CONTENTS

ANNEXES

6 *WATER QUALITY ASSESSMENT*

6.1 *INTRODUCTION*

This Section of the EIA describes the impacts on water quality by the construction and operation of the proposed LNG terminal and associated facilities. Impacts have been assessed with reference to the relevant environmental legislation, standards and tolerance criteria.

6.2 *LEGISLATIVE REQUIREMENTS AND ASSESSMENT CRITERIA*

The following relevant legislation and associated guidance are applicable to the evaluation of water quality impacts associated with the Project.

- *Water Pollution Control Ordinance (WPCO);*
- *Environmental Impact Assessment Ordinance (Cap. 499. S.16), Technical Memorandum on Environmental Impact Assessment Process (EIAO-TM), Annexes 6 and 14.*

Apart from these statutory requirements, the *Practice Note for Professional Persons, Construction Site Drainage (ProPECC PN 1/94)*, issued by ProPECC in 1994, also provides useful guidance on the management of construction site drainage and the prevention of water pollution associated with construction activities.

6.2.1 *Water Pollution Control Ordinance*

Under the *WPCO*, Hong Kong waters are divided into 10 Water Control Zones (WCZs), each of which has a set of statutory Water Quality Objectives (WQOs) designed to protect the marine environment and its users.

The proposed LNG terminal, water main and submarine cable are within the Southern WCZ. The proposed gas pipeline route is from South Soko within the Southern WCZ, passing through the North Western WCZ, to Black Point within the Outer Deep Bay WCZ (*Figure 6.1*). The applicable WQOs associated with the WCZs are summarised in *Table 6.1*.

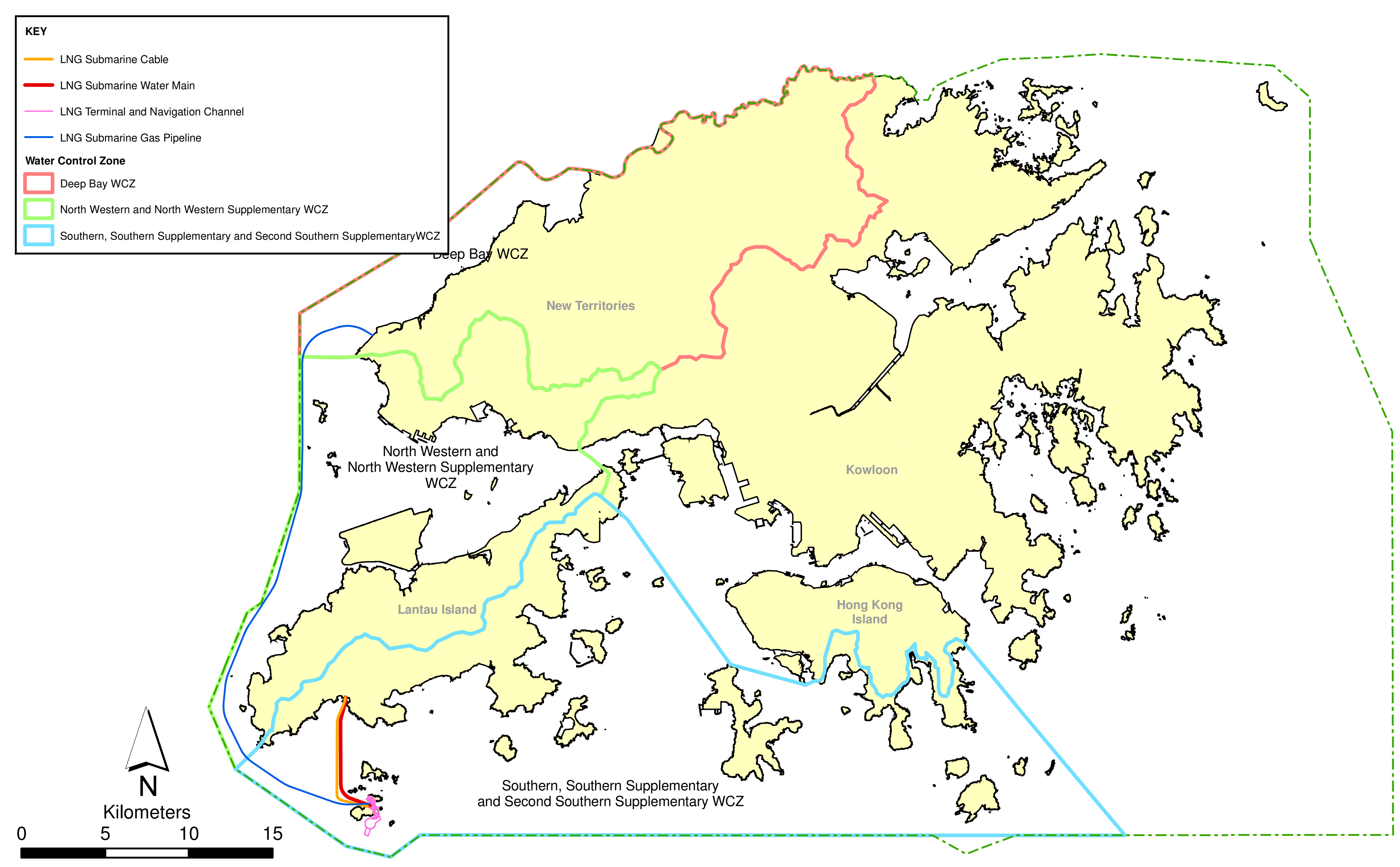

Figure 6.1

The Proposed Pipeline Route and LNG Terminal and the Water Control Zones

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Table 6.1 Water Quality Objectives Applicable to the Study

Water Quality Objective	Deep Bay WCZ	North Western WCZ	Southern WCZ
A. AESTHETIC APPEARANCE			
a) Waste discharges shall cause no objectionable odours or discolouration of the water.	Whole zone	Whole zone (including North Western Supplementary Zone)	Whole zone (including Southern Supplementary Zone and Second Southern Supplementary Zone)
b) Tarry residues, floating wood, articles made of glass, plastic, rubber or of any other substances should be absent.	Whole zone	Whole zone (including North Western Supplementary Zone)	Whole zone (including Southern Supplementary Zone and Second Southern Supplementary Zone)
c) Mineral oil should not be visible on the surface. Surfactants should not give rise to a lasting foam.	Whole zone	Whole zone (including North Western Supplementary Zone)	Whole zone (including Southern Supplementary Zone and Second Southern Supplementary Zone)
d) There should be no recognisable sewage-derived debris.	Whole zone	Whole zone (including North Western Supplementary Zone)	Whole zone (including Southern Supplementary Zone and Second Southern Supplementary Zone)
e) Floating, submerged and semi-submerged objects of a size likely to interfere with the free movement of vessels, or cause damage to vessels, should be absent.	Whole zone	Whole zone (including North Western Supplementary Zone)	Whole zone (including Southern Supplementary Zone and Second Southern Supplementary Zone)
f) Waste discharges shall not cause the water to contain substances which settle to form objectionable deposits.	Whole zone	Whole zone (including North Western Supplementary Zone)	Whole zone (including Southern Supplementary Zone and Second Southern Supplementary Zone)
B. BACTERIA			
a) The level of *Escherichia coli* should not exceed 610 per 100 mL, calculated as the geometric mean of all samples collected in one calendar year..	Secondary Contact Recreation Subzone and Mariculture Subzone	Secondary Contact Recreation Subzone and North Western Supplementary Zone	Secondary Contact Recreation Subzones and Fish Culture Subzones; and Second Southern Supplementary

Water Quality Objective	Deep Bay WCZ	North Western WCZ	Southern WCZ
			Zone
b) The level of *Escherichia coli* should not exceed 180 per 100 mL, calculated as the geometric mean of all samples collected from March to October inclusive in one calendar year. Samples should be taken at least 3 times in a calendar month at intervals of between 3 and 14 days.	Yung Long Bathing Beach Subzone	Bathing Beach Subzone	Bathing Beach Subzones
c) The level of *Escherichia coli* should be less than 1 per 100 mL, calculated as the geometric mean of the most recent 5 consecutive samples taken at intervals of between 7 and 21 days.	-	-	Southern Supplementary Zone
C. DISSOLVED OXYGEN			
a) Waste discharges shall not cause the level of dissolved oxygen to fall below 4 mg per litre for 90% of the sampling occasions during the year; values should be taken at 1 metre below surface.	Inner Marine Subzone excepting Mariculture Subzone	-	-
b) Waste discharges shall not cause the level of dissolved oxygen to fall below 4 mg per litre for 90% of the sampling occasions during the year; values should be calculated as water column average. In addition, the concentration of dissolved oxygen should not be less than 2 mg per litre within 2 metres of the seabed for 90% of the sampling occasions during the year.	Outer Marine Subzone excepting Mariculture Subzone (water column average specified as arithmetic mean of at least 2 measurements at 1 metre below surface and 1 metre above seabed)	Marine Waters (water column average specified as arithmetic mean of at least 3 measurements at 1 metre below surface, mid-depth and 1 metre above seabed); and North Western Supplementary Zone	Marine waters excepting Fish Culture Subzones and Second Supplementary Zone
c) The dissolved oxygen level should not be less than 5 mg per litre for 90% of the sampling occasions during the year; values should be taken at 1 metre below surface.	Mariculture Subzone	-	Fish Culture Subzones
d) Waste discharges shall not cause the level of dissolved	-	-	Inland waters of the Zone and

Water Quality Objective	Deep Bay WCZ	North Western WCZ	Southern WCZ
oxygen to be less than 4 milligrams per litre.			Southern Supplementary Zone
D. pH			
a) The pH of the water should be within the range of 6.5 - 8.5 units. In addition, waste discharges shall not cause the natural pH range to be extended by more than 0.2 units.	Marine waters excepting Yung Long Bathing Beach Subzone	Marine waters (including North Western Supplementary Zone) excepting Bathing Beach Subzones	Beach Subzones; Mui Wo (A), Mui Wo (B), Mui Wo (C), Mui Wo (E), Mui Wo (F) Subzones; and Second Southern Supplementary Zone
b) The pH of the water should be within the range of 6.0 - 9.0 units for 95% of samples. In addition, waste discharges shall not cause the natural pH range to be extended by more than 0.5 units.	Yung Long Bathing Beach Subzone	Bathing Beach Subzones	Bathing Beach Subzones
c) The pH of the water should be within the range of 6.0-9.0 units.	-	-	Mui Wo (D) Sub-zone and other inland waters
d) Human activity should not cause the pH of the water to exceed the range of 6.5-8.5 units.	-	-	Southern Supplementary Zone
E. TEMPERATURE			
Waste discharges shall not cause the natural daily temperature range to change by more than 2.0 °C.	Whole zone	Whole zone (including North Western Supplementary Zone)	Whole zone (including Southern Supplementary Zone and Second Southern Supplementary Zone)
F. SALINITY			
Waste discharges shall not cause the natural ambient salinity level to change by more than 10%.	Whole zone	Whole zone (including North Western Supplementary Zone)	Whole zone (including Southern Supplementary Zone and Second Southern Supplementary Zone)
G. SUSPENDED SOLIDS			
a) Waste discharges shall neither cause the natural ambient level to be raised by 30% nor give rise to accumulation of suspended solids which may adversely affect aquatic	Marine waters	Marine waters (including North Western Supplementary Zone)	Marine waters (including Second Southern Supplementary Zone)

Water Quality Objective	Deep Bay WCZ	North Western WCZ	Southern WCZ
communities.			
b) Waste discharges shall not cause the annual median of suspended solids to exceed 20 milligrams per litre.	-	-	Beach Subzones; Mui Wo (A), Mui Wo (B), Mui Wo (C), Mui Wo (E), Mui Wo (F) Subzones; and Southern Supplementary Zone
c) Waste discharges shall not cause the annual median of suspended solids to exceed 25 milligrams per litre.	-	-	Mui Wo (D) Subzone and other Inland Waters
H. AMMONIA			
The un-ionized ammoniacal nitrogen level should not be more than 0.021 mg per litre, calculated as the annual average (arithmetic mean).	Whole zone	Whole zone (including North Western Supplementary Zone)	Whole zone (including Southern Supplementary Zone and Second Southern Supplementary Zone)
I. NUTRIENTS			
a) Nutrients shall not be present in quantities sufficient to cause excessive or nuisance growth of algae or other aquatic plants.	Inner and Outer marine Subzones	Marine waters (including North Western Supplementary Zone)	Marine waters (including Second Southern Supplementary Zone)
b) Without limiting the generality of objective (a) above, the level of inorganic nitrogen should not exceed 0.1 milligram per litre, expressed as annual water column average (arithmetic mean of at least 3 measurements at 1 metre below surface, mid-depth and metre above seabed).	-	-	Marine waters (including Second Southern Supplementary Zone)
c) Without limiting the generality of objective (a) above, the level of inorganic nitrogen should not exceed 0.3 mg per litre, expressed as annual water column average (arithmetic mean of at least 3 measurements at 1m below surface, mid-depth and 1m above seabed).	-	Castle Peak Bay Subzone	-
d) Without limiting the generality of objective (a) above, the level of inorganic nitrogen should not exceed 0.7 mg per litre,	Inner Marine Subzone	-	-

Water Quality Objective	Deep Bay WCZ	North Western WCZ	Southern WCZ
expressed as annual mean.			
e) Without limiting the generality of objective (a) above, the level of inorganic nitrogen should not exceed 0.5 mg per litre, expressed as annual water column average.	Outer Marine Subzone (water column average specified as arithmetic mean of at least 2 measurements at 1 metre below surface and 1 metre above seabed)	Marine waters (including North Western Supplementary Zone) excepting Castle Peak Bay Subzone (water column average specified as arithmetic mean of at least 3 measurements at 1m below surface, mid-depth and 1m above seabed)	-
J. 5-DAY BIOCHEMICAL OXYGEN DEMAND			
a) Waste discharges shall not cause the 5-day biochemical oxygen demand to exceed 5 milligrams per litre.	Yuen Long & Kam Tin (Lower) Subzone and other inland waters	Inland waters (except the subzones stated in b))	Inland waters of the Zone
b) Waste discharges shall not cause the 5-day biochemical oxygen demand to exceed 3 milligrams per litre.	Yuen Long & Kam Tin (Upper) Subzone, Beas Subzone, Indus Subzone, Ganges Subzone and Water Gathering Ground Subzones	Tuen Mun (A), Tuen Mun (B) and Tuen Mun (C) Subzones and Water Gathering Ground Subzones	Southern Supplementary Zone
K. CHEMICAL OXYGEN DEMAND			
a) Waste discharges shall not cause the chemical oxygen demand to exceed 30 milligrams per litre.	Yuen Long & Kam Tin (Lower) Subzone and other inland waters	Inland waters (except the subzones stated in b))	Inland waters of the Zone
b) Waste discharges shall not cause the chemical oxygen demand to exceed 15 milligrams per litre.	Yuen Long & Kam Tin (Upper) Subzone, Beas Subzone, Indus Subzone, Ganges Subzone and Water Gathering Ground Subzones	Tuen Mun (A), Tuen Mun (B) and Tuen Mun (C) Subzones and Water Gathering Ground Subzones	Southern Supplementary Zone
L. TOXINS			
a) Waste discharges shall not cause the toxins in water to attain such levels as to produce significant toxic, carcinogenic, mutagenic or teratogenic effects in humans, fish or any other aquatic organisms, with due regard to biologically cumulative effects in food chains and to interactions of toxic	Whole zone	Whole zone (including North Western Supplementary Zone)	Southern Supplementary Zone and Second Southern Supplementary Zone

Water Quality Objective	Deep Bay WCZ	North Western WCZ	Southern WCZ
substances with each other.			
b) Waste discharges shall not cause a risk to any beneficial uses of the aquatic environment.	Whole zone	Whole zone (including North Western Supplementary Zone)	Southern Supplementary Zone and Second Southern Supplementary Zone
M. DANGEROUS SUBSTANCES			
a) Waste discharges shall not cause the concentrations of dangerous substances in marine waters to attain such levels as to produce significant toxic effects in humans, fish or any other aquatic organisms, with due regard to biologically cumulative effects in food chains and to toxicant interactions with each other.	-	-	Whole zone
b) Waste discharges of dangerous substances shall not put a risk to any beneficial uses of the aquatic environment.	-	-	Whole zone
N. PHENOLS			
Phenols shall not be present in such quantities as to produce a specific odour, or in concentration greater than 0.05 mg per litre as C_6H_5OH.	Yung Long Bathing Beach Subzone	Bathing Beach Subzones	-
O. TURBIDITY			
Waste discharges shall not reduce light transmission substantially from the normal level.	Yung Long Bathing Beach Subzone	Bathing Beach Subzones	-

6.2.2 *Technical Memorandum Standards for Effluents Discharged into Drainage and Sewerage Systems, Inland and Coastal Waters*

All discharges during both the construction and operational phases of the proposed development are required to comply with the *Technical Memorandum Standards for Effluents Discharged into Drainage and Sewerage Systems, Inland and Coastal Waters (TM)* issued under *Section 21* of the *WPCO*.

The *TM* defines acceptable discharge limits to different types of receiving waters. Under the *TM*, effluents discharged into the drainage and sewerage systems, inshore and coastal waters of the WCZs are subject to pollutant concentration standards for specified discharge volumes. These are defined by the Environmental Protection Department (EPD) and are specified in licence conditions for any new discharge within a WCZ.

The proposed LNG terminal at South Soko will be required to comply with *Table 10a* of the *TM* - *Standards for effluents discharged into the inshore waters of Southern, Mirs Bay, Junk Bay, North Western, Eastern Buffer and Western Buffer Water Control Zones*.

6.2.3 *Technical Memorandum on Environmental Impact Assessment Process (EIAO-TM)*

Annexes 6 and *14* of the *EIAO-TM* provide general guidelines and criteria to be used in assessing water quality impacts.

The *EIAO-TM* recognises that, in the application of the above water quality criteria, it may not be possible to achieve the WQO at the point of discharge as there are areas which are subjected to greater impacts (which are termed by the EPD as the **mixing zones**), where the initial dilution of the discharge takes place. The definition of this area is determined on a case-by-case basis. In general, the criteria for acceptance of the mixing zones are that it must not impair the integrity of the water body as a whole and must not damage the ecosystem.

6.2.4 *Suspended Solids Impacts*

The Water Quality Objective (WQO) for suspended solids in marine waters of the Southern WCZ, the North Western WCZ and the Deep Bay WCZ states that:

> *Waste discharges shall neither cause the natural ambient level to be raised by 30% nor give rise to accumulation of suspended solids, which may adversely affect aquatic communities*

As the proposed submarine pipeline alignment passes through these three WCZs, the impact assessment of the submarine pipeline will be divided between the respective WCZs.

Analysis of EPD routine water quality monitoring data from the years of 1996 to 2006 has been undertaken to determine the allowable increase in suspended solids concentrations within the WCZ. Data have been analysed from EPD monitoring stations that are in the proximity of the proposed works (*Figure 6.2*).

The SS criterion, in accordance with the WQO, at specific sensitive receivers is discussed in *Section 6.3.5*, *Part 2*.

WQO for SS in Deep Bay Water Control Zone

Suspended solids data from EPD monitoring station DM4 and DM5, have been analysed to determine the allowable increase at the sensitive receivers close to the shore approach at Black Point within the outer Deep Bay WCZ. For those sensitive receivers within the inner Deep Bay WCZ, the SS criterion will make reference to station DM4.

WQO for SS North Western Water Control Zone

Suspended solids data from EPD monitoring stations NM5, NM6 and NM8, have been analysed to determine the allowable increase at the sensitive receivers close to relevant sections of the proposed submarine gas pipeline.

WQO for SS Southern Water Control Zone

Suspended solids data from EPD monitoring station SM20 have been analysed to determine the allowable increase at sensitive receivers close to the proposed terminal at South Soko within the Southern WCZ. The SS criteria derived from stations SM13 and SM17 will be used for those respective sensitive receivers near to them.

SS Criterion for Seawater Intakes

The power station intakes have specific requirements for intake water quality. The applicable criteria for the Black Point Power Station and Castle Peak Power Station seawater intakes are temperature between 17 and 32°C and SS levels below 764 mg L^{-1} respectively. It is hence reasonable to adopt an SS assessment criterion of **700 mg L^{-1}** for these two seawater intakes.

There are no particular criteria specified for the industrial intake at Tuen Mun Area 38, the Airport intakes [(1)] and Tai Kwai Wan pumping station intakes and hence the WQO was used as the criteria for these intakes.

The Water Supplies Department (WSD) has a set of standards for the quality of abstracted seawater (*Table 6.2*). Water quality at the Tuen Mun WSD sea water intake has been assessed against these standards, in addition to the WQOs.

(1) It was confirmed with the Airport Authority that the WQOs were suitable to be used as the criterion of the intakes at the Airport.

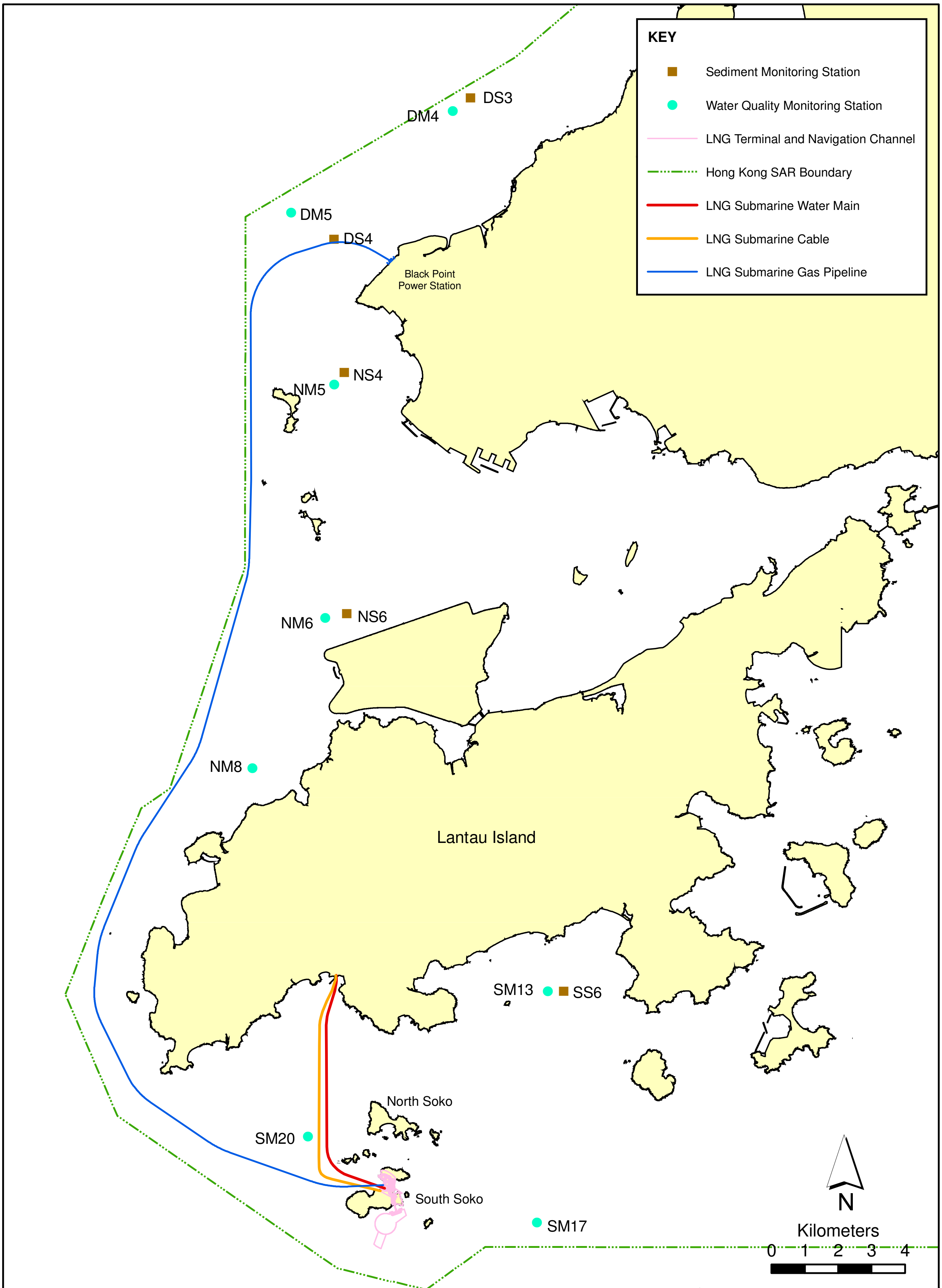

FIGURE 6.2

EPD Routine Water and Sediment Quality Monitoring Stations in the Vicinity of the Proposed LNG Terminal at South Soko and along the Pipeline Route

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Table 6.2 WSD Water Quality Criteria for Abstracted Seawater

Parameter	Criterion
Colour (HU)	< 20
Turbidity (NTU)	< 10
Threshold Odour No.	< 100
Ammoniacal Nitrogen (mg L^{-1})	< 1
Suspended Solids (mg L^{-1})	< 10 (20 is the upper threshold)
Dissolved Oxygen (mg L^{-1})	> 2
5-day Biochemical Oxygen Demand (mg L^{-1})	< 10
Synthetic Detergents (mg L^{-1})	< 5
E. coli (cfu $100mL^{-1}$)	< 20,000

SS Criterion for Fish Culture Zones

There is a general water quality protection guideline for suspended solids (SS), which has been proposed by the AFCD (1). The guideline requires the maximum SS levels to remain below **50 mg L^{-1}**. This criterion has been adopted in approved EIA Reports (2) (3).

SS Criterion for Subtidal Hard Bottom Habitat

There are no established legislative criteria for water quality at subtidal hard bottom habitat (coral). An elevation criterion of **10 mg L^{-1}** in SS has been adopted as the critical value above which impacts to the habitat may occur, as adopted in approved EIA Reports (4).

6.2.5 Sediment Quality

Dredged sediments destined for marine disposal are classified according to a set of regulatory guidelines (*Management of Dredged / Excavated Sediment, ETWBTC No. 34/2002*) issued by the Environment, Transport and Works Bureau (ETWB) in August 2002. These guidelines comprise a set of sediment quality criteria, which include organic pollutants and other substances. The requirements for the marine disposal of sediment are specified in the *ETWBTC No. 34/2002*. Marine disposal of dredged materials is controlled under the *Dumping at Sea Ordinance 1995*.

(1) City University of Hong Kong (2001) Agreement No. CE 62/98, Consultancy Study on Fisheries and Marine Ecological Criteria for Impact Assessment, Final Report, for the Agriculture, Fisheries and Conservation Department, Hong Kong SAR Government.

(2) ERM – Hong Kong, Ltd (2002) EIA for the Proposed Submarine Gas Pipeline from Cheng Tou Jiao Liquefied Natural Gas Receiving Terminal, Shenzhen to Tai Po Gas Production Plank, Hong Kong. Final EIA Report. For the Hong Kong and China Gas Co., Ltd.

(3) Maunsell (2001) EIA for Tai Po Sewage Treatment Works - Stage V. Final EIA Report. For Drainage Services Department, Hong Kong SAR Government.

(4) ERM - Hong Kong Ltd (2002) Op Cit

6.2.6 *Other Assessment Criteria*

Sediment Deposition

In the marine ecological impact assessment, a hard coral species was found at the south western coast of South Soko (see *Part 2 - Sections 6.3* and *6.9*). Impacts to coral communities have also been assessed with regard to sediment deposition. The assessment criterion of **200 g m^{-2} day^{-1}**, has been used in an approved EIA Report [(1)] and has been adopted here. Impacts to artificial reefs (ARs) through deposited sediments have also been assessed using this criterion.

Dissolved Oxygen

The release of sediment contaminants into the water column or the effluent discharge due to the Project may consume the dissolved oxygen (DO) in the receiving water. Oxygen depletion resulting from the dredging operations or the effluent discharge will be assessed against the WQO. The allowable change in DO levels in each WCZ has been calculated based on the EPD routine water quality monitoring data over the period 1996 to 2006.

The assessment criterion for DO, in accordance with the WQO, at each sensitive receiver is discussed in *Section 6.3.5*, *Part 2*.

In addition, the WQO that is specific to Fish Culture Zones is set at no less than **5 mg L^{-1}** measured at 1 m below the water surface (*Table 6.1*).

Dissolved Metals and Organic Compounds

There are no quantitative standards for dissolved metals in the marine waters of Hong Kong. It is thus proposed to make reference to the relevant UK water quality standards [(2)]. This standard has been adopted in the previous approved EIAs, i.e., *EIA for Decommissioning of Cheoy Lee Shipyard at Penny's Bay* [(3)], *EIA for Disposal of Contaminated Mud in the East Sha Chau Marine Borrow Pit* [(4)] and *EIA for Wanchai Development Phase II* [(5)].

Water sampling was conducted and the results showed that the concentrations of the dissolved metals in the marine water column at all sampling stations were found below the reporting limits, with the exception of

(1) ERM – Hong Kong, Ltd (2000) EIA for Construction of an International Theme Park in Penny's Bay of North Lantau together with its Essential Associated Infrastructures - Environmental Impact Assessment. Final EIA Report. For Civil Engineering Department, Hong Kong SAR Government.

(2) Her Majesty's Inspectorate of Pollution (HMIP) (1994). Environmental Economic and BPEO Assessment Principals for Integrated Pollution Control.

(3) Maunsell (2002). EIA for Decommissioning of Cheoy Lee Shipyard at Penny's Bay. For Civil Engineering Department, Hong Kong SAR Government.

(4) ERM – Hong Kong (1997). EIA for Disposal of Contaminated Mud in the East Sha Chau Marine Borrow Pit. For Civil Engineering Department, Hong Kong SAR Government.

(5) Maunsell (2001). EIA for Wanchai Development Phase II - Comprehensive Feasibility Study. For Territory Development Department, Hong Kong SAR Government.

copper. This indicates that the ambient concentrations of these dissolved metals are minimal. For copper, the mean concentration has been calculated based on the water sampling results for each WCZ. *Table 6.3* shows the assessment criteria and the respective allowable increases for dissolved metals due to the Project.

Table 6.3 Summary of Assessment Criteria and the Allowable Increases for Dissolved Metals due to the Project

Parameter	**Assessment Criterion ($\mu g\ L^{-1}$)**	**Ambient Concentration [a] ($\mu g\ L^{-1}$)**	**Allowable Increase ($\mu g\ L^{-1}$)**
Arsenic	25.0	<1	24.5
Cadmium	2.5	<0.5	2.25
Chromium	15.0	<5	12.5
Copper – Deep Bay WCZ	5.0	2.3	2.7
Copper – North Western WCZ	5.0	2.3	2.7
Copper – Southern WCZ	5.0	2.6	2.4
Lead	25.0	<2	24
Mercury	0.3	<0.2	0.2
Nickel	30.0	<2	29.0
Silver	2.3	<1	1.8
Zinc	40.0	<10	35.0
Total PCBs	0.03	-	-
Total PAHs	3.0	-	-
TBT	0.1	-	-
Alpha-BHC	0.0049 [c]	-	-
Beta BHC	0.017 [c]	-	-
Gamma BHC	0.16 [b]	-	-
Delta-BHC	- [d]	-	-
Heptachlor	0.053 [b]	-	-
Aldrin	1.3 [b]	-	-
Heptachlor epoxide	0.053 [b]	-	-
Alpha Endosulfan	0.034 [b]	-	-
p, p'-DDT	0.13 [b]	-	-
p, p'-DDD	0.00031 [c]	-	-
p, p'-DDE	0.00022 [c]	-	-
Endosulfan sulfate	89 [c]	-	-

Notes:

(a) The ambient concentrations were derived from the water sampling results for this project.

(b) The water quality criteria were derived from the USEPA water quality criteria. The Criteria Maximum Concentration (CMC) is an estimate of the highest concentration of a material in surface water to which an aquatic community can be exposed briefly without resulting in an unacceptable effect. CMC is used as the criterion of the respective compounds in this study.

(c) No saltwater criteria for this chlorinated pesticide were defined by USEPA. The water quality criterion to protect human health for the consumption of aquatic organisms is provided for reference.

(d) No water quality criteria for delta-BHC were defined by USEPA.

The water sampling results also showed that the concentrations of the organic compounds were all below the reporting limits. There are no existing regulatory standards or guidelines for total PCBs, total PAHs and TBT in water and hence reference has been made to the USEPA water quality criteria

[1], Australian water quality guidelines [2], and international literature [3], respectively. The assessment criteria for total PCBs, total PAHs and TBT are **0.03 µg L^{-1}**, **3.0 µg L^{-1}** and **0.1 µg L^{-1}**.

Residual Chlorine

As discussed in the *Project Description* (*Section 3*) the water system used to warm up the LNG will require the use of chlorine as an antifoulant. The resultant discharge to the marine environment will contain total residual chlorine. A suggested water quality criterion for total residual chlorine has been proposed by the EPD based on the results of the *Harbour Area Treatment Scheme (HATS) Environmental and Engineering Feasibility Assessment Studies.* The criterion value of 0.01 mg L^{-1} (daily maximum) at the edge of the mixing zone has been chosen as the criterion against which to assess the results from the computer modelling of chlorine dispersion. This is also the criterion adopted in the previously approved EIA for the 1,800 MW Gas-fired Power Station at Lamma Extension [4].

6.3 BASELINE CONDITIONS AND WATER QUALITY SENSITIVE RECEIVERS

6.3.1 Hydrodynamics

In general, long period swell waves generated in the South China Sea propagate into Hong Kong waters, with energy dissipation due to refraction, diffraction, shoaling, wave breaking, bottom friction and shielding due to offshore islands. This results in wave energy reduction inshore of the outer islands and into shallower Hong Kong waters. It also gives Hong Kong a distinctive two peak frequency distribution, where one peak represents offshore swells and the other the shorter period inshore wind-driven waves. The NE Monsoon is generally stronger and more persistent than the SW Monsoon. The highest percentage of strong winds and hence waves are generated from north to southeast.

Current velocities are influenced by the semi-diurnal tidal regime of the South China Sea and the freshwater flows of the Pearl River Estuary during the wet season. The further upstream of the Pearl River Estuary the greater the tidal distortion, shorter floodtide, longer ebb, and the greater the effect of fresh water flows.

(1) United States Environmental Protection Agency (1998). Water Quality Standards, Establishment of Numeric Criteria for Priority Toxic Pollutants; States' Compliance - Revision of Polychlorinated Biphenyls (PCBs) Criteria.

(2) Australian and New Zealand Environment and Conservation Council (1992). Australian Water Quality Guidelines for Fresh and Marine Waters.

(3) Salazar, M.H. and Salazar, S.M. (1996). "Mussels as Bioindicators: Effects of TBT on Survival, Bioaccumulation, and Growth under Natural Conditions" in *Organotin*, edited by M.A. Champ and P.F. Seligman. Chapman & Hall, London.

(4) ERM - Hong Kong, Ltd (1999) EIA for a 1,800 MW Gas-fired Power Station at Lamma Extension. Final EIA Report. For the Hongkong Electric Co., Ltd.

Deep Bay Water Control Zone

The Black Point landing point is surrounded by a shallow and sediment-laden water body in the Outer Deep Bay region between Hong Kong and Shenzhen. Deep Bay has a surface area of approximately 112 km^2 (11,200 ha) with a length of about 15 km and an average depth of 3 m (1). The hydrodynamic regime of the Deep Bay area is unidirectional and the current direction reverses during ebb and flood tides. Tidal flow is dynamic and complex in the Deep Bay areas due to the seasonal influx of freshwater from the Pearl River to the Urmston Road. The Urmston Road is one of the main flow routes into and out of the Pearl River Estuary and carries significant volumes of water on each tide (2).

North Western Water Control Zone

The North Western WCZ is situated at the mouth of the Pearl River Estuary and, as such, is heavily influenced by the freshwater flows from the hinterland. The area shows distinct seasonality as a result of the seasonal influx of freshwater from the Pearl River. The estuarine influence is especially pronounced in the wet summer months when the freshwater flows are greatest and strong salinity and temperature stratification is prominent. During winter months water conditions are more typically marine (with lower nutrient levels and higher DO levels) and salinity and other parameters vary less with depth. Ebb tide currents are towards the southeast where the flood tide currents move to the northwest. Current velocities in areas near to East of Sha Chau have been predicted in previous studies to be less than 2.0 m s^{-1} on the surface and rarely exceeding 0.25 m s^{-1} near seabed (3).

Southern Water Control Zone

Hydrodynamics at South Soko are influenced by the fringing coastal estuarine plume to the west generated by the output from the Pearl River. These are stronger in the summer months when rainfall increases. Tidal currents are moderate at the south-eastern side of South Soko Island relative to the northern-western side. The northern side of the Island is, however, less exposed to the oceanic swells than the southern side of the Island.

The southern waters are also influenced by the semi diurnal tidal regime of the South China Sea and the freshwater flows of the Pearl River Estuary, particularly during the wet season. The southern waters wave climate is mostly determined by the seasonal monsoon winds, typhoon events and the

(1) Scott Wilson (2003). Extension of Existing Landfills and Identification of Potential New Waste Disposal Sites. For the Environmental Protection Department, Hong Kong SAR Government.

(2) ERM-Hong Kong, Ltd (1993). EIA of the Proposed 6000MW Thermal Power Station at Black Point: Key Issue Assessment-Marine Water Quality, Final Report, prepared for Castle Peak Power Company Limited.

(3) ERM-Hong Kong, Ltd (2004) Detailed Site Selection Study for a Proposed Contaminated Mud Disposal Facility within the Airport East/East of Sha Chau Area. Agreement No. CE 12/2002 (EP). Environmental Impact Assessment and Final Site Section Report, for Civil Engineering and Development Department, Hong Kong SAR Government.

coastal geomorphology, which influences the wave trains as they propagate inshore. Long period swell waves generated in the South China Sea propagate into Hong Kong waters, with energy dissipation due to refraction, diffraction, shoaling, wave breaking, bottom friction and shielding due to offshore islands.

6.3.2 *Water Quality*

Water quality has been determined through a review of EPD routine water quality monitoring data collected between 1996 and 2006. This dataset provides Hong Kong's most comprehensive long term water quality monitoring data and provides an indication of temporal and spatial change in marine water quality in Hong Kong.

Deep Bay Water Control Zone

On the basis of the 1996 to 2006 monitoring data, Dissolved Oxygen (DO) levels in Deep Bay the WCZ exhibited a decline from 1996 to 2003 followed by an increase, whereas, Total Inorganic Nitrogen (TIN) and Unionised Ammonia have been increasing over time. An increasing trend of SS levels between 1998 and 2001 is observed; however, between 2002 and 2006 SS levels have been declining. It is noted from reviewing the data for SS that the range of values recorded is high and values up to 62 mg L^{-1} at DM5 and 66 mg L^{-1} at DM4 have been recorded. Water quality within the Deep Bay WCZ is generally compliant with the WQOs. The exception as discussed above has been TIN, the levels of which have exceeded the WQO of < 0.5 mg L^{-1} in all years. The increased levels in *E. coli* have been attributed to discharges from the Pearl River Estuary (*Table 6.4*).

North Western Water Control Zone

The water quality in the North Western WCZ is influenced by effluent discharges from sewage treatment works, such as those at Siu Ho Wan and Pillar Point and Pearl River Delta flows in general. Data collected between 1996 and 2006 indicate that there have been elevations of SS and Unionised Ammonia. A decreasing trend for DO is observed over 1996-2003 and an increase is found afterwards. In terms of compliance with the WQOs, no exceedances have been recorded, with the exception of TIN, which exceeds the WQO of 0.5 mg L^{-1} on a continual basis, particularly at NM5 and NM6 (*Table 6.4*). It is noted from reviewing the data for SS that the range of values recorded is high and values up to 81 mg L^{-1} at NM5 and 73 mg L^{-1} at NM8 have been recorded. Among the mentioned monitoring stations, NM5 recorded the highest geometric mean of *E. coli*, equals to 520 cfu $100mL^{-1}$.

Southern Water Control Zone

Data collected between 1996 and 2006 indicate that there is an increasing trend for DO, Unionised Ammonia and TIN within the Southern WCZ and followed by a decrease since 2004. *E. coli*, has exhibited a decrease since 2002 and *E.*

coli levels in the Southern WCZ are considered to be low in comparison to other stations in Hong Kong. In terms of WQO compliance, only exceedances in TIN (> 0.1 mg L^{-1}) have been recorded consistently over time (*Table 6.4*). It is noted from reviewing the data for SS that the range of values recorded is moderate and values up to 53 mg L^{-1} at SM20, 40 mg L^{-1} at SM17 and 42 mg L^{-1} at SM13 have been recorded.

6.3.3 *Water Quality in the Marine Park*

The Agriculture, Fisheries and Conservation Department (AFCD) commenced a routine water quality monitoring programme in 1999 to collect baseline water quality data from the Sha Chau and Lung Kwu Chau Marine Park. The water quality monitoring results for the Sha Chau and Lung Kwu Chau Marine Park (1999 – 2005) are presented in *Table 6.5*.

It is apparent from the data that the mean values of suspended sediment range between stations from 9.7 to 37.2 mg L^{-1}.

Table 6.4 EPD Water Quality Monitoring Data 1996 - 2006 in the Deep Bay, North Western and Southern Water Control Zones

Water Quality Parameter	Deep Bay WCZ		North Western WCZ			Southern WCZ		
	DM4	DM5	NM5	NM6	NM8	SM13	SM17	SM20
Temperature (ºC)	23.9 (14.4 - 32.8)	23.6 (14.4 - 31.1)	23.4 (15.5 - 30.3)	23.5 (15.1 - 29.8)	23.5 (15.4 - 30.1)	23.5 (15.5 - 29.8)	23.1 (15.6 - 29.8)	23.4 (15.4 - 29.8)
pH	7.9 (6.3 - 9.0)	7.9 (6.2 - 8.7)	8.0 (7.3 - 8.7)	8.1 (6.9 - 8.5)	8.1 (7.4 - 8.7)	8.2 (7.6 - 9.1)	8.1 (7.2 - 9.3)	8.1 (7.6 - 8.9)
Dissolved Oxygen (mg L^{-1}) Depth-averaged	6.0 (0.6 - 10.2)	5.9 (2.6 - 10.0)	5.9 (2.3 - 9.2)	6.4 (3.3 - 11.8)	6.5 (2.7 - 11.7)	6.9 (1.8 - 10.3)	6.6 (2.4 - 10.4)	6.5 (2.3 - 9.9)
Dissolved Oxygen (mg L^{-1}) Bottom	6.1 (2.9 - 10.2)	5.7 (2.6 - 10.0)	5.5 (2.3 - 8.8)	6.3 (3.3 - 11.8)	6.4 (2.7 - 11.7)	6.6 (1.8 - 10.2)	6.1 (2.4 - 10.4)	6.3 (2.3 - 8.6)
Dissolved Oxygen (% sat.) Depth-averaged	82.2 (8.8 - 144.9)	81.2 (37.7 - 136.0)	80.4 (32.7 - 130.0)	87.2 (47.1 - 170.2)	89.8 (40.0 - 166.5)	97.2 (26.9 - 157.8)	92.6 (36.0 - 207.3)	91.5 (32.3 - 147.4)
Dissolved Oxygen (% sat.) Bottom	82.5 (40.1 - 144.9)	79.1 (37.7 - 122.1)	76.1 (32.7 - 110.3)	86.5 (47.1 - 167.4)	88.2 (40.0 - 166.5)	93.3 (26.9 - 156.9)	85.4 (36.0 - 145.6)	88.5 (32.3 - 131.2)
5-day Biochemical Oxygen Demand (mg L^{-1})	1.1 (<0.1 - 3.7)	0.9 (<0.1 - 4.9)	0.8 (<0.1 - 4.1)	0.9 (<0.1 - 4.9)	0.8 (<0.1 - 5.5)	1.0 (<0.1 - 6.7)	0.7 (<0.1 - 4.0)	0.8 (<0.1 - >7.4)
Suspended Solids (mg L^{-1})	14.3 (2.4 - 66.0)	11.1 (1.1 - 62.0)	12.3 (1.6 - 81.0)	9.6 (0.9 - 48.0)	13.3 (1.3 - 73.0)	7.8 (1.0 - 42.0)	6.8 (0.8 - 40.0)	10.0 (1.0 - 53.0)
Total Inorganic Nitrogen (mg L^{-1})	1.02 (0.13 - 2.77)	0.67 (0.14 - 2.46)	0.56 (0.03 - 2.30)	0.51 (0.01 - 1.74)	0.33 (0.01 - 1.80)	0.19 (0.02 - 0.59)	0.14 (0.01 - 0.68)	0.19 (0.01 - 0.87)
Unionised Ammonia (mg L^{-1})	0.012 (0.000 - 0.050)	0.007 (0.000 - 0.028)	0.006 (0.000 - 0.027)	0.005 (0.000 - 0.027)	0.003 (0.000 - 0.016)	0.003 (0.000 - 0.011)	0.002 (0.000 - 0.008)	0.002 (0.000 - 0.009)
Chlorophyll-a (microgram L^{-1})	3.2	2.3	2.5	3.4	3.5	5.0	3.2	4.2

Water Quality Parameter	Deep Bay WCZ		North Western WCZ			Southern WCZ		
	DM4	**DM5**	**NM5**	**NM6**	**NM8**	**SM13**	**SM17**	**SM20**
	(<0.2 - 63.0)	(<0.2 - 49.0)	(<0.2 - 28.0)	(<0.2 - 44.0)	(<0.2 - 50.0)	(<0.2 - 27.0)	(<0.2 - 30.0)	(0.2 - 28.0)
Escherichia coli (cfu $100mL^{-1}$)	222 (2 - 9,500)	408 (4 - 41,000)	520 (4 - 28,000)	27 (<1 - 4,200)	3 (<1 - 270)	3 (<1 - 2,000)	1 (<1 - 200)	1 (<1 - 320)

Notes:

1. Data presented are depth averaged calculated by taking the means of three depths, i.e. surface (S), mid-depth (M) and bottom (B), except as specified.
2. Data presented are annual arithmetic means except for *E. coli*, which are geometric means.
3. Data enclosed in brackets indicate the ranges regardless of the depths.
4. Shaded cells indicate non-compliance with the WQOs.
5. Outliers have been removed.

Table 6.5 Summary of Water Quality in the Sha Chau & Lung Kwu Chau Marine Park (1)

Water Quality Parameter	**Sha Chau and Lung Kwu Chau Marine Park**			
	N Lung Kwu Chau	**N Sha Chau**	**Pak Chau**	**SE Sha Chau**
	(1999 – 2005)	**(1999 – 2000)**	**(1999 – 2005)**	**(1999 – 2000)**
Temperature (°C)	24.1	24.3	24.1	24.3
Salinity (ppt)	24.7	23.9	25.1	25.1
pH	7.9	8.1	7.9	8.1
Dissolved Oxygen (mg L^{-1})	6.2	5.8	6.2	5.8
Turbidity (NTU)	1.1	1.1	1.2	1.3
Suspended Solids (mg L^{-1})	20.3	9.7	37.2	10.0
BOD_5 (mg L^{-1})	1.1	0.8	1.2	0.7
Ammonia Nitrogen (mg L^{-1})	0.2	0.2	0.2	0.2
Unionized Ammonia (mg L^{-1})	0.050	0.029	0.071	0.030
Nitrite Nitrogen (mg L^{-1})	0.29	0.34	0.29	0.33
Nitrate Nitrogen (mg L^{-1})	1.50	3.77	1.38	3.68
Total Inorganic Nitrogen (mg L^{-1})	1.38	0.54	1.31	0.56
Total Kjeldahl Nitrogen (mg L^{-1})	2.26	3.98	2.37	3.81

(1) AFCD (2005). Marine Park Water Quality Report. Web site: www.afcd.gov.hk.

Water Quality Parameter	**Sha Chau and Lung Kwu Chau Marine Park**			
	N Lung Kwu Chau	**N Sha Chau**	**Pak Chau**	**SE Sha Chau**
	(1999 – 2005)	**(1999 – 2000)**	**(1999 – 2005)**	**(1999 – 2000)**
Total Nitrogen (mg L^{-1})	5.18	14.82	5.13	16.21
Orthophosphate Phosphorus (mg L^{-1})	0.27	0.06	0.13	0.05
Total Phosphorus (µg L^{-1})	0.74	0.10	0.65	0.09
Silica (mg L^{-1})	1.02	1.16	1.02	1.10
Chlorophyll-a (µg L^{-1})	2.59	2.59	2.09	2.78
Phaeo-pigment (µg L^{-1})	1.90	1.07	1.81	1.09
E. coli (CFU/100 mL)	343	54	201	58
Faecal Coliforms (CFU/100 mL)	1298	117	1070	114

Notes:
Data presented are mean depth averaged calculated by taking the means of three depths, i.e. surface (S), mid-depth (M) and bottom (B), except as specified.

6.3.4 *Sediment Quality*

EPD Sediment Quality Monitoring

EPD collects sediment quality data as part of the marine water quality monitoring programme. There are five relevant monitoring stations in the vicinity of the proposed South Soko LNG terminal and along the proposed pipeline route, i.e., Station SS6 in the Southern WCZ, Stations NS4 and NS6 in the Northwestern WCZ and Stations DS3 and DS4 in the Deep Bay WCZ. The locations of these stations are shown in *Figure 6.2*. Data for these stations, which were obtained from the EPD, are presented in *Table 6.6*. The data represent the range of values obtained over the period 1996 to 2005. As with the water quality data, this dataset provides Hong Kong's most comprehensive long term sediment quality monitoring data and provides an indication of temporal and spatial change in marine sediment quality in Hong Kong. The values for metals, Polycyclic Aromatic Hydrocarbons (PAHs) and Polychlorinated Biphenyls (PCBs) may also be compared to the relevant sediment quality criteria specified in the *Environment Transport & Works Bureau Technical Circular No 34/2002 Management of Dredged/Excavated Sediment (ETWBTC 34/2002)*.

A comparison of the data with the sediment quality criteria (i.e., Lower Chemical Exceedance Level (LCEL) and Upper Chemical Exceedance Level (UCEL)) shows that the levels of arsenic (expressed in arithmetic mean) for Stations DS3 and DS4 have exceeded the LCEL and they are classified as Category M but neither of them has exceeded the UCEL. Though the maximum values of arsenic recorded at NS4 and NS6 and copper and zinc recorded at DS3 have exceeded the LCELs, their mean values were below the LCELs. The sediments in the Southern WCZ (SS6) were all below the LCEL and this suggests that the sediment quality in the southern Hong Kong waters was the least polluted of the three WCZs.

Ground Investigation Works (1)

In addition to the background data presented above, a ground investigation and marine sediment sampling survey was conducted within the proposed dredging areas at South Soko and those areas associated with the proposed submarine utilities. A combination of grab samples and vibrocore samples was taken. Vibrocore samples were taken down to the proposed dredging depth. The contaminants tested included all of the contaminants stated in *Table 1 - Analytical Methodology* in *Appendix B* of *ETWBTC No 34/2002* plus PCBs and 12 Chlorinated Pesticides.

Tier III biological screening was also performed on samples with one or more contaminant levels exceeding the LCEL and exceeding 10 times the UCEL (2).

(1) Lam Environmental Services (2005). Site Investigation Works from South Soko to Black Point.

(2) LCEL and UCEL are Dredged/Excavated Sediment Quality Criteria for the Classification prescribed under *ETWBTC No 34/2002* and are presented in *Table 7.3*.

The ecotoxicological testing programme featured a suite of tests that include three phylogenetically distinct species (amphipod, polychaete and bivalve larvae) which interact with bedded sediments in different ways. The objective of the bioassays was to determine if there is a potential risk of toxicological impacts from the sediment to the marine biota, and whether there is any difference in the toxicity of the sediment samples taken from the Project site and the reference station (1) .

Based on the results, which are presented in detail in the *Waste Management* section (*Part 2 - Section 7*), metal concentrations exceeding the LCEL (including nickel, lead, arsenic and silver) were found at a locations along the proposed pipeline route and to the south of the South Soko Island. In the areas where the sediment samples failed the biological tests, the sediments were classified for Type 2 disposal (disposal at a confined marine disposal site). At the Urmston Road crossing, i.e., drill no. DC2 (*Part 2 – Figure 7.2*), nickel concentrations in the sediment sample exceeded the UCEL but were within the 10 x LCEL. This sediment sample was classified as Category H (requiring Type 2 confined marine disposal). Next to the Lung Kwu Chau and Sha Chau Marine Park, i.e., drill no. GV16 (*Part 2 – Figure 7.2*), lead concentrations in the sediment sample exceeded the UCEL but also were below the 10 x LCEL and thus was classified as Category H.

Among the sampling stations, GSH6, GSH7 and GSH8 were located near to the EPD sediment monitoring station, DS4. The sediment test results at those stations were generally comparable with EPD routine monitoring data. For other sampling stations, they were remote from the respective EPD sediment monitoring stations and hence no comparison is applicable. In addition, elutriate tests have also been undertaken. The results of the elutriate tests are presented and discussed in *Part 2 – Section 6.6*.

6.3.5 *Water Quality Sensitive Receivers*

The construction and operation phases of the proposed LNG terminal and the installation of the submarine gas pipeline, water main and power cable have the potential to affect local water quality. The Sensitive Receivers (SRs) that may be affected by changes in water quality are identified in accordance with the *EIAO-TM*. For each of the sensitive receivers, established threshold criteria or guidelines have been utilised for establishing the significance of impacts to water quality. The locations of the sensitive receivers are provided in *Figures 6.3* and *6.4*. The shortest distances from the identified water quality sensitive receivers to the proposed LNG terminal and the pipeline route alignment are detailed in *Table 6.7*. A summary of the WQO assessment criteria of SS and DO for each of the sensitive receivers is presented in *Table 6.8* and *Table 6.9* respectively.

(1) Marine sediment samples are collected from a clean area in Port Shelter, New Territories to allow a comparison with sediment from the project site.

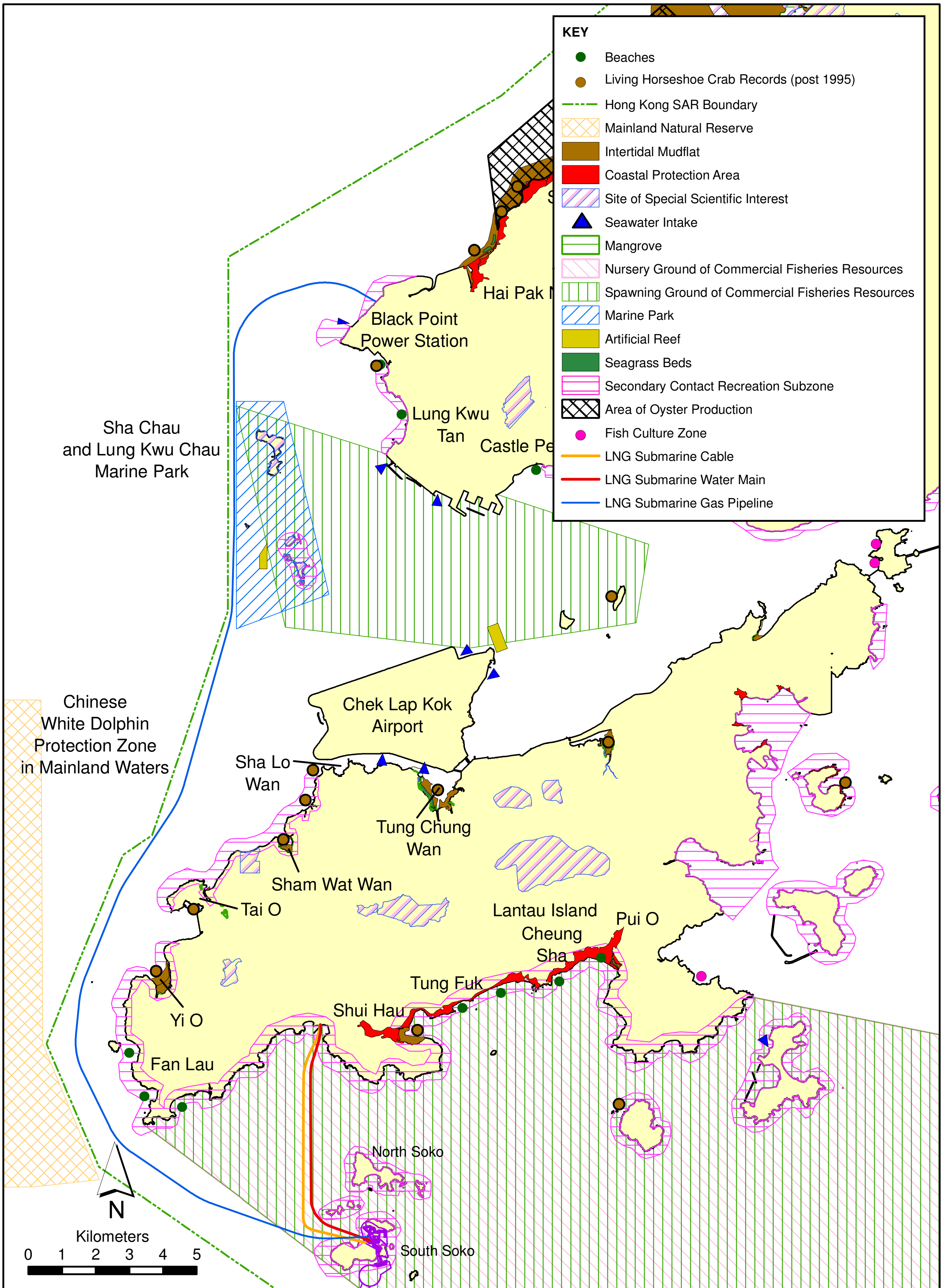

FIGURE 6.3

Surrounding Environment in the Vicinity of the Proposed LNG Terminal at Soko Islands and along the Proposed Pipeline Route

File: EIA/0018180_Wtr_Sen_Recvr.mxd
Date: 27/09/2006

Environmental Resources Management
ERM

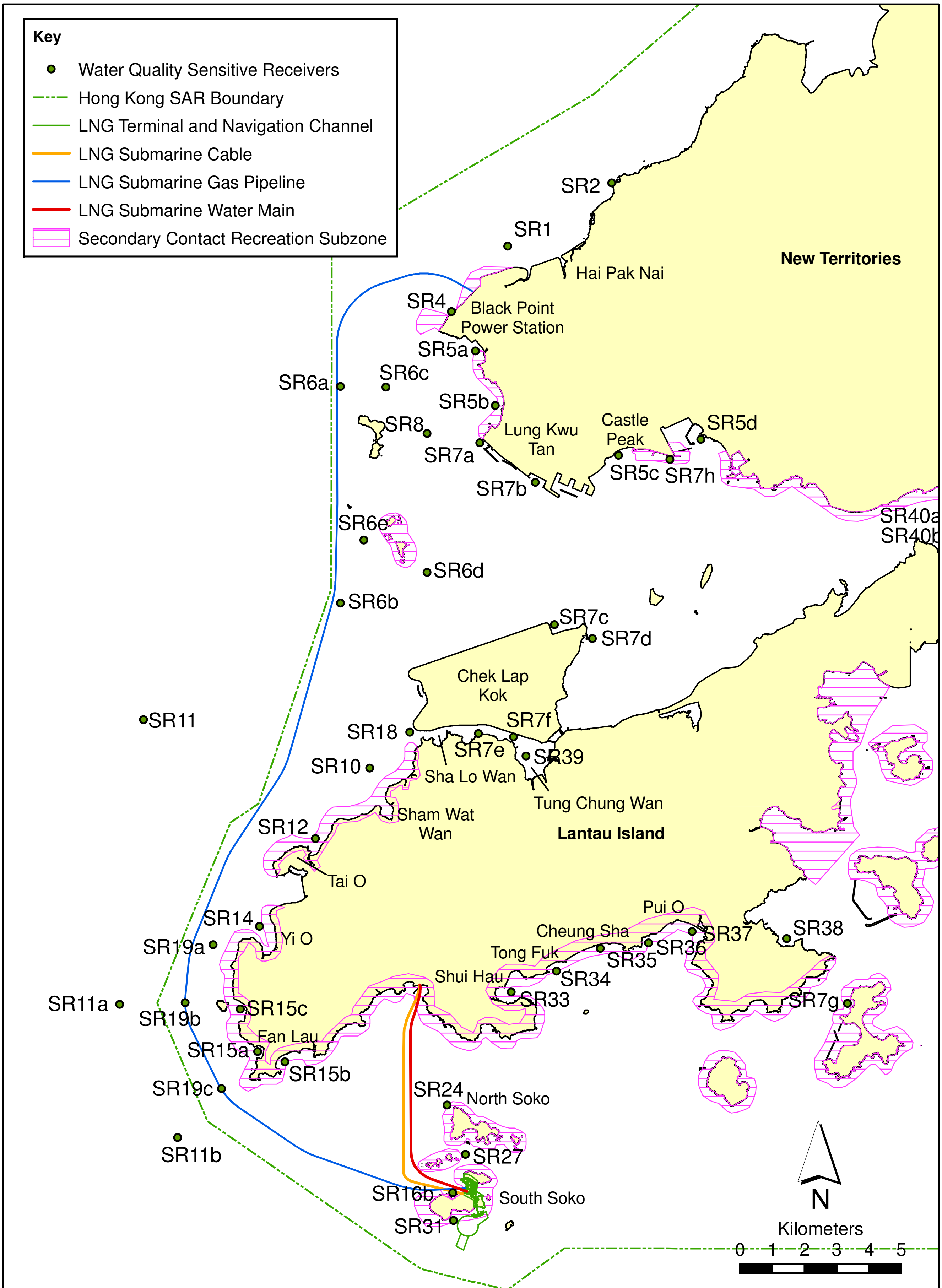

FIGURE 6.4

Water Quality Sensitive Receivers
in the Vicinity of the Proposed LNG Terminal
at South Soko and along the Pipeline Route

File: EIA/0018180_Wtr_Sen_Recvr_2.mxd
Date: 28/11/2006

Environmental
Resources
Management

ERM

Table 6.6 Summary of EPD Sediment Quality Monitoring Data Collected between 1996 and 2005

Parameter	Deep Bay WCZ		North Western WCZ		Southern WCZ	Sediment Quality Criteria	
	DS3	DS4	NS4	NS6	SS6	LCEL	UCEL
COD (mg kg-1)	14,885 (7,700 - 18,000)	14,540 (8,800 - 20,000)	13,635 (6,700 - 19,000)	13,300 (7,400 - 20,000)	9,945 (7,700 - 12,000)	-	-
Total Carbon (% w/w)	0.5 (0.4 - 0.8)	0.6 (0.3 - 1.3)	0.6 (0.3 - 0.8)	0.5 (0.4 - 0.8)	0.5 (0.2 - 0.6)	-	-
Ammonia Nitrogen (mg kg-1)	4.9 (0.2 - 20.0)	6.3 (<0.05 - 36.0)	14.2 (0.2 - 39.0)	4.3 (0.1 - 16.0)	7.8 (0.3 - 21.0)	-	-
TKN (mg kg-1)	316 (150 - 470)	285 (110 - 820)	275 (160 - 530)	269 (140 - 480)	290 (200 - 410)	-	-
Total Phosphorous (mg kg-1)	208 (100 - 320)	165 (77 - 270)	145 (92 - 220)	150 (73 - 260)	191 (130 - 260)	-	-
Total Sulphide (mg kg-1)	44 (2 - 160)	15 (<0.2 - 76)	23 (<0.2 - 77)	6 (<0.2 - 38)	18 (0.2 - 59)	-	-
Arsenic (mg kg-1)	16 (8 - 20)	14 (8 - 19)	12 (9 - 18)	11 (6 - 22)	6 (5 - 8)	12	42
Cadmium (mg kg-1)	0.2 (<0.1 - 0.4)	0.1 (<0.1 - 0.2)	0.1 (<0.1 - 0.2)	0.1 (<0.1 - 0.2)	0.1 (<0.1 - 0.1)	1.5	4
Chromium (mg kg-1)	43 (23 - 53)	32 (14 - 50)	28 (20 - 44)	28 (15 - 45)	23 (16 - 32)	80	160
Copper (mg kg-1)	48 (12 - 77)	26 (6 - 64)	23 (17 - 42)	17 (7 - 34)	12 (8 - 17)	65	110
Lead (mg kg-1)	54 (30 - 69)	40 (18 - 68)	39 (29 - 47)	30 (17 - 49)	26 (22 - 32)	75	110

Parameter	Deep Bay WCZ		North Western WCZ		Southern WCZ	Sediment Quality Criteria	
	DS3	DS4	NS4	NS6	SS6	LCEL	UCEL
Mercury (mg kg-1)	0.12 (<0.05 - 0.18)	0.07 (<0.05 - 0.15)	0.08 (<0.05 - 0.23)	0.06 (<0.05 - 0.15)	0.06 (<0.05 - 0.10)	0.5	1
Nickel (mg kg-1)	28 (14 - 37)	19 (7 - 31)	18 (13 - 30)	18 (9 - 28)	15 (11 - 22)	40	40
Silver (mg kg-1)	0.5 (<0.2 - 0.8)	0.4 (<0.2 - 0.5)	0.4 (<0.2 - 0.5)	0.4 (<0.2 - 0.5)	0.4 (<0.2 - 0.5)	1	2
Zinc (mg kg-1)	145 (69 - 230)	96 (36 - 180)	96 (67 - 110)	74 (34 - 120)	66 (52 - 86)	200	270
Total PCBs (μg kg-1)	18 (18 - 18)	18 (18 - 18)	18 (18 - 18)	18 (18 - 18)	18 (18 - 18)	23	180
Low Molecular Wt PAHs (μg kg-1)	92 (90 - 96)	91 (90 - 94)	92 (90 - 99)	90 (90 - 94)	90 (90 - 90)	550	3,160
High Molecular Wt PAHs (μg kg-1)	83 (29 - 151)	60 (16 - 254)	59 (21 - 139)	29 (16 - 84)	27 (19 - 47)	1,700	9,600

Notes:

1. Data presented in bracket is the minimum and maximum data range of each parameter.
2. Low Molecular Wt PAHs include acenaphthene, acenaphthylene, anthracene, fluoreneand phenanthrene.
3. High Molecular Wt PAHs include benzo[a]anthracene, benzo[a]pyrene, chrysene, dibenzo[a,h]anthracene, fluoranthene, pyrene, benzo[b]fluoranthene, benzo[k]fluoranthene, indeno[1,2,3- c,d]pyrene and benzo[g,h,I]perylene.
4. LCEL = Lower Chemical Exceedance Level
5. UCEL = Upper Chemical Exceedance Level
6. Shaded cells indicate exceedance of LCEL

Table 6.7 Shortest Distance to Sensitive Receivers (SRs) around Proposed LNG Terminal at South Soko and Submarine Pipeline Section from South Soko to Black Point

Sensitive Receiver	Name	ID	Shortest Distance to the LNG terminal	Shortest Distance to the Submarine Water Main[1]	Shortest Distance to the Submarine Cable[1]	Shortest Distance to the Pipeline[1]	Assessment Criteria[2]
Fisheries and Marine Ecological Sensitive Receivers							
Fisheries Resources							
Spawning/ Nursery Grounds	Fisheries Spawning/Nursery Grounds in South Lantau	SR24	2.6 km	1.1 km	1.3 km	2.4 km	Water Quality Objectives (WQO)
		SR27	1.1 km	1.7 km	1.9 km	1.0 km	Water Quality Objectives (WQO)
	Fisheries Spawning Ground in North Lantau	SR8	> 10 km	> 10 km	> 10 km	2.7 km	Water Quality Objectives (WQO)
Artificial Reef Deployment Area	Sha Chau and Lung Kwu Chau	SR6e	> 10 km	> 10 km	> 10 km	< 1 km	• Water Quality Objectives (WQO) • Deposition Rate below 200 gm^{-2} day^{-1}
	Northeast Airport	SR7d	>10 km	> 10 km	> 10 km	7.7 km	• Water Quality Objectives (WQO) • Deposition Rate below 200 gm^{-2} day^{-1}
Fish Fry Habitat	Pak Tso Wan	SR16b	< 1 km	< 1 km	< 1 km	< 1 km	Water Quality Objectives (WQO)
Fish Culture Zone	Cheung Sha Wan FCZ	SR38	> 10 km	> 10 km	> 10 km	> 10 km	Water Quality Objectives (WQO) ; except SS elevation below 50 mgL^{-1}
	Ma Wan	SR40a-b	> 10 km	> 10 km	> 10 km	> 10 km	Water Quality Objectives (WQO); except SS elevation below 50 mgL^{-1}

Sensitive Receiver	Name	ID	Shortest Distance to the LNG terminal	Shortest Distance to the Submarine Water Main[1]	Shortest Distance to the Submarine Cable[1]	Shortest Distance to the Pipeline[1]	Assessment Criteria[2]
Oyster Production Farm	Pak Nai	SR2	> 10 km	> 10 km	> 10 km	5.1 km	Water Quality Objectives (WQO)
Marine Ecological Resources							
Seagrass Beds	Pak Nai	SR2	> 10 km	> 10 km	> 10 km	5.1 km	Water Quality Objectives (WQO)
	Tung Chung Bay	SR39	> 10 km	7.8 km	7.8 km	6.6 km	Water Quality Objectives (WQO)
Marine Park	Designated Sha Chau and Lung Kwu Chau	SR6a	> 10 km	> 10 km	> 10 km	< 1 km	Water Quality Objectives (WQO)
		SR6b	> 10 km	> 10 km	> 10 km	< 1 km	Water Quality Objectives (WQO)
		SR6c	> 10 km	> 10 km	> 10 km	1.4 km	Water Quality Objectives (WQO)
		SR6d	> 10 km	> 10 km	> 10 km	2.7 km	Water Quality Objectives (WQO)
	Potential Southwest Lantau Marine Park	SR19a	> 10 km	6.2 km	6.2 km	< 1 km	Water Quality Objectives (WQO)
		SR19b	> 10 km	6.5 km	6.3 km	< 1 km	Water Quality Objectives (WQO)
		SR19c	7.8 km	5.5 km	5.3 km	< 1 km	Water Quality Objectives (WQO)
Intertidal Mudflats	Pak Nai	SR1	> 10 km	> 10 km	> 10 km	1.7 km	Water Quality Objectives (WQO)
	Yi O	SR14	>10 km	5.6 km	5.1 km	1.7 km	Water Quality Objectives (WQO)
	Shui Hau Wan	SR33	6.6 km	2.9 km	2.1 km	5.9 km	Water Quality Objectives (WQO)
Mangroves	Pak Nai	SR2	> 10 km	> 10 km	> 10 km	5.1 km	Water Quality Objectives (WQO)
	Tung Chung Bay	SR39	> 10 km	7.8 km	7.8 km	6.6 km	Water Quality Objectives (WQO)
	Fan Lau Tung Wan	SR15b	7.05 km	3.9 km	3 km	1.8 km	Water Quality Objectives (WQO)
Horseshoe Crab Nursery Grounds	Pak Nai	SR1	> 10 km	> 10 km	> 10 km	1.7 km	Water Quality Objectives (WQO)
	Sham Wat Wan	SR10	> 10 km	6.9km	6.9 km	2.3 km	Water Quality Objectives (WQO)
	Tai O	SR12	> 10 km	5.7 km	5.7 km	1.9 km	Water Quality Objectives (WQO)
	Yi O	SR14	>10 km	5.6 km	5.1 km	1.6 km	Water Quality Objectives (WQO)

Sensitive Receiver	Name	ID	Shortest Distance to the LNG terminal	Shortest Distance to the Submarine Water Main[1]	Shortest Distance to the Submarine Cable[1]	Shortest Distance to the Pipeline[1]	Assessment Criteria[2]
	Sha Lo Wan	SR18	> 10 km	7.7 km	7.7 km	3.1 km	Water Quality Objectives (WQO)
	Tong Fuk Miu Wan	SR33	6.6 km	2.9 km	2.1 km	5.9 km	Water Quality Objectives (WQO)
	Tung Chung Bay	SR39	> 10 km	7.8 km	7.8 km	6.6 km	Water Quality Objectives (WQO)
Protection Zone	Chinese White Dolphin Protection Zone in Mainland Waters	SR11	>10 km	>10 km	>10 km	4.2 km	Water Quality Objectives (WQO)
		SR11a	>10 km	9.2 km	8.3 km	1.9 km	Water Quality Objectives (WQO)
		SR11b	9.15 km	7.2 km	6. 5 km	1.9 km	Water Quality Objectives (WQO)
Subtidal Hard Bottom Habitat (coral)	Southern Side of South Soko	SR 31	370 m	1 km	1 km	< 1 km	• Water Quality Objectives (WQO) • SS elevations below 10 mg L^{-1} • Deposition rate below 200 g m^{-2} day^{-1}
Water Quality Sensitive Receivers							
Others							
Gazetted Beaches	Butterfly Beach	SR5c	>10 km	>10 km	>10 km	8.1 km	Water Quality Objectives (WQO)
	Tuen Mun Beaches	SR5d	>10 km	>10 km	>10 km	>10 km	Water Quality Objectives (WQO)
	Tong Fuk	SR34	7.8 km	4.4 km	4.4 km	6.9 km	Water Quality Objectives (WQO)
	Upper Cheung Sha Beach	SR35	8.93 km	5.9 km	5.9 km	8.0 km	Water Quality Objectives (WQO)
	Lower Cheung Sha Beach	SR36	9.8 km	7.2 km	7.2 km	8.9 km	Water Quality Objectives (WQO)
	Pui O Wan	SR37	> 10 km	9.8 km	9.8 km	>10 km	Water Quality Objectives (WQO)

Sensitive Receiver	Name	ID	Shortest Distance to the LNG terminal	Shortest Distance to the Submarine Water Main[1]	Shortest Distance to the Submarine Cable[1]	Shortest Distance to the Pipeline[1]	Assessment Criteria[2]
Non-gazetted Beaches	Lung Kwu Sheung Tan	SR5a	> 10 km	> 10 km	> 10 km	4.0 km	Water Quality Objectives (WQO)
	Lung Kwu Tan	SR5b	> 10 km	> 10 km	> 10 km	4.7 km	Water Quality Objectives (WQO)
	Fan Lau Sai Wan	SR15a	7.95 km	4.7 km	3.8 km	1.4 km	Water Quality Objectives (WQO)
	Fan Lau Tung Wan	SR15b	7.05 km	3.9 km	3 km	1.8 km	Water Quality Objectives (WQO)
	Tsin Yue Wan	SR15c	9.0 km	5.4 km	4.5 km	1.6 km	Water Quality Objectives (WQO)
Seawater Intakes	Black Point Power Station	SR4	> 10 km	> 10 km	> 10 km	< 1 km	• Temperature between 17-32 °C • SS elevations less than 700 mg L^{-1}
	Castle Peak Power Station	SR7a	> 10 km	> 10 km	> 10 km	4.1 km	• Temperature between 17-32 °C • SS elevations less than 700 mg L^{-1}
	Tuen Mun Area 38	SR7b	>10 km	> 10 km	> 10 km	5.8 km	Water Quality Objectives (WQO)
	Tuen Mun Flushing Water	SR 7h	>10 km	> 10 km	> 10 km	9.67 km	WSD Water Quality Standards
	Airport	SR7c	>10 km	> 10 km	> 10 km	6.4 km	Water Quality Objectives (WQO)
		SR7d		> 10 km	> 10 km	7.7 km	
		SR7e		8.1 km	8.1 km	5.1 km	
		SR7f		8.1 km	8.1 km	6.1 km	
	Pumping Station at Tai Kwai Wan	SR7g	>10 km	> 10 km	> 10 km	> 10 km	Water Quality Objectives (WQO)

Notes:
1. Distances are approximate and will depend on the final design of the alignment of the submarine utilities which will be determined during the detailed design stage.
2. Refer to next two tables for the details of the WQO criteria for SS and DO at each station.

Table 6.8 Ambient Level and WQO Allowable Increase in SS at Sensitive Receivers (SRs) around Proposed LNG Terminal at South Soko and Submarine Pipeline from South Soko to Black Point

Sensitive Receiver	Name	ID	Respective EPD Monitoring Station	Relevant Depth	Suspended Solids (mg L^{-1})					
					Annual		Dry		Wet	
					Ambient Level	WQO Allowable Increase	Ambient Level	WQO Allowable Increase	Ambient Level	WQO Allowable Increase
Fisheries and Marine Ecological Sensitive Receivers										
Fisheries Resources										
Spawning/Nursery Grounds	Fisheries Spawning/Nursery Grounds in South Lantau	SR24, 27	SM20	Depth-averaged	22.2	6.7	23	6.9	18.3	5.5
	Fisheries Spawning Ground in North Lantau	SR8	NM5	Depth-averaged	23.2	7	27.2	8.2	18.6	5.6
Artificial Reef Deployment Area	Sha Chau and Lung Kwu Chau	SR6e	NM5	Depth-averaged	23.2	7	27.2	8.2	18.6	5.6
	Northeast Airport	SR7d	NM3	Depth-averaged	17	5.1	15.6	4.7	17.4	5.2
Fish Fry Habitat	Pak Tso Wan	SR16b	SM20	Depth-averaged	22.2	6.7	23	6.9	18.3	5.5
Fish Culture Zone	Cheung Sha Wan	SR38	NM3	Depth-averaged	17	N/A	15.6	N/A	17.4	N/A
	Ma Wan	SR40a, 40b	SM13	Depth-averaged	15.7	N/A	15.8	N/A	13.1	N/A
Oyster Production Farm	Pak Nai	SR2	DM4	Surface [4]	21.7	6.5	23.6	7.1	12	3.6
Marine Ecological Resources										
Seagrass Beds	Pak Nai	SR2	DM4	Surface [4]	21.7	6.5	23.6	7.1	12	3.6
	Tung Chung Bay	SR39	NM8	Surface [4]	17.5	5.3	21.5	6.5	12	3.6

Sensitive Receiver	Name	ID	Respective EPD Monitoring Station	Relevant Depth	Suspended Solids (mg L^{-1})					
					Annual		Dry		Wet	
					Ambient Level	WQO Allowable Increase	Ambient Level	WQO Allowable Increase	Ambient Level	WQO Allowable Increase
Marine Park	Designated Sha Chau and Lung Kwu Chau	SR6a-d	NM5	Depth-averaged	23.2	7	27.2	8.2	18.6	5.6
	Potential Southwest Lantau	SR19a-c	NM8	Depth-averaged	28.3	8.5	29.7	8.9	21.7	6.5
Intertidal Mudflats	Pak Nai	SR1	DM4	Surface [4]	21.7	6.5	23.6	7.1	12	3.6
	Yi O	SR14	NM8	Surface [4]	17.5	5.3	21.5	6.5	12	3.6
	Shui Hau Wan	SR33	SM13	Surface [4]	12	3.6	13	3.9	8.3	2.5
Mangroves	Pak Nai	SR2	DM4	Surface [4]	21.7	6.5	23.6	7.1	12	3.6
	Tung Chung Bay	SR39	NM8	Surface [4]	17.5	5.3	21.5	6.5	12	3.6
	Fan Lau Tung Wan	SR15b	SM20	Surface [4]	14	4.2	15	4.5	10	3
Horseshoe Crab Nursery Grounds	Pak Nai	SR1	DM4	Depth-averaged	32.4	9.7	32.2	9.7	19.9	6
	Sham Wat Wan	SR10	NM8	Depth-averaged	28.3	8.5	29.7	8.9	21.7	6.5
	Tai O	SR12	NM8	Depth-averaged	28.3	8.5	29.7	8.9	21.7	6.5
	Yi O	SR14	NM8	Depth-averaged	28.3	8.5	29.7	8.9	21.7	6.5
	Sha Lo Wan	SR18	NM6	Depth-averaged	20.8	6.2	25.9	7.8	16	4.8
	Tong Fuk Miu Wan	SR33	SM13	Depth-averaged	15.7	4.7	15.8	4.8	13.1	3.9
	Tung Chung Bay	SR39	NM8	Depth-averaged	28.3	8.5	29.7	8.9	21.7	6.5
Protection Zone	Chinese White Dolphin Protection Zone in Mainland	SR11, 11a-b	NM8	Depth-averaged	28.3	8.5	29.7	8.9	21.7	6.5

Sensitive Receiver	Name	ID	Respective EPD Monitoring Station	Relevant Depth	Suspended Solids (mg L-1)					
					Annual		Dry		Wet	
					Ambient Level	WQO Allowable Increase	Ambient Level	WQO Allowable Increase	Ambient Level	WQO Allowable Increase
	Waters									
Others										
Gazetted Beaches	Butterfly Beach	SR5c	NM5	Depth-averaged	23.2	7	27.2	8.2	18.6	5.6
	Tuen Mun Beaches	SR5d	NM3	Depth-averaged	17	5.1	15.6	4.7	17.4	5.2
	Tong Fuk	SR34	SM13	Depth-averaged	15.7	4.7	15.8	4.8	13.1	3.9
	Upper Cheung Sha Beach	SR35	SM13	Depth-averaged	15.7	4.7	15.8	4.8	13.1	3.9
	Lower Cheung Sha Beach	SR36	SM13	Depth-averaged	15.7	4.7	15.8	4.8	13.1	3.9
	Pui O Wan	SR37	SM13	Depth-averaged	15.7	4.7	15.8	4.8	13.1	3.9
Non-gazetted Beaches	Lung Kwu Sheung Tan	SR5a	NM5	Depth-averaged	23.2	7	27.2	8.2	18.6	5.6
	Lung Kwu Tan	SR5b	NM5	Depth-averaged	23.2	7	27.2	8.2	18.6	5.6
	Fan Lau Sai Wan	SR15a	SM20	Depth-averaged	22.2	6.7	23	6.9	18.3	5.5
	Fan Lau Tung Wan	SR15b	SM20	Depth-averaged	22.2	6.7	23	6.9	18.3	5.5
	Tsin Yue Wan	SR15c	SM20	Depth-averaged	22.2	6.7	23	6.9	18.3	5.5
Seawater Intakes	Tuen Mun Area 38	SR7b	NM3	Bottom	51	15.3	47.4	14.2	32.8	9.8

Sensitive Receiver	Name	ID	Respective EPD Monitoring Station	Relevant Depth	Suspended Solids (mg L^{-1})					
					Annual		Dry		Wet	
					Ambient Level	WQO Allowable Increase	Ambient Level	WQO Allowable Increase	Ambient Level	WQO Allowable Increase
	Airport	SR7c-f	NM6	Bottom	25.5	7.7	29.6	8.9	29.4	8.8
	Pumping Station at Tai Kwai Wan	SR7g	SM17	Bottom	26	7.8	25	7.5	26.2	7.9
	Tuen Mun WSD [5]	SR7h	NM3	Bottom	51	N/A	47.4	N/A	32.8	N/A

Notes:

1. Ambient level is calculated as 90th percentile of the EPD routine monitoring data (1996-2006) at respective EPD station close to the WSRs.
2. Allowable increase is calculated as 30% of the ambient SS levels in accordance with the WQO.
3. This table is applicable for those sensitive receivers which were assessed against the WQO. "N/A" denotes that the WQO is not applicable for the assessment and it should refer to *Section 6.2.4* for the specific assessment criterion of SS for the other sensitive receivers.
4. These intertidal sensitive receivers occur at the water surface and are in fact completely unsubmerged for a substantial proportion of the time. Tidal range in Hong Kong is 2.5 m and this is the maximum depth these sensitive receivers would be submerged during the tidal cycle. It is considered that water quality reflecting surface conditions is appropriate for these periodically submerged sensitive receivers.
5. Seawater is abstracted via a box culvert of 1.38 m height situating at the seabed.

Table 6.9 Ambient Level and Allowable Increase in DO at Sensitive Receivers (SRs) around Proposed LNG Terminal at South Soko and Submarine Pipeline from South Soko to Black Point

Sensitive Receiver	Name	ID	Respective EPD Monitoring Station	Relevant Depth	Dissolved Oxygen (mg L-1)					
					Annual		Dry		Wet	
					Ambient Level	Allowable Change	Ambient Level	Allowable Change	Ambient Level	Allowable Change
Fisheries and Marine Ecological Sensitive Receivers										
Fisheries Resources										
Spawning/Nursery Grounds	Fisheries Spawning/Nursery Grounds in South Lantau	SR24, 27	SM20	Depth-averaged	8	-4	8.2	-4.2	7.8	-3.8
	Fisheries Spawning Ground in North Lantau	SR8	NM5	Depth-averaged	8	-4	7.9	-3.9	6.8	-2.8
Artificial Reef Deployment Area	Sha Chau and Lung Kwu Chau	SR6e	NM5	Depth-averaged	8	-4	7.9	-3.9	6.8	-2.8
	Northeast Airport	SR7d	NM3	Depth-averaged	5.8	-1.8	6.6	-2.6	5.2	-1.2
Fish Fry Habitat	Pak Tso Wan	SR16b	SM20	Depth-averaged	8	-4	8	-4	7.9	-3.9
Fish Culture Zone	Cheung Sha Wan	SR38	SM13	Depth-averaged	8	-3	7.8	-2.8	8.5	-3.5
	Ma Wan	SR40a-b	NM3	Depth-averaged	5.8	-0.8	6.6	-1.6	5.2	-0.2
Oyster Production Farm	Pak Nai	SR2	SM20	Surface [5]	7.6	-3.6	7.6	-3.6	7.3	-3.3
Marine Ecological Resources										
Seagrass Beds	Pak Nai	SR2	DM4	Surface [5]	7.6	-3.6	7.6	-3.6	7.3	-3.3
	Tung Chung Bay	SR39	NM8	Surface [5]	7.9	-3.9	8	-4	7.9	-3.9
Marine Park	Designated Sha Chau and Lung Kwu Chau	SR6a-d	NM5	Depth-averaged	8	-4	7.9	-3.9	6.8	-2.8

Sensitive Receiver	Name	ID	Respective EPD Monitoring Station	Relevant Depth	Dissolved Oxygen (mg L^{-1})					
					Annual		Dry		Wet	
					Ambient Level	Allowable Change	Ambient Level	Allowable Change	Ambient Level	Allowable Change
	Potential Southwest Lantau	SR19a-c	NM8	Depth-averaged	7.9	-3.9	8.0	-4.0	7.9	-3.9
Intertidal Mudflats	Pak Nai	SR1	DM4	Surface [5]	7.6	-3.6	7.6	-3.6	7.3	-3.3
	Yi O	SR14	NM8	Surface [5]	7.9	-3.9	8.0	-4.0	7.9	-5.1
	Shui Hau Wan	SR33	SM13	Surface [5]	8.4	-4.4	7.8	-3.8	9.1	-5.1
Mangroves	Pak Nai	SR2	DM4	Surface [5]	7.6	-3.6	7.6	-3.6	7.3	-3.3
	Yi O	SR14	NM8	Surface [5]	7.9	-3.9	8	-4.0	7.9	-3.9
	Shui Hau Wan	SR33	SM13	Surface [5]	8.4	-4.4	7.8	-3.8	9.1	-5.1
Horseshoe Crab Nursery Grounds	Pak Nai	SR1	DM4	Depth-averaged	7.5	-3.5	7.6	-3.6	7.3	-3.3
	Sham Wat Wan	SR10	NM8	Depth-averaged	7.9	-3.9	8.0	-4.0	7.9	-3.9
	Tai O	SR12	NM8	Depth-averaged	7.9	-3.9	8.0	-4.0	7.9	-3.9
	Yi O	SR14	NM8	Depth-averaged	7.9	-3.9	8.0	-4.0	7.9	-3.9
	Sha Lo Wan	SR18	NM6	Depth-averaged	8.1	-4.1	8.1	-4.1	8.0	-4.0
	Tong Fuk Miu Wan	SR33	SM13	Depth-averaged	8.0	-4.1	7.8	-3.8	8.5	-4.5
	Tung Chung Bay	SR39	NM8	Depth-averaged	7.9	-3.9	8.0	-4.0	7.9	-3.9
Protection Zone	Chinese White Dolphin Protection Zone in Mainland Waters	SR11, 11a-b	NM8	Depth-averaged	7.9	-3.9	8.0	-4.0	7.9	-3.9
Subtidal Hard Bottom Habitat (coral)	Southern Side of South Soko	SR31	SM20	Depth-averaged	8.0	-4.0	8.0	-4.0	7.9	-3.9

Water Quality Sensitive Receivers

Sensitive Receiver	Name	ID	Respective EPD Monitoring Station	Relevant Depth	Dissolved Oxygen (mg L^{-1})					
					Annual		Dry		Wet	
					Ambient Level	Allowable Change	Ambient Level	Allowable Change	Ambient Level	Allowable Change
Others										
Gazetted Beaches	Butterfly Beach	SR5c	NM5	Depth-averaged	8.0	-4.0	7.9	-3.9	6.8	-2.8
	Tuen Mun Beaches	SR5d	NM3	Depth-averaged	5.8	-1.8	6.6	-2.6	5.2	-1.2
	Tong Fuk	SR34	SM13	Depth-averaged	8.0	-4.1	7.8	-3.8	8.5	-4.5
	Upper Cheung Sha Beach	SR35	SM13	Depth-averaged	8.0	-4.1	7.8	-3.8	8.5	-4.5
	Lower Cheung Sha Beach	SR36	SM13	Depth-averaged	8.0	-4.1	7.8	-3.8	8.5	-4.5
	Pui O Wan	SR37	SM13	Depth-averaged	8.0	-4.1	7.8	-3.8	8.5	-4.5
Non-gazetted Beaches	Lung Kwu Sheung Tan	SR5a	NM5	Depth-averaged	8.0	-4.0	7.9	-3.9	6.8	-2.8
	Lung Kwu Tan	SR5b	NM5	Depth-averaged	8.0	-4.0	7.9	-3.9	6.8	-2.8
	Fan Lau Sai Wan	SR15a	SM20	Depth-averaged	8.0	-4.0	8.0	-4.0	7.9	-3.9
	Fan Lau Tung Wan	SR15b	SM20	Depth-averaged	8.0	-4.0	8.0	-4.0	7.9	-3.9
	Tsin Yue Wan	SR15c	SM20	Depth-averaged	8.0	-4.0	8.0	-4.0	7.9	-3.9
Seawater Intakes	Black Point Power Station	SR4	DM5	Bottom	7.3	-5.3	7.7	-5.7	6.5	-4.5
	Castle Peak Power Station	SR7a	NM5	Bottom	8.0	-6.0	7.6	-5.6	6.2	-4.2
	Tuen Mun Area 38	SR7b	NM5	Bottom	8.0	-6.0	7.6	-5.6	6.2	-4.2
	Airport	SR7c-f	NM6	Bottom	8.2	-6.2	8.3	-6.3	7.6	-5.6
	Pumping Station at Tai Kwai Wan	SR7g	SM17	Bottom	8.0	-6.0	8.0	-6.0	7.9	-5.9

Sensitive Receiver	Name	ID	Respective EPD Monitoring Station	Relevant Depth	Dissolved Oxygen (mg L^{-1})					
					Annual		Dry		Wet	
					Ambient Level	Allowable Change	Ambient Level	Allowable Change	Ambient Level	Allowable Change
	Tuen Mun WSD [4]	SR7h	NM3	Bottom	5.6	3.6	6.7	4.7	4.7	2.7

Notes:

1. Ambient level is calculated as 90th percentile of the EPD routine monitoring data (1996-2006) at respective EPD station close to the WSRs.
2. For depth-averaged, surface layer and middle layer, allowable change is calculated as WQO criterion of 4 mg L^{-1} minus the ambient level.
3. For bottom layer, allowable change is calculated as WQO criterion of 2 mg L^{-1} minus the ambient level.
4. Tuen Mun WSD intake has a DO criterion of more than 2 mg L^{-1}. Seawater is abstracted via a box culvert of 1.38 m height situating at the seabed.
5. These intertidal sensitive receivers occur at the water surface and are in fact completely unsubmerged for a substantial proportion of the time. Tidal range in Hong Kong is 2.5 m and this is the maximum depth these sensitive receivers would be submerged during the tidal cycle. It is considered that water quality reflecting surface conditions is appropriate for these periodically submerged sensitive receivers.

Fisheries Resources

The following fisheries resources have been identified as water quality sensitive receivers:

- Commercial Fisheries Spawning Grounds/Nursery Areas;
- Artificial Reef Deployment Sites;
- Fish Culture Zone; and
- Oyster Production.

Brief descriptions of these sensitive receivers are presented below.

Commercial Fisheries Spawning Grounds/Nursery Areas

The waters of South Lantau and Northwest Lantau have been identified as important fisheries spawning/nursery grounds for commercial fisheries in Hong Kong (1). A recent study has shown that the marine waters near Pak Tso Wan in South Soko support fish fry and hence this beach has been identified as a sensitive receiver (2). Recent findings from ichthyoplankton and fish fry baseline survey undertaken as part of this EIA have indicated that the waters at Pak Tso Wan do not appear to support fish fry abundances that are significantly different to other sites in Hong Kong (see *Part 2 – Section 10: Fisheries Impact Assessment* for further details).

To date there are no legislated water quality standards for spawning and nursery grounds in Hong Kong. Guideline values have been identified for fisheries and selected marine ecological sensitive receivers as part of the AFCD study, *Consultancy Study on Fisheries and Marine Ecological Criteria for Impact Assessment*. (3) The AFCD study recommends a maximum SS concentration of 50 mg L^{-1}. Although a maximum concentration value is recommended, the study acknowledges that site-specific data should be considered on a case-by-case basis and hence the WQOs are adopted in this Study as the assessment criteria for the grounds.

With regard to the water quality modelling, impacts to these and other transitory or mobile sensitive receivers were not plotted as discrete points, rather, an assessment of potential impacts was undertaken through a review of the modelling results and is discussed separately in the *Fisheries Impact Assessment* (*Part 2 - Section 10*).

(1) ERM-Hong Kong, Ltd (1998). Fisheries Resources and Fishing Operations in Hong Kong Waters. Final Report. For the Agriculture, Fisheries and Conservation Department, Hong Kong SAR Government.

(2) Shin P.K.S. & Cheung S.G. (2004) A Study of Soft Shore Habitats in Hong Kong for Conservation and Education Purposes: Revised Final Report.

Artificial Reef Deployment Sites

There are two gazetted Artificial Reef Deployment Sites (ARs):

- the Sha Chau and Lung Kwu Chau AR site (situated within the Sha Chau and Lung Kwu Chau Marine Park); and
- the Airport AR site (located at the northeast of the Hong Kong International Airport) (*Figure 6.3*).

The Sha Chau and Lung Kwu Chau AR site and the Airport AR site are approximately 0.8 km and 8.3 km from proposed pipeline alignment, respectively. The ARs have been deployed to act as a fisheries resource enhancement tool, to encourage growth and development of a variety of marine organisms, and to provide feeding opportunities for the Indo-Pacific Humpback Dolphin (see *Part 2 - Section 9: Marine Ecology Assessment*).

There is no specific water quality criterion for the AR sites, thus the WQOs were adopted as assessment criteria.

AR sites were treated as discrete assessment points in the model.

Fish Culture Zones

There are two fish culture zones (FCZs), which are Ma Wan North and East and Cheung Sha Wan, located within the North Western waters and the Southern waters, respectively. These FCZs are each over 10 km from the proposed terminal and pipeline. The only Water Quality Objective (WQO) that is specific to FCZs is for dissolved oxygen, which is set at no less than 5 mg L^{-1}. In addition to dissolved oxygen, there is a general water quality protection guideline for suspended solids (SS), which has been proposed by AFCD. The guideline requires that the SS levels remain below 50 mg L^{-1}.

With regard to the water quality modelling, the FCZs were regarded as discrete points for evaluation in the assessment against the above criterion and guideline.

Oyster Production Area

There is an area of oyster production along the coast of Deep Bay in Hong Kong waters. The shallowness of Deep Bay as a result of silt carried down from the Pearl River and typical estuarine conditions within Deep Bay enhances oyster cultivation.

There is no specific water quality criterion for an oyster production farm, thus water quality impacts have been assessed with reference to the WQOs.

(3) City University of Hong Kong (2001) Agreement No. CE 62/98, Consultancy Study on Fisheries and Marine Ecological Criteria for Impact Assessment, Final Report, for the Agriculture, Fisheries and Conservation Department, Hong Kong SAR Government.

The area was regarded as the nearest discrete point to the works site. If no non-compliances are found at the point, it is assumed that there will be no impacts to the area beyond this point.

Marine Ecological Resources

The following Marine Ecological Resources have been identified as water quality sensitive receivers.

- Marine Park;
- Seagrass Beds, Mangroves, Intertidal Mudflats and Horseshoe Crabs;
- Chinese White Dolphin Protection Zone in Mainland China; and
- Subtidal Hard Bottom Habitat.

Marine Park

The Sha Chau and Lung Kwu Chau Marine Park, designated specifically for the protection of the Indo-Pacific Humpback Dolphin (*Sousa chinensis*), lies within the study area (*Figure 6.3*). Water quality impacts are compared to the WQO for SS. For the water quality assessment, discrete points have been plotted at a number of locations along the boundaries of the Marine Park which face the proposed pipeline alignment. A potential Marine Park is located to the southwest of Lantau Island.

Seagrass Beds, Mangroves, Intertidal Mudflats & Horseshoe Crabs

Seagrass beds, mangroves, mudflats and areas where horseshoe crabs are known to breed are identified (*Figure 6.3*). There are no specific legislative water quality criteria for these habitats and hence the WQO has been adopted. These habitats have been plotted as discrete points for evaluation. Note that SR2 is representative for the habitats at Pak Nai. If no impacts are determined at SR2, it is assumed that the impacts will not occur beyond SR2.

Marine Mammal Habitat

Of the two resident Hong Kong marine mammal species, Chinese White Dolphins (also called Indo-Pacific Humpback dolphins) have been recorded across all waters of the Study Area from Deep Bay to South Lantau, whereas Finless Porpoises are only recorded in the South Lantau part of the Study Area. The baseline conditions and ecological importance evaluated for these two species are elaborated in *Part 2 – Section 9: Marine Ecology Assessment*.

Given that the marine mammals are mobile within the Study Area, the habitat is not plotted as a discrete point for evaluation; rather it is assessed through the contour plots which show the mixing zones of the water quality assessment parameters.

Chinese White Dolphin Protection Zone in Mainland China

A Chinese White Dolphin Protection Zone is located west of Lantau Island, close to the Hong Kong SAR boundary, in Mainland Chinese waters (*Figure 6.3*). The closest boundary of the Protection Zone is approximately 8 km from the proposed terminal at South Soko and approximately 0.8 km from the proposed pipeline alignment. The Chinese White Dolphin Protection Zone is identified as a sensitive receiver and has been plotted as discrete points for evaluation in the water quality assessment. Water quality impacts are compared to the WQOs.

Subtidal Hard Bottom Habitat

Dive surveys have been conducted at South Soko and the results showed that hard corals were in low abundance and diversity (see *Part 2 – Section 9: Marine Ecology Assessment* for further details). The corals recorded during the dive surveys are all common Hong Kong species with the exception of the relatively little known hard coral recorded on the southern coast of the South Soko Island. The habitat has been plotted as a discrete point (1) for evaluation in the water quality assessment and specific tolerance criteria relevant to corals have been adopted.

Other Water Quality Sensitive Receivers

The following additional water quality sensitive receivers have been identified and included in the assessment.

- Bathing Beaches; and
- Seawater Intakes.

Bathing Beaches

There are several gazetted beaches identified and a number of non-gazetted bathing beaches (*Figure 6.3*). Gazetted beaches include the beaches at Tong Fuk, Cheung Sha and Tuen Mun. Non-gazetted beaches are located at Lung Kwu Tan and around Fan Lau. The closest non-gazetted beach to the pipeline alignment is Fan Lau Sai Wan at a distance of approximately 1 km. The closest gazetted bathing beach is Tong Fuk at a distance of approximately 4.4 km from the water main and power cable. Bathing beaches have been plotted as discrete points for evaluation in the water quality assessment.

Water quality impacts at gazetted and non-gazetted bathing beaches have been determined based on the compliance with the WQOs (*Table 6.1*).

(1) The location of the habitat should refer to the dive survey findings in *Annex 9 – Section 9.3.10*.

Seawater Intakes

There are nine seawater intakes identified as potential sensitive receivers, namely those at Black Point Power Station, Castle Peak Power Station, Tuen Mun Area 38, Tuen Mun WSD and the Airport and Tai Kwai Wan pumping station. The intakes are situated submerged in the water near to the seabed.

The intakes have been plotted as discrete points for evaluation in the water quality assessment.

6.4 *POTENTIAL SOURCES OF IMPACT*

Potential sources of impacts to water quality as a result of the project may occur during both the construction and operation phases.

6.4.1 *Construction Phase*

The main construction activities associated with the proposed project that have the potential to cause impacts to water quality involve the following:

- Dredging and filling for seawall enhancements for the LNG terminal at South Soko;
- Filling for reclamation at the berths;
- Dredging for the approach channel and turning basin near the terminal for the LNG carrier;
- Dredging and jetting for the installation of the submarine gas pipeline connecting the LNG terminal at South Soko to the power station at Black Point;
- Dredging and jetting for the installation of the submarine water main connecting the LNG terminal at South Soko to Shek Pik Reservoir;
- Jetting for the installation of the submarine cable circuits connecting the LNG terminal at South Soko to the electricity sub station at Shek Pik;
- Piling for the jetty near the terminal for LNG carriers;
- Sewage discharges due to the on-site workforce;
- Site runoff including stockpiling of excavated materials and pollutants entering the receiving waters and/or water drainage system;
- Hydrotest water discharges; and,
- Oil spills due to accidental events.

6.4.2 *Operational Phase*

The potential impacts to water quality arising from the operation of the LNG terminal have been identified as follows:

- Changes to the hydrodynamic regime through the reclamation of the terminal site;
- Maintenance dredging of the approach channel and turning basin for the LNG carrier causing a temporary increase in SS concentrations in the water column;
- Discharge of cooled water from the regasification process resulting in a decrease in temperature and the input of antifoulants into the surrounding waters;
- Storm water run-off from the terminal site;
- Sewage discharges due to the operational workforce;
- Vessel discharges;
- LNG spillage due to accidental events; and
- Fuel spillage due to accidental events.

6.5 *WATER QUALITY IMPACT ASSESSMENT METHODOLOGY*

6.5.1 *General Methodology*

The methodology employed to assess the above impacts is presented in the *Water Quality Method Statement* (*Annex 6A*) and has been based on the information presented in the *Project Description* (*Part 2 - Section 3*).

Impacts due to the dispersion of fine sediment in suspension during the construction of the proposed LNG terminal and associated facilities have been assessed using computational modelling. Mitigation measures, as proposed in *Section 6.8* such as the use of silt curtain, were assumed to be absent for modelling the worst case scenario.

The simulation of operational impacts on water quality has also been performed by means of computational modelling. The models have been used to simulate the effects of cooled water discharges on temperature and water quality (due to antifoulants).

Full details of the scenarios examined in the modelling works are provided in *Annex 6A*. As discussed previously, the water quality sensitive receivers as well as the additional water quality modelling output points in the vicinity of the proposed LNG terminal at South Soko Island and the submarine utilities are presented in *Figure A2.1*.

6.5.2 *Uncertainties in the Assessment Methodology*

Uncertainties in the assessment of the impacts from suspended sediment plumes should be considered when drawing conclusions from the assessment. In carrying out the assessment, worse case assumptions have been made in order to provide a conservative assessment of environmental impacts. These assumptions are as follows.

- The assessment is based on the peak dredging and filling rates. In reality, these will only occur for short periods of time; and
- The calculations of loss rates of sediment to suspension are based on conservative estimates for the types of plant and methods of working.

The assumptions presented above allow a conservative approach to be applied to the water quality assessment.

The following uncertainties has not included in the modelling assessment:

- *Ad hoc* navigation of marine traffic;
- Near shore scouring of bottom sediment; and
- Transits of marine barges to and from the site.

It is noted that the above present mechanisms through which minor localised and short term changes in SS levels may occur during construction. Elevations of this type will be picked up and monitored during the water quality monitoring programme for the construction works which is presented in *Section 6.10*.

6.6 CONSTRUCTION PHASE WATER QUALITY IMPACT ASSESSMENT

6.6.1 *Suspended Sediment*

The potential main impacts to water quality arising from this project during the construction phase relate to disturbances to the seabed and re-suspension of some marine sediment leading to the potential for physio-chemical changes in the water column.

Assessment of Concurrent Construction Phase Activities

As discussed in the *Water Quality Method Statement (Annex 6A)*, during the construction phases, a number of marine activities have the potential to occur simultaneously. The locations of the marine activities are shown in *Figure 6.5* and the indicative drawings for each activity are illustrated in *Figures 6.6 – 6.9*.

In order to assess the potential cumulative impacts to water quality as a result of activities running concurrently, a total of 13 scenarios have been developed (*Table 6.10*). It should be noted that of these 13 scenarios, SR4a and SR4b are

Key

- LNG Submarine Watermain (solid line)
- LNG Submarine Cable (dashed line)
- Dredging Area (red outline)

Distance Point	Easting	Northing
KP0	808726.9977	802997.01011
KP1	807727.9242	802953.97430
KP5	803911.5167	804063.85511
KP6.84	802366.6748	805058.82235
KP14	800558.6637	811325.19124
KP20	803307.7451	816625.93301
KP24.5	804528.1988	820957.27149
KP31	804746.8102	827438.17932
KP33.5	804870.8264	829922.45140
KP33.976	805090.6327	830343.39191
KP35.39	806219.719	831145.91776
KP37	807788.6034	831403.29772
KP37.803	808532.0085	831113.16768
KP38.303	808942.7082	830874.20005

* Refer to Figure 3.12 for the details of the cross-section of each trench.

Zone				Trench Type	Plant Type	No. of Plants
KP	0	-	1	2A	Grab Dredger	1
KP	1	-	5	1B	TSHD	1
KP	5	-	6.84	3B	TSHD	1
KP	6.84	-	14	3A	TSHD	1
KP	14	-	20	3B	TSHD	1
KP	20		24.5	1B	TSHD	1
KP	24.5	-	31	1B	Grab Dredger	3
KP	31	-	33.5	1B	Grab Dredger	1
KP	33.5	-	33.976	3B	Grab Dredger	1
KP	33.976	-	35.39	3A	Grab Dredger	1
KP	35.39	-	37	3B	Grab Dredger	1
KP	37	-	37.803	1B	Grab Dredger	1
KP	37.803	-	38.303	2B	Grab Dredger	1

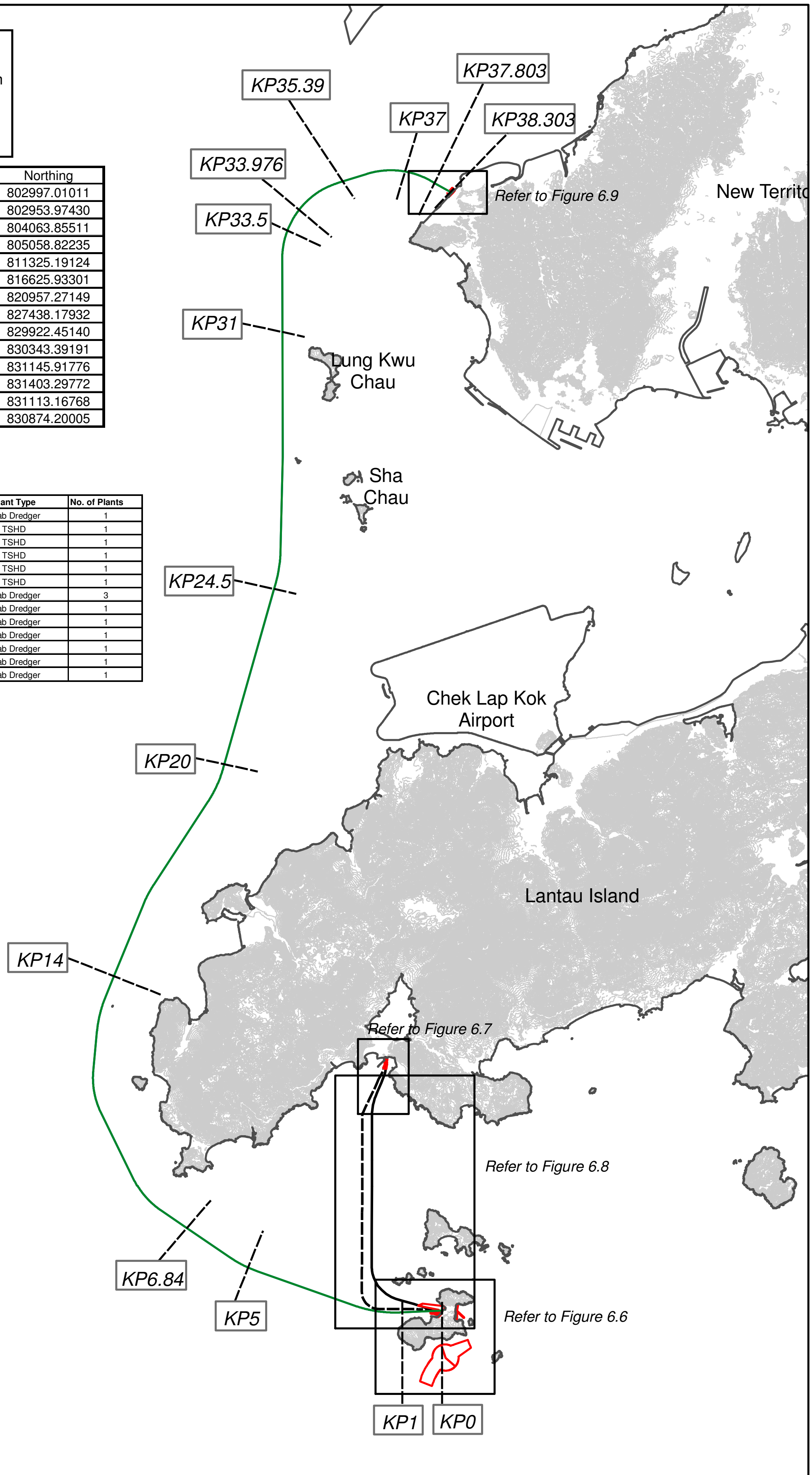

FIGURE 6.5

Locations of Marine Works

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Date: 13/11/2006

Environmental Resources Management
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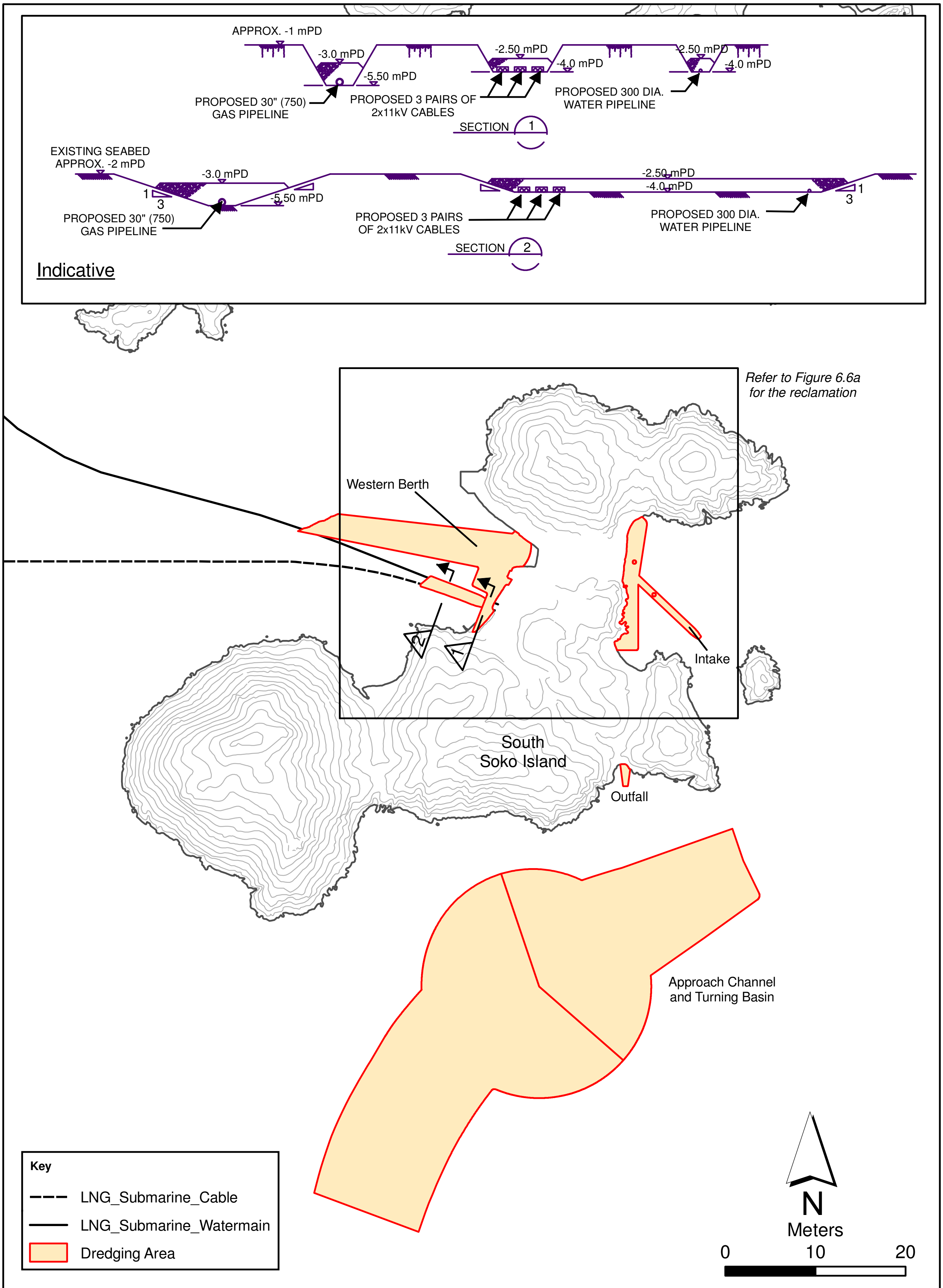

FIGURE 6.6

Marine Works near South Soko Island

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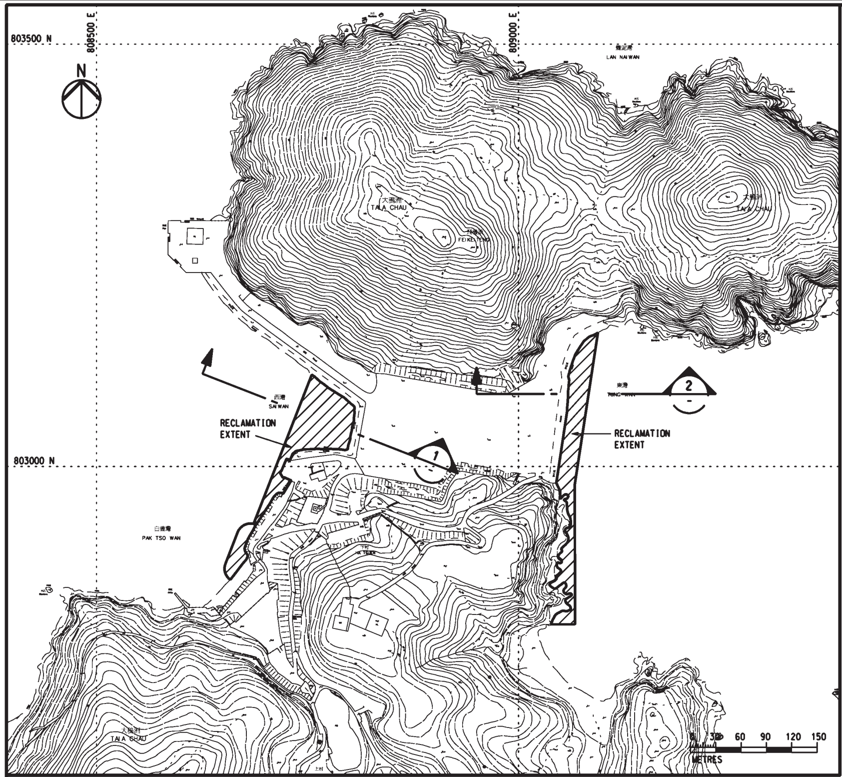

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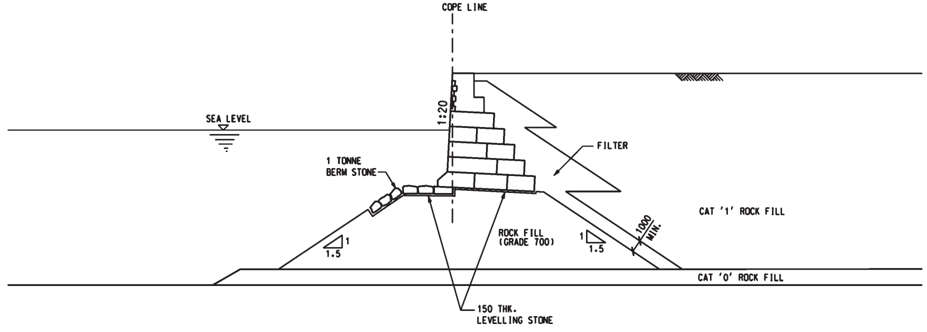

SECTION 1
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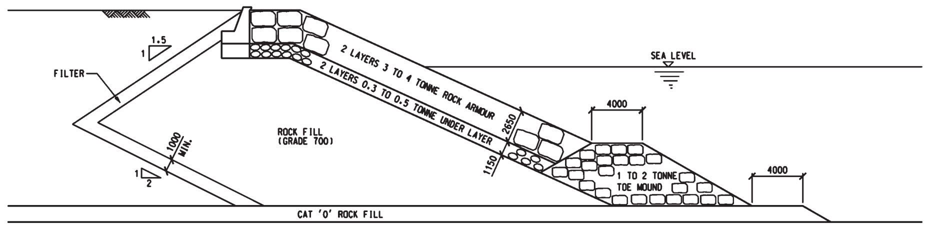

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Figure 6.6a

Marine Works Near South Soko Island

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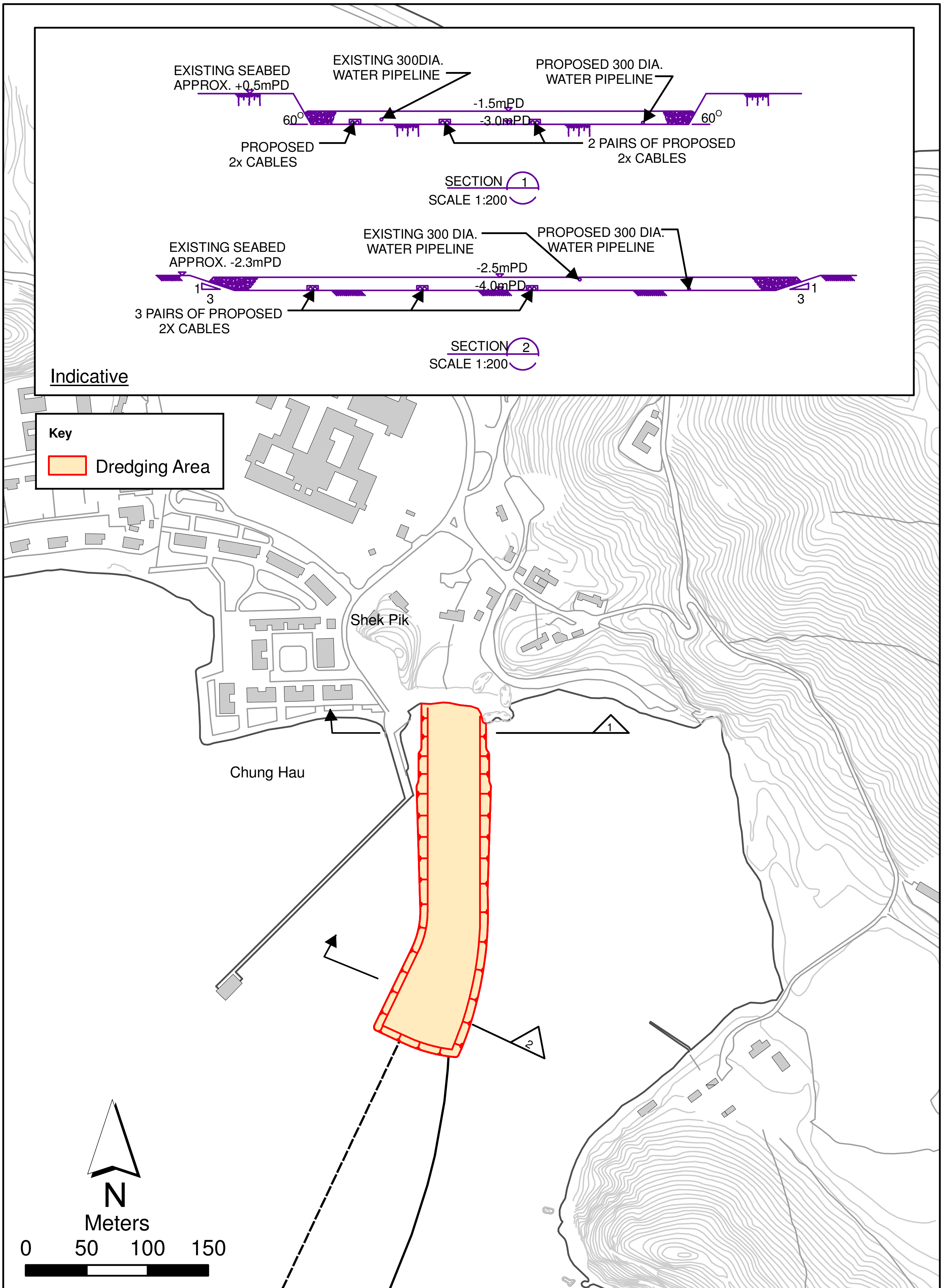

FIGURE 6.7

Marine Works near Shek Pik

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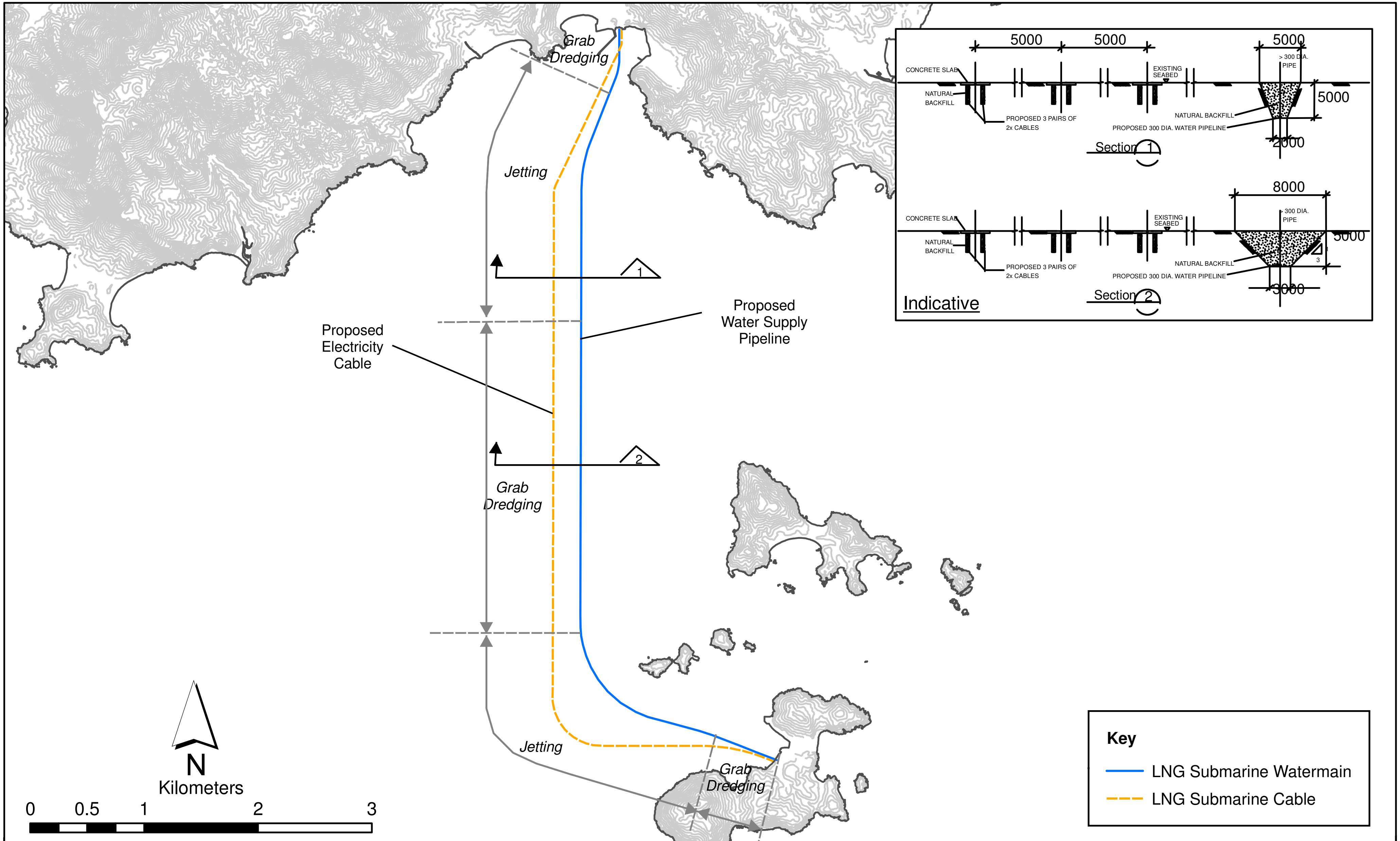

Figure 6.8

South Soko Island Proposed Water Supply and Electricity Cable Trench Details

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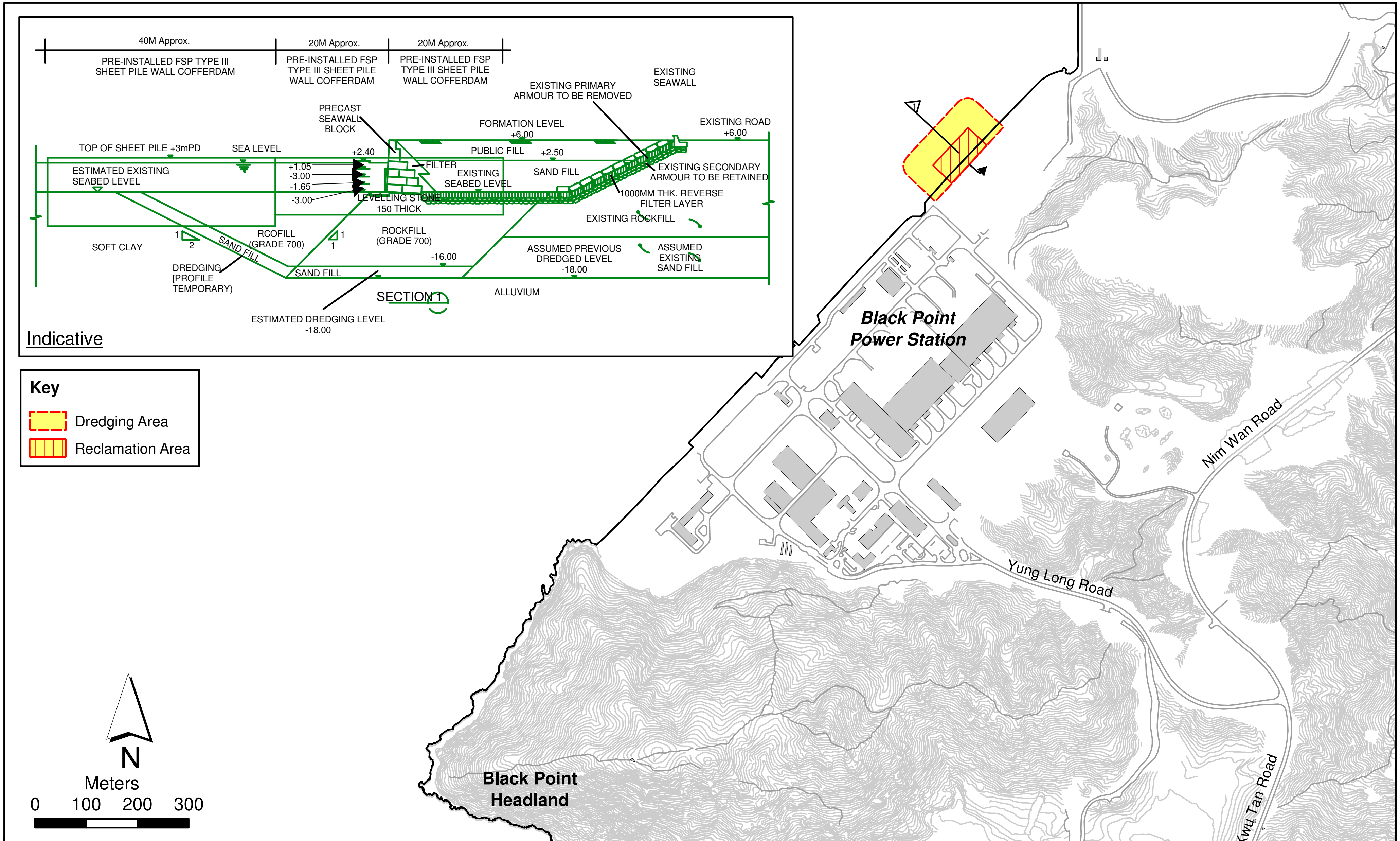

Figure 6.9

Marine Works near Black Point

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Date: 26/09/2006

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variations of the same construction activities, i.e., trailing suction hopper dredger versus closed grab dredger.

The selected scenarios represent periods during the construction programme when the maximum number of activities may take place in close proximity at any given time. Such works include those associated with the construction of the LNG terminal at South Soko Island, as well as the installation of the submarine pipeline (including the gas receiving station) and utilities (i.e., water main and power cable). The construction programme and the construction sequence for the marine works is shown in *Part 2 - Annex 6A*.

Note that the scenarios may not occur in sequential order, for example, Scenario 1 may not necessarily be the first batch of works to be performed whereas it is possible that Scenario 2 will be taken place prior to it. Assessment of each scenario enables the examination of impacts due to the concurrent activities. Whenever the scenarios are compliant with the assessment criteria, the individual activities are considered to be environmentally acceptable. When any non-compliances with the WQO or specific assessment criteria are identified in the assessment, further discussions on the activity(ies) that contribute to the exceedance will be presented. Mitigation measures, if deemed necessary, will also be recommended.

Data were extracted from the modelling results to determine the predicted levels of suspended sediment at each of the sensitive receivers. The maximum and mean elevations of SS at relevant depths for the respective sensitive receivers are presented under each scenario.

The determination of the acceptability of any elevation in SS levels has been based on the WQO or specific tolerance criteria. It should be noted that elevations in the SS level due to concurrent operations have been assessed as the maximum concentrations at water depths over a full 15 day spring-neap tidal cycle in both the dry and wet season, as required by the EIA Study Brief (*ESB-126/2005*).

In the following text, each scenario shown in *Table 6.10* will be discussed in the subsequent paragraphs followed by a discussion of the results for the gas pipeline installation works.

Table 6.10 Construction Phase Scenarios to be examined in the Water Quality Impact Assessment for LNG

Scenario ID	Tasks	Details of Construction Activities	No. of Plant	Plant Type	Code
Scenario 1	Reclamation Areas	Grab Dredging underneath Seawall at Tung Wan (Area A)	1 no.	Grab Dredger	SS 01
	Reclamation Areas	Grab Dredging underneath Seawall for Western Berth at Sai Wan (Area B)	1 no.	Grab Dredger	SS 02
	Reclamation Areas	Sand filling Seawall Trench and Reclamation for the Western Berth	1 no.	Pelican Barge	SS 32
Scenario 2	Submarine Water Main	Grab Dredging at South Soko Shore Approach	1 no.	Grab Dredger	SS 06
	Submarine Water Main	Grab Dredging at Shek Pik Shore Approach	1 no.	Grab Dredger	SS 07
	Submarine Water Main	Grab Dredging Waterway Crossing Sand Borrow Area & Marine Navigation Channel	1 no.	Grab Dredger	SS 08
Scenario 3	Submarine Water Main	Post Trenching Jetting near South Soko	1 no.	Jetting Machine	SS 09
	Submarine Water Main	Post Trenching Jetting near Shek Pik	1 no.	Jetting Machine	SS 10
Scenario 4a	Jetty Box	Grab Dredging at Jetty Box	1 no.	Grab Dredger	SS 03
	Approach Channel and Turning Basin	Grab Dredging at Approach Channel & TB at Area C	1 no.	Grab Dredger	SS 04a
	Approach Channel and Turning Basin	Grab Dredging at Approach Channel & TB at Area D	1 no.	Grab Dredger	SS 05
Scenario 4b	Jetty Box	Grab Dredging at Jetty Box	1 no.	Grab Dredger	SS 03
	Approach Channel and Turning Basin	TSHD Dredging at Approach Channel & TB at Area C	1 no.	TSHD	SS 04b
	Approach Channel and Turning Basin	Grab Dredging at Approach Channel & TB at Area D	1 no.	Grab Dredger	SS 05
Scenario 5	Submarine Cable Circuit	Submarine Cable Installation by Direct Burying (Jetting)	1 no.	Jetting Machine	SS 14
	Submarine Intake	Grab Dredging under intake	1 no.	Grab Dredger	SS 15
	Cooled Water Outfall	Grab Dredging under outfall	1 no.	Grab Dredger	SS 28
Scenario 6	Gas Receiving Station	Grab Dredging at GRS	1 no.	Grab Dredger	SS 29
	Gas Receiving Station	Grab Dredging at GRS	1 no.	Grab Dredger	SS 30
	Gas Receiving Station	Sand filling Seawall Trench and Reclamation at GRS	1 no.	Pelican Barge	SS 31
Scenario 7	Submarine Gas Pipeline	Grab Dredging at South Soko Shore Approach (KP 0 - KP 1)	1 no.	Grab Dredger	SS 21
Scenario 8	Submarine Gas Pipeline	TSHD Dredging from Fan Lau Crossing to West Lantau (KP 1 - KP 24.5)	1 no.	TSHD	SS 32

Scenario ID	Tasks	Details of Construction Activities	No. of Plant	Plant Type	Code
Scenario 9	Submarine Gas Pipeline	Grab Dredging from Northwest Lantau to Urmston Road Crossing (KP 24.5 – KP 31)	3 nos.	Grab Dredger	SS 33
Scenario 10	Submarine Gas Pipeline	Grab Dredging across Urmston Road Crossing (KP31– KP 33.5)	1 no.	Grab Dredger	SS 34
Scenario 11	Submarine Gas Pipeline	Grab Dredging at West of Black Point (KP33.5 – KP 37)	3 nos.	Grab Dredger	SS 19
Scenario 12	Submarine Gas Pipeline	Grab Dredging at West of Black Point (KP 37 – KP 37.803)	1 no.	Grab Dredger	SS 35
Scenario 13	Submarine Gas Pipeline	Grab Dredging at Black Point Shore Approach (KP37.803 - KP38.303)	1 no.	Grab Dredger	SS 16

Notes:
1. Grab dredger with a minimum 8m^3 closed grab
2. TSHD denotes Trailing Suction Hopper Dredger with hopper capacity of 11,300m^3.
3. TB denotes Turning Basin.
4. GRS denotes Gas Receiving Station.
5. KP in the bracket denotes the distance point.

Scenario 1

Scenario 1 allows the assessment of impacts through concurrent dredging works for the western berth at Sai Wan and seawall modification works at Tung Wan lasting for about 45 days and sandfilling for the seawall trench and reclamation lasting for about 15 days. There is no sandfilling works for the seawall modification at Tung Wan.

Modelling results indicate that SS elevations will be compliant with the WQO at all sensitive receivers in both seasons (*Table 6.11*) with the exception of SR16b (fish fry habitat at Pak Tso Wan).

Contour plots (*Annex 6C*) show the SS dispersion (> 5 mg L^{-1}) due to the dredging works at Sai Wan and Tung Wan will be confined to the dredging area. It is predicted that a mean (over 15 days spring-neap cycle) depth-averaged SS level of > 5 mg L^{-1} with respect to dredging works at Tung Wan will occur within 200 m from the source and maximum (over 15 days spring-neap cycle) depth-averaged SS level of > 5 mg L^{-1} will take place within 500 m from the source.

The sediment plume extension due to sandfilling for the seawall trench at the western berth would have a size of less than 1 km from the source. The sandfilling works will be carried out over a short duration (about a week) and hence the impact to water quality would be in short-term. It is worth to note that in the model, the reclamation for the western berth is assumed to be filled with marine sands without deploying any mitigation measures to minimise the dispersion of SS such as the preconstruction of a seawall. In reality it is likely that a completed seawall will be in place during reclamation and the filling works will be taken place behind the seawall. In addition, the seawall trench will be filled with rocks instead of marine sand. The tentative layout showing the seawall construction is illustrated in *Figure 6.6a*.

As a completed seawall will likely be in place to a level above the high tide level during filling it will act as an effective barrier against the ocean currents washing out the filling materials. Therefore, the impact of sand filling on the surrounding water and hence suspended solid elevations will be substantially reduced from the levels determined from the model.

Impact of SS elevations on fish fry habitat at Pak Tso Wan is discussed in the marine ecology assessment (see *Part 2 – Section 9: Marine Ecology Assessment*). Mitigation measures such as silt curtain (stand type) installed at Pak Tso Wan are suggested to avoid any adverse impacts due to sandfilling works to SR16b. Details will be discussed in *Section 6.8*.

Table 6.11 Predicted SS Elevation (mg L^{-1}) in Scenario 1

Sensitive Receiver	Name	ID	Relevant Water Depth [(a)]	Allowable Elevation		Predicted SS Elevation (mg L^{-1})					
				Dry	Wet	Dry Max	Wet Max	Dry Mean	Wet Mean	Dry 90%-tile	Wet 90%-tile
Protection Zone	Chinese White Dolphin Protection Zone in Mainland Waters	SR11	a	8.9	6.5	0.1	0.1	0.0	0.0	0.0	0.0
Protection Zone	Chinese White Dolphin Protection Zone in Mainland Waters	SR11a	a	8.9	6.5	0.1	0.1	0.0	0.0	0.0	0.0
Protection Zone	Chinese White Dolphin Protection Zone in Mainland Waters	SR11b	a	8.9	6.5	0.1	0.1	0.0	0.0	0.1	0.1
Horseshoe Crab Nursery Grounds	Tai O	SR12	a	8.9	6.5	0.0	0.0	0.0	0.0	0.0	0.0
Intertidal Mudflats	Yi O	SR14	s	6.5	3.6	0.0	0.0	0.0	0.0	0.0	0.0
Horseshoe Crab Nursery Grounds	Yi O	SR14	a	8.9	6.5	0.0	0.1	0.0	0.0	0.0	0.0
Non-gazetted Beaches	Fan Lau Sai Wan	SR15a	a	6.9	5.5	0.0	0.1	0.0	0.0	0.0	0.0
Mangroves	Fan Lau Tung Wan	SR15b	s	4.5	3	0.0	0.0	0.0	0.0	0.0	0.0
Non-gazetted Beaches	Fan Lau Tung Wan	SR15b	a	6.9	5.5	0.0	0.1	0.0	0.0	0.0	0.0
Non-gazetted Beaches	Tsin Yue Wan	SR15c	a	6.9	5.5	0.0	0.0	0.0	0.0	0.0	0.0
Fish Fry Habitat	Pak Tso Wan	SR16b	a	6.9	5.5	22.9 [(c)]	36.8 [(c)]	5.0	8.9	11.0	19.1
Horseshoe Crab Nursery Grounds	Sha Lo Wan	SR18	a	7.8	4.8	0.0	0.0	0.0	0.0	0.0	0.0
Spawning/Nursery Grounds	Fisheries Spawning/Nursery Grounds in South Lantau	SR24	a	6.9	5.5	0.6	0.4	0.1	0.1	0.2	0.1

Sensitive Receiver	Name	ID	Relevant Water Depth (a)	Allowable Elevation		Predicted SS Elevation (mg L^{-1})					
				Dry	Wet	Dry Max	Wet Max	Dry Mean	Wet Mean	Dry 90%-tile	Wet 90%-tile
Spawning/Nursery Grounds	Fisheries Spawning/Nursery Grounds in South Lantau	SR27	a	6.9	5.5	2.5	2.6	0.3	0.5	0.6	1.4
Subtidal Hard Bottom Habitat (coral)	Southern Side of South Soko	SR31	a	10 (b)	10 (b)	2.9	1.6	0.7	0.3	1.5	0.6
Intertidal Mudflats	Shui Hau Wan	SR33	s	3.9	2.5	0.0	0.0	0.0	0.0	0.0	0.0
Horseshoe Crab Nursery Grounds	Tong Fuk Miu Wan	SR33	a	4.8	3.9	0.0	0.0	0.0	0.0	0.0	0.0
Gazetted Beaches	Tong Fuk	SR34	a	4.8	3.9	0.0	0.0	0.0	0.0	0.0	0.0
Gazetted Beaches	Upper Cheung Sha Beach	SR35	a	4.8	3.9	0.0	0.0	0.0	0.0	0.0	0.0
Seagrass Beds/Mangroves	Tung Chung Bay	SR39	s	6.5	3.6	0.0	0.0	0.0	0.0	0.0	0.0
Horseshoe Crab Nursery Grounds	Tung Chung Bay	SR39	a	8.9	6.5	0.0	0.0	0.0	0.0	0.0	0.0

Notes:

a. s = surface, m = middle, b = bottom, a = depth-averaged

b. The tolerance assessment criterion of 10 mg L^{-1} was adopted for the coral.

c. Shaded area indicates non-compliance with the assessment criterion.

Scenario 2

Scenario 2 allows the assessment of impacts through concurrent dredging works for the South Soko and Shek Pik shore approach and crossings of the sand borrow area and marine navigation channel. All the dredging works at the three areas will be carried out by a closed grab dredger and will last for less than 3 months.

Modelling results indicate that SS elevations will be compliant with the WQO at all sensitive receivers in both seasons (*Table 6.12*) with the exception of SR16b (fish fry habitat at Pak Tso Wan).

As seen from the contour plots (*Annex 6C*), a sediment plume of > 5 mg L^{-1} (maximum over a complete sprint-neap cycle at any depth during both seasons) would constitute < 2.3% of south Lantau fisheries spawning/nursery ground (22,000 ha). In view of the relatively limited spread of SS due to the dredging works, the detailed fisheries assessment (see *Section 10: Fisheries Impact Assessment*) concludes that unacceptable impacts on the fisheries area would not arise.

Mitigation measures have been suggested to avoid any adverse impacts of the dredging works to SR16b. Details will be discussed in *Section 6.8*.

Table 6.12 Predicted SS Elevation (mg L^{-1}) in Scenario 2

Sensitive Receiver	Name	ID	Relevant Water Depth [(a)]	Allowable Elevation		Predicted SS Elevation (mg L^{-1})					
				Dry	Wet	Dry Max	Wet Max	Dry Mean	Wet Mean	Dry 90%-tile	Wet 90%-tile
Protection Zone	Chinese White Dolphin Protection Zone in Mainland Waters	SR11	a	8.9	6.5	0.0	0.0	0.0	0.0	0.0	0.0
Protection Zone	Chinese White Dolphin Protection Zone in Mainland Waters	SR11a	a	8.9	6.5	0.0	0.0	0.0	0.0	0.0	0.0
Protection Zone	Chinese White Dolphin Protection Zone in Mainland Waters	SR11b	a	8.9	6.5	0.0	0.1	0.0	0.0	0.0	0.0
Horseshoe Crab Nursery Grounds	Tai O	SR12	a	8.9	6.5	0.0	0.0	0.0	0.0	0.0	0.0
Intertidal Mudflats	Yi O	SR14	s	6.5	3.6	0.0	0.0	0.0	0.0	0.0	0.0
Horseshoe Crab Nursery Grounds	Yi O	SR14	a	8.9	6.5	0.0	0.0	0.0	0.0	0.0	0.0
Non-gazetted Beaches	Fan Lau Sai Wan	SR15a	a	6.9	5.5	0.1	0.1	0.0	0.0	0.0	0.0
Mangroves	Fan Lau Tung Wan	SR15b	s	4.5	3	0.1	0.0	0.0	0.0	0.0	0.0
Non-gazetted Beaches	Fan Lau Tung Wan	SR15b	a	6.9	5.5	0.2	0.1	0.0	0.0	0.0	0.0
Non-gazetted Beaches	Tsin Yue Wan	SR15c	a	6.9	5.5	0.1	0.1	0.0	0.0	0.1	0.0
Fish Fry Habitat	Pak Tso Wan	SR16b	a	6.9	5.5	16.2 [(c)]	15.5 [(c)]	1.6	3.1	4.4	7.8 [(c)]
Horseshoe Crab Nursery Grounds	Sha Lo Wan	SR18	a	7.8	4.8	0.0	0.0	0.0	0.0	0.0	0.0
Spawning/Nursery Grounds	Fisheries Spawning/Nursery Grounds in South Lantau	SR24	a	6.9	5.5	2.5	1.1	0.1	0.1	0.2	0.2
Spawning/Nursery Grounds	Fisheries Spawning/Nursery Grounds in South Lantau	SR27	a	6.9	5.5	0.8	0.4	0.0	0.0	0.1	0.1
Subtidal Hard Bottom Habitat (coral)	Southern Side of South Soko	SR31	a	10 [(b)]	10 [(b)]	0.2	0.2	0.0	0.0	0.1	0.0

Sensitive Receiver	Name	ID	Relevant Water Depth [(a)]	Allowable Elevation		Predicted SS Elevation (mg L^{-1})					
				Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet
						Max	Max	Mean	Mean	90%-tile	90%-tile
Intertidal Mudflats	Shui Hau Wan	SR33	s	3.9	2.5	0.0	0.0	0.0	0.0	0.0	0.0
Horseshoe Crab Nursery Grounds	Tong Fuk Miu Wan	SR33	a	4.8	3.9	0.0	0.0	0.0	0.0	0.0	0.0
Gazetted Beaches	Tong Fuk	SR34	a	4.8	3.9	0.0	0.0	0.0	0.0	0.0	0.0
Gazetted Beaches	Upper Cheung Sha Beach	SR35	a	4.8	3.9	0.0	0.0	0.0	0.0	0.0	0.0
Seagrass Beds/Mangroves	Tung Chung Bay	SR39	s	6.5	3.6	0.0	0.0	0.0	0.0	0.0	0.0
Horseshoe Crab Nursery Grounds	Tung Chung Bay	SR39	a	8.9	6.5	0.0	0.0	0.0	0.0	0.0	0.0

Notes:

a. s = surface, m = middle, b = bottom, a = depth-averaged

b. The tolerance assessment criterion of 10 mg L^{-1} was adopted for the coral.

c. Shaded area indicates non-compliance with the assessment criterion.

Scenario 3

Scenario 3 assesses the impacts due to post trenching jetting near South Soko and Shek Pik. The jetting works [(1)] at these two areas are unlikely to be carried out simultaneously and the works will probably be conducted sequentially (each of which will last for less than 15 days). Thus Scenario 3 is regarded as a highly conservative case.

Modelling results indicate that SS elevations will be compliant with the WQO in both seasons (*Table 6.13*) with exception of SR16b (fish fry habitat at Pak Tso Wan).

Though the maximum depth-averaged SS at SR16b is predicted to be above the tolerance criterion in both seasons, the 90th percentile SS is well below the criterion. As shown by the time-series plots (*Annex 6C*) several peaks for exceedances are observed and this suggests that the impact to the fish fry habitat is instantaneous rather than continuous. In addition, the jetting works will only last for approximately half a month and hence the impact to the fish fry habitat would be temporary. Hence, it is anticipated that the short-term exceedances would not cause any unacceptable impacts to the habitat.

From contour plots (*Annex 6C*), it could be seen that the sediment plume of > 5 mg L^{-1} (maximum bottom SS elevation per day) is expected to constitute < 4.9% (jetting near Shek Pik) to < 5.3% (jetting near South Soko Island) of south Lantau fisheries spawning/nursery area (22,000 ha). The two plumes at Shek Pik and South Soko will not overlap with each other. It can be concluded that the spread of SS will be minimal and if any exceedances do arise they will be of a short duration. It is concluded in the detailed fisheries assessment (see *Part 2 – Section 10: Fisheries Impact Assessment*) that this limited sediment plume would not attribute to unacceptable impacts in the fisheries area.

Mitigation measures have been suggested to avoid any adverse impacts from jetting works to SR16b. Details will be discussed in *Section 6.8*.

(1) Information of jetting operations is enclosed in *Annex 6K*.

Table 6.13 Predicted SS Elevation (mg L-1) in Scenario 3

Sensitive Receiver	Name	ID	Relevant Water Depth (a)	Allowable Elevation		Predicted SS Elevation (mg L-1)					
				Dry	Wet	Dry Max	Wet Max	Dry Mean	Wet Mean	Dry 90%-tile	Wet 90%-tile
Protection Zone	Chinese White Dolphin Protection Zone in Mainland Waters	SR11	a	8.9	6.5	0.1	0.0	0.0	0.0	0.0	0.0
Protection Zone	Chinese White Dolphin Protection Zone in Mainland Waters	SR11a	a	8.9	6.5	0.1	0.0	0.0	0.0	0.1	0.0
Protection Zone	Chinese White Dolphin Protection Zone in Mainland Waters	SR11b	a	8.9	6.5	0.3	0.1	0.0	0.0	0.1	0.0
Horseshoe Crab Nursery Grounds	Tai O	SR12	a	8.9	6.5	0.1	0.0	0.0	0.0	0.0	0.0
Intertidal Mudflats	Yi O	SR14	s	6.5	3.6	0.1	0.0	0.0	0.0	0.0	0.0
Horseshoe Crab Nursery Grounds	Yi O	SR14	a	8.9	6.5	0.1	0.0	0.0	0.0	0.0	0.0
Non-gazetted Beaches	Fan Lau Sai Wan	SR15a	a	6.9	5.5	0.1	0.0	0.0	0.0	0.1	0.0
Mangroves	Fan Lau Tung Wan	SR15b	s	4.5	3	1.6	0.0	0.1	0.0	0.2	0.0
Non-gazetted Beaches	Fan Lau Tung Wan	SR15b	a	6.9	5.5	2.3	0.1	0.1	0.0	0.3	0.0
Non-gazetted Beaches	Tsin Yue Wan	SR15c	a	6.9	5.5	0.2	0.0	0.0	0.0	0.1	0.0
Fish Fry Habitat	Pak Tso Wan	SR16b	a	6.9	5.5	36.1 (c)	57.4 (c)	0.7	1.2	1.4	0.5
Horseshoe Crab Nursery Grounds	Sha Lo Wan	SR18	a	7.8	4.8	0.0	0.0	0.0	0.0	0.0	0.0
Spawning/Nursery Grounds	Fisheries Spawning/Nursery Grounds in South Lantau	SR24	a	6.9	5.5	0.2	0.1	0.0	0.0	0.1	0.0
Spawning/Nursery Grounds	Fisheries Spawning/Nursery Grounds in South Lantau	SR27	a	6.9	5.5	2.5	2.6	0.1	0.1	0.2	0.1
Subtidal Hard Bottom Habitat (coral)	Southern Side of South Soko	SR31	a	10 (b)	10 (b)	3.7	2.3	0.1	0.0	0.3	0.1

Sensitive Receiver	Name	ID	Relevant Water Depth (a)	Allowable Elevation		Predicted SS Elevation (mg L^{-1})					
				Dry	Wet	Dry Max	Wet Max	Dry Mean	Wet Mean	Dry 90%-tile	Wet 90%-tile
Intertidal Mudflats	Shui Hau Wan	SR33	s	3.9	2.5	0.0	0.0	0.0	0.0	0.0	0.0
Horseshoe Crab Nursery Grounds	Tong Fuk Miu Wan	SR33	a	4.8	3.9	0.0	0.0	0.0	0.0	0.0	0.0
Gazetted Beaches	Tong Fuk	SR34	a	4.8	3.9	0.0	0.0	0.0	0.0	0.0	0.0
Gazetted Beaches	Upper Cheung Sha Beach	SR35	a	4.8	3.9	0.0	0.0	0.0	0.0	0.0	0.0
Seagrass Beds/Mangroves	Tung Chung Bay	SR39	s	6.5	3.6	0.0	0.0	0.0	0.0	0.0	0.0
Horseshoe Crab Nursery Grounds	Tung Chung Bay	SR39	a	8.9	6.5	0.0	0.0	0.0	0.0	0.0	0.0

Notes:

a. s = surface, m = middle, b = bottom, a = depth-averaged

b. The tolerance assessment criterion of 10 mg L^{-1} was adopted for the coral.

c. Shaded area indicates non-compliance with the assessment criterion.

Scenario 4a

Scenario 4a examined the impacts due to concurrent dredging works at the approach channel and turning basin which would last for about 3 months. All dredging works have been modelled assuming the use of grab dredgers which is thereafter regarded as "Case 1" for the dredging at the approach channel and turning basin.

Modelling results indicate that SS elevations will be compliant with the WQO and tolerance criterion at most sensitive receivers in both seasons (*Table 6.14*), with the exception of SR31, i.e., subtidal hard bottom habitat (coral).

Though the maximum depth-averaged SS at SR31 is predicted to marginally exceed the tolerance criterion of 10 mg L^{-1} in the dry season, the 90th percentile SS is well below the criterion.

It should be noted that the sediment release due to the grab dredging at the approach channel was modelled to be stationary and close to the shore in order to look into the most conservative case. In reality, the grab dredger will move around within the approach channel and off shore turning basin. Hence, the SS elevations at SR 31 will be much less than the predicted value.

It is also worth noting that the dredging works at the main jetty may be combined with that for Area C. In other words, a grab dredger would be mobilised for dredging the main jetty followed by dredging at Area C. If this is the case, there would be only two grab dredgers on site and not three as modelled.

Mitigation measures such as deployment of a silt curtain (stand type) surrounding the coral habitat have been suggested to avoid any adverse impacts of dredging works to SR31. Details will be discussed in *Section 6.8*.

The sediment plume of > 5 mg L^{-1} (maximum over a complete spring-neap cycle at any depth during both seasons) is expected to constitute < 2.1% of the spawning/nursery ground (*Annex 6C*). The detailed fisheries assessment (see *Part 2 – Section 10: Fisheries Impact Assessment*) concludes that this limited spread of sediment in the fisheries area would not cause any unacceptable impacts.

Scenario 4b

An alternative to Scenario 4a is to dredge the approach channel and turning basin using a Trailing Suction Hopper Dredger (TSHD) which is thereafter regarded as "Case 2" for the dredging at the approach channel and turning basin which would last for less than 3 months. This has been modelled as Scenario 4b. The other assumptions modelled in Scenario 4a remain the same.

Modelling results indicate that SS elevations will be compliant with the WQO and tolerance criterion at most sensitive receivers in both seasons (*Table 6.15*) with the exception of SR31, i.e., subtidal hard bottom habitat (coral).

Though the maximum depth-averaged SS at SR31 is predicted to marginally exceed the tolerance criterion of 10 mg L^{-1} in both seasons, the 90^{th} percentile SS is well below the criterion. The exceedances are likely due to the dredging at the approach channel and turning basin. As aforesaid, the sediment release due to the grab dredging at the approach channel was modelled to be stationary and close to the shore in order to look into the most conservative case. In reality, the grab dredger will move around within the approach channel and off shore turning basin. Hence, the SS elevations at SR 31 will be much less than the predicted value.

Mitigation measures have been suggested to avoid any adverse impacts of dredging works to SR31. Details will be discussed in *Section 6.8*.

The sediment plume of > 5 mg L^{-1} (maximum bottom SS elevation per day) is expected to constitute < 3.7% of the fisheries spawning/nursery ground in south Lantau (*Annex 6C*). The detailed fisheries assessment (see *Part 2 – Section 10: Fisheries Impact Assessment*) concludes that this limited spread of sediment in the fisheries area would not cause any unacceptable impacts.

Table 6.14 Predicted SS Elevation (mg L^{-1}) in Scenario 4a

Sensitive Receiver	Name	ID	Relevant Water Depth [a]	Allowable Elevation Dry	Allowable Elevation Wet	Predicted SS Elevation (mg L^{-1}) Dry Max	Wet Max	Dry Mean	Wet Mean	Dry 90%-tile	Wet 90%-tile
Protection Zone	Chinese White Dolphin Protection Zone in Mainland Waters	SR11	a	8.9	6.5	0.1	0.0	0.0	0.0	0.0	0.0
Protection Zone	Chinese White Dolphin Protection Zone in Mainland Waters	SR11a	a	8.9	6.5	0.1	0.0	0.0	0.0	0.1	0.0
Protection Zone	Chinese White Dolphin Protection Zone in Mainland Waters	SR11b	a	8.9	6.5	0.1	0.0	0.0	0.0	0.1	0.0
Horseshoe Crab Nursery Grounds	Tai O	SR12	a	8.9	6.5	0.1	0.1	0.0	0.0	0.0	0.0
Intertidal Mudflats	Yi O	SR14	s	6.5	3.6	0.1	0.0	0.0	0.0	0.0	0.0
Horseshoe Crab Nursery Grounds	Yi O	SR14	a	8.9	6.5	0.1	0.0	0.0	0.0	0.0	0.0
Non-gazetted Beaches	Fan Lau Sai Wan	SR15a	a	6.9	5.5	0.0	0.0	0.0	0.0	0.0	0.0
Mangroves	Fan Lau Tung Wan	SR15b	s	4.5	3	0.0	0.0	0.0	0.0	0.0	0.0
Non-gazetted Beaches	Fan Lau Tung Wan	SR15b	a	6.9	5.5	0.0	0.0	0.0	0.0	0.0	0.0
Non-gazetted Beaches	Tsin Yue Wan	SR15c	a	6.9	5.5	0.0	0.0	0.0	0.0	0.0	0.0
Fish Fry Habitat	Pak Tso Wan	SR16b	a	6.9	5.5	0.3	0.2	0.1	0.0	0.1	0.1
Horseshoe Crab Nursery Grounds	Sha Lo Wan	SR18	a	7.8	4.8	0.1	0.0	0.0	0.0	0.0	0.0
Spawning/Nursery Grounds	Fisheries Spawning/Nursery Grounds in South Lantau	SR24	a	6.9	5.5	0.2	0.1	0.0	0.0	0.0	0.0
Spawning/Nursery Grounds	Fisheries Spawning/Nursery Grounds in South Lantau	SR27	a	6.9	5.5	0.2	0.2	0.0	0.0	0.1	0.1
Subtidal Hard Bottom Habitat (coral)	Southern Side of South Soko	SR31	a	10 [b]	10 [b]	15.5 [4, 5]	10.0	5.0	3.7	8.3	6.0

Sensitive Receiver	Name	ID	Relevant Water Depth (a)	Allowable Elevation		Predicted SS Elevation (mg L^{-1})					
				Dry	Wet	Dry Max	Wet Max	Dry Mean	Wet Mean	Dry 90%-tile	Wet 90%-tile
Intertidal Mudflats	Shui Hau Wan	SR33	s	3.9	2.5	0.0	0.0	0.0	0.0	0.0	0.0
Horseshoe Crab Nursery Grounds	Tong Fuk Miu Wan	SR33	a	4.8	3.9	0.0	0.0	0.0	0.0	0.0	0.0
Gazetted Beaches	Tong Fuk	SR34	a	4.8	3.9	0.0	0.0	0.0	0.0	0.0	0.0
Gazetted Beaches	Upper Cheung Sha Beach	SR35	a	8.9	6.5	0.0	0.0	0.0	0.0	0.0	0.0
Seagrass Beds/Mangroves	Tung Chung Bay	SR39	s	8.9	6.5	0.0	0.0	0.0	0.0	0.0	0.0
Horseshoe Crab Nursery Grounds	Tung Chung Bay	SR39	a	8.9	6.5	0.0	0.0	0.0	0.0	0.0	0.0

Notes:

a. s = surface, m = middle, b = bottom, a = depth-averaged

b. The tolerance assessment criterion of 10 mg L^{-1} was adopted for the coral.

c. Shaded area indicates non-compliance with the assessment criterion.

d. Contribution of each individual activities are 24% from grab dredging at jetty box, 29% from grab dredging at approach channel and turning basin (area C), 46% from grab dredging at approach channel and turning basin (area D).

Table 6.15 Predicted SS Elevation (mg L^{-1}) in Scenario 4b

Sensitive Receiver	Name	ID	Relevant Water Depth [a]	Allowable Elevation		Predicted SS Elevation (mg L^{-1})					
				Dry	Wet	Dry Max	Wet Max	Dry Mean	Wet Mean	Dry 90%-tile	Wet 90%-tile
Protection Zone	Chinese White Dolphin Protection Zone in Mainland Waters	SR11	a	8.9	6.5	0.1	0.0	0.0	0.0	0.0	0.0
Protection Zone	Chinese White Dolphin Protection Zone in Mainland Waters	SR11a	a	8.9	6.5	0.1	0.0	0.0	0.0	0.1	0.0
Protection Zone	Chinese White Dolphin Protection Zone in Mainland Waters	SR11b	a	8.9	6.5	0.2	0.1	0.1	0.0	0.1	0.0
Horseshoe Crab Nursery Grounds	Tai O	SR12	a	8.9	6.5	0.1	0.1	0.0	0.0	0.0	0.0
Intertidal Mudflats	Yi O	SR14	s	6.5	3.6	0.1	0.0	0.0	0.0	0.0	0.0
Horseshoe Crab Nursery Grounds	Yi O	SR14	a	8.9	6.5	0.1	0.0	0.0	0.0	0.0	0.0
Non-gazetted Beaches	Fan Lau Sai Wan	SR15a	a	6.9	5.5	0.0	0.0	0.0	0.0	0.0	0.0
Mangroves	Fan Lau Tung Wan	SR15b	s	4.5	3	0.0	0.0	0.0	0.0	0.0	0.0
Non-gazetted Beaches	Fan Lau Tung Wan	SR15b	a	6.9	5.5	0.0	0.0	0.0	0.0	0.0	0.0
Non-gazetted Beaches	Tsin Yue Wan	SR15c	a	6.9	5.5	0.0	0.0	0.0	0.0	0.0	0.0
Fish Fry Habitat	Pak Tso Wan	SR16b	a	6.9	5.5	0.2	0.3	0.1	0.0	0.2	0.1
Horseshoe Crab Nursery Grounds	Sha Lo Wan	SR18	a	7.8	4.8	0.0	0.0	0.0	0.0	0.0	0.0
Spawning/Nursery Grounds	Fisheries Spawning/Nursery Grounds in South Lantau	SR24	a	6.9	5.5	0.2	0.1	0.0	0.0	0.1	0.0
Spawning/Nursery Grounds	Fisheries Spawning/Nursery Grounds in South Lantau	SR27	a	6.9	5.5	0.2	0.3	0.0	0.0	0.1	0.1
Subtidal Hard Bottom Habitat (coral)	Southern Side of South Soko	SR31	a	10 [b]	10 [b]	12.1 [c], [d]	10.5 [c], [e]	2.9	2.5	5.6	4.3

Sensitive Receiver	Name	ID	Relevant Water Depth [(a)]	Allowable Elevation		Predicted SS Elevation (mg L^{-1})					
				Dry	Wet	Dry Max	Wet Max	Dry Mean	Wet Mean	Dry 90%-tile	Wet 90%-tile
Intertidal Mudflats	Shui Hau Wan	SR33	s	3.9	2.5	0.0	0.0	0.0	0.0	0.0	0.0
Horseshoe Crab Nursery Grounds	Tong Fuk Miu Wan	SR33	a	4.8	3.9	0.0	0.0	0.0	0.0	0.0	0.0
Gazetted Beaches	Tong Fuk	SR34	a	4.8	3.9	0.0	0.0	0.0	0.0	0.0	0.0

Notes:

a. s = surface, m = middle, b = bottom, a = depth-averaged

b. The tolerance assessment criterion of 10 mg L^{-1} was adopted for the coral.

c. Shaded area indicates non-compliance with the assessment criterion.

d. Contribution of each individual activities are 31% from grab dredging at jetty box, 10% from grab dredging at approach channel and turning basin (area C), 59% from TSHD dredging at approach channel and turning basin (area D).

e. Contribution of each individual activities are 16% from grab dredging at jetty box, 46% from TSHD dredging at approach channel and turning basin (area C), 37% from grab dredging at approach channel and turning basin (area D).

Scenario 5

Scenario 5 allows the assessment of impacts through dredging works at the outfall and intake as well as jetting for the submarine cable circuit between Shek Pik and South Soko.

This scenario is also taken as a conservative case. The tentative construction programme shows that the probability of concurrent dredging and jetting works is very low. Besides, dredging under the intake and outfall is likely to be carried out sequentially and will not overlap.

Modelling results also indicate that SS elevations will be compliant with the WQO and tolerance criterion at most sensitive receivers in both seasons (*Table 6.16*) with the exception of SR16b (fish fry habitat at Pak Tso Wan).

The maximum depth-averaged SS at SR16b is predicted to marginally exceed the tolerance criterion in the wet season. As shown in the time-series plots (*Annex 6C*), the exceedances will be of a short duration. Hence it is anticipated that the exceedances would be temporary and they would not cause any unacceptable impacts to the habitat. The exceedance is likely to be attributable to jetting for the submarine cable as presented in the contour plots (*Annex 6C*).

Due to the relatively limited spread of SS, any exceedances of the WQOs or tolerance criterion at sensitive receivers are predicted to be transient. In addition, the SS elevation could be further reduced by implementing mitigation measures. No unacceptable impacts are thus expected to occur.

Scenarios 1 to 5 simulate the marine works in the vicinity of Soko Islands. The model results for the intertidal and subtidal coastal areas around Soko Islands are presented in *Table C1* in *Annex 6C* for reference.

Based on the results of Scenarios 1 to 5, it is worth noting the following:

- Should some of the aforementioned dredging/jetting works at northwest, east and south of South Soko Island be carried out concurrently, it is expected that the sediment plumes from these three areas will not overlap. This is illustrated in the contour plots (*Annex 6C*) which show that South Soko Island itself serves as a natural barrier.

- It is concluded that SS elevations due to grab dredging are generally confined to the works area whereas those due to TSHD dredging and jetting are confined not only to the works area but also to the bottom layer of the water column.

- It is expected that the non-compliances at SR16b and SR31 would be temporary rather than persistent (short duration of disturbance in which the works are close to the sensitive receivers).

- For the moving sources including in Scenarios 3, 4b and 5, snap-shots of maximum SS elevation per day are presented to show the maximum values occurring at a certain moment of time in a day. It is considered the snap-shots are more appropriate than the SS elevation plots of maximum values over a complete spring neap cycle which are gestalt images and may not be representative of any given moment in time. This means the time in which each grid cell's maximum occurred is independent of the other grid cells and therefore should not be interpreted against the WQO.

Table 6.16 Predicted SS Elevation (mg L^{-1}) in Scenario 5

Sensitive Receiver	Name	ID	Relevant Water Depth (a)	Allowable Elevation		Predicted SS Elevation (mg L^{-1})					
				Dry	Wet	Dry Max	Wet Max	Dry Mean	Wet Mean	Dry 90%-tile	Wet 90%-tile
Protection Zone	Chinese White Dolphin Protection Zone in Mainland Waters	SR11	a	8.9	6.5	0.1	0.0	0.0	0.0	0.0	0.0
Protection Zone	Chinese White Dolphin Protection Zone in Mainland Waters	SR11a	a	8.9	6.5	0.1	0.0	0.0	0.0	0.0	0.0
Protection Zone	Chinese White Dolphin Protection Zone in Mainland Waters	SR11b	a	8.9	6.5	0.1	0.0	0.0	0.0	0.1	0.0
Horseshoe Crab Nursery Grounds	Tai O	SR12	a	8.9	6.5	0.1	0.1	0.0	0.0	0.0	0.0
Intertidal Mudflats	Yi O	SR14	s	6.5	3.6	0.0	0.0	0.0	0.0	0.0	0.0
Horseshoe Crab Nursery Grounds	Yi O	SR14	a	8.9	6.5	0.1	0.0	0.0	0.0	0.0	0.0
Non-gazetted Beaches	Fan Lau Sai Wan	SR15a	a	6.9	5.5	0.1	0.0	0.0	0.0	0.0	0.0
Mangroves	Fan Lau Tung Wan	SR15b	s	4.5	3	0.4	0.0	0.0	0.0	0.0	0.0
Non-gazetted Beaches	Fan Lau Tung Wan	SR15b	a	6.9	5.5	0.5	0.1	0.0	0.0	0.1	0.0
Non-gazetted Beaches	Tsin Yue Wan	SR15c	a	6.9	5.5	0.2	0.0	0.0	0.0	0.0	0.0
Fish Fry Habitat	Pak Tso Wan	SR16b	a	6.9	5.5	3.5	5.7 (c)	0.2	0.1	0.4	0.1
Horseshoe Crab Nursery Grounds	Sha Lo Wan	SR18	a	7.8	4.8	0.0	0.0	0.0	0.0	0.0	0.0
Spawning/Nursery Grounds	Fisheries Spawning/Nursery Grounds in South Lantau	SR24	a	6.9	5.5	3.2	0.3	0.1	0.0	0.1	0.0
Spawning/Nursery Grounds	Fisheries Spawning/Nursery Grounds in South Lantau	SR27	a	6.9	5.5	3.1	1.8	0.1	0.1	0.1	0.1
Subtidal Hard Bottom Habitat (coral)	Southern Side of South Soko	SR31	a	10 (b)	10 (b)	6.1	3.7	1.9	1.3	3.9	2.4

Sensitive Receiver	Name	ID	Relevant Water Depth [(a)]	Allowable Elevation		Predicted SS Elevation (mg L-1)					
				Dry	Wet	Dry Max	Wet Max	Dry Mean	Wet Mean	Dry 90%-tile	Wet 90%-tile
Intertidal Mudflats	Shui Hau Wan	SR33	s	3.9	2.5	0.0	0.0	0.0	0.0	0.0	0.0
Horseshoe Crab Nursery Grounds	Tong Fuk Miu Wan	SR33	a	4.8	3.9	0.0	0.0	0.0	0.0	0.0	0.0
Gazetted Beaches	Tong Fuk	SR34	a	4.8	3.9	0.0	0.0	0.0	0.0	0.0	0.0
Gazetted Beaches	Upper Cheung Sha Beach	SR35	a	4.8	3.9	0.0	0.0	0.0	0.0	0.0	0.0
Seagrass Beds/Mangroves	Tung Chung Bay	SR39	s	6.5	3.6	0.0	0.0	0.0	0.0	0.0	0.0
Horseshoe Crab Nursery Grounds	Tung Chung Bay	SR39	a	8.9	6.5	0.0	0.0	0.0	0.0	0.0	0.0

Notes:

a. s = surface, m = middle, b = bottom, a = depth-averaged

b. The tolerance assessment criterion of 10 mg L^{-1} was adopted for the coral.

c. Shaded area indicates non-compliance with the assessment criterion.

Scenario 6

Scenario 6 allows the assessment of impacts due to concurrent dredging works and backfilling works for the seawall trench and GRS reclamation at Black Point. The dredging works will be carried by two closed grab dredgers while the sandfilling works will be conducted by a pelican barge. The construction of the GRS requires a small area to be dredged (*Figure 6.9*) prior to the installation works for the submarine gas pipeline.

In the model, it has been assumed that the sandfilling works are continuous over a spring-neap cycle. In view of small volume of seawall trench to be filled, this assumption will be very conservative as the filling works are expected to be completed within a few days.

It is worth to note that in the model the reclamation for the GRS is assumed to be undertaken without applying any mitigation measures (the most conservative case) such as the preconstruction of a seawall. In reality, however, a completed seawall will be in place while reclamation works are taking place. The tentative layout of the seawall is illustrated in *Figure 6.9*. Seawalls which are constructed above the high tide level are an effective barrier against the washing out of filling materials by water currents. Therefore, the impact of sand filling on the surrounding water and hence suspended solid elevations will be substantially reduced from the levels determined from the model.

Modelling results indicate that SS elevations will be compliant with the WQO at all sensitive receivers in both seasons (*Table 6.17*). Due to the relatively limited spread of SS and no exceedances of the WQOs or tolerance criterion at sensitive receivers, no unacceptable impacts would be expected to occur.

Table 6.17 Predicted SS Elevation (mg L^{-1}) in Scenario 6

Sensitive Receiver	Name	ID	Relevant Water Depth (a)	Allowable Elevation		Predicted SS Elevation (mg L^{-1})					
				Dry	Wet	Dry Max	Wet Max	Dry Mean	Wet Mean	Dry 90%-tile	Wet 90%-tile
Intertidal Mudflats	Pak Nai	SR01	s	7.1	3.6	1.0	0.8	0.0	0.0	0.1	0.0
Horseshoe Crab Nursery Grounds	Pak Nai	SR01	a	9.7	6	4.5	1.2	0.2	0.1	0.6	0.3
Seagrass Beds/Mangroves/Oyster Farm	Pak Nai	SR02	s	7.1	3.6	0.0	0.1	0.0	0.0	0.0	0.0
Seawater Intakes	Black Point Power Station	SR04	b	700 (b)	700 (b)	48.7	38.3	2.7	3.0	7.7	9.2
Non-gazetted Beaches	Lung Kwu Sheung Tan	SR05a	a	8.2	5.6	0.9	0.2	0.0	0.0	0.1	0.0
Non-gazetted Beaches	Lung Kwu Tan	SR05b	a	8.2	5.6	0.6	0.4	0.0	0.0	0.1	0.1
Gazetted Beaches	Butterfly Beach	SR05c	a	8.2	5.6	0.0	0.0	0.0	0.0	0.0	0.0
Marine Park	Designated Sha Chau and Lung Kwu Chau	SR06a	a	8.2	5.6	0.2	0.1	0.0	0.0	0.0	0.0
Marine Park	Designated Sha Chau and Lung Kwu Chau	SR06b	a	8.2	5.6	0.1	0.1	0.0	0.0	0.0	0.0
Marine Park	Designated Sha Chau and Lung Kwu Chau	SR06c	a	8.2	5.6	0.2	0.2	0.0	0.0	0.1	0.1
Marine Park	Designated Sha Chau and Lung Kwu Chau	SR06d	a	8.2	5.6	0.2	0.2	0.0	0.0	0.0	0.0
Artificial Reef Deployment Area	Sha Chau and Lung Kwu Chau	SR06e	a	8.2	5.6	0.1	0.1	0.0	0.0	0.0	0.0
Seawater Intakes	Castle Peak Power Station	SR07a	b	700 (b)	700 (b)	2.9	2.0	0.1	0.2	0.3	0.5
Seawater Intakes	Tuen Mun Area 38	SR07b	b	14.2	9.8	0.4	0.5	0.0	0.1	0.1	0.2
Seawater Intakes	Airport	SR07c	b	8.9	8.8	0.1	0.0	0.0	0.0	0.0	0.0
Seawater Intakes	Airport	SR07d	b	8.9	8.8	0.0	0.0	0.0	0.0	0.0	0.0
Artificial Reef Deployment Area	Northeast Airport	SR07d	a	4.7	5.2	0.0	0.0	0.0	0.0	0.0	0.0
Seawater Intakes	Airport	SR07e	b	8.9	8.8	0.0	0.0	0.0	0.0	0.0	0.0
Seawater Intakes	Airport	SR07f	b	8.9	8.8	0.0	0.0	0.0	0.0	0.0	0.0

Sensitive Receiver	Name	ID	Relevant Water Depth [a]	Allowable Elevation		Predicted SS Elevation (mg L^{-1})					
				Dry	Wet	Dry Max	Wet Max	Dry Mean	Wet Mean	Dry 90%-tile	Wet 90%-tile
Spawning/Nursery Grounds	Fisheries Spawning Ground in North Lantau	SR08	a	8.2	5.6	0.2	0.3	0.0	0.0	0.1	0.1
Horseshoe Crab Nursery Grounds	Sham Wat Wan	SR10	a	8.9	6.5	0.1	0.1	0.0	0.0	0.0	0.0

Notes:

a. s = surface, m = middle, b = bottom, a = depth-averaged

b. The assessment criterion of 700 mg L^{-1} was adopted for these seawater intakes.

Scenarios 7 to 14 (Gas Pipeline)

The proposed pipeline installation methods have been presented in the *Project Description* (*Part 2 – Section 3*). Modelling details are presented in *Part 2 - Annex 6A* and a brief description is presented below.

12-hour dredging works undertaken by closed grab dredger(s) for the installation of the pipeline will be undertaken in four separate zones. These zones refer to the types of protection proposed for the pipeline (*Figure 6.5*) and are presented below (corresponding sections of the pipeline route with distance points (KP) are presented in brackets).

- Scenario 7: South Soko Shore Approach (KP 0 – KP 1)
- Scenario 9: Northwest Lantau to Urmston Road Crossing (KP 24.5 – KP 31)
- Scenario 10: Urmston Road Crossing (KP 31 – KP 33.5)
- Scenario 11: West of Black Point (KP 33.5 – KP 37)
- Scenario 12: West of Black Point (KP 37 – KP 37.803)
- Scenario 13: Black Point Shore Approach (KP 37.803 – KP 38.303)

For the zone of West of South Soko to West Lantau, TSHD dredging will be used and hence the following scenario has been defined:

- Scenario 9: Fan Lau Crossing to West Lantau (KP 5 – KP 24.5)

The TSHD will conduct dredging for approximately 45 minutes and will travel to the disposal site before the next dredging event starts. The model has assumed 24-hour operation [(1)]. It is proposed to be used mainly in the West Lantau areas, where Chinese White Dolphins are present, because a TSHD will extensively reduce the construction duration and hence cause less disturbances to dolphins (for details refer to *Part 2 – Section 9: Marine Ecology Assessment*).

The alignment of the submarine gas pipeline, the respective construction works and trench type in each zone, as well as the coordinates of the distance points (KP) are shown in *Figure 6.5*.

<u>Grab Dredging for the Submarine Gas Pipeline</u>

Grab dredging will be carried out along the majority of the gas pipeline section including the South Soko Shore Approach, Northwest Lantau to Urmston Road Crossing, West of Black Point, Black Point Shore Approach and at the gas receiving station (GRS). Potential impacts from dredging works at

(1) In reality the TSHD will be operated for 12 hours a day and avoid the calving season from March to August.

the GRS have been discussed in the previous section (see *Scenario 6)*, no unacceptable impacts were predicted. Potential impacts to water quality as a result of the other pipeline works are discussed below.

- *Scenario 7: Grab Dredging for South Soko Shore Approach (KP 0-1):* Modelling results (*Table 6.18*) indicate that SS elevations will be compliant with the WQO at all sensitive receivers in both seasons, with the exception of SR16b (fish fry habitat at Pak Tso Wan). As seen from *Table 6.18*, the maximum depth-averaged SS elevations at Pak Tso Wan would be about 10.6 and 6.0 mg L^{-1}, marginally exceeding the WQOs of 6.9 and 5.5 mg L^{-1} in the dry and wet seasons, respectively.

  The contour plots [(1)] (*Annex 6C*), however, show that the sediment plume (maximum depth averaged of > 5 mg L^{-1}) would disperse a maximum of 300 m from the centreline of the gas pipeline over a short period. In view of the short period of dredging at the shore approach (less than 1 month), the non-compliance will be temporary and water quality will return to normal after the construction period ends.

  As discussed above, the plume will be confined largely to the construction works area and hence it is anticipated that there will be no significant adverse impacts to the nursery/spawning ground of commercial fisheries resources. It should be noted that although the WQO is temporarily exceeded the elevations area within the reported tolerance criteria of fish. Literature reviews indicate that lethal responses had not been reported in adult fish at values below 125 mg L^{-1} [(2)] and that sublethal effects were only observed when levels exceeded 90 mg L^{-1} [(3)]. A recent study indicated that an appropriate tolerance level for fish in Hong Kong would be 50 mg L^{-1} [(4)].

  The impacts to the fish fry habitat and the nursery/spawning ground will be discussed in detail in *Part 2 – Section 10: Fisheries Impact Assessment*.

  In order to avoid any adverse impacts to water quality at Pak Tso Wan, it is recommended that 2 layers of silt curtain (stand type enclosing Pak Tso Wan and cage type enclosing the grab dredging area) will be installed. Details are discussed in *Section 6.8*.

(1) It should be noted that these plots show the highest level recorded in each model grid cell over the entire 15 day cycle and are hence a worse case image. They do not represent simultaneous snap shots and therefore should not be interpreted against the WQO as the SS elevations in one grid cell (ie area) will occur during a different day/hour than in another grid cell.

(2) References cited in BCL (1994). Marine Ecology of the Ninepin Islands including Peddicord R and McFarland V (1996) Effects of suspended dredged material on the commercial crab, *Cancer magister*. in PA Krenkel, J Harrison and JC Burdick (Eds) Dredging and its Environmental Effects. Proc. Speciality Conference. American Society of Engineers.

(3) Alabaster JS & Lloyd R (1984). Water Quality Criteria for Freshwater Fisheries. Butterworths, London.

(4) City University of Hong Kong, Final Report, Agreement No CE 62/98, Consultancy Study on Fisheries and Marine Ecological Criteria for Impact Assessment, AFCD, July 2001.

- *Scenario 9: Grab Dredging in Northwest Lantau to Urmston Road Crossing West of Black Point (KP 24.5-31)*: This scenario simulates three grab dredgers, which are located evenly at least 2,167 m apart, conducting the works simultaneously. Modelling results (*Table 6.20*) indicate that SS elevations will be compliant with the WQO and tolerance criterion at all sensitive receivers in both seasons.

  From the daily maximum contour plots (*Figures 6.11a* to *6.11f*), it is expected that the sediment plumes (maximum depth-averaged of > 5 mg L^{-1}) will extend just inside the Marine Park, i.e. at the boundary of the Marine Park. WQO exceedances will not be expected for the waters inside the Marine Park.

  As a mitigation measure, a cage type silt curtain will be deployed for each grab dredger to enclose the dredging area in order to avoid the plume entering the Marine Park. Hence no unacceptable adverse impact to the Marine Park and water quality are expected.

- *Scenario 10: Grab Dredging for Black Point Shore Approach across Urmston Road Crossing (KP 31–33.5):* Modelling results (*Table 6.21*) indicate that SS elevations will be compliant with the WQO and tolerance criterion at all sensitive receivers in both seasons.

  The contour plots (1) (*Annex 6C*) show the maximum depth-averaged SS plume of > 5 mg L^{-1} will not disperse more than 200 m from the centreline of the gas pipeline. The plume would not reach any sensitive receivers and its maximum extent will be limited to a period of less than 2 hours over the tidal cycle, it is expected that no unacceptable water quality impacts will arise.

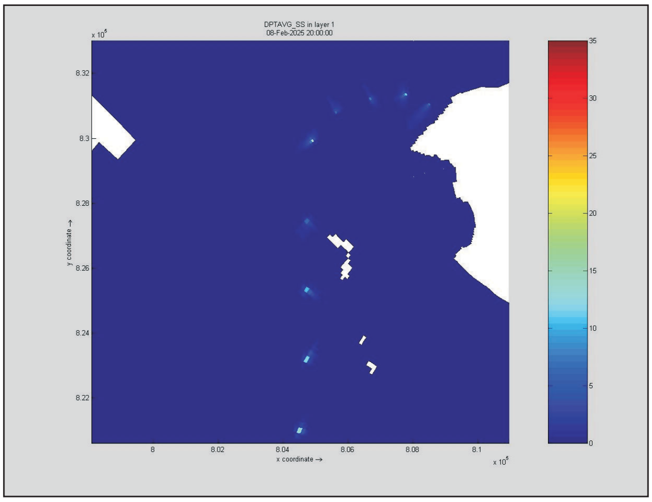
- *Scenario 11: Grab Dredging at West of Black Point (KP 33.5-37):* Modelling results (*Table 6.22*) indicate that SS elevations will be compliant with the WQO and tolerance criterion at all sensitive receivers in both seasons.

  The contour plots (2) (*Annex 6C*) show the maximum depth-averaged SS plume of > 5 mg L^{-1} will not disperse more than 300 m from the centreline of the gas pipeline and its maximum extent will be limited to a period of less than 2 hours over a tidal cycle. The plume would remain in the open water in the Urmston Road. Since the sediment plume will not reach any sensitive receivers, no unacceptable impacts to water quality are expected.

- *Scenario 12: Grab Dredging at West of Black Point (KP 37-37.803):* Modelling results (*Table 6.23*) indicate that SS elevations will be compliant with the WQO and tolerance criterion at all sensitive receivers in both seasons.

(1) It should be noted that these plots show the highest level recorded in each model grid cell over the entire 15 day cycle and are hence a worse case image. They do not represent simultaneous snap shots and therefore should not be interpreted against the WQO as the SS elevations in one grid cell (ie area) will occur during a different day/hour than in another grid cell.

(2) ditto



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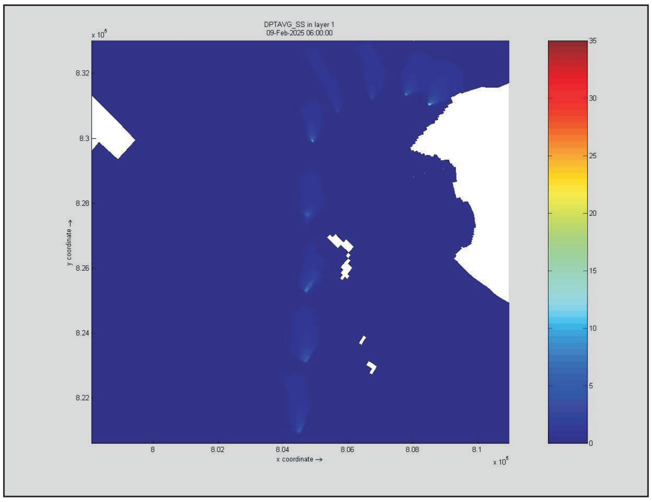

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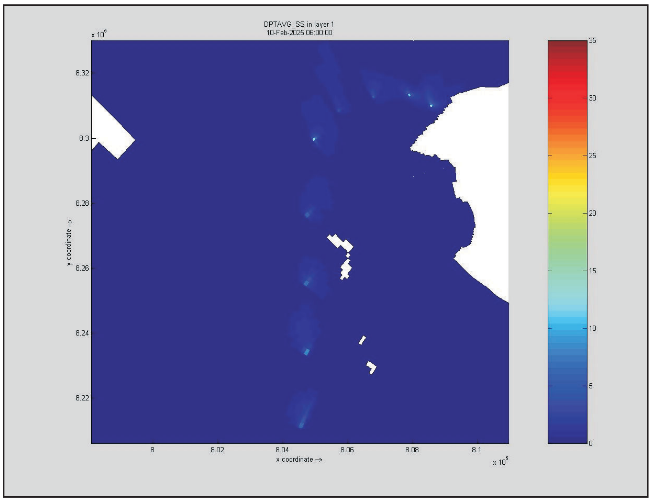

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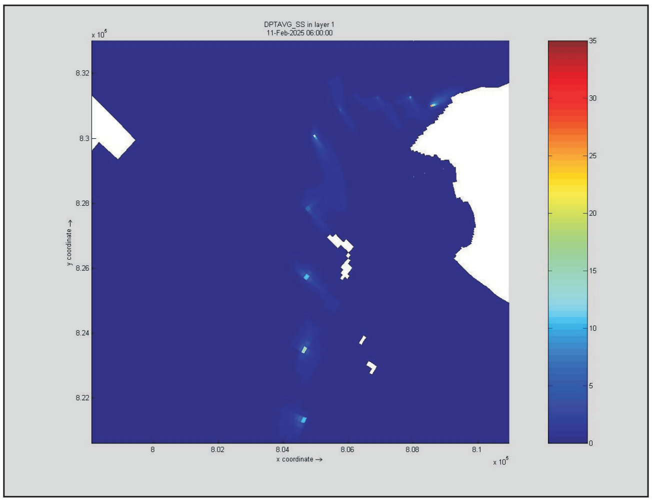

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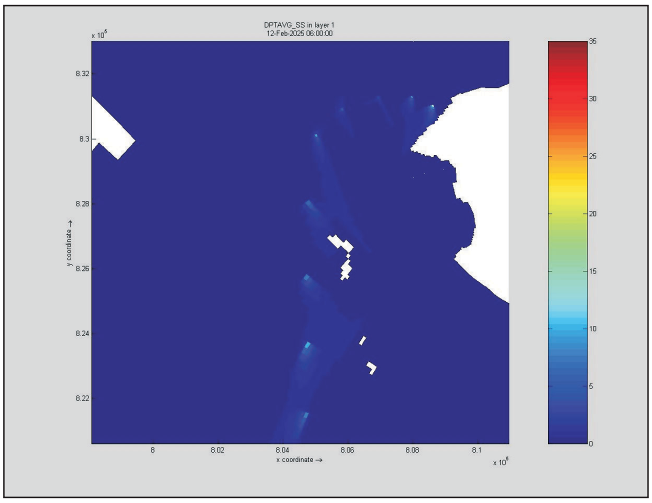

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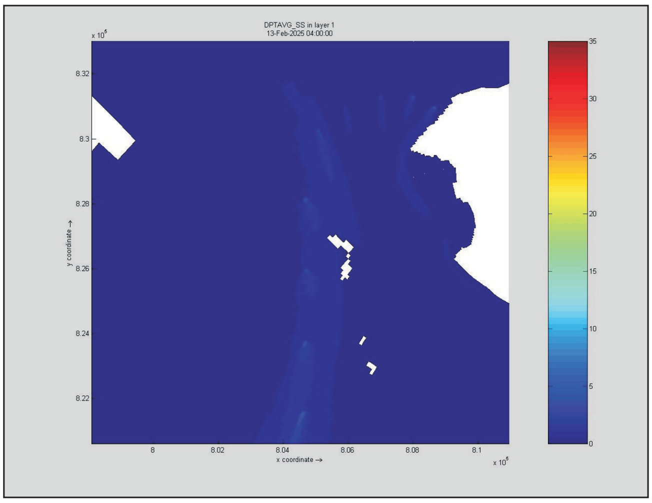

Day 6

Figure 6.11a

Maximum depth averaged SS elevation (mgL^{-1}) per day in wet season (spring-neap tidal cycle) using Grab Dredgers

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DATE: 16/11/2006

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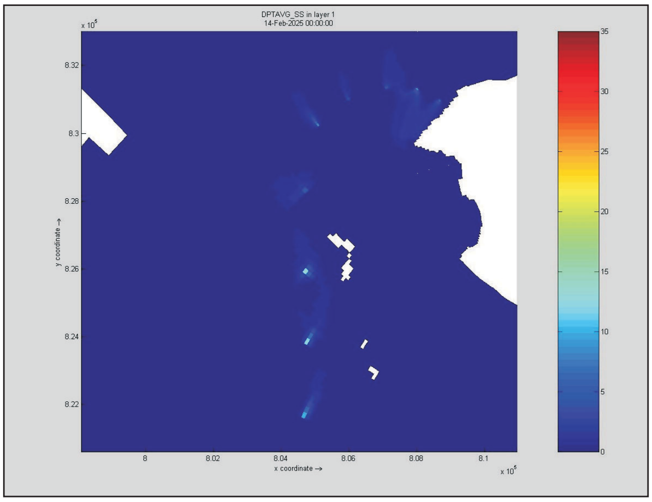

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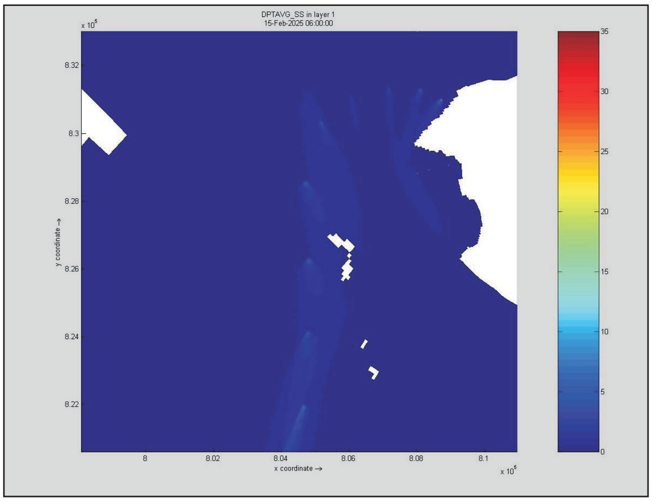

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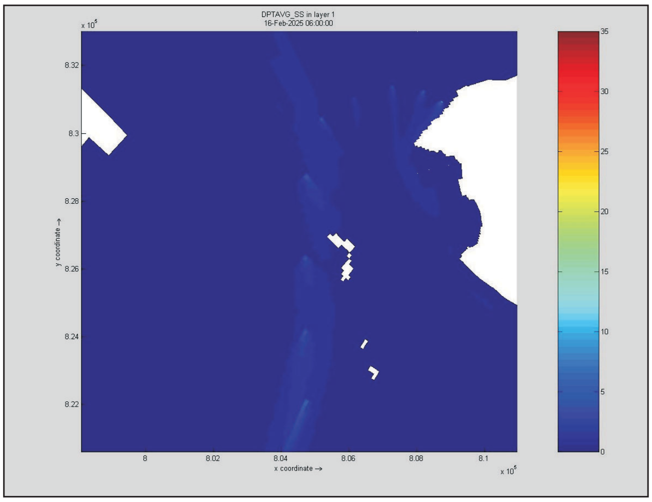

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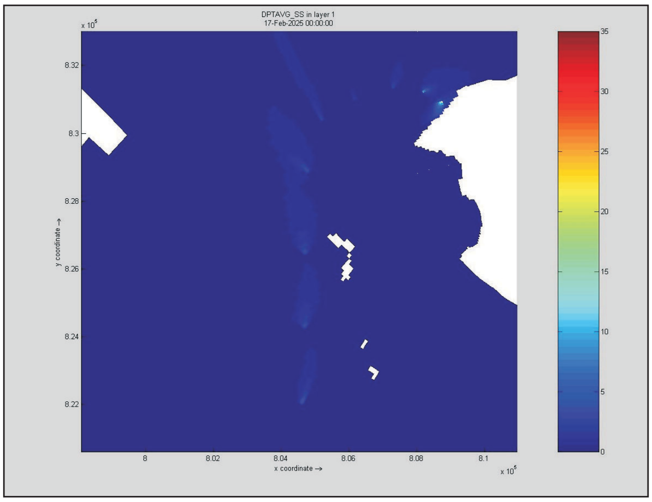

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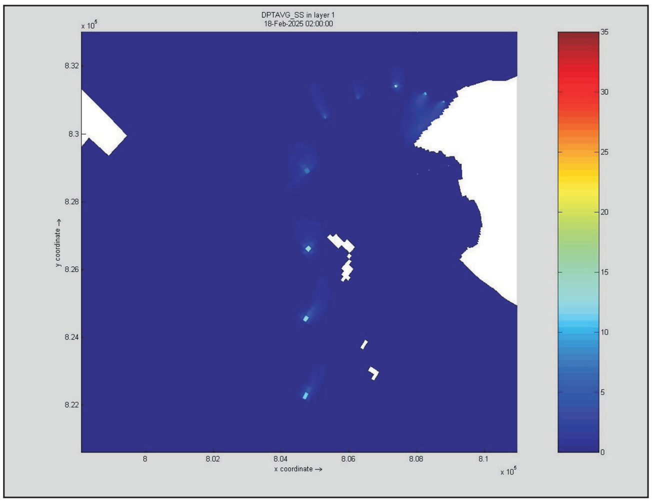

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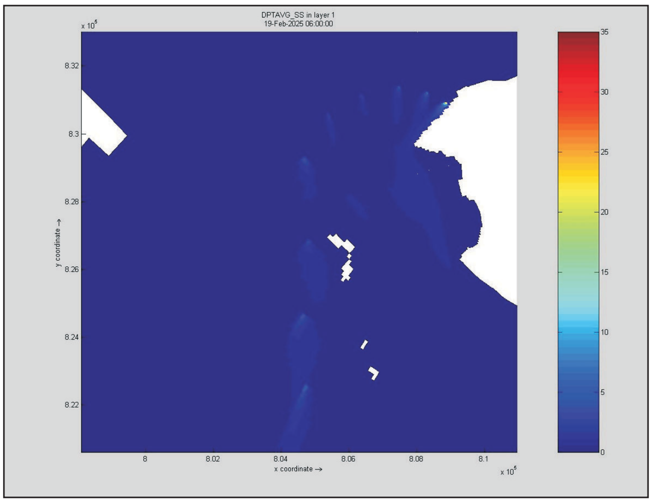

Day 12

Figure 6.11b

Maximum depth averaged SS elevation (mgL^{-1}) per day in dry season (spring-neap tidal cycle) using Grab Dredgers

FILE: 0018180Z16g
DATE: 16/11/2006

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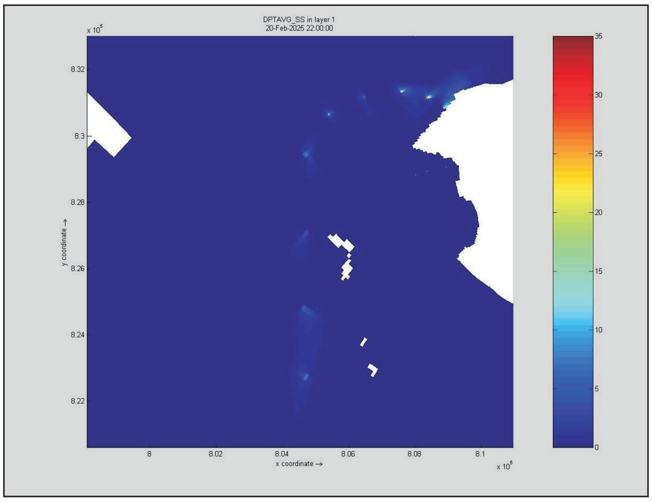

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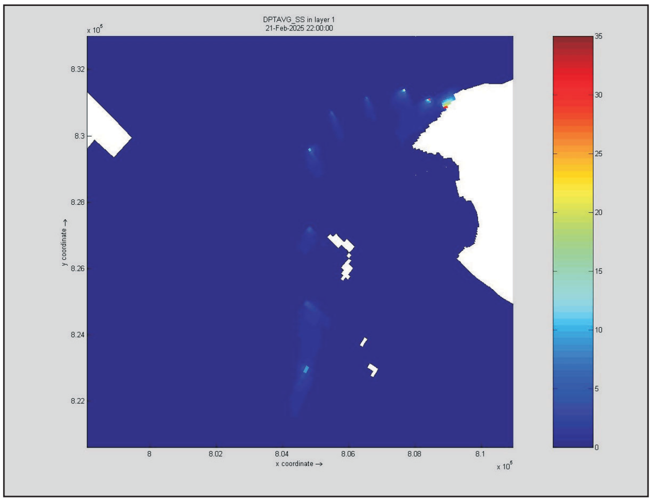

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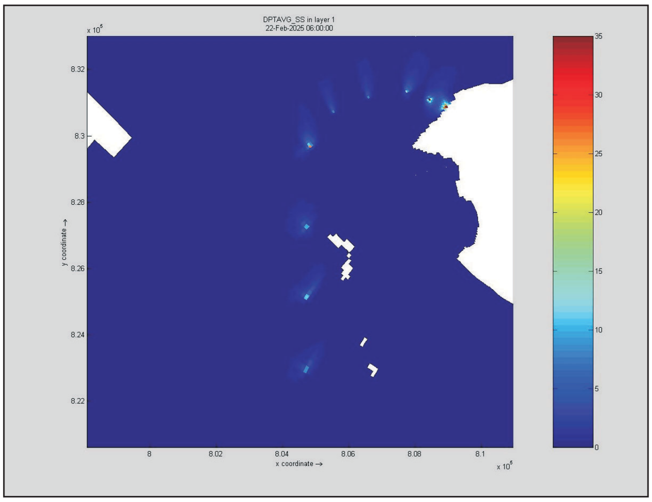

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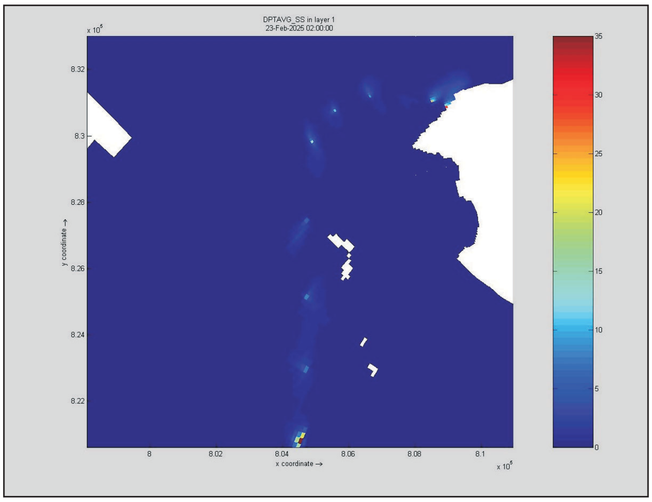

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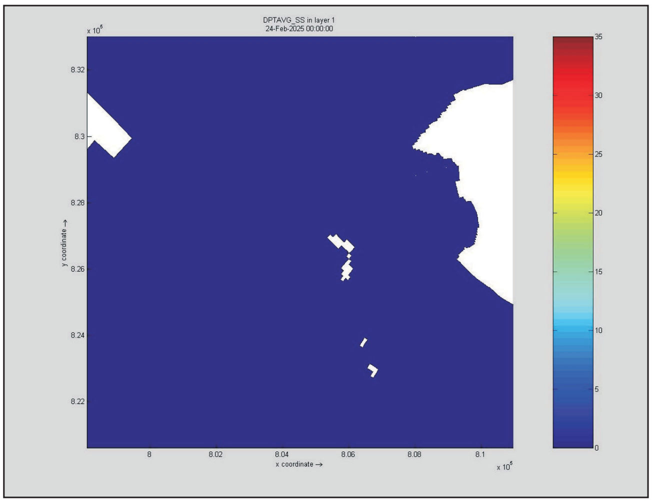

Day 17

Figure 6.11c

Maximum depth averaged SS elevation (mgL^{-1}) per day in dry season (spring-neap tidal cycle) using Grab Dredgers

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DATE: 16/11/2006

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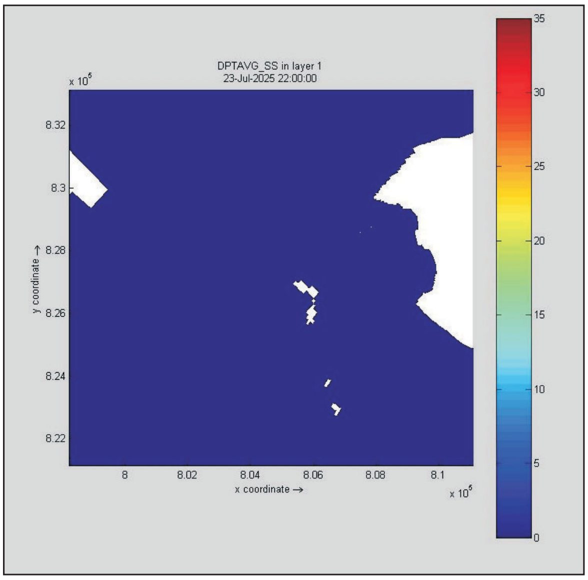

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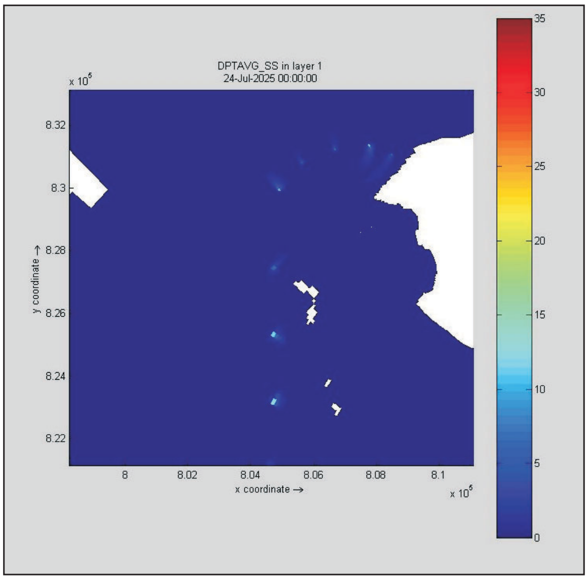
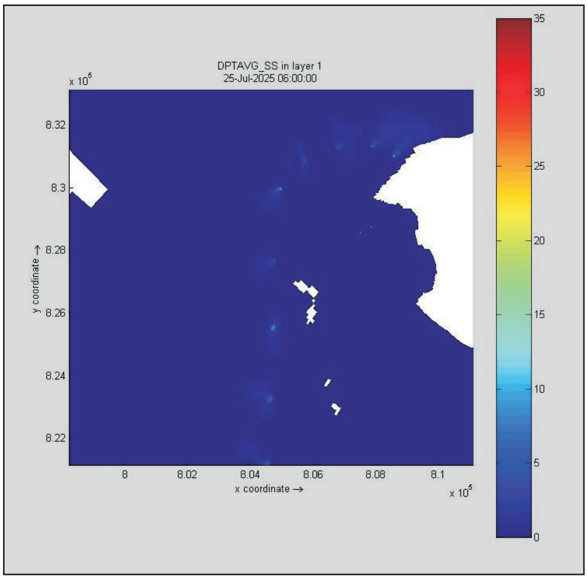


Day 2



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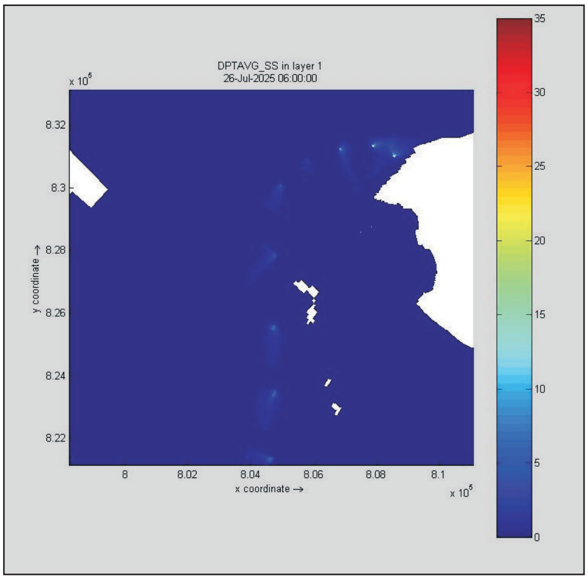

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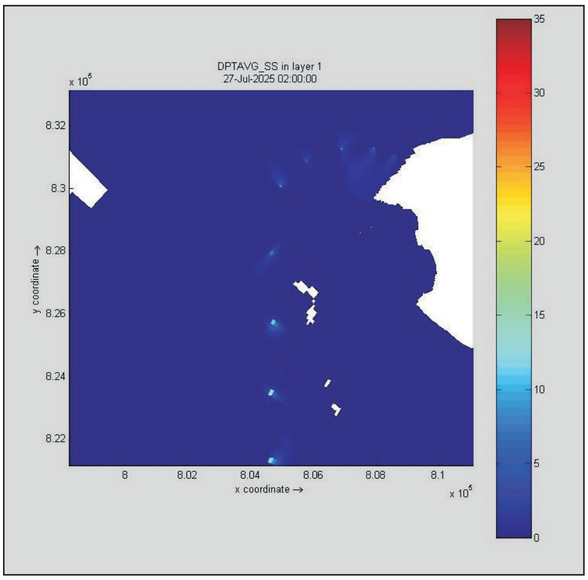

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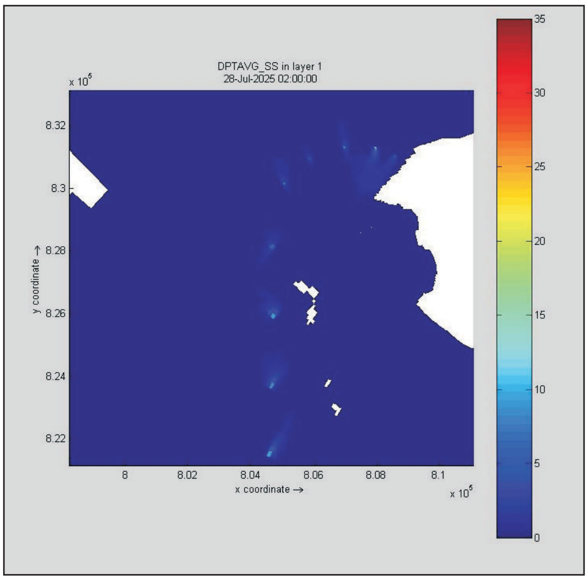

Day 6

Figure 6.11d

Maximum depth averaged SS elevation (mgL^{-1}) per day in wet season (spring-neap tidal cycle) using Grab Dredgers

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DATE: 16/11/2006

Environmental Resources Management

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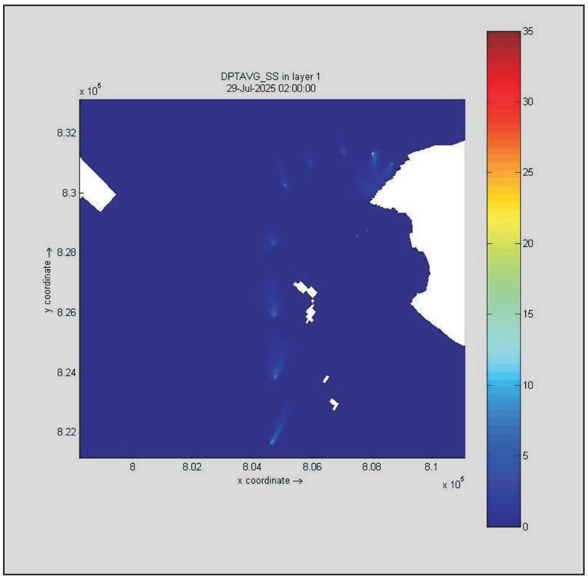
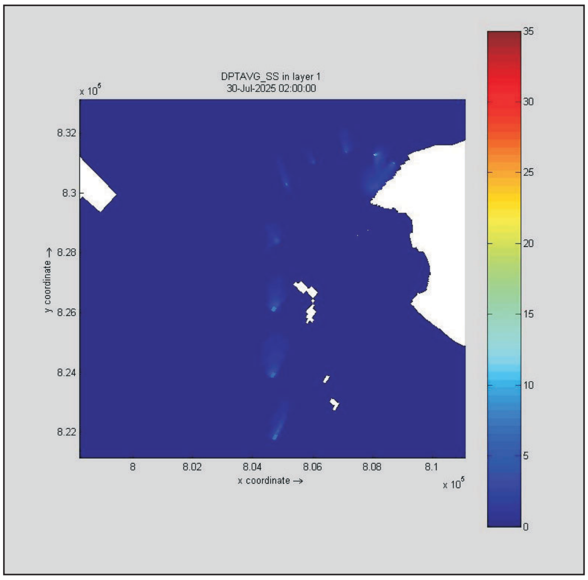


Day 7



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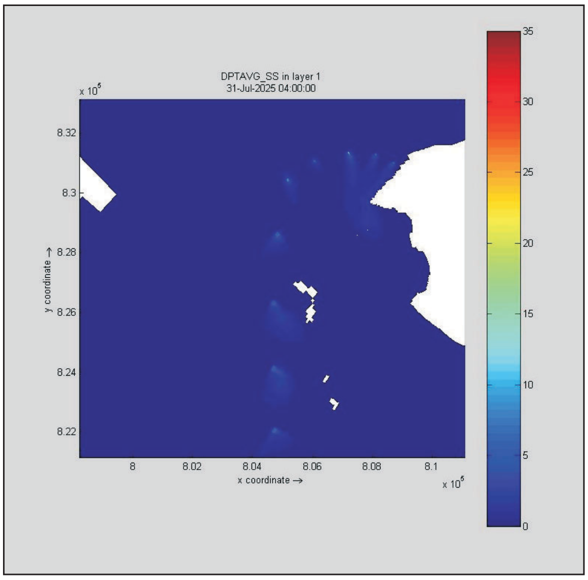

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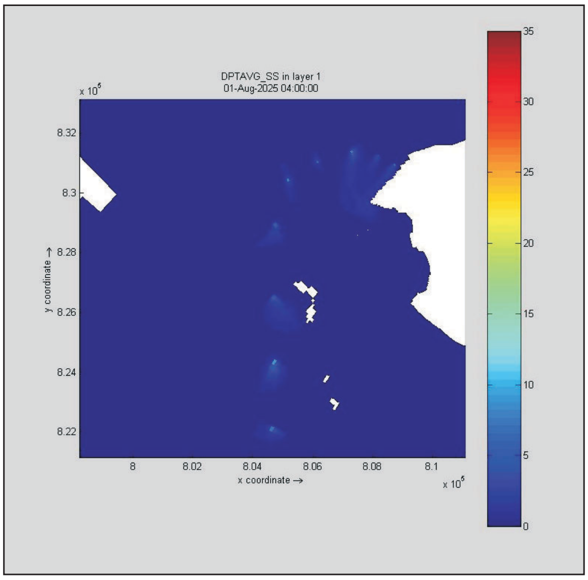

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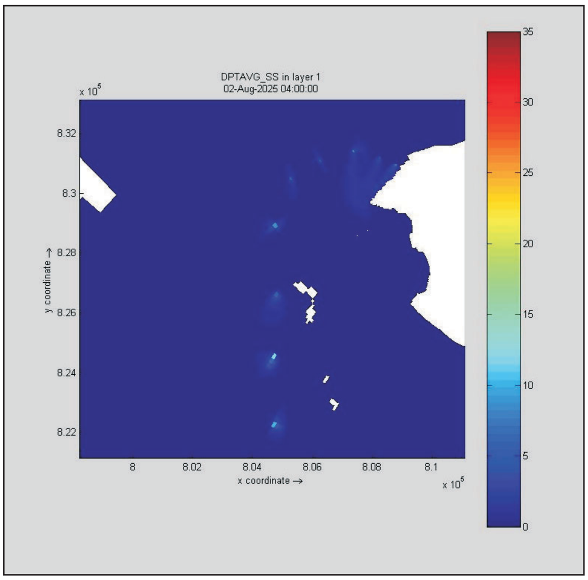

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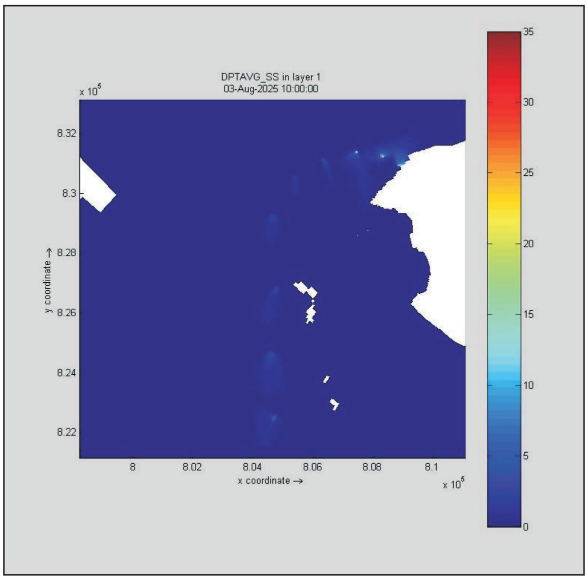

Day 12

Figure 6.11e

Maximum depth averaged SS elevation (mgL^{-1}) per day in wet season (spring-neap tidal cycle) using Grab Dredgers

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DATE: 16/11/2006

Environmental Resources Management

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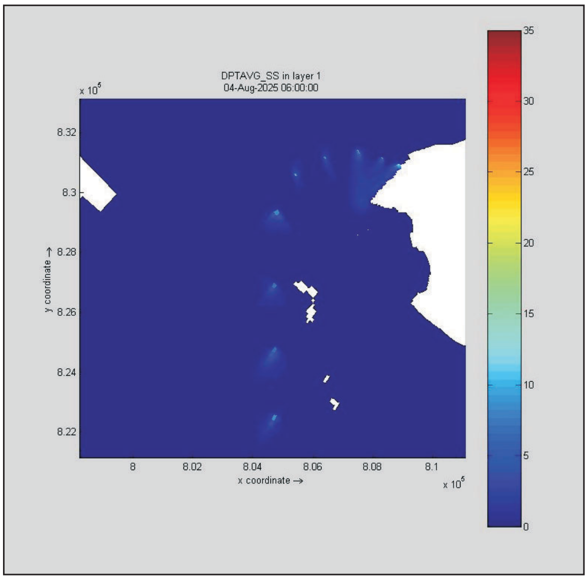

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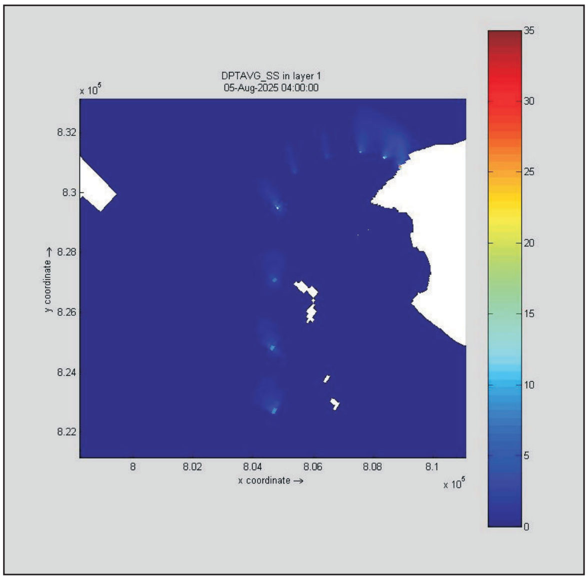

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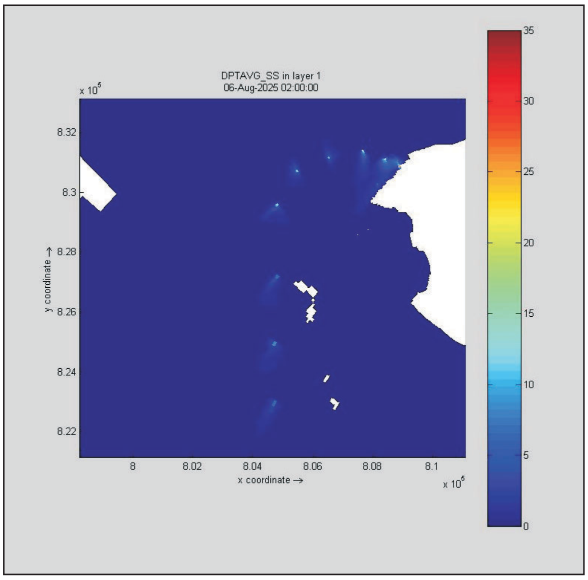

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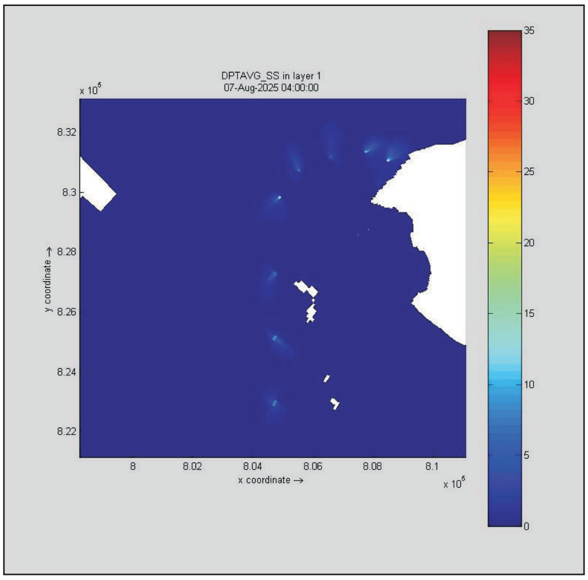
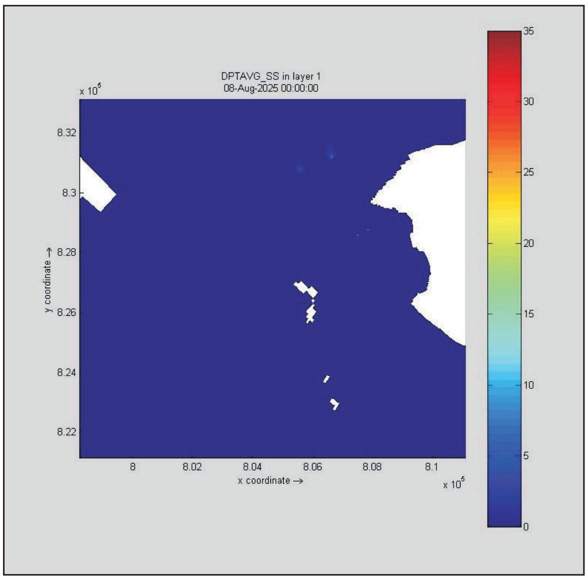
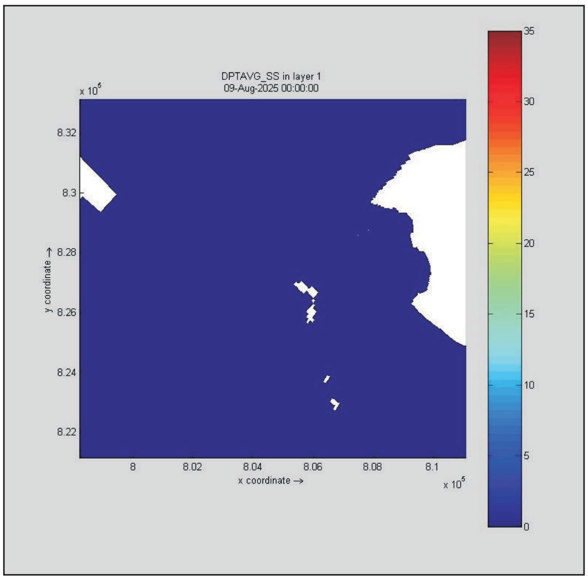


Day 16



Day 17



Day 18

Figure 6.11f

Maximum depth averaged SS elevation (mgL^{-1}) per day in wet season (spring-neap tidal cycle) using Grab Dredgers

FILE: 0018180Z16k
DATE: 16/11/2006

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The contour plots (1) (*Annex 6C*) show the maximum depth-averaged SS plume > 5 mg L^{-1} will not disperse more than 350 m from the centreline of the gas pipeline and its maximum extent will be limited to a period of less than 2 hours over a tidal cycle. The plume would not reach the coast and any sensitive receivers. Therefore, no unacceptable adverse water quality impacts are expected.

- *Scenario 13: Grab Dredging at Black Point Shore Approach (KP 37.803-38.303):* Modelling results (*Table 6.24*) indicate that SS elevations will be compliant with the WQO and tolerance criterion at all sensitive receivers in both seasons.

  The contour plots (2) (*Annex 6C*) show the maximum depth-averaged SS plume > 5 mg L^{-1} will not disperse more than 350 m from the centreline of the gas pipeline and its maximum extent will be limited to a period of less than 2 hours over a tidal cycle. The plume would reach the coast but since it is an artificial seawall of low ecological value, it is expected that no unacceptable impacts will arise.

<u>TSHD Dredging for the Submarine Gas Pipeline</u>

As an alternative to grab dredging, TSHD will be undertaken for the pipeline section crossing west of South Soko to West Lantau. Potential impacts to water quality as a result of the works are discussed below.

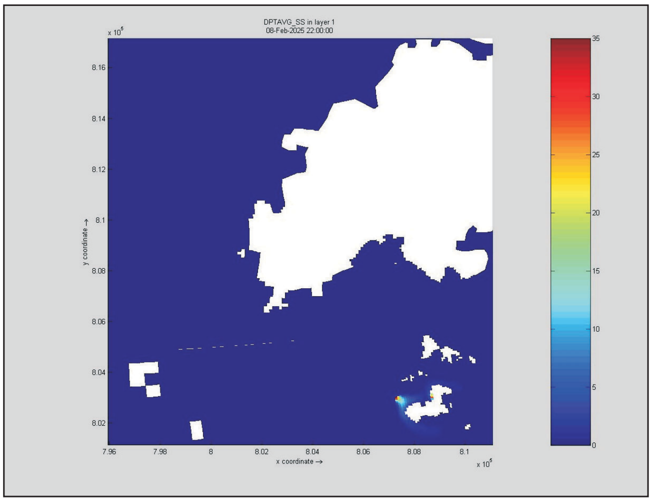
- *Scenario 8: TSHD Dredging from Fan Lau Crossing to West Lantau (KP 1-24.5):* Modelling results (*Table 6.19*) indicate that SS elevations will be compliant with the WQO and tolerance criterion at all sensitive receivers in both seasons with the exception of minor WQO exceedance at the boundary of the potential Marine Park in Southwest Lantau.

  As shown in *Table 6.19*, the maximum SS elevations will comply with the WQO in the dry season and will marginally exceed the WQO in the wet season by 0.4 mg L^{-1} and 2.4 mg L^{-1} at SR19b and SR19c respectively. The exceedances are predicted to occur in the wet season but in face no TSHD dredging works will be conducted in Indo-Pacific Humpback Dolphin peak calving season of March through August, i.e. the wet season. Therefore, no unacceptable adverse impacts due to the dredging works on the potential Marine Park will be expected.

  As seen from the daily maximum depth-averaged SS plots shown in *Figures 6.12a* to *6.12f*, the sediment plume > 5 mg L^{-1} due to dredging would be confined to the works area and remain in the open waters. It

(1) It should be noted that these plots show the highest level recorded in each model grid cell over the entire 15 day cycle and are hence a worse case image. They do not represent simultaneous snap shots and therefore should not be interpreted against the WQO as the SS elevations in one grid cell (ie area) will occur during a different day/hour than in another grid cell.

(2) ditto



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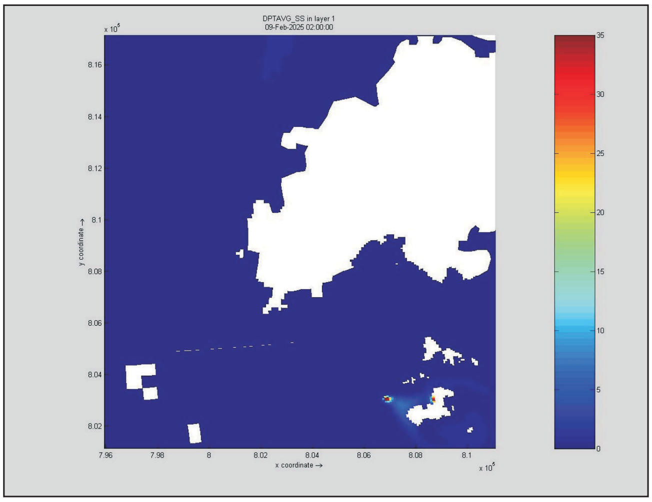

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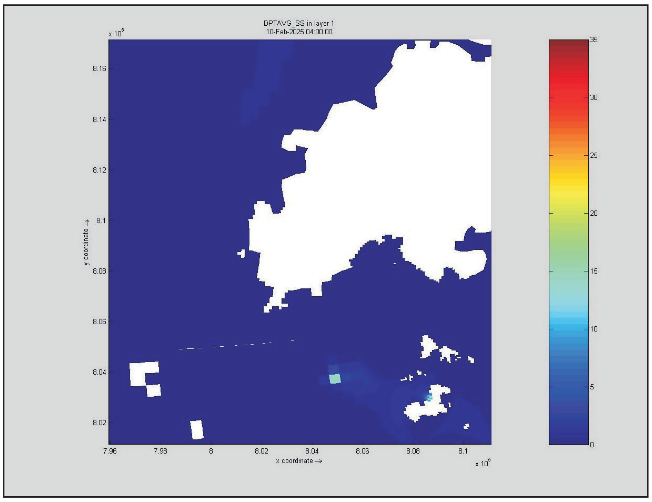

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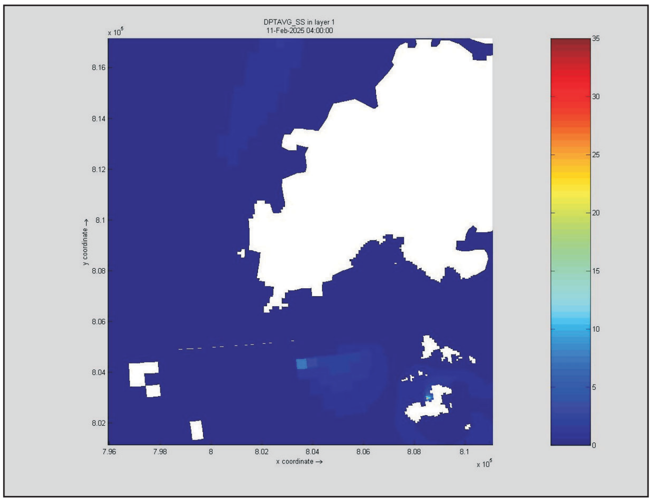

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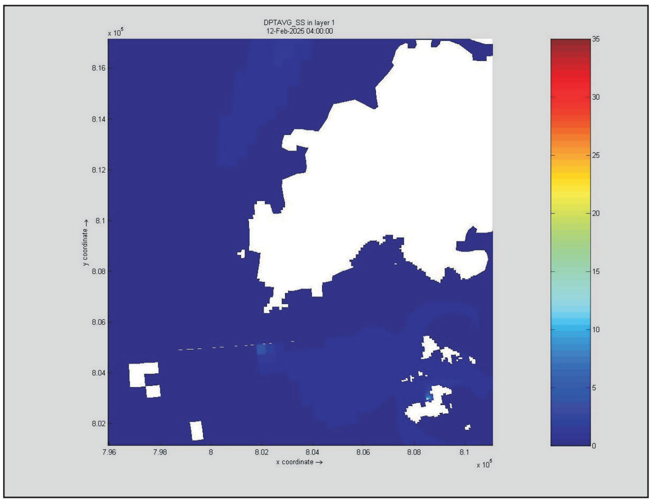

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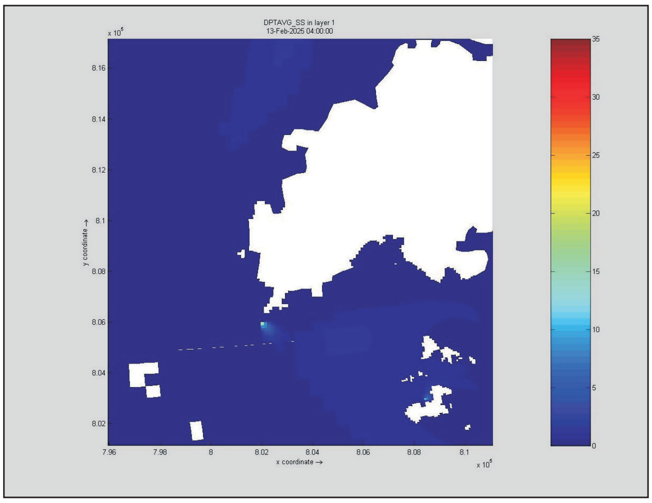

Day 6

Figure 6.12a

Maximum depth averaged SS elevation (mgL^{-1}) per day in dry season (spring-neap tidal cycle) using TSHD

FILE: 0018180Z16
DATE: 16/11/2006

Environmental Resources Management

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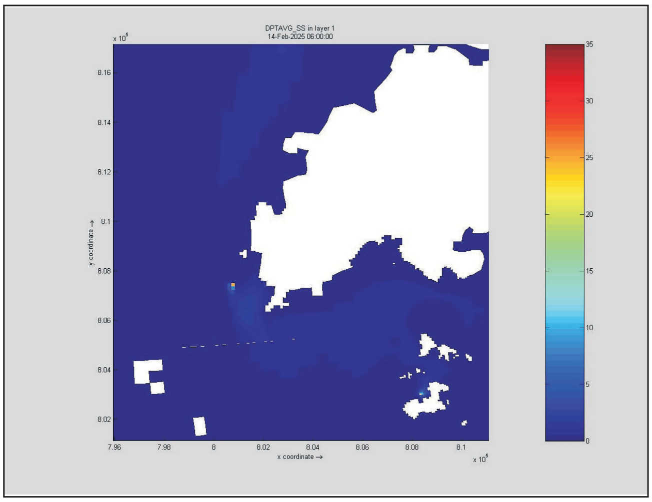

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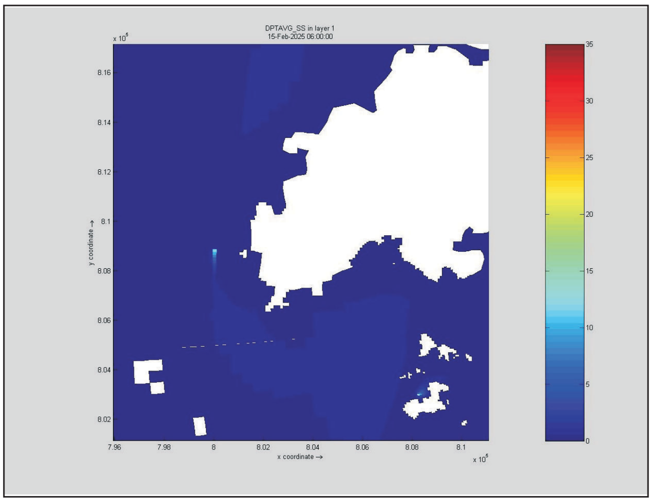

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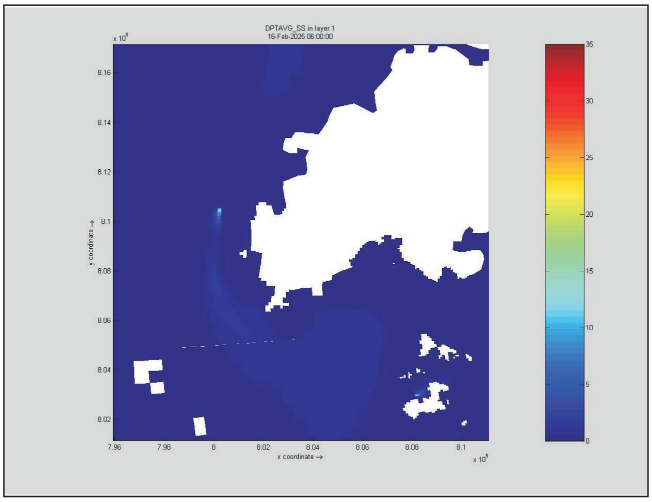

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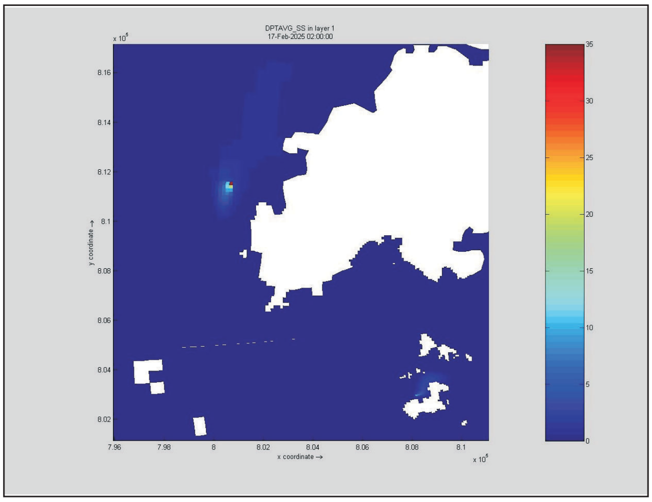

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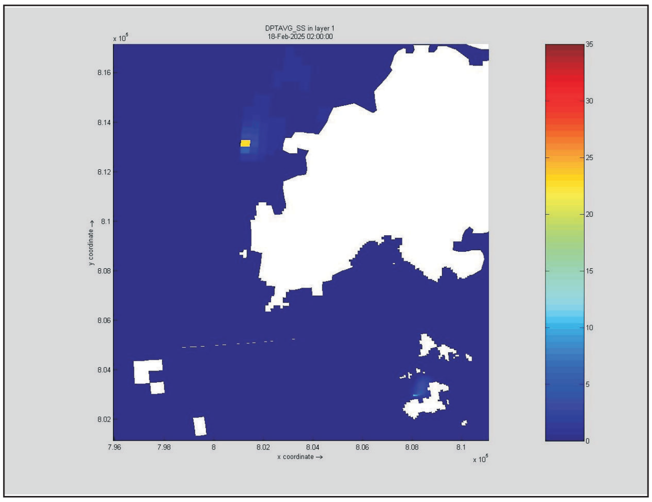

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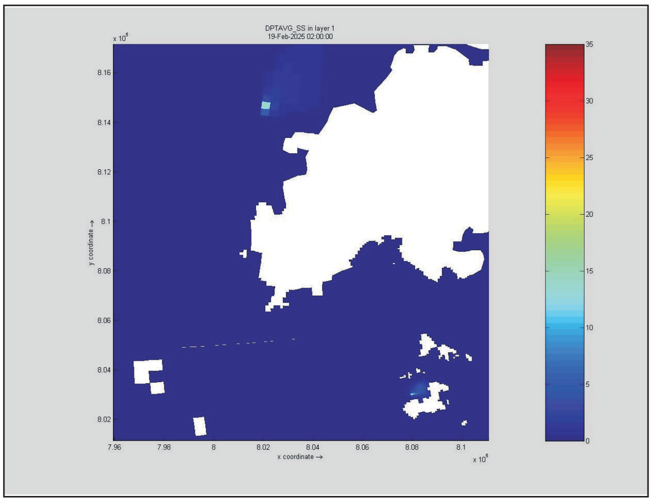

Day 12

Figure 6.12b

Maximum depth averaged SS elevation (mgL^{-1}) per day in dry season (spring-neap tidal cycle) using TSHD

FILE: 0018180Z16a
DATE: 16/11/2006

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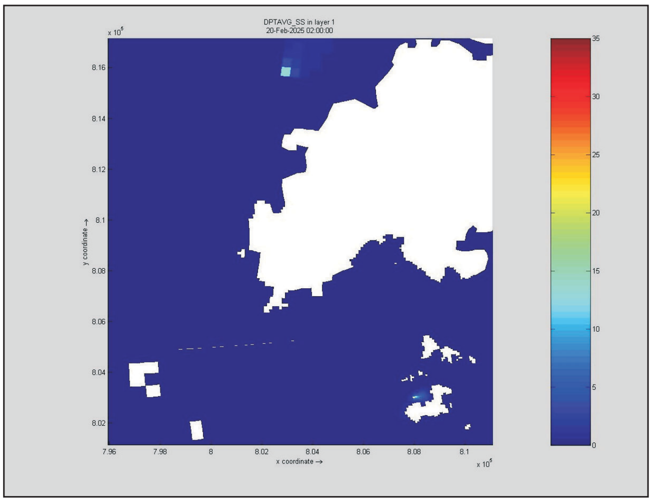
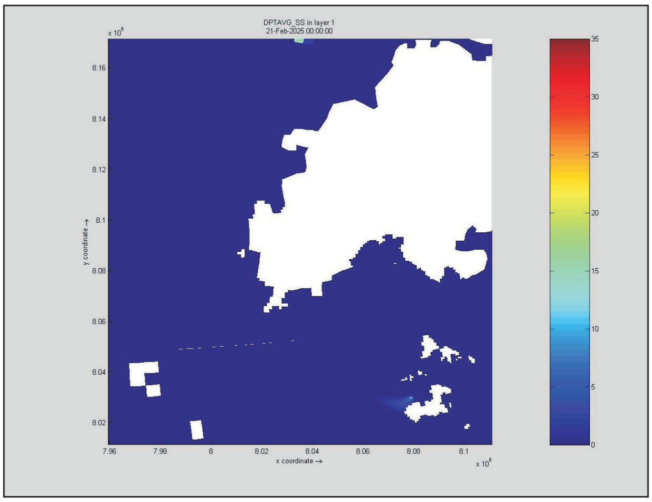


Day 13



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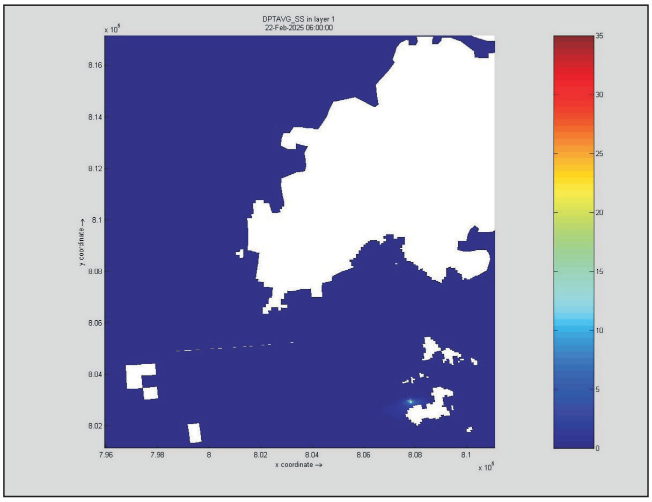

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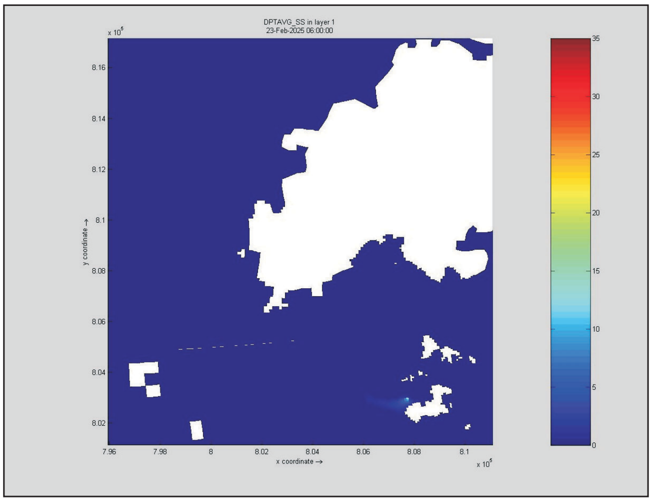

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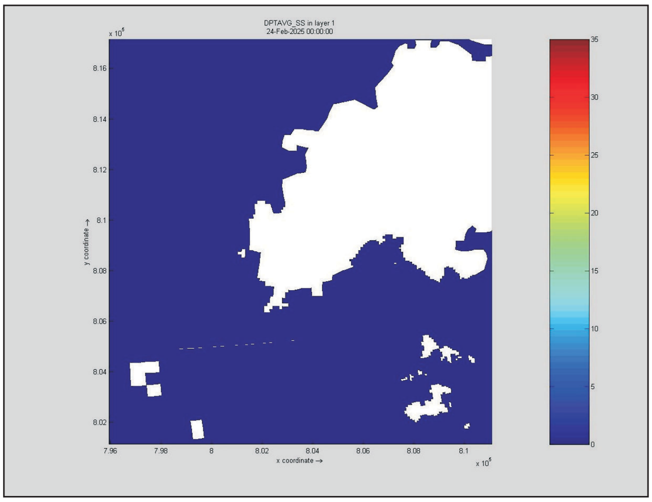

Day 17

Figure 6.12c

Maximum depth averaged SS elevation (mgL^{-1}) per day in dry season (spring-neap tidal cycle) using TSHD

FILE: 0018180Z16b
DATE: 16/11/2006

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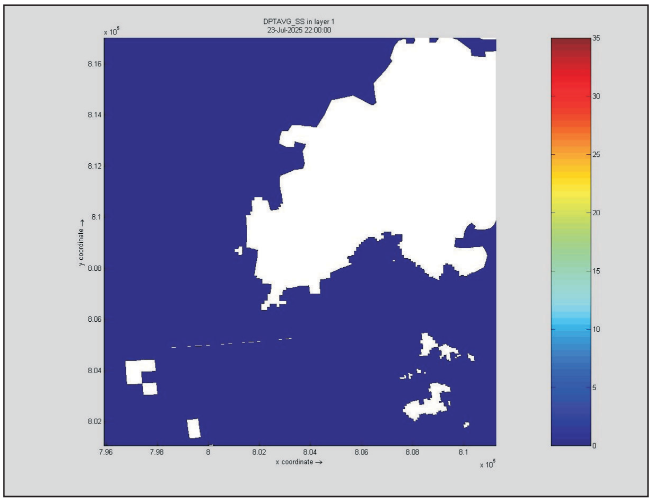

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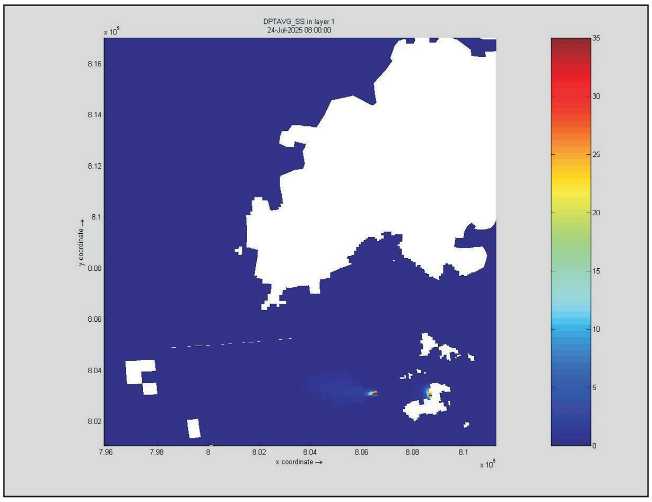

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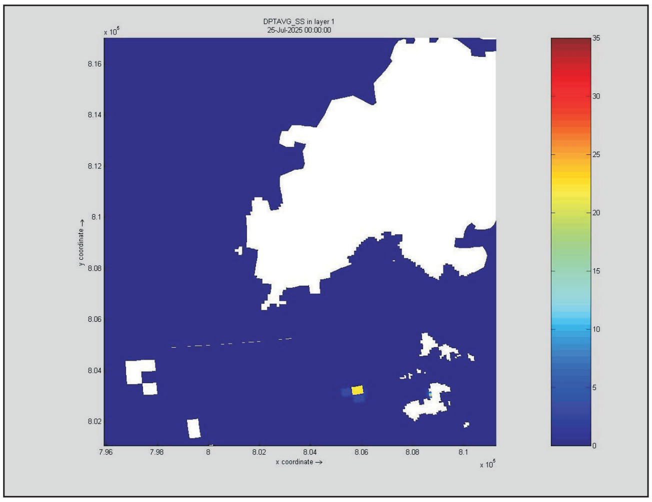

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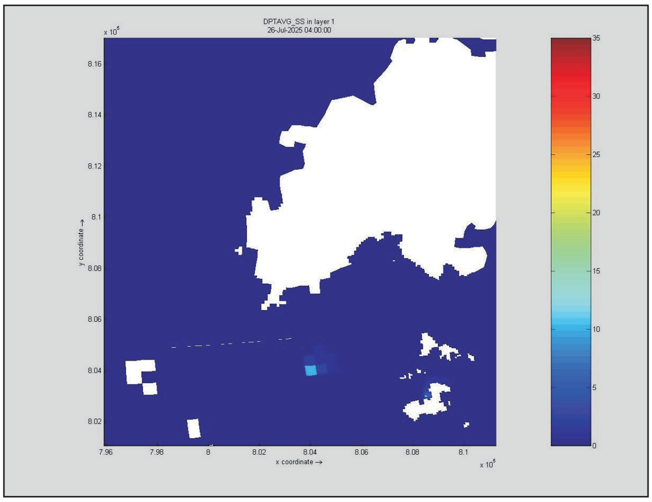

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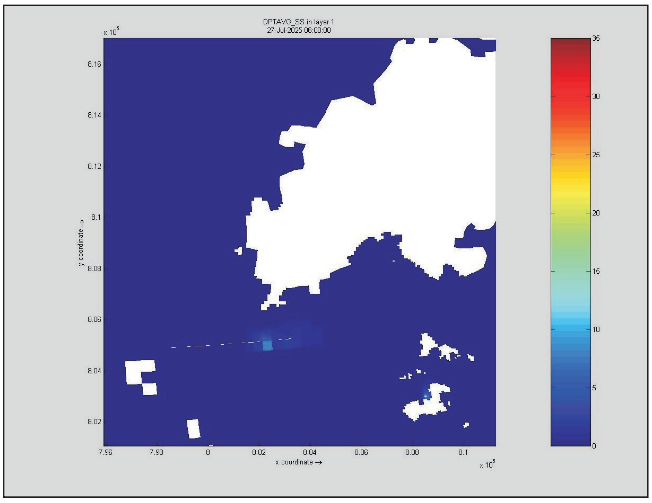

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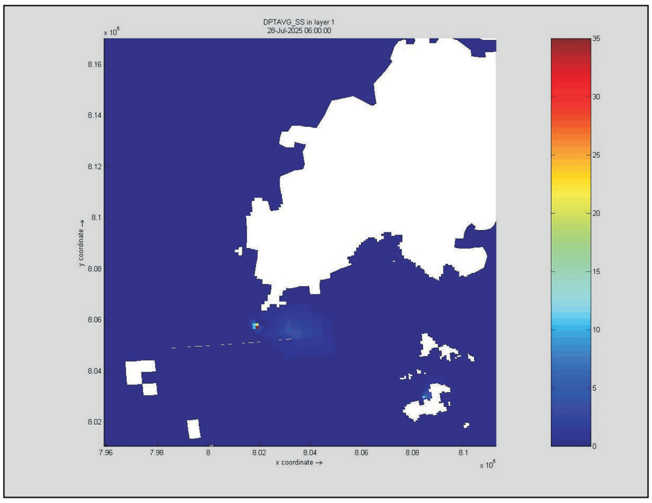

Day 6

Figure 6.12d

Maximum depth averaged SS elevation (mgL^{-1}) per day in wet season (spring-neap tidal cycle) using TSHD

FILE: 0018180Z16c
DATE: 16/11/2006

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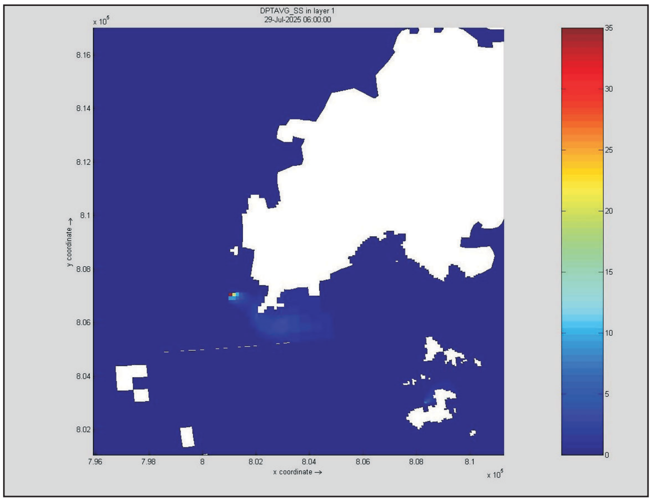
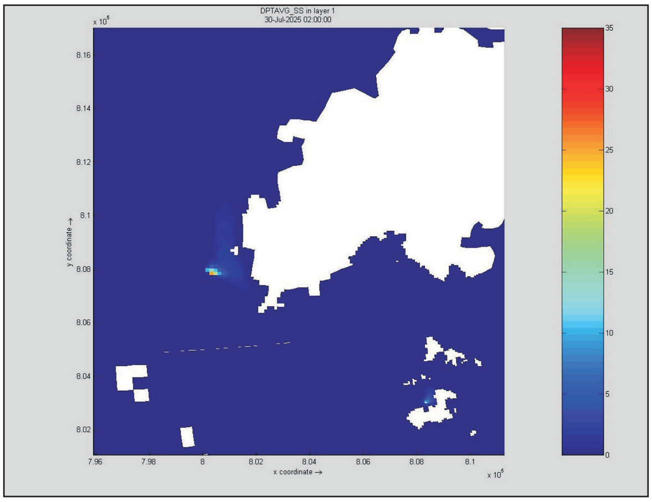


Day 7



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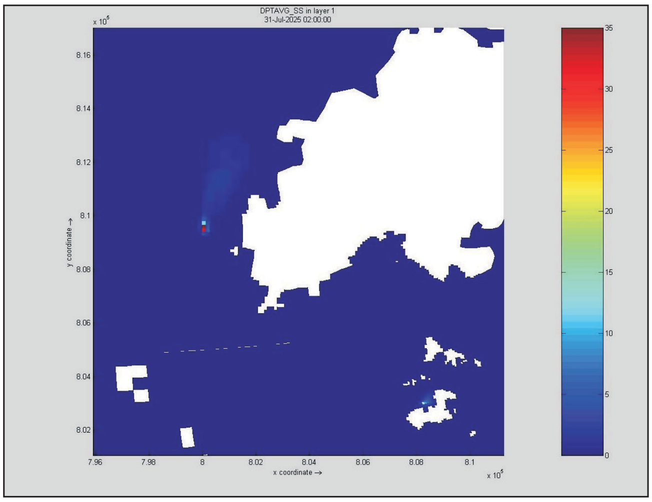

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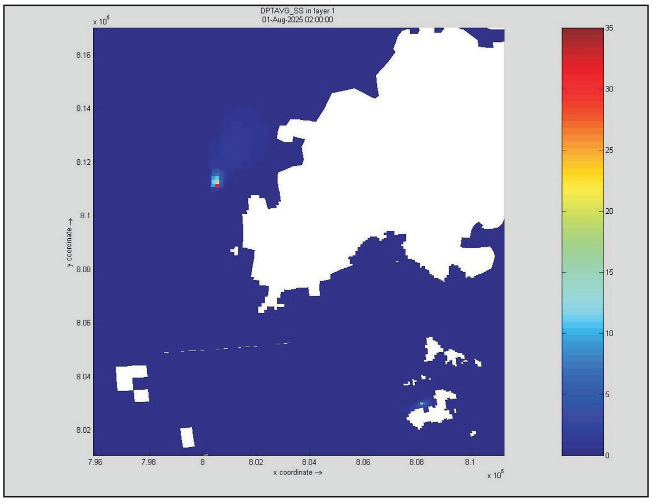

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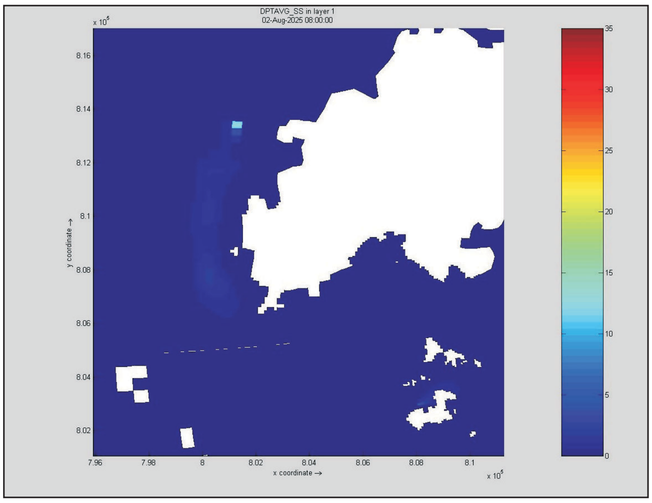

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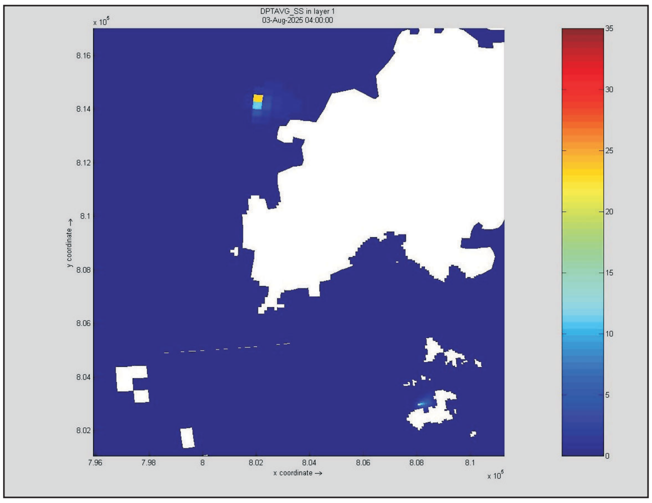

Day 12

Figure 6.12e

Maximum depth averaged SS elevation (mgL^{-1}) per day in wet season (spring-neap tidal cycle) using TSHD

FILE: 0018180Z16d
DATE: 16/11/2006

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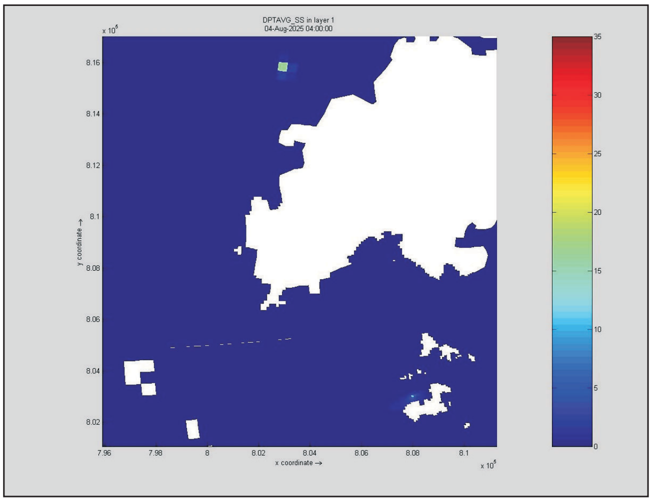
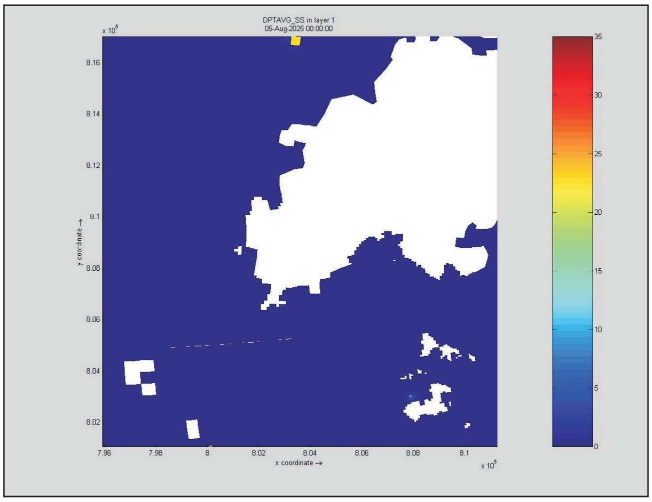
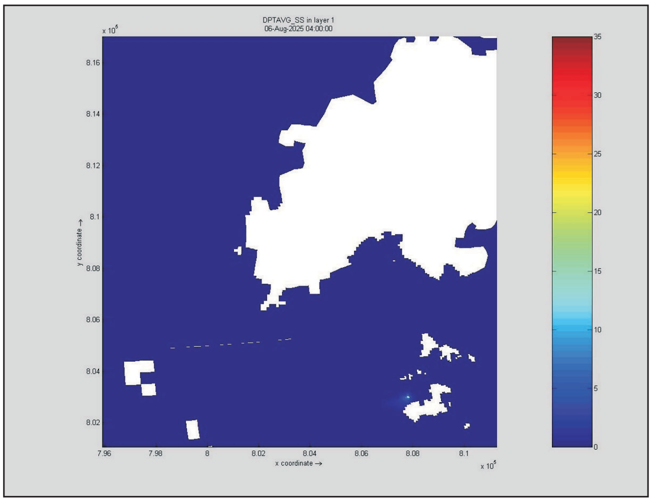


Day 13



Day 14



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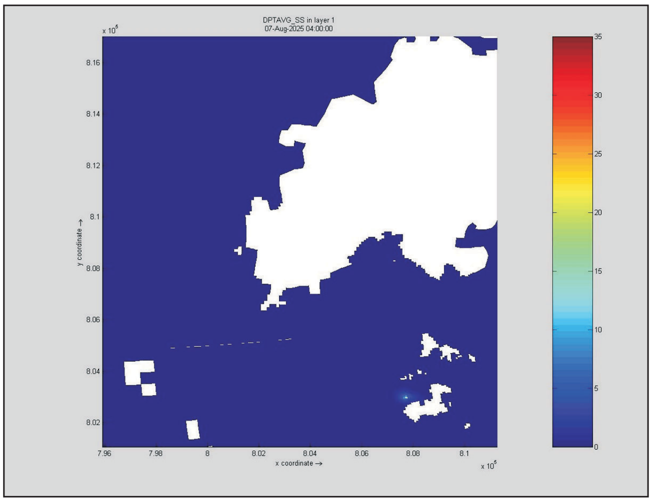
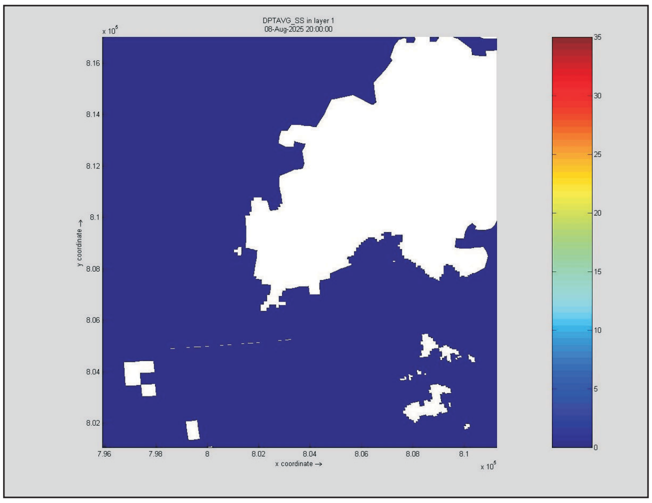


Day 16



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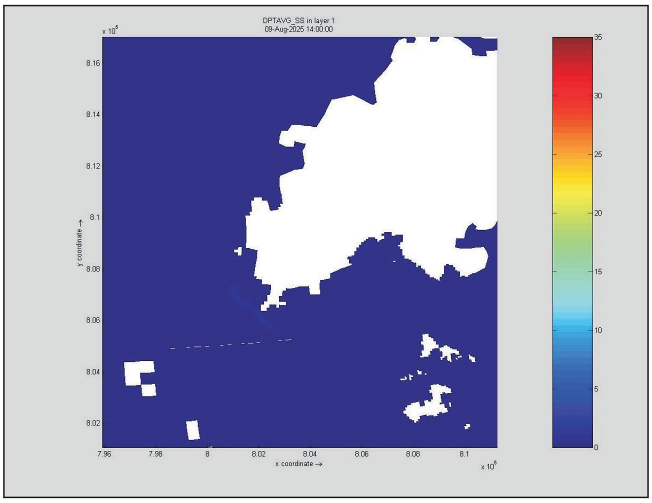

Day 18

Figure 6.12f

Maximum depth averaged SS elevation (mgL^{-1}) per day in wet season (spring-neap tidal cycle) using TSHD

FILE: 0018180Z16e
DATE: 16/11/2006

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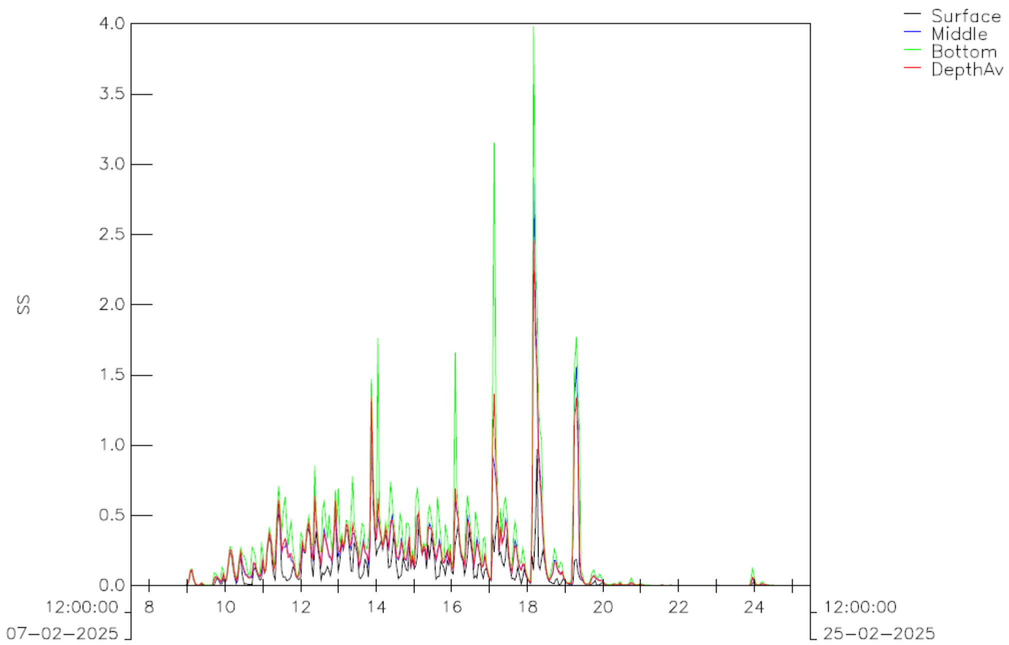
is expected that the plume will disperse to a maximum extent of approximately 200 m from the centreline of the gas pipeline in the direction of the current and would stay away from the nursery/spawning ground of commercial fisheries resources in south Lantau and the proposed Marine Park.

It is also considered that SS elevations have no direct impacts to the Chinese White Dolphins. It is aforementioned that the TSHD is assumed in the modelling to be operated for 24 hours a day (1) and the dredging works carried out by the TSHD is non-continuous. The TSHD will conduct dredging for approximately 45 minutes and will travel to the disposal site before the next dredging event starts. Consequently the sediment plumes will settle rapidly before the next dredging cycle commences as evidenced in the time-series plots (*Figures 6.13a to 6.13c*). It is proposed to be mainly used in the West Lantau areas, where Chinese White Dolphins are present because a TSHD will extensively reduce the construction duration and hence cause less disturbance to dolphins (details refer to *Part 2 – Section 9: Marine Ecology Assessment*).

(1) In reality the TSHD will be operated for 12 hours a day and avoid the calving season from March to August.



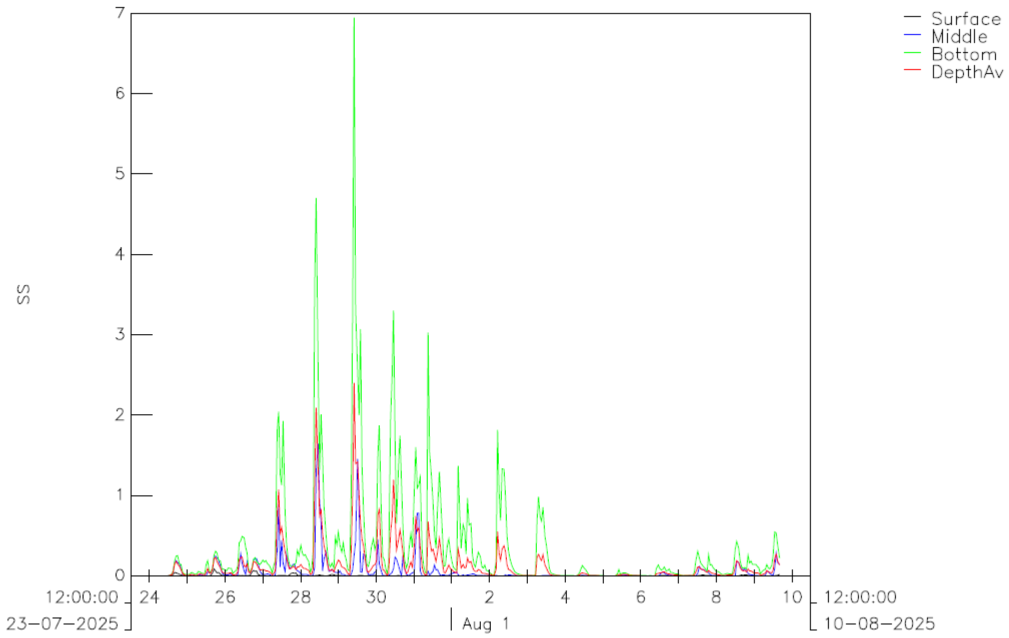


Figure 6.13a ***Predicted SS Elevations at SR19a (Boundary of the Proposed Southwest Lantau Marine Park) over a Simulation Period (upper: Dry Season; lower: Wet Season)***

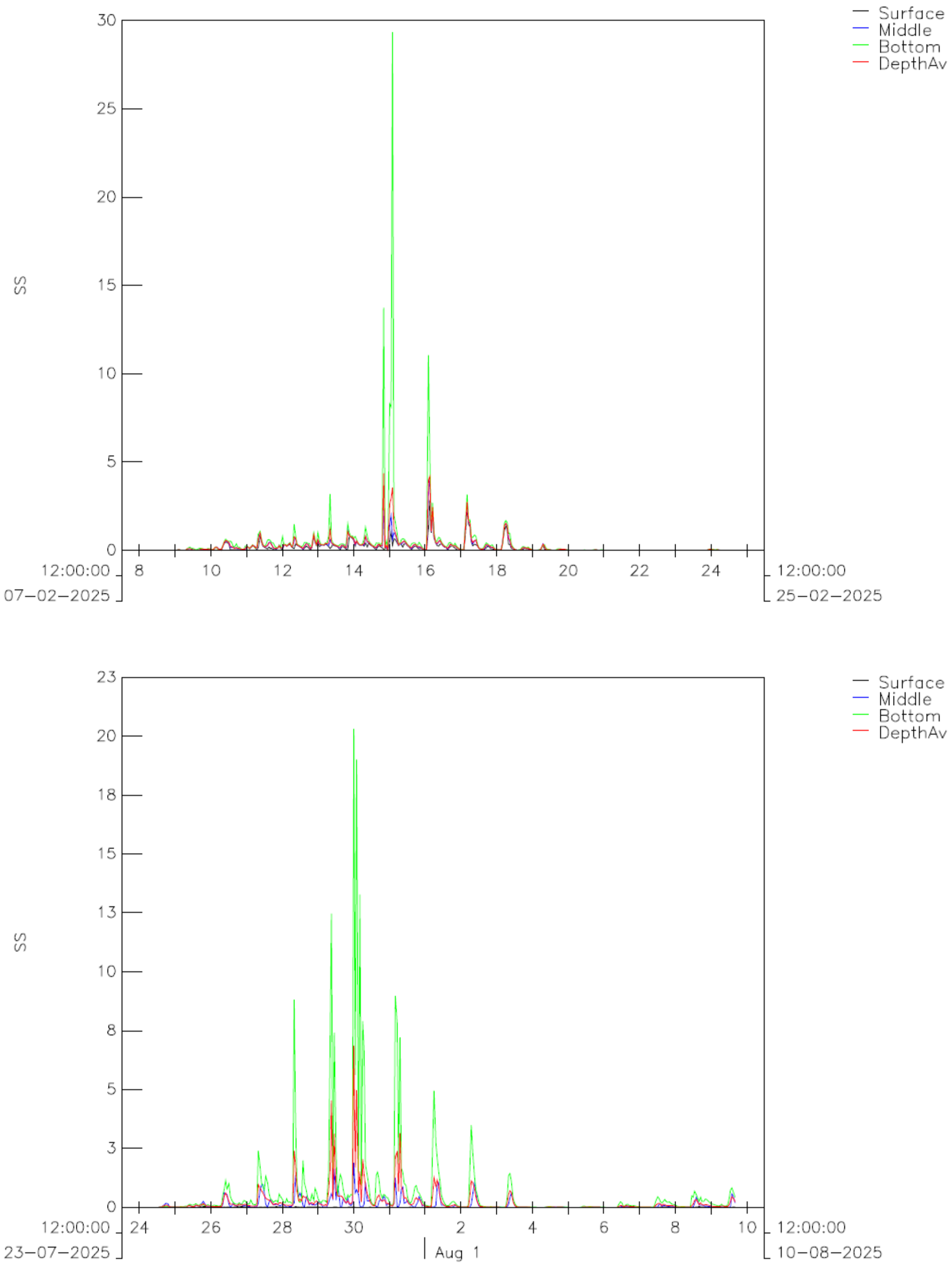


Figure 6.13b ***Predicted SS Elevations at SR19b (Boundary of the Proposed Southwest Lantau Marine Park) over a Simulation Period (upper: Dry Season; lower: Wet Season)***

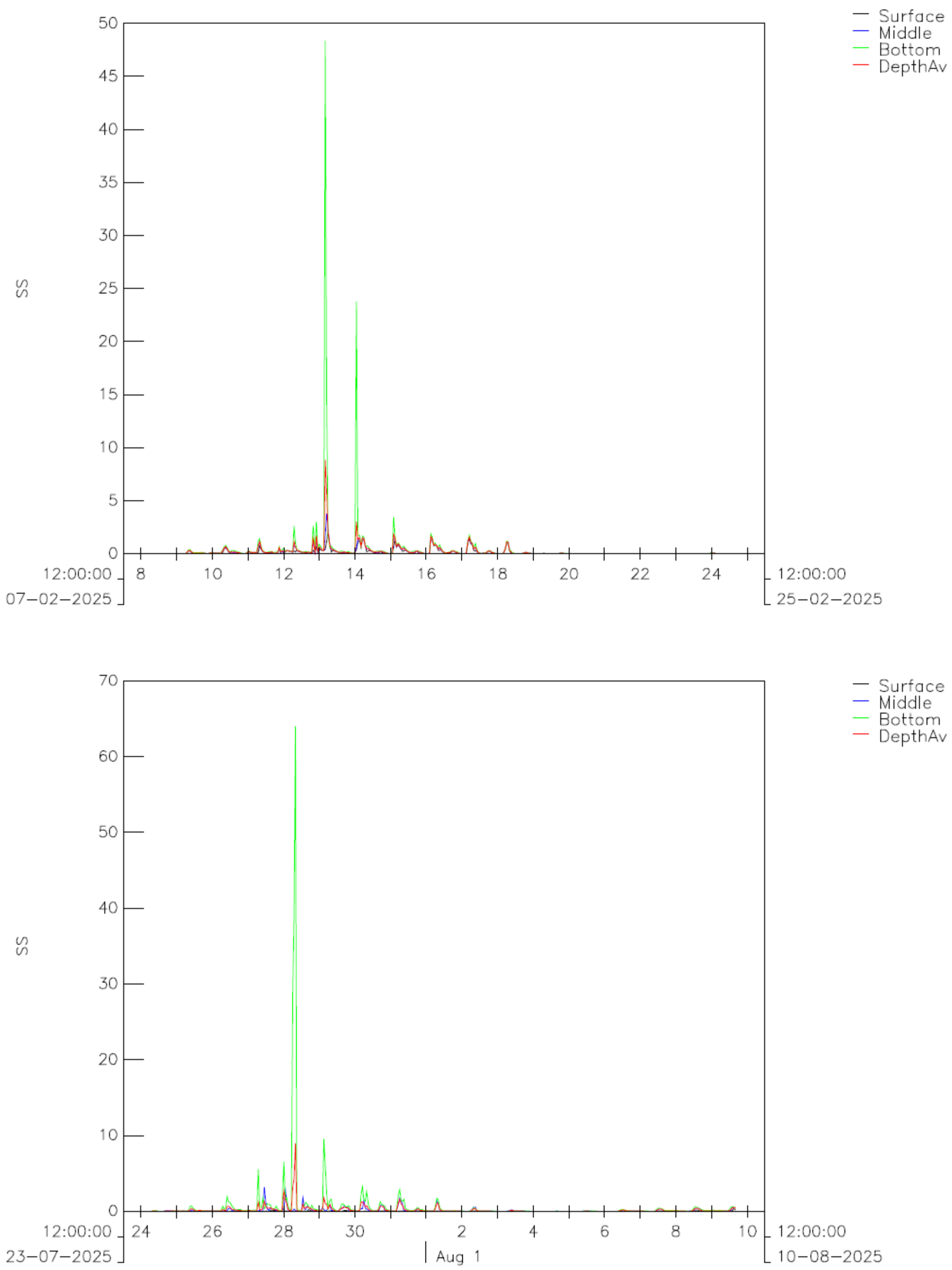


Figure 6.13c Predicted SS Elevations at SR19c (Boundary of the Proposed Southwest Lantau Marine Park) over a Simulation Period (upper: Dry Season; lower: Wet Season)

Table 6.18 Predicted SS Elevation (mg L^{-1}) for Scenario 7 - Grab Dredging for the South Soko Shore Approach (KP0-1)

Sensitive Receiver	Name	ID	Relevant Water Depth (a)	Allowable Elevation		Predicted SS Elevation (mg L^{-1})					
				Dry	Wet	Dry Max	Wet Max	Dry Mean	Wet Mean	Dry 90%-tile	Wet 90%-tile
Intertidal Mudflats	Pak Nai	SR01	s	7.1	3.6	0.0	0.0	0.0	0.0	0.0	0.0
Horseshoe Crab Nursery Grounds	Pak Nai	SR01	a	9.7	6	0.0	0.0	0.0	0.0	0.0	0.0
Seagrass Beds/Mangroves/Oyster Farm	Pak Nai	SR02	s	7.1	3.6	0.0	0.0	0.0	0.0	0.0	0.0
Seawater Intakes	Black Point Power Station	SR04	b	700 (b)	700 (b)	0.0	0.0	0.0	0.0	0.0	0.0
Non-gazetted Beaches	Lung Kwu Sheung Tan	SR05a	a	8.2	5.6	0.0	0.0	0.0	0.0	0.0	0.0
Non-gazetted Beaches	Lung Kwu Tan	SR05b	a	8.2	5.6	0.0	0.0	0.0	0.0	0.0	0.0
Gazetted Beaches	Butterfly Beach	SR05c	a	8.2	5.6	0.0	0.0	0.0	0.0	0.0	0.0
Marine Park	Designated Sha Chau and Lung Kwu Chau	SR06a	a	8.2	5.6	0.0	0.0	0.0	0.0	0.0	0.0
Marine Park	Designated Sha Chau and Lung Kwu Chau	SR06b	a	8.2	5.6	0.0	0.0	0.0	0.0	0.0	0.0
Marine Park	Designated Sha Chau and Lung Kwu Chau	SR06c	a	8.2	5.6	0.0	0.0	0.0	0.0	0.0	0.0
Marine Park	Designated Sha Chau and Lung Kwu Chau	SR06d	a	8.2	5.6	0.0	0.0	0.0	0.0	0.0	0.0
Artificial Reef Deployment Area	Sha Chau and Lung Kwu Chau	SR06e	a	8.2	5.6	0.0	0.0	0.0	0.0	0.0	0.0
Seawater Intakes	Castle Peak Power Station	SR07a	b	700 (b)	700 (b)	0.0	0.0	0.0	0.0	0.0	0.0
Seawater Intakes	Tuen Mun Area 38	SR07b	b	14.2	9.8	0.0	0.0	0.0	0.0	0.0	0.0
Seawater Intakes	Airport	SR07c	b	8.9	8.8	0.0	0.0	0.0	0.0	0.0	0.0

Sensitive Receiver	Name	ID	Relevant Water Depth (a)	Allowable Elevation		Predicted SS Elevation (mg L-1)					
				Dry	Wet	Dry Max	Wet Max	Dry Mean	Wet Mean	Dry 90%-tile	Wet 90%-tile
Seawater Intakes	Airport	SR07d	b	8.9	8.8	0.0	0.0	0.0	0.0	0.0	0.0
Artificial Reef Deployment Area	Northeast Airport	SR07d	a	4.7	5.2	0.0	0.0	0.0	0.0	0.0	0.0
Seawater Intakes	Airport	SR07e	b	8.9	8.8	0.0	0.0	0.0	0.0	0.0	0.0
Seawater Intakes	Airport	SR07f	b	8.9	8.8	0.0	0.0	0.0	0.0	0.0	0.0
Spawning/Nursery Grounds	Fisheries Spawning Ground in North Lantau	SR08	a	8.2	5.6	0.0	0.0	0.0	0.0	0.0	0.0
Horseshoe Crab Nursery Grounds	Sham Wat Wan	SR10	a	8.9	6.5	0.0	0.0	0.0	0.0	0.0	0.0
Protection Zone	Chinese White Dolphin Protection Zone in Mainland Waters	SR11	a	8.9	6.5	0.0	0.0	0.0	0.0	0.0	0.0
Protection Zone	Chinese White Dolphin Protection Zone in Mainland Waters	SR11a	a	8.9	6.5	0.0	0.0	0.0	0.0	0.0	0.0
Protection Zone	Chinese White Dolphin Protection Zone in Mainland Waters	SR11b	a	8.9	6.5	0.0	0.0	0.0	0.0	0.0	0.0
Horseshoe Crab Nursery Grounds	Tai O	SR12	a	8.9	6.5	0.0	0.0	0.0	0.0	0.0	0.0
Intertidal Mudflats	Yi O	SR14	s	6.5	3.6	0.0	0.0	0.0	0.0	0.0	0.0
Horseshoe Crab Nursery Grounds	Yi O	SR14	a	8.9	6.5	0.0	0.0	0.0	0.0	0.0	0.0
Non-gazetted Beaches	Fan Lau Sai Wan	SR15a	a	6.9	5.5	0.0	0.0	0.0	0.0	0.0	0.0
Mangroves	Fan Lau Tung Wan	SR15b	s	4.5	3	0.0	0.0	0.0	0.0	0.0	0.0

Sensitive Receiver	Name	ID	Relevant Water Depth [(a)]	Allowable Elevation		Predicted SS Elevation (mg L⁻¹)					
				Dry	Wet	Dry Max	Wet Max	Dry Mean	Wet Mean	Dry 90%-tile	Wet 90%-tile
Non-gazetted Beaches	Fan Lau Tung Wan	SR15b	a	6.9	5.5	0.0	0.0	0.0	0.0	0.0	0.0
Non-gazetted Beaches	Tsin Yue Wan	SR15c	a	6.9	5.5	0.0	0.0	0.0	0.0	0.0	0.0
Fish Fry Habitat	Pak Tso Wan	SR16b	a	6.9	5.5	10.6 [(d)]	6.0 [(d)]	0.7	0.5	1.6	1.6
Horseshoe Crab Nursery Grounds	Sha Lo Wan	SR18	a	7.8	4.8	0.0	0.0	0.0	0.0	0.0	0.0
Spawning/Nursery Grounds	Fisheries Spawning/Nursery Grounds in South Lantau	SR24	a	6.9	5.5	0.0	0.0	0.0	0.0	0.0	0.0
Spawning/Nursery Grounds	Fisheries Spawning/Nursery Grounds in South Lantau	SR27	a	6.9	5.5	0.1	0.2	0.0	0.0	0.0	0.1
Subtidal Hard Bottom Habitat (coral)	Southern Side of South Soko	SR31	a	10 [(c)]	10 [(c)]	0.2	0.3	0.0	0.0	0.1	0.0
Intertidal Mudflats	Shui Hau Wan	SR33	s	3.9	2.5	0.0	0.0	0.0	0.0	0.0	0.0
Horseshoe Crab Nursery Grounds	Tong Fuk Miu Wan	SR33	a	4.8	3.9	0.0	0.0	0.0	0.0	0.0	0.0
Gazetted Beaches	Tong Fuk	SR34	a	4.8	3.9	0.0	0.0	0.0	0.0	0.0	0.0
Gazetted Beaches	Upper Cheung Sha Beach	SR35	a	4.8	3.9	0.0	0.0	0.0	0.0	0.0	0.0
Seagrass Beds/Mangroves	Tung Chung Bay	SR39	s	6.5	3.6	0.0	0.0	0.0	0.0	0.0	0.0
Horseshoe Crab Nursery Grounds	Tung Chung Bay	SR39	a	8.9	6.5	0.0	0.0	0.0	0.0	0.0	0.0

Notes:

a. s = surface, m = middle, b = bottom, a = depth-averaged

b. The assessment criterion of 700 mg L^{-1} was adopted for these seawater intakes.

Sensitive Receiver	Name	ID	Relevant Water Depth [a]	Allowable Elevation		Predicted SS Elevation (mg L^{-1})					
				Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet
						Max	Max	Mean	Mean	90%-tile	90%-tile

c. The tolerance assessment criterion of 10 mg L^{-1} was adopted for the coral.
d. Shaded area indicates non-compliance with the assessment criterion.

Table 6.19 Predicted SS Elevation (mg L^{-1}) for Scenario 8 - TSHD Dredging for Pipeline Section in Northwest of South Soko to West Lantau (KP 1-24.5)

Sensitive Receiver	Name	ID	Relevant Water Depth [a]	Allowable Elevation		Predicted SS Elevation (mg L^{-1})					
				Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet
						Max	Max	Mean	Mean	90%-tile	90%-tile
Intertidal Mudflats	Pak Nai	SR01	s	7.1	3.6	0.0	0.0	0.0	0.0	0.0	0.0
Horseshoe Crab Nursery Grounds	Pak Nai	SR01	a	9.7	6	0.0	0.0	0.0	0.0	0.0	0.0
Seagrass Beds/Mangroves/Oyster Farm	Pak Nai	SR02	s	7.1	3.6	0.0	0.0	0.0	0.0	0.0	0.0
Seawater Intakes	Black Point Power Station	SR04	b	700 [b]	700 [b]	0.0	0.0	0.0	0.0	0.0	0.0
Non-gazetted Beaches	Lung Kwu Sheung Tan	SR05a	a	8.2	5.6	0.0	0.0	0.0	0.0	0.0	0.0
Non-gazetted Beaches	Lung Kwu Tan	SR05b	a	8.2	5.6	0.0	0.0	0.0	0.0	0.0	0.0
Gazetted Beaches	Butterfly Beach	SR05c	a	8.2	5.6	0.0	0.0	0.0	0.0	0.0	0.0
Marine Park	Designated Sha Chau and Lung Kwu Chau	SR06a	a	8.2	5.6	0.0	0.0	0.0	0.0	0.0	0.0
Marine Park	Designated Sha Chau and Lung Kwu Chau	SR06b	a	8.2	5.6	1.8	2.9	0.0	0.0	0.0	0.0

Sensitive Receiver	Name	ID	Relevant Water Depth [(a)]	Allowable Elevation		Predicted SS Elevation (mg L^{-1})					
				Dry	Wet	Dry Max	Wet Max	Dry Mean	Wet Mean	Dry 90%-tile	Wet 90%-tile
Marine Park	Designated Sha Chau and Lung Kwu Chau	SR06c	a	8.2	5.6	0.0	0.0	0.0	0.0	0.0	0.0
Marine Park	Designated Sha Chau and Lung Kwu Chau	SR06d	a	8.2	5.6	0.0	0.0	0.0	0.0	0.0	0.0
Artificial Reef Deployment Area	Sha Chau and Lung Kwu Chau	SR06e	a	8.2	5.6	0.1	0.4	0.0	0.0	0.0	0.0
Seawater Intakes	Castle Peak Power Station	SR07a	b	700 [(b)]	700 [(b)]	0.0	0.0	0.0	0.0	0.0	0.0
Seawater Intakes	Tuen Mun Area 38	SR07b	b	14.2	9.8	0.0	0.0	0.0	0.0	0.0	0.0
Seawater Intakes	Airport	SR07c	b	8.9	8.8	0.0	0.0	0.0	0.0	0.0	0.0
Seawater Intakes	Airport	SR07d	b	8.9	8.8	0.0	0.0	0.0	0.0	0.0	0.0
Artificial Reef Deployment Area	Northeast Airport	SR07d	a	4.7	5.2	0.0	0.0	0.0	0.0	0.0	0.0
Seawater Intakes	Airport	SR07e	b	8.9	8.8	0.0	0.0	0.0	0.0	0.0	0.0
Seawater Intakes	Airport	SR07f	b	8.9	8.8	0.0	0.0	0.0	0.0	0.0	0.0
Spawning/Nursery Grounds	Fisheries Spawning Ground in North Lantau	SR08	a	8.2	5.6	0.0	0.0	0.0	0.0	0.0	0.0
Horseshoe Crab Nursery Grounds	Sham Wat Wan	SR10	a	8.9	6.5	0.3	0.1	0.0	0.0	0.1	0.0
Protection Zone	Chinese White Dolphin Protection Zone in Mainland Waters	SR11	a	8.9	6.5	0.5	0.1	0.1	0.0	0.2	0.0
Protection Zone	Chinese White Dolphin Protection Zone in Mainland Waters	SR11a	a	8.9	6.5	0.4	0.2	0.1	0.0	0.2	0.1

Sensitive Receiver	Name	ID	Relevant Water Depth [a]	Allowable Elevation		Predicted SS Elevation (mg L-1)					
				Dry	Wet	Dry Max	Wet Max	Dry Mean	Wet Mean	Dry 90%-tile	Wet 90%-tile
Protection Zone	Chinese White Dolphin Protection Zone in Mainland Waters	SR11b	a	8.9	6.5	0.5	0.2	0.1	0.0	0.2	0.1
Horseshoe Crab Nursery Grounds	Tai O	SR12	a	8.9	6.5	0.5	0.5	0.1	0.0	0.2	0.1
Intertidal Mudflats	Yi O	SR14	s	6.5	3.6	0.2	0.0	0.0	0.0	0.1	0.0
Horseshoe Crab Nursery Grounds	Yi O	SR14	a	8.9	6.5	0.4	0.5	0.1	0.0	0.2	0.0
Non-gazetted Beaches	Fan Lau Sai Wan	SR15a	a	6.9	5.5	1.3	0.6	0.1	0.0	0.2	0.1
Mangroves	Fan Lau Tung Wan	SR15b	s	4.5	3	0.2	0.1	0.0	0.0	0.0	0.0
Non-gazetted Beaches	Fan Lau Tung Wan	SR15b	a	6.9	5.5	0.3	1.5	0.0	0.0	0.0	0.1
Non-gazetted Beaches	Tsin Yue Wan	SR15c	a	6.9	5.5	1.4	0.3	0.1	0.0	0.2	0.1
Fish Fry Habitat	Pak Tso Wan	SR16b	a	6.9	5.5	3.5	1.1	0.1	0.0	0.2	0.0
Horseshoe Crab Nursery Grounds	Sha Lo Wan	SR18	a	7.8	4.8	0.1	0.0	0.0	0.0	0.0	0.0
Potential Marine Park	Southwest Lantau	SR19a	a	8.9	6.5	2.5	2.4	0.2	0.1	0.4	0.3
Potential Marine Park	Southwest Lantau	SR19b	a	8.9	6.5	4.4	6.9 [d]	0.2	0.2	0.5	0.5
Potential Marine Park	Southwest Lantau	SR19c	a	8.9	6.5	8.8	8.9 [d]	0.2	0.2	0.5	0.4
Spawning/Nursery Grounds	Fisheries Spawning/Nursery Grounds in South Lantau	SR24	a	6.9	5.5	1.1	0.5	0.0	0.0	0.1	0.0

Sensitive Receiver	Name	ID	Relevant Water Depth (a)	Allowable Elevation		Predicted SS Elevation (mg L^{-1})					
				Dry	Wet	Dry Max	Wet Max	Dry Mean	Wet Mean	Dry 90%-tile	Wet 90%-tile
Spawning/Nursery Grounds	Fisheries Spawning/Nursery Grounds in South Lantau	SR27	a	6.9	5.5	1.1	0.2	0.0	0.0	0.1	0.0
Subtidal Hard Bottom Habitat (coral)	Southern Side of South Soko	SR31	a	10 (c)	10 (c)	0.5	0.3	0.0	0.0	0.1	0.0
Intertidal Mudflats	Shui Hau Wan	SR33	s	3.9	2.5	0.0	0.0	0.0	0.0	0.0	0.0
Horseshoe Crab Nursery Grounds	Tong Fuk Miu Wan	SR33	a	4.8	3.9	0.0	0.0	0.0	0.0	0.0	0.0
Gazetted Beaches	Tong Fuk	SR34	a	4.8	3.9	0.0	0.0	0.0	0.0	0.0	0.0
Gazetted Beaches	Upper Cheung Sha Beach	SR35	a	4.8	3.9	0.0	0.0	0.0	0.0	0.0	0.0
Seagrass Beds/Mangroves	Tung Chung Bay	SR39	s	6.5	3.6	0.0	0.0	0.0	0.0	0.0	0.0
Horseshoe Crab Nursery Grounds	Tung Chung Bay	SR39	a	8.9	6.5	0.0	0.0	0.0	0.0	0.0	0.0

Notes:

a. s = surface, m = middle, b = bottom, a = depth-averaged
b. The assessment criterion of 700 mg L^{-1} was adopted for these seawater intakes.
c. The tolerance assessment criterion of 10 mg L^{-1} was adopted for the coral.
d. Shaded area indicates non-compliance with the assessment criterion.

Table 6.20 Predicted SS Elevation (mg L^{-1}) for Scenario 9 - Grab Dredging for Pipeline Section from West Lantau to Urmston Road Crossing (KP 24.5-31)

Sensitive Receiver	Name	ID	Relevant Water Depth [(a)]	Allowable Elevation		Predicted SS Elevation (mg L^{-1})					
				Dry	Wet	Dry Max	Wet Max	Dry Mean	Wet Mean	Dry 90%-tile	Wet 90%-tile
Intertidal Mudflats	Pak Nai	SR01	s	7.1	3.6	0.0	0.0	0.0	0.0	0.0	0.0
Horseshoe Crab Nursery Grounds	Pak Nai	SR01	a	9.7	6	0.0	0.0	0.0	0.0	0.0	0.0
Seagrass Beds/Mangroves/Oyster Farm	Pak Nai	SR02	s	7.1	3.6	0.0	0.0	0.0	0.0	0.0	0.0
Seawater Intakes	Black Point Power Station	SR04	b	700 [(b)]	700 [(b)]	0.0	0.0	0.0	0.0	0.0	0.0
Non-gazetted Beaches	Lung Kwu Sheung Tan	SR05a	a	8.2	5.6	0.0	0.0	0.0	0.0	0.0	0.0
Non-gazetted Beaches	Lung Kwu Tan	SR05b	a	8.2	5.6	0.0	0.0	0.0	0.0	0.0	0.0
Gazetted Beaches	Butterfly Beach	SR05c	a	8.2	5.6	0.0	0.0	0.0	0.0	0.0	0.0
Marine Park	Designated Sha Chau and Lung Kwu Chau	SR06a	a	8.2	5.6	0.7	0.8	0.1	0.1	0.3	0.2
Marine Park	Designated Sha Chau and Lung Kwu Chau	SR06b	a	8.2	5.6	4.6	5.4	0.2	0.1	0.6	0.3
Marine Park	Designated Sha Chau and Lung Kwu Chau	SR06c	a	8.2	5.6	0.0	0.0	0.0	0.0	0.0	0.0
Marine Park	Designated Sha Chau and Lung Kwu Chau	SR06d	a	8.2	5.6	0.0	0.1	0.0	0.0	0.0	0.0
Artificial Reef Deployment Area	Sha Chau and Lung Kwu Chau	SR06e	a	8.2	5.6	0.8	0.5	0.1	0.1	0.2	0.2
Seawater Intakes	Castle Peak Power Station	SR07a	b	700 [(b)]	700 [(b)]	0.0	0.0	0.0	0.0	0.0	0.0
Seawater Intakes	Tuen Mun Area 38	SR07b	b	14.2	9.8	0.0	0.0	0.0	0.0	0.0	0.0

Sensitive Receiver	Name	ID	Relevant Water Depth (a)	Allowable Elevation		Predicted SS Elevation (mg L-1)					
				Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet
						Max	Max	Mean	Mean	90%-tile	90%-tile
Seawater Intakes	Airport	SR07c	b	8.9	8.8	0.0	0.0	0.0	0.0	0.0	0.0
Seawater Intakes	Airport	SR07d	b	8.9	8.8	0.0	0.0	0.0	0.0	0.0	0.0
Artificial Reef Deployment Area	Northeast Airport	SR07d	a	4.7	5.2	0.0	0.0	0.0	0.0	0.0	0.0
Seawater Intakes	Airport	SR07e	b	8.9	8.8	0.0	0.0	0.0	0.0	0.0	0.0
Seawater Intakes	Airport	SR07f	b	8.9	8.8	0.0	0.0	0.0	0.0	0.0	0.0
Spawning/Nursery Grounds	Fisheries Spawning Ground in North Lantau	SR08	a	8.2	5.6	0.0	0.0	0.0	0.0	0.0	0.0
Horseshoe Crab Nursery Grounds	Sham Wat Wan	SR10	a	8.9	6.5	0.1	0.1	0.0	0.0	0.0	0.0
Protection Zone	Chinese White Dolphin Protection Zone in Mainland Waters	SR11	a	8.9	6.5	0.1	0.1	0.0	0.0	0.1	0.0
Protection Zone	Chinese White Dolphin Protection Zone in Mainland Waters	SR11a	a	8.9	6.5	0.1	0.0	0.0	0.0	0.0	0.0
Protection Zone	Chinese White Dolphin Protection Zone in Mainland Waters	SR11b	a	8.9	6.5	0.1	0.0	0.0	0.0	0.0	0.0
Horseshoe Crab Nursery Grounds	Tai O	SR12	a	8.9	6.5	0.1	0.2	0.0	0.0	0.1	0.0
Intertidal Mudflats	Yi O	SR14	s	6.5	3.6	0.1	0.0	0.0	0.0	0.0	0.0
Horseshoe Crab Nursery Grounds	Yi O	SR14	a	8.9	6.5	0.1	0.1	0.0	0.0	0.0	0.0
Non-gazetted Beaches	Fan Lau Sai Wan	SR15a	a	6.9	5.5	0.0	0.0	0.0	0.0	0.0	0.0

Sensitive Receiver	Name	ID	Relevant Water Depth [(a)]	Allowable Elevation		Predicted SS Elevation (mg L^{-1})					
				Dry	Wet	Dry Max	Wet Max	Dry Mean	Wet Mean	Dry 90%-tile	Wet 90%-tile
Mangroves	Fan Lau Tung Wan	SR15b	s	4.5	3	0.0	0.0	0.0	0.0	0.0	0.0
Non-gazetted Beaches	Fan Lau Tung Wan	SR15b	a	6.9	5.5	0.0	0.0	0.0	0.0	0.0	0.0
Non-gazetted Beaches	Tsin Yue Wan	SR15c	a	6.9	5.5	0.0	0.0	0.0	0.0	0.0	0.0
Fish Fry Habitat	Pak Tso Wan	SR16b	a	6.9	5.5	0.0	0.0	0.0	0.0	0.0	0.0
Horseshoe Crab Nursery Grounds	Sha Lo Wan	SR18	a	7.8	4.8	0.0	0.1	0.0	0.0	0.0	0.0
Spawning/Nursery Grounds	Fisheries Spawning/Nursery Grounds in South Lantau	SR24	a	6.9	5.5	0.0	0.0	0.0	0.0	0.0	0.0
Spawning/Nursery Grounds	Fisheries Spawning/Nursery Grounds in South Lantau	SR27	a	6.9	5.5	0.0	0.0	0.0	0.0	0.0	0.0
Subtidal Hard Bottom Habitat (coral)	Southern Side of South Soko	SR31	a	10 [(c)]	10 [(c)]	0.0	0.0	0.0	0.0	0.0	0.0
Intertidal Mudflats	Shui Hau Wan	SR33	s	3.9	2.5	0.0	0.0	0.0	0.0	0.0	0.0
Horseshoe Crab Nursery Grounds	Tong Fuk Miu Wan	SR33	a	4.8	3.9	0.0	0.0	0.0	0.0	0.0	0.0
Gazetted Beaches	Tong Fuk	SR34	a	4.8	3.9	0.0	0.0	0.0	0.0	0.0	0.0
Gazetted Beaches	Upper Cheung Sha Beach	SR35	a	4.8	3.9	0.0	0.0	0.0	0.0	0.0	0.0
Seagrass Beds/Mangroves	Tung Chung Bay	SR39	s	6.5	3.6	0.0	0.0	0.0	0.0	0.0	0.0
Horseshoe Crab Nursery Grounds	Tung Chung Bay	SR39	a	8.9	6.5	0.0	0.0	0.0	0.0	0.0	0.0

Notes:

a. s = surface, m = middle, b = bottom, a = depth-averaged

Sensitive Receiver	Name	ID	Relevant Water Depth [a]	Allowable Elevation		Predicted SS Elevation (mg L^{-1})					
				Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet
						Max	Max	Mean	Mean	90%-tile	90%-tile

b. The assessment criterion of 700 mg L^{-1} was adopted for these seawater intakes.
c. The tolerance assessment criterion of 10 mg L^{-1} was adopted for the coral.

Table 6.21 Predicted SS Elevation (mg L^{-1}) for Scenario 10 - Grab Dredging across Urmston Road Crossing (KP 31-33.5)

Sensitive Receiver	Name	ID	Relevant Water Depth [a]	Allowable Elevation		Predicted SS Elevation (mg L^{-1})					
				Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet
						Max	Max	Mean	Mean	90%-tile	90%-tile
Intertidal Mudflats	Pak Nai	SR01	s	7.1	3.6	0.0	0.0	0.0	0.0	0.0	0.0
Horseshoe Crab Nursery Grounds	Pak Nai	SR01	a	9.7	6	0.0	0.0	0.0	0.0	0.0	0.0
Seagrass Beds/Mangroves/Oyster Farm	Pak Nai	SR02	s	7.1	3.6	0.0	0.0	0.0	0.0	0.0	0.0
Seawater Intakes	Black Point Power Station	SR04	b	700 [b]	700 [b]	0.0	0.0	0.0	0.0	0.0	0.0
Non-gazetted Beaches	Lung Kwu Sheung Tan	SR05a	a	8.2	5.6	0.0	0.0	0.0	0.0	0.0	0.0
Non-gazetted Beaches	Lung Kwu Tan	SR05b	a	8.2	5.6	0.0	0.0	0.0	0.0	0.0	0.0
Gazetted Beaches	Butterfly Beach	SR05c	a	8.2	5.6	0.0	0.0	0.0	0.0	0.0	0.0
Marine Park	Designated Sha Chau and Lung Kwu Chau	SR06a	a	8.2	5.6	4.3	2.0	0.2	0.1	0.7	0.4
Marine Park	Designated Sha Chau and Lung Kwu Chau	SR06b	a	8.2	5.6	0.3	0.1	0.0	0.0	0.1	0.0
Marine Park	Designated Sha Chau and Lung Kwu Chau	SR06c	a	8.2	5.6	0.1	0.1	0.0	0.0	0.0	0.0

Sensitive Receiver	Name	ID	Relevant Water Depth [a]	Allowable Elevation		Predicted SS Elevation (mg L-1)					
				Dry	Wet	Dry Max	Wet Max	Dry Mean	Wet Mean	Dry 90%-tile	Wet 90%-tile
Marine Park	Designated Sha Chau and Lung Kwu Chau	SR06d	a	8.2	5.6	0.0	0.0	0.0	0.0	0.0	0.0
Artificial Reef Deployment Area	Sha Chau and Lung Kwu Chau	SR06e	a	8.2	5.6	0.3	0.2	0.0	0.0	0.1	0.0
Seawater Intakes	Castle Peak Power Station	SR07a	b	700 [b]	700 [b]	0.0	0.0	0.0	0.0	0.0	0.0
Seawater Intakes	Tuen Mun Area 38	SR07b	b	14.2	9.8	0.0	0.0	0.0	0.0	0.0	0.0
Seawater Intakes	Airport	SR07c	b	8.9	8.8	0.0	0.0	0.0	0.0	0.0	0.0
Seawater Intakes	Airport	SR07d	b	8.9	8.8	0.0	0.0	0.0	0.0	0.0	0.0
Artificial Reef Deployment Area	Northeast Airport	SR07d	a	4.7	5.2	0.0	0.0	0.0	0.0	0.0	0.0
Seawater Intakes	Airport	SR07e	b	8.9	8.8	0.0	0.0	0.0	0.0	0.0	0.0
Seawater Intakes	Airport	SR07f	b	8.9	8.8	0.0	0.0	0.0	0.0	0.0	0.0
Spawning/Nursery Grounds	Fisheries Spawning Ground in North Lantau	SR08	a	8.2	5.6	0.0	0.0	0.0	0.0	0.0	0.0
Horseshoe Crab Nursery Grounds	Sham Wat Wan	SR10	a	8.9	6.5	0.0	0.0	0.0	0.0	0.0	0.0
Protection Zone	Chinese White Dolphin Protection Zone in Mainland Waters	SR11	a	8.9	6.5	0.0	0.1	0.0	0.0	0.0	0.0
Protection Zone	Chinese White Dolphin Protection Zone in Mainland Waters	SR11a	a	8.9	6.5	0.0	0.0	0.0	0.0	0.0	0.0
Protection Zone	Chinese White Dolphin Protection Zone in Mainland	SR11b	a	8.9	6.5	0.0	0.0	0.0	0.0	0.0	0.0

Sensitive Receiver	Name	ID	Relevant Water Depth [(a)]	Allowable Elevation		Predicted SS Elevation (mg L^{-1})					
				Dry	Wet	Dry Max	Wet Max	Dry Mean	Wet Mean	Dry 90%-tile	Wet 90%-tile
	Waters										
Horseshoe Crab Nursery Grounds	Tai O	SR12	a	8.9	6.5	0.0	0.0	0.0	0.0	0.0	0.0
Intertidal Mudflats	Yi O	SR14	s	6.5	3.6	0.0	0.0	0.0	0.0	0.0	0.0
Horseshoe Crab Nursery Grounds	Yi O	SR14	a	8.9	6.5	0.0	0.0	0.0	0.0	0.0	0.0
Non-gazetted Beaches	Fan Lau Sai Wan	SR15a	a	6.9	5.5	0.0	0.0	0.0	0.0	0.0	0.0
Mangroves	Fan Lau Tung Wan	SR15b	s	4.5	3	0.0	0.0	0.0	0.0	0.0	0.0
Non-gazetted Beaches	Fan Lau Tung Wan	SR15b	a	6.9	5.5	0.0	0.0	0.0	0.0	0.0	0.0
Non-gazetted Beaches	Tsin Yue Wan	SR15c	a	6.9	5.5	0.0	0.0	0.0	0.0	0.0	0.0
Fish Fry Habitat	Pak Tso Wan	SR16b	a	6.9	5.5	0.0	0.0	0.0	0.0	0.0	0.0
Horseshoe Crab Nursery Grounds	Sha Lo Wan	SR18	a	7.8	4.8	0.0	0.0	0.0	0.0	0.0	0.0
Spawning/Nursery Grounds	Fisheries Spawning/Nursery Grounds in South Lantau	SR24	a	6.9	5.5	0.0	0.0	0.0	0.0	0.0	0.0
Spawning/Nursery Grounds	Fisheries Spawning/Nursery Grounds in South Lantau	SR27	a	6.9	5.5	0.0	0.0	0.0	0.0	0.0	0.0
Subtidal Hard Bottom Habitat (coral)	Southern Side of South Soko	SR31	a	10 [(c)]	10 [(c)]	0.0	0.0	0.0	0.0	0.0	0.0
Intertidal Mudflats	Shui Hau Wan	SR33	s	3.9	2.5	0.0	0.0	0.0	0.0	0.0	0.0

Sensitive Receiver	Name	ID	Relevant Water Depth [(a)]	Allowable Elevation		Predicted SS Elevation (mg L^{-1})					
				Dry	Wet	Dry Max	Wet Max	Dry Mean	Wet Mean	Dry 90%-tile	Wet 90%-tile
Horseshoe Crab Nursery Grounds	Tong Fuk Miu Wan	SR33	a	4.8	3.9	0.0	0.0	0.0	0.0	0.0	0.0
Gazetted Beaches	Tong Fuk	SR34	a	4.8	3.9	0.0	0.0	0.0	0.0	0.0	0.0
Gazetted Beaches	Upper Cheung Sha Beach	SR35	a	4.8	3.9	0.0	0.0	0.0	0.0	0.0	0.0
Seagrass Beds/Mangroves	Tung Chung Bay	SR39	s	6.5	3.6	0.0	0.0	0.0	0.0	0.0	0.0
Horseshoe Crab Nursery Grounds	Tung Chung Bay	SR39	a	8.9	6.5	0.0	0.0	0.0	0.0	0.0	0.0

Notes:

a. s = surface, m = middle, b = bottom, a = depth-averaged
b. The assessment criterion of 700 mg L^{-1} was adopted for these seawater intakes.
c. The tolerance assessment criterion of 10 mg L^{-1} was adopted for the coral.

Table 6.22 Predicted SS Elevation (mg L^{-1}) for Scenario 11 - Grab Dredging for Pipeline Section at West of Black Point (KP 33.5-37)

Sensitive Receiver	Name	ID	Relevant Water Depth [(a)]	Allowable Elevation		Predicted SS Elevation (mg L^{-1})					
				Dry	Wet	Dry Max	Wet Max	Dry Mean	Wet Mean	Dry 90%-tile	Wet 90%-tile
Intertidal Mudflats	Pak Nai	SR01	s	7.1	3.6	0.0	0.0	0.0	0.0	0.0	0.0
Horseshoe Crab Nursery Grounds	Pak Nai	SR01	a	9.7	6	0.1	0.1	0.0	0.0	0.0	0.0
Seagrass Beds/Mangroves/Oyster Farm	Pak Nai	SR02	s	7.1	3.6	0.0	0.0	0.0	0.0	0.0	0.0

Sensitive Receiver	Name	ID	Relevant Water Depth [(a)]	Allowable Elevation		Predicted SS Elevation (mg L^{-1})					
				Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet
						Max	Max	Mean	Mean	90%-tile	90%-tile
Seawater Intakes	Black Point Power Station	SR04	b	700 [(b)]	700 [(b)]	0.4	0.9	0.0	0.1	0.1	0.1
Non-gazetted Beaches	Lung Kwu Sheung Tan	SR05a	a	8.2	5.6	0.1	0.0	0.0	0.0	0.0	0.0
Non-gazetted Beaches	Lung Kwu Tan	SR05b	a	8.2	5.6	0.1	0.0	0.0	0.0	0.0	0.0
Gazetted Beaches	Butterfly Beach	SR05c	a	8.2	5.6	0.0	0.0	0.0	0.0	0.0	0.0
Marine Park	Designated Sha Chau and Lung Kwu Chau	SR06a	a	8.2	5.6	0.4	0.4	0.0	0.1	0.1	0.2
Marine Park	Designated Sha Chau and Lung Kwu Chau	SR06b	a	8.2	5.6	0.2	0.1	0.0	0.0	0.0	0.0
Marine Park	Designated Sha Chau and Lung Kwu Chau	SR06c	a	8.2	5.6	0.6	0.4	0.1	0.1	0.3	0.2
Marine Park	Designated Sha Chau and Lung Kwu Chau	SR06d	a	8.2	5.6	0.3	0.2	0.0	0.0	0.1	0.1
Artificial Reef Deployment Area	Sha Chau and Lung Kwu Chau	SR06e	a	8.2	5.6	0.2	0.2	0.0	0.0	0.1	0.0
Seawater Intakes	Castle Peak Power Station	SR07a	b	700 [(b)]	700 [(b)]	0.5	0.5	0.1	0.1	0.2	0.1
Seawater Intakes	Tuen Mun Area 38	SR07b	b	14.2	9.8	0.3	0.2	0.0	0.0	0.1	0.1
Seawater Intakes	Airport	SR07c	b	8.9	8.8	0.1	0.1	0.0	0.0	0.0	0.0
Seawater Intakes	Airport	SR07d	b	8.9	8.8	0.0	0.0	0.0	0.0	0.0	0.0
Artificial Reef Deployment Area	Northeast Airport	SR07d	a	4.7	5.2	0.0	0.0	0.0	0.0	0.0	0.0
Seawater Intakes	Airport	SR07e	b	8.9	8.8	0.0	0.0	0.0	0.0	0.0	0.0
Seawater Intakes	Airport	SR07f	b	8.9	8.8	0.0	0.0	0.0	0.0	0.0	0.0
Spawning/Nursery Grounds	Fisheries Spawning Ground in North Lantau	SR08	a	8.2	5.6	0.4	0.3	0.1	0.1	0.3	0.2

Sensitive Receiver	Name	ID	Relevant Water Depth [(a)]	Allowable Elevation		Predicted SS Elevation (mg L^{-1})					
				Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet
						Max	Max	Mean	Mean	90%-tile	90%-tile
Horseshoe Crab Nursery Grounds	Sham Wat Wan	SR10	a	8.9	6.5	0.0	0.1	0.0	0.0	0.0	0.0
Protection Zone	Chinese White Dolphin Protection Zone in Mainland Waters	SR11	a	8.9	6.5	0.0	0.1	0.0	0.0	0.0	0.0
Protection Zone	Chinese White Dolphin Protection Zone in Mainland Waters	SR11a	a	8.9	6.5	0.0	0.0	0.0	0.0	0.0	0.0
Protection Zone	Chinese White Dolphin Protection Zone in Mainland Waters	SR11b	a	8.9	6.5	0.0	0.0	0.0	0.0	0.0	0.0
Horseshoe Crab Nursery Grounds	Tai O	SR12	a	8.9	6.5	0.0	0.0	0.0	0.0	0.0	0.0
Intertidal Mudflats	Yi O	SR14	s	6.5	3.6	0.0	0.0	0.0	0.0	0.0	0.0
Horseshoe Crab Nursery Grounds	Yi O	SR14	a	8.9	6.5	0.0	0.0	0.0	0.0	0.0	0.0
Non-gazetted Beaches	Fan Lau Sai Wan	SR15a	a	6.9	5.5	0.0	0.0	0.0	0.0	0.0	0.0
Mangroves	Fan Lau Tung Wan	SR15b	s	4.5	3	0.0	0.0	0.0	0.0	0.0	0.0
Non-gazetted Beaches	Fan Lau Tung Wan	SR15b	a	6.9	5.5	0.0	0.0	0.0	0.0	0.0	0.0
Non-gazetted Beaches	Tsin Yue Wan	SR15c	a	6.9	5.5	0.0	0.0	0.0	0.0	0.0	0.0
Fish Fry Habitat	Pak Tso Wan	SR16b	a	6.9	5.5	0.0	0.0	0.0	0.0	0.0	0.0
Horseshoe Crab Nursery Grounds	Sha Lo Wan	SR18	a	7.8	4.8	0.0	0.0	0.0	0.0	0.0	0.0

Sensitive Receiver	Name	ID	Relevant Water Depth [(a)]	Allowable Elevation		Predicted SS Elevation (mg L^{-1})					
				Dry	Wet	Dry Max	Wet Max	Dry Mean	Wet Mean	Dry 90%-tile	Wet 90%-tile
Spawning/Nursery Grounds	Fisheries Spawning/Nursery Grounds in South Lantau	SR24	a	6.9	5.5	0.0	0.0	0.0	0.0	0.0	0.0
Spawning/Nursery Grounds	Fisheries Spawning/Nursery Grounds in South Lantau	SR27	a	6.9	5.5	0.0	0.0	0.0	0.0	0.0	0.0
Subtidal Hard Bottom Habitat (coral)	Southern Side of South Soko	SR31	a	10 [(c)]	10 [(c)]	0.0	0.0	0.0	0.0	0.0	0.0
Intertidal Mudflats	Shui Hau Wan	SR33	s	3.9	2.5	0.0	0.0	0.0	0.0	0.0	0.0
Horseshoe Crab Nursery Grounds	Tong Fuk Miu Wan	SR33	a	4.8	3.9	0.0	0.0	0.0	0.0	0.0	0.0
Gazetted Beaches	Tong Fuk	SR34	a	4.8	3.9	0.0	0.0	0.0	0.0	0.0	0.0
Gazetted Beaches	Upper Cheung Sha Beach	SR35	a	4.8	3.9	0.0	0.0	0.0	0.0	0.0	0.0
Seagrass Beds/Mangroves	Tung Chung Bay	SR39	s	6.5	3.6	0.0	0.0	0.0	0.0	0.0	0.0
Horseshoe Crab Nursery Grounds	Tung Chung Bay	SR39	a	8.9	6.5	0.0	0.0	0.0	0.0	0.0	0.0

Notes:

a. s = surface, m = middle, b = bottom, a = depth-averaged
b. The assessment criterion of 700 mg L^{-1} was adopted for these seawater intakes.
c. The tolerance assessment criterion of 10 mg L^{-1} was adopted for the coral.

Table 6.23 Predicted SS Elevation (mg L^{-1}) for Scenario 12 - Grab Dredging for Pipeline Section at West of Black Point (KP 37-37.803)

Sensitive Receiver	Name	ID	Relevant Water Depth (a)	Allowable Elevation		Predicted SS Elevation (mg L^{-1})					
				Dry	Wet	Dry Max	Wet Max	Dry Mean	Wet Mean	Dry 90%-tile	Wet 90%-tile
Intertidal Mudflats	Pak Nai	SR01	s	7.1	3.6	0.1	0.3	0.0	0.0	0.0	0.0
Horseshoe Crab Nursery Grounds	Pak Nai	SR01	a	9.7	6	0.4	0.5	0.0	0.0	0.1	0.1
Seagrass Beds/Mangroves/Oyster Farm	Pak Nai	SR02	s	7.1	3.6	0.0	0.0	0.0	0.0	0.0	0.0
Seawater Intakes	Black Point Power Station	SR04	b	700 (b)	700 (b)	6.1	4.3	0.6	0.4	1.8	1.7
Non-gazetted Beaches	Lung Kwu Sheung Tan	SR05a	a	8.2	5.6	0.3	0.0	0.0	0.0	0.0	0.0
Non-gazetted Beaches	Lung Kwu Tan	SR05b	a	8.2	5.6	0.2	0.1	0.0	0.0	0.0	0.0
Gazetted Beaches	Butterfly Beach	SR05c	a	8.2	5.6	0.0	0.0	0.0	0.0	0.0	0.0
Marine Park	Designated Sha Chau and Lung Kwu Chau	SR06a	a	8.2	5.6	0.0	0.0	0.0	0.0	0.0	0.0
Marine Park	Designated Sha Chau and Lung Kwu Chau	SR06b	a	8.2	5.6	0.0	0.0	0.0	0.0	0.0	0.0
Marine Park	Designated Sha Chau and Lung Kwu Chau	SR06c	a	8.2	5.6	0.1	0.1	0.0	0.0	0.0	0.0
Marine Park	Designated Sha Chau and Lung Kwu Chau	SR06d	a	8.2	5.6	0.1	0.0	0.0	0.0	0.0	0.0
Artificial Reef Deployment Area	Sha Chau and Lung Kwu Chau	SR06e	a	8.2	5.6	0.0	0.0	0.0	0.0	0.0	0.0
Seawater Intakes	Castle Peak Power Station	SR07a	b	700 (b)	700 (b)	0.4	0.6	0.0	0.0	0.1	0.1
Seawater Intakes	Tuen Mun Area 38	SR07b	b	14.2	9.8	0.1	0.2	0.0	0.0	0.1	0.0
Seawater Intakes	Airport	SR07c	b	8.9	8.8	0.0	0.0	0.0	0.0	0.0	0.0

Sensitive Receiver	Name	ID	Relevant Water Depth (a)	Allowable Elevation		Predicted SS Elevation (mg L^{-1})					
				Dry	Wet	Dry Max	Wet Max	Dry Mean	Wet Mean	Dry 90%-tile	Wet 90%-tile
Seawater Intakes	Airport	SR07d	b	8.9	8.8	0.0	0.0	0.0	0.0	0.0	0.0
Artificial Reef Deployment Area	Northeast Airport	SR07d	a	4.7	5.2	0.0	0.0	0.0	0.0	0.0	0.0
Seawater Intakes	Airport	SR07e	b	8.9	8.8	0.0	0.0	0.0	0.0	0.0	0.0
Seawater Intakes	Airport	SR07f	b	8.9	8.8	0.0	0.0	0.0	0.0	0.0	0.0
Spawning/Nursery Grounds	Fisheries Spawning Ground in North Lantau	SR08	a	8.2	5.6	0.1	0.1	0.0	0.0	0.0	0.0
Horseshoe Crab Nursery Grounds	Sham Wat Wan	SR10	a	8.9	6.5	0.0	0.0	0.0	0.0	0.0	0.0
Protection Zone	Chinese White Dolphin Protection Zone in Mainland Waters	SR11	a	8.9	6.5	0.0	0.0	0.0	0.0	0.0	0.0
Protection Zone	Chinese White Dolphin Protection Zone in Mainland Waters	SR11a	a	8.9	6.5	0.0	0.0	0.0	0.0	0.0	0.0
Protection Zone	Chinese White Dolphin Protection Zone in Mainland Waters	SR11b	a	8.9	6.5	0.0	0.0	0.0	0.0	0.0	0.0
Horseshoe Crab Nursery Grounds	Tai O	SR12	a	8.9	6.5	0.0	0.0	0.0	0.0	0.0	0.0
Intertidal Mudflats	Yi O	SR14	s	6.5	3.6	0.0	0.0	0.0	0.0	0.0	0.0
Horseshoe Crab Nursery Grounds	Yi O	SR14	a	8.9	6.5	0.0	0.0	0.0	0.0	0.0	0.0
Non-gazetted Beaches	Fan Lau Sai Wan	SR15a	a	6.9	5.5	0.0	0.0	0.0	0.0	0.0	0.0
Mangroves	Fan Lau Tung Wan	SR15b	s	4.5	3	0.0	0.0	0.0	0.0	0.0	0.0

Sensitive Receiver	Name	ID	Relevant Water Depth [a]	Allowable Elevation		Predicted SS Elevation (mg L^{-1})					
				Dry	Wet	Dry Max	Wet Max	Dry Mean	Wet Mean	Dry 90%-tile	Wet 90%-tile
Non-gazetted Beaches	Fan Lau Tung Wan	SR15b	a	6.9	5.5	0.0	0.0	0.0	0.0	0.0	0.0
Non-gazetted Beaches	Tsin Yue Wan	SR15c	a	6.9	5.5	0.0	0.0	0.0	0.0	0.0	0.0
Fish Fry Habitat	Pak Tso Wan	SR16b	a	6.9	5.5	0.0	0.0	0.0	0.0	0.0	0.0
Horseshoe Crab Nursery Grounds	Sha Lo Wan	SR18	a	7.8	4.8	0.0	0.0	0.0	0.0	0.0	0.0
Spawning/Nursery Grounds	Fisheries Spawning/Nursery Grounds in South Lantau	SR24	a	6.9	5.5	0.0	0.0	0.0	0.0	0.0	0.0
Spawning/Nursery Grounds	Fisheries Spawning/Nursery Grounds in South Lantau	SR27	a	6.9	5.5	0.0	0.0	0.0	0.0	0.0	0.0
Subtidal Hard Bottom Habitat (coral)	Southern Side of South Soko	SR31	a	10 [c]	10 [c]	0.0	0.0	0.0	0.0	0.0	0.0
Intertidal Mudflats	Shui Hau Wan	SR33	s	3.9	2.5	0.0	0.0	0.0	0.0	0.0	0.0
Horseshoe Crab Nursery Grounds	Tong Fuk Miu Wan	SR33	a	4.8	3.9	0.0	0.0	0.0	0.0	0.0	0.0
Gazetted Beaches	Tong Fuk	SR34	a	4.8	3.9	0.0	0.0	0.0	0.0	0.0	0.0
Gazetted Beaches	Upper Cheung Sha Beach	SR35	a	4.8	3.9	0.0	0.0	0.0	0.0	0.0	0.0
Seagrass Beds/Mangroves	Tung Chung Bay	SR39	s	6.5	3.6	0.0	0.0	0.0	0.0	0.0	0.0
Horseshoe Crab Nursery Grounds	Tung Chung Bay	SR39	a	8.9	6.5	0.0	0.0	0.0	0.0	0.0	0.0

Notes:

a. s = surface, m = middle, b = bottom, a = depth-averaged

b. The assessment criterion of 700 mg L^{-1} was adopted for these seawater intakes.

Sensitive Receiver	Name	ID	Relevant Water Depth (a)	Allowable Elevation		Predicted SS Elevation (mg L-1)					
				Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet
						Max	Max	Mean	Mean	90%-tile	90%-tile

c. The tolerance assessment criterion of 10 mg L^{-1} was adopted for the coral.

Table 6.24 Predicted SS Elevation (mg L^{-1}) for Scenario 13 - Grab Dredging for Pipeline Section at Black Point Shore Approach (KP 37.803-38.303)

Sensitive Receiver	Name	ID	Relevant Water Depth (a)	Allowable Elevation		Predicted SS Elevation (mg L-1)					
				Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet
						Max	Max	Mean	Mean	90%-tile	90%-tile
Intertidal Mudflats	Pak Nai	SR01	s	7.1	3.6	0.1	0.2	0.0	0.0	0.0	0.0
Horseshoe Crab Nursery Grounds	Pak Nai	SR01	a	9.7	6	0.3	0.4	0.0	0.0	0.1	0.1
Seagrass Beds/Mangroves/Oyster Farm	Pak Nai	SR02	s	7.1	3.6	0.0	0.0	0.0	0.0	0.0	0.0
Seawater Intakes	Black Point Power Station	SR04	b	700 (b)	700 (b)	1.5	1.4	0.1	0.1	0.3	0.3
Non-gazetted Beaches	Lung Kwu Sheung Tan	SR05a	a	8.2	5.6	0.2	0.0	0.0	0.0	0.0	0.0
Non-gazetted Beaches	Lung Kwu Tan	SR05b	a	8.2	5.6	0.1	0.1	0.0	0.0	0.0	0.0
Gazetted Beaches	Butterfly Beach	SR05c	a	8.2	5.6	0.0	0.0	0.0	0.0	0.0	0.0
Marine Park	Designated Sha Chau and Lung Kwu Chau	SR06a	a	8.2	5.6	0.0	0.0	0.0	0.0	0.0	0.0
Marine Park	Designated Sha Chau and Lung Kwu Chau	SR06b	a	8.2	5.6	0.0	0.0	0.0	0.0	0.0	0.0
Marine Park	Designated Sha Chau and Lung Kwu Chau	SR06c	a	8.2	5.6	0.1	0.1	0.0	0.0	0.0	0.0

Sensitive Receiver	Name	ID	Relevant Water Depth (a)	Allowable Elevation		Predicted SS Elevation (mg L^{-1})					
				Dry	Wet	Dry Max	Wet Max	Dry Mean	Wet Mean	Dry 90%-tile	Wet 90%-tile
Marine Park	Designated Sha Chau and Lung Kwu Chau	SR06d	a	8.2	5.6	0.1	0.0	0.0	0.0	0.0	0.0
Artificial Reef Deployment Area	Sha Chau and Lung Kwu Chau	SR06e	a	8.2	5.6	0.0	0.0	0.0	0.0	0.0	0.0
Seawater Intakes	Castle Peak Power Station	SR07a	b	700 (b)	700 (b)	0.3	0.4	0.0	0.0	0.1	0.1
Seawater Intakes	Tuen Mun Area 38	SR07b	b	14.2	9.8	0.2	0.1	0.0	0.0	0.1	0.0
Seawater Intakes	Airport	SR07c	b	8.9	8.8	0.0	0.0	0.0	0.0	0.0	0.0
Seawater Intakes	Airport	SR07d	b	8.9	8.8	0.0	0.0	0.0	0.0	0.0	0.0
Artificial Reef Deployment Area	Northeast Airport	SR07d	a	4.7	5.2	0.0	0.0	0.0	0.0	0.0	0.0
Seawater Intakes	Airport	SR07e	b	8.9	8.8	0.0	0.0	0.0	0.0	0.0	0.0
Seawater Intakes	Airport	SR07f	b	8.9	8.8	0.0	0.0	0.0	0.0	0.0	0.0
Spawning/Nursery Grounds	Fisheries Spawning Ground in North Lantau	SR08	a	8.2	5.6	0.1	0.1	0.0	0.0	0.0	0.0
Horseshoe Crab Nursery Grounds	Sham Wat Wan	SR10	a	8.9	6.5	0.0	0.0	0.0	0.0	0.0	0.0
Protection Zone	Chinese White Dolphin Protection Zone in Mainland Waters	SR11	a	8.9	6.5	0.0	0.0	0.0	0.0	0.0	0.0
Protection Zone	Chinese White Dolphin Protection Zone in Mainland Waters	SR11a	a	8.9	6.5	0.0	0.0	0.0	0.0	0.0	0.0
Protection Zone	Chinese White Dolphin Protection Zone in Mainland	SR11b	a	8.9	6.5	0.0	0.0	0.0	0.0	0.0	0.0

Sensitive Receiver	Name	ID	Relevant Water Depth (a)	Allowable Elevation		Predicted SS Elevation (mg L^{-1})					
				Dry	Wet	Dry Max	Wet Max	Dry Mean	Wet Mean	Dry 90%-tile	Wet 90%-tile
	Waters										
Horseshoe Crab Nursery Grounds	Tai O	SR12	a	8.9	6.5	0.0	0.0	0.0	0.0	0.0	0.0
Intertidal Mudflats	Yi O	SR14	s	6.5	3.6	0.0	0.0	0.0	0.0	0.0	0.0
Horseshoe Crab Nursery Grounds	Yi O	SR14	a	8.9	6.5	0.0	0.0	0.0	0.0	0.0	0.0
Non-gazetted Beaches	Fan Lau Sai Wan	SR15a	a	6.9	5.5	0.0	0.0	0.0	0.0	0.0	0.0
Mangroves	Fan Lau Tung Wan	SR15b	s	4.5	3	0.0	0.0	0.0	0.0	0.0	0.0
Non-gazetted Beaches	Fan Lau Tung Wan	SR15b	a	6.9	5.5	0.0	0.0	0.0	0.0	0.0	0.0
Non-gazetted Beaches	Tsin Yue Wan	SR15c	a	6.9	5.5	0.0	0.0	0.0	0.0	0.0	0.0
Fish Fry Habitat	Pak Tso Wan	SR16b	a	6.9	5.5	0.0	0.0	0.0	0.0	0.0	0.0
Horseshoe Crab Nursery Grounds	Sha Lo Wan	SR18	a	7.8	4.8	0.0	0.0	0.0	0.0	0.0	0.0
Spawning/Nursery Grounds	Fisheries Spawning/Nursery Grounds in South Lantau	SR24	a	6.9	5.5	0.0	0.0	0.0	0.0	0.0	0.0
Spawning/Nursery Grounds	Fisheries Spawning/Nursery Grounds in South Lantau	SR27	a	6.9	5.5	0.0	0.0	0.0	0.0	0.0	0.0
Subtidal Hard Bottom Habitat (coral)	Southern Side of South Soko	SR31	a	10 (c)	10 (c)	0.0	0.0	0.0	0.0	0.0	0.0
Intertidal Mudflats	Shui Hau Wan	SR33	s	3.9	2.5	0.0	0.0	0.0	0.0	0.0	0.0

Sensitive Receiver	Name	ID	Relevant Water Depth (a)	Allowable Elevation		Predicted SS Elevation (mg L^{-1})					
				Dry	Wet	Dry Max	Wet Max	Dry Mean	Wet Mean	Dry 90%-tile	Wet 90%-tile
Horseshoe Crab Nursery Grounds	Tong Fuk Miu Wan	SR33	a	4.8	3.9	0.0	0.0	0.0	0.0	0.0	0.0
Gazetted Beaches	Tong Fuk	SR34	a	4.8	3.9	0.0	0.0	0.0	0.0	0.0	0.0
Gazetted Beaches	Upper Cheung Sha Beach	SR35	a	4.8	3.9	0.0	0.0	0.0	0.0	0.0	0.0
Seagrass Beds/Mangroves	Tung Chung Bay	SR39	s	6.5	3.6	0.0	0.0	0.0	0.0	0.0	0.0
Horseshoe Crab Nursery Grounds	Tung Chung Bay	SR39	a	8.9	6.5	0.0	0.0	0.0	0.0	0.0	0.0

Notes:

a. s = surface, m = middle, b = bottom, a = depth-averaged
b. The assessment criterion of 700 mg L^{-1} was adopted for these seawater intakes.
c. The tolerance assessment criterion of 10 mg L^{-1} was adopted for the coral.

6.6.2 *Sediment Deposition*

The majority of SS elevations in water have been predicted to be temporary and to remain within relatively close proximity to the dredging or jetting works and, as such, the majority of sediment has been predicted to settle within relatively close proximity of the works areas.

The simulated deposition rates (1) at the artificial reefs (ARs), i.e., SR6e and SR7d and the subtidal hard bottom habitat, i.e., SR31 during the dry and wet seasons have been assessed for the respective construction works. *Table 6.25* summarises the predicted deposition rates. The exceedances, which are predicted to occur at SR31 only, are marginally above the criterion of 200 g m^{-2} day^{-1}. Based on the model results, the exceedances are mainly due to the dredging works at the approach channel and the turning basin.

It is anticipated that the exceedances could be mitigated by deploying a silt curtain (stand type) enclosing the coral area. The SS elevations would be reduced by a factor of 2.5 or about 60% (2) and hence the deposition rates will be reduced and a level well below the criterion. Thus, no unacceptable impacts are expected to be posed by the works.

(1) The deposition rate is simulated as the total deposition divided by the duration of complete tidal cycle.

(2) Maunsell (2001) Wan Chai Development Phase II - Comprehensive Feasibility Study. Final EIA Report.

Table 6.25 Predicted Deposition Rate (g m^{-2} day^{-1}) for the Marine Works at the Artificial Reefs and Subtidal Hard Bottom Habitat

LNG Terminal, Submarine Water Main and Submarine Cable Circuit

Sensitive Receiver	Name	ID	Assessment Criterion	Scenario 1		Scenario 2		Scenario 3	
			(g m^{-2} day^{-1})	Dry	Wet	Dry	Wet	Dry	Wet
Artificial Reef Deployment Area	Sha Chau and Lung Kwu Chau	SR06e	200	0.0	0.0	0.0	0.0	0.0	0.0
Artificial Reef Deployment Area	Northeast Airport	SR07d	200	0.0	0.0	0.0	0.0	0.0	0.0
Subtidal Hard Bottom Habitat (coral)	Southern Side of South Soko	SR31	200	33.9	31.6	1.6	1.5	4.9	3.7

LNG Terminal, Submarine Water Main and Submarine Cable Circuit

Sensitive Receiver	Name	ID	Assessment Criterion	Scenario 4a		Scenario 4b		Scenario 5		Scenario 6	
			(g m^{-2} day^{-1})	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet
Artificial Reef Deployment Area	Sha Chau and Lung Kwu Chau	SR06e	200	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0
Artificial Reef Deployment Area	Northeast Airport	SR07d	200	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0
Subtidal Hard Bottom Habitat (coral)	Southern Side of South Soko	SR31	200	209.4 (a)	221.5 (a)	131.1	182.4	85.6	90.4	0.0	0.0

Table 6.25 (cont'd) Predicted Deposition Rate (g m^{-2} day^{-1}) for the Marine Works at the Artificial Reefs and Subtidal Hard Bottom Habitat

Submarine Gas Pipeline

Sensitive Receiver	Name	ID	Assessment Criterion (g m^{-2} day^{-1})	Scenario 7 (Grab Dredging at KP 0-1)		Scenario 8 (TSHD Dredging at KP 1-24.5)		Scenario 9 (Grab Dredging at KP 24.5-31)	
				Dry	**Wet**	**Dry**	**Wet**	**Dry**	**Wet**
Artificial Reef Deployment Area	Sha Chau and Lung Kwu Chau	SR06e	200	0.0	0.0	0.1	0.2	2.7	2.6
Artificial Reef Deployment Area	Northeast Airport	SR07d	200	0.0	0.0	0.0	0.0	0.0	0.0
Subtidal Hard Bottom Habitat (coral)	Southern Side of South Soko	SR31	200	1.0	1.4	1.1	0.6	0.0	0.0

Table 6.25 (cont'd) Predicted Deposition Rate (g m^{-2} day^{-1}) for the Marine Works at the Artificial Reefs and Subtidal Hard Bottom Habitat

Sensitive Receiver	Name	ID	Assessment Criterion (g m^{-2} day^{-1})	Scenario 10 (Grab Dredging at KP 31-33.5)		Scenario 11 (Grab Dredging at KP 33.5-37)		Scenario 12 (Grab Dredging at KP 37-37.803)		Scenario 13 (Grab Dredging at KP 37.803-38.303)	
				Dry	**Wet**	**Dry**	**Wet**	**Dry**	**Wet**	**Dry**	**Wet**
Artificial Reef Deployment Area	Sha Chau and Lung Kwu Chau	SR06e	200	0.6	0.3	0.5	0.5	0.1	0.1	0.1	0.1
Artificial Reef Deployment Area	Northeast Airport	SR07d	200	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Subtidal Hard Bottom Habitat (coral)	Southern Side of South Soko	SR31	200	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Notes:

a. The shaded area indicates non-compliance with the assessment criterion.

6.6.3 *Dissolved Oxygen Depletion*

The dispersion of sediment due to dredging/jetting operations is not expected to impact the general water quality of the receiving waters. Due to the low nutrient content of sediments (see *Part 2 – Section 7: Waste Management*), the elevation in SS levels is not expected to cause a pronounced increase in oxygen demand and, therefore, the effect on dissolved oxygen (DO) is anticipated to be minor. Therefore, the effects of increased SS concentrations as a result of the proposed works on levels of dissolved oxygen, biochemical oxygen demand and nutrients (as unionised ammonia) are predicted to be minimal. Effects will be transient, localised in extent and of a small magnitude. As such, no adverse impacts to water quality through sediment release are expected to occur.

In order to verify the above assessment, depletion of dissolved oxygen has been calculated. The sediment plumes predicted from the modelling runs described above would have a negligible effect on dissolved oxygen levels in the receiving waters. The degree of oxygen depletion exerted by a sediment plume is a function of the sediment oxygen demand of the sediment, its concentration in the water column and the rate of oxygen replenishment.

The impact of the sediment oxygen demand (SOD) on dissolved oxygen concentrations has been calculated based on the following equation (1):

$$DO_{Dep} = C * SOD * K * 10^{-6}$$

where DO_{Dep} = Dissolved oxygen depletion (mg L^{-1})

C = Suspended solids concentration (mg L^{-1})

SOD = Sediment oxygen demand (mg kg^{-1})

K = Daily oxygen uptake factor (set as 1 (2))

By reviewing the EPD sediment quality monitoring data and the recent approved EIA Report (3) which used 15,000 mg kg^{-1} for North Western WCZ, the sediment oxygen demand criteria used in this study are 20,000 mg kg^{-1} for Deep Bay WCZ and North Western WCZ and 12,000 mg kg^{-1} for Southern WCZ.

In the abovementioned EIA Report, K was set to be 1, which means instantaneous oxidation of the sediment oxygen demand. This was a conservative prediction of DO depletion since oxygen depletion is not instantaneous and will depend on tidally averaged suspended sediment concentrations.

(1) ERM - HK Ltd (1997). EIA for Disposal of Contaminated Mud in the East of Sha Chau Marine Borrow Pit. For Civil Engineering Department of the SAR Government.

(2) Mouchel (2002). EIA for Permanent Aviation Fuel Facility. For Hong Kong Airport Authority.

(3) Mouchel (2002). *Op. Cit.*

It is worth noting that the above equation does not account for re-aeration which would tend to reduce impacts of SS on the DO concentrations in the water column. The proposed analysis, which is on the conservative side, will not, therefore, underestimate the DO depletion.

Further, it should be noted that time has to pass for sediment in suspension to exert any oxygen demand in the water column and, in the meantime, the sediment will be transported and mixed or dispersed with oxygenated water. As a result, the oxygen demand and the impact on DO concentrations will diminish as the suspended sediment concentrations decrease.

The most sensitive receivers to the DO depletion are likely to be the ecological and fisheries resources. The results (*Table 6.26*) show that the predicted oxygen depletion at these WSRs is predicted to be compliant with the WQO criterion, with the exception of SR16b (fish fry habitat at Pak Tso Wan).

For SR16b, mitigation measures such as deployment of a silt screen enclosing the bay are recommended to be used to reduce the SS level and hence the DO depletion to an acceptable level. Details of the mitigation measures are discussed in *Section 6.8*.

Contour plots of maximum DO depletion are shown in *Annex 6C*. It shows that DO is depleted by less than 1 mg L^{-1} for most of construction works with exception for the sandfilling works and those non-stationary works, i.e. jetting for water main (Scenario 3), TSHD dredging for approach channel and turning basin (Scenario 4b), and jetting for submarine cable (Scenario 5). Interpreting the maximum depletion plots for the moving sources should be treated with caution. The maximum DO level plots for those moving sources are gestalt image and may not be representative of any given moment in time. The time in which each grid cell's maximum occurs is independent of the other grid cells.

For the sandfilling works, the impacts would be substantially reduced when the seawall in reality (1) is to be in place, as aforementioned in *Section 6.6.1*, to minimise the spread of sediment and hence DO depletion.

(1) A completed seawall will be constructed for the western berth at South Soko Island and for the GRS at Black Point prior to the commencement of sandfilling works.

Table 6.26 Predicted Dissolved Oxygen Depletion (mg L^{-1}) for Scenarios 1 to 3 due to Increase in SS Concentrations (only results where depletions are predicted have been presented)

LNG Terminal, Submarine Water Main and Submarine Cable Circuit

Sensitive Receiver	Name	ID	Relevant Depth [1]	WQO Allowable Depletion		Scenario 1		Scenario 2		Scenario 3	
				Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet
						Max	Max	Max	Max	Max	Max
Fish Fry Habitat	Pak Tso Wan	SR16b	a	4	3.9	0.3	0.4	0.2	0.2	0.4	0.7
Spawning/Nursery Grounds	Fisheries Spawning/Nursery Grounds in South Lantau	SR24	a	4.2	3.8	0.0	0.0	0.0	0.0	0.0	0.0
		SR27	a	4.2	3.8	0.0	0.0	0.0	0.0	0.0	0.0
Subtidal Hard Bottom Habitat (coral)	Southern Side of South Soko	SR31	a	4	3.9	0.0	0.0	0.0	0.0	0.0	0.0

Table 6.26 (cont'd) Predicted Dissolved Oxygen Depletion (mg L^{-1}) for Scenarios 4a to 5 due to Increase in SS Concentrations (only results where depletions are predicted have been presented)

LNG Terminal, Submarine Water Main and Submarine Cable Circuit

Sensitive Receiver	Name	ID	Relevant Depth [1]	WQO Allowable Depletion		Scenario 4a		Scenario 4b		Scenario 5	
				Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet
						Max	Max	Max	Max	Max	Max
Fish Fry Habitat	Pak Tso Wan	SR16b	a	4	3.9	0.0	0.0	0.0	0.0	0.0	0.1
Spawning/Nursery Grounds	Fisheries Spawning/Nursery Grounds in South Lantau	SR24	a	4.2	3.8	0.0	0.0	0.0	0.0	0.0	0.0
		SR27	a	4.2	3.8	0.0	0.0	0.0	0.0	0.0	0.0

LNG Terminal, Submarine Water Main and Submarine Cable Circuit

Sensitive Receiver	Name	ID	Relevant Depth [1]	WQO Allowable Depletion		Scenario 4a		Scenario 4b		Scenario 5	
				Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet
						Max	Max	Max	Max	Max	Max
Subtidal Hard Bottom Habitat (coral)	Southern Side of South Soko	SR31	a	4	3.9	0.2	0.1	0.2	0.2	0.1	0.0

Table 6.26 (cont'd) Predicted Dissolved Oxygen Depletion (mg L^{-1}) for Scenario 6 due to Increase in SS Concentrations (only results where depletions are predicted have been presented)

LNG Terminal, Submarine Water Main and Submarine Cable Circuit

Sensitive Receiver	Name	ID	Relevant Depth [1]	WQO Allowable Depletion		Scenario 6	
				Dry	Wet	Dry	Wet
						Max	Max
Intertidal Mudflats	Pak Nai	SR01	s	3.6	3.3	0.0	0.0
Horseshoe Crab Nursery Grounds	Pak Nai	SR01	a	3.6	3.3	0.1	0.0
Seagrass Beds/Mangroves/Oyster Farm	Pak Nai	SR02	s	3.6	3.3	0.0	0.0
Artificial Reef Deployment Area	Sha Chau and Lung Kwu Chau	SR06e	a	3.9	2.8	0.0	0.0
Fish Fry Habitat	Pak Tso Wan	SR16b	a	4	3.9	0.0	0.0
Spawning/Nursery Grounds	Fisheries Spawning/Nursery Grounds in South Lantau	SR24	a	4.2	3.8	0.0	0.0
		SR27	a	4.2	3.8	0.0	0.0
Subtidal Hard Bottom Habitat (coral)	Southern Side of South Soko	SR31	a	4	3.9	0.0	0.0

Table 6.26 (cont'd) Predicted Dissolved Oxygen Depletion (mg L^{-1}) for Scenario 7 due to Increase in SS Concentrations (only results where depletions are predicted have been presented)

Submarine Gas Pipeline

Sensitive Receiver	Name	ID	Relevant Depth [1]	WQO Allowable Depletion		Scenario 7	
				Dry	Wet	Dry	Dry
						Max	Max
Marine Park	Designated Sha Chau and Lung Kwu Chau	SR06a	a	3.9	2.8	0.0	0.0
Marine Park	Designated Sha Chau and Lung Kwu Chau	SR06b	a	3.9	2.8	0.0	0.0
Artificial Reef Deployment Area	Sha Chau and Lung Kwu Chau	SR06e	a	3.9	2.8	0.0	0.0
Spawning/Nursery Grounds	Fisheries Spawning/Nursery Grounds in North Lantau	SR08	a	3.9	2.8	0.0	0.0
Fish Fry Habitat	Pak Tso Wan	SR16b	a	4	3.9	0.0	0.0
Subtidal Hard Bottom Habitat (coral)	Southern Side of South Soko	SR31	a	4	3.9	0.0	0.0

Table 6.26 (cont'd) Predicted Dissolved Oxygen Depletion (mg L^{-1}) for Scenarios 8 and 9 due to Increase in SS Concentrations (only results where depletions are predicted have been presented)

Submarine Gas Pipeline

Sensitive Receiver	Name	ID	Relevant Depth [1]	WQO Allowable Depletion		Scenario 8		Scenario 9	
				Dry	Wet	Dry	Wet	Dry	Wet
						Max	Max	Max	Max
Marine Park	Designated Sha Chau and Lung Kwu Chau	SR06a	a	3.9	2.8	0.0	0.0	0.0	0.0
Marine Park	Designated Sha Chau and Lung Kwu Chau	SR06b	a	3.9	2.8	0.0	0.0	0.1	0.1
Marine Park	Potential Southwest Lantau	SR19a	a	4	3.9	0.5	0.5	0.1	0.0
Marine Park	Potential Southwest Lantau	SR19b	a	4	3.9	0.9	1.4	0.1	0.0
Marine Park	Potential Southwest Lantau	SR19c	a	4	3.9	1.8	1.8	0.0	0.0
Artificial Reef Deployment Area	Sha Chau and Lung Kwu Chau	SR06e	a	3.9	2.8	0.0	0.0	0.0	0.0
Spawning/Nursery Grounds	Fisheries Spawning/Nursery Grounds in North Lantau	SR08	a	3.9	2.8	0.0	0.0	0.0	0.0
Fish Fry Habitat	Pak Tso Wan	SR16b	a	4	3.9	0.0	0.0	0.0	0.0
Subtidal Hard Bottom Habitat (coral)	Southern Side of South Soko	SR31	a	4	3.9	0.0	0.0	0.0	0.0

Table 6.26 (cont'd) Predicted Dissolved Oxygen Depletion (mg L^{-1}) for Scenarios 10 and 11 due to Increase in SS Concentrations (only results where depletions are predicted have been presented)

Submarine Gas Pipeline

Sensitive Receiver	Name	ID	Relevant Depth [1]	WQO Allowable Depletion		Scenario 10		Scenario 11	
				Dry	Wet	Dry	Wet	Dry	Wet
						Max	Max	Max	Max
Marine Park	Designated Sha Chau and Lung Kwu Chau	SR06a	a	3.9	2.8	0.1	0.0	0.0	0.0
Marine Park	Designated Sha Chau and Lung Kwu Chau	SR06b	a	3.9	2.8	0.0	0.0	0.0	0.0
Artificial Reef Deployment Area	Sha Chau and Lung Kwu Chau	SR06e	a	3.9	2.8	0.0	0.0	0.0	0.0
Spawning/Nursery Grounds	Fisheries Spawning/Nursery Grounds in North Lantau	SR08	a	3.9	2.8	0.0	0.0	0.0	0.0
Fish Fry Habitat	Pak Tso Wan	SR16b	a	4	3.9	0.0	0.0	0.0	0.0
Subtidal Hard Bottom Habitat (coral)	Southern Side of South Soko	SR31	a	4	3.9	0.0	0.0	0.0	0.0

Table 6.26 (cont'd) Predicted Dissolved Oxygen Depletion (mg L^{-1}) for Scenarios 12 and 13 due to Increase in SS Concentrations (only results where depletions are predicted have been presented)

Submarine Gas Pipeline

Sensitive Receiver	Name	ID	Relevant Depth [(a)]	WQO Allowable Depletion		Scenario 12		Scenario 13	
				Dry	Wet	Dry	Wet	Dry	Wet
						Max	Max	Max	Max
Marine Park	Designated Sha Chau and Lung Kwu Chau	SR06a	a	3.9	2.8	0.0	0.0	0.0	0.0
Marine Park	Designated Sha Chau and Lung Kwu Chau	SR06b	a	3.9	2.8	0.0	0.0	0.0	0.0
Artificial Reef Deployment Area	Sha Chau and Lung Kwu Chau	SR06e	a	3.9	2.8	0.0	0.0	0.0	0.0
Spawning/Nursery Grounds	Fisheries Spawning/Nursery Grounds in North Lantau	SR08	a	3.9	2.8	0.0	0.0	0.0	0.0
Fish Fry Habitat	Pak Tso Wan	SR16b	a	4	3.9	0.0	0.0	0.0	0.0
Subtidal Hard Bottom Habitat (coral)	Southern Side of South Soko	SR31	a	4	3.9	0.0	0.0	0.0	0.0

Notes:

a. s = surface, m = middle, b = bottom, a = depth-averaged

6.6.4 Nutrients

An assessment of nutrient release during dredging has been carried out in relation to the modelling results of the sediment plume due to unmitigated dredging works and the sediment testing results. In the calculation it has been assumed that all TIN and unionised ammonia (NH_3-N) concentrations in the sediments are released to the water. This is the most conservative assumption and will likely result in an overestimation of the potential impacts.

The maximum predicted SS concentration at each SR is multiplied by the maximum concentration of TIN in sediment (mg kg^{-1}) in the corresponding WCZ to give the maximum increase in TIN (mg L^{-1}). The calculations of TIN are shown below.

Deep Bay WCZ	NW WCZ	South WCZ
Max SS * 142 * 10^{-6}	Max SS * 100 * 10^{-6}	Max SS * 71 * 10^{-6}

The calculated TIN concentrations due to the increase in SS by the dredging works are presented in *Annex 6D* based on the marine sediment testing results (*Part 2 – Section 7: Waste Management*). The existing water quality conditions in Deep Bay WCZ, North Western WCZ and Southern WCZ have already breached the WQO for TIN. The increase in TIN concentrations at all sensitive receivers would be less than 0.006 mg L^{-1}, which is considered to be a minimal effect on the water quality. The dredging works will not significantly contribute to the non-compliance with the WQO.

Ammoniacal Nitrogen (NH_4-N) is the sum of ionised ammoniacal nitrogen and unionised nitrogen (NH_3-N). Under normal conditions of Hong Kong waters, more than 90% of the ammoniacal nitrogen would be in the ionised form. For the purpose of assessment, a correction (as a function of temperature, pH, and salinity) has been applied based on the EPD monitoring data, i.e. temperature of 24 degrees Celsius, salinity of 28 ppt and pH of 8 which represent the typical conditions of Hong Kong waters. From this it derived that NH_3-N constitutes 5% of ammoniacal nitrogen. In view that the mineralisation of the organic nitrogen will also contribute to ammonia, the calculations of NH_3-N are based on maximum TKN concentrations (mg kg^{-1}) in the sediment in each WCZ. Note that it is a highly conservative approach since it is assumed that 100% of organic nitrogen will be mineralised to ammonium but this is unlikely to occur in reality.

The maximum SS concentration at each SR is multiplied by the following factors for the calculations of NH_3-N.

Deep Bay WCZ	NW WCZ	South WCZ
Max SS * 2,600 * 10^{-6} * 5%	Max SS * 2,100 * 10^{-6} * 5%	Max SS * 1,300 * 10^{-6} * 5%

The results which are presented in *Annex 6D* show that the increase in NH_3-N concentrations due to the dredging works would be negligible relative to the ambient concentrations. The total concentrations of NH_3-N at the water quality sensitive receivers are predicted to be well below the WQO criterion of 0.021 mg L^{-1}.Thus it is anticipated that the impacts of the SS elevations due to the dredging works on the nutrient levels are minimal and acceptable.

6.6.5 *Heavy Metals and Micro-Organic Pollutants*

Elutriate tests were carried out to assess the potential of release of heavy metals and micro-organic pollutants from the dredged marine mud. The test results have been assessed and compared to the relevant water quality standards as shown in *Annex 6D*.

The results show that dissolved metal concentrations for all samples are below the reporting limits, with the exception of copper. In addition, all dissolved metal concentrations are found to be well below the water quality standards.

The results also show that PAHs, PCBs, TBT and chlorinated pesticides are all below the reporting limits. This indicates that the leaching of these pollutants is unlikely to occur at levels of concern.

Unacceptable water quality impacts due to the potential release of heavy metals and micro-organic pollutants from the dredged sediment are not expected to occur.

6.6.6 *Piling Works*

The LNG jetty will be located to the south of the South Soko Island. There will be two installation methods for the piling works (see *Part 2 – Section 3: Project Description*), namely bored piles and percussive piles.

Bored Piles

For the bored piles, a permanent casing will be driven into the seabed and the excavation of the marine soil will then be occur inside. After the removal of marine soil, an I-beam will be put inside the casing, followed by concreting. Since the excavation of mud will be carried out inside the casing, it is anticipated that any sediment will be trapped within the casing. In addition, the quantity of the excavated marine mud is expected to be minimal and the mud will be disposed of by a barge. Therefore, it is unlikely to cause unacceptable impacts to the surrounding water.

Percussive Piles

The percussive piles comprising steel piles below seabed level and cast in situ reinforced concrete piles above seabed level. This is achieved by driving steel tubes down to required design soil resistances then filling the tubes from just below seabed level. No soil or sediment excavation will be carried out. It is hence expected that the piling works will cause limited disturbance to the sediments and are unlikely to cause unacceptable impacts to the receiving water.

6.6.7 *Wastewater Discharges*

It is conservatively assumed that a workforce of up to 1,600 people may be required during the construction stage. Wastewater from temporary on-site facilities will be controlled to prevent direct discharges to marine waters adjacent to the reclamation. Wastewater may include sewage effluent from toilets and discharges from on-site kitchen facilities. It is assumed that the unit flow per construction worker on a remote site will be similar to a temporary housing area for which a value of 150 L per head per day is adopted. For a workforce of 1,600 people this will equate to a flow of $240m^3$ day^{-1}. The influent strength will be in accordance with *Table 4* of the *DSD's sewage manual*.

The options for dealing with sewage generated from a construction site work force are as follows:

- **Option 1, Septic Tank Soakaway**: This is considered acceptable for small quantities of sewage and where the ground conditions are suitable with appropriate soak away capacity. This will only be considered for a small number of workers at an isolated location, but not for the main site area for which a more robust system is required to handle the estimated flow of $240m^3$ day^{-1}.

- **Option 2, Collect and Convey to a Public STW**: This is a commonly adopted approach by contractors working in the more urbanised areas of Hong Kong, where there is no viable public sewer or a septic tank soakaway near to the site. South Soko Island is a remote island for which there is no existing public sewage works available. During the early stages of the site formation works when the construction force is relatively low, i.e. up to 500 people, this option would likely to be viable and cost effective and as such the contractor may elect to collect and convey the sewage from the island to a Public Sewage Treatment Plant in a nearby land base area such as Tsing Yi. However, if the anticipated average sewage volume of 150 L per head per day is actually realised, the viability and cost effectiveness of this option may diminish as the workforce increases to the assumed 1,600 people during the construction of the process facility. In this event the contractor may consider setting up a temporary sewage treatment facility on site as described in Option 3. In reality, the actual sewage flow generated from the construction work force is likely to be much less than the assumed average of 150 L per head per day and also the maximum number of workers is considered to be a conservative estimate. The viability and selection of this option would therefore need to be assessed by the contractor at the time of construction. However, it is noted that collection and conveyance of the sewage provides a secure disposal option without the risk of operational problems that may occur with a temporary sewage treatment works.

- **Option 3, Provision of Temporary STW to Serve the Work Force**: Due to the remoteness of the site and the relatively large sewage volume it is feasible that the contractor may elect to construct a temporary sewage treatment works. For this scenario, during the construction stage, the contractor would likely choose the nearest sensible point to dispose of the treated sewage. For this purpose a point immediately north of the proposed Tung Wan area is selected as the most likely location for discharge into the sea in order to place it within an area with active currents to assist with dispersion (*Figure 6.10*). It is assumed that the treated sewage will be discharged through an open pipe without the need for dispersers.

For the purpose of the EIA, Option 3 is adopted in the computational model for the water quality assessment as it is the most onerous scenario assuming the anticipated larger sewage flow may be generated and the contractor may wish to consider this option. Modelling has been conducted to determine the dispersion of treated wastewater discharges during the construction phase as described in the *Water Quality Method Statement* (*Annex 6A*).

In order to satisfy the requirements of the *WPCO-TM* effluent discharge standard, a Blivet Process train sewage treatment plant is recommended although the Contractor will select their own preferred solution.

The results (*Annex 6E*) indicate that the impacts are negligible. No non-compliances with the WQO or tolerance criterion are predicted to occur in either the dry or wet seasons.

6.6.8 Land Based Construction Activities

During land based construction activities for the LNG terminal and for the access roads, the primary sources of potential impacts to water quality will be from pollutants in site run-off which may enter marine waters.

Due to limited space at South Soko site, all excavated soil will be delivered off-site (see details in *Part 2 – Section 7: Waste Management*).

A drainage system will be constructed around the land based working sites for the tanks. However, such drainage system can only be constructed after slope cutting works which is required for the site formation. The drainage will collect the site runoff and prevent it from running into the surrounding water.

With the proper implementation of mitigation measures as recommended in (*Section 6.8*.2), it is anticipated that no adverse water quality impacts would arise from the land based works.

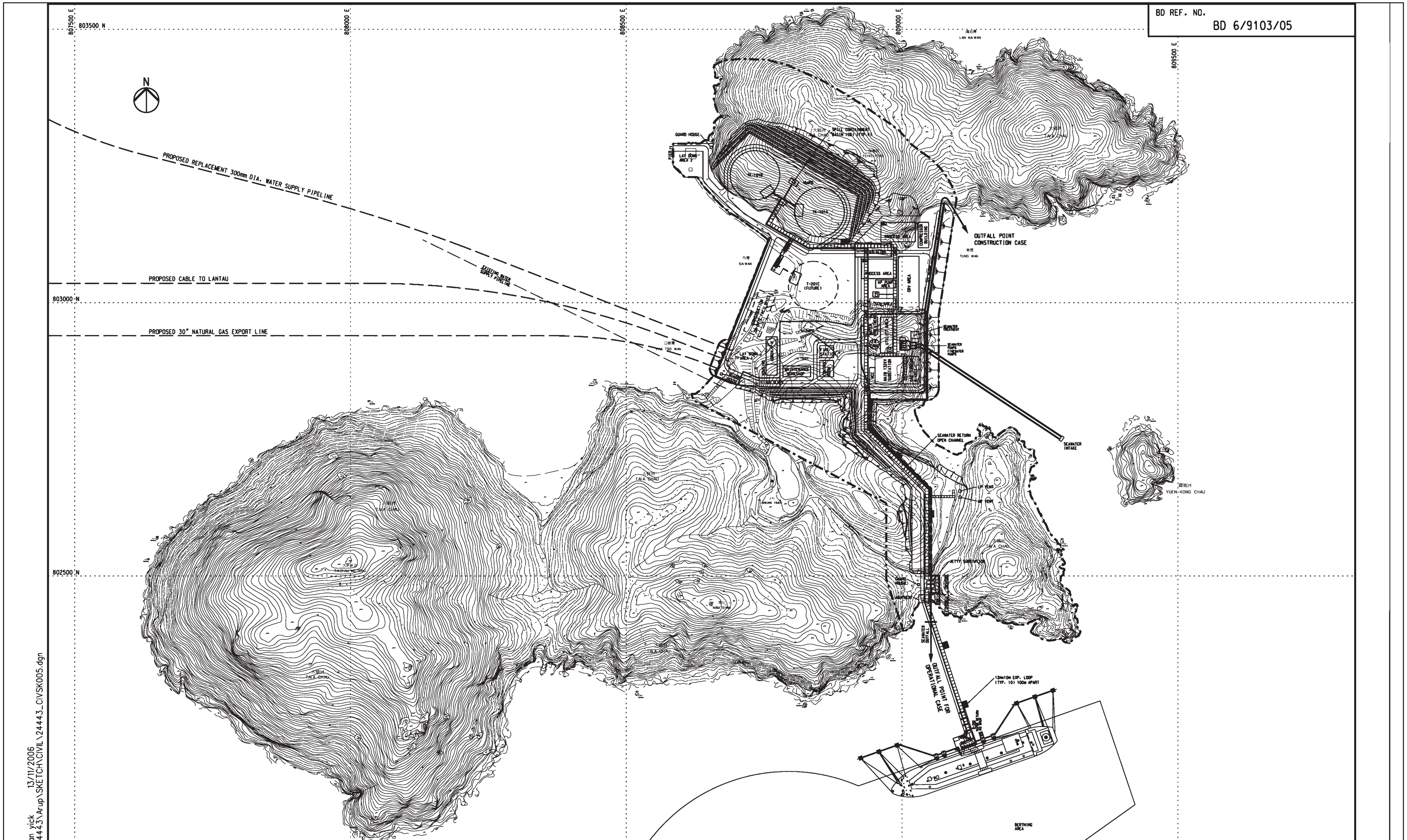


Figure 6.10

South Soko Island Outfall Point for Sewage Treatment

Environmental Resources Management

ERM

FILE: c2662(0018180)eia_docu-set2_95h_1.cdr
DATE: 13/11/2006

6.6.9 *Vessel Discharges*

Construction vessels have the potential to generate the following liquid discharges:

- Uncontaminated deck drainage;
- Ballast water (in emergency situations only);
- Potentially contaminated drainage from machinery spaces; and
- Sewage/grey water.

Deck drainage is likely to be uncontaminated and is not likely to impact water quality.

Ballast water will be taken on and will therefore not be discharged during normal operations. In the event that ballast water does need to be discharged, it will not be contaminated and thus has no implications for water quality.

Other sources of possible impacts to water quality may arise from discharges of hydrocarbons (oil and grease) from machinery space drainage and Biochemical Oxygen Demand (BOD) and microbiological constituents associated with sewage/grey water. These waste streams are all readily amenable to control as part of appropriate practice on vessels. Possible impacts associated with construction vessels discharges are therefore considered to be minor.

No solid wastes will be permitted to be disposed of overboard by vessels during construction works, thus impacts from such sources will be eliminated.

6.6.10 *Hydrotest Water*

Before installation of the tank wall insulation, raw freshwater will be needed to hydrotest the LNG tanks and associated gas pipeline. Similarly, the submarine pipeline would be hydrotested with water prior to commissioning.

Hydrotest for Tanks

The potential additive to the hydrotest water will be low concentrations of chlorine (approximately 0.05 mg L^{-1}). It is expected that the discharged water will be discharged at the new outfall at South Soko, which will comply with the WQOs and discharge license requirements.

Hydrotest for Pipeline

Hydrotest water will not contain a dye chemical but may contain trace concentrations of a corrosion inhibitor. Added chemicals may include an oxygen scavenger (e.g., Ammonium bisulphite) and an antifoulant (e.g., Phosphonium sulphate). The purpose of the oxygen scavenger would be to react with the oxygen within the hydrotest water to form an aggregate, ideally consuming all oxygen in the water. Oxygen scavengers are designed to be non-toxic.

The antifoulant would be added to inhibit biological growth within the tanks and the pipeline. Potential impacts to water quality would arise from the potentially anoxic condition of the hydrotest water, as well as potential toxicity presented by the antifoulant.

The corrosion inhibitor for the hydrotest is widely used in the oil and gas industry. The ecotoxicity and safety information for the proposed corrosion inhibitor to be used for the hydrotest is summarised below and presented in *Annex 6J*. It shows that the corrosion inhibitor is harmless to moderately toxic to organisms.

The hydrotested water will be discharged at a discharge rate of 0.19 $m^3 s^{-1}$ from either the existing Black Point Power Station cooling water outfall or the new South Soko outfall. The discharge will only last for about 2 days.

A near-field modelling study has been carried out to assess the initial dilution since the decay rate of the chemicals involved in the pipeline testing is unclear. The model assumptions are presented in *Annex 6A*.

Table 6.27 shows the LC_{50} (1) / EC_{50} (2) determined from the toxicity test results for each group (*Annex 6J*). The corrosion inhibitor (with initial concentration of 50,000 mg L^{-1}) will be diluted to these values in order to avoid adverse impacts to these organisms and hence a dilution factor for each group is determined.

Table 6.27 Toxicity Results (LC_{50} /EC_{50}) and the Corresponding Dilution Factor

Organism to be Responded	LC_{50} /EC_{50} (mg L^{-1})	Dilution Factor (Dilution Rate)
Fish	LC_{50} >1000	50 (0.02)
Marine invertebrates	EC_{50} = 260.1	200 (0.005)

Tables 6.28 and *6.29* show the distance away from the release point to achieve the required dilution rates for both seasons.

Table 6.28 Model Results for Hydrotested Water Released at Black Point

Dilution Factor (Dilution Rate)	Achieved during Dry Season:	Achieved during Wet Season:
50 (0.02)	< 100m	< 100m
200 (0.005)	< 100m	< 100m

(1) Lowest Concentration to kill 50% of the fish during a 96 hour test

(2) Effective Concentration, the amount of material which inhibited algal growth rate by 50% over the test period

Table 6.29 Model Results for Hydrotested Water Released at South Soko

Dilution rate	Achieved during Dry Season:	Achieved during Wet Season:
50 (0.02)	13 – 50 m	200 – 300 m
200 (0.005)	150 – 500 m	0.7 – 1 km

The results show that when the hydrotested water is released at the Black Point Power Station cooling water outfall, the required dilution of 50 and 200 will be achieved in the close proximity of the outfall. Assuming that the hydrotested water is released at the new South Soko outfall, the dilution achievement is slightly better in the dry season than in the wet season. For both seasons, a dilution of 50 and 200 would be obtained within less than 1 km from the outfall. Hence the effect of the corrosion inhibitor on the fish and marine invertebrates is minimal.

6.7 OPERATION PHASE WATER QUALITY IMPACT ASSESSMENT

6.7.1 Hydrodynamics

Changes to water quality, sedimentation and erosion processes would arise if there was a significant change to the hydrodynamic regime of the South Soko coastline due to the reclamation works and seawall construction in the eastern and western sides of the island.

The design of the proposed LNG terminal has incorporated considerations to reduce impacts to hydrodynamics. The terminal footprint is relatively small (with less than 2 hectares of reclaimed land, see *Part 2 – Section 3: Project Description*) and is confined to areas of low current movement and water circulation (*Figures SK_B01-B08* in *Annex 6B*). As such, adverse impacts to hydrodynamics are not expected to occur.

The approach channel and the turning basin will be located to the south of the South Soko Island. The approach channel and turning basin will be dredged to approximately -15.0 mPD. The results of modelling current velocities (*Figures SK_F01-08* in *Annex 6F*) indicated that hydrodynamic changes due to the deepened seabed level are negligible. No adverse impacts to water quality as a result of these minor changes in hydrodynamics are expected to occur.

The model results also show that at the location of the outfall, i.e. to the southeast of South Soko Island, the low speed currents inhibit the spread of pollutants resulting in no impacts to the water quality sensitive receivers.

6.7.2 Suspended Sediments

Maintenance Dredging

Dredging works associated with maintenance of the approach channel and turning basin are predicted to be approximately 10 to 20 kiloton year^{-1}, which is equivalent to approximately 1 to 2 cm $year^{-1}$, which is of a lower magnitude than those associated with the construction phase dredging. According to these estimates, maintenance dredging is expected to be required once every ten years and will be restricted to specific small areas.

Apart from the low frequency of the maintenance dredging, the scale of the maintenance dredging would be much less than the dredging works for the approach channel and turning basin which has been assessed as unlikely to pose any adverse water quality impacts on the sensitive receivers. Hence, although increases in suspended solids in the water column may occur, these would be expected to be compliant with applicable standards. By implementing applicable mitigation measures such as deployment of silt curtain (stand type and/or cage type) the SS elevation would be further reduced. Thus, any associated impacts are expected to be of a relatively low scale, temporary and localised to the works area.

6.7.3 *Temperature*

Cooled Water Discharge

During the operation of the LNG terminal, there will be cooled water discharges from the terminal outfall as seawater will be used in the Open Rack Vaporizers. Cooled water with a temperature of approximately 12.5°C below ambient will be discharged at the seawater outfall, which is located close to the seabed in the vicinity of the LNG carrier jetty. There are no water quality sensitive receivers in the immediate vicinity of the proposed discharge point.

The maximum flow rate of the discharge is expected to be equivalent to 18,000 m^3 hr^{-1}. Compliance with the WQO ($\Delta \pm 2$ °C from ambient) must be achieved at sensitive receivers. The discharge of cooled water has been simulated using computational modelling.

The results from the cooled water discharge modelling are included in *Annex 6G* and have been presented as contour plots showing impacts of cooled water discharges in the vicinity of the outfall. *Figures SK_G01-G02* show the differences of the maximum temperature reduction between the maximum operational discharges and the baseline, representing the most conservative case.

It can be seen from the contour plots that the extent of temperature change from ambient for both the wet and dry seasons is predicted to be confined to the bottom layer, with no impact to the surface layer of the water column and no impact at sensitive receivers. This may be expected as the discharge of cooled water is close to the bottom and the relatively higher density of the cooled water results in weak vertical mixing.

Due to the distance to sensitive receivers, no non-compliance with the WQO has been predicted in either the dry or wet seasons. For the most conservative case (maximum operational discharge, see *Figures SK_G01 and*

SK_G02), the temperature change is predicted to be less than 2 °C in both the dry and wet seasons. The temperature change of 2 °C will be confined to < 200 m from the outfall in the dry season and the wet season. The model results indicate that the dispersion of cooled water is rapid and not expected to cause an unacceptable impact.

6.7.4 *Residual Chlorine Dispersion*

To counteract settling and actively growing fouling organisms, the LNG cooled water circuits will be dosed with antifoulants. An efficient anti-biofouling system will be designed to prevent the growth of micro and macrofouling organisms on surfaces that are immersed in or in contact with seawater. Anitfoulant control in the once through seawater is critical since marine growth in the piping and equipment must be controlled. This includes the Open Rack Vaporizers (ORVs) which will become fouled and lose heat transfer efficiency if algae or marine animals are allowed to build up on the heat transfer panels within these units. More importantly, marine growth will promote pitting corrosion. Biological control must not only render the incoming biological material incapable of growth, but it must carry a residual concentration through the system to protect it from new growth caused by airborne biological agents or prior contamination that could possibly cause growth in the system.

Sodium Hypochlorite

Chlorine, typically in the form of sodium hypochlorite, is commonly used as an antifouling agent in plants worldwide where seawater is used for cooling/warming. Sodium hypochlorite is an antifoulant that has been researched intensively. In once-through systems sodium hypochlorite is the most important antifoulant that is applied. Sodium hypochlorite is generated in a sodium hypochlorite generator by passing electrical current through seawater causing it to form sodium hypochlorite and small amounts of hydrogen. The hydrogen is vented to a safe location which is 2 to 3 meters above any personnel or adjacent equipment and will readily disperse upwards in a dilute form that is below the Lower Explosive Limit (LEL) for hydrogen. Hydrogen readily disperses since it is lighter than air. The sodium hypochlorite generators can be controlled to only generate as much sodium hypochlorite as required. Sodium hypochlorite will provide free residual chlorine in the seawater that can be adjusted to carry over to the ORVs providing them with protection from air borne algae that could cause algae growth on the ORVs.

The ORV residual chlorine discharge will be at 0.3 mg L^{-1}. This limit will be maintained by controlling sodium hypochlorite feed automatically using residual chlorine monitors in the discharge. When chlorine (or hypochlorite) is added to seawater a series of chemical reactions occurs. The end products of these reactions include a wide range of halogenated organic compounds. Using a low level of chlorine to prevent settlement of marine organism, rather than killing them, reduces the likelihood of halogenated organics being formed.

According to the Integrated Pollution Prevention and Control (IPPC), Reference Document on the application of Best Available Techniques to Industrial Cooling Systems (BREF) (2001), "Sodium hypochlorite is the most commonly oxidising antifoulant used in large once-through systems. It can be produced on marine sites by electrolysis of seawater. This process, called electrochlorination, avoids the transport and storage of dangerous chlorine gas or solution. The consumption of sodium hypochlorite as active chlorine demand is generally lower in and around saltwater systems than on freshwater systems, because of a higher level of dissolved and particulate organic matter in fresh water. Due to its higher bromide content, the formation of halogenated organics in seawater is reported to be lower than in freshwater (rivers), but no publications could confirm this."

Other Alternatives

There are a number of alternatives to sodium hypochlorite for controlling biological growth that have been considered, including:

- Ultra Violet (UV) Light;
- Ozone;
- Chlorine Dioxide;
- Copper Systems; and
- Commercial antifoulants.

Ultra Violet (UV) Light

A non-chemical alternative to sodium hypochlorite is the use of UV light to control biological growth in the seawater cooling system. UV light serves as an antifoulant by damaging a microorganism's DNA structure, inhibiting its ability to reproduce or killing the organism outright. UV treatment does not require chemicals nor does it produce harmful reaction products.

According to the Integrated Pollution Prevention and Control (IPPC), Reference Document on the application of Best Available Techniques to Industrial Cooling Systems (BREF) (2001), "UV-light may also offer possibilities in recirculating systems as a supplementary technique. UV-light alone however, cannot attack the biofouling that has settled on the surfaces of the Cooling Water System. In order to be effective, relatively clear cooling water is needed, since the light must be able to penetrate into the water column."

While UV light has been a useful technique for certain cooling water systems, there are several issues that limit its applicability to the treatment of the

Project's ORV system. There is a notable lack of operational experience with UV treatment in subsurface marine applications. Monitoring the operation and changing the UV lights once every 5,000 hours would be difficult when the system is located at 15 - 25 m below sea level. Silt and other materials present in the seawater would foul the lights, requiring frequent cleaning for it to remain effective at these depths. Expensive additional pre-treatment of the water might even be necessary to ensure that the UV light penetrates the water column. As a direct, non-chemical process, UV light does not provide residual biological control which is necessary to protect the ORVs.

While the environmental effects of UV light are expected to be less harmful then halogenated antifoulants, the technique requires special care, is expensive, is unproven in subsurface marine applications, does not provide residual fouling protection and is not applicable in all situations. UV-light alone cannot attack the biofouling that has settled on the surfaces of the ORV since it does not provide residual biological control. Thus, UV light is not considered technically acceptable for this application.

Ozone

In recent years, ozone has been employed as an alternative to chlorine disinfection in potable water and wastewater applications. Ozone kills microorganisms by damaging or destroying the cell wall. Ozone can be generated onsite with electricity using commercially available ozone generators which use either a Pressure Swing Absorption (PSA) unit or liquid oxygen tank to provide a pure or enriched source of oxygen

According to the Integrated Pollution Prevention and Control (IPPC), Reference Document on the application of Best Available Techniques to Industrial Cooling Systems (BREF) (2001), "With the relatively smaller volumes of recirculating wet systems alternative treatments are successfully applied, such as ozone, but they require specific process conditions and can be quite costly."

There are several notable environmental and safety issues that limit the applicability of ozone for the proposed use. Corrosion is a particularly complex problem with ozone treatment. As a strong oxidant, ozone accelerates the corrosion of metals in water, damaging any pipes and equipment not made of corrosion-resistant materials. Without corrosion protection measures, ozone could accelerate the corrosion of the vaporizers causing them to have a shortened lifespan and possible failure. Correcting this problem would necessitate the use of exotic metallurgy, introducing the risk of putting metallic ions to the seawater which could also damage the ORVs.

Ozone production requires a considerable amount of energy and is relatively expensive due to the fact that the efficiency of the ozone generators is very low. The ozone generators would require an ozone destruction unit (fired unit) to destroy any excess ozone production which would be harmful to the atmosphere. This destruction unit is also expensive and would represent an additional source of NOX emissions. Additionally, ozone, like UV, does not provide residual biological control since it is very reactive and will be consumed in the first few seconds after application.

In terms of safety, ozone is a noxious gas which can damage lung function. Any uncontrolled ozone release from a generator or destruction unit would represent a potential hazard to site workers.

Ozone is preferably used in very clean recirculating cooling systems, and it is noted that its high reactivity makes ozone unsuitable for application in once-through system or long line systems. Ozone is not practical in this application due to the lack of experience of this size unit, corrosion concerns, lack of residual biological control, high costs, increased NOx emissions and potential environmental hazard from ozone releases.

Chlorine Dioxide

Chlorine dioxide is an effective biological control agent normally used in applications onshore where ammonia or other agents make the use of free chlorine ineffective. Unlike UV light or ozone, chlorine dioxide does provide a residual that would protect the ORVs. Chlorine dioxide must be generated onsite using special equipment.

According to the Integrated Pollution Prevention and Control (IPPC), Reference Document on the application of Best Available Techniques to Industrial Cooling Systems (BREF) (2001), "Chlorine dioxide (ClO_2) has been considered as an alternative to hypochlorite (HOCl) for seawater conditions and as a freshwater biocide due to its effectiveness as a disinfectant and to its strong reduction in the formation of organohalogenated by-products in the effluent. It has been reported as an effective and economical application in cooling water systems for control of micro-organisms at relatively low dosages."

There are several notable environmental and safety issues that limit the applicability of chlorine dioxide for the proposed use. The generation of chlorine dioxide would depend on the delivery of hazardous chemicals to the site. The generation equipment would consume a large area of space along with chemical storage. As a consequence, capital and operating costs for a chlorine dioxide system would be considerably higher than those for a conventional sodium hypochlorite system.

While some residual antifouling capacity is beneficial, chlorine dioxide can leave undesirable residuals that are much more persistent in the environment than free chlorine. Since chlorine dioxide is resistant to oxidation and reaction with ammonia, it will persist in the seawater much longer than the other options. Chlorine dioxide can react with other compounds to form undesirable by-products such as aldehydes, ketones and quinones or even epoxydes under certain circumstances. Some aldehydes and eopxydes are known to be carcinogens or mutagens which may persist past the mixing zone upon discharge into the open sea. Since chlorine dioxide is not widely used for this purpose, the impacts of reactions with organic compounds that form undesirable disinfection by-products are not as well studied.

The environmental and safety risks of using chlorine dioxide prevent this option from being further considered for this application.

Copper Systems

Copper systems use copper ions to control biological growth by inhibiting the attachment of fouling organisms to process piping and equipment surfaces. The copper ions are supplied by the electrolysis of seawater which eliminates the need to transport and store hazardous chemicals.

According to notes on copper ion treatment provided in the Integrated Pollution Prevention and Control (IPPC), Reference Document on the application of Best Available Techniques to Industrial Cooling Systems (BREF) (2001), "…the residual concentration of the lethal copper compounds needs further examination as the discharge to the receiving water could cause harmful effects."

There are several notable operational and environmental issues that limit the applicability of copper ions for the proposed use. One basic concern is that copper ion treatment is not a common technique and that to our knowledge none of the LNG terminal operators have experience operating this unconventional control system. Another concern is that existing copper ion treatment has not yet been attempted in a system that contains aluminium. As such, there is the potential that an undesirable reduction-oxidation reaction may take place between the copper ions and the aluminium in the ORVs, accelerating the corrosion of the vaporizers.

While copper is commonly used as a protective coating for vessels, the proposed application would introduce considerable amounts of the metal directly into the marine environment. The concentrations of copper at the seawater outfall could potentially reach levels of concern given the high volume of ORV throughput and the duration of the project.

Given the uncertainty of ORV corrosion and the introduction of a non-biodegradable metal to the marine environment, copper ion treatment is not considered technically acceptable for this application.

Commercial Antifoulants

One chemical company produces an antifoulant that is a catatonic surfactant that is short-lived in plant systems and the environment because of rapid absorption onto anionic substrates and sediments in natural aquatic ecosystems.

Mussels do not detect this chemical as a noxious compound, and they do not close their shells. This allows the mussels to be killed quickly, with significant mortality in 4 to 24 hours. The agent causes detachment of adults and is effective on molluscs at all life stages. It also effectively controls microfouling organisms, barnacles, hydrozoa, bryozoa, bacteria, fungi, algae, Asiatic clams, and bacterial, fungal, and algal slime. The agent is compatible with stainless steel, copper alloys, most plastics and rubbers, chrome alloys, aluminium, and FRP piping.

There are several notable operational and environmental issues that limit the applicability of this antifouling agent for the proposed use. The chemical is corrosive to skin and is flammable, making it a hazard to handle. The high residual levels after discharge along with the extremely high cost of this material make it operationally and environmentally unsuitable for this application. As such, the chemical is not considered suitable for this application due to its potential negative effects on sea life and excessive cost.

Summary

To conclude, UV and ozone generator options are not recommended because they do not provide the required residual biological control for the ORVs along with other operational difficulties. Although chlorine dioxide provides residual control, it uses hazardous chemicals and will consume considerable space for producing the chlorine dioxide and chemical storage and unloading, in addition to operator safety issues. The proposed commercial antifoulant is not considered suitable for this application due to its potential negative effects on sea life and excessive cost.

Copper ion treatment is currently not in wide use and there is limited operating experience for this unconventional system. Additionally, the potential corrosion problems with the copper-aluminium interaction on the Open Rack Vaporizers (ORV's) are unknown and are therefore currently not viewed as a viable option.

The one viable option remaining is sodium hypochlorite. It is a safe, proven option that has been used successfully for many years on many once through seawater applications with ORVs. For most applications, a carefully designed sodium hypochlorite system offers the most complete and comprehensive technique for the reduction of both macrofouling and microfouling.

Careful design can also dramatically reduce the environmental impact of modern sodium hypochlorite systems. This includes a properly designed chlorine monitor to control the residual chlorine levels in the system with care being taken to choose an instrument that has the proper operating range to provide maximum sensitivity throughout all foreseeable operational scenarios.

Residual chlorine in the marine environment can be harmful to marine organisms only if concentrations exceed tolerance levels. It has been found that harmful effects begin to occur at concentrations above 0.02 mg L^{-1} in water [(1)]. The discharge limit for residual chlorine is 1.0 mg L^{-1} according to EPD's *Technical Memorandum for Effluents* issued under *Section 21 Water Pollution Control Ordinance, Cap 358*. There is no value specified in the WQOs for the Southern WCZ, nor for any other WCZ. The criterion value of **0.01 mg L^{-1}** (daily maximum) at the edge of the mixing zone has been chosen as the criterion against which to assess the results from the computer modelling of chlorine dispersion, which is also the criterion adopted in the approved EIA Report for the 1,800 MW Gas-fired Power Station at Lamma Extension [(2)].

The water quality impacts due to chlorine discharges have been assessed using computational modelling (see *Water Quality Method Statement* in *Annex 6A*). The results from the chlorine simulations are presented as contour plots of mean and depth averaged chlorine concentrations for the spring and neap tidal periods in the wet and dry seasons. The contour plots are provided in *Annex 6H*. *Figures SK_H01-08* present the maximum operational discharges, while *Figures SK-H09-16* show the fluctuating operational discharges. Both discharge rates appear to result in a similar pattern of residual chlorine dispersion.

The dispersion results obtained for both the wet and dry seasons have shown that the majority of the residual chlorine is contained within the bottom layer, with little or no chlorine in the middle and the surface layers. This indicates that the release of the chlorine near to the seabed and the relatively higher density of the cooled water, in which the chlorine is discharged, results in weak vertical mixing.

The model used the assumption that the terminal would discharge total residual chlorine at a maximum concentration of 0.3 mg L^{-1}. This concentration is similar to that for most power stations in Hong Kong and is below the EPD's limit of 1.0 mg L^{-1}

Based on the predictions, the maximum extent of the > 0.01 mg L^{-1} contour is <300 m from the discharge point during the dry season and <100 m during the wet season (*Figure SK_H01* and *Figure SK_H05*). These areas were defined as the "mixing zones".

Due to the small extent of the plumes, and the fact that no sensitive receivers would be affected, no unacceptable water quality impacts from residual chlorine discharge are expected to occur. The short duration peaks of residual chlorine discharge will also not contribute to any unacceptable

(1) Langford, TE (1983) Electricity Generation and the Ecology of Natural Waters. Liverpool University Press, Liverpool.

(2) ERM - Hong Kong, Ltd (1999) EIA for a 1,800MW Gas-fired Power Station at Lamma Extension. Final EIA Report. For The Hongkong Electric Co., Ltd.

adverse impacts. The assessment confirms the environmental suitability of the proposed discharge.

6.7.5 *On-site Wastewater Discharges*

During operation of the LNG Receiving Terminal, it is expected that there will be a workforce of about 100 people. It has been conservatively estimated that an average of approximately 35 m^3 of sewage would be produced by this workforce per day (*Annex 6A*). This is based on an average unit flow factor of 60 L per day per head for each person employed based on the Drainage Service Departments (DSD's) *Sewerage Manual* and an additional commercial unit flow factor of 290 L per day per head.

As the sewage from the LNG Plant is of domestic sewage type, BOD, SS, TN and *E.Coli* are applicable to the sewage treatment process. Whilst the treated effluent shall comply with all parameters in the *TM*, the discharge of chemical substances are not a concern for domestic type sewage and are not considered. Oil and grease will be controlled by fitting grease traps to the wastewater outlets from the kitchens.

A sewage treatment system will be provided for the treatment of wastewater. A sanitary waste system consisting of a collection system will be provided. Due to the low number of operational staff in the terminal, the volume of the sewage generated would be limited and would be treated on-site before being discharged in accordance with the EPD's required standards under the *Water Pollution Control Ordinance*. The sewage will be discharged from the seabed outfall to the south of the South Soko Island (*Figure 6.10*).

The sewage flow generated from the LNG Receiving Terminal operations is small. For this scale of flow a packaged sewage treatment plant offers the optimum solution such as a rotating biological contactor (RBC) plant or blivet plant coupled with a disinfection system.

Modelling has been conducted to determine the dispersion of the treated wastewater discharge during the operation phase. Modelling methods are discussed in the *Water Quality Method Statement* (*Annex 6A*). The results (see *Annex 6I*) indicate that the impacts of the wastewater discharges are negligible. No non-compliance with the WQO is predicted to occur in either the dry or wet seasons throughout the operation phase.

6.7.6 *Vessel Discharges*

No adverse impacts are expected to occur from vessel discharges during the operation phase.

No ballast water from the LNG Carrier will be discharged in Hong Kong waters. The LNG Carrier will arrive at the Hong Kong terminal loaded with LNG and with empty ballast water tanks. Ballast water will be taken into the LNG carrier ballast tanks at the discharge terminal simultaneously with the LNG discharge.

The handling of that ballast water by the LNG Carrier will then always be in accordance with *IMO resolution A.868(20)* adopted by the IMO assembly in November 1997. This requires the LNG Carrier to have the ability to change all ballast water at sea between discharge port and load port. In addition, the provisions of the *Convention for the Control and Management of Ship's Ballast Water and Sediments* adopted 13 February 2004 (which entered into force at a later date) will also be fully complied with.

6.7.7 *Accidental Spill of LNG*

An LNG release would be vaporized quickly into the atmosphere and would not be expected to impact water or sediment quality. If spilled onto the LNG Terminal jetty deck or into the ocean (LNG is less dense than water), LNG would boil rapidly (due to exposure to higher ambient temperatures). Because of the material's density and turbulence created by the rapid boiling, an LNG spill would vaporize rapidly, leaving no environmental residue.

It is worth noting that there is a sump at the berth large enough to capture and manage a major spill from the unloading lines and contain it on the site. Other leaks at the terminal are designed to be routed to containment basins for evaporation and treatment and would not reach the sea. Therefore an LNG spill would be only associated with the unloading arms, which are hanging out to the sea, outside of the spill containment area. It should also be noted that the LNG terminal has an emergency shutdown system (PERC) that continuously monitors the mooring system and motions of the unloading arms. Upon sensing any irregularities in either of these systems, the unloading operation is automatically shutdown. This system has quick operating shutoff valves that among other places are located at the unloading arm connection to minimize the possibility of a LNG spill. The system can also be actuated manually by the terminal operator who is always present at the dock during unloading or the ship's cargo master who is also present. Thus, if the ship were to break from its mooring, the LNG transfer would shutdown instantly without loss of cargo.

A leak from the unloading arms has a frequency of 4 $\times 10^{-3}$ per year, while a full rupture has a frequency of 4 $\times 10^{-5}$ per year (for details refer to *Part 2 - Section 13.5*). Other sections of LNG Receiving Terminal have an even lower frequency of leakage and hence the leak from the unloading arms is examined. To investigate the effects of a spill on water quality, a full bore rupture scenario was modelled. It was assumed that unloading arms part when an extremely high atypical wave due to a passing ship causes the LNG Carrier to break free from its moorings.

The pumping rate during carrier unloading is 601 kg s^{-1} (equivalent to 1.3 $m^3 s^{-1}$) per unloading arm. For the purpose of modelling, if a rupture occurs, a 30 seconds release of LNG is assumed. This is based on the closing time of the emergency shutdown valves (ESV) and the reaction time of personnel to activate the emergency shutdown device (ESD). However, the inventory of LNG between ESVs is about $80m^3$. A release would therefore consist of the inventory plus 30s of pumping, a total of about 120 m^3. The modelling assumes this is released at a constant rate of 1.3 $m^3 s^{-1}$ for 92s. In reality, once the ESVs close, the discharge rate will decrease beyond 30s and be caused by gravity draining only. The modelling approach is therefore conservative.

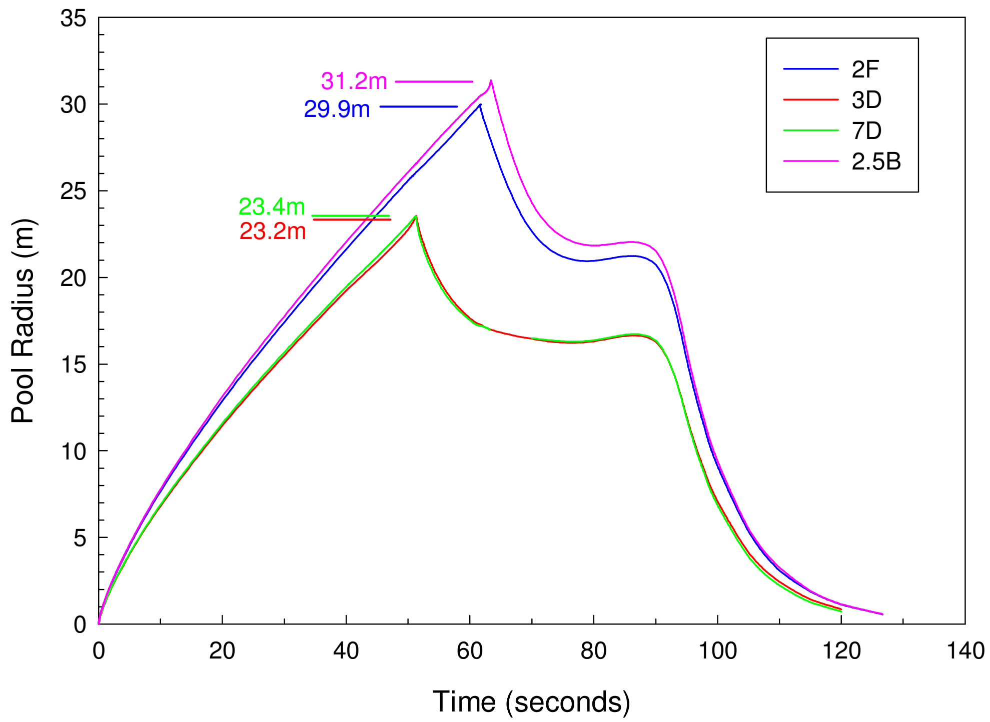
The spill is further assumed to take place on water and is allowed to spread isotropically without confinement. Modelling was performed using PHAST for four weather conditions covering a range of atmospheric stability classes of B through to F, and a range of wind speeds from 2m s^{-1} to 7m s^{-1}. The model includes the effects of gravitational spreading, surface tension forces and vaporisation rate in calculating the pool size. The PHAST model was adopted as it is used in the Quantitative Risk Assessments (QRAs) for the terminal and marine transit of the LNG Carrier.

The results (*Figure 6.14*) show transient pool behaviour, growing to maximum size after about 1 minute and completely vaporising after 2 minutes. The liquid rainout fraction is about 20% whereas 80% of LNG would be vaporised (conservatively a release height of 1 m was specified in the modelling) but depends on weather conditions. This factor explains the difference in the four curves. The results show that the pool size is likely to be affected by atmospheric stability and less so by wind speed. The pool size radius is in a range of 23 m and 31 m, which is considered to be small. It is hence anticipated that substantial vaporisation, which is caused by turbulent mixing and heat transfer from the air to vaporise the LNG, will take place before the LNG reaches the water.

Similarly, results of the QRA of the LNG Carrier transit have indicated that in the highly unlikely event of a breach of containment of the double hull of the LNG Carrier the spill would have a maximum radius of 85 m in the worse case event. This has been determined through mathematical modelling, again using the PHAST model for consistency amongst the QRAs.

In summary, should an accidental spill of LNG occur on the sea surface the LNG will not mix with water or dissolve in water but will stay on the surface and evaporate rapidly leaving no residue. The LNG spill will cause immediate cooling of the surface water which will rapidly return to normal temperature due to the buffering effect of the ocean. Hence no impacts to water quality would be expected in the unlikely event of an accidental spill of LNG on the water.

Figure 6.14 LNG Pool Size for a Spill from the Unloading Arm



Notes:
"2F" denotes a wind speed of 2 m s^{-1} under stable air-turbulence conditions.
"3D" denotes a wind speed of 3 m s^{-1} under neutral air-turbulence conditions.
"7D" denotes a wind speed of 7 m s^{-1} under neutral air-turbulence conditions.
"2.5B" denotes a wind speed of 2.5 m s^{-1} under unstable air-turbulence conditions.

6.7.8 Accidental Spill of Fuel from LNG Carrier

In the event of an accident, the special design of the storage tanks will prevent the fuel from leaking into the sea. Fuel for propulsion and ship services is carried in storage tanks installed inside double hulls at the forward end and the aft end of the vessel. The forward storage tanks are located aft of the fore peak tank and forward ballast tank or bow thruster room at a distance about 10 to 20 m from the bow to afford protection against collision. The outboard sides and bottom of all fuel tanks are separated from the hull sides and bottom with abutting ballast tanks or void spaces so that any potential oil tank boundary leakage will not reach the sea. In addition, hull bottom or side damage will not impair the tank boundary thus preventing pollution of the sea. This feature constitutes double hull protection and hence reduces the likelihood of failure as far as reasonably practicable.

It is considered that a spillage of fuel is highly unlikely given the above. However, the Study Brief requires that a potential scenario is examined.

Uncertainty of Fuel Spill

How much fuel will actually be contained within the ship's fuel storage system for every voyage cannot be estimated with certainty; however the following factors have to be taken into account:

- LNG tanks not filled to capacity;
- Protective location of fuel tanks; and
- Geometric factor of fuel tanks.

Therefore, although the worst case analysis of the largest single tank being breached was modelled, the frequency of such an event is very small and hence in the unlikely event of such an event arising the quantity of fuel released will be lower than that modelled. In the model, it is assumed that all oil is released from a fulfilled tank and the protection features of the tank are not considered in the model although it is unlikely to occur.

Impact Assessment

Should any rupture in the tank occur it is essential to implement the emergency contingency plans to effectively control and clean up accidental spillages and to reduce the quantities of fuel reaching water sensitive receivers. This is the purpose of carrying out athematical modelling to assess the behaviour of a hypotetical fuel spill from and LNG carrier. The modelling assumptions are presented in *Annex 6A*.

It is important to note that the modelling is based on a multiplicity of conservative parameter inputs to identify an extreme range of plume movement. The output is intended to facilitate implementation of an effective contingency plan to ensure best practice of controlling accidental oil spillages, notwithstanding the very low likelihood of such an event occurring in practice.

The most conservative case considered is the holing of the largest single tank containing fuel on board a 215,000 m^3 class LNG Carrier, which is a carrier class considered in the MQRA. This worst case scenario considers only the consequence on water quality and as it does not consider the low frequency it is extremely conservative in nature.

In the model, a point close to South Soko Island was chosen based on the potential LNG carrier transit route and the closeness to the sensitive receivers at the south of the South Soko Island.

In order to examine the dispersion pattern and movement of an oil plume, it is assumed that no evaporation and emulsification is allowed and consequently a highly conservative case has been simulated. The modelling has been conducted using the Oil module of the particle tracking (PART) model of the Delft 3D suite of models.

It is assumed that necessary contingency actions will be implemented within 24 hours after the release and hence a summary of the fuel spill travel route and corresponding time during a 24 hour period is shown in *Tables 6.30* and *6.31*.

Table 6.30 *Movement of Fuel Spill (Dry Season)*

Location	The n^{th} hour after Release
South of South Soko Island (release point)	0 – 16
South coast of Tau Lo Chau	17 – 23
Open water to southeast of South Soko Island	24

Table 6.31 *Movement of Fuel Spill (Wet Season)*

Location	The n^{th} hour after Release
South of South Soko Island (release point)	0
Tau Lo Chau (to southeast of South Soko Island)	2 – 5
East coast of South Soko Island	6
Open water (southeast to South Soko Island)	7 – 10
Open water (southeast to Cheung Chau)	11 – 22
Open water (southeast to Lamma Island)	23 – 24

For the dry season, the contingency actions should be implemented to control and contain the fuel plume within 24 hours before it disperses farther to the open water.

For the wet season, the plume is likely to move much faster and farther. In order to control and contain the fuel plume, it is recommended that the contingency actions should be implemented within 6 to 10 hours.

6.7.9 *Contaminated Site Run-off*

Measures have been put in place to ensure the management and control of day-to-day activities at the terminal that involve the use of potentially contaminating materials, such as fuel and lube oils. These measures are presented and discussed in *Section 14*. The measures will ensure that surrounding marine waters are not affected by contaminants in run-off from the site.

6.8 *WATER QUALITY MITIGATION MEASURES – CONSTRUCTION PHASE*

The water quality modelling works have indicated that for both the dry and wet seasons, the works can proceed at the recommended working rates without causing unacceptable impacts to water quality sensitive receivers. In instances where there are exceedances of the applicable standards, they have been predicted to be transient and not of concern.

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 LNG terminal and the associated pipeline, water main and cable routes, with the principal aim of avoiding direct impacts to sensitive receivers.

- **Reduction in Indirect Impacts:** The LNG terminal and the associated pipeline, water main and cable routes are located at a sufficient distance from 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 criteria).

- **Adoption of Acceptable Working Rates:** The modelling work has demonstrated that the selected working rates for the dredging and jetting operations will not cause unacceptable impacts to the receiving water quality. Details regarding the working rates for different scenarios are presented in *Section 3.4 of Annex 6A*.

- **Pipeline Alignment:** A number of alternative gas pipeline routes were studied and the preferred alignment avoids direct impacts to sensitive receivers (See *Part 2 – Section 2: Consideration of Alternatives*).

In addition to these pro-active measures that have been adopted for the proposed Project, the following operational constraints and good site practice measures for dredging and construction run-off are also recommended. It should be noted that there is no requirement for constraints on the timing or sequencing of the works, as all concurrent scenarios have been demonstrated not to cause adverse water quality impacts.

6.8.1 Dredging

The impacts to water quality from the loss of sediment to suspension was assessed in terms of the maximum rates of dredging and/or filling during the construction of the seawall, reclamation, approach channel and turning basin, water main and the gas receiving station. The assessment was carried out based on the predicted loss rates of fine sediment to suspension from the different types of plant working on the site during the times of maximum dredging and/or filling. The highest loss rate was predicted to occur during the time at which the maximum rate of dredging was occurring. The maximum loss rate should then be limited to the values adopted in the Study and it was predicted that this rate of loss would not give rise to adverse impacts. It is therefore recommended that the maximum loss rate during the dredging works be kept at these limits.

The following measures shall also apply at all times:

- No overflow is permitted from the trailing suction hopper dredger and the Lean Mixture Overboard (LMOB) system will only be in operation at the beginning and end of the dredging cycle when the drag head is being lowered and raised.

- Dredged marine mud will be disposed of in a gazetted marine disposal area in accordance with the *Dumping at Sea Ordinance* (*DASO)* permit conditions.

- Disposal vessels will be fitted with tight bottom seals in order to prevent leakage of material during transport.

- Barges will be filled to a level, which ensures that material does not spill over during transport to the disposal site and that adequate freeboard is maintained to ensure that the decks are not washed by wave action.

- After dredging, any excess materials will be cleaned from decks and exposed fittings before the vessel is moved from the dredging area.

- The contractor(s) will ensure that the works cause no visible foam, oil, grease, litter or other objectionable matter to be present in the water within and adjacent to the dredging site.

- If installed, degassing systems will be used to avoid irregular cavitations within the pump.

- Monitoring and automation systems will be used to improve the crew's information regarding the various dredging parameters to improve dredging accuracy and efficiency.

- Control and monitoring systems will be used to alert the crew to leaks or any other potential risks.

- When the dredged material has been unloaded at the disposal areas, any material that has accumulated on the deck or other exposed parts of the vessel will be removed and placed in the hold or a hopper. Under no circumstances will decks be washed clean in a way that permits material to be released overboard.Dredgers will maintain adequate clearance between vessels and the seabed at all states of the tide and reduce operations speed to ensure that excessive turbidity is not generated by turbulence from vessel movement or propeller wash.

- Deploy silt curtain to reduce the elevation of suspended solids to nearby sensitive receivers during specific works described in *Section 6.6*.

As discussed in *Section 6.6*, it is expected that the construction works are generally environmentally acceptable for most sensitive receivers. They will give rise to short-term exceedances at three sensitive receivers, i.e., fish fry habitat at Pak Tso Wan, subtidal hard bottom habitat at the southern side of South Soko and in some areas of the Sha Chau and Lung Kwu Chau Marine Park. The assessment presented in *Section 6.6* is based on the unmitigated situation and assumed that no mitigation measures are adopted during construction. In view of these exceedances, specific mitigation measures are recommended, as summarised in *Table 6.32*. Deployment of both stand type and cage type silt curtains is proposed to reduce the SS elevation at Pak Tso Wan. *Figure 6.15* depicts the envisaged double layers stand type silt curtain installation at Pak Tso Wan and a stand type silt curtain enclosing the sandfilling area in case the seawall trench is to be filled with sand. A stand type silt curtain is recommended enclosing the subtidal hard bottom habitat at the southern side of South Soko (see *Figure 6.16*) and the deployment of a cage type silt curtain is proposed for enclosing the dredging areas next to the grab dredgers at the approach channel and turning basin. If the water monitoring results show any exceedances which are confirmed to be caused by the dredging works, an additional stand type silt curtain will be installed where considered appropriate and effective. *Figure 6.16* illustrates its possible location. Cage type silt curtains are proposed to be adopted for the grab dredgers at those dredging areas that are close to the western boundary of the Marine Park (see *Figure 6.17*).

Details of silt curtain installation should be proposed by the contractor prior to the commencement of dredging/jetting works and submitted to the IEC for approval.

Reduction factors for SS elevations are taken from a review of approved EIAs presented in *Annex 6L*.

For Scenario 3, the predicted exceedances at Pak Tso Wan after deployment of the proposed mitigation measures are regarded as residual impact and the evaluation of the residual impact is discussed in *Section 6.11.1*.

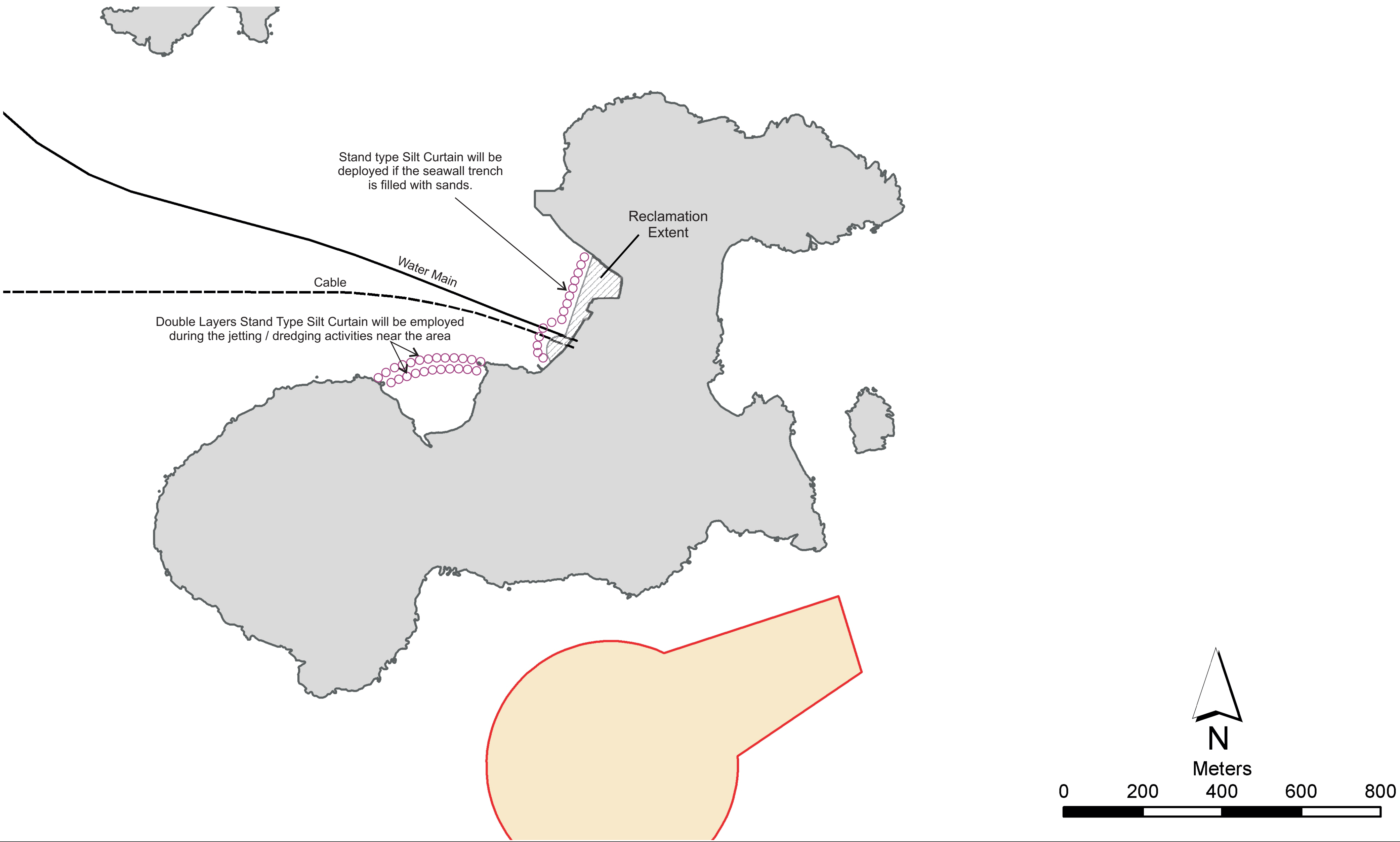


Figure 6.15

Indicative Arrangement of Silt Curtain (Stand Type) for Jetting / Dredging and Sanfilling Activities near South Soko

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Environmental Resources Management

ERM

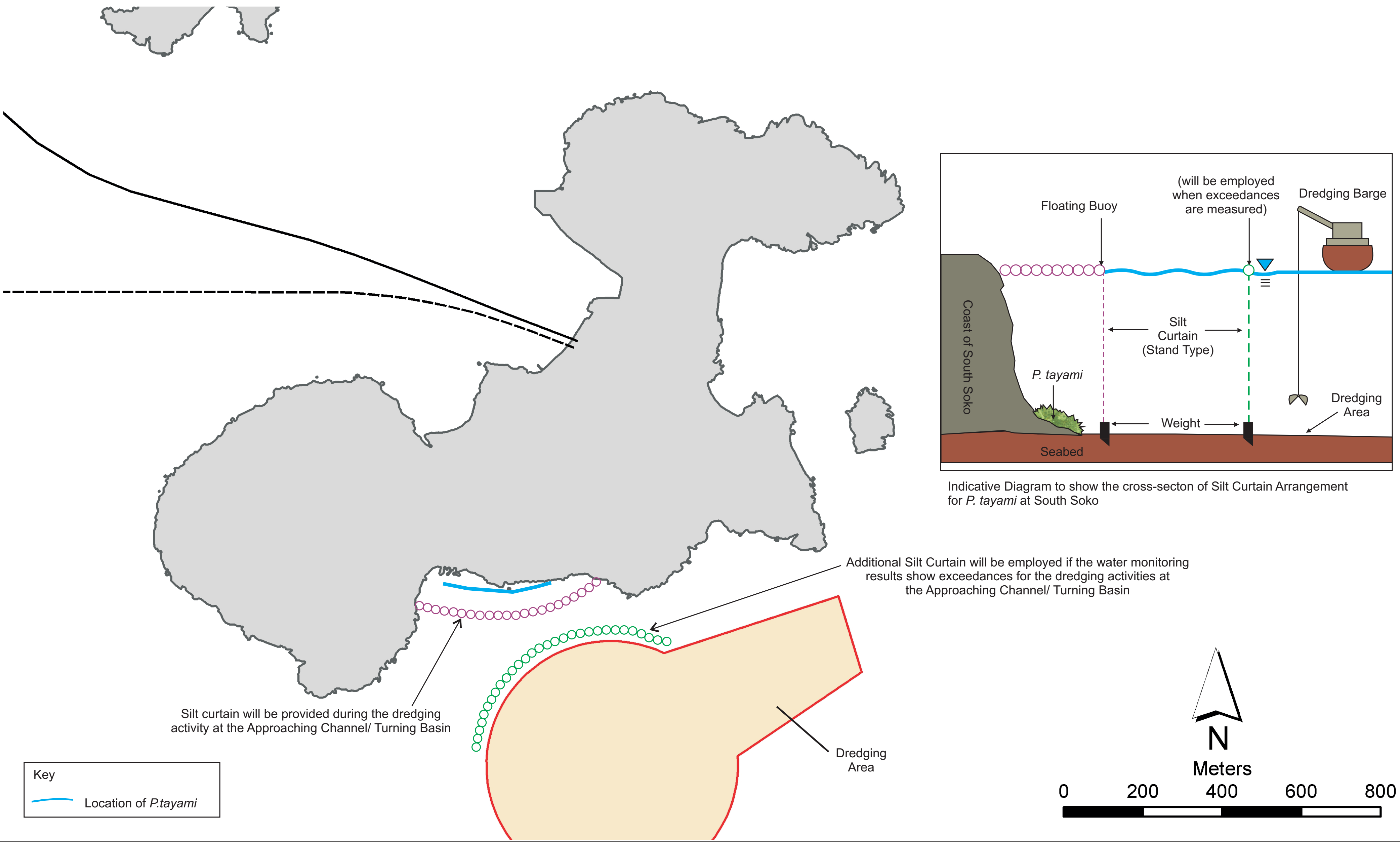

Figure 6.16

Indicative Arrangement of Silt Curtain (Stand Type) of *P. tayami*

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Environmental Resources Management

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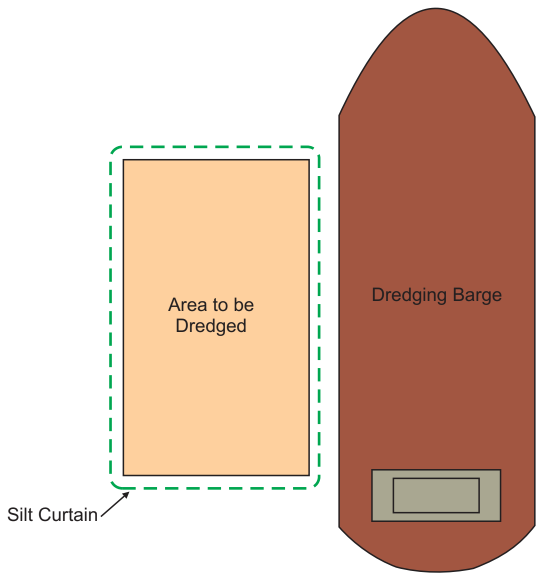
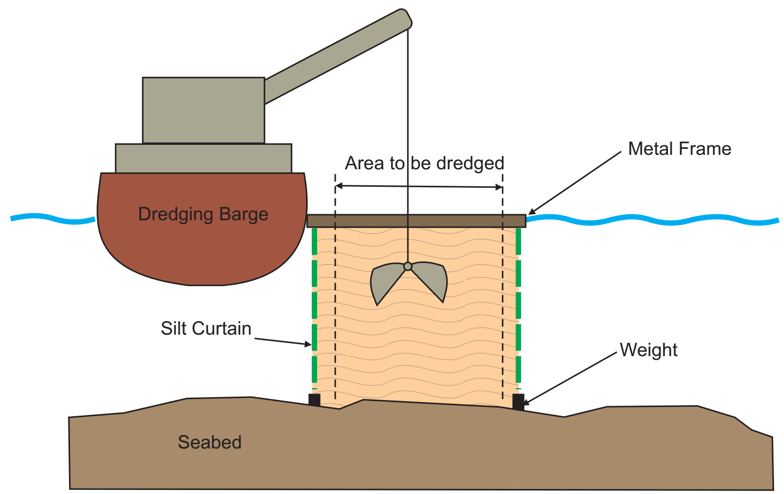


(a) Cage Type Silt Curtain Arrangement for Grab Dredging



(b) Cross-secton of Cage Type Silt Curtain Arrangment

Figure 6.17

Indicative Arrangement of Cage Type / Metal Frame Type Silt Curtain

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Table 6.32 Predicted SS Elevations after Implementation of Mitigation Measures

Sensitive Receiver	Name	ID	Scenario	WQO Allowable Elevation		Without Mitigation Measures – Maximum Predicted SS Elevation (mg L^{-1})		Proposed Mitigation Measures	Reduction Factor of Cage Type Curtain	With Cage Type Curtain – Maximum Predicted SS Elevation(mg L^{-1})		Reduction Factor of Stand Type Curtain	With Stand Type Curtain – Maximum Predicted SS Elevation (mg L^{-1})	
				Dry	Wet	Dry	Wet			Dry	Wet		Dry	Wet
Fish Fry Habitat	Pak Tso Wan	SR16b	1	6.9	5.5	22.9	36.8	Seawall (completely constructed) in place prior to the reclaiming works and 2 layer silt curtains (stand type enclosing SR16b and cage type next to grab dredger)	75%	5.7	9.2	60%	-	3.7
Fish Fry Habitat	Pak Tso Wan	SR16b	2	6.9	5.5	16.2	15.5	2 layers of silt curtains (stand type enclosing SR16b and cage type next to grab dredger)	75%	4.1	3.9	60%	-	-
Fish Fry Habitat	Pak Tso Wan	SR16b	3	6.9	5.5	36.1	57.4	Double layers silt curtain (stand type enclosing SR16b)	N/A	N/A	N/A	80% (a)	7.2	11.5
Subtidal Hard Bottom Habitat (coral)	Southern Side of South Soko	SR31	4a	10	10	15.5	-	2 layers of silt curtains (stand type enclosing SR31 and cage type next to grab dredgers)	75%	3.9	-	60%	1.6	-

Sensitive Receiver	Name	ID	Scenario	WQO Allowable Elevation		Without Mitigation Measures Maximum Predicted SS Elevation (mg L-1)		Proposed Mitigation Measures	Reduction Factor of Cage Type Curtain	With Cage Type Curtain Maximum Predicted SS Elevation(mg L-1)		Reduction Factor of Stand Type Curtain	With Stand Type Curtain Maximum Predicted SS Elevation (mg L-1)	
				Dry	Wet	Dry	Wet			Dry	Wet		Dry	Wet
Subtidal Hard Bottom Habitat (coral)	Southern Side of South Soko	SR31	4b	10	10	12.2 (b)	12.7 (b)	2 layers of silt curtains (stand type enclosing SR31 and cage type next to grab dredgers)	75%	8.4	7.6	60%	3.4	3.0
Fish Fry Habitat	Pak Tso Wan	SR16b	5	6.9	5.5	-	5.7	2 layers of silt curtains (stand type enclosing SR16b and cage type next to grab dredger)	75%	-	1.4	60%	-	-
Fish Fry Habitat	Pak Tso Wan	SR16b	7	6.9	5.5	10.6	6.0	2 layers of silt curtains (stand type enclosing SR16b and cage type next to grab dredger)	75%	2.65	1.5	60%	-	-
Potential Marine Park	Southwest Lantau	SR19b	8	8.9	6.5	-	6.9	TSHD operated in 12 hrs and avoid the calving season of March through August	-	-	-	-	-	-
Potential Marine Park	Southwest Lantau	SR19c	8	8.9	6.5	-	8.9	TSHD operated in 12 hrs and avoid the calving season of March through August	-	-	-	-	-	-
Entire Designated Marine Park	Sha Chau and Lung Kwu Chau	-	9	8.2	5.6	< 10 (c)	< 10 (c)	Silt curtain (cage type next to grab dredger)	75%	< 2.5	< 2.5	-	-	-

Notes:

a. The reduction factor is calculated as (1 - 40%(first layer of silt curtain) x 50%(second layer of silt curtain)) = 80% (The first layer of silt curtain could filter mainly the coarse fraction of the sediment whereas the second layer of silt curtain may be slightly less effective to deal with the fine fraction of the sediment left by the first layer.)

b. Contribution of SS from TSHD is predicted to be 59% and 46% during the dry and wet seasons respectively.

c. The exceedance occurs just at the western boundary of the Marine Park.

As presented in *Table 6.34*, the majority of the SS impacts could be mitigated to a level below the WQO. The only residual impacts greater than the WQO would be due to the jetting works close to Pak Tso Wan (*Scenario 3*). The evaluation of residual impacts is presented in *Section 6.11*.

6.8.2 *Jetting*

Impacts to water quality sensitive receivers would largely be avoided during the installation of the water main and cable circuits through the following measures.

- Jetting speeds should be limited to a maximum of 65 m hr^{-1} for water mains construction.
- Jetting speeds should be limited to a maximum of 150 m hr^{-1} for cable circuit installation.

6.8.3 *Land Based Construction Activities*

Appropriate on-site measures are defined to reduce potential impacts, which will be sufficient to prevent adverse impacts to water quality from land based construction activities. These measures are appropriate for general land based construction activities.

Construction Run-off

- Prior to the commencement of the site formation earthworks, surface water flowing into the site from uphill will be intercepted through perimeter channels at site boundaries and safely discharged from the site via adequately designed sand/silt removal facilities such as sand traps.
- Channels, earth bunds or sand bag barriers will be provided on site to direct stormwater to silt removal facilities. The design of silt removal facilities will make reference to the guidelines in *Appendix A1* of *ProPECC PN 1/94*.
- The surface runoff or extracted ground water contaminated by silt and suspended solids will be collected by the on-site drainage system and discharged into storm drains after the removal of silt in silt removal facilities.
- Unprotected partially formed soil slopes will be temporarily protected by plastic sheetings, suitably secured against the wind, at the end of each working day.
- Earthworks to form the final surfaces will be followed up with surface protection and drainage works to prevent erosion caused by rainstorms.

- Appropriate surface drainage will be designed and provided where necessary. All slope drainage will be designed to the Geotechnical Manual for Slopes published by the Geotechnical Engineering Office of The Civil Engineering and Development Department.

- Temporary trafficked areas and access roads formed during construction will be protected by coarse stone ballast or equivalent. These measures shall prevent soil erosion caused by rainstorms.

- Drainage systems, erosion control and silt removal facilities will be regularly inspected and maintained to ensure proper and efficient operation at all times and particularly following rainstorms. Deposited silt and grit will be removed regularly.

- Measures will be taken to reduce the ingress of site drainage into excavations. If trenches have to be excavated during the wet season, they will be excavated and backfilled in short sections wherever practicable. Water pumped out from trenches or foundation excavations will be discharged into storm drains via silt removal facilities.

- Open stockpiles of construction materials (for example, aggregates, sand and fill material) of more than 50 m^3 will have measures in place to prevent the washing away of construction materials, soil, silt or debris into any drainage system.

- Manholes (including newly constructed ones) will be adequately covered and temporarily sealed so as to prevent silt, construction materials or debris being washed into the drainage system.

- The precautions to be taken at any time of year when rainstorms are likely together with the actions to be taken when a rainstorm is imminent or forecasted and actions to be taken during or after rainstorms are summarised in *Appendix A2* of *ProPECC PN 1/94*.

- Oil interceptors will be provided in the drainage system where necessary and regularly emptied to prevent the release of oil and grease into the storm water drainage system after accidental spillages.

- Temporary and permanent drainage pipes and culverts provided to facilitate runoff discharge will be adequately designed for the controlled release of storm flows.

- The temporary diverted drainage will be reinstated to the original condition when the construction work has finished or when the temporary diversion is no longer required.

Boring and Drilling Water

- Water used in ground boring and drilling for preparation of blasting or rock / soil slope stabilization works will be re-circulated to the extent practicable after sedimentation. When there is a need for final disposal, the wastewater will be discharged into storm drains via silt removal facilities.

Wastewater from Building Construction

- Wastewater generated from concreting, plastering, internal decoration, cleaning work and other similar activities, will undergo large object removal by installing bar traps at the drain inlets. It is not considered necessary to carry out silt removal due to the small quantities of water involved. Similarly, pH adjustment of such water is not considered necessary due to the small quantities and the fact that the water is only likely to be mildly alkaline.

Wastewater from Site Facilities

- During the early stages of work, portable chemical toilets will be used and the effluent will be shipped offsite until the temporary sewage treatment work (STW) plant is operational.

- Sewage from toilets, kitchens and similar facilities will be discharged into a foul sewer. Wastewater collected from canteen kitchens, including that from basins, sinks and floor drains, will be discharged into foul sewers via grease traps. The foul sewer will then lead to the temporary STW plant prior to effluent discharge to the ocean.

- Vehicle and plant servicing areas, vehicle wash bays and lubrication bays will, as far as practical, be located within roofed areas. The drainage in these covered areas will be connected to foul sewers via an oil/water interceptor.

- Oil leakage or spillage will be contained and cleaned up immediately. Waste oil will be collected and stored for recycling or disposal, in accordance with the *Waste Disposal Ordinance*.

Storage and Handling of Oil, Other Petroleum Products and Chemicals

- Fuel tanks and chemical storage areas will be provided with locks and be sited on sealed areas.

- The storage areas of oil, fuel and chemicals will be surrounded by bunds or other containment device to prevent spilled oil, fuel and chemicals from reaching the receiving waters.

- The Contractors will prepare guidelines and procedures for immediate clean-up actions following any spillages of oil, fuel or chemicals.

- Surface run-off from bunded areas will pass through oil/water separators prior to discharge to the stormwater system.

Wastewater from Concrete Batching Plant

- Wastewater generated from the washing down of mixer trucks and drum mixers and similar equipment should be recycled to the extent practicable. To prevent pollution from wastewater overflow, the pump sump of any wastewater recycling system will be provided with a standby pump of adequate capacity.

- Under normal circumstances, surplus wastewater from the concrete batching will be treated in silt removal and pH adjustment facilities before it is discharged into foul sewers. Discharge of this wastewater into storm drains will require more elaborate treatment and regular testing checks. Surface run-off will be separated from the concrete batching plant to the extent practical and diverted to the stormwater drainage system. Surface run-off contaminated by materials in the concrete batching plant will be adequately treated before disposal into stormwater drains.

6.9 WATER QUALITY MITIGATION MEASURES – OPERATION PHASE

6.9.1 Hydrodynamics

The hydrodynamic modelling has predicted that the reclamations and the marine works and structures will have minimal effects on hydrodynamics and water quality. Mitigation measures are not considered to be necessary.

6.9.2 Cooled Water and Residual Chlorine Discharge

The relatively low concentration of antifoulant combined with the high degree of mixing inherent in the coastal margin will result in rapid dilution of the effluent to non-significant concentrations and hence mitigation measures are considered unnecessary.

6.9.3 Storage and Handling of Oil, Other Petroleum Products and Chemicals

- Fuel tanks and chemical storage areas should be provided with locks and be sited on sealed areas.

- The storage areas of oil, fuel and chemicals should be surrounded by bunds to prevent spilled oil, fuel and chemicals from reaching the receiving waters.

- Guidelines and procedures will be developed for immediate clean-up actions following any spillages of oil, fuel or chemicals.

- Surface run-off from bunded areas should pass through oil/grease traps prior to discharge to the stormwater system.

Other measures are detailed in *Section 14* for the prevention of groundwater contamination.

6.9.4 *Wastewater*

- Sewage from toilets, kitchens and similar facilities should be discharged into a foul sewer. Wastewater collected from canteen kitchens, including that from basins, sinks and floor drains, should be discharged into foul sewers via grease traps. The foul sewer will then lead to the sewage treatment plant prior to discharge to the ocean.

- Vehicle and plant servicing areas, vehicle wash bays and lubrication bays should, to the extent practical, be located within roofed areas. The drainage in these covered areas should be connected to foul sewers via a oil / water separator.

- Oil leakage or spillage should be contained and cleaned up immediately. Waste oil should be collected and stored for recycling or disposal, in accordance with the *Waste Disposal Ordinance*.

6.10 ENVIRONMENTAL MONITORING AND AUDIT (EM&A)

6.10.1 *Construction Phase*

Water quality monitoring and auditing is recommended for the construction phase. The specific monitoring requirements are detailed in the *Environmental Monitoring and Audit Manual* (EM&A) associated with this EIA Report.

6.10.2 *Operation Phase*

As no unacceptable impacts have been predicted to occur during the operation of the LNG terminal at South Soko Island, monitoring of impacts to marine water quality during the operational phase is not considered necessary. It is noted that discharges from the site will require a license under the *WPCO* which stipulates regular effluent monitoring as part of the license conditions.

6.11 *RESIDUAL ENVIRONMENTAL IMPACTS*

6.11.1 *Construction Phase*

Unmitigated scenarios have been evaluated in *Section 6.6* and most of the impacts in terms of WQO exceedances could be mitigated by adopting effective mitigation measures such as silt curtains. *Table 6.35* shows a schedule of proposed mitigation measures for all marine works.

Table 6.35 Summary of Proposed Mitigation Measures

Marine Work Location (Zone)	Marine Work and Plant Type	No. of Plants	Proposed Mitigation Measures
Western Berth, South Soko	Dredging by Closed Grab Dredger	1	Double-Layer stand type silt curtain will be provided at Pak Tso Wan (see *Figure* 6.15) during the dredging activities at western berth. Cage type silt curtain will be installed next to the grab dredger.
Sai Wan (western berth), South Soko	Sandfilling by Pelican Barge	1	Seawall (completely constructed) in place prior to the reclaiming works. In case the seawall trench is filled with sand instead of rock, a silt curtain (stand type enclosing the sandfilling area, see *Figure 6.15*) will be installed.
Tung Wan, South	Dredging by Closed Grab Dredger	1	Although no predicted WQO exceedances, cage type silt curtain will be installed next to the grab dredger to minimise the sediment dispersion.
Approach Channel and Turning Basin	Dredging by Closed Grab Dredger or TSHD	3 grabs or 2 grabs + 1 TSHD (please refer to EIA S6 for further details)	Silt curtain (cage type, see *Figure 6.17*) will be used during grab dredging activities at AC/TB. Silt curtain (stand type) will be provided at South of South Soko to protect the coral (see *Figure 6.16*). Should exceedance occur during water quality monitoring, additional silt curtain (stand type) (see *Figure 6.16*) will be installed at the edge of the channel dredging area.
Submarine Water Main (at South Soko shore approach)	Dredging by Closed Grab Dredger	1	Double-Layer silt curtain will be provided at Pak Tso Wan (see *Figure* 6.15) during the dredging activities at western berth. Cage type silt curtain will be installed next to the grab dredger.
Submarine Water Main (at Shek Pik shore approach)	Dredging by Closed Grab Dredger	1	Not required due to no predicted WQO exceedances.

Marine Work Location (Zone)	Marine Work and Plant Type	No. of Plants	Proposed Mitigation Measures
Submarine Water Main (waterway crossing sand borrow area and marine navigation channel)	Dredging by Closed Grab Grab Dredger	1	Not required due to no predicted WQO exceedances.
Submarine Water Main (near South Soko)	Jetting by Jetting machine	1	Double-Layer silt curtain (*Figure 6.15*) will be provided at Pak Tso Wan during the jetting activities near Pak Tso Wan, South Soko
Submarine Water Main (near Shek Pik)	Jetting by Jetting machine	1	Not required due to no predicted WQO exceedances.
Submarine Cable Circuit	Jetting by Jetting machine	1	Double-Layer silt curtain (*Figure 6.15*) will be provided at Pak Tso Wan during the jetting activities near Pak Tso Wan, South Soko
Submarine Intake	Dredging by Closed Grab Dredger	1	Not required due to no predicted WQO exceedances.
Cooled Water Outfall	Dredging by Closed Grab Dredger	1	Not required due to no predicted WQO exceedances.
Gas Receiving Station at Black Point	Dredging by Closed Grab Dredger	2	Not required due to no predicted WQO exceedances.
Gas Receiving Station at Black Point	Sandfilling by Pelican Barge	1	Not required due to no predicted WQO exceedances.
Gas Pipeline (KP 0 – 1)	Dredging by Closed Grab Dredger	1	Double-Layer silt curtain (see *Figure 6.15*) will be provided at Pak Tso Wan during the dredging activities near the west of South Soko. Cage type silt curtain will be installed next to the grab dredger.
Gas Pipeline (KP 1 – 24.5)	Dredging by TSHD	1	The TSHD will be operated 12 hours a day and the dredging works will avoid the Chinese While Dolphin calving season from March to August.
Gas Pipeline (KP 24.5 – 31)	Dredging by Closed Grab Dredger	3	Cage type silt curtain will be used during grab dredging activities along Lung Kwu Chau/Sha Chau Marine Park Boundary.
Gas Pipeline (KP 31 – 33.5)	Dredging by Closed Grab Dredger	1	Not required due to no predicted WQO exceedances. Should exceedance occur during water quality monitoring, silt curtain (cage type) (see *Figure 6.17*) will be used during the dredging activity.
Gas Pipeline (KP 33.5 – 33.976)	Dredging by Closed Grab Dredger	1	Not required due to no predicted WQO exceedances. Should exceedance occur during water quality monitoring, silt curtain (cage type) (see *Figure 6.17*) will be used during the dredging activity.

Marine Work Location (Zone)	Marine Work and Plant Type	No. of Plants	Proposed Mitigation Measures
Gas Pipeline (KP 33.976 – 35.39)	Dredging by Closed Grab Dredger	1	Not required due to no predicted WQO exceedances. Should exceedance occur during water quality monitoring, silt curtain (cage type) (see *Figure 6.17*) will be used during the dredging activity.
Gas Pipeline (KP 35.39 – 37)	Dredging by Closed Grab Dredger	1	Not required due to no predicted WQO exceedances. Should exceedance occur during water quality monitoring, silt curtain (cage type) (see *Figure 6.17*) will be used during the dredging activity.
Gas Pipeline (KP 37 – 37.803)	Dredging by Closed Grab Dredger	1	Not required due to no predicted WQO exceedances. Should exceedance occur during water quality monitoring, silt curtain (cage type) (see *Figure 6.17*) will be used during the dredging activity.
Gas Pipeline (KP 37.803 – 38.303)	Dredging by Closed Grab Dredger	1	Not required due to no predicted WQO exceedances. Should exceedance occur during water quality monitoring, silt curtain (cage type) (see *Figure 6.17*) will be used during the dredging activity.

The predicted residual impacts would be in three main areas, i.e. Pak Tso Wan, West Lantau and the fisheries spawning/nursery ground in South Lantau.

For Pak Tso Wan, it is anticipated that no unacceptable residual impacts will arise from the jetting works based on the impact assessment presented in *Section 6.6* and summarised below:

- The mitigated maximum short-term SS elevation is predicted to be 7.2 and 11.5 mg L^{-1} marginally exceeding the WQO of 6.9 and 5.5 mg L^{-1} for the dry and wet seasons respectively.
- The elevation of SS levels will be of a short duration (< 2 days) and the levels will return to normal shortly after the jetting machine has moved elsewhere.
- The mixing zone is expected to be confined to the immediate vicinity of the works area.
- The short-term maximum residual SS concentration is predicted to be well below the level used to assess impacts to fisheries (50 mgL^{-1}).

For West Lantau, it is anticipated that no unacceptable residual impacts will arise based on the impact assessment presented in *Section 6.6* and summarised below:

- The daily maximum SS elevation of > 5 mg L^{-1} is predicted to be confined to the works sites and the mean SS elevations are well below the WQO.

- The model assumes 24-hour operation but according to the construction schedule the dredging works will be carried out for the daytime (12 hours per day).

- Based on the model results, the predicted exceedances of SS at the boundary of the potential Southwest Lantau Marine Park will occur only in the wet season. In reality, the TSHD dredging will avoid the Indo-Pacific Humpback Dolphin calving season period of March to August, i.e. the wet season. For the remaining period that TSHD dredging will be scheduled, no WQO exceedances are predicted and hence no adverse impact on the potential Marine Park as well as other water sensitive receivers in West Lantau waters will arise.

- Based on the model results, the predicted exceedances of SS at the boundary of the potential Southwest Lantau Marine Park will occur only in the wet season. In reality, the TSHD dredging will avoid the Indo-Pacific Humpback Dolphin calving season period of March to August, i.e. the wet season. For the remaining period that TSHD dredging will be scheduled, no WQO exceedances are predicted and hence no adverse impact on the potential Marine Park as well as other water sensitive receivers in West Lantau waters will arise.

- Each TSHD dredging event will last for about 45 minutes within 2 to 3 hour period during a 12-hour working day.
- The elevation of SS levels will be of a short duration and intermittent.
- TSHD dredging largely reduce the construction period and hence cause less disturbance to the fisheries/ecological resources.

For the fisheries spawning/nursery ground in South Lantau, it is anticipated that no unacceptable residual impacts will arise based on the impact assessment presented in *Section 6.6* and summarised below:

- Mixing zones due to the dredging/jetting works are expected to be confined to the works areas.

- The short-term maximum residual SS concentration is predicted to be well below the level used to assess impacts to fisheries (50 mgL^{-1}).

- The sediment plume caused by the non-concurrent activities occupy a relatively small portion of the fisheries ground.

- With proper mitigation measures and good working practices, the impacts will be largely reduced.

An evaluation of the residual impacts on the above water sensitive areas is presented in *Table 6.36*.

Table 6.36 Evaluation of Residual Impact on Water Quality Sensitive Areas

Evaluation Criteria	**Water Quality Sensitive Areas**		
	Fish fry habitat at Pak Tso Wan	**Fisheries Spawning/Nursery Ground in South Lantau**	**Marine mammal habitat in West Lantau including the Potential Marine Park**
Effects on Public health and health of biota or risk to life	Water quality exceedance is not expected to adversely affect fish fry (refer to *Part 2 – Section 10: Fisheries Impact Assessment*).	Water quality exceedance is not expected to adversely affect the fisheries ground (refer to *Part 2 – Section 10: Fisheries Impact Assessment*).	Water quality exceedances would not directly impact dolphins (*Sousa chinensis*) and are not expected to have indirect biological consequences affecting their health. WQO is mainiained at the boundary of the Potential Marine Park.
The magnitude of the adverse environmental impacts	Although there would be exceedance of the WQO, water quality will comply with fisheries assessment criteria. No adverse impact is predicted.	Exceedances of the WQO will be minor. Therefore the magnitude of impact to water quality sensitive receivers would be low.	Exceedances of the WQO will be minor offshore and of relatively short duration. Therefore the magnitude of impact to water quality sensitive receivers would be low.
The geographic extent of the adverse environmental impacts	Geographic extent of mixing zone is small.	Geographic extent of mixing zone is small and will be centred on the position where dredging/jetting works is being conducted.	Geographic extent of mixing zone is small and will be centred on the position where dredging works is being conducted along the route and does not enter the Potential Marine Park.
The duration and frequency of the adverse environmental impacts	Occasional, short duration, minor exceedances of WQO during a 2 month period.	The mixing zone will persist during dredging/jetting works.	The mixing zone will persist during dredging works which last for 40-45 minutes every 2-3 hours for 12 hours per day.
The likely size of the community or the environment that may be affected by the adverse impacts	The sandy shore at Pak Tso Wan is small in extent.	The area of fisheries ground occupied by the mixing zone is small.	The area of West Lantau waters occupied by the mixing zone is very small.
The degree to which the adverse environmental impacts are reversible or irreversible	Water quality exceedances are completely reversible as suspended sediment will settle out of the water column.	Water quality exceedances are completely reversible as suspended sediment will settle out of the water column.	Water quality exceedances are completely reversible as suspended sediment will settle out of the water column. Affected benthic communities are expected to recover quickly.

Evaluation Criteria	**Water Quality Sensitive Areas**		
	Fish fry habitat at Pak Tso Wan	**Fisheries Spawning/Nursery Ground in South Lantau**	**Marine mammal habitat in West Lantau including the Potential Marine Park**
The ecological context	Pak Tso Wan is considered to be of medium ecological value (refer to *Part 2 – Section 9: Marine Ecology Assessment)*	South Lantau waters are valuable for fisheries operations.	West Lantau waters are high ecological value marine mammal habitat for Indo-Pacific Humpback dolphins.
International and regional importance (details refer to *Part 2 – Section 9: Marine Ecology Assessment)*	No adverse impact is predicted. Pak Tso Wan sandy shore is not of international or regional importance.	South Lantau waters have been classified as commercial importance for fisheries.	West Lantau has the highest density of dolphins and highest encounter rate of young animals compared to other Hong Kong waters.
Both the likelihood and degree of uncertainty of adverse environmental impacts	No adverse impacts are predicted. Predictions are based on water quality modelling results with highly conservative assumptions.	Assessment is based on water quality modelling results with highly conservative assumptions and hence low likelihood of adverse environmental impacts is expected.	Assessment is based on water quality modelling results with highly conservative assumptions and hence low likelihood of adverse environmental impacts is expected.
Compliance with relevant established principles and criteria	Yes	Yes	Yes

6.11.2 *Operation Phase*

Given the rapid dilution of the cooled water discharges from the terminal outfall and that the limited volume of sewage generated would be treated on site before being discharged in accordance with the EPD's required standards, residual environmental impacts during the operation phase are not expected.

6.12 *CUMULATIVE IMPACTS*

At present there are no committed projects that could have cumulative impacts with the construction of the terminal at South Soko and the associated submarine utilities. For the projects discussed below, installation of the gas pipeline will be of most relevance due to its proximity to these projects.

The construction of the HK-Zhuhai-Macau Bridge (HZMB) is now at the preliminary design stage and hence the available information is not sufficient for cumulative impact assessment. Discussions with the Highways Department (HyD) have been conducted regarding the construction programme for the HZMB. It is understood that the design of the HZMB is now progressing and that all design details and the construction programme are confidential. Should it be confirmed that the pipeline and HZMB construction programmes overlap, the cumulative impacts would need to be addressed in the EIA Study for the HZMB.

There is a possibility for an overlap of construction works for the submarine natural gas pipeline and the construction of the Emissions Control Project at Castle Peak Power Station. The submarine gas pipeline will be located more than 4 km to the west of the dredging area of the Emission Control Project (ECP). The water quality modelling results of the ECP EIA showed that the maximum westward extension of the sediment plume due to the dredging works was predicted to be less than 1 km in both seasons. In this Study, it is predicted that the sediment plume due to the jetting for the gas pipeline will not extend eastward by more than 1 km. This means the sediment plumes raised by the two projects are unlikely to overlap and that cumulative impacts are not predicted.

The Lantau Logistics Park (LLP) is proposed to be developed on a reclamation area off the north shore of Lantau Island, immediately to the north of, and encompassing, the existing Siu Ho Wan railway depot. With reference to the Project Profile for the LLP (1), the exact layout of the proposed LLP reclamation is the subject of further study and will be confirmed by the detailed investigations which are ongoing. The way forward and construction programme of the LLP are also uncertain at this stage. Should the construction works of the LLP and the gas pipeline overlap, the sediment plumes are unlikely to coincide as the works areas are more than 6 km apart.

6.13 CONCLUSIONS

This Section of the EIA has described the impacts on water quality arising from the construction and operation of the proposed LNG terminal and the installation of the submarine gas pipeline, watermain and cable. The purpose of the assessment was to evaluate the acceptability of predicted impacts to water quality.

Computer modelling has been used to simulate the loss of sediment to suspension during the construction phase and the impacts due to cooled water discharges during the operation phase. The results and findings of the computer modelling have been provided and summarized.

Potential impacts arising from the proposed dredging or jetting works are predicted to be largely confined to the specific works areas. The predicted elevations of suspended sediment concentrations are transient in nature and not predicted to cause adverse impacts to water quality at the sensitive receivers.

(2) Civil Engineering Development Department (2004). Project Profile for Lantau Logistic Park, October 2006.

During the operation phase, adverse impacts to water quality are not expected to occur as the area affected by the cooled water discharge is extremely small and in the immediate vicinity of the discharge point.