Annex 6A

Water Quality Method Statement

CONTENTS

1 INTRODUCTION

This *Method Statement* presents information on the approach for the water quality assessment and modelling works for the study. The methodology has been based on the following three focus areas, as follows:

- Model Selection;
- Input Data; and,
- Scenarios.

1.1 INTERPRETATION OF THE REQUIREMENTS: KEY ISSUES AND CONSTRAINTS

The objectives of the modelling exercise are to assess:

- Effects of construction, which comprises the study of the dispersion of sediments released during construction;

- Effects of operation due to reclamations (affecting flows and potentially water quality due to changing flows); discharges (potentially affecting temperatures and water quality due to chlorine or other antifoulants); and maintenance dredging (potentially increasing suspended solids in water column);

- Any residual impacts, which include any change in hydrodynamic regime; and

- Any cumulative impacts due to other projects or activities within the study area.

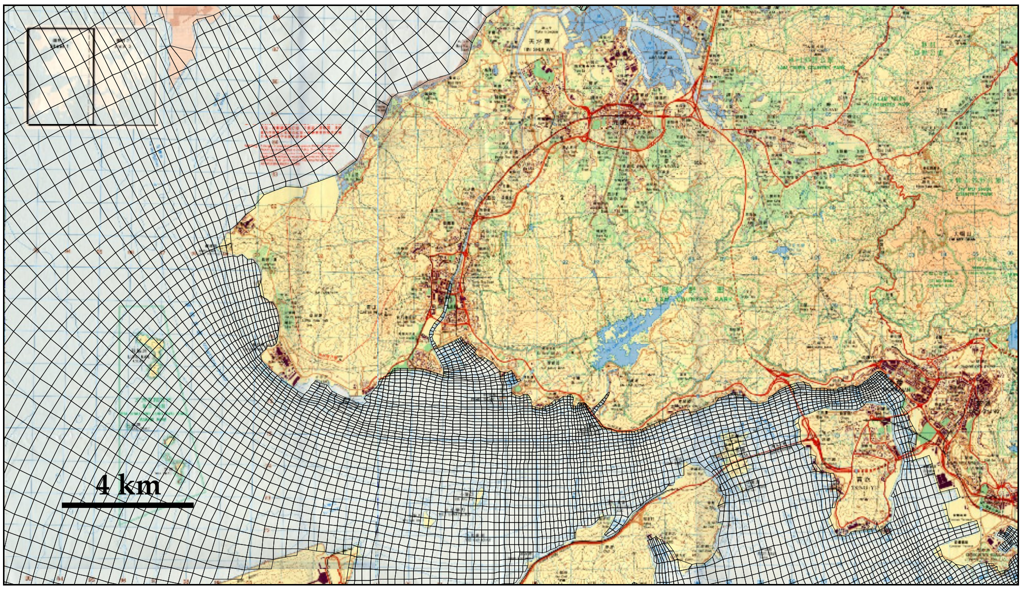
The construction and operational effects have been studied by means of mathematical modelling using existing models that have been set up by WL | Delft Hydraulics (Delft) on behalf of the Environmental Protection Department (EPD) or approved by the EPD for use in environmental assessments.

1.2 MODEL SELECTION

The existing Western Harbour Model of the Delft 3D water quality (WAQ) and hydrodynamic suite of models have been used to simulate effects on hydrodynamics and water quality. These models have been calibrated as part of the Landfill Extension Study.

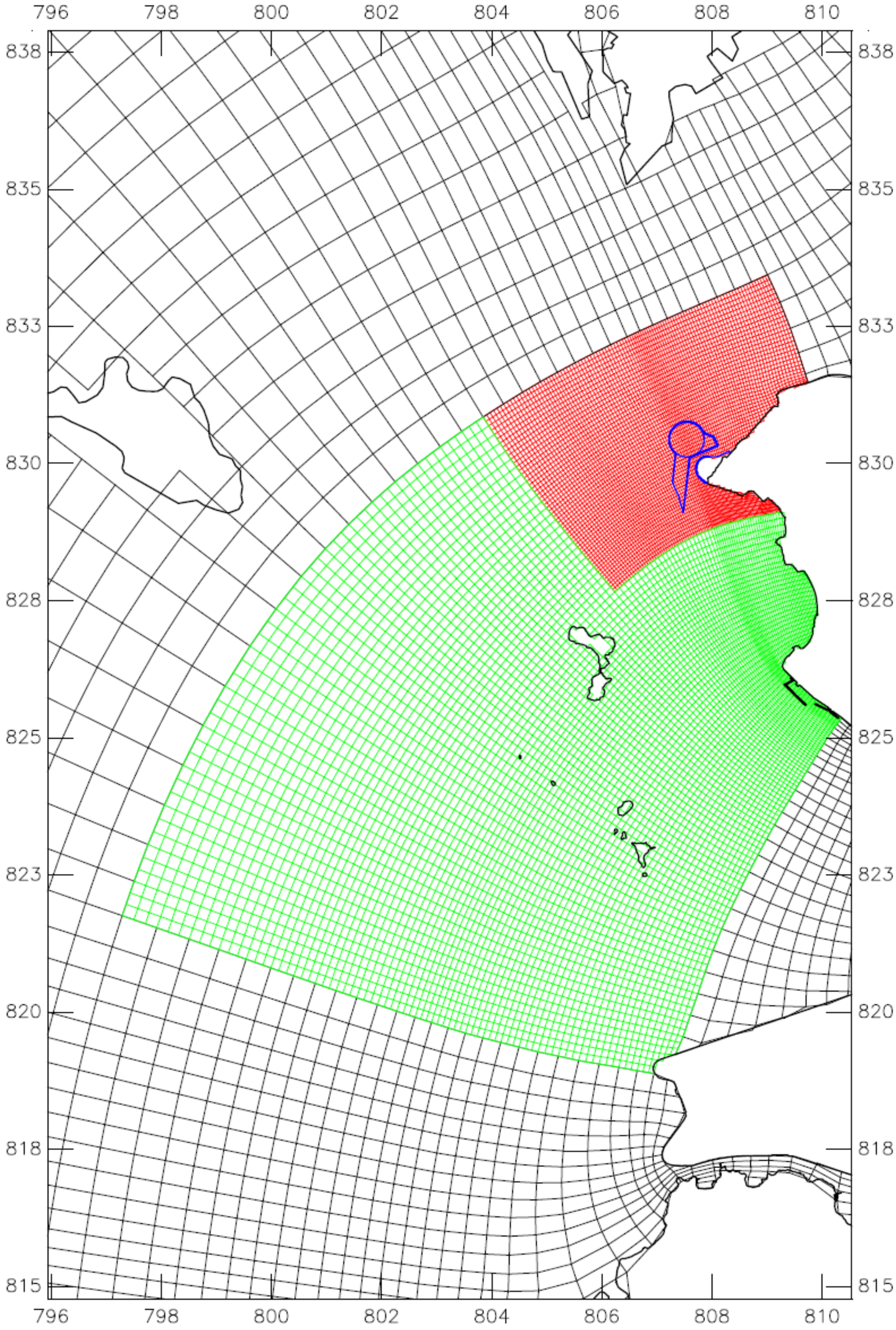
The WAQ model has been used to simulate water quality impacts during construction and operation of the facility. The existing Update model has the required spatial extent. The existing grid of the model in the vicinity of Black Point is shown in *Figure A1.1*.

Figure A1.1 Model Grid of the Update Model in the Vicinity of Black Point



As seen in *Figure A1.1*, the grid size of the existing model near the site is in the order of about 300m. The extent of the reclamation at the site is such that it covers approximately one grid cell. It was therefore considered appropriate to carry out refinement of the water quality and hydrodynamic grids to provide improved resolution (less than 75m) in some of the key areas of interest. The refinements of the model grid of the Update Model in the vicinity of Black Point are shown in *Figure A1.2*.

Figure A1.2 Model Grid of the Update Model in the Vicinity of Black Point



1.3 COASTLINE & BATHYMETRY

Hydrodynamic data have been obtained using coastline and bathymetry for a time horizon representative of the construction and operation of the facility (i.e., 2007 onwards). *Figure A1.3a and A1.3b* show the bathymetry and coastline during construction phase, whereas *Figure A1.4* during the operational phase at the Black Point site.

Figure A1.3a Bathymetry and Coastline in the Vicinity of Black Point (2007 onwards)

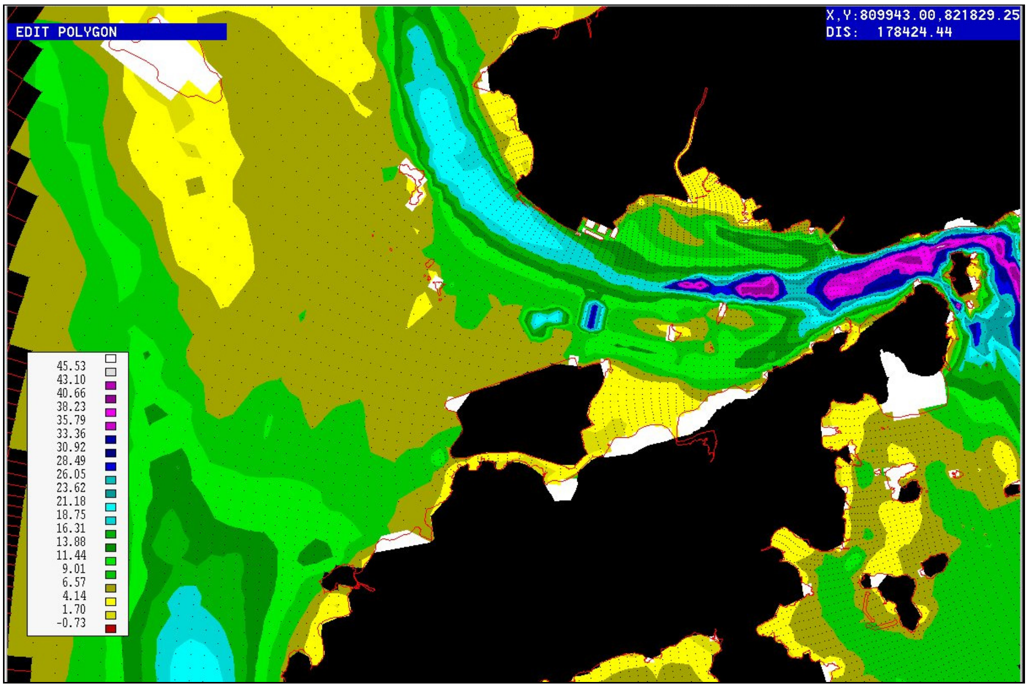


Figure A1.3b Coastline Used in the Model for the Project Area (2007 onwards)

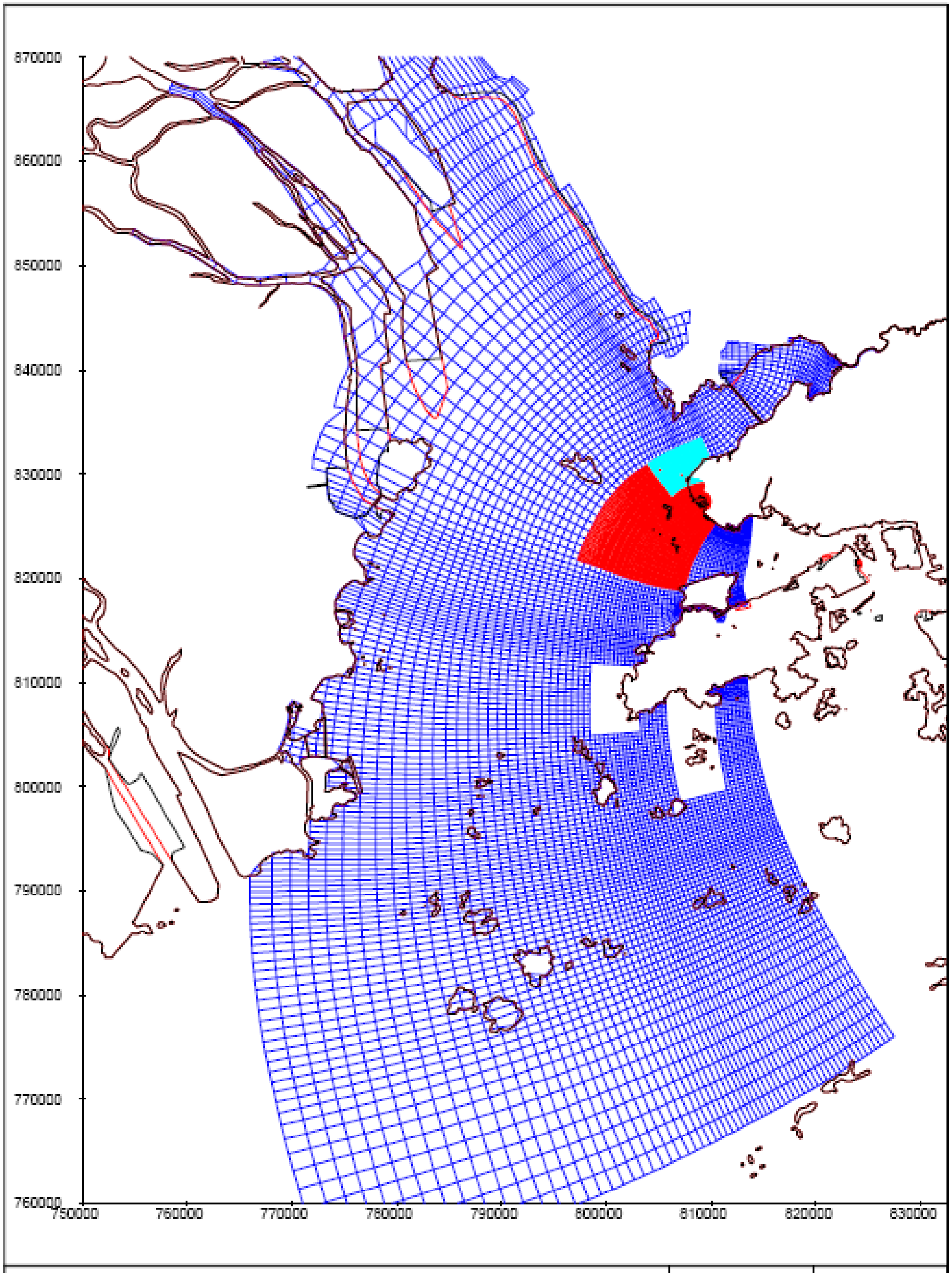
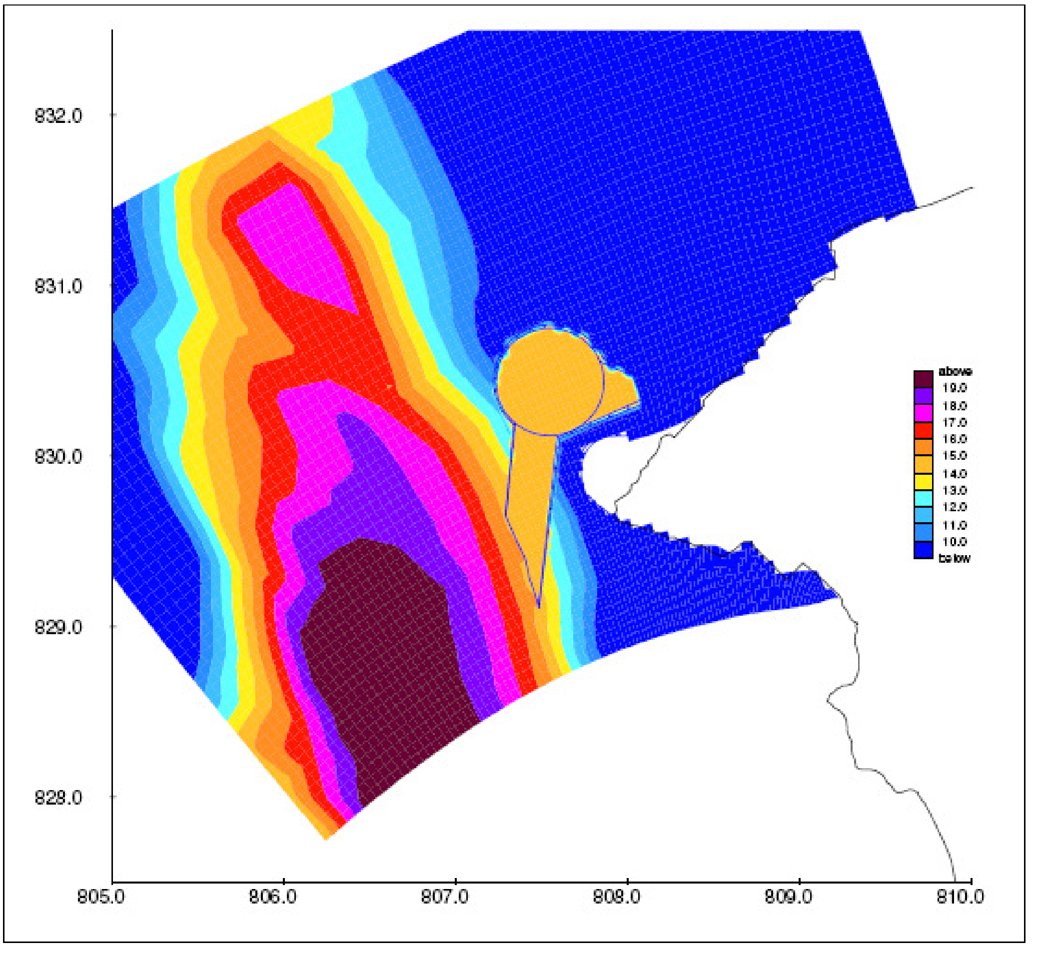


Figure A1.4 Operational Bathymetry at Black Point



1.4 *VECTOR INFORMATION*

The current patterns in the project area prior to the commissioning of the Project are presented in *Figures BP_B01-B08* in *Annex 6B*. The current patterns in the project area after the completion of the Project are presented in *Figures BP_F01_F08* in *Annex 6F*.

Under the pre-project condition, the plots indicate that, in general, for the area in around the LNG terminal at Black Point current velocities rarely exceed 1.0 m s^{-1} in the dry and wet seasons. Maximum current velocities appear at the surface layer to be in the order of 1.4 m s^{-1} during both seasons, in areas predominantly offshore, or to the north-west of Black Point.

Under the post-project condition, the plots indicate that, in general, maximum current velocities appear at the surface layer to be in the order of 1.3 m s^{-1} in the dry season, in the area of the approach channel turning basin. In the wet season, maximum current velocities appear at the surface layer to be in the order of 1.5 m s^{-1}, in the area of the southern approach channel. In the turning basin, the maximum current velocities are predicted to be 1.1 m s^{-1}.

1.5 *INFORMATION ON MODEL INPUTS*

Details on the model input parameters are presented in *Appendix 6A* in Annex 6A.

1.6 *UNCERTAINTIES IN ASSESSMENT METHODOLOGIES*

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, the worst 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 period 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 conservative assumptions presented above allow a prudent 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
- Access of marine barges back and forth the site.

2 WATER SENSITIVE RECEIVERS

The water quality sensitive receivers (SRs) have been identified in the EIA (*Part 2 - Section 6: Water Quality Assessment*) in accordance with *Annex 14* of the *Technical Memorandum* on EIA Process (*EIAO, Cap.499, S.16*). These SRs are illustrated in *Figure A2.1* and listed in *Table A2.1*. For the assessment purpose, water modelling output points (MPs and SRs) at some representative locations are selected for further analysis and they are listed in *Tables A2.1 and A2.2* and also presented in *Figure A2.1*.

Table A2.1 Water Quality Sensitive Receivers (WSRs) around Proposed LNG Terminal at Black Point

Sensitive Receiver	Name	Water Quality Modelling Output Location	Included in the Model
Fisheries Resources			
Spawning/ Nursery Grounds	Fisheries Spawning Ground in North Lantau	SR8	Yes
		SR8a-b	No
Artificial Reef Deployment Area	Sha Chau and Lung Kwu Chau	SR6e	Yes
	Airport	SR7d	Yes
Fish Culture Zone	Ma Wan	SR40a-b	No
Oyster Bed	Lau Fau Shan	SR2c	No
Marine Ecological Resources			
Seagrass Beds	Pak Nai	SR2	Yes
	Ngau Ho Shek	SR2a	No
	Tung Chung Bay	SR39	Yes
Marine Parks	Designated Sha Chau and Lung Kwu Chau	SR6a-d	Yes
Intertidal Mudflats	Pak Nai	SR1	Yes
Mangroves	Pak Nai	SR2	Yes
	Ngau Ho Shek	SR2b	No
	Tung Chung Bay	SR39	Yes
Horseshoe Crab Nursery Grounds	Pak Nai	SR1	Yes
		SR2a	No
		SR10	Yes
		SR18	Yes
		SR39	Yes
Others			
Gazetted Beaches	Butterfly Beach	SR5c	Yes
Non-gazetted Beaches	Lung Kwu Sheung Tan	SR5a	Yes

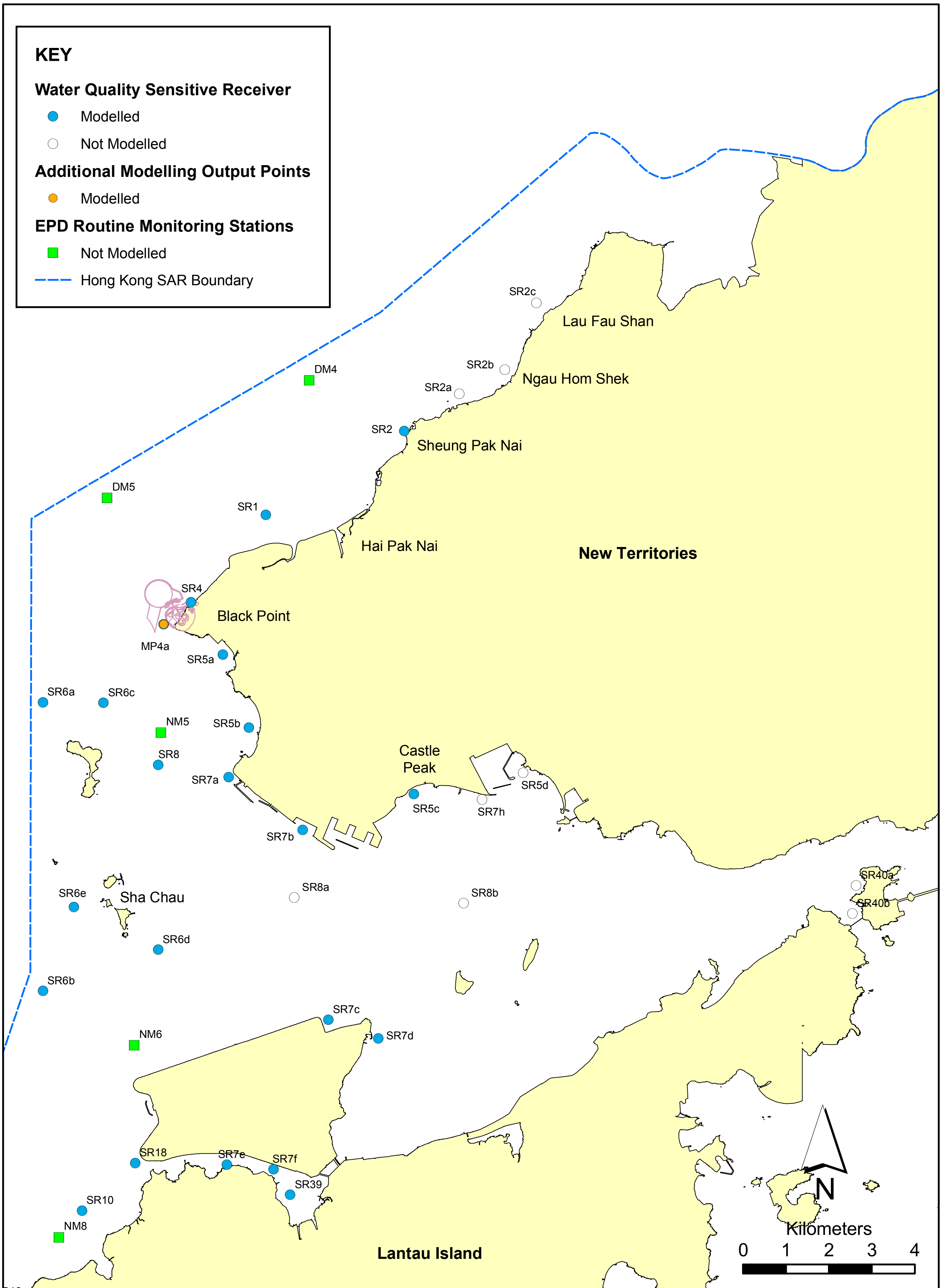


FIGURE A2.1

Water Quality Sensitive Receivers and
Additional Modelling Output Points in the Vicinity of
the Proposed LNG Terminal at Black Point

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Sensitive Receiver	Name	Water Quality Modelling Output Location	Included in the Model
	Lung Kwu Tan	SR5b	Yes
Seawater Intakes	Black Point Power Station	SR4	Yes
	Castle Peak Power Station	SR7a	Yes
	Tuen Mun Area 38	SR7b	Yes
	Airport	SR7c-f	Yes
	Tuen Mun WSD	SR7h	No

Table A2.2 Water Quality Modelling Output Points (MPs) around Proposed LNG Terminal at Black Point

Sensitive Receiver	Name	Water Quality Modelling Output Location	Included in the Model
Seawater Intakes	Operational Phase LNG Intake	MP4a	Yes

Table A2.3 EPD Routine Water Quality Monitoring Stations in the Vicinity of the Project Area

EPD Monitoring Stations	Respective WCZ	Included in the Model
Seawater Intakes	Operational Phase LNG Intake	Yes

3 CONSTRUCTION PHASE

For the construction phase the WAQ model has been used to **directly** simulate the following parameters:

- suspended sediments; and
- sediment deposition.

It is assumed that the worst-case construction phase impacts will be at the commencement of dredging, when there is no depression formed to trap sediments disturbed during dredging.

Note that DO, TIN and NH_3-N are calculated based on the modelled maximum SS concentrations as shown in *Section 6: Water Quality Impact Assessment*.

3.1 WORKING TIME

The estimation of programme for dredging activity at Black Point is based on the assumption of a 16 working hours per day with 6 working days per week. An arrangement of 24 working hours and 7 working days is unlikely to be feasible for Black Point due to the potential noise impact generated by barges travelling at night to the villages located in close proximity to the route of Black Point and the dumping sites at South Cheung Chau.

3.2 OVERVIEW OF DREDGING PLANTS

3.2.1 Grab Dredgers

Grab dredgers will be utilised in the dredging works for the reclamation works at the terminal as well as the navigation channel, turning circle and berthing box. Also the submarine water mains and some of the sections of the submarine pipeline may need to be pre-trenched and this is likely to be done utilising a grab dredger.

Grab dredgers may release sediment into suspension by the following mechanisms:

- Impact of the grab on the seabed as it is lowered;
- Washing of sediment off the outside of the grab as it is raised through the water column and when it is lowered again after being emptied;
- Leakage of water from the grab as it is hauled above the water surface;
- Spillage of sediment from over-full grabs;
- Loss from grabs which cannot be fully closed due to the presence of debris;
- Release by splashing when loading barges by careless, inaccurate methods; and
- Disturbance of the seabed as the closed grab is removed.

In the transport of dredging materials, sediment may be lost through leakage from barges. However, dredging permits in Hong Kong include requirements that barges used for the transport of dredging materials have bottom-doors that are properly maintained and have tight-fitting seals in order to prevent leakage. Given this requirement, sediment release during transport is not proposed for modelling and its impact on water quality is not addressed under this Study.

Sediment is also lost to the water column when discharging material at disposal sites. The amount that is lost depends on a large number of factors including material characteristics, the speed and manner in which it is discharged from the vessel, and the characteristics of the disposal sites. As impacts due to disposal operations at potential disposal sites have been assessed under separate studies, they are not addressed further in this document.

The modelling of dredging using grabs has assumed a loss rate of 17 kg m^{-3} dredged sediment. This rate is representative of grab dredgers (with a closed grab size of approximately 8 m^3 minimum) working in areas without debris. It is possible that the contractor may utilise a larger grab in the construction. The loss rate for a larger grab is lower than for a smaller grab.

Generally, a split-bottom barge could have a capacity of 900 m^3. A bulk factor of 1.3 would normally be applied, giving a dredging rate of 700 m^3 per barge. The hopper dry density for an 800 to 1,000 m^3 capacity barge is around 0.75 to 1.24 ton m^{-3}. Assuming 16 working hours per day for Black Point, with allowance on the demobilisation of filled barge and remobilisation of empty barges, a maximum of 7 barges could be filled per day. Therefore, the average daily dredging rate would be approximately 4,900 m^3. The use of grab with bigger size (16 m^3) can increase the daily dredging rate to a maximum of 6,500 m^3, though it is not readily available for all the dredging and reclamation contractors in the local market.

Assuming the worse case, when the grabs are just commencing dredging in relatively shallow water and hence a higher production output, the maximum daily rate of production will be about 8,000 m^3 day^{-1} (0.14 m^3 s^{-1}), giving a rate of release (in kg s^{-1}) for the dredger as follows:

Loss Rate (kg s^{-1})

*= Dredging Rate (m^3 s^{-1}) * Loss Rate (kg m^{-3})*

*= 0.14 m^3 s^{-1} * 17 kg m^{-3}*

*= **2.36 kg s^{-1}***

The average release rates will, in fact, be somewhat less than those indicated above. The instantaneous dredging (and loss) rates will also decrease as the depth increases. This is because the assumed dredging production rates are instantaneous rates that will not be maintained due to delays for breakdowns, maintenance, crew changes and time spent relocating the dredgers. The release rates that are to be modelled therefore represent conservative worst-case conditions that will not prevail for any great length of time.

A review of the vector plots at the sites allowed identification of areas that would disperse sediment further than other areas due to higher current velocities. These areas were consequently chosen as the locations of the sources of sediment in the model.

3.2.2 *Trailing Suction Hopper Dredgers*

Trailing Suction Hopper Dredgers (TSHD) will be used mainly for the navigation channels and turning circle.

The hopper dry density for a TSHD is typically 0.75 ton m^{-3}. TSHD could dredge at a faster rate than grab dredgers (typical dredging rate of 5,400 m^3 per trip per TSHD with a maximum dredging rate up to 7,200 m^3 per trip depending on the vessel size).

For the modelling scenarios it has been assumed that the Contractor will utilise a small (<5,000 m^3) to medium (5,000 – 10,000 m^3) TSHD. The suggested size of trailer dredger is approximately 8,000 m^3, which commonly operate in Hong Kong.

The rate of loss for trailer dredgers is 7 kg m^{-3} dredged which is considered to be a conservative assumption and at the upper end of measured loss rates for TSHD [(1)] [(2)], and assumes that no overflow is permitted but the Lean Mixture Overboard (LMOB) system is in operation at the beginning and end of the dredging cycle when the drag head is being lowered and raised from the seabed. Assuming that no more than one dredger operates simultaneously and the loading time for each dredging trip is approximately 0.75 hour a loss rate (in kg s^{-1}) is calculated as follows:

Loss Rate (kg s^{-1})

*= Dredging Rate Per Trip (m^3 s^{-1}) * Loss Rate (kg m^{-3})*

*= 7,200 m^3 trip $^{-1}$ / 0.75 hr / 3600 s hr^{-1} * 7 kg m^{-3}*

= 18.67 kg s^{-1}

For the THSD working at Black Point the modelling has assumed that the trailer will dispose at the South Cheung Chau which would introduce the travelling time to and from the site to be 3.32 hours and a cycle time would be approximately 5.32 hours. This would equate to 3 trips per day, which means a daily dredging rate of 21,600 m^3 day^{-1} [(3)].

During dredging the drag head will sink below the level of the surrounding seabed and the seabed sediments will be extracted from the base of the trench formed by the passage of the draghead. The main source of sediment release is the bulldozing effect of the draghead when it is immersed in the mud. This mechanism means that sediment is lost to suspension very close to the

(1) Kirby, R and Land J M (1991). The impact of Dredging - A Comparison of Natural and Man-Made Disturbances to Cohesive Sedimentary Regimes. Proceedings CEDA-PIANC Conference (incorporating CEDA Dredging Days), November 1991, Amsterdam. Central Dredging Association, the Netherlands.

(2) Environment Canada (1994). Environmental Impacts of Dredging and Sediment Disposal. Les Consultants Jaques Beraube Inc for the Technology Development Section, Environmental Protection Branch, Environment Canada, Quebec and Ontario Branch.

(3) The maximum dredging rate for THSD per day is 21,600 m^3. Three trips can be conducted per day and the dredging rate for each trip is 7,200 m^3.

level of the surrounding seabed and a height of 1 m has been adopted for the initial location of sediment release in the model.

3.3 CONSTRUCTION SCENARIOS

3.3.1 Scenario 1a

Scenario 1a simulates dredging works at seawall, jetty box, approach channel and turning basin and outfall as well as sandfilling works for seawall trench and reclamation (*Figure A3.1*). The total dredged volume is approximately 3.15 Mm^3. All dredging works will be carried out by grab dredgers while sandfilling works is conducted by a pelican barge.

Dredging Works for Seawall Areas

It is estimated that dredged volume under the seawall is approximately 0.63 Mm^3. Two grab dredgers in total will be used for the construction, starting from each end of the seawall in reverse direction. Hence in the water quality model two moving emission sources, BP01 and BP02, initially locate at the ends of dredging underneath seawall in Area A and Area C respectively, moving towards Area B (*Figure A3.1*). All the releases are continuously emitted in the whole water column with an emission rate of **2.36 kg s^{-1}** (refer to *Section 3.2.1* for detailed calculations).

Dredging Works for Jetty Box, Approach Channel and Turning Basin

The estimated dredged volume along the approach channel/turning basin and berthing area is approximately 2.52 Mm^3 in total. *Figure A3.1* shows the dredging area of the approach channel and turning basin which is divided into three areas, namely Area D, Area E and Area F. A jetty box which is inside Area E will be dredged as well.

Three stationary sources, BP08a, BP09a and BP10a, are assumed in the model to represent the grab dredgers in Areas D, E and F respectively and another stationary source, BP07, represents a grab dredger at the jetty box. The most conservative case is simulated as making the four sources close to other sources. In reality, the grab dredgers will move away from each other and will not retain this proximity to others for a period as long as modelled. In addition, the dredging works at jetty box may be conducted before dredging for Area E and thus concurrent dredging for jetty box and Area E is unlikely to occur.

All the *releases* are continuously emitted in the whole water column with *an* emission rate of **2.36 kg s^{-1}** (refer to *Section 3.2.1* for detailed calculations).

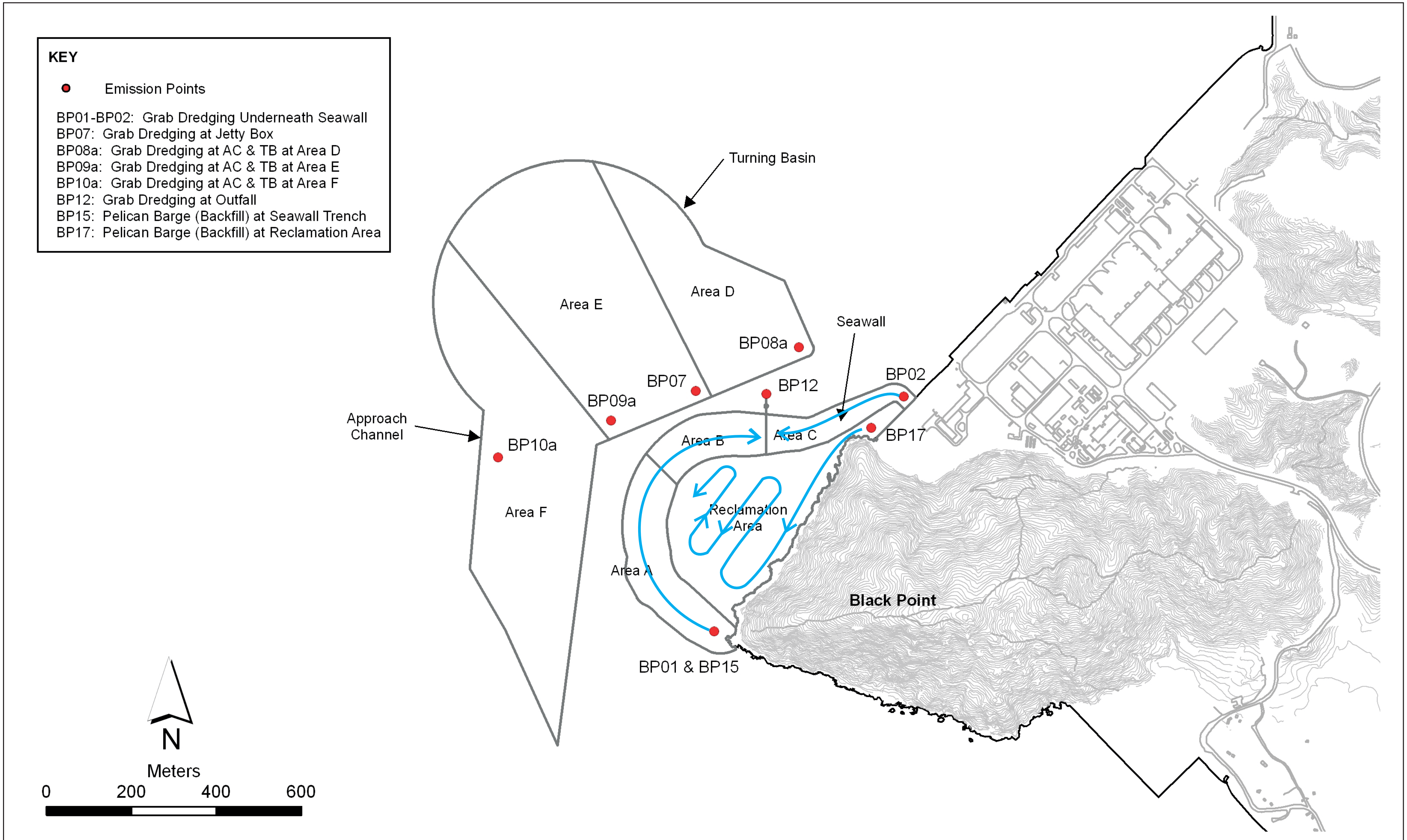

Figure A3.1

Emission Points Defined in the Model for Scenario 1a

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Dredging Works for Submarine Outfall

As shown in *Figure A3.1*, the dredging will be carried under seawater outfall. A stationary point, BP12 is defined in the model which is assumed to be a continuous emission with rate of **2.36 kg s^{-1}** (refer to *Section 3.2.1* for detailed calculations) at the whole water column.

Backfilling for Seawall Trench

Sandfilling for sloping seawall trench (represented by Areas A and B in *Figure A3.1*) by a pelican barge (rainbowing) is simulated by assuming a filling rate of 50,000 m^3 day^{-1} with working hours to be 16 per day.

The fill material will be marine sand which generally has a fine content ranging from 2% to 10%. As the source of material could not be confirmed at the time of this EIA compiled, the upper bound of the fine content, i.e. 10% is assumed for the conservative case.

With a representative dry density of the sand fill taken as 1,938 kg m^{-3}, the loss rate in kg s^{-1} (continuous emission in the whole water column) is calculated as follows:

Loss Rate (kg s^{-1})

*= Percentage Loss Rate * Filling Rate (m^3 s^{-1}) * Dry Density of Sand Fill (kg m^{-3})*

*= 1% * 50,000 m^3 day^{-1} * 1/16/3600 day s^{-1} * 1,938 kg m^{-3}*

= 16.8 kg s^{-1}

A moving source, BP15, is assumed in the model moving along the same trajectory as BP01 which covers Areas A and B. Note that there is no sand filling works for the vertical seawall which locates at the north-eastern side of Black Point. In addition, the backfilling operations for the reclamation will be carried out behind a completely constructed seawall and hence it is not considered in the model simulations.

Backfilling for Reclamation Area

Backfilling for reclamation area is assumed to be filled with marine sand by a pelican barge (rainbowing). On the same basis of backfilling for the seawall trench, a continuous emission of **16.8 kg s^{-1}** (in the whole water column) is assumed in the model. An indicative trajectory of the moving source, BP17, is shown in *Figure A3.1*.

3.3.2 *Scenario 1b*

Scenario 1b simulates the same construction activities as those modelled in Scenario 1a. The difference between Scenario 1b and 1a is a TSHD will be used for dredging at an area of approach channel and turning basin (Area D shown in *Figure A3.2*).

As indicated in *Figure A3.2*, the approach channel and turning basin will be divided into four areas, Areas D, E, F and G. Area D is proposed to be dredged by a TSHD whereas Areas E to G will be dredged by a grab dredger. For each trip travelled by the TSHD, the loss rate will be **18.67 kg s^{-1}** (refer to *Section 3.2.2* for detailed calculations).

A moving source, BP08b, is assumed in the model and it will start at the utmost south of the area and move at a speed of 0.3 m s^{-1} in north-eastern direction following the angle of the approach channel. In order to account for the disposal events as aforementioned in *Section 3.2.2*, the emission is assumed to be instantaneous with a 0.75 hour dredging followed by 1.25-hour on-site idle time and a 3.32-hour disposal whereas disposal will be at South Cheung Chau.

3.3.3 *Construction Programme and Sequence*

Tentative construction programme and indicative construction sequence are shown in *Figures A3.3* and *A3.4* respectively.

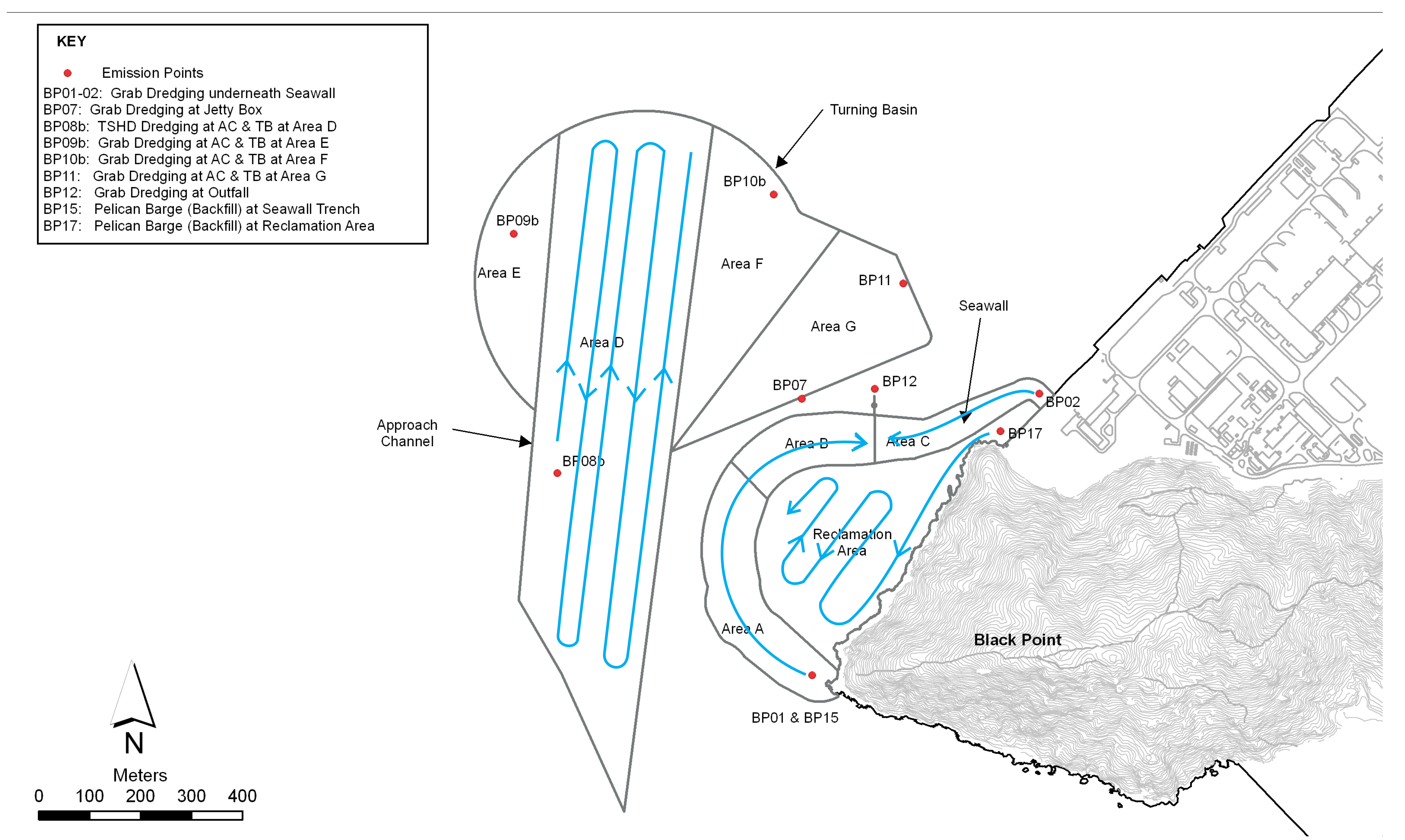

Figure A3.2

Emission Points Defined in the Model for Scenario 1b

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Figure A3.3 Tentative Construction Programme

Task Name	Respective Scenario	Respective ID Code	Month																			
			M1	M2	M3	M4	M5	M6	M7	M8	M9	M10	M11	M12	M13	M14	M15	M16	M17	M18	M19	M20
Reclamation Works - Seawall																						
Dredging Underneath Seawall (Area A and B)	1a and 1b	BP01																				
Dredging Underneath Seawall (Area C)	1a and 1b	BP02																				
Sandfill for Sloping Seawall Trench (Area A and B)	1a and 1b	BP15																				
Reclamation Works - Reclamation																						
Area A1 - Placing Sandfill	1a and 1b	BP17																				
Area A2 - Placing Sandfill	1a and 1b	BP17																				
Area B1 - Placing Sandfill	1a and 1b	BP17																				
Area B2 - Placing Sandfill	1a and 1b	BP17																				
Area C1 - Placing Sandfill	1a and 1b	BP17																				
Area C2 - Placing Sandfill	1a and 1b	BP17																				
Main Jetty (Using Grab Dredgers)																						
Dredging at Jetty Box	1a	BP07																				
Dredging at Approach Channel and Turning Basin at Area D	1a	BP08a																				
Dredging at Approach Channel and Turning Basin at Area E	1a	BP09a																				
Dredging at Approach Channel and Turning Basin at Area F	1a	BP10a																				
Main Jetty (Using Grab Dredgers and a TSHD)																						
Dredging at Jetty Box		BP07																				
Dredging at Approach Channel and Turning Basin at Area D	1b	BP08b																				
Dredging at Approach Channel and Turning Basin at Area E	1b	BP09b																				
Dredging at Approach Channel and Turning Basin at Area F	1b	BP10b																				
Dredging at Approach Channel and Turning Basin at Area G	1b	BP11																				
Outfall Construction																						
Dredging Under Outfall	1a and 1b	BP12																				

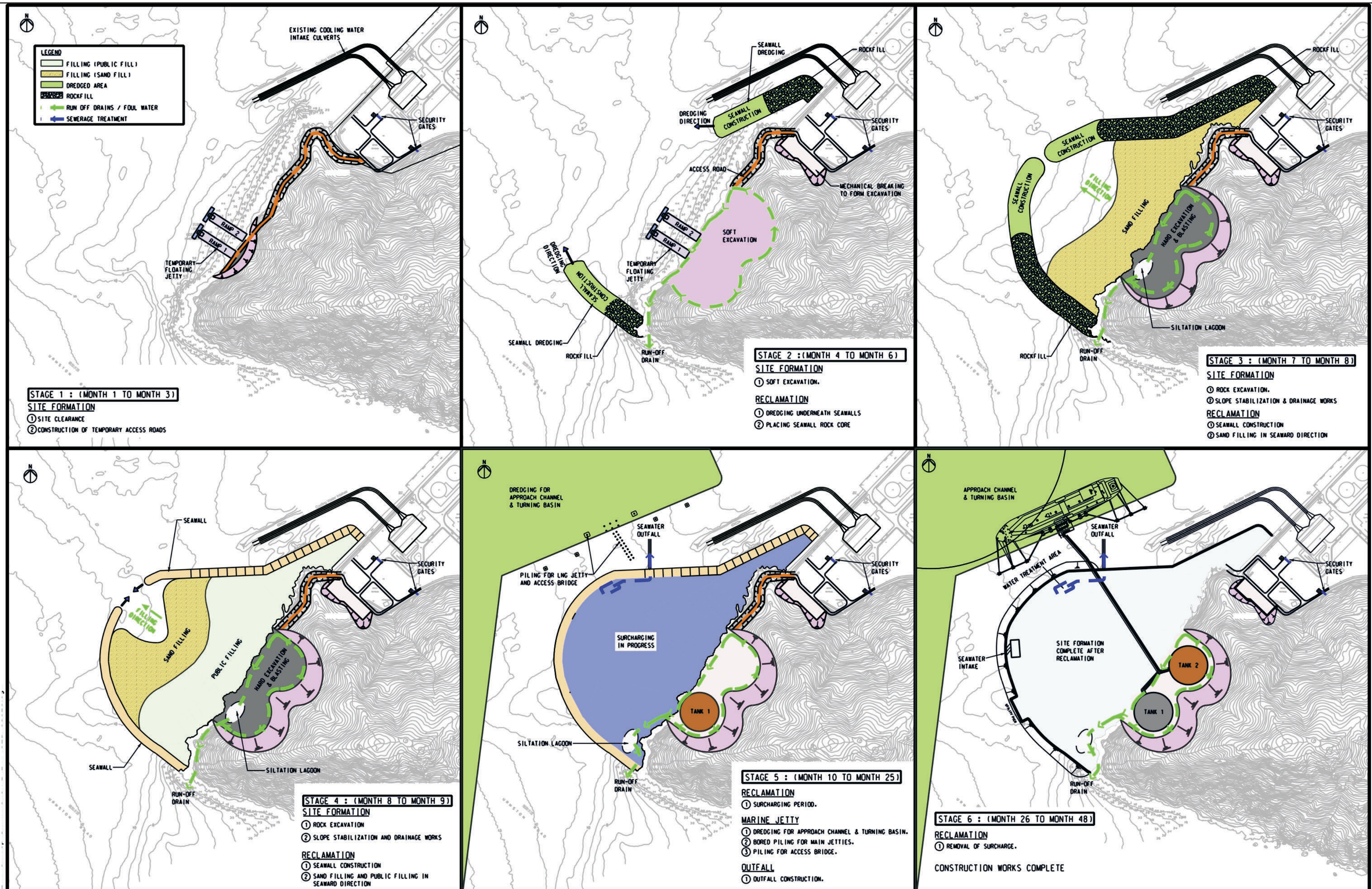

Figure A3.4

Black Point Indicative Construction Sequence

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3.4 SEWAGE DISCHARGE

During construction of the LNG receiving terminal the maximum work force is estimated to be around 1,600 people maximum. Based on *Table 2* of the *Drainage Service Department's (DSD's) Sewerage Manual* for domestic type sewage, the unit flow factor for an employed population is 150 L per head per day. A calculation of the Average Dry Weather Flow (ADWF) is given in *Table A3.1*. According to the Sewerage Manual, a peaking factor of 6 should be applied to the average flow to determine the peak flow which is shown in *Table A3.1*.

Table A3.1 Calculation of Sewage Flow LNG Construction Phase

Population	Unit Flow Factor (L/head/day)	Average Dry Weather Flow (m^3/day)	Peak Flow (6 x ADWF) (m^3/day)
1,600	Domestic Type 150 L/head/day	240	1,440
	Total	***240***	***1,440***

From the above, the effluent discharge consent standard, based on the ADWF, can be obtained from *Table 8* of the *TM* and is summarised in *Table A3.2*. As the sewage from the LNG Plant is of domestic sewage type, the parameters as shown in *Table A3.1* and *Table A3.2* are applicable to the sewage treatment process. The other parameters that comprise restrictions on chemicals are not a concern for domestic type sewage and are therefore considered. For oil and grease this requires to be controlled by fitting grease traps to the sewage outlets from the kitchens. The design load of the sewage discharge is the same as the effluent discharge standard and also shows in *Table A3.2*.

Table A3.2 Effluent Discharge Standard and Design Load for the Sewage Treatment Works during Construction Phase

Site	Corresponding WCZ	BOD (mg/L)	SS (mg/L)	Total Nitrogen (mg/L)	*E.Coli* (count/100mL)
Black Point	Deep Bay	20	50	100	1,000

The sewage discharge location is shown in *Figure 6.7* in *Part 3 - Section 6: Water Quality Impact Assessment*. The outfall will be a single pipe, without diffusers, with a diameter of 1.83 m located near the seabed.

4 OPERATIONAL PHASE

For the study of operational effects, the approach requires several steps:

1) Running a near-field model (i.e., CORMIX) for the operational discharges, and any existing discharges in the vicinity (eg Black Point Power Station discharge) to characterise the initial mixing of the effluent discharge. The results of the near-field model has been used to define the manner in which the discharge would be included in the far-field hydrodynamic and the water quality models (at which depth, the number of cells over which the discharge will be distributed). The results from the CORMIX analysis has also provided information of the near field dispersion and dilution of the effluent plumes and hence chlorine and/or other biocide concentrations.

   Details of CORMIX simulation is presented in *Appendix 6B* in this Annex.

2) Adapting the hydrodynamic model for the new conditions, including the reclamations and discharges.

3) Running the hydrodynamic model for the specified conditions (wet/dry season). Both sites can be implemented within one hydrodynamic run for a dry and wet seasons spring-neap cycle, since there will be no significant interaction between the effects of the two sites.

4) Running the water quality model (i.e., Delft3D-WAQ). The objectives are twofold:

   a) to qualitatively assess the concentrations of residual chlorine or other biocides: to this end up to 5 decayable tracers may be defined, which will be released from the two candidate sites (the analysis has been carried out assuming that the background concentration is zero); and

   b) to qualitatively assess the potential changes in water quality as a result of changes in the circulation near the project sites: to this end up to 5 conservative, ie non-decayable, tracers have been defined, which will be discharged from a number of locations representing main pollution sources (e.g. Hong Kong as a whole, major point sources in the vicinity of the candidate sites).

The general water quality is the result of transport phenomena and transformation and retention processes. The operation of the project may locally affect the transport patterns. Transformation and retention processes are not affected. Consequently, validation of the Delft3D-WAQ model is not required. The analysis under 4b) requires the running of a baseline scenario to assess the pre-project conditions.

4.1 THERMAL AND ANTIFOULANT DISCHARGE

Stored LNG will need to be re-gasified in order for it to be conveyed along the gas pipeline to the point of use. This will be accomplished via LNG Vaporisers, which will either utilise piped seawater (in open rack vaporisers) or hot combustion gases (in so-called submerged combined vaporisers) to raise the temperature of the LNG to ambient, thereby causing it to re-gasify. Once vaporised the LNG gas is then regulated for pressure and piped to the consumer (1).

- *Open Rack Vaporisers* - In open-rack vaporisers (ORVs) downward seawater flows over the exterior of the vaporizer panels, which internally channel an upward flow of high-pressure LNG. LNG will then be vaporized by exchanging heat with seawater in the ORV's. The seawater falls over the panels to a trough below and is then discharged back to the sea. The seawater will pass through a series of screens to remove debris to prevent blockage or damage to the seawater pumps. Upon leaving the vaporisers, the (cooled) seawater will be collected in a sump and discharged back to the sea via a submarine outfall. The design seawater temperature drop is 12.5°C at the discharge point.

- *Submerged Combined Vaporisers* - In Submerged Combined Vaporisers (SCVs), LNG flows through tubes that are submerged in a heated water bath.

The present design intention for the terminal is that the gas will be vaporised using ORV, with a SCV unit as back-up.

The seawater discharge is expected to have a decreased temperature of approximate Δ 12.5°C at the discharge point. The flow rate is expected to be equivalent to 18,000 $m^3 hr^{-1}$ (peak flow).

The dosing level of Chlorine is expected to be at approximately 3 mg L^{-1}. Residual Chlorine level is expected to be 0.3 mg L^{-1}. Residual chlorine is known to decay rapidly in the marine environment, as the chlorine demand of the receiving waters is likely to be high. A preliminary review of literature on chlorine decay has indicated that there are a number of factors that determine decay, including reactivity of organic matter, temperature, (UV) light, pH and salinity. However, chlorine decay has been studied mostly for freshwater systems and in distribution system. The discharge of residual chlorine has been modelled based on both the peak flow of 18,000 $m^3 hr^{-1}$ and the seasonal varied flow as shown in *Table A4.1*.

(1) The LNG terminal is assumed to connect to the Black Point Power Station. Should the site location require a subsea pipeline to Black Point, the pipeline will be installed in accordance with the Marine Department and Civil Engineering Department's requirements.

Table A4.1 Cooling Water Discharge Flow Rate

Hour	Summer ($m^3 hr^{-1}$)	Winter ($m^3 hr^{-1}$)
0	13500	9000
1	13500	6750
2	11250	4500
3	11250	4500
4	11250	4500
5	11250	4500
6	11250	4500
7	11250	6750
8	15750	9000
9	18000	11250
10	18000	15750
11	18000	18000
12	18000	18000
13	18000	18000
14	18000	18000
15	18000	18000
16	18000	18000
17	18000	18000
18	18000	18000
19	18000	18000
20	18000	18000
21	18000	18000
22	18000	15750
23	15750	11250

Based on this review, a conservative rate of decay has been taken as first order decay (ie 100 day^{-1}) at 30°C. As chlorine will be discharged in cooled water from the gas warming vapourisation system, a similarly conservative temperature dependency of 1.0996 has been used in the modelling (1).

4.2 *SEWAGE DISCHARGE*

During operation of the LNG receiving terminal the maximum work force is estimated to be around 100 people maximum. Based on *Table 2* of the *Drainage Service Department's (DSD's) Sewerage Manual*, the unit flow factor for an employed population is 60 L per head per day.

However, this unit flow rate does not comprise wastewater generated from staff showers or any canteen facilities to be provided. Considering the nature of the work and remote locations, some of the work force may use shower facilities and also canteen facilities will be required. In this case subject to discussion and agreement with Environmental Protection Department (EPD) a commercial unit flow factor may be applied to the work force on top of the employed population unit flow factor. *Table A4.1* shows a calculation of the Average Dry Weather Flow (ADWF) and the peak flow for which a peaking factor of 6 is applied.

(1) McClellan, John N., David A. Reckhow, John E. Tobiason, James K. Edzwald: A Comprehensive Kinietic Model for Chlorine Decay and Chlorination Byproduct Formation, Department of Civil and Environmental Engineering, University of Massachusetts/Amherst,

Table A4.1 Calculation of Sewage Flow LNG Operational Phase

Population	Unit Flow Factor (L/head/day)	Average Dry Weather Flow (m^3/day)	Peak Flow (6 x ADWF) (m^3/day)
100	Employed Population 60L/head/day	6.0	36.0
100	Commercial Activities	29.0	174.0
	Total	*35.0*	*210.0*

From the above, the effluent discharge standard, based on the ADWF, can be obtained from *Table 8* of the *TM* and is summarised in *Table A4.2*. As the sewage from the LNG Plant is of domestic sewage type, the parameters as shown in *Table A4.1* and *Table A4.2* are applicable to the sewage treatment process. The other parameters that comprise restrictions on chemicals are not a concern for domestic type sewage and are therefore considered. For oil and grease this requires to be controlled by fitting grease traps to the sewage outlets from the kitchens. The design load of the sewage discharge is decided to be same as the effluent discharge standard (*Table A4.2*).

Table A4.2 Effluent Discharge Standard and Design Load for the Sewage Treatment Works during Operational Phase

Site	Corresponding WCZ	BOD (mg/L)	SS (mg/L)	Total Nitrogen (mg/L)	*E.Coli* (count/100mL)
Black Point	Deep Bay	20	50	100	1,000

The sewage discharge location is shown in *Figure 6.7* in *Part 3 - Section 6: Water Quality Impact Assessment*. The outfall will be a single pipe, without diffusers, with a diameter of 1.83 m located near the seabed.

4.3 MAINTENANCE DREDGING

The study has considered the following three steps that steer sedimentation. Two types of material have been taken into account, i.e. mud (cohesive) and sand (non-cohesive). Mud is transported in suspension and sand is transported as suspended load or bed load, depending on the grain size and wave/current conditions.

1) To estimate the rate of sediment supply, data on bed composition in the vicinity of the LNG terminals (if available also sediment cores), data on suspended sediment concentration (preferably also during or just after typhoons) and data on the sediment load and the extent of the sediment transport of Pearl River has been analysed. From the mineralogical composition, sediment sources can be identified.

http://www.ecs.umass.edu/cee/reckhow/publ/84/acschapter/html

2) The current velocity in and around the navigation channel and the resulting bed shear stress. To this end, results from existing hydrodynamic model simulations can be used.

- The influence of waves has been evaluated based on a combination of wave climate data analysis from measurements, existing wave model results and desk analysis.

- An analysis of recirculation patterns by wind and tide to identify transport pathways. The tidal excursion length is also an important parameter to consider.

- Based on available data, it has been assessed what the effect of seasonal variations is and what the importance of density-driven effects is, e.g. salinity, fluid mud, temperature.

3) From the analysis on sediment supply and transport, an estimate can be made on the sedimentation rate in the navigation channel and in the neighbourhood of the terminal. From the average and maximum shear stress in the trench induced by currents and waves, the sediment trapping efficiency can be estimated. The product of supply and trapping efficiency yields the sedimentation rate.

Following the above approach, the frequency of the maintenance dredging has been estimated. For the impact assessment of the maintenance dredging, the qualitative assessment has been conducted (discussed in the *Section 6 – Water Quality Impact Assessment*) since the scale of the maintenance dredging would be much less than the dredging works for the approach channel and turning basin during construction phase which has been modelled as described in the previous section.

4.4 ACCIDENTAL FUEL SPILLAGE

4.4.1 *Locations*

A release point (808583 easting, 825632 northing) is defined. A spill occurring along the Urmston Road prior to reaching the Black Point site is assumed in the model. This location is selected due to its proximity to CPPS and also the Marine Park at Lung Kwu Chau/Sha Chau.

4.4.2 *Fuel Type*

Based on the information, it is assumed that the fuel is Heavy Fuel Oil (HFO i.e., 100% No 6).

4.4.3 *Volume to be spilled*

The most conservative case scenario was modelled, i.e. the largest single HFO storage tank from a 210 km^3 SSD propulsion vessel which is 5,043 m^3. The inventory released should equate to 60% of the tank contents.

4.4.4 *Discharge Rate*

It is assumed the large carrier will be used and its large collision event has a release rate of 8,060 kg s^{-1}, even though the small carrier will also be adopted in reality, giving a large collision event having a lower release rate of 7,720 kg s^{-1}.

4.4.5 *Model Selection*

The oil spillage has been simulated using hydrodynamic and particle tracking models (oil module of Delft3D-PART) to assess the movement of the oil spill. This Delft3D-PART forms part of the well-calibrated Delft 3D suite of models, as described in *Section 1* of this Annex. This particle tracking model has been adopted in the EIA of Permanent Aviation Fuel Facility [(1)].

4.4.6 *Key Modelling Assumptions*

Fuel spill is modelled by surface particles (floating since the density of the oil is less than that of the water). The initial radius is calculated on the basis of the Fay and Hoult equation [(2)] that calculates the extent of the patch after gravitational spreading. This spreading occurs in a matter of minutes rather than hours. The radius is related to the density difference between the oil and the water and the volume of spilled oil). The spill as used in the present case, of heavy fuel oil would lead to an initial patch of a diameter of 440 m. This implies a thickness of about 5 mm. In addition, no evaporation rate and emulsification is assumed in the model. The wind data at Cheung Chau and Sha Chau as shown in *Annex 13A3* in *Section 13* is used in the model.

4.4.7 *Scenarios*

The PART model has been simulated for the dry and wet seasons with typical real time wind time series. The simulations were run for periods of 5 days to capture the transport route of the oil spill in the first 24 hours to facilitate the development of an emergency contingency plan.

(1) Mouchel Asia Ltd (2002). EIA of Permanent Aviation Fuel Facility. For Airport Authority Hong Kong. Final Report.
(2) Fay, J. and D. Hoult, 1971. Physical processes in the spread of oil on a water surface, Report DOT-CG-01 381-A, U.S. Coast Guard, Washington, D.C.

5 CUMULATIVE IMPACTS

At present there are no committed projects that could have cumulative impacts with the construction of the terminal at Black Point. No projects are planned to be constructed in sufficient proximity to the Project to cause cumulative effects and hence, cumulative impacts are not expected to occur.

6 INPUT PARAMETERS

6.1 SEDIMENT PARAMETERS

For simulating sediment impacts the following general parameters has been used:

Settling velocity – 0.5 mm s^{-1}

Critical shear stress for deposition – 0.2 N m^{-2}

Critical shear stress for erosion – 0.3 N m^{-2}

Minimum depth where deposition allowed – 1 m

Resuspension rate – 30 g m^{-2} d^{-1}

Wave calculation method – Tamminga

Chezy calculation method – White/Colebrook

Bottom roughness – 0.001 m (1)

Fetch for wave driven erosion – 35 km

Depth gradient effect on waves – absent

The above parameters have been used to simulate the impacts from sediment plumes in Hong Kong associated with uncontaminated mud disposal into the Brothers MBA (2) and dredging for the Permanent Aviation Fuel Facility at Sha Chau (3). The critical shear stress values for erosion and deposition were determined by laboratory testing of a large sample of marine mud from Hong Kong as part of the original WAHMO studies associated with the new airport at Chek Lap Kok.

(1) The particular formulations used express the bottom roughness by the so-called Nikuradse roughness coefficient, which has the dimension m. (Nikuradse, J., 1932: Gesetzmassigkeiten der turbulenten Stromungen in glatten Rohren. Frosch. Ver. Deutscher Ing. No. 356.)

(2) Mouchel (2002a). Environmental Assessment Study for Backfilling of Marine Borrow Pits at North of the Brothers. Environmental Assessment Report.

(3) Mouchel (2002b). Permanent Aviation Fuel Facility. EIA Report. Environmental Permit EP-139/2002.

7 SCENARIOS

7.1 CONSTRUCTION PHASE

The scenarios are constructed in accordance with the tentative construction programme (*Figure A3.3*). To simulate conservative worse cases, all the potential concurrent activities would be simulated at the same time regardless the reality that they may not all occur simultaneously.

The proposed scenarios for the construction phase of the Black Point Option are presented in *Table A7.1*. *Table A7.2* summarises the inputs defined in the water quality model.

Table A7.1 Scenarios of the Construction Works for Black Point Option

Scenario ID (report)	Tasks	Details of Construction Activities	No. of Plant and Plant Type	Code	
Scenario 1a	Seawall	Dredging underneath seawall (Area A and B)	1 no. Grab Dredger	BP	01
	Seawall	Dredging underneath seawall (Area C)	1 no. Grab Dredger	BP	02
	Seawall	Sand fill for seawall trench (Area A and B)	1 no. Pelican Barge	BP	15
	Reclamation	Sand fill for reclamation area	1 no. Pelican Barge	BP	17
	Jetty Box	Grab Dredging at Jetty Box	1 no. Grab Dredger	BP	07
	Approach Channel and Turning Basin	Grab Dredging at Approach Channel & TB at Area D	1 no. Grab Dredger	BP	08a
	Approach Channel and Turning Basin	Grab Dredging at Approach Channel & TB at Area E	1 no. Grab Dredger	BP	09a
	Approach Channel and Turning Basin	Grab Dredging at Approach Channel & TB at Area F	1 no. Grab Dredger	BP	10a
	Cooled Water Outfall	Grab Dredging under outfall	1 no. Grab Dredger	BP	12
Scenario 1b	Seawall	Dredging underneath seawall (Area A)	1 no. Grab Dredger	BP	01
	Seawall	Dredging underneath seawall (Area	1 no. Grab Dredger	BP	02

Scenario ID (report)	Tasks	Details of Construction Activities	No. of Plant and Plant Type	Code	
		C)			
	Seawall	Sand fill for seawall trench (Area A and B)	1 no. Pelican Barge	BP	15
	Reclamation	Sand fill for reclamation area	1 no. Pelican Barge	BP	17
	Jetty Box	Grab Dredging at Jetty Box	1 no. Grab Dredger	BP	07
	Approach Channel and Turning Basin	TSHD Dredging at Approach Channel & TB at Area D	1 no. TSHD	BP	08b
	Approach Channel and Turning Basin	Grab Dredging at Approach Channel & TB at Area E	1 no. Grab Dredger	BP	09b
	Approach Channel and Turning Basin	Grab Dredging at Approach Channel & TB at Area F	1 no. Grab Dredger	BP	10b
	Approach Channel and Turning Basin	Grab Dredging at Approach Channel & TB at Area G	1 no. Grab Dredger	BP	11
	Cooled Water Outfall	Grab Dredging under outfall	1 no. Grab Dredger	BP	12

Table A7.2 Summary of Modelling Inputs

Code	Emission Point	Working Plant	Dredging/ Filling Rate	Operation Duration	Loss Type	Loss Rate	Loss Rate	Input Layer
			m3/day/plant	hours	-	kg/m3	kg/s	-
SCENARIO 1a								
Dredging underneath Seawall								
BP 01	Dredging underneath seawall (Area A and B)	Grab Dredger [(a)]	8,000	16	Continuous	17	2.36	whole column
BP 02	Dredging underneath seawall (Area C)	Grab Dredger [(a)]	8,000	16	Continuous	17	2.36	whole column
Sandfilling for Seawall								
BP 15	Sand fill for seawall trench (Area A and B)	Pelican Barge	50,000	16	Continuous	1%	16.8	whole column
Sandfilling for Reclamation								
BP 17	Sand fill for reclamation	Pelican Barge	50,000	16	Continuous	1%	16.8	whole column
Dredging for Approach Channel, Turning Basin								
BP 07	Dredging at jetty box	Grab Dredger [(a)]	8,000	16	Continuous	17	2.36	whole column
BP 08a	Dredging at approach channel & turning basin at Area D	Grab Dredger [(a)]	8,000	16	Continuous	17	2.36	whole column
BP 09a	Dredging at approach channel & turning basin at Area E	Grab Dredger [(a)]	8,000	16	Continuous	17	2.36	whole column
BP 10a	Dredging at approach channel & turning basin at Area F	Grab Dredger [(a)]	8,000	16	Continuous	17	2.36	whole column
Dredging for Outfall								
BP 12	Dredging under outfall	Grab Dredger [(a)]	8,000	16	Continuous	17	2.36	whole column
SCENARIO 1b								
Dredging underneath Seawall								
BP 01	Dredging underneath seawall (Area A and B)	Grab Dredger [(a)]	8,000	16	Continuous	17	2.36	whole column
BP 02	Dredging underneath seawall (Area C)	Grab Dredger [(a)]	8,000	16	Continuous	17	2.36	whole column
Sandfilling for Seawall								
BP 15	Sand fill for seawall trench (Area A and B)	Pelican Barge	50,000	16	Continuous	1%	16.8	whole column
Sandfilling for Reclamation								
BP 17	Sand fill for reclamation	Pelican Barge	50,000	16	Continuous	1%	16.8	whole column

Code	Emission Point	Working Plant	Dredging/ Filling Rate	Operation Duration	Loss Type	Loss Rate	Loss Rate	Input Layer
			m3/day/plant	hours	-	kg/m3	kg/s	-
Dredging for Approach Channel, Turning Basin								
BP 07	Dredging at Jetty Box	Grab Dredger [(a)]	8,000	16	Continuous	17	2.36	whole column
BP 08b	Dredging at approach channel & turning basin at Area D	TSHD [(b)]	7,200	0.75	Piecewise	7	18.67	bed layer [(c)]
BP 09b	Dredging at approach channel & turning basin at Area E	Grab Dredger [(a)]	8,000	16	Continuous	17	2.36	whole column
BP 10b	Dredging at approach channel & turning basin at Area F	Grab Dredger [(a)]	8,000	16	Continuous	17	2.36	whole column
BP 11	Dredging at approach channel & turning basin at Area G	Grab Dredger [(a)]	8,000	16	Continuous	17	2.36	whole column
Dredging for Outfall								
BP 12	Dredging under outfall	Grab Dredger [(a)]	8,000	16	Continuous	17	2.36	whole column

Notes:

(a) Grab dredger refers to closed grab dredger with a minimum grab size of 8 m^3.

(b) For TSHD, with hopper capacity of 8,000 m^3, the duration stated refers to the operation time per trip and each dredging event will last for around 0.8 hour.

(c) Bed layer refers to the bottom 10% of the water column.

Appendix 6A

Information on the Model Inputs

CONTENTS

1 *METHODOLOGY USED FOR THE GRID REFINEMENT*

The applied grid refinements have been realised in the Delft3D-FLOW model by means of the so-called domain decomposition technique. The FLOW model grid has subsequently been adopted without further aggregation in the water quality models.

Domain decomposition is a technique in which a model domain is subdivided into several smaller model domains, which are called sub-domains. Domain decomposition allows for local grid refinement, both in horizontal direction and in vertical direction. Grid refinement in horizontal direction means that in one sub-domain smaller mesh sizes (fine grid) are used than in other sub-domains (coarse grid) (see *Figure A1.1*).

The FLOW computations are carried out separately on the sub-domains. The communication between the sub-domains takes place along internal open boundaries, or so-called dd-boundaries. The resulting equations are solved simultaneously for all boundaries.

In the current model, 5 horizontally refined sub-domains are distinguished. The division in sub-domains is based on the requirements for horizontal model resolution in order to represent the coastline and bathymetry near the project sites and to adequately simulate physical processes.

The domain decomposition approach implemented in Delft3D-FLOW is based on a subdivision of the domain into non-overlapping sub-domains. An efficient iterative method is used for solving the discretised equations over the sub-domains. A direct iterative solver is used for the continuity equation, which is comparable to the single domain implementation. For the momentum equations, the transport equation and the turbulence equations the so-called additive Schwarz method is used, which allows for parallelism over the sub-domains. Upon convergence, this type of iteration process is comparable to the corresponding iterative solution methods in the single domain code, and features a comparable robustness. As witnessed by numerical experiments carried out during the development of the technique, the differences introduced by separating domains turn out to be of insignificance.

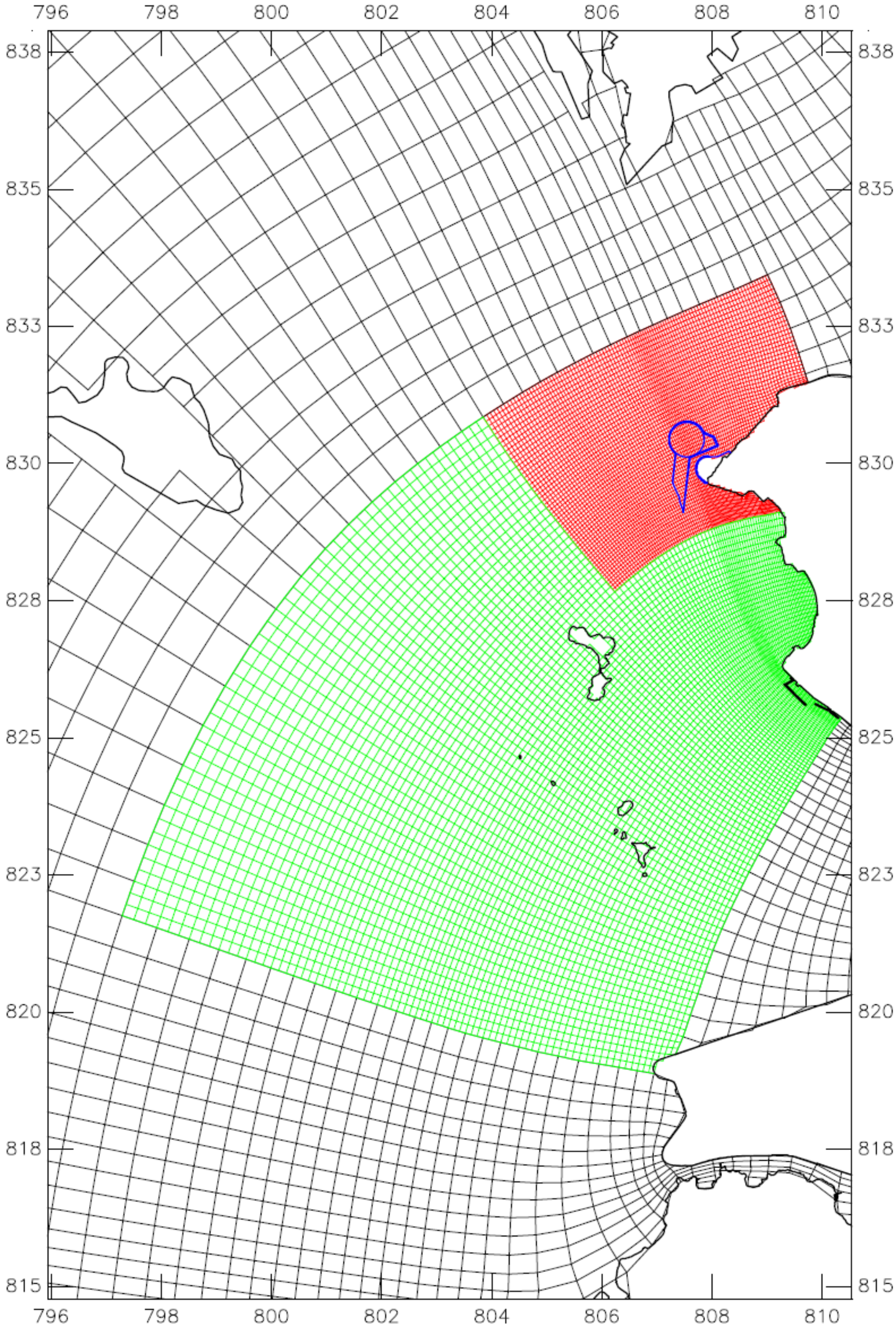

Figure A1.1 Refinement of Model Grid of the Model in the Vicinity of Black Point

2 VERIFICATION OF THE GRID REFINEMENT

The verification of the correct implementation of the grid refinement has been carried out by graphically comparing the results from the original, unrefined model with the refined model. This has been done for two locations:

- A location near the intake point of Black Point Power Station, inside the refined domain around the Black Point site.

The results are shown in *Figures A2.1* (wet season) and *Figures A2.2* (dry season). The comparison includes the water level (top graph), the current speed (second graph), the surface and bottom salinity (third graph) and the surface and bottom temperature (bottom graph). The comparison has been carried out for both the wet and the dry season simulations.

The results clearly demonstrate that the overall behaviour of both models is consistent, while the results are slightly different in the details. This is exactly as it would be expected from a locally refined model.

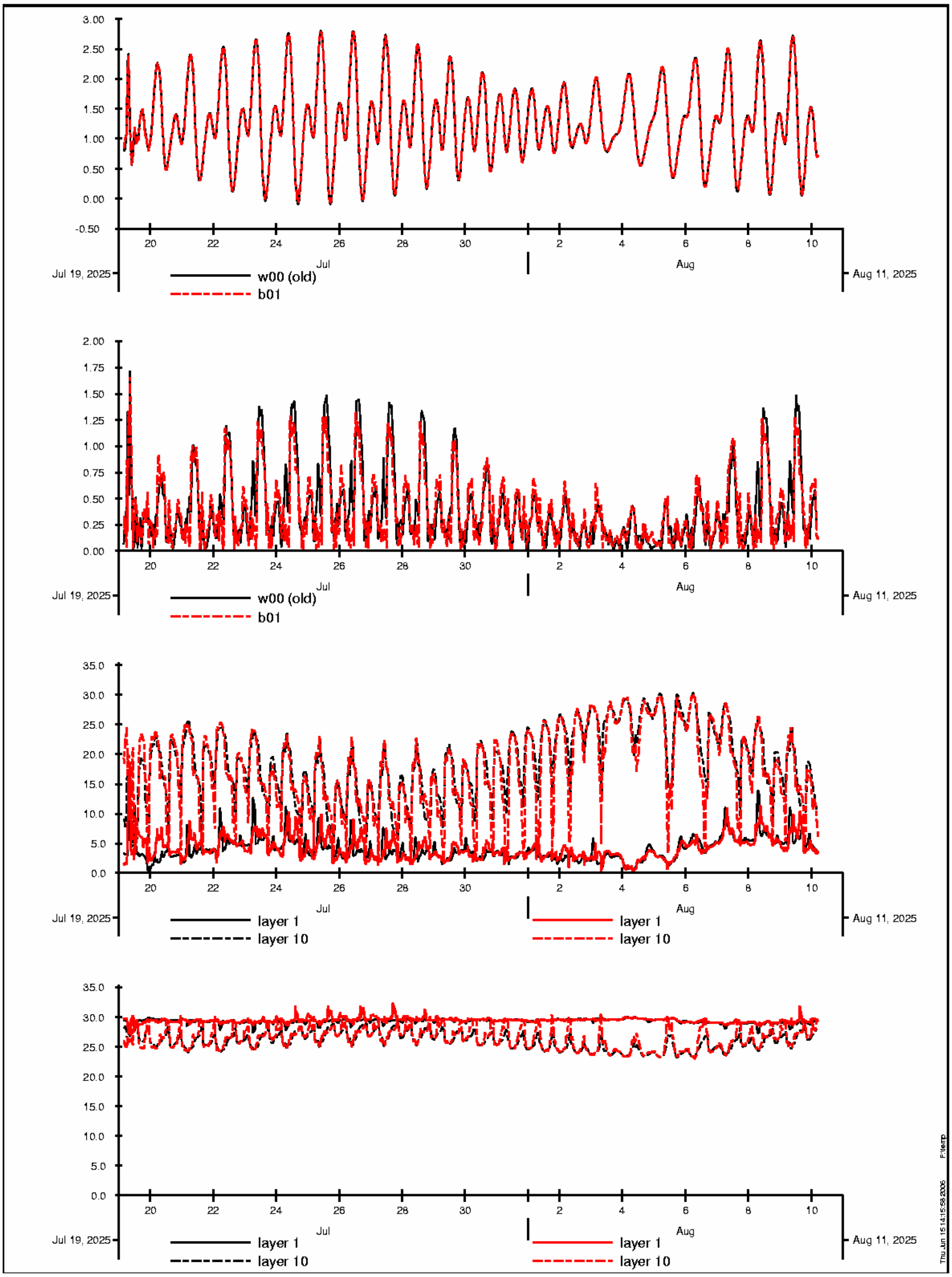

Figure A2.1 *Comparison (Wet Season) between Unrefined Model (in black) and Refined Model (in red) at the Black Point Power Station Intake in (Top graph: Water Level; Second graph: Current Speed; Third graph: Surface (layer 1) and Bottom (layer 10) Salinity; and Bottom graph: Surface (layer 1) and Bottom Temperature)*

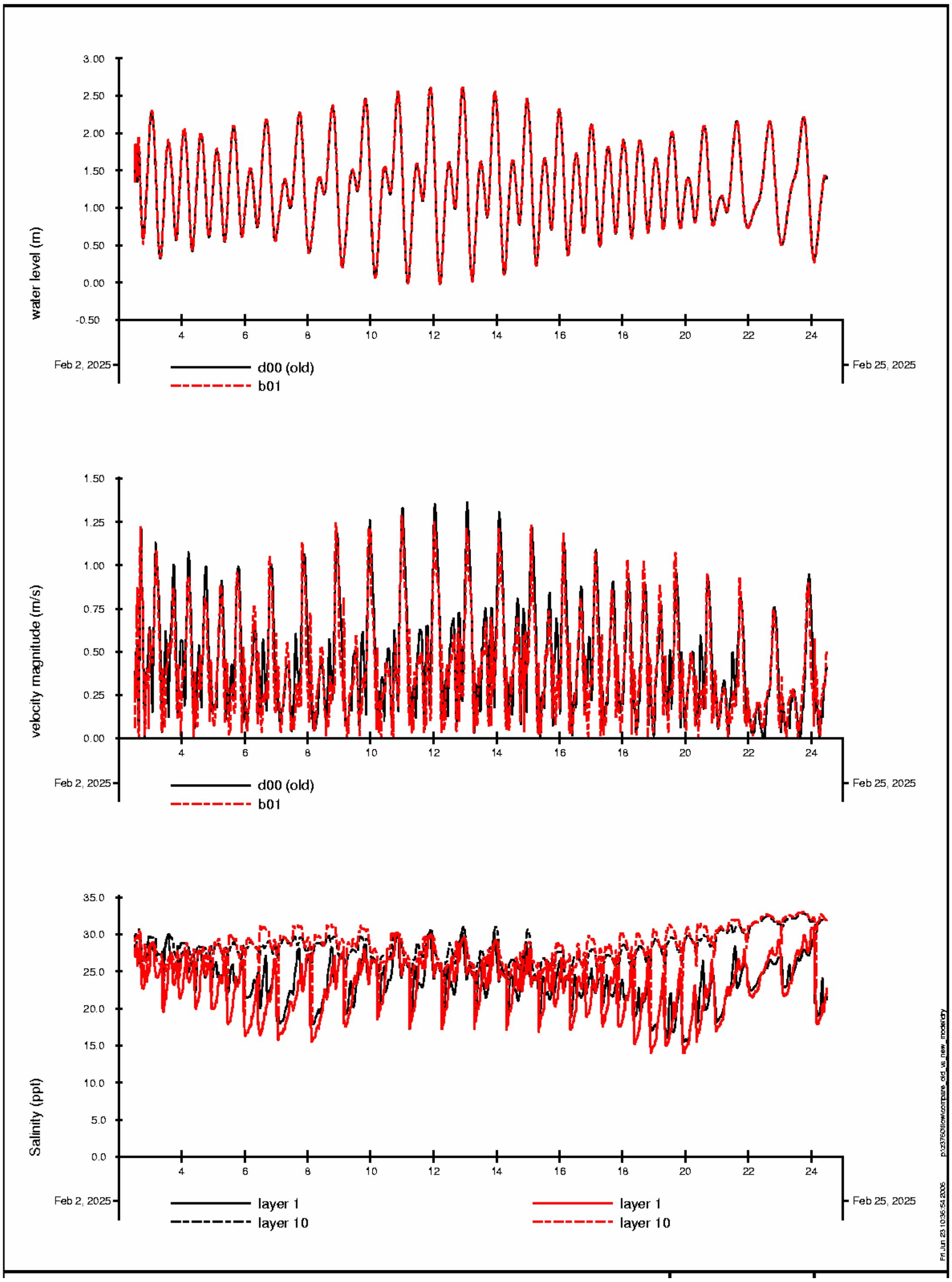

Figure A2.2 *Comparison (Dry Season) between Unrefined Model (in black) and Refined Model (in red) at the Black Point Power Station Intake in (Top graph: Water Level; Second graph: Current Speed; Bottom graph: Surface (layer 1) and Bottom (layer 10) Salinity*

3 DETAILS OF HYDRODYNAMIC SIMULATIONS

All hydrodynamic scenarios are simulated for a spring-neap-cycle during the dry season and a spring-neap-cycle during the wet season. The simulated periods are:

- Dry season: simulation period from 2 February 12:00h to 22 February 12:00h, simulation period 20 days, time step 30 seconds.
- Wet season: simulation period from 19 July 04:00h to 10 August 04:00h, simulation period 22 days, time step 30 seconds.

Adequate spin-up has been provided for salinity and temperature by means of initial conditions files (as shown by verification results). The first 5 days of both simulation periods are also used as spin-up, and are not used for the assessments purpose.

The wind has been set to typical seasonally averaged values:

- Dry season: northeast, 5 m s^{-1}.
- Wet season: southwest, 5 m s^{-1}.

The rivers have been set to typical seasonal values:

	Dry ($m^3 s^{-1}$)	Wet ($m^3 s^{-1}$)
Humen	1248	7442
Jiaomen	527	4732
Hongqili	128	1535
Hengmen	136	2805
Deep Bay	2.5	16

4 DEEP BAY FLUSHING CAPACITY ASSESSMENT

4.1 INTRODUCTION

As part of the project, one of the objectives of the modelling exercise is to assess "any residual impacts, which include any change in hydrodynamic regime" due to construction and operation of the LNG. In this respect, the construction of the Black Point Terminal may affect the circulation of water in the Deep Bay due to changes in coastline morphology, bathymetry and project related discharges. This, in turn, may induce a change in the flushing efficiency, and hence, in the water quality of the Deep Bay.

The objective of this study is "to assess, by modelling, the impact of the Black Point Terminal on the flushing efficiency of the Deep Bay".

In that respect, we propose to perform a set of tracer simulations. It is suggested to add a tracer in the Shenzhen river discharge, and to calculate the concentration of this tracer without the terminal (Case 1: Baseline), and with the terminal (Case 2: Operation Phase). The simulations for both cases would be done during neap-spring cycles in the dry and wet seasons.

4.2 MODELLING METHODOLOGY

4.2.1 Model selection

The study is based on the already existing hydrodynamic simulations using the Delft3D hydrodynamic model (FLOW). The tracer simulations have been done using the Delft3D water quality model (WAQ), and have used the output from the FLOW simulations as hydrodynamic inputs into WAQ.

4.2.2 Model inputs

The study assesses the flushing capacity of Deep Bay by looking at the concentrations inside Deep Bay as a result of a constant tracer release in Shenzen River. When a (dynamic) equilibrium is reached, the amount of tracer entering Deep Bay will be the same as the amount of tracer leaving Deep Bay. The rate of flushing however will determine the tracer concentrations inside Deep Bay: if the flushing is effective the concentrations are low, if the flushing is not effective the concentrations are high. By comparing the concentrations before and after the implementation of the project it can be known whether the flushing has been affected, i.e., a concentration increase indicates a reduction of the flushing while a concentration decrease indicates an increased flushing.

The situation prior to the project implementation is represented by the **Baseline flow calculation**, while the situation after the project implementation is represented by the **Operational flow calculation** (Seasonal Varied Flow).

Simulations have been carried out for typical wet season and typical dry season conditions. The duration of the run is one neap-spring cycle. The time series output data have been acquired with a time step of 10 minutes. The output stations are chosen as the locations of the sensitive receivers (SRs) around Black Point (as identified in the EIA study, *Part 2, Section 6: Water Quality Impact Assessment*). On top of this, a series of additional output stations has been defined (see *Figure A4.1*), as well as a monitoring area to evaluate the average tracer concentration over the whole water volume of Inner Deep Bay (see area east of the read line, *Figure A4.1*).

In this exercise, the boundary conditions are set to zero with respect to the tracer concentration. The Shenzhen River constitutes the only source of tracer. The flow of the Shenzhen River has been attributed a constant tracer concentration of 1 g m^{-3}.

The simulations are given sufficient spin-up to reach a dynamic equilibrium in the system.

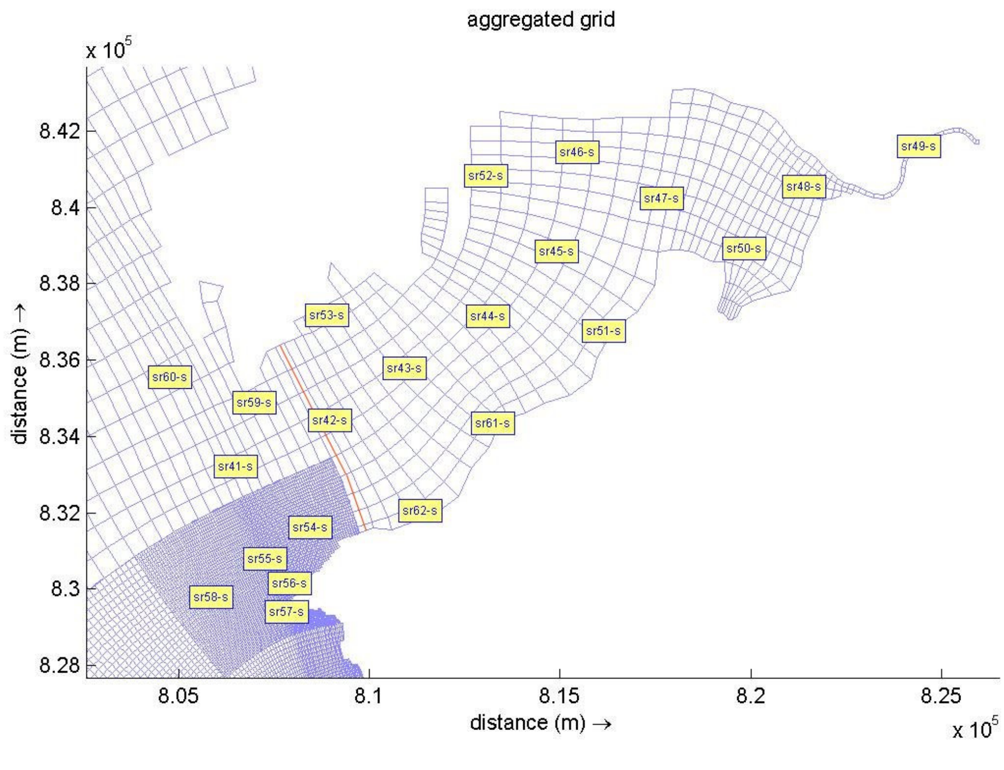

Figure A4.1 *Stations and area (east of red line) for time series output*

4.3 *MODELLING RESULTS*

The results of the simulations are presented as a time-averaged over the last week of the simulation (after the dynamic equilibrium has been obtained), before and after the implementation of the project, in the dry and wet seasons, see *Table 4.1*.

Table 4.1 Tracer concentration at SR's under baseline conditions, and relative change due to project implementation

Station	Baseline		Ope/Bas [1, 2]	
	Dry	Wet	Dry	Wet
	Concentration (mg L^{-1})		Relative Change	
Deep Bay	0.0123	0.0114	0.997	1.005
sr52-surf	0.0119	0.0132	0.998	1.024
sr45-surf	0.0128	0.0109	0.989	1.019
sr51-surf	0.0175	0.0043	1.000	1.001
sr46-surf	0.0212	0.0228	1.000	1.007
sr47-surf	0.0326	0.0240	0.999	1.010
sr50-surf	0.0532	0.0545	1.000	1.001
sr48-surf	0.1448	0.0910	1.000	1.001
sr49-surf	0.6155	0.1562	1.000	1.000

Notes:
1. Ope = Operational Flow Calculation
2. Bas = Baseline Flow Calculation

The results show that for Deep Bay as a whole there is a marginal increase of the flushing during the dry season, indicated by a decrease of the concentration. During the wet season there is a marginal decrease of the flushing, indicated by an increase of the concentration.

Looking at those individual SRs which show tracer concentrations higher than 1% of the discharge concentration, it can be seen that a similar picture as for Deep Bay as a whole: a small increase of the flushing during the dry season and a small decrease of the flushing during the wet season. At individual SRs the maximum concentration change is -1.1% during the dry season and 2.4% during the wet season.

From the modelling results as shown above, it is thus considered that the change in flushing capacity due to the reclamation at outer Deep Bay is minimal.

Appendix 6B

Information on CORMIX Model

CONTENTS

1 CORMIX SIMULATIONS

1.1 INTRODUCTION

The effluent from the LNG terminal will be discharged through the outfall located to the north of Black Point. The outfall is a single pipe with a diameter of 1.83 m, without diffusers.

The aim of the CORMIX modelling is to determine the near field mixing characteristics. These characteristics will be used to set the manner in which the discharge is introduced in the 3D hydrodynamic model.

1.2 CONDITIONS AROUND THE OUTFALL LOCATIONS

From the information that was provided is derived that the outfall is located at (807995, 830190) (Hong Kong 1980 coordinate system). The hydrodynamic conditions were determined for the wet and dry seasons. These conditions were taken from existing baseline computation (*Tables 1.1* and *1.2*).

When currents are relatively low during the wet season, the Near Field Region (NFR) is about 100 m and for higher currents about 200 m. At the edge of the NFR the plume has a width of the order of 5-10 m. In the wet season calculations, the plume at the end of the NFR is in the order of 2.5-4 m thick and is near the bottom (which is about half the total water depth). The discharge cells are about 40 * 65 m. Hence, the discharge during the wet season should be covering about 2 grid cells around the discharge location. The effluent should be discharge in the lower half of the water column.

For the dry season the effluent mixes over the entire depth when currents are higher (mid tide conditions), whilst under lower currents the effluent sinks towards the bed and at the edge of the mixing zone the layer thickness is about 3 m thick. The size of the plume is approximately similar to the plume under wet season conditions. Thus the horizontal distribution of the discharge cells may be the same for the dry as wet season conditions.

Table 1.1 Wet Season Conditions

Bottom -7 mPD

	Neap tide			**Spring tide**		
	HW	**LW**	**Mid**	**HW**	**LW**	**Mid**
Depth (m)	9.2	7.5	8.4	9.8	7	8.4
T_{bot} (°C)	25	27.5	26.5	25.5	28.4	27
S_{bot} (ppt)	24	14	16	22	8.5	13
ρ_{bot} (kg m^{-3})	1015.1	1006.9	1008.7	1013.5	1002.5	1006.3
T_{surf} (°C)	30	29.5	29.5	29	29.5	29.5
S_{surf} (ppt)	2	5	5	9	5	5
ρ_{surf} (kg m^{-3})	997.2	999.6	999.6	1002.7	999.6	999.6
V_{bot} (m s^{-1})	0.3	0.25	0.7	0.4	0.45	0.5
V_{surf} (m s^{-1})	0.4	0.65	1.5	0.85	0.35	0.95
T_{out} (°C)	19	20	19.5	18.75	20.45	19.75
S_{out} (ppt)	13	9.5	10.5	15.5	6.75	9
ρ_{out} (kg m^{-3})	1008.2	1005.4	1006.2	1010.2	1003.2	1005.0

Notes:

(a) "bot" denotes the bed
(b) "surf" denotes the surface
(c) "out" denotes the effluent characteristics

Table 1.2 Dry Season Conditions

Bottom (from model) -7 m PD

	Neap tide			Spring tide		
	HW	**LW**	**Mid**	**HW**	**LW**	**Mid**
Depth (m)	8.8	7.6	8.2	9.6	7	8.3
T_{bot} (°C)	23	23	23	23	23	23
S_{bot} (ppt)	28.5	29	28.5	31.5	25.5	28.5
ρ_{bot} (kg m^{-3})	1019.1	1019.5	1019.1	1021.4	1016.8	1019.1
T_{surf} (°C)	25	23.5	23	23.5	24	23
S_{surf} (ppt)	25	26.5	25	29.5	24.5	25
ρ_{surf} (kg m^{-3})	1015.9	1017.4	1016.4	1019.7	1015.8	1016.4
V_{bot} (m s^{-1})	0.15	0.1	0.4	0.1	0.3	0.9
V_{surf} (m s^{-1})	0.4	0.2	0.9	0.35	0.5	1.5
T_{out} (°C)	15.5	14.75	14.5	14.75	15	14.5
S_{out} (ppt)	26.75	27.75	26.75	30.5	25	26.75
ρ_{out} (kg m^{-3})	1019.5	1020.4	1019.7	1022.5	1018.2	1019.7

Notes:

(d) "bot" denotes the bed

(e) "surf" denotes the surface

(f) "out" denotes the effluent characteristics