So Shing Beach, VSR4 Ferry to Cheung Chau, VSR 5 Cheung Chau, VSR6 Discovery Bay, VSR 8 Chi Ma Wan Peninsula, VSR 9 Cheung Sha, VSR 10 Lantau Trail, VSR 12 Queen Mary Hospital and Mount Davis, VSR 13 Pok Fu Lam - Pauline Chan Building at HKU, VSR16 Ocean Park, and VSR 18 Penny's Bay.

3. Moderate residual visual impacts have been identified at VSR7 Silvermine Bay (Mui Wo), VSR11 The Peak, VSR 17 Mt Stenhouse and VSR 19 East Lamma Channel.

Visual mitigation measures are proposed that will reduce the severity of these visual impacts. These include tree and shrub planting, relocation of trees and site hoardings. The choice of turbines array layout, turbines colours and blade rotation will also be used to reduce visibility where technically feasible.

According to *Annex 10* of the *Technical Memorandum on the Environmental Impact Assessment Process* (EIAO-TM) the Landscape and Visual Impacts are considered *acceptable with mitigation*.

3.9 *CULTURAL HERITAGE*

The potential impacts to cultural heritage caused by construction and operational activities of the proposed offshore wind farm and its components have been assessed in the *EIA Report*. The impacts have been identified and assessed to be in compliance with the criteria and guidelines stated in the *EIAO – TM Annexes 10* and *19* respectively. The assessment has included a terrestrial and marine archaeological investigation as well as a built heritage investigation.

No declared monuments, graded historic buildings, government historic sites and archaeological sites listed by *AMO* have been identified within or adjacent to the proposed works. One potential marine archaeological site (SC007/57262) was identified from a review of geophysical data. . This site, potentially a shipwreck, is located outside of any area of works and will not be directly or indirectly affected by construction or operation of the wind farm. The avoidance of direct impacts to the shipwreck identified during the geophysical survey will be verified by the Environmental Team and the Independent Environmental Checker through review of the final design prior to the installation of turbines and submarine cable. Designs and subsequent construction works will be checked to ensure that no works will occur within 50 m of the shipwreck.

No marine archaeological sites will be affected by works, and therefore the proposed development imposes no marine archaeological impact and no mitigation measures are considered necessary.

3.10 STAKEHOLDER ENGAGEMENT

HK Electric has conducted consultations and engagement with project stakeholders to hear their views on the project plan while at the same time, addressing their concerns. These stakeholders include representatives from fishermen groups, green groups, District Councillors, Rural Committees Members, government advisory committee Members, various Government Departments, learned institutions, industry practitioners and members of the public. The feedback from these consultations has been considered in the preparation of this EIA Study Report.

Table 3.2 below provides a summary of the Stakeholder Engagement Record detailing the organizations and parties that HK Electric has consulted with regard to the proposed offshore wind farm project.

Table 3.2 Stakeholder Engagement Record

Meeting	Date	Organization
1	24 Apr 2007	Civil Aviation Department officials
2	2 May 2007	Marine Department officials
3	17 Apr 2008	Civil Aviation Department officials
4	29 Apr 2008	Sky Shuttle Limited
5	21 May 2008	Marine Department officials
6	29 May 2008	Agriculture, Fisheries and Conservation Department officials
7	27 Sep 2008	Customer Liaison Group
8	17 Oct 2008	Presentation for 2008 Hong Kong Awards for Industries: Environmental Performance
9	6 Jan 2009	1st International Conference on Applied Energy ICEA '09
10	10 Jan 2009	Customer Liaison Group officials
11	5 May 2009	Civil Aviation Department
12	11 Nov 2009	Chairman and Vice-chairman of Southern District Council
13	11 Nov 2009	Legislative Council member
14	24 Nov 2009	Energy Advisory Committee member
15	25 Nov 2009	Chairman and Vice-chairman of Lamma Island (North) Rural

Meeting	Date	Organization
		Committee Chairman of Lamma Island (South) Rural Committee Islands District Council member
16	25 Nov 2009	CEO of WWF – Hong Kong
17	26 Nov 2009	Representatives of Hong Kong Fishery Alliance Representatives of Hong Kong Fishermen's Association
18	26 Nov 2009	Energy Advisory Committee member
19	2 Dec 2009	CEO of Green Power
20	2 Dec 2009	Islands District Council members
21	16 Dec 2009	Director and Environmental Affairs Manager of Friends of the Earth (Hong Kong)
22	17 Dec 2009	Vice -chairman of The Hong Kong Bird Watching Society
23	25 Jan 2010 (Planned)	Acting Chief Executive of Conservancy Association
24	26 Jan 2010 (Planned)	CEO of Business Environment Council
25	27 Jan 2010 (Planned)	Climate and Energy Campaigners, Greenpeace China

3.11 *ENVIRONMENTAL MONITORING AND AUDIT (EM&A)*

The construction and operation of the proposed offshore wind farm development has been demonstrated in the *EIA Report* to comply with the *EIAO-TM* requirements. Actual impacts during the works will be monitored through a detailed Environmental Monitoring and Audit (EM&A) programme. Full details of the EM&A programme are presented in the *EM&A Manual* for the *EIA Report*. This programme will provide management actions and supplemental mitigation measures to be employed should impacts arise, thereby ensuring the environmental acceptability of the construction and operation of the proposed offshore wind farm development.

3.12 *ENVIRONMENTAL OUTCOMES*

No unacceptable residual impacts have been predicted for the construction and operation of the offshore wind farm or its associated facilities. It must be noted that for all of the components assessed in the *EIA Report*, the assessments and the residual impacts have been shown to be acceptable and in compliance with the relevant assessment standards/criteria of the *EIAO-TM* and its associated *Annexes*.

3.13 *ENVIRONMENTALLY RESPONSIBLE DESIGNS*

The EIA Study has facilitated the integration of environmental considerations into the design process for the Project. One of the key environmental outcomes has been the ability to plan, design and ultimately construct the offshore wind farm so that direct impacts to sensitive receivers are avoided, as far as practically possible. A detailed assessment of alternative sites within

the Study Area has been conducted as well as an assessment of the site layouts and construction methods.

3.14 *ENVIRONMENTAL BENEFITS OF THE PROJECT*

Implementation of the Project will make a contribution to managing emissions of air pollutants and climate change and will provide diversity of fuel supply. The purpose of the proposed project is to utilize wind as source of renewable energy for power generation to supplement fossil fuels, and to make contributions to the improvement of the air quality in Hong Kong.

The operation of the proposed offshore wind farm with an estimated annual generation of around 175GWh electricity would offset approximately:

- Annual use of 62,000T of coal
- Annual emission of 150,000T of carbon dioxide
- Annual emission of 520T of sulphur dioxide
- Annual emission of 240T of nitrogen oxide

The electricity generation from the proposed wind farm would be adequate to meet the consumption for 50,000 families in Hong Kong and is roughly around 1.6% of HK Electric's total electricity sent out in 2008. This is in support of HKSAR Government policy of generating 1 - 2% of electricity output using renewable energy by 2012.