Appendix E

Water Quality Assessment Supporting Information

CONTENTS

LIST OF FIGURES

1 WATER QUALITY MODELLING

Water quality modelling has been employed to assess the water quality impacts to the nearby water and ecological sensitive receivers during the construction and operation phases of the Study. The activities during the construction phase include dredging for the proposed beach and groynes and eastern box culvert as well as sandfilling and the activities during the operation phase include the discharges in the vicinity of the project area and from sensitive receivers. This section presents information on the approach for the water quality modelling works for the construction and operation phases of the Study.

The modelling methodology was 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 (Water Quality) of construction, which comprises the study of the dispersion of sediments released during dredging work required for the proposed beach development; and,
- Effects (Water Quality) of operation due to discharges from surrounding areas (with consideration on the pollution reduction due to the sewerage construction works at time of anticipated operation year).

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

1.2.1 Introduction

Plover Cove Model (PCM), a refinement of Tolo Harbour Model (THM) of the Delft 3D water quality (WAQ) and hydrodynamic suite of models were used to simulate effects on hydrodynamics and water quality. *Figures E1.1a* and *E1.1b* show the THM (with refined PCM) for the models during construction and operational phases respectively. PCM was a 2D model developed and used in the 'Feasibility Study for Proposed Beach Improvement Work at Lung Mei Beach'. The PCM had been verified in the feasibility study and this was upgraded to a 3D model for this assessment. The PCM as presented in Figures *E1.2a* and *E1.2b* focuses on the areas of the proposed beach. The model has the refined spatial extent of approximately 20 m in the Project Site fanning out to 50 – 100 m away from the Project Site. Validation of the model was conducted for this Study.

1.3 Coastline and Bathymetry

Hydrodynamic data have been obtained using coastline and bathymetry for a time horizon representative of the construction (assumed to be 2008) and operation (assumed to be 2010) of the proposed bathing beach.

The coastline and the bathymetry were revised to reflect the potential changes during the construction phase and operational phase of the Beach. No existing or planned future activity which might affect the coastline and bathymetry in the vicinity of the Beach is anticipated.

Details regarding the coastline and bathymetry to be used for the construction (assumed to be 2008) and operational (assumed to be 2010) phases assessment were agreed with EPD prior the commencement of modelling.

1.4 Vector Information

The velocities and directions of the flows for both dry and wet seasons during the construction and operation phases of the study area were assessed using the Delft3D-FLOW model. Water quality modelling was exercised using the results from the Delft3D-FLOW model.

1.5 Model Inputs

1.5.1 Hydrodynamics

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

- Dry season: simulation period from 8 February 03:30h to 23 February 03:30h, simulation period 15 days, time step 30 seconds.

- Wet season: simulation period from 15 July 03:30h to 1 August 03:30h, simulation period 17 days, time step 30 seconds.

Adequate spin-up has been provided for salinity and temperature by means of initial conditions files. Typical 15 days of both simulation periods were used as spin-up, and were 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}.

1.5.2 Sediment Parameters

For simulating sediment impacts the following general parameters were 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 – 0.1 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 – 2000 m

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.

1.5.3 Chlorophyll-a and E.Coli Modelling

In the approved EIA study (ERM, 2003) (8), chlorophyll-*a* modelling was carried for Tolo Harbour and Mirs bay, i.e. the same region as covered by the current modelling. The study involved the impact of dredging for submarine gas pipelines on chlorophyll-*a*. As this modelling approach has already been accepted by the EPD, the same modelling approach is used to assess the impact of dredging for the Lung Mei beach development on chlorophyll-*a*.

The chlorophyll-*a* model was set up in the Delft3D-WAQ model. Delft3D-WAQ has been calibrated extensively in Hong Kong waters, including Tolo Harbour and Mirs Bay. Background pollution loadings and parameters settings, with exception of the loading at Shan Liu River and four drains in the vicinity of the Project Site which is discussed below, are unchanged from ERM (2003). Instead of annual simulations, a typical dry season month (February) and a typical wet season (July) were simulated. The simulations made use of initial conditions derived from the ERM (2003). Hence, the simulations were already close to equilibrium at the start. Subsequently, a spin-up time of 15 days (one spring-neap cycle) was used.

The simulated periods were:

- Dry season: simulation period from 23 February 03:30h to 10 March 03:30h, simulation period 15 days, time step 15 minutes.

- Wet season: simulation period from 30 July 03:30h to 14 August 03:30h, simulation period 15 days, time step 15 minutes.

In addition to the background pollution loadings included in ERM (2003), the four discharges at drains W3, W4, W5 and W6 near to Lung Mei were included. *E.Coli* concentrations in these discharges were derived from field measurements carried out during December 2006 to January 2007.

As no measurements were available for nutrients, organic matter, etc. for the discharges via drains W3 to W6, the loadings for these drains were estimated based on the nearest stream, Shan Liu Stream. EPD routinely conduct monitoring works at Shan Liu Stream, namely station TR4. The sampling location of TR4 is shown in *Figure E1.5a*. The sampling location is downstream of Ting Kok village. In other words, Shan Liu River collects the surface water and some unsewered sewage from Ting Kok village. This is highly similar to the catchment of Lung Mei and Tai Mei Tuk. Drains W3 to W6 mainly collect surface runoff as well as some unsewered sewage from villages in Lung Mei and Tai Mei Tuk. In this regard, the physical characteristics of the water in these drains would be highly similar to that at Shan Liu Stream. It is hence considered the EPD monitoring data collected at TR4 is representative of the drains W3-W6.

Table E1.1 presents the summary of EPD monitoring data at TR4 whereas *Table E1.2* shows the pollution inventories assumed in the model for drains W3 to W6. In *Table E1.2*, the baseline condition refers to the situation in which there is no Lung Mei bathing beach development and the village sewers are not connected to Drainage Services Department (DSD)'s new public sewerage system. The operation phase refers to the situation in which Lung Mei bathing beach development is in place. Three scenarios have been considered, ie 20%, 40% and 60% of village sewers are connected to DSD's new public sewerage system.

Table E1.1: EPD Routine Monitoring Data at TR4

Parameters	Season	
	Dry	Wet
Flow (cubic meter/s)	0.056	0.105
Dissolved Oxygen (%saturation)	89.417	91.021
Dissolved Oxygen (mg/L)	7.906	7.277
Water Temperature (deg.C)	21.383	26.706
pH	7.419	7.365
Turbidity (NTU)	16.804	5.650
Salinity (psu)	0.185	0.150
Total Suspended Solids (mg/L)	19.767	7.728
5-day Biochemical Oxygen Demand (mg/L)	1.889	1.450
Escherichia coli (cfu/100ml)	2715	3499
Ammonia-nitrogen (mg/L)	0.484	0.245
Nitrite-nitrogen (mg/L)	0.042	0.025
Nitrate-nitrogen (mg/L)	0.592	0.740
Total Kjeldahl nitrogen (mg/L)	0.686	0.409
Ortho-phosphate as phosphorus (mg/L)	0.113	0.093
Total phosphorus (mg/L)	0.166	0.126

Table E1.2: Pollution Inventory for Drains W3, W4, W5 and W6

Drain ID	Flow [a] (m^3/s)	Salinity [a] (psu)	ModTemp' [a] [d] (deg.C)	E coli' [a] (cfu/100ml)	OXY' [a] [e] (mg/l)	CBOD5' [a] (mg/l)	NO3' [a] [b] (mg/l)	NH4' [a] [b] (mg/l)	PO4' [a] [c] (mg/l)	AAP' [a] [c] (mg/l)	Si' [a] (mg/l)	DetN' [a] [b] (mg/l)	DetP' [a] [c] (mg/l)	IM1' [a] [f] (mg/l)
Dry season - Baseline														
W3	0.056	0.19	21.40	907	7.90	1.90	0.63	0.48	0.11	0.03	2.00	0.20	0.02	19.80
W4	0.056	0.19	21.40	23360	7.90	1.90	0.63	0.48	0.11	0.03	2.00	0.20	0.02	19.80
W5	0.056	0.19	21.40	5909	7.90	1.90	0.63	0.48	0.11	0.03	2.00	0.20	0.02	19.80
W6	0.056	0.19	21.40	60	7.90	1.90	0.63	0.48	0.11	0.03	2.00	0.20	0.02	19.80
Wet season - Baseline														
W3	0.105	0.15	26.70	907	7.30	1.50	0.77	0.24	0.09	0.01	2.00	0.17	0.02	7.70
W4	0.105	0.15	26.70	23360	7.30	1.50	0.77	0.24	0.09	0.01	2.00	0.17	0.02	7.70
W5	0.105	0.15	26.70	5909	7.30	1.50	0.77	0.24	0.09	0.01	2.00	0.17	0.02	7.70
W6	0.105	0.15	26.70	60	7.30	1.50	0.77	0.24	0.09	0.01	2.00	0.17	0.02	7.70
Dry season Operational - 60% connection rate														
W3	0.0224	0.19	21.40	907	7.90	1.90	0.63	0.48	0.11	0.03	2.00	0.20	0.02	19.80
W4	0.0224	0.19	21.40	23360	7.90	1.90	0.63	0.48	0.11	0.03	2.00	0.20	0.02	19.80
W5	0.0224	0.19	21.40	5909	7.90	1.90	0.63	0.48	0.11	0.03	2.00	0.20	0.02	19.80
W6	0.0224	0.19	21.40	60	7.90	1.90	0.63	0.48	0.11	0.03	2.00	0.20	0.02	19.80
Wet season Operational - 60% connection rate														
W3	0.0714	0.15	26.70	907	7.30	1.50	0.77	0.24	0.09	0.01	2.00	0.17	0.02	7.70
W4	0.0714	0.15	26.70	23360	7.30	1.50	0.77	0.24	0.09	0.01	2.00	0.17	0.02	7.70
W5	0.0714	0.15	26.70	5909	7.30	1.50	0.77	0.24	0.09	0.01	2.00	0.17	0.02	7.70
W6	0.0714	0.15	26.70	60	7.30	1.50	0.77	0.24	0.09	0.01	2.00	0.17	0.02	7.70
Dry season Operational - 40% connection rate														
W3	0.0336	0.19	21.40	907	7.90	1.90	0.63	0.48	0.11	0.03	2.00	0.20	0.02	19.80
W4	0.0336	0.19	21.40	23360	7.90	1.90	0.63	0.48	0.11	0.03	2.00	0.20	0.02	19.80
W5	0.0336	0.19	21.40	5909	7.90	1.90	0.63	0.48	0.11	0.03	2.00	0.20	0.02	19.80
W6	0.0336	0.19	21.40	60	7.90	1.90	0.63	0.48	0.11	0.03	2.00	0.20	0.02	19.80

Drain ID	Flow [(a)] (m^3/s)	Salinity [(a)] (psu)	ModTemp' [(a) (d)] (deg.C)	E coli' [(a)] (cfu/100ml)	OXY' [(a) (e)] (mg/l)	CBOD5' [(a)] (mg/l)	NO3' [(a) (b)] (mg/l)	NH4' [(a) (b)] (mg/l)	PO4' [(a) (c)] (mg/l)	AAP' [(a) (c)] (mg/l)	Si' [(a)] (mg/l)	DetN' [(a) (b)] (mg/l)	DetP' [(a) (c)] (mg/l)	IM1' [(a) (f)] (mg/l)
Wet season Operational - 40% connection rate														
W3	0.0826	0.15	26.70	907	7.30	1.50	0.77	0.24	0.09	0.01	2.00	0.17	0.02	7.70
W4	0.0826	0.15	26.70	23360	7.30	1.50	0.77	0.24	0.09	0.01	2.00	0.17	0.02	7.70
W5	0.0826	0.15	26.70	5909	7.30	1.50	0.77	0.24	0.09	0.01	2.00	0.17	0.02	7.70
W6	0.0826	0.15	26.70	60	7.30	1.50	0.77	0.24	0.09	0.01	2.00	0.17	0.02	7.70
Dry season Operational - 20% connection rate														
W3	0.0448	0.19	21.40	907	7.90	1.90	0.63	0.48	0.11	0.03	2.00	0.20	0.02	19.80
W4	0.0448	0.19	21.40	23360	7.90	1.90	0.63	0.48	0.11	0.03	2.00	0.20	0.02	19.80
W5	0.0448	0.19	21.40	5909	7.90	1.90	0.63	0.48	0.11	0.03	2.00	0.20	0.02	19.80
W6	0.0448	0.19	21.40	60	7.90	1.90	0.63	0.48	0.11	0.03	2.00	0.20	0.02	19.80
Wet season Operational - 20% connection rate														
W3	0.0938	0.15	26.70	907	7.30	1.50	0.77	0.24	0.09	0.01	2.00	0.17	0.02	7.70
W4	0.0938	0.15	26.70	23360	7.30	1.50	0.77	0.24	0.09	0.01	2.00	0.17	0.02	7.70
W5	0.0938	0.15	26.70	5909	7.30	1.50	0.77	0.24	0.09	0.01	2.00	0.17	0.02	7.70
W6	0.0938	0.15	26.70	60	7.30	1.50	0.77	0.24	0.09	0.01	2.00	0.17	0.02	7.70

Notes:

(a) All flows and concentrations are derived from EPD routine monitoring data for Shan Liu Stream, TR4, with exception of *E.coli* and Silicon (Si). *E.coli* concentrations at four drains are taken from field surveys data collected during December 2006 to January 2007. An estimated value of Si was used.

(b) Nitrogen species are composed as follows:

NO_3 = nitrates + nitrites

NH_4 = ammonia

DetN = Kjeldahl nitrogen - ammonia

(c) Phosphorus species are composed as follows:

PO_4 = phosphates

DetP = 0.02 (about 10% of Det N)

AAP = remaining part of total P

(d) ModTemp = modelled temperature

(e) OXY = dissolved oxygen

(f) IM1 = total suspended solids

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 were as follows:

- The assessment was 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 were 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 have not been included in the modelling assessment. However, their impacts related to water quality were assessed in the EIA.

- Ad hoc navigation of marine traffic;
- Near shore scouring of bottom sediment; and
- Access of marine barges back and forth the site.

1.7 Water Sensitive Receivers for Modelling

The Project Site is located in the Tolo Harbour, near Ting Kok SSSI & Coastal Protection Areas, Yim Tin Tsai East & West Fish Culture Zones, Sha Lan Non-gazetted Beach, Lung Mei & Yim Tin Tsai Mangroves, Pak Sha Tau coral, WSD Seawater Intakes for Tai Po Industrial Estate and Marine Science Laboratory (MSL) of Chinese University. *Table E1.2* shows the identified water sensitive receivers (WSRs) (including ecological sensitive receivers) in the vicinity of the Beach (see Figure 6.1 in the EIA Report which illustrates the surrounding environment and the modelling output locations for the WSRs).

Table E1.2: Water Quality Modelling Output Locations in the Vicinity of the Beach

Sensitive Receiver	Name	Water Quality Modelling Output Location
Fisheries Resources		
Fish Culture Zone	Fish Culture Zone in Yim Tin Tsai East	SR1
	Fish Culture Zone in Yim Tin Tsai West	SR2
Marine Ecological Resources		
SSSI/Coastal Protection Area	Ting Kok SSSI, near Ting Kok	SR3
	Ting Kok SSSI, near Shuen Wan	SR4
Mangrove	Ting Kok	SR5
	Yim Tin Tsai, next to Yim Tin Tsai West Fish Culture Zone	SR6
Coral	Pak Sha Tau	SR7
Others		
Proposed Gazetted Beaches (used only for the operation phase)	Lung Mei, four corners and middle of proposed site	SR8 – SR12
Non-gazetted Beaches	Sha Lan	SR13
Seawater Intakes	MSL of Chinese University	SR14
	Tai Po Industrial Estate	SR15
Other Recreational Areas	Tai Mei Tuk Water Sports Centre	SR16
EPD Monitoring Stations	Tolo Harbour & Channel WCZ	TM3, TM5, TM6

2 CONSTRUCTION AND OPERATIONAL SCENARIOS

2.1 Construction Phase

The construction for the proposed beach will involve the followings:

- Dredging at the proposed beach area;
- Dredging at the two groynes; and
- Sandfilling at the proposed beach area.

Hence, the water quality model was used to assess the construction phase impacts. The WAQ model was used to directly simulate the following parameters:

- Suspended solids; and
- Sediment deposition.

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

Based upon the results from above, the DO depletion and nutrients release were assessed (1). In addition to the modelling, results from the elutriate test were used to assess the impacts of the dredging for various parameters. Such assessment is presented in the EIA Report.

2.1.1 Dredging

The model was used to assess the impacts posed by dredging for groynes construction and the beach.

Assuming only dredging for the groynes and beach, the dredging volume has been estimated to be approximately 10,500 m^3 but a more conservative value of 12,000 m^3 was assumed in the model for assessment purpose. Dredging in the offshore area will be conducted by Closed Grab Dredger whereas Excavator will be used in the onshore area. Bulldozer will be used to profiling the deposited sand.

Dredging by Closed Grab Dredger

The type of dredgers used will depend on the geometry of the areas to be dredged, programme requirements and any constraints imposed by EPD on production rates. As the dredging is for the groynes and beach, it seems likely that the dredging would be undertaken using grab dredgers. Simulations and related assumptions for grab dredgers are discussed below.

(1) By reviewing the results of SS elevations, SS impacts are found to be minimal. Hence DO depletion was calculated based on the SS to give most conservative results and potential nutrients release was predicted based on the modelling results and sediment sampling test results.

Closed grab dredgers will be utilised in the dredging works for the beach. Note that proper closed grabs (ie so-called "watertight" grabs) have not yet been used in Hong Kong so far. The limited measurement evidence suggests that conventional closed grabs do not significantly reduce the overall rate of sediment release but do tend to confine the sediment release to the near-bed zone which tends to reduce the distance over which it transported before settling. In order to be properly effective, highly specialised proprietary systems (such as the Cable Arm grab) need to be used in conjunction with washing tanks, silt screens and special operating methods. Such an approach would normally only be deemed necessary in the case of highly contaminated sediments.

Closed 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.

There are two situations that the sediment release would occur as follows, however, these were not included in the model.

- 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 was 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 were not addressed further in this document.

There are a few assumptions made in the sediment plume modelling simulations for grab dredging as listed in details below.

Working Time - Based on current Hong Kong working practice with grab dredgers a 12 hour (7am to 7pm) working day is typical for major dredging and sandfilling works. A seven-day working week is also typical for this sort of construction work in Hong Kong. However, it is anticipated that the construction work will not be conducted during Sundays and Public Holidays. The duration of the work will be dictated by the programme requirements of the development, which is anticipated to last for 2 months. For the simulation of the scenario, 8-working hour per day and 6-working day per week are assumed in the model.

Dredging Rate - 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. Assuming a 3 m^3 closed grab will be used and the above working time, the production rates for dredging marine mud will be approximately 31 m^3 hr^{-1} (12,000 m^3 ÷ 48 days ÷ 8 hours per day). For the modelling exercise, 31 m^3 hr^{-1} (0.009 m^3 s^{-1}), was assumed.

Loss Rate - For the assessment purpose, it is assumed that a typical grab size of 3 m^3 will be used for dredging operations. Loss rates have been taken from previously accepted EIAs in Hong Kong (4) (5) (6) and has been based on a review of world wide data on loss rates from dredging operations undertaken as part of assessing the impacts of dredging areas of Kellett Bank for mooring buoys (7). Although the Hebe Haven EIA used a loss rate of 0.5 kg s^{-1}, with considerations on other studies, the assessment concluded that for small size grab dredgers (up to 8 m^3) working in areas with significant amounts of debris on the seabed (such as in the vicinity of existing mooring buoys) that the loss rates would be 25 kg m^{-3} dredged, while the loss rate in areas where debris is less likely to hinder operations would be 17 kg m^{-3} dredged. The loss rate to be used is better to make reference to the geophysical surveys which will show whether there are significant quantities of debris in the vicinity of the dredging works. In order to look into the worst case, the higher loss rate, ie 25 kg m^{-3}, is adopted in this Study. The loss rate in kg s^{-1} was calculated based on the dredging rate as follows:

Loss Rate (kg s^{-1})

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

= 0.009 m^3 s^{-1} * 25 kg m^{-3}

= **0.22 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 are, therefore, considered to represent conservative conditions that will not prevail for any great length of time.

Number of Plants - The number of dredgers in operation at any one time will depend on the programmed requirements of the port development. It is assumed that one dredger will be used at one time during the dredging work.

Trajectory of Dredging - In the model, it is assumed that the grab dredger will move anti-clockwise. In reality, the grab dredger is stationary at a location for some time before moving on to another location. In the model, it is assumed that the trajectory will be covered by one grab dredger in a 15-day spring-neap cycle.

Other Assumptions - The sediment loss during dredging by closed grab dredger is assumed to be continuous throughout the working time, ie 8 hours a day, 6 days per week. Besides, dredging of contaminated and uncontaminated mud is assumed to be conducted at the same rate. In addition, the spread of released sediment is assumed to take place uniformly over the water column.

From the finding of the Working Paper 2.5 – Wave and Sediment Modelling Report, the actual annual net drift rate is likely to be in a range of 10 to 150 m^3 yr^{-1}, and therefore, no maintenance dredging is anticipated during the operational stage of the Project.

2.1.2 Sandfilling

Sandfilling was assumed to be conducted without the groynes (see *Section 2.1.3* for details of the groynes) in the model. This will give more conservative results since in reality it will be conducted after the construction of the groynes. For the sandfilling at the beach area on land above the high water level, dozers will be used. It is anticipated that about 1/2 area of the sandfilling work will be conducted on land above the high water level, whereas approximately 1/2 area might be exposed to water during high water condition.

Number of Plants – One sandfilling barge will be used for sandfilling of sand materials onto the intertidal area of the proposed beach development works. The sand materials will be placed onto the sandfilling area via a conveyor belt installed on barge extends to the area. Onshore filling will be conducted by end-tipping.

Working Time – The marine works for sandfilling will be completed in 3 to 4 months. It is anticipated that the filling operation will last about 2 months and the marine transportation between the sand loading point and the Project site will take about 1 month.

Filling Rate – It is estimated that 37,500 m^3 of sandfilling material (sand) will be required for the project. However, in order simulate a worse scenario, the proposed allowable maximum filling rate is 1,000 m^3 day^{-1} with a continuous filling operation of 3 hrs per day.

Loss Rate – The sandfilling material (yellowish brown sand) will be imported from Shajao of Pearl River Delta and is primarily sand grains with D_{50} of 0.2 to 0.5mm. The fine particles (silt) content is anticipated to be less than 1%. Dry density is assumed to be 1,600 kg m^{-3}. By assuming 10% of sandfilling material will be lost to the water column, the loss rate is calculated as 0.15 kg s^{-1}, continuously released within 3 hours per day.

Location of Filling – Sandfilling will be conducted without two groynes. Sandfilling will be conducted within the same area as for dredging. This again would give conservative results since the design sandfilling area would not be beyond the groynes.

According to the Port Works Design Manual Part 5 Guide to Design of Beaches published by CEDD, the settling velocity of the proposed sand grains is much higher than that of the fine particles (mud) due to their significant size difference. Even when the sand grains are in suspension, they are still close to the seabed because of the relative high settling velocity.

It is considered that the modelling for the sandfilling is based on the conservative assumptions since the works will be carried out with the following conditions:

- Less than 1/2 of sandfilling will be exposed to water during high water level;
- Sandfilling will be conducted within the groynes;
- High settling velocity for the proposed sand grains;
- Only one sandfilling barge will be used for backfilling of sand materials onto the intertidal area of the proposed beach development works. The sand materials will be placed onto the sandfilling area via a conveyor belt installed on barge extends to the area; and
- Silt curtain will be provided around the proposed dredging extent as a precautionary measure during the sandfilling activities.

No near future filling work is anticipated during the operation phase of this Project. However, monitoring programme on the sand drift such as by conducting a hydrographic survey every year is proposed.

2.1.3 Groynes Structure

Prior to the sandfilling operations, two groynes will be built at the western and eastern edges of the bathing beach area. The cross-sections of the Western Groyne and Eastern Groyne are shown in *Figures E2.1a* and *E2.1b* respectively. These two groynes are inclined, ie the toes of the groynes are submerged in the water. This is circumvented by combining thin dams (closing off the whole water column) and so-called 'gate structures' that close off only part of the water column. The thin dam and gate structure is defined for the Western Groyne and Eastern Groyne as follows:

- For Eastern Groyne, use a thin dam for the first cell (the closest cell to the coast) and a gate structure closing the lower 50% and 25% of the water column for the second and third grid cells respectively; and
- For Western Groyne, use a thin dam for the first cell (the closest cell to the coast) and a gate structure closing the lower 50% of the water column for the second grid cell.

The above closure percentage of water column is estimated referring to the mean higher high water mark (MHHW), ie +2.0mPD.

2.2 Operation Phase

In order to determine whether the existing Lung Mei non-gazetted beach will comply with the WQOs to be proposed to become a gazetted beach, it is necessary to determine the relative change in *E. coli* level at the beach between pre-development and operation phases.

During the operation of the proposed beach, the sewage from the beach building will be connected to the public sewer and no sewage will be discharged onto the beach from the beach building. In addition, the wastewater from the upstream villages is estimated to be reduced by 60% after the sewerage construction works.

The modelling and assessment has assessed the *E. coli* level at the proposed beach and other WSRs during its operation in 2010, which would take into consideration on the pollution reduction from the sewerage construction works at the representative discharges in the vicinity of the Study Area. The 2010 model grid has incorporated the beach facilities to account for the latest coastline. No other modification to the coastline is anticipated in 2010.

The WAQ model was used to directly simulate the following parameters:

- *E. coli*; and
- Chlorophyll-*a*.

2.2.1 Input Parameter for E. coli

The *E. coli* level used in the model will be primarily based upon the field measurements and EPD's routine monitoring data for the current non-gazetted bathing beach at Lung Mei. A separate proposal 'Determination of Discharge Water Characteristics at Lung Mei Area' was also conducted to investigate the *E. coli* level from the key sources which would affect the project area. Water samples were collected at the representative discharge outlets and their upstream locations during different period of the days, to identify the *E. coli* levels. The pollution inventory is presented in *Table E1.1*.

3 RESIDUAL IMPACT

Residual impact for the dredging works during the construction phase and the operation phase has been determined based upon the results from the water quality modelling.

4 CUMULATIVE IMPACT

4.1 Potential Concurrent Projects

It is anticipated that no other potential concurrent marine projects will be carried out in Tolo Harbour near the Study Area during the construction phase. Therefore, assessment on the cumulative impacts as a result of concurrent projects will not be required.

5 REFERENCE

1. The particular formulations used express the bottom roughness by the so-called Nikuradse roughness coefficient, which has the dimension of meter.
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.
4. ERM - Hong Kong, Ltd (2005) Op Cit.
5. ERM-Hong Kong, Ltd (2000) *Construction of an International Theme Park in Penny's Bay of North Lantau together with its Essential Associated Infrastructures - Final EIA Report*. For the Civil Engineering and Development Department, Hong Kong SAR Government. Approved on 28 April 2000.
6. Hyder Consulting Ltd (1999) *Hebe Haven Yacht Club Development Phase 2 EIA Report*. Approved on 3 Jan 2000.
7. ERM - Hong Kong, Ltd (1997) *Environmental Impact Assessment: Dredging an Area of Kellett Bank for Reprovisioning of Six Government Mooring Buoys. Working Paper on Design Scenarios.* For the Civil Engineering Department, Hong Kong Government.
8. ERM - Hong Kong, Ltd (2003). The Proposed Submarine Gas Pipelines from Cheng Tou Jiao Liquefied Natural Gas Receiving Terminal, Shenzhen to Tai Po Gas Production Plant, Hong Kong. For The Hong Kong and China Gas Company Ltd. EIA Study. Approved on 23 April 2003.

Appendix E1

Figures

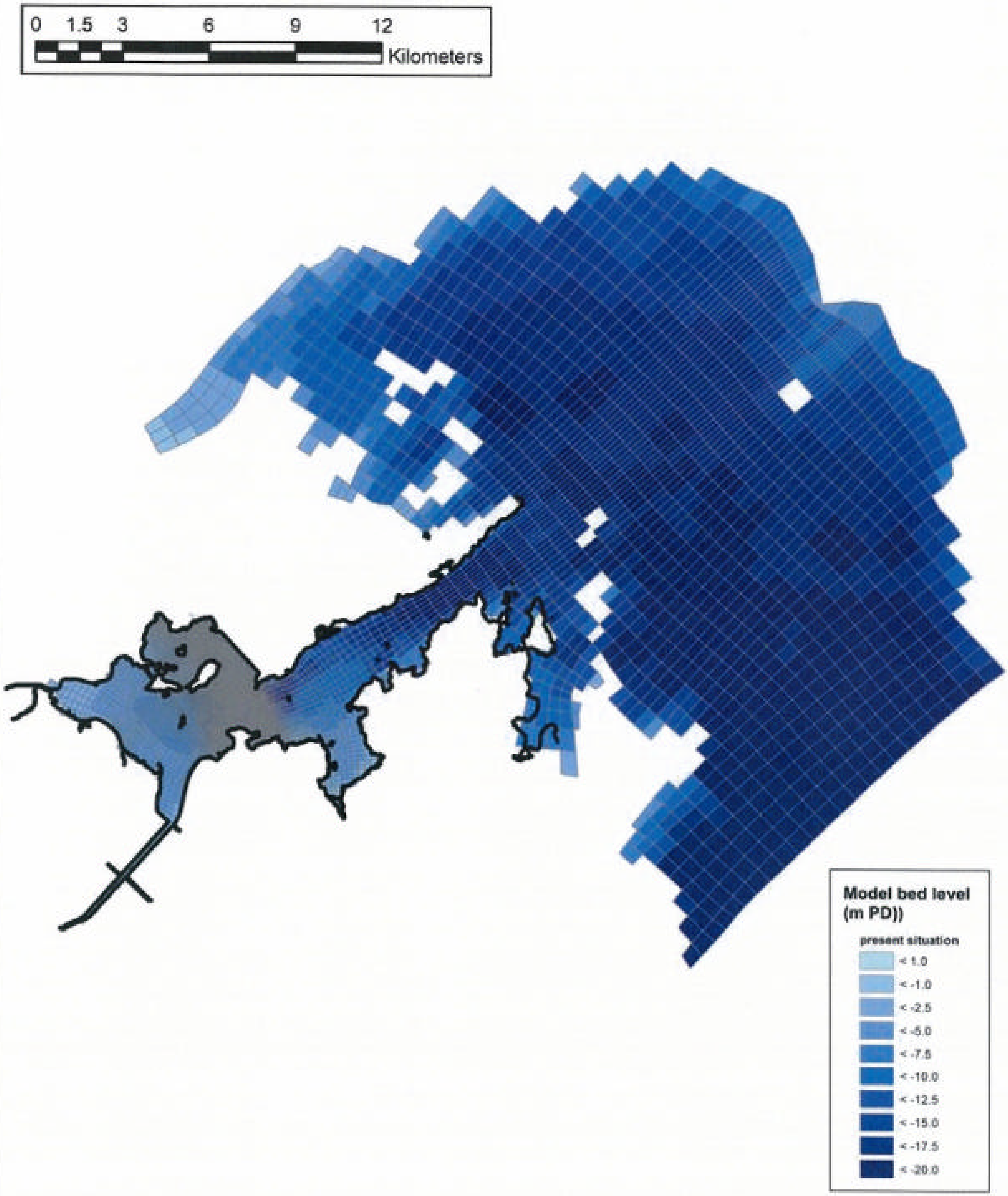


Figure E1.1a: THM Model Grid and Bathymetry (with refined PCM) for Tolo Harbour Area for Construction Phase in 2008.

Agreement No.: CE 59/2005(EP)	DEVELOPMENT OF A BATHING BEACH AT LUNG MEI, TAI PO	FIGURE E1.1a
Client: CEDD CIVIL ENGINEERING AND DEVELOPMENT DEPARTMENT	Consulting Engineer: Halcrow Halcrow China Ltd. ERM Environmental Resources Management as sub-consultant	ENVIRONMENTAL IMPACT ASSESSMENT REPORT

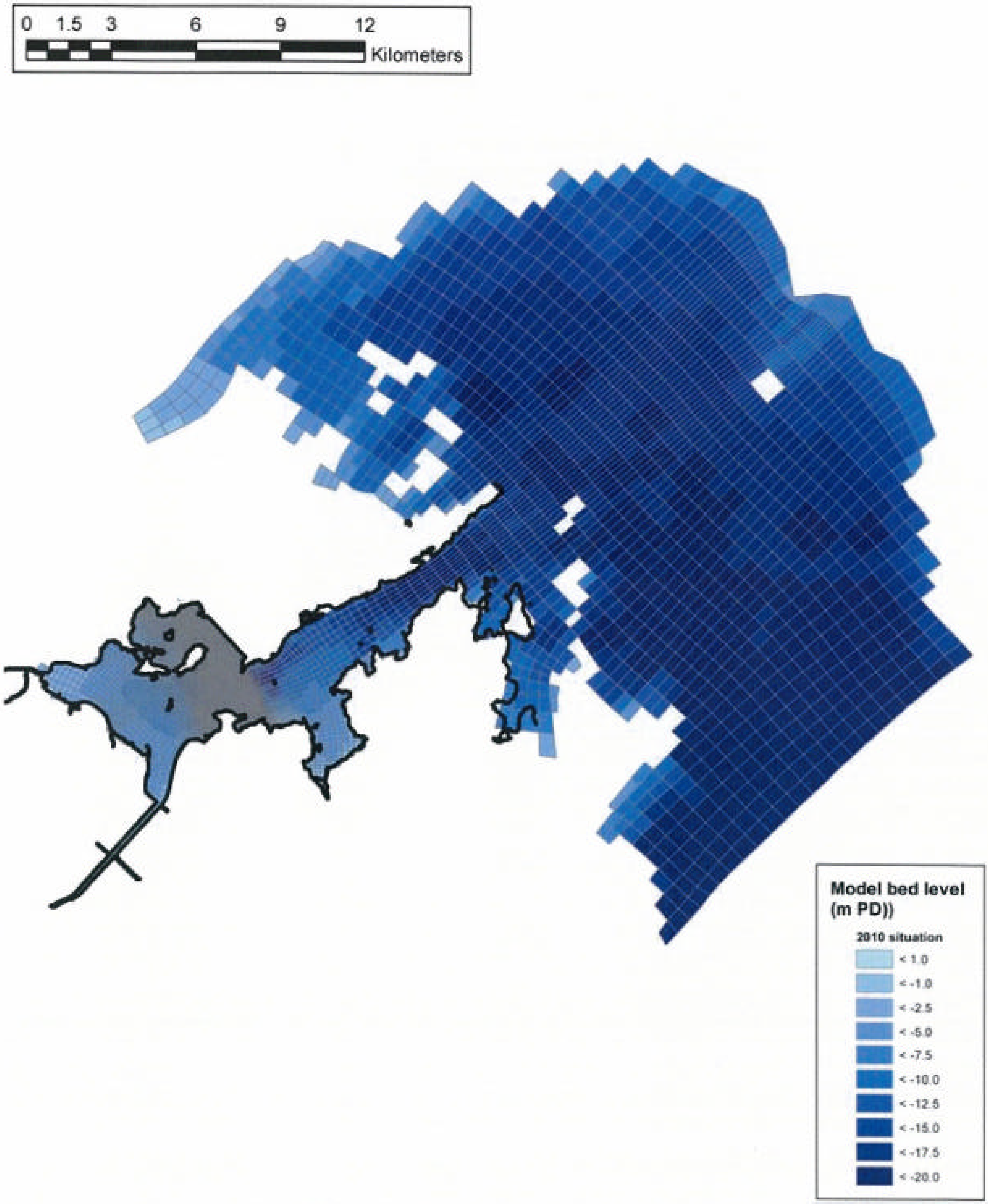


Figure E1.1b: THM Model Grid and Bathymetry (with refined PCM) for Tolo Harbour Area for Operational Phase in 2010

Agreement No.: CE 59/2005(EP)	DEVELOPMENT OF A BATHING BEACH AT LUNG MEI, TAI PO	FIGURE E1.1b
Client: CEDD CIVIL ENGINEERING AND DEVELOPMENT DEPARTMENT	Consulting Engineer: Halcrow, Halcrow China Ltd. ERM Environmental Resources Management as sub-consultant	ENVIRONMENTAL IMPACT ASSESSMENT REPORT

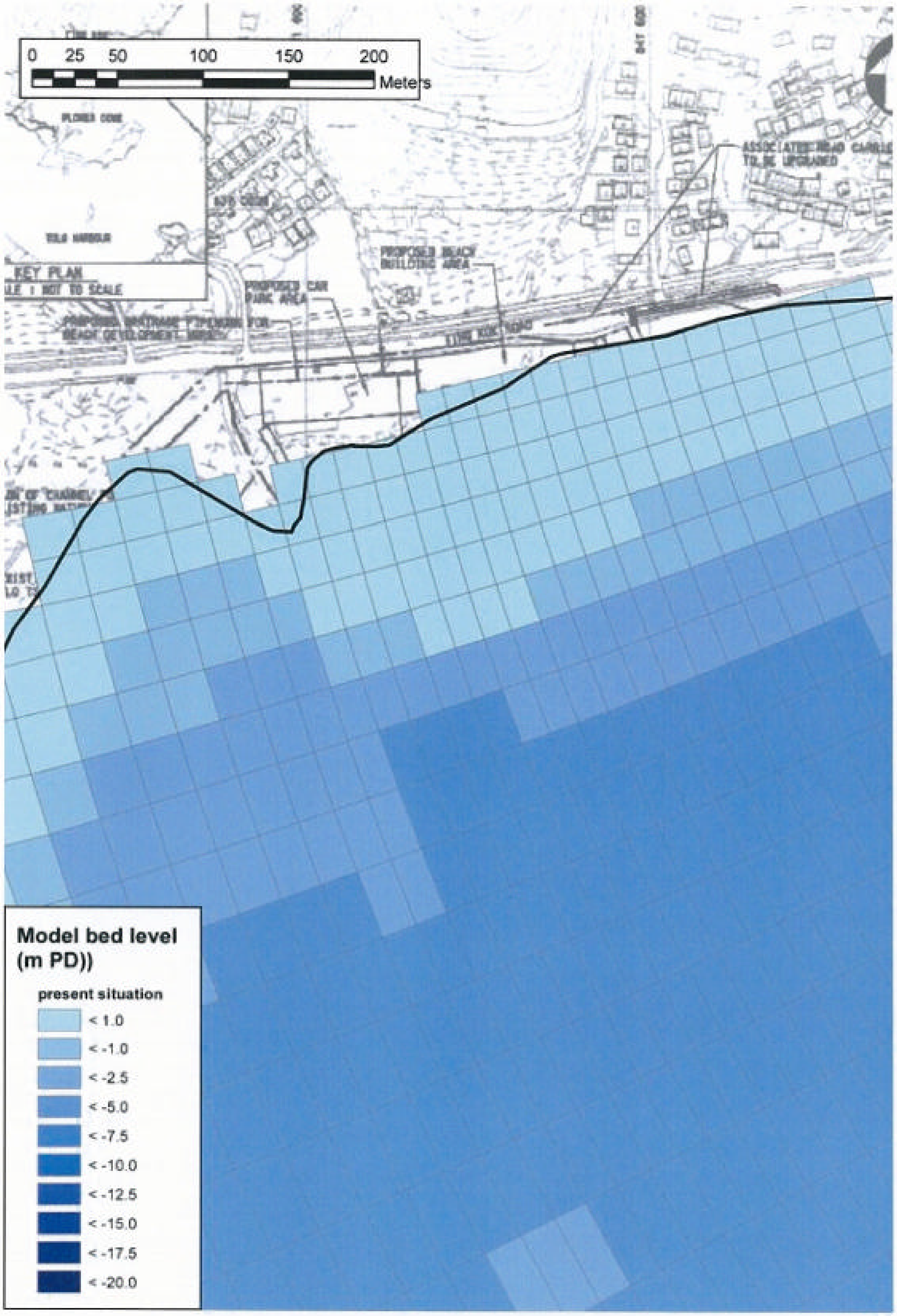


Figure E1.2a: Refined Model Grid and Bathymetry for PCM for the Study Area for Construction Phase in 2008

Agreement No.: CE 59/2005(EP)	DEVELOPMENT OF A BATHING BEACH AT LUNG MEI, TAI PO	FIGURE E1.2a
Client: CEDD CIVIL ENGINEERING AND DEVELOPMENT DEPARTMENT	Consulting Engineer: Halcrow, Halcrow China Ltd.; ERM Environmental Resources Management as sub-consultant	ENVIRONMENTAL IMPACT ASSESSMENT REPORT

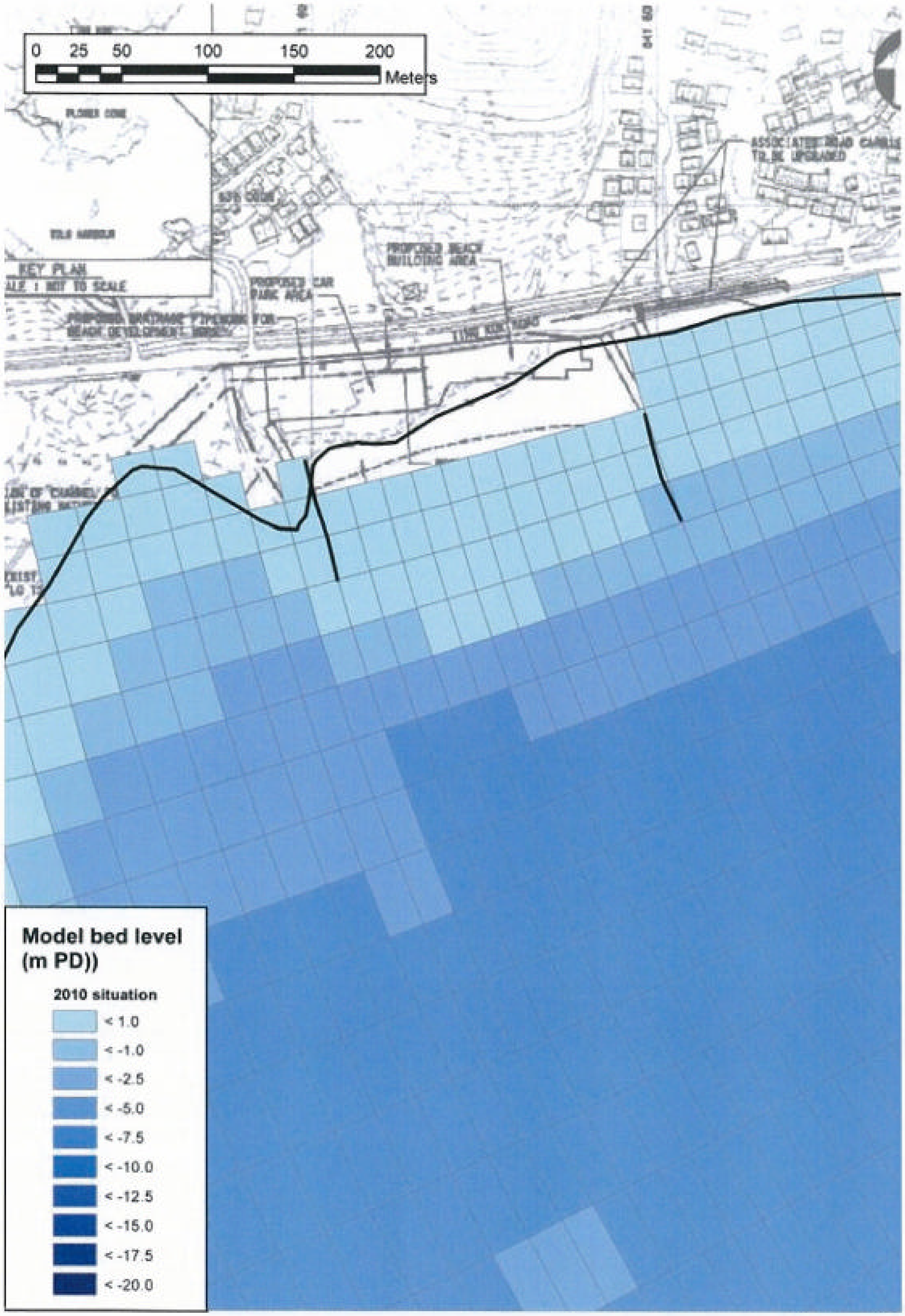
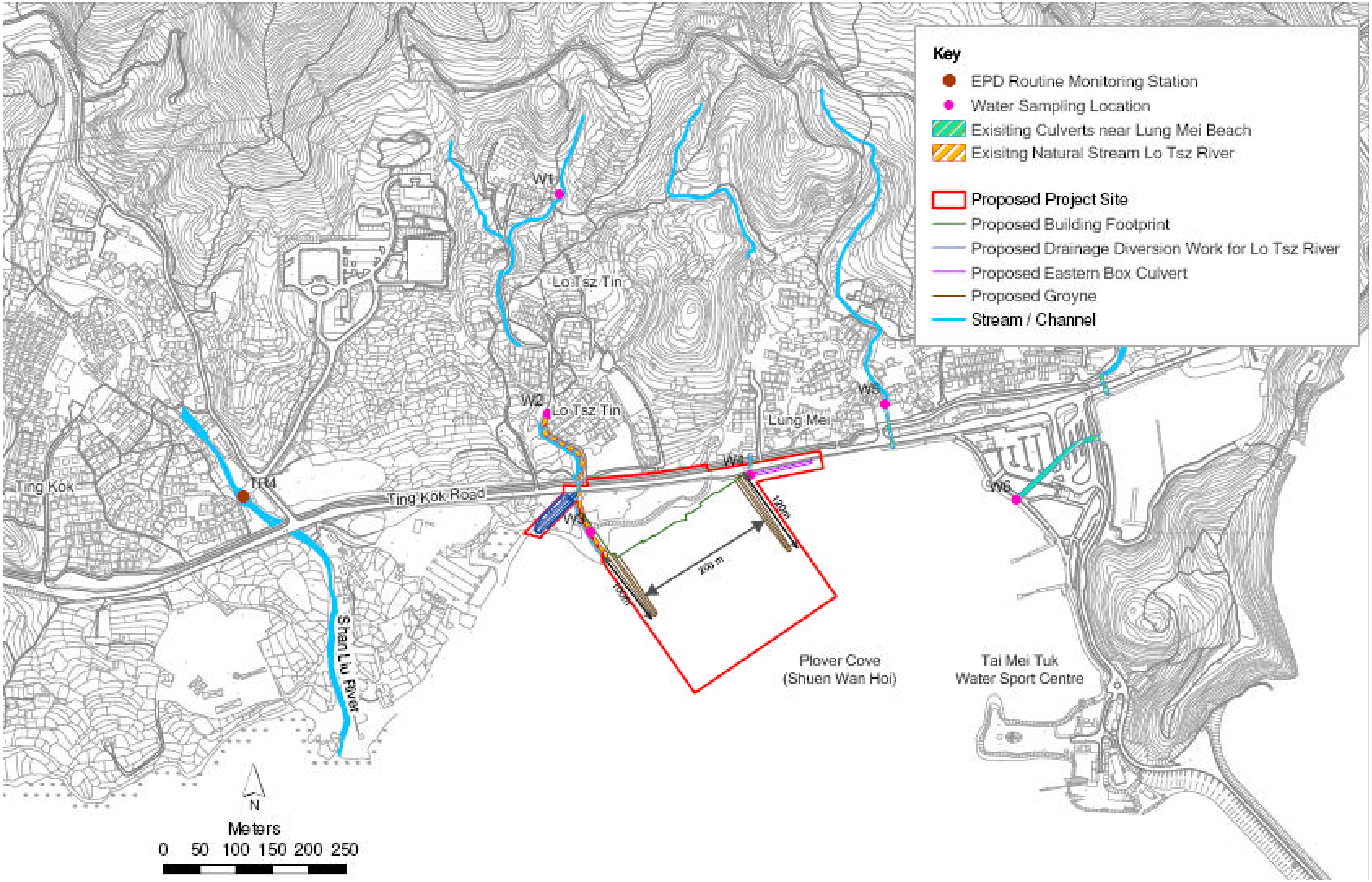


Figure E1.2b: Refined Model Grid and Bathymetry for PCM for the Study Area for Operational Phase in 2010

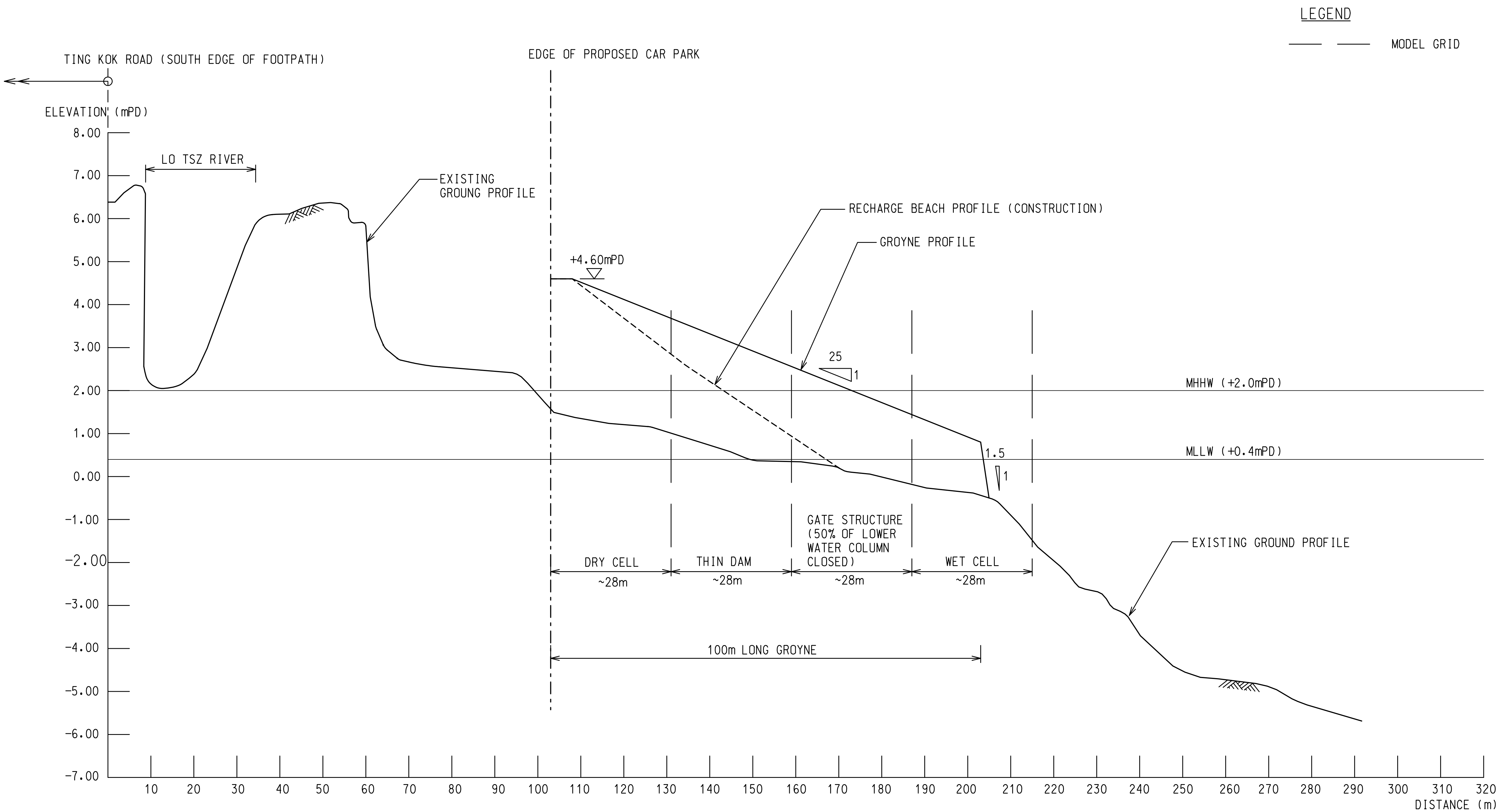
Agreement No.: CE 59/2005(EP)	DEVELOPMENT OF A BATHING BEACH AT LUNG MEI, TAI PO	FIGURE E1.2b
Client: CEDD CIVIL ENGINEERING AND DEVELOPMENT DEPARTMENT	Consulting Engineer: Halcrow, Halcrow China Ltd. ERM Environmental Resources Management as sub-consultant	ENVIRONMENTAL IMPACT ASSESSMENT REPORT



CEDD CIVIL ENGINEERING AND DEVELOPMENT DEPARTMENT	Consulting Engineer: Halcrow, Halcrow China Ltd.; ERM Environmental Resources Management as sub-consultant	Agreement No.: CE 59/2005(EP)	ENVIRONMENTAL IMPACT ASSESSMENT REPORT
		Project Title: DEVELOPMENT OF A BATHING BEACH AT LUNG MEI, TAI PO	Figure Title: LOCATION OF EPD ROUTINE RIVER MONITORING STATION, SHAN LIU STREAM (SAMPLING POINT TR4)

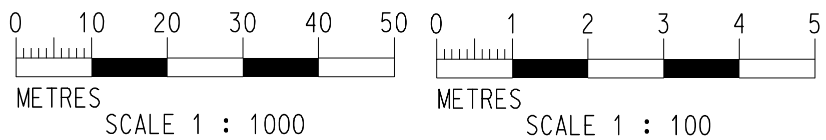
APPENDIX E – FIGURE E1.5a

Checked	Scale	Rev.
-	AS SHOWN	-
Designed	**Drawn**	**Date**
-	-	19/09/2007



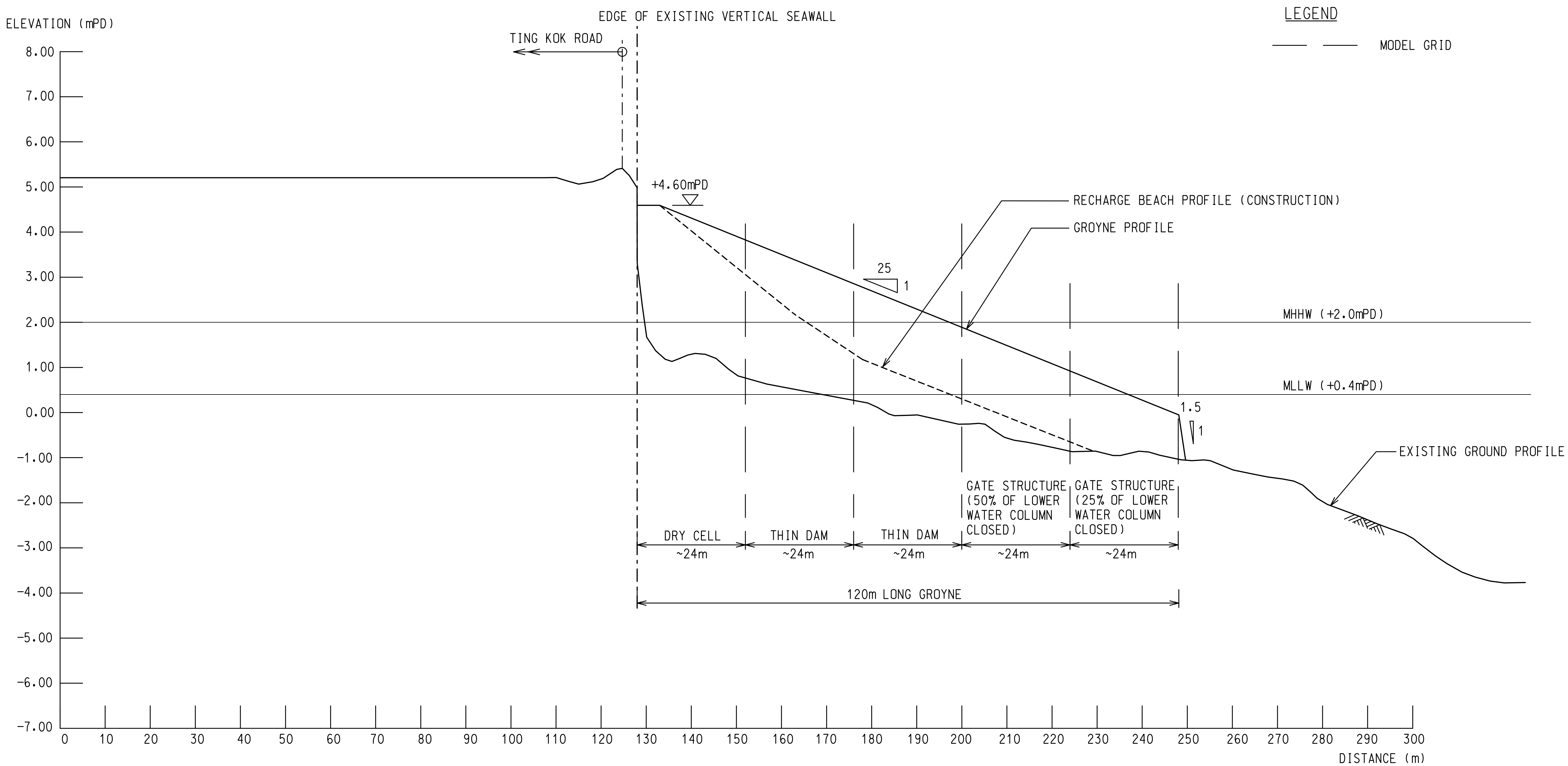
PROFILE X1

(PLANTER NOT SHOWN FOR CLARITY)
VERTICAL SCALE 1:100 HORIZONTAL SCALE 1:1000



CEDD CIVIL ENGINEERING AND DEVELOPMENT DEPARTMENT	Consulting Engineer: Halcrow, Halcrow China Ltd. ERM Environmental Resources Management as sub-consultant	Agreement No. : CE 59/2005 (EP)	ENVIRONMENTAL IMPACT ASSESSMENT REPORT	APPENDIX E - FIGURE E2.1a
		Project Title: DEVELOPMENT OF A BATHING BEACH AT LUNG MEI, TAI PO	Figure Title: PROFILE OF WESTERN GROYNE (PROFILE X1) - PREFERRED OPTION	Checked: PS; Scale: AS SHOWN; Rev.: 0; Designed: YC; Drawn: MJY; Date: 28/09/2007

philipF 13/11/2007
e:*proj*CALBDS*Figure*E_IA_Rpt*Fig2_1a_0_EIA_RPT.dgn



PROFILE X2

(PLANTER NOT SHOWN FOR CLARITY)
VERTICAL SCALE 1:100 HORIZONTAL SCALE 1:1000

0 10 20 30 40 50
METRES
SCALE 1 : 1000

0 1 2 3 4 5
METRES
SCALE 1 : 100

CEDD CIVIL ENGINEERING AND DEVELOPMENT DEPARTMENT	Consulting Engineer: Halcrow, Halcrow China Ltd.; ERM Environmental Resources Management as sub-consultant	Agreement No.: CE 59/2005 (EP)	ENVIRONMENTAL IMPACT ASSESSMENT REPORT
		Project Title: DEVELOPMENT OF A BATHING BEACH AT LUNG MEI, TAI PO	Figure Title: PROFILE OF EASTERN GROYNE (PROFILE X2) - PREFERRED OPTION

APPENDIX E - FIGURE E2.1b

Checked	Scale	Rev.
PS	AS SHOWN	0
Designed	**Drawn**	**Date**
YC	MJY	28/09/2007

philipF 13/11/2007
e:\proj\CALBDS\Figure\E_IA_Rpt\Fig2_1b_0_EIA_RPT.dgn