APPENDIX I
EXTRACT OF FINAL WATER QUALITY AND HYDRODYNAMIC ASSESSMENT REPORT (NOVEMBER 2002)

1. INTRODUCTION

1.1.1.1 Scott Wilson (Hong Kong) Ltd was commissioned by Environmental Protection Department (EPD) to carry out the *Extension of Existing Landfills and Identification of Potential New Waste Disposal Sites Study* under *Agreement No. CE 45/99*. Environmental Management Ltd is the sub-consultant of Scott Wilson to undertake preliminary water quality modelling of reclaimed and offshore sites.

1.1.1.2 An artificial island would be constructed to provide new land for provision of a landfill site. The fill materials to be used for filling consist of inert construction and demolition (C&D) materials and uncontaminated sediment. The major components of the C&D materials are rock, soil and concrete. The carrying out of filling activities would cause the release of fines and sediment particles into the surrounding water environment leading to water pollution. After the completion of the filling operations, the artificial island would be formed. The presence of the artificial island may change the hydrodynamic and water quality conditions in the surrounding waters.

1.1.1.3 The purpose of the modelling works is to determine the feasibility of the potential new waste disposal sites through the assessment of the potential impacts on hydrodynamic and water quality during the construction and operation of the Project. **Figure 1.1** shows the locations of the potential sites for construction of the artificial island. The Sites are divided into Western Sites and Eastern Sites and are listed as follows:

<u>Western Sites</u>

- M1 – Deep Bay
- M2 – Sha Chau
- M3 – Lantau Nouthwest
- M4 – Soko Islands
- M5 – South Cheung Chau Disposal Ground
- M6 – Lamma Breakwater
- M11 – Lamma North
- M12 – Lamma South

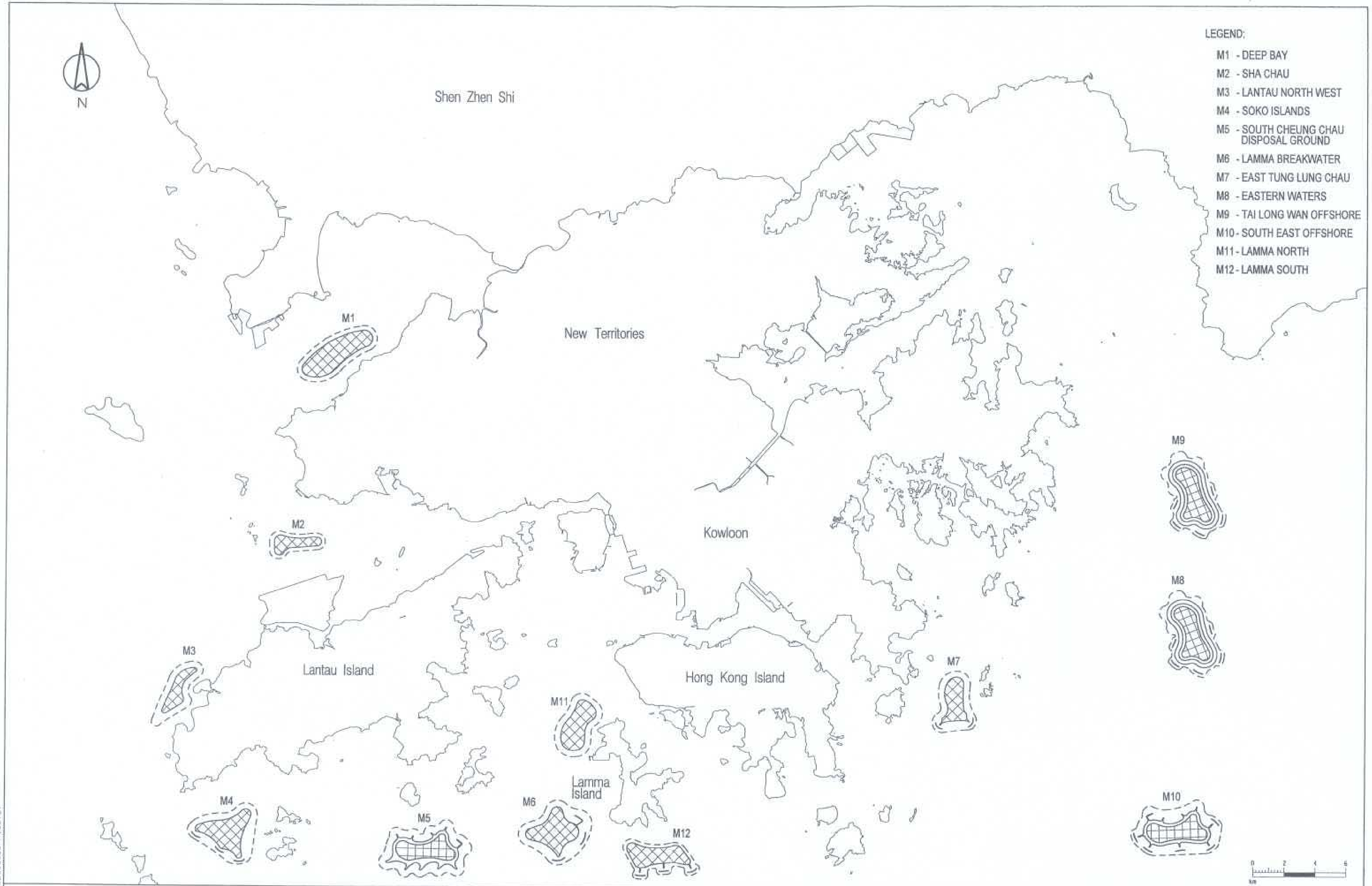
<u>Eastern Sites</u>

- M7 – East Tung Lung Chau
- M8 – Eastern Waters
- M9 – Tai Long Wan Offshore
- M10 – South East Offshore

1.1.1.4 This report presents the assessment of the potential hydrodynamic and water quality impacts during the construction and operation of the Project. The modelling methodology and relevant legislation and guidelines for the assessment are included and the approach to assess the water quality impacts arising from the construction and operational phases of the Project are also presented.

1.1.1.5 The structure of this report is outlined as follows:

Section	Title	Content
1	Introduction	General introduction of the background of the Study and the purpose of the report
2	Legislation and Guidelines	Legislation and guidelines relevant to the water quality impact assessment of the present study
3	Key Water Quality Parameters and Sensitive Receivers	A list of the key water quality parameters to be assessed and identification of water quality sensitive receivers
4	Modelling Tools	Description of the model set up, model input data and model verification
5	Model Runs	Details of the baseline, construction phase and operational phase model runs
6	Operational Phase Modelling Results	Discussion of the changes in hydrodynamic and water quality conditions due to the presence of the artificial island.
7	Construction Phase Modelling Results	Sediment plume modelling results for the assessment of the increase in suspended solids (SS) levels in the surrounding waters and the nearby water quality sensitive receivers during the construction phase.
8	Summary and Conclusion	Conclusion of the assessment



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Project	EXTENSION OF EXISTING LANDFILLS AND IDENTIFICATION OF POTENTIAL NEW WASTE DISPOSAL SITES	Date NOV.01 Scale 1:225000	Environmental Management Limited
	LOCATIONS OF POTENTIAL WASTE DISPOSAL SITES	Figure 1.1	

2. LEGISLATION AND GUIDELINES

2.1.1.1 The relevant legislation and guidelines to be used for water quality impact assessment within the Hong Kong waters include:

- Water Pollution Control Ordinance (WPCO) Chapter 358 (as amended by the Water Pollution Control (Amendment) Ordinance 1990 and 1993);
- Water Pollution Control (General) Regulations (as amended by the Water Pollution Control (General) (Amendment) Regulations 1990 and 1994);
- Environmental Impact Assessment Ordinance (EIAO) (Cap. 499), Technical Memorandum on Environmental Impact Assessment Process (EIAO-TM), Annexes 6 and 14;
- Water Quality Objectives (WQOs) for relevant Water Control Zones (WCZs).

2.1.1.2 The 12 potential new waste disposal sites for construction of the artificial island fall within the following WCZs:

- Deep Bay Water Control Zone (DBWCZ);
- North Western Water Control Zone (NWWCZ);
- North Western Supplementary Water Control Zone (NWSWCZ);
- Second Southern Supplementary Water Control Zone (SSSWCZ);
- Southern Water Control Zone (SWCZ); and
- Mirs Bay Water Control Zone (MBWCZ).

2.1.1.3 **Table 2.1** summarizes the WQOs for marine waters in Hong Kong.

2.1.1.4 The Water Supplies Department (WSD) issued Water Quality Objectives of Sea Water for Flushing Supply (at intake point). The criteria for assessing the water quality impacts on the WSD's seawater intakes will be based on the objectives shown in **Table 2.2**.

2.1.1.5 The locations of some of the Sites are near the waters in Shenzhen. The assessment of the water quality impacts within the Mainland waters will make reference to the *Sea Water Quality Standard (GB3097-1997)* established under the *National Standard of the People's Republic of China UCD 551463*. **Table 2.3** shows some of the selected parameters included in the Sea Water Quality Standard.

Table 2.1 Summary of Water Quality Objectives (WQOs) for Marine Waters of Hong Kong

Parameters	Water Quality Objective	Water Control Zone (WCZ)/Part(s) of zone/Subzones to which the WQOs apply
D.O. (within 2 m of bottom)	Not less than 2 mg/L for 90% samples	Marine waters of all WCZs except Tolo Harbour & Channel WCZ
D.O. (Depth averaged)	Not less than 4 mg/L for 90% samples	Marine waters of all WCZs except Tolo Harbour & Channel WCZ
D.O. (within 2 m of bottom)	Not less than 2mg/L	Harbour Subzone, Tolo Harbour & Channel WCZ
	Not less than 3mg/L	Buffer Subzone, Tolo Harbour & Channel WCZ
	Not less than 4mg/L	Channel Subzone, Tolo Harbour & Channel WCZ
D.O. (rest of water column)	Not less than 4mg/L	Tolo Harbour & Channel WCZ – whole zone
Nutrients	Not to be present in quantities that cause excessive algal growth	Marine waters of all WCZs except Tolo Harbour & Channel WCZ
Nutrients	Annual mean depth average inorganic nitrogen not to exceed 0.1 mg/L	Marine waters of Southern WCZ and Port Shelter WCZ
	Annual mean depth average inorganic nitrogen not to exceed 0.3 mg/L	Marine waters of Mirs Bay WCZ, Junk Bay WCZ, North Western WCZ (Castle Peak Subzone)
	Annual mean depth average inorganic nitrogen not to exceed 0.4 mg/L	Marine waters of Eastern Buffer WCZ, Western Buffer WCZ, Victoria Harbour WCZ
	Annual mean depth average inorganic nitrogen not to exceed 0.5 mg/L	Marine waters of Deep Bay WCZ (Outer Subzone) and North Western WCZ (Whole zone except Castle Peak Subzone).
	Annual mean depth average inorganic nitrogen not to exceed 0.7 mg/L	Marine waters of Deep Bay WCZ (Inner Subzone)
Unionized ammonia	Annual mean not to exceed 0.021 mg/L	All WCZs (whole zone) except Tolo Harbour & Channel WCZ
E.coli	Annual geometric mean not to exceed 610cuf/100mL	Secondary contact recreation subzones in Tolo Harbour & Channel WCZ, Southern WCZ, Port Shelter WCZ, Mirs Bay WCZ, Deep Bay WCZ, North Western WCZ, Western Buffer WCZ
	Annual geometric mean not to exceed 610cuf/100mL	Fish culture subzones in Tolo Harbour & Channel WCZ, Southern WCZ, Port Shelter WCZ, Junk Bay, Mirs Bay WCZ, Deep Bay WCZ, Eastern Buffer WCZ, Western Buffer WCZ
pH	To be in the range 6.5 – 8.5, change due to waste discharge not to be exceed 0.2	Marine waters of all WCZs except Tolo Harbour & Channel WCZ
pH	Change due to waste discharge not to be greater than ±0.5	Harbour Subzone, Tolo Harbour & Channel WCZ
	Change due to waste discharge not to be greater than ±0.3	Buffer Subzone, Tolo Harbour & Channel WCZ
	Change due to waste discharge not to be greater than ±0.1	Channel Subzone, Tolo Harbour & Channel WCZ
Salinity	Change due to waste discharge not to exceed 10% of natural ambient level	All WCZs (Whole zone) except Tolo Harbour & Channel WCZ
	Change due to waste discharge not to be greater than ±3ppt	Tolo Harbour & Channel WCZ
Temperature	Change due to waste discharge not to exceed 2^0C	All WCZs (Whole zone) except Tolo Harbour & Channel WCZ
	Change due to waste discharge not to exceed 1^0C	Tolo Harbour & Channel WCZ
Suspended solids	Waste discharge not to raise the natural ambient level by 30% nor cause the accumulation of suspended solids which may adversely affect aquatic communities	Marine waters of all WCZs except Tolo Harbour & Channel WCZ
Toxicants	Not to be present at levels producing significant toxic effect	All WCZs (Whole zone)
Chlorophyll-a	Not to exceed 20mg/m^3(μg/L) calculated as running arithmetic mean of 5 daily measurements for any location and depth	Harbour subzone, Tolo Harbour & Channel WCZ
	Not to exceed 10mg/m^3(μg/L) calculated as running arithmetic mean of 5 daily measurements for any location and depth	Buffer Subzone, Tolo Harbour & Channel WCZ
	Not to exceed 6mg/m^3(μg/L) calculated as running arithmetic mean of 5 daily measurements for any location and depth	Channel Subzone, Tolo Harbour & Channel WCZ

Table 2.2 Water Quality Objectives of Sea Water for Flushing Supply (at Intake Point)

Parameters	Target
Colour (H.U.)	< 20
Turbidity (N.T.U.)	< 10
Threshold Odour No.	< 100
Ammonical Nitrogen (mg/L)	< 1
Suspended Solids (mg/L)	< 10
Dissolved Oxygen (mg/L)	> 2
Biochemical Oxygen Demand (mg/L)	< 10
Synthetic Detergents (mg/L)	< 5
E.coli (count per 100 mL)	< 20,000

Source: Water Supplies Department, Hong Kong

Table 2.3 Relevant Mainland Sea Water Quality Standard

No	Item	Category 1	Category 2	Category 3	Category 4
1	Floating matter	No oil film, floating foam and other debris on water surface			No obvious oil film, floating foam and other debris on water surface
2	Colour, Odour, Taste	No abnormal colour, odour and taste should be presented in sea water			No disgusting colour, odour and taste should be presented in sea water
3	Suspended matter	Man-made increment ≤10	Man-made increment ≤ 100		Man-made increment ≤ 150
4	Coliform index (count/L)	10000; ≤ 700 for shellfish culture zone			—
5	Faecal coliform (count/L)	2000; ≤ 140 for shellfish culture zone			—
6	Pathogen	Should not be contained in the water of shellfish culture zone			
7	Temperature (°C)	Man-made increment should not exceed 1 in summer and 2 in other seasons		Man-made increment should not exceed 4	
8	pH	7.8 - 8.5 and change in pH level should not exceed 0.2 pH unit as compared to the ambient level		6.8～8.8 and change in pH level should not exceed 0.5 pH unit as compared to the ambient level	
9	Dissolved oxygen	> 6	> 5	> 4	> 3
10	Chemical oxygen demand（COD）	≤ 2	≤ 3	≤ 4	≤ 5
11	Biochemical oxygen demand (BOD_5）	≤ 1	≤ 3	≤ 4	≤ 5
12	Inorganic（as N）	≤ 0.20	≤ 0.30	≤ 0.40	≤ 0.50
13	No-ionic ammonia (as N）	≤ 0.020			
14	Activated phosphate (as P）	≤ 0.015	≤ 0.030		≤ 0.045
15	Mercury	≤ 0.00005	≤ 0.0002		≤ 0.0005
16	Cadmium	≤ 0.001	≤ 0.005	≤ 0.010	
17	Lead	≤ 0.001	≤ 0.005	≤ 0.010	≤ 0.050
18	Chromium (VI)	≤ 0.005	≤ 0.010	≤ 0.020	≤ 0.050
19	Total Chromium	≤ 0.05	≤ 0.10	≤ 0.20	≤ 0.50
20	Arsenic	≤ 0.020	≤ 0.030	≤ 0.050	
21	Copper	≤ 0.005	≤ 0.010	≤ 0.050	
22	Zinc	≤ 0.020	≤ 0.050	≤ 0.10	≤ 0.50
23	Selenium	≤ 0.010	≤ 0.020		≤ 0.050
24	Nickel	≤ 0.005	≤ 0.010	≤ 0.020	≤ 0.050

Remarks:
1. Category 1 represents marine fisheries zone, marine natural reserve area and critically endangered marine habitat protection area;
2. Category 2 represents marine cultural zone, marine bathing water, secondary contact or marine recreation area, and marine water which is directly related to human consumption;
3. Category 3 represents marine water for general industrial use and marine scenic area;
4. Category 4 represents marine harbour area and marine development area; and
5. All units in mg/L unless otherwise stated.

Source: Sea Water Quality Standard GB3097-1997

3. KEY WATER QUALITY PARAMETERS AND SENSITIVE RECEIVERS

3.1 Key Water Quality Parameters

3.1.1.1 The key concern during the construction phase of the Project is the release of contaminants from the filling actives. The fill materials are mainly inert C&D materials and uncontaminated sediment, and would not contain biodegradable and toxic substances. Sediment plume modelling will therefore be conducted to assess the increase in suspended solids (SS) levels in the surrounding waters and the nearby water quality sensitive receivers.

3.1.1.2 For the operational phase, the changes in hydrodynamic and water quality conditions due to the presence of the artificial island are of concern. The flushing capacity through the major channels in Hong Kong will be calculated to determine the reduction rate. The major water quality parameters assessed for the operational phase impact assessment include dissolved oxygen (DO), salinity, total inorganic nitrogen (TIN), unionized ammonia (UIA), SS, and *E.coli*.

3.2 Sensitive Receivers

3.2.1.1 The Western and Eastern Sites are located within 4 WCZs and 2 supplementary WCZs. The influence from the Sites may depend on the distance between the Sites and the locations of the affected areas. The water quality sensitive receivers that are potentially affected by this Project may include:

<u>Hong Kong Waters</u>

- Marine parks at Sha Chau and Lung Kwu Chau, Yan Chau Tong, Hoi Ha Wan, Tung Ping Chau and a marine reserve at Cape D'Aguilar
- Potential marine parks/marine reserve near Fan Lau, south of Lamma Island, Shelter Island, Long Ke Wan and Tai Long Wan Region, Ninepin Islands and Soko Islands
- Finless Porpoise Area
- Seagrass bed and horseshoe crab area near Ha Pak Nai
- Chinese White Dolphin feeding ground in the area covering Urmston Road Channel, and in the waters north, east and south of Lantau Island
- Secondary contact recreational zones
- Gazetted beaches
- Fish culture zones
- Cooling water intakes
- Pak Nai Site of Special Scientific Interest (Pak Nai SSSI)
- Tai Long Wan SSSI
- Oyster beds near Lau Fau Shan and Pak Nai
- Mai Po Nature Reserve in the Inner Deep Bay
- Tsim Bei Tsui SSSI
- WSD seawater intakes
- Sensitive coral areas such as near Beaufort Island, Tung Lung Chau and Ching Chau
- Proposed Fisheries Protection Area (FPA) at Port Shelter

Mainland Waters

- Oyster beds at Shekou
- Mangroves and mudflat at Futian
- Swimming beaches
- Fish, scallop and rockshore culture area

3.2.1.2 **Table 3.1** lists the potential water quality sensitive receivers to be included in the water quality models. The locations of these sensitive receivers are shown in **Figure 3.1a** and **3.1b**. **Figure 3.2** shows the secondary contact recreation zones.

3.2.1.3 The EPD marine water sampling stations within the concerned WCZs and in the WCZs close to the potential waste disposal sites are also included in the models as indicator points. **Figure 3.3** shows the locations of these stations.

Table 3.1 Water Quality Sensitive Receivers

No.	Sensitive Receivers	
1	CW1	Cooling Water Intake at Black Point
2	CW2	Cooling Water Intake at New Air Port
3	CW3	Cooling Water Intake at Tsing Yi
4	CW4	Cooling Water Intake at Lamma Island & Gazetted Beach at Lamma Beach
5	CW5	Cooling Water Intakes near Wanchai
6	CW6	Cooling Water Intakes at South East Kowloon Development
7	CW7	Cooling Water Intakes at Castle Peak Power Station
8	FC1	Fish Culture Zone at Ma Wan
9	FC2	Fish Culture Zone at Cheung Sha Wan
10	FC3	Fish Culture Zone at Lo Tik Wan
11	FC4	Fish Culture Zone at Sok Kwu Wan
12	FC5	Fish Culture Zone at Tung Lung Chau
13	FC6	Fish Culture Zone at Po Toi O
14	FC7	Fish Culture Zone at Ma Nam Wat & Gazetted Beach at Trio Beach
15	FC8	Fish Culture Zone at Kau Sai
16	FC9	Fish Culture Zone at Leung Shuen Wan
17	FC10	Fish Culture Zone at Kai Lung Wan
18	FC11	Fish Culture Zone at Tai Tau Chau
19	FC12	Fish Culture Zone at Tap Mun
20	FC13	Fish Culture Zone at Wong Wan
21	FC14	Fish Culture Zone at O Pui Tong
22	FN1a-d	Fisheries Protection Area (FPA) at Port Shelter
23	FP1	Finless Porpoise Area (near Lamma Island South)
24	FP2	Finless Porpoise Area Fishery Nursery/Spawning Ground near Cheung Chau
25	FP3	Finless Porpoise Area (near Mong Tung Wan, Lantau Island)
26	FP4	Finless Porpoise Area (near Tung Wan, Lantau Island)
27	FP5	Finless Porpoise Area (near Wong Ma Kok)
28	FP6	Finless Porpoise Area (near Po Toi)

No.	Sensitive Receivers	
29	FP7	Finless Porpoise Area (offshore to the South of Lantau Island)
30	FP8	Finless Porpoise Area (near Lamma Island East)
31	FP9	Finless Porpoise at Southeast Offshore Island Landfill
32	GB1	Gazetted Beaches in Tuen Mun District
33	GB2	Gazetted Beaches in Tsuen Wan District
34	GB3	Gazetted Beach at Cheung Sha
35	GB4	Gazetted Beach at Silvermine Bay
36	GB5	Gazetted Beach in Southern District
37	GB6	Gazetted Beach at Shek O
38	GB7	Gazetted Beach at Clear Water Bay
39	GB8	Gazetted Beaches at Kiu Tsui and Hap Mun Bay & Surveyed Coral near Sharp Island
40	GB9	Gazetted Beach at Hebe Haven
41	GB10	Gazetted Beach at Silverstrand
42	GB11	Gazetted Beaches in Cheung Chau (Tung Wan and Kwun Yan Wan)
43	GB12	Gazetted Beach at Tong Fuk
44	GB13	Gazetted Beach at Pui O
45	HC1	Horseshoe Crab Area near Tong Fuk
46	HC2	Horseshoe Crab Area Tai O South
47	HC3	Horseshoe Crab Area Tai O North
48	MA	Mai Po Nature Reserve Area
49	MP1	Yat Chau Tong Marine Park
50	MP2	Hoi Ha Wan Marine Park
51	MP3	Sha Chau Lung Kwun Chau Marine Park
52	MP4	Tung Ping Chau Marine Park
53	MP5	Potential Marine Park/Marine Reserve near Fan Lau
54	MP6	Potential Marine Park/Marine Reserve to the South of Lamma Island
55	MP7	Potential Marine Park/Marine Reserve near Shelter Island
56	MP8	Potential Marine Park/Marine Reserve and SSSI at Tai Long Wan
57	MP8b	Water Quality Monitoring Station at Tai Long Wan
58	MP9	Potential Marine Park/Marine Reserve at Long Ke, Pak Lap Tsai and Pak Lap
59	MP10	Potential Marine Park/Marine Reserve near North Ninepin Island
60	MP11	Potential Marine Park/Marine Reserve near South Ninepin Island
61	MP12	Potential Marine Park/Marine Reserve & Fishery Nursery/Spawning Ground near Soko Island
62	MP13	Potential Marine Park/Marine Reserve at South West Lantau
63	MR1	Cape D' Aguilar Marine Reserve
64	NS1	Fishery Nursery/Spawning Ground South of Pak Tso Wan, Cheung Chau
65	NS2	Fishery Nursery/Spawning Ground South of Nam Tam Wan, Cheung Chau

No.	Sensitive Receivers	
66	NS3	Fishery Nursery/Spawning Ground Southwest of Cheung Chau
67	NS4	Fishery Nursery/Spawning Ground South of Lamma Island
68	NS5	Fishery Nursery/Spawning Ground South of Lamma Island
69	NS6	Fishery Nursery/Spawning Ground North of Po Toi Island
70	NS7	Fishery Nursery/Spawning Ground near Sung Kong and Waglan Island
71	NS8	Fishery Nursery/Spawning Ground north of Ngai Tau, Lamma Island
72	NS9	Fishery Nursery/Spawning Ground off Sok Kwu Wan, Lamma Island
73	NS10	Fishery Nursery/Spawning Ground West of Cheung Chau
74	NS11	Fishery Nursery/Spawning Ground South of Lantau Island
75	OB1	Oyster Beds near Lau Fau Shan
76	SC1	Surveyed Corals and Green Turtle Site near Lamma Island North
77	SC2	Surveyed Corals near Round Island
78	SC3	Surveyed Corals near Beaufort Island
79	SC4	Surveyed Corals near Sun Kong Island
80	SC5	Surveyed Corals and Green Turtle Site near Tung Lung Chau
81	SC6	Surveyed Corals and Green Turtle Site near Nine Pine Island
82	SC7	Surveyed Corals and Green Turtle Site near Ching Chau
83	SC8	Surveyed Corals near Basalt Island
84	SC9	Surveyed Corals near Tolo Channel
85	SC10	Surveyed Corals near Ocean Point
86	SC11	Surveyed Corals near Po Toi Island
87	SC12	Surveyed Corals near Long Ke Wan
88	SC13	Surveyed Corals near Pak Lap Wan
89	SC14	Surveyed Corals near Victor Rock
90	SC15	Surveyed Corals & Potential Marine Park near Bluff Island
91	SC16	Surveyed Corals near Tai Lak Lei (Trio Island)
92	SC17	Surveyed Corals near Breakers Reef
93	SC18	Surveyed Corals near Waglan Island
94	SC19	Surveyed Corals near Soko Island
95	SC20	Surveyed Corals near Shek Kok Tsui, Green Island
96	SC21	Surveyed Corals near Wong Mau Chau
97	SI1	Pak Nai SSSI
98	SI2	Tsim Bei Tsui SSSI
99	SG	Seagrass Bed and Horseshoe Crab Area at Ha Pak Nai
100	GT1	Green Turtle Site at Lamma Island
101	GT2	Green Turtle Site at Po Toi
102	GT3	Green Turtle Site near Port Island
103	WI1	WSD Sea Water Intake at Tuen Mum
104	WI2	WSD Sea Water Intake at Ap Lei Chau
105	WI3	WSD Sea Water Intake at Kennedy Town
106	WI4	WSD Sea Water Intake at Chai Wan
107	WD1	Chinese White Dolphin Feeding Ground

No.	Sensitive Receivers	
108	WD2	Chinese White Dolphin Conservation Zone in Mainland waters (offshore to the southwest of Lantau Island)
109	WD3	Chinese White Dolphin in Mainland waters (offshore to the west of the New Airport)
110	RD	Proposed Resort Development at Tai A Chau
111	MF	Fish Culture Areas (Mainland Waters)
112	MF2	Fish/Scallop/Rockshore Culture Areas near Zhongxinzhou (Mainland Waters)
113	MF3	Fish/Scallop/Rockshore Culture Areas near Northern Guishan Island (Mainland Waters)
114	MF4	Fish/Scallop/Rockshore Culture Areas near Eastern Guishan Island (Mainland Waters)
115	MF5	Fish/Scallop/Rockshore Culture Areas near Zhizhou Islands (Mainland Waters)
116	MF6	Fish/Scallop/Rockshore Culture Areas near Zhizhou Islands (Mainland Waters)
117	MF7	Fish/Scallop/Rockshore Culture Areas near Aizhou Islands (Mainland Waters)
118	MF8	Fish/Scallop/Rockshore Culture Areas near Heizhou (Mainland Waters)
119	MF9	Fish/Scallop/Rockshore Culture Areas near Wailingding Island (Mainland Waters)
120	MF10	Fish/Scallop/Rockshore Culture Areas near Dong'ao Island (Mainland Waters)
121	MF11	Fish/Scallop/Rockshore Culture Areas near Baili Island (Mainland Waters)
122	MF12	Fish/Scallop/Rockshore Culture Areas near Hengzhou Island (Mainland Waters)
123	MF13	Fish/Scallop/Rockshore Culture Areas near Beijian Island (Mainland Waters)
124	MF14	Fish/Scallop/Rockshore Culture Areas near Erzhou Island (Mainland Waters)
125	MF15	Fish/Scallop/Rockshore Culture Areas near Dangan Island (Mainland Waters)
126	MG	Mangroves at Futian (Mainland Waters)
127	OB2	Oyster Beds at Shekou (Mainland Waters)
128	SB	Da & Xiao Mei Sha Swimming Beaches (Mainland Waters)

NOTE: PLEASE REFER TO FIGURE 3.1b FOR SENSITIVE RECEIVERS SOUTH OF LANTAU ISLAND (MAINLAND WATERS)

Project		
EXTENSION OF EXISTING LANDFILLS AND IDENTIFICATION OF POTENTIAL NEW WASTE DISPOSAL SITES	Date NOV 01	Environmental Management Limited
	Scale 1:200000	
WATER QUALITY SENSITIVE RECEIVERS	Figure 3.1a	

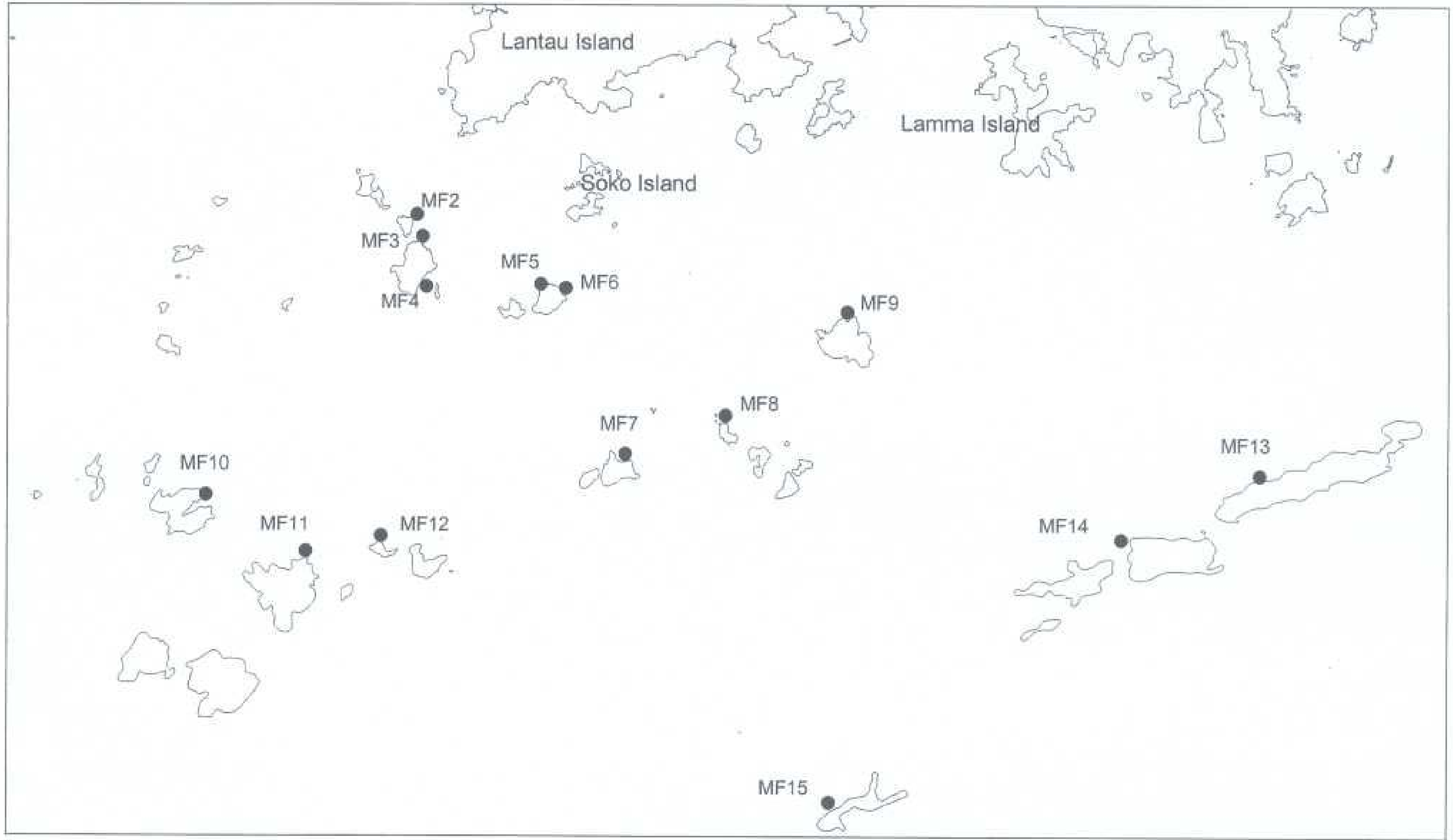
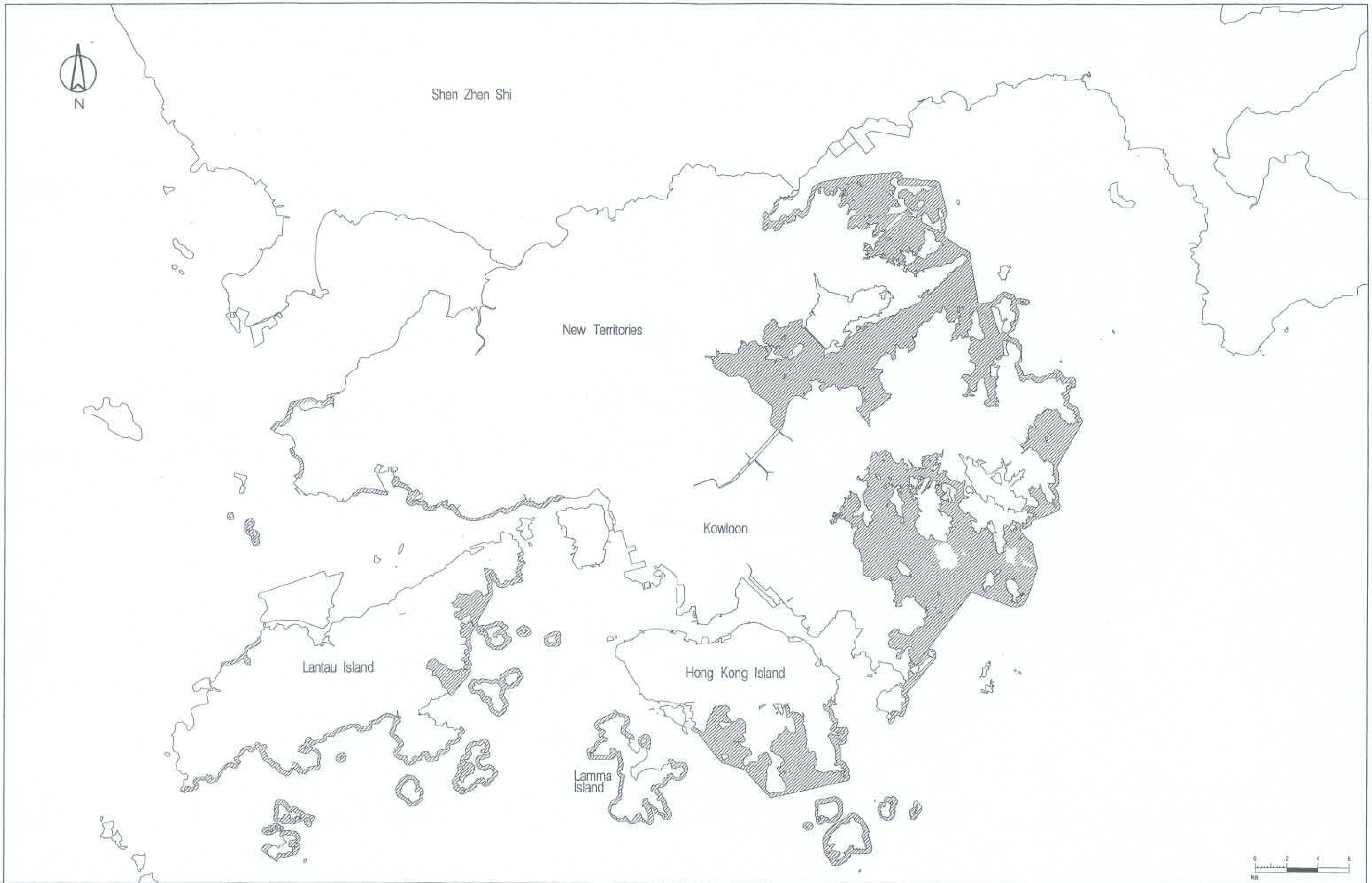


Figure 3.1b Water Quality Sensitive Receivers in Mainland Waters South of Lantau Island



Project

EXTENSION OF EXISTING LANDFILLS AND IDENTIFICATION OF POTENTIAL NEW WASTE DISPOSAL SITES

SECONDARY CONTACT RECREATION ZONES

Date NOV.01

Scale 1:200000

Figure 3.2

Environmental Management Limited

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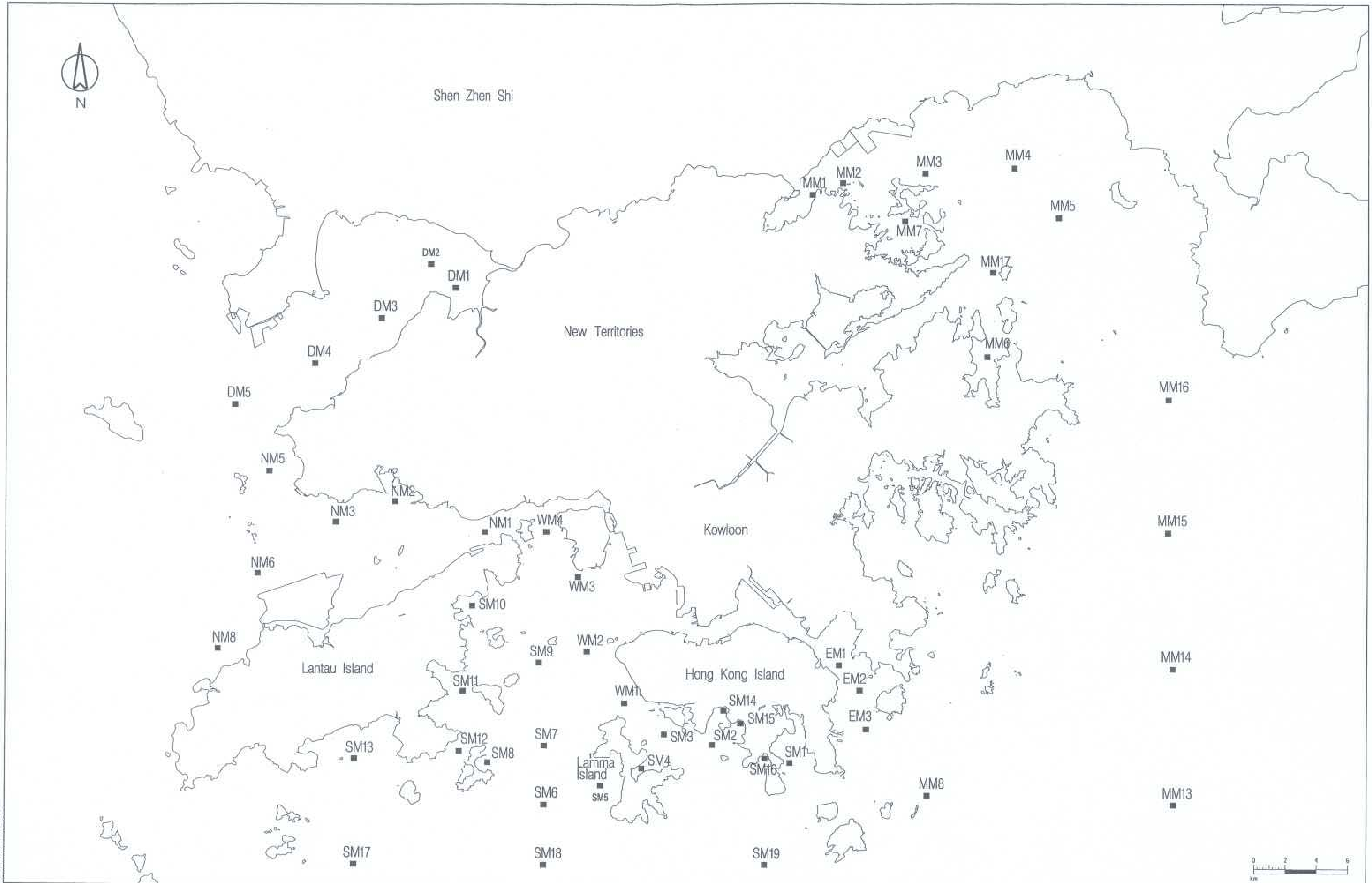

Project		
EXTENSION OF EXISTING LANDFILLS AND IDENTIFICATION OF POTENTIAL NEW WASTE DISPOSAL SITES	Date NOV.01 Scale 1:200000	Environmental Management Limited
SELECTED EPD MARINE WATER SAMPLING STATIONS	Figure 3.3	

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4. MODELLING TOOLS

4.1 General

4.1.1.1 The Delft3D suite of models is used as a modelling platform for the hydrodynamic and water quality simulations. The Delft3D suite of models can perform 3-dimensional simulations of water movement and dispersion of pollutants with chemical reaction and decay. The vertical water column can be divided up to 10 layers for hydrodynamic computations. This reproduces the stratification condition in the water column.

4.1.1.2 The Delft3D suite of models consists of a range of modules to perform different types of simulation. The main modules that are applied in this study include Delft3D-FLOW and Delft3D-WAQ. The Delft3D-FLOW is programmed for hydrodynamic simulation. The key parameters of computations include water level, current magnitude, current direction, temperature and salinity. A set of governing equations for conservation of mass and momentum are solved numerically in this module.

4.1.1.3 The Delft3D-WAQ module, which incorporates the transport of substances and associated water quality processes, is for water quality simulation. This module allows physical transport, chemical / biological reactions, or accumulation of substances in the segments to calculate the concentrations of the substances. The water quality simulation can cover a wide range of substances such as suspended solids, biochemical oxygen demand, dissolved oxygen, *E.coli*, nutrients, etc. The water body is divided into homogeneous segments between which mass transport is allowed through the interfacial layer. This module is capable of simulating sediment plume dispersion generated from dredging and filling activities.

4.1.1.4 In this study, two detailed models with refined grid sizes have been used for hydrodynamic and water quality simulations. In addition, the Update model, which was developed under "*Update on Cumulative Water Quality and Hydrological Effect of Coastal Development and Upgrading of Assessment Tool (Agreement No. CE42/97)*" have also been used to provide boundary conditions to the two detailed models. This larger model covers the discharges from the major Pearl River estuaries, which include Humen, Jiaomen, Hongqili, Hengmen, Muodaomen, Jitimen, Hutiaomen and Aimen. The influences on hydrodynamics and water quality due to the discharges from Pearl River estuaries can be incorporated into the detailed models.

4.2 Detailed Models

Model Setup

4.2.1.1 Two detailed models namely the Western Model and the Eastern Model have been developed based on the Fine Grid Model and the Tolo Harbour Model to cover the Western Sites and Eastern Sites. The Fine Grid and Tolo Harbour Models had been calibrated for hydrodynamics under a separate study but not for water quality. The modelling domain of the Fine Grid Model covers all the Western Sites. Therefore, only water quality simulation has been verified for the Western Model under the present study. Expansion of the model coverage of the Tolo Harbour Model is required in order to cover all the Eastern Sites. Therefore, verification for both the hydrodynamic and water quality simulations has been conducted for the Eastern Model.

4.2.1.2 Model grid is generated using the Delft-RGFGRID module. Curvilinear grid lines are adopted to take into account the coastline configuration of the study area. This aims to achieve the requirements of smoothness and orthogonality. A high grid resolution is applied in the areas near the sensitive receivers, which are potentially affected by the Project, and the major channels. A low grid resolution is adopted in open waters. **Figures 4.1** and **4.2** shows the grid schematizations for the Eastern and Western Models.

4.2.1.3 The bathymetry configurations of the Western and Eastern Models were interpolated from the bathymetry data adopted in the Fine Grid Model, Tolo Harbour Model and the Update Model. For the operational phase assessment, the bathymetry conditions as a result of forming the artificial island have been updated to reflect the size and shape of the island.

4.2.1.4 The coastline configurations for the detailed models have been updated based on the latest and planned coastal developments. The present Project is proposed to commence in 2007 and is expected to complete in 2025. **Table 4.1** summarizes the major development and reclamation projects that have been incorporated into the models to form the coastline configurations.

Table 4.1 Developments to be Included in Coastline Configurations

Developments	Construction Phase (2007 – before 2025)	Operational Phase (2025)
South East Kowloon Development – KTAC Reclamation, Hoi Sham (Earth Bund and Phase 1 Stages 1 & 2, and Kwun Tong Typhoon Shelter.	√	√
South East Kowloon Development – Hoi Sham Phase 1 Stage 3 and Phase 2 and Cha Kwo Ling	X (before 2011) √ (after 2011)	√
Central Reclamation Phase III	√	√
Wan Chai Development Phase II	√	√
Tseung Kwan O Reclamation	√	√
Jordan Road Reclamation Phase III	√	√
Lamma Island Reclamation (Yung Shue Wan Development Engineering Works, Phase II)	√	√
Container Terminal No. 9	√	√
Penny’s Bay Stages I & II Reclamation	√	√
Peng Chau Reclamation	√	√
Tuen Mun Area 38 Reclamation	√	√
North Lantau Development	√	√
Chok Ko Wan Link Road Reclamation	√	√
North Tsing Yi District Open Space and Government, Institute and Community Facilities Reclamation	√	√
Yam O Reclamation	√	√
Yau Tong Bay Reclamation	√	√
Pak Shek Kok and Ma Liu Shui Reclamation	√	√

Notes:

1. √ represents the development to be included in the construction/operational phase model runs;
2. X represents the development not to be included in the construction/operational phase model runs; and
3. The sites proposed for Container Terminals CT10 and CT11 are reserved for the Theme Part at Penny’s Bay. Therefore, CT10, CT11 and the Lamma Breakwater will not be included in the model runs.

4.2.1.5 The Western and Eastern Models are constructed as 3-dimensional detailed models to simulate the vertical structure of the water body and the distribution of pollutants in the water column.

4.2.1.6 The hydrodynamic computations of the detailed models provide input data to drive the water quality computations. The model set up for water quality simulation incorporates suitable meteorological forcing, initial and boundary conditions, flow aggregation and modelling substances. The substance file used for water quality simulation incorporates the substances of salinity, temperature, dissolved oxygen, suspended solids, BOD, *E.coli*, phytophankton, organic and inorganic nitrogen, phosphorus and silicate. In addition, the water quality simulation takes into account air-water exchange and benthic processes. The contaminant in the C&D materials would mainly contain suspended solids and this parameter would be the key factor to be determined in the construction phase water quality impact assessment. The other major parameters as included in the substance file have been considered to assess the changes in water quality during the operational phase of the project.

Simulation Period

4.2.1.7 Hydrodynamic and water quality model runs cover at least a real sequence of 15 days spring-neap tidal cycle in the dry and wet seasons. The model spin up covers 7 days prior to the actual model simulation period. Meanwhile, the 7-days spin-up uses 'warm-start' conditions, obtained from the Update Model results that had been simulated for 22 days. The proposed dry and wet season simulation periods are presented in **Table 4.2**.

Table 4.2 Model Simulation Periods

Season	Spin Up	Model Start Time	Model End Time
Wet	19 July 2025 04:00 – 26 July 2025 04:00	26 July 2025 04:00	10 August 2025 04:00
Dry	2 Feb 2025 12:00 – 9 Feb 2025 12:00	9 Feb 2025 12:00	24 Feb 2025 12:00

Meteorological Forcing

4.2.1.8 The ambient environmental conditions are closely linked to the processes of water quality changes. Meteorological forcing including wind speed, solar surface radiation and water temperature for the dry and wet seasons need to be defined in the hydrodynamic and water quality computations of the detailed models. The data for meteorological forcing was based on the past records from Hong Kong Observatory.

4.2.1.9 The wind conditions applied in the hydrodynamic simulation are 5 m/s NE for dry season and 5 m/s SW for the wet season. Monthly averaged values of solar surface radiation and water temperature were used in the models. It is assumed that solar radiation and water temperature are constant over the entire domain of the models. Solar radiation is recorded only at King's Park station by Hong Kong Observatory. The monthly averaged solar radiation was calculated based on the hourly data recorded at this station. The average values of solar radiation adopted are 132 W/m^2 in the dry season and 237 W/m^2 in the wet season.

4.2.1.10 The ambient water temperature was determined based on the EPD routine monitoring data collected within the WCZs. The average water temperature values used in the water quality models are 16 °C in the dry season and 29 °C in the wet season.

Initial and boundary conditions

4.2.1.11 The Western and Eastern Models are linked to the Update model. Hydrodynamic computations were first carried out using the Update model to generate the open boundary conditions for the two detailed models. In order to start the water quality model run from a more realistic condition, a longer spin-up period of two full spring/neap cycles was adopted prior to the actual water quality simulation. After performing the spin-up, the influence on initial conditions would be subsided and would not affect the concentrations of the simulated parameters.

Flow Aggregation

4.2.1.12 Aggregation of the hydrodynamics has been performed to reduce the vertical resolution from 10 layers to 5 layers. The vertical distribution of the layers for the detailed water quality model is 10%, 20%, 20%, 30% and 20% of the hydrodynamic layers from surface to bottom. This optimizes the computational time and data storage without a significant influence on the quality of the modelling results. A 2x2 flow aggregation was applied in the spatial level.

Model Outputs

4.2.1.13 Statistical analysis of water quality changes was conducted at representative indicator points near the filling sites. Some of the indicator points are located at the water quality sensitive receivers and at the same locations as EPD's routine marine water sampling stations to check for WQO compliance. The locations of all the indicator points and EPD marine water sampling stations are shown in **Figures 3.1a, 3.1b** and **3.3**.

4.2.1.14 Meanwhile, for hydrodynamic results, the impacts due to the proposed sites are assessed in terms of accumulated flow and current velocity. **Figure 4.3** shows the location of the cross sections where the accumulated flow are assessed while **Figure 6.1** shows the location of the indicator points where the current velocities are assessed.

4.2.1.15 The model outputs are presented in form of table, contour plot, vector plot and time series plot. All contour and vector plots in the operational and construction phase assessments are 'snapshot' results indicating periods at either "mid-flood" or "mid-ebb". All results presented in the tables are depth-averaged (except for bottom DO) and time-averaged (except for 90%ile DO and 90%ile depth-averaged DO) values.

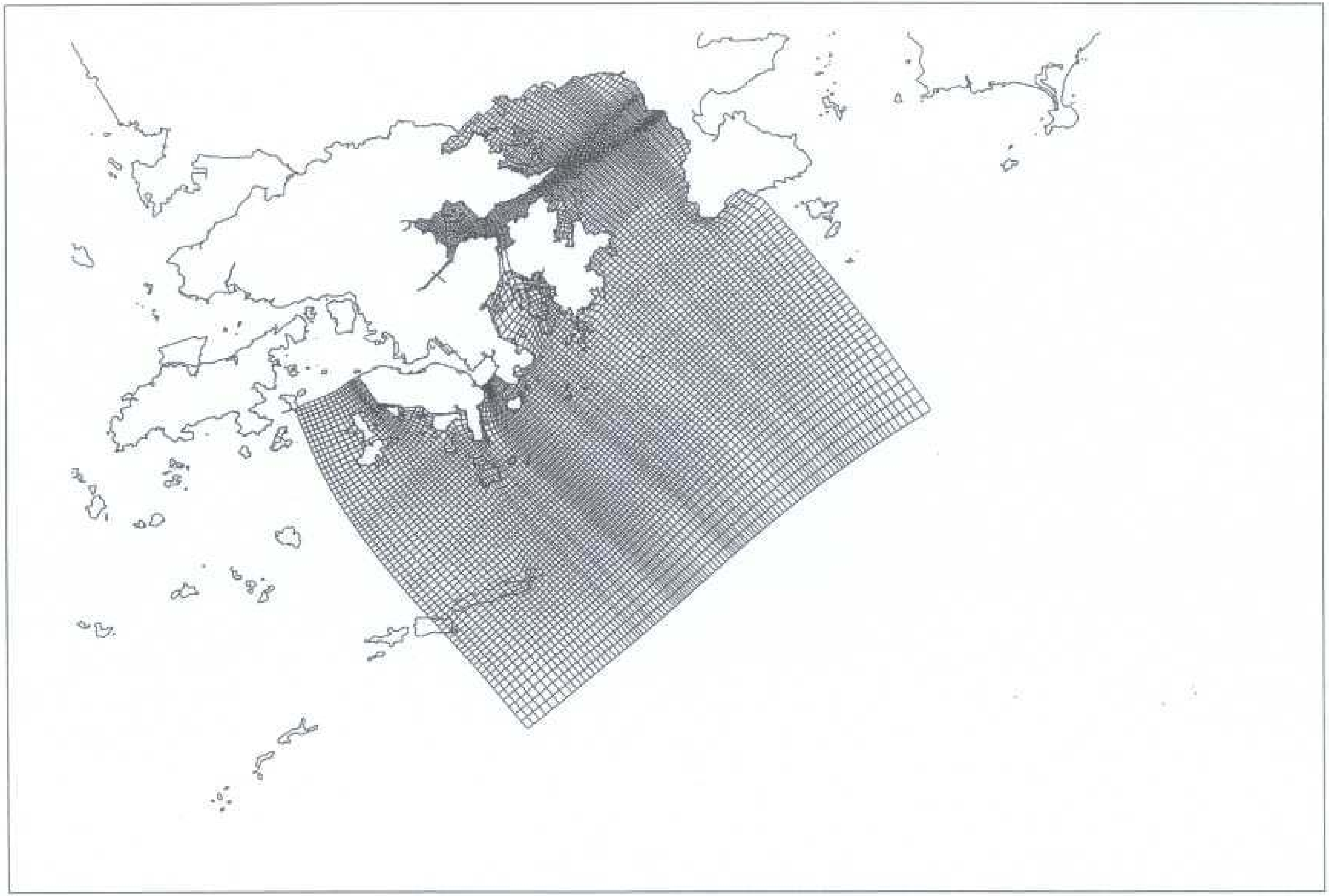


Figure 4.1 Grid Layout for the Eastern Model

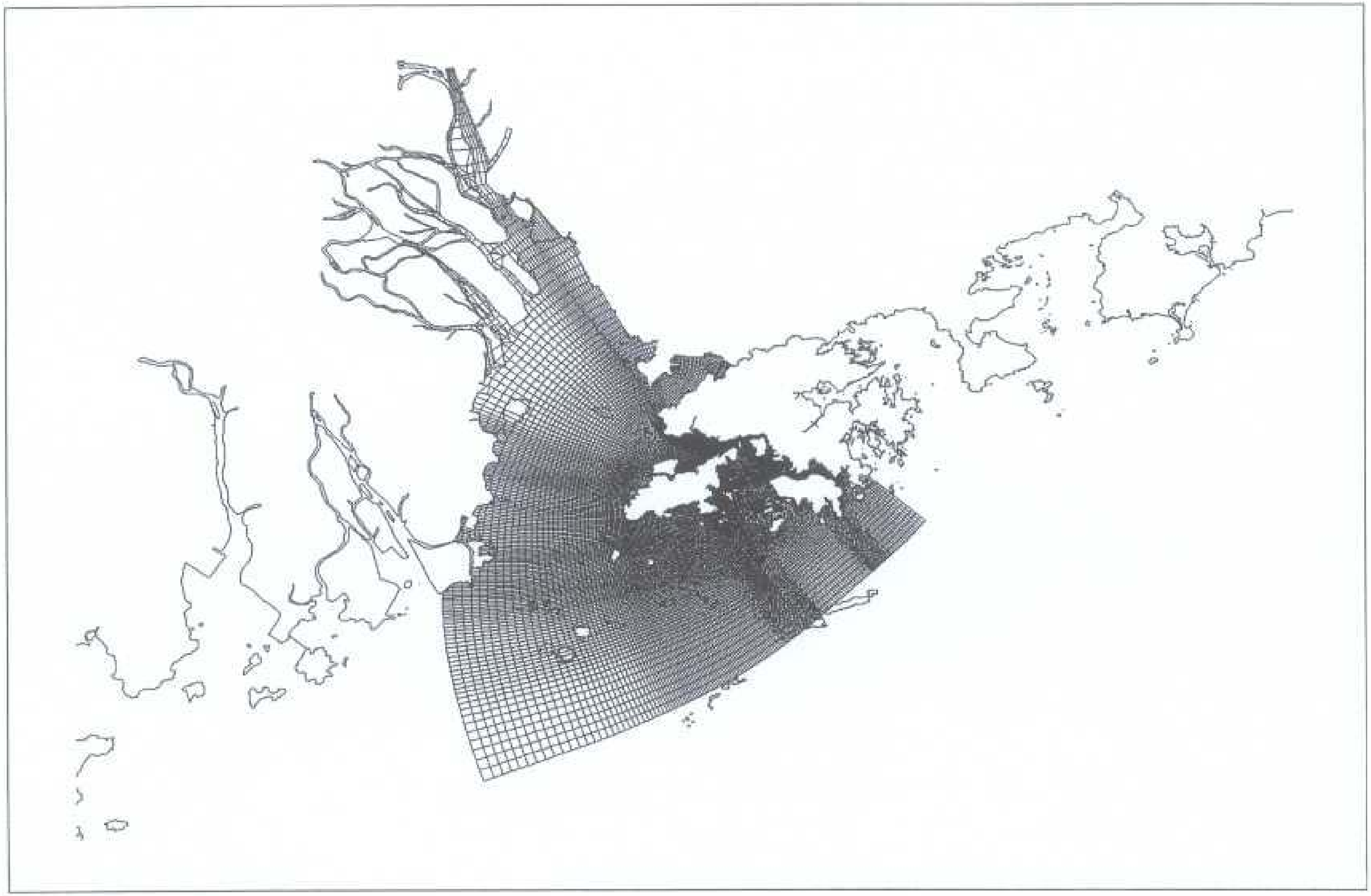
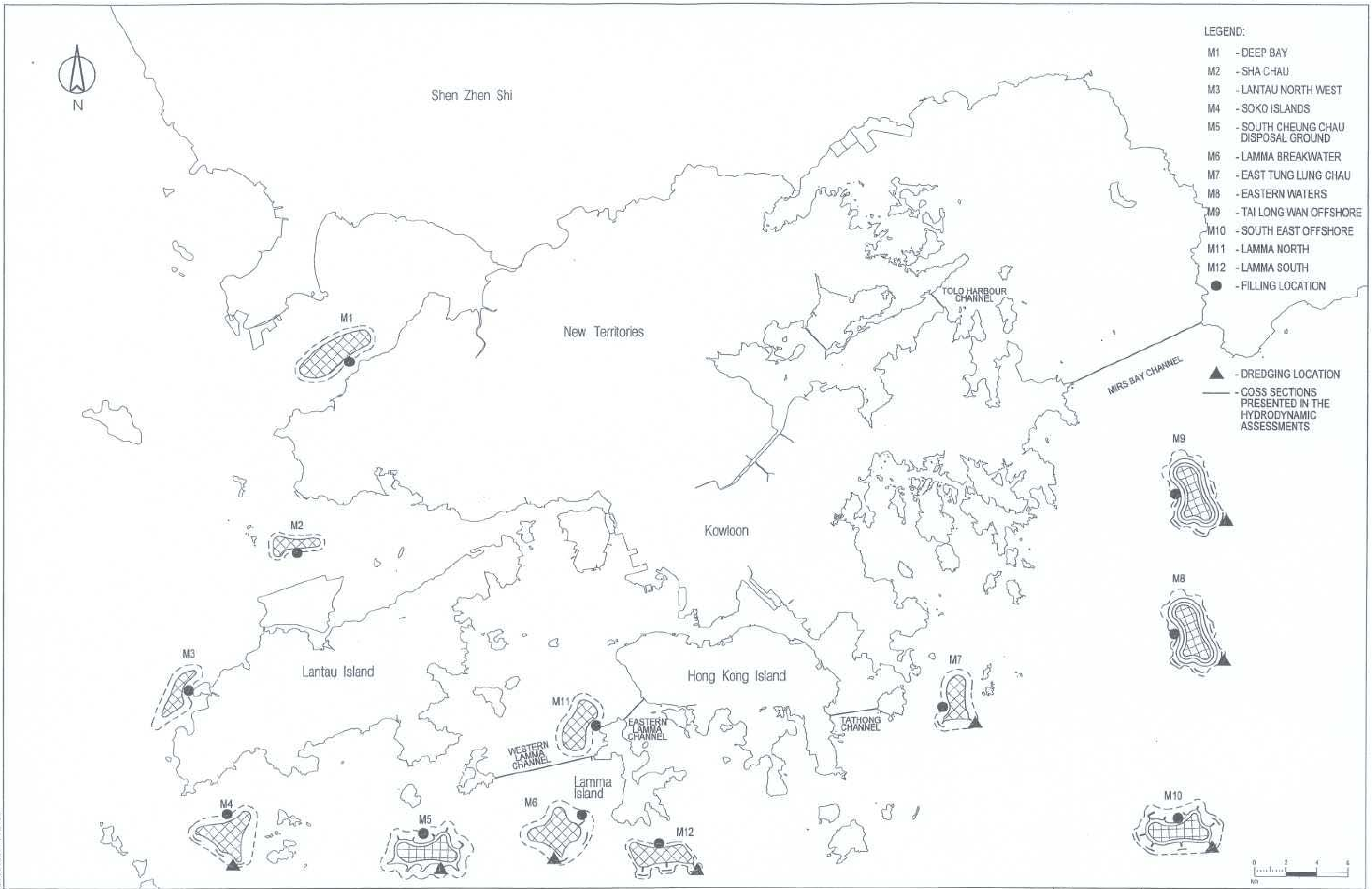


Figure 4.2 Grid Layout for the Western Model



Project	EXTENSION OF EXISTING LANDFILLS AND IDENTIFICATION OF POTENTIAL NEW WASTE DISPOSAL SITES	Date NOV.01 Scale 1:225000	Environmental Management Limited
	LOCATIONS OF CROSS SECTIONS, FILLING AND DREDGING ACTIVITIES IN THE HYDRODYNAMIC / WATER QUALITY MODEL	Figure 4.3	

Cad Ref. L:/CAD/882000028/FIG_4_3

5. MODEL RUNS

5.1.1.1 The model runs were divided into two packages. Package 1 model runs consist of Sites M4, M5, M6 (Western Sites) and M8 (Eastern Site). Package 2 model runs cover Sites M1, M2, M3, M11 and M12 (Western Sites) and Sites M7, M9 and M10 (Eastern Sites).

5.1.1.2 The modelling scenarios for each of the packages include the baseline, construction phase and operational phase.

5.2 Baseline Model Runs

5.2.1.1 The baseline scenario represents the case without the project and is to provide background conditions for comparison with the water quality conditions in the operational phase of the Project so as to evaluate the potential impacts. As such, the year of simulation for the baseline scenario is 2025 and is the same as the year to be adopted in the operational phase model runs.

5.2.1.2 Hydrodynamic and water quality computations using the Western and Eastern Models were carried out to obtain the baseline conditions. There will be no wastewater discharges or release of contaminants from filling activities at the locations of the potential new waste disposal sites over the entire simulation period. The discharges to be included in the water quality simulation will be from the existing outfalls, stormdrains, nullahs and rivers. At this stage, it is difficult to estimate the changes in pollution loads, which enter the Hong Kong waters, after 20 years or more. In addition, the water quality impact assessment for this study is to compare the cases with and without the Project and there would be no discharge from the project site. It is, therefore, proposed that the pollution loading to be adopted in the baseline model runs will be based on the pollution load inventory compiled under the "*Review of North District and Tolo Harbour Sewerage Master Plans*" for year 2016. Reference was also made to the pollution load inventory derived under "*Update on Cumulative Water Quality and Hydrological Effect of Coastal Development and Upgrading of Assessment Tool*".

5.2.1.3 Model results to be obtained from the baseline model runs include:

- Momentary and accumulated flows through East Lamma Channel, Tathong Channel and West Lamma Channel for the Western Model as well as Tolo Channel, Mirs Bay and Tathong Channel for the Eastern Model; and
- Water quality conditions including the parameters of 90%ile depth-averaged dissolved oxygen (DO), 90%ile bottom DO, depth-averaged salinity, depth-averaged total inorganic nitrogen (TIN), depth-averaged unionized ammonia (UIA), depth-averaged SS, and depth-averaged *E.coli*.

5.3 Construction Phase Model Runs

5.3.1.1 The potential water quality impacts that may arise during the construction phase of the Project would be the release of fines and sediment particles from the filling and dredging activities. Sediment plume modelling will be conducted to predict the dispersion of sediment and the increases in SS levels in the surrounding waters.

5.3.1.2 The hydrodynamic conditions to be generated using the two detailed models for hydrodynamic computations will be used for the sediment plume modelling. The processes of settling of sediment particles and exchange of sediment particles between the water column and the seabed govern the sediment transport. Sediment deposition and erosion would occur when the bed shear stress is below or above the critical shear stress. The deposition rate and erosion rate were calculated using the following equations:

(1) Bed Shear Stress (τ) < Critical Shear Stress for Deposition (τ_d = 0.05 Pascal)
Deposition rate = $V_s C_b (1 - \tau / \tau_d)$

Where: V_s = settling velocity (= 0.1mm/s); and C_b = bottom layer SS concentration

(2) Bed Shear Stress (τ) > Critical Shear Stress for Erosion (τ_e = 0.15 Pascal)
Erosion rate = $R_e (\tau / \tau_e - 1)$

Where: R_e = erosion coefficient (= 0.0002 kg/m^2/s).

5.3.1.3 The sediment loss rate is the key factor affecting the water quality conditions in the surrounding waters. The fine content of C&D materials may vary in a wide range and would be up to 40%. The fine content of sediment would be lower when compared to the C&D materials. As the fill materials include both the C&D materials and uncontaminated sediment. A higher value of fine content of 30% is assumed to determine the sediment loss rate.

5.3.1.4 It is assumed that bottom dumping dredger with a capacity of 2,000m^3 would be used to carry out the filling. Filling is assumed to be a 3-minute per 2.5-hour cycle. The allowable working hour would be from 7 a.m. to 7 p.m. with a total of 12 working hours each day for the filling activities. There would be 6 working days per week. The maximum weekly rate of production is therefore calculated to be approximately 57,600m^3 (=2,000m^3 x 12hr/day ÷ 2.5hr x 6day/week). The estimated loss rate is calculated assuming that the bulk density of the fill materials is 2,000 kg/m^3 and the total quantity of fines that will be lost to suspension is 5%. Given a fine content of 30% for C&D materials as discussed above, the estimated loss rate for a release duration of 3 minutes would therefore be 333 kg/s.

5.3.1.5 The artificial island will be formed in a series of approximately 50 hectare cells of a regular shape and seawalls protection will be constructed for the cells. It is proposed that dredging will not be carried out during the reclamation process. However, for a number of sites in the unsheltered area where the seawalls are exposed to considerable wind and wave action, a dredged foundation trench may be required to ensure adequate stability. In order to take a 'worst case' approach, it is assumed that dredging for seawall formation be carried out at the following sites:

- Western Sites: M4 to M6 and M12
- All Eastern Sites: M7 to M10

5.3.1.6 It is assumed that Trailing Suction Hopper Dredgers (TSHD) are utilized for dredging. The operation of dredging is assumed to be continuous (i.e. 7 days per week and 24 hours per day). The sediment loss rate during dredging for the TSHD is assumed to be 7kg/m^3. Thus, the sediment loss rate in unit time would equal to the product of the dredging rate and the sediment loss rate (7kg/m^3) for TSHD. **Table 5.1** summarised for each site the sediment loss rates that were adopted in the sediment plume model as well as the volume of dredged mud, dredging duration and the corresponding dredging rates.

Table 5.1 Assumed Dredging Rates and Sediment Loss Rates

Sites Required Dredging	Volume of Dredged Mud (x10^6 m^3)	Dredging Duration (month)	Dredging Rates[1] (m^3/s)	Sediment Loss Rate Adopted in Model[2] (kg/s)
Western				
M4	8	12	0.254	1.78
M5	20	24	0.318	2.23
M6	10	12	0.318	2.23
M12	10	12	0.318	2.23
Eastern				
M7	4	6	0.254	1.78
M8	25	36	0.265	1.85
M9	15	24	0.238	1.67
M10	15	24	0.238	1.67

Note 1. Dredging Rates = Volume of Dredged Mud / (Dredging Duration/12x52x7x86400)
2. Sediment Loss Rate [kg/s] = Dredging Rate [m^3/s] x 7 [kg/m^3]

5.3.1.7 The seawall formation and the subsequent dredging activities will be taken place concurrent with the filling activities. In the model, discharge points representing dredging activities were situated where the foundation trenches are most likely be constructed. Meanwhile, in order to model the worse case scenario, the discharge locations for the filling activities of the construction phases are placed closest to the sensitive receivers or shoreline. **Figure 4.3** shows the locations of the dredging and filling discharge points modelled in the water quality scenarios.

5.3.1.8 The modelling scenarios for the construction phase include:

Phase	***Description***	***Dredging/Filling***
Construction Phase 1:	At the early stage of the Project when the filling activities begin	Assumed both dredging and filling activities will be carried out
Construction Phase 2:	At approximately mid-stage of the Project where half of the proposed island (in size) have been constructed	Assumed both dredging and filling activities will be carried out
Construction Phase 3:	At the closing stage of the Project where the island reaches its proposed size.	Assumed only filling activities will be carried out.

5.3.1.9 It is assumed that dredging activities will be carried out during Construction Phase 1 and 2 only while filling activities will be carried throughout the 3 construction phases.

5.3.1.10 The year of simulation for the Construction Phase 1 model runs will be 2007. The sediment loss will be evenly distributed in the vertical water column of a grid cell, which represents the filling location. In general, tidal current speeds are higher near the water surface. The sediment particles in the upper layer take a longer time to settle onto the seabed than the sediment particles in the lower layer.

5.3.1.11 After a prolonged period of filling, the artificial island will be created at the filling location and it may affect the tidal flows in the area near the island. For Construction Phases 2 and 3, the dispersion of sediment will be influenced by the presence of the artificial island. It is assumed that Construction Phase 2 would exist between 2011 and 2016. The coastline configurations for this case would be the same as the operational phase. The sediment loss will be evenly distributed in the vertical water column from the submerged ground surface at the filling location to the water surface. **Figure 4.4** shows the configuration of Construction Phase 2.

5.3.1.12 For the Construction Phase 3 model runs, hydrodynamic data for year 2025 with the artificial island in place were used for the sediment plume modelling. All the sediment loss was allocated into the upper layer of the grid cell in the immediate vicinity of the artificial island. Appropriate coastline configurations for various construction phase simulations were adopted.

5.3.1.13 The sediment plume modelling results are compared with the Water Quality Objective for SS at the nearby water quality sensitive receivers to check for compliance. The daily sedimentation rates at the coral sites near the potential filling locations/artificial islands are presented.

5.4 Operational Phase Model Runs

5.4.1.1 The expected completion date for this Project is in 2025. The presence of the artificial island may affect the hydrodynamic and water quality conditions in the surrounding waters and may affect the flushing capacity through the major channels.

5.4.1.2 During the model setup, sections at the major channels including East Lamma Channel, Tathong Channel and West Lamma Channel for the Western Model as well as Tolo Channel, Mirs Bay and Tathong Channel for the Eastern Model were defined to calculate the inflow and outflow through these channels during the hydrodynamic simulation. The Western and Eastern Models produced both the accumulated flow and momentary flow through these major channels. Comparisons between the baseline conditions and the operational phase conditions were made to assess whether there would be any effects on the exchange of flow through these major channels.

5.4.1.3 For the water quality simulation, the pollution loading adopted in the operational phase model runs are based on the pollution load inventory compiled under the "*Review of North District and Tolo Harbour Sewerage Master Plans*" for year 2016. The predicted water quality conditions at the sensitive receivers and EPD marine water sampling stations near the artificial island were assessed. The water quality parameters to be assessed will include 90%ile depth-averaged dissolved oxygen (DO), 90%ile bottom DO, depth-averaged salinity, depth-averaged total inorganic nitrogen (TIN), depth-averaged unionized ammonia (UIA), depth-averaged SS, and depth-averaged *E.coli*. Comparisons of the operational phase conditions with the baseline conditions and the relevant WQOs were also made.

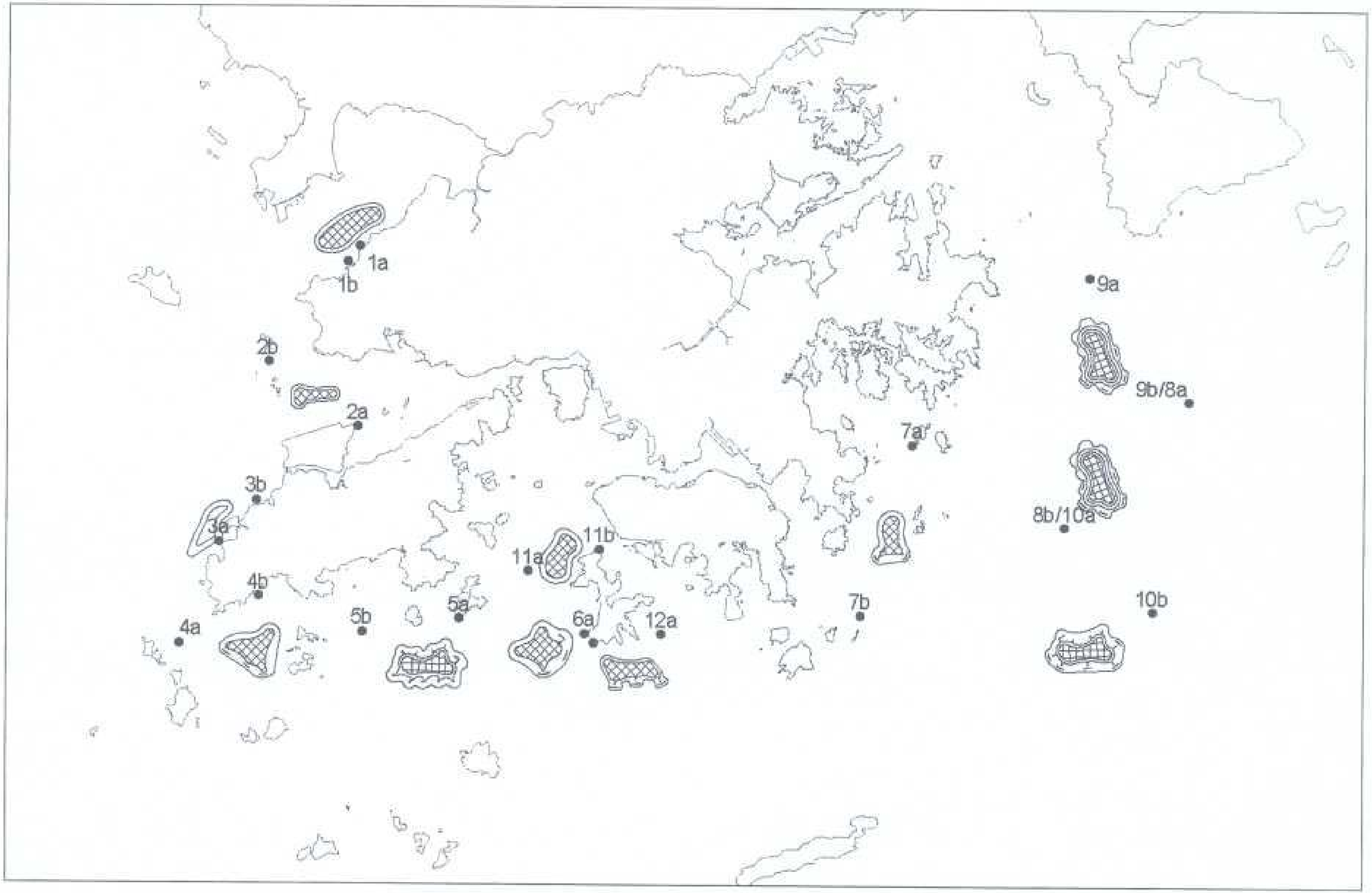


Figure 6.1 Hydrodynamic Modelling Indicator Points

APPENDIX A: Additional Flow Analysis

This section provides supplementary information on the effect of flow via major channels due to the presence of Sites M1 (Deep Bay), M2 (Sha Chau), M5 (South Cheung Chau) and M6 (Lamma Breakwater). The relative changes of tidal flow through major channels due to the presence of the proposed island were calculated for the following tide phases:

- Wet season spring flood phase
- Wet season spring ebb phase
- Wet season neap flood phase
- Wet season neap ebb phase
- Dry season spring flood phase
- Dry season spring ebb phase
- Dry season neap flood phase
- Dry season neap ebb phase

For each particular site, the relative differences in tidal flux are compared between different major channels. Based on the review of the flow data, it was found that the presence of the island would not induce any phase shift in tidal flow at a same channel. However, the tidal flow would experience minor phase shift spatially across different channels. Based on the review of momentary flow and water level data at different channels, the time periods chosen for different tide phases for different channels were adjusted to take into account such minor phase change and to make sure that the tidal elevations for different channels that are using for the comparison are exactly in phase.

Site M2

From Table 1, it can be seen that the presence of Site M2 would result in small reduction (<3%) in the calculated fluxes across Tai Lam Channel during dry season: at spring ebb and neap flood periods; and wet season: at spring flood, neap flood and neap ebb periods. During all the remaining tide phases, there would be minimal increases in the tidal fluxes across the channel (<0.2%).

This means that the presence of the M2 island will have a general minor reduction of flow through the harbour west area. Consequently, the pollution dispersion capacity of the harbour west area will be slightly reduced.

Site M5

Table 2 presents the predicted accumulated fluxes across Victoria Harbour Channel, East Lamma Channel, West Lamma Channel and Adamasta Channel. Figure 1 shows the locations of these major channels.

Victoria Harbour

The presence of Site M5 would cause a small reduction in the accumulated fluxes during wet season neap ebb and neap flood periods (-0.91% and -1.44% respectively). Changes in the tidal fluxes were minimal during all the other remaining tide phases (ranged from 0.00% to + 0.41%).

East Lamma Channel

Again, the presence of Site M5 would cause a small reduction in the accumulated fluxes during wet season neap ebb and neap flood periods (-1.34% and -0.52% respectively). There would be small increases in the accumulated fluxes at all the remaining tide phases (ranged from +0.05% to +1.17%)

West Lamma Channel

The presence of Site M5 would cause moderate impact on the tidal fluxes during dry season (changes of –5.38% to +14.76% were predicted by the model). There would be small increases (ranged from +0.58% to +2.53%) in accumulated fluxes during wet season at all tide phases except only for spring flood period where a small reduction (-3.77%) in the calculated fluxes was predicted by the model.

Adamasta Channel

The effect on Adamasta Channel is moderate during dry season (changes of –14.66% to 0.00% were predicted by the model. The effect is however considered quite large during the wet season. There would be a large reduction in the calculated fluxes during wet season spring ebb and neap ebb periods (-24.40% and –62.64%) respectively. During wet season spring flood and neap flood periods, the effects were predicted to be relatively smaller (+11.6% and 0.94% respectively).

Overall Effect

The effect on the overall changes in flow discharges through these four channels is however small. The net reductions are within 2% (average change is negligible). This relatively small change in flow indicating that the dispersion capability of harbour west area has not been changed by the presence of the island M5. However, the flow has been redistributed to from Adamasta Channel to the other channels. West Lamma Channel received the least share of redistribution.

Site M6

Table 3 presents the predicted accumulated fluxes across Victoria Harbour Channel, East Lamma Channel, West Lamma Channel and Adamasta Channel. Figure 1 shows the locations of these major channels.

Victoria Harbour

The presence of Site M6 would cause a small increase in the accumulated fluxes (ranged from 0.96% to 2.74%) at all tide phases except for during wet season neap flood period where there would be a small reduction in the calculated fluxes (-3.02%).

East Lamma Channel

The proposed island would increase the accumulated fluxes at all tide phases (ranged from 1.08% to 7.25%).

West Lamma Channel

The proposed island would reduce the accumulated fluxes at all tide phases (ranged from -4.87% to -9.66%).

Adamasta Channel

The effect on Adamasta Channel is considered quite large. The model predicted that there would be increases in the tidal fluxes through the channel at all tide phases (ranged from +6.05% to +89.66%).

Overall Effect

It is considered that the presence of the proposed island would in general reduce the fluxes through West Lamma Channel and redistributed to the remaining three channels. East Lamma Channel receives the largest share of the West Lamma Channel flow. The effect on the overall changes in the flow discharges through the four channels is however small. The net reductions are within 1% (average change is less than 0.5%). Therefore, the pollutant dispersion capability of harbour west area has only been marginally reduced.

Site M1

The results for accumulated total discharges through inner Deep Bay and outer Deep Bay were analyzed. Table 4 shows the changes in the predicted fluxes due to Site M1. Figure 2 shows the locations of the cross sections used. The island would be located in between the inner and outer Deep Bay cross sections. It was predicted that Site M1 would reduce the fluxes through both inner and outer Deep Bay Channels with a considerably higher relative reduction (ranged from -5.37% to -7.02%) at the outer Deep Bay as compared to the inner Deep Bay (ranged from +0.06% to -2.08%). It is believed that the proposed island would reduce the flushing capacity of Deep Bay. The pollutant levels within Deep Bay would potentially be increased as more pollutant (discharged from the Deep Bay catchments) would tend to accumulate inside the bay due to the reduction in the flushing capacity. This can be further supported by the changes in salinity levels at the stations within the inner Deep Bay. The model predicted that the salinity levels would be decreased in the inner Deep Bay due to the proposed island suggesting that more freshwater (and thus more pollutants) discharged from the rivers flowing into the inner Deep Bay would be accumulated inside the bay.

The apparent reduction in nutrient levels is due to the fact that a very conservative pollution loading (for year 1998) was adopted for Pearl River discharges whilst a less conservative scenario (for year 2016) was adopted for the pollution discharged from the Deep Bay catchments. Under the baseline scenario (without the island), the model predicted that a significant amount of nutrients from Pearl River would be washed into the Deep Bay. The presence of Site M1 would reduce the tidal flows into Deep Bay and thus blocking part of the nutrients from entering the Deep Bay. Although the water quality modelling revealed that there would be an improvement in the nutrient levels inside the Deep Bay, it is considered that Site M1 is not a preferred site in terms of water quality impact due to the fact that the proposed island would potentially reduce the self-cleansing capacity of Deep Bay, and there are uncertainties about the future pollution loading discharged into Deep Bay, especially a portion of the pollutants loadings is from Shenzhen, which is not under the control of HKSAR Government, (i.e. the future pollution loading from Pearl River would likely be smaller than that currently adopted in the model while the future pollution loading discharged from the Deep Bay catchments may not be as low as currently predicted).

Figure 1 Location of Major Channels

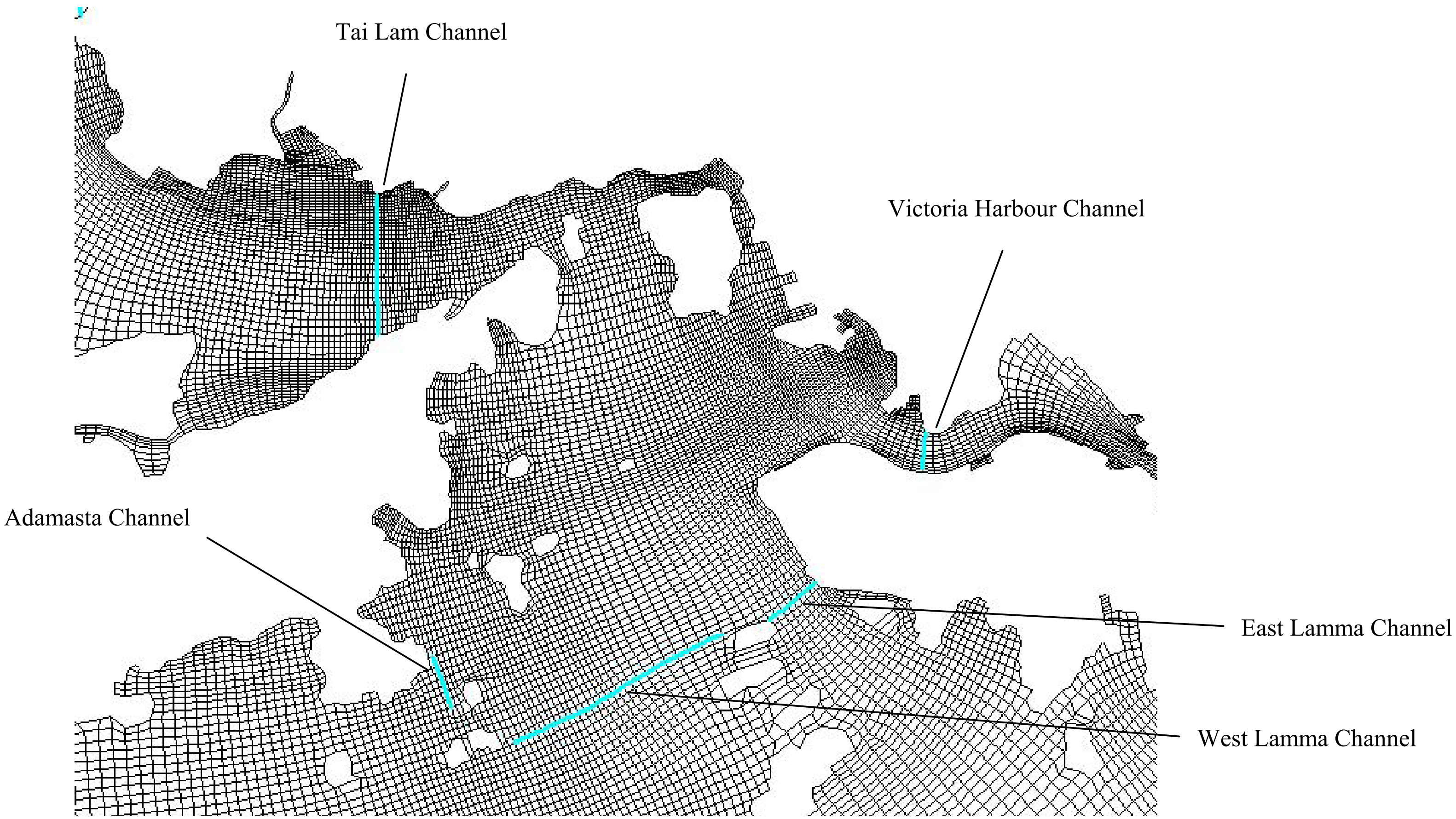


Figure 2 Locations of Deep Bay Channels

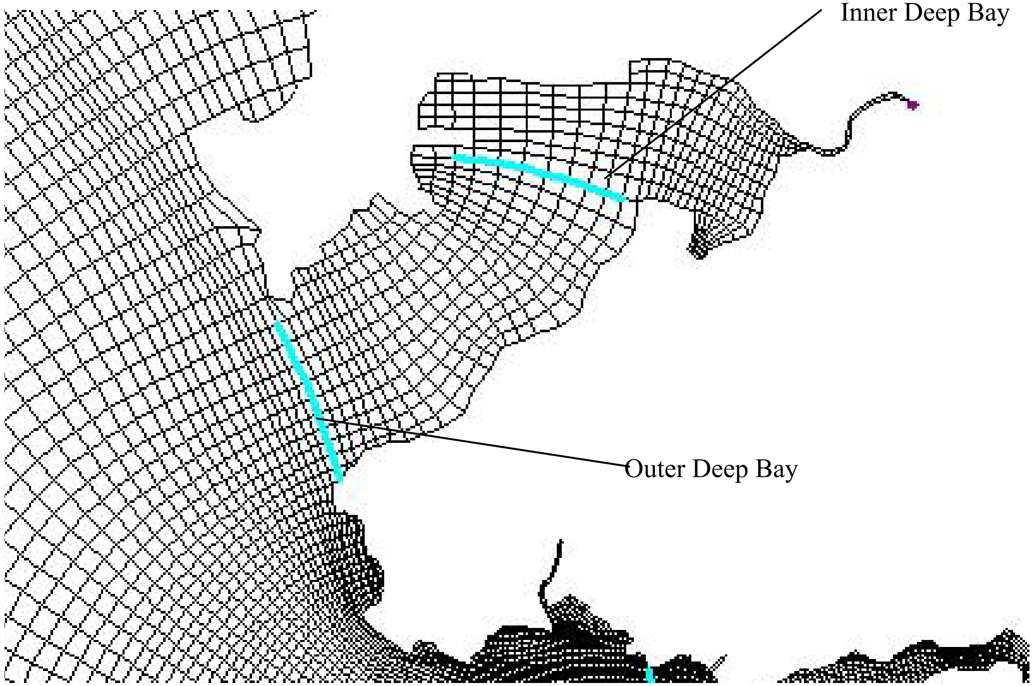


Table 1 Changes in Accumulated Flow at Tai Lam Channel Due to Site M2

Table 1			Tai Lam			
			Accumulated Flow (m^3)			
			Baseline Scenario	Operational Scenario	Difference	Relative Difference
Dry Season						
Spring Tide	Flood Phase	2/11/2025 16:00	-7.04712E+08	-7.14612E+08		
		2/11/2025 22:15	-1.30291E+09	-1.31381E+09		
		Difference	-5.98200E+08	-5.99200E+08	-1.00E+06	0.17%
	Ebb Phase	2/11/2025 22:30	-1.30041E+09	-1.31141E+09		
		2/12/2025 5:45	-3.86882E+08	-3.98421E+08		
		Difference	9.13530E+08	9.12991E+08	-5.39E+05	-0.06%
Neap Tide	Flood Phase	2/18/2025 7:45	-1.28259E+09	-1.23019E+09		
		2/18/2025 14:00	-1.77559E+09	-1.70999E+09		
		Difference	-4.93000E+08	-4.79800E+08	1.32E+07	-2.68%
	Ebb Phase	2/18/2025 15:00	-1.76279E+09	-1.69679E+09		
		2/18/2025 19:45	-1.41549E+09	-1.34919E+09		
		Difference	3.47300E+08	3.47600E+08	3.00E+05	0.09%
Wet Season						
Spring Tide	Flood Phase	7/26/2025 5:00	1.42E+07	1.47E+07		
		7/26/2025 10:30	-5.92E+08	-5.83E+08		
		Difference	-6.06E+08	-5.97E+08	8.90E+06	-1.47%
	Ebb Phase	7/26/2025 11:15	-6.07E+08	-5.97E+08		
		7/26/2025 18:45	3.91E+08	4.01E+08		
		Difference	9.98E+08	9.99E+08	1.20E+06	0.12%
Neap Tide	Flood Phase	7/31/2025 20:00	-1.51E+08	-6.21E+07		
		8/1/2025 3:00	-6.22E+08	-5.25E+08		
		Difference	-4.71E+08	-4.62E+08	8.50E+06	-1.81%
	Ebb Phase	8/1/2025 3:30	-6.17E+08	-5.20E+08		
		8/1/2025 8:15	-3.31E+08	-2.37E+08		
		Difference	2.86E+08	2.83E+08	-3.22E+06	-1.12%

Convention : -ve means flow leaving the control voulme bounded by Victoria Harbour, East & West Lamma, Adamasta and Tai Lam Channel.

Table 2 Changes in Accumulated Flow through Major Channels Due to Site M5

Table 2			Victoria Harbour				East Lamma Channel				West Lamma Channel				Adamasta Channel				**Overall Changes**			
			Accumulated Flow (m^3)				Accumulated Flow (m^3)				Accumulated Flow (m^3)				Accumulated Flow (m^3)				**Accumulated Flow (m^3)**			
			Baseline Scenario	Operational Scenario	Difference	Relative Difference	Baseline Scenario	Operational Scenario	Difference	Relative Difference	Baseline Scenario	Operational Scenario	Difference	Relative Difference	Baseline Scenario	Operational Scenario	Difference	Relative Difference	**Baseline Scenario**	**Operational Scenario**	**Difference**	**Relative Difference**
Dry Season																						
Spring Tide	Flood Phase	2/11/2025 16:00	8.33E+08	8.32E+08			-3.10E+09	-3.10E+09			2.43E+09	2.47E+09			3.21E+08	2.75E+08						
		2/11/2025 21:30	9.26E+08	9.26E+08			-2.81E+09	-2.81E+09			2.75E+09	2.79E+09			3.52E+08	3.06E+08						
		Difference	9.36E+07	9.37E+07	1.00E+05	0.11%	2.88E+08	2.89E+08	1.00E+06	0.35%	3.21E+08	3.21E+08	0.00E+00	0.00%	3.05E+07	3.05E+07	0.00E+00	0.00%	**7.34E+08**	**7.35E+08**	**1.10E+06**	**0.15%**
	Ebb Phase	2/11/2025 22:00	9.25E+08	9.25E+08			-2.81E+09	-2.81E+09			2.74E+09	2.76E+09			3.55E+08	3.09E+08						
		2/12/2025 4:15	8.16E+08	8.16E+08			-3.38E+09	-3.38E+09			2.30E+09	2.34E+09			3.16E+08	2.69E+08						
		Difference	-1.09E+08	-1.09E+08	-2.00E+05	0.18%	-5.72E+08	-5.73E+08	-1.00E+06	0.17%	-4.44E+08	-4.20E+08	2.39E+07	-5.38%	-3.96E+07	-3.96E+07	0.00E+00	0.00%	**-1.17E+09**	**-1.14E+09**	**2.27E+07**	**-1.95%**
Neap Tide	Flood Phase	2/18/2025 7:45	1.33E+09	1.33E+09			-3.44E+09	-3.44E+09			2.82E+09	2.85E+09			2.52E+08	2.06E+08						
		2/18/2025 13:30	1.42E+09	1.41E+09			-3.15E+09	-3.15E+09			3.04E+09	3.07E+09			2.62E+08	2.15E+08						
		Difference	8.90E+07	8.90E+07	0.00E+00	0.00%	2.89E+08	2.89E+08	1.50E+05	0.05%	2.20E+08	2.20E+08	0.00E+00	0.00%	9.81E+06	9.81E+06	0.00E+00	0.00%	**6.08E+08**	**6.08E+08**	**1.50E+05**	**0.02%**
	Ebb Phase	2/18/2025 14:00	1.41E+09	1.41E+09			-3.15E+09	-3.15E+09			2.98E+09	3.04E+09			3.18E+08	2.61E+08						
		2/18/2025 19:00	1.36E+09	1.36E+09			-3.34E+09	-3.35E+09			2.85E+09	2.89E+09			2.43E+08	1.96E+08						
		Difference	-5.12E+07	-5.12E+07	0.00E+00	0.00%	-1.95E+08	-1.96E+08	-6.00E+05	0.31%	-1.33E+08	-1.52E+08	-1.96E+07	14.76%	-7.57E+07	-6.46E+07	1.11E+07	-14.66%	**-4.55E+08**	**-4.64E+08**	**-9.10E+06**	**2.00%**
Wet Season																						
Spring Tide	Flood Phase	7/26/2025 4:45	3.92E+07	3.93E+07			1.63E+09	1.63E+09			-2.12E+09	-2.12E+09			5.75E+08	5.77E+08						
		7/26/2025 9:45	1.10E+08	1.10E+08			2.02E+09	2.03E+09			-1.84E+09	-1.85E+09			6.33E+08	6.41E+08						
		Difference	7.06E+07	7.09E+07	2.64E+05	0.37%	3.93E+08	3.98E+08	4.60E+06	1.17%	2.79E+08	2.68E+08	-1.05E+07	-3.77%	5.74E+07	6.40E+07	6.65E+06	11.60%	**8.00E+08**	**8.01E+08**	**1.01E+06**	**0.13%**
	Ebb Phase	7/26/2025 11:00	9.99E+07	1.00E+08			2.04E+09	2.04E+09			-1.81E+09	-1.83E+09			6.32E+08	6.42E+08						
		7/26/2025 16:30	-2.58E+07	-2.59E+07			1.54E+09	1.54E+09			-2.38E+09	-2.40E+09			6.15E+08	6.29E+08						
		Difference	-1.26E+08	-1.26E+08	-5.10E+05	0.41%	-4.95E+08	-5.00E+08	-5.12E+06	1.03%	-5.69E+08	-5.72E+08	-3.30E+06	0.58%	-1.68E+07	-1.27E+07	4.10E+06	-24.40%	**-1.21E+09**	**-1.21E+09**	**-4.83E+06**	**0.40%**
Neap Tide	Flood Phase	7/31/2025 8:30	1.05E+08	9.93E+07			3.22E+09	3.21E+09			-4.12E+09	-4.21E+09			1.03E+09	1.11E+09						
		7/31/2025 13:15	1.65E+08	1.59E+08			3.49E+09	3.48E+09			-3.98E+09	-4.07E+09			1.07E+09	1.15E+09						
		Difference	6.02E+07	5.94E+07	-8.70E+05	-1.44%	2.71E+08	2.69E+08	-1.42E+06	-0.52%	1.45E+08	1.46E+08	1.62E+06	1.12%	3.62E+07	3.65E+07	3.40E+05	0.94%	**5.12E+08**	**5.11E+08**	**-3.30E+05**	**-0.06%**
	Ebb Phase	7/31/2025 14:00	1.62E+08	1.55E+08			3.50E+09	3.49E+09			-3.97E+09	-4.06E+09			1.07E+09	1.15E+09						
		7/31/2025 18:15	9.74E+07	9.15E+07			3.34E+09	3.33E+09			-4.15E+09	-4.25E+09			1.07E+09	1.15E+09						
		Difference	-6.45E+07	-6.39E+07	5.90E+05	-0.91%	-1.58E+08	-1.56E+08	2.11E+06	-1.34%	-1.84E+08	-1.88E+08	-4.65E+06	2.53%	-1.74E+06	-6.50E+05	1.09E+06	-62.64%	**-4.08E+08**	**-4.09E+08**	**-8.60E+05**	**0.21%**

Convention : -ve means flow leaving the control voulme bounded by Victoria Harbour, East & West Lamma, Adamasta and Tai Lam Channel.

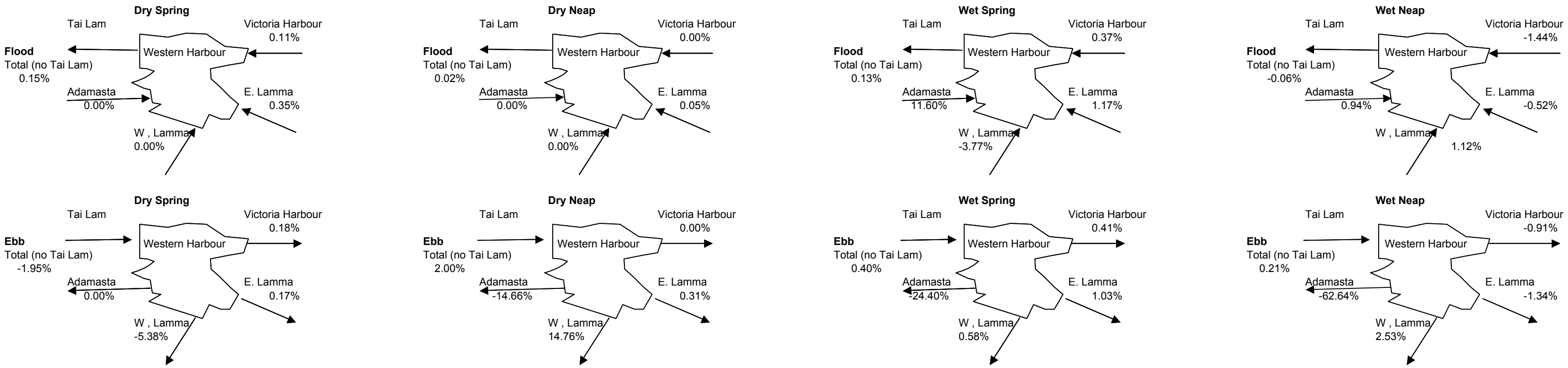
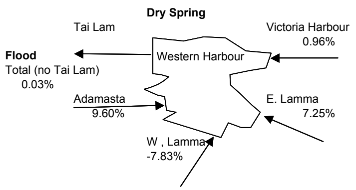
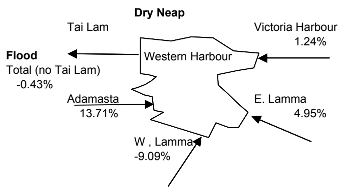


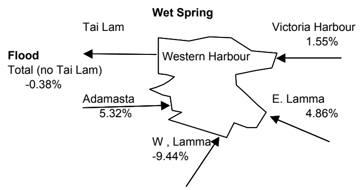
Table 3 Changes in Accumulated Flow through Major Channels Due to Site M6

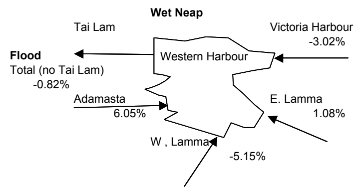
Table 3			Victoria Harbour Accumulated Flow (m^3)				East Lamma Channel Accumulated Flow (m^3)				West Lamma Channel Accumulated Flow (m^3)				Adamasta Channel Accumulated Flow (m^3)				**Overall Changes Accumulated Flow (m^3)**			
			Baseline Scenario	Operational Scenario	Difference	Relative Difference	Baseline Scenario	Operational Scenario	Difference	Relative Difference	Baseline Scenario	Operational Scenario	Difference	Relative Difference	Baseline Scenario	Operational Scenario	Difference	Relative Difference	**Baseline Scenario**	**Operational Scenario**	**Difference**	**Relative Difference**
Dry Season																						
Spring Tide	Flood Phase	2/11/2025 15:45	8.33E+08	8.33E+08			-3.10E+09	-3.03E+09			2.42E+09	2.35E+09			3.33E+08	3.43E+08						
		2/11/2025 19:00	9.26E+08	9.27E+08			-2.81E+09	-2.72E+09			2.74E+09	2.64E+09			3.68E+08	3.81E+08						
		Difference	9.36E+07	9.45E+07	9.00E+05	0.96%	2.88E+08	3.09E+08	2.09E+07	7.25%	3.18E+08	2.93E+08	-2.49E+07	-7.83%	3.45E+07	3.78E+07	3.31E+06	9.60%	**7.34E+08**	**7.35E+08**	**2.10E+05**	**0.03%**
	Ebb Phase	2/11/2025 22:00	9.25E+08	9.26E+08			-2.81E+09	-2.72E+09			2.74E+09	2.65E+09			3.71E+08	3.84E+08						
		2/12/2025 2:15	8.16E+08	8.15E+08			-3.38E+09	-3.31E+09			2.29E+09	2.21E+09			3.29E+08	3.38E+08						
		Difference	-1.09E+08	-1.11E+08	-1.80E+06	1.65%	-5.72E+08	-5.86E+08	-1.40E+07	2.45%	-4.55E+08	-4.33E+08	2.28E+07	-5.01%	-4.22E+07	-4.54E+07	-3.21E+06	7.61%	**-1.18E+09**	**-1.18E+09**	**3.79E+06**	**-0.32%**
Neap Tide	Flood Phase	2/18/2025 7:30	1.33E+09	1.33E+09			-3.44E+09	-3.21E+09			2.76E+09	2.52E+09			3.07E+08	3.46E+08						
		2/18/2025 10:15	1.42E+09	1.42E+09			-3.15E+09	-2.91E+09			2.98E+09	2.72E+09			3.19E+08	3.59E+08						
		Difference	8.90E+07	9.01E+07	1.10E+06	1.24%	2.89E+08	3.03E+08	1.43E+07	4.95%	2.16E+08	1.96E+08	-1.96E+07	-9.09%	1.19E+07	1.35E+07	1.63E+06	13.71%	**6.06E+08**	**6.03E+08**	**-2.61E+06**	**-0.43%**
	Ebb Phase	2/18/2025 14:00	1.41E+09	1.41E+09			-3.15E+09	-2.91E+09			2.98E+09	2.72E+09			3.18E+08	3.58E+08						
		2/18/2025 17:15	1.36E+09	1.36E+09			-3.34E+09	-3.11E+09			2.79E+09	2.54E+09			2.99E+08	3.38E+08						
		Difference	-5.12E+07	-5.22E+07	-1.00E+06	1.95%	-1.95E+08	-2.01E+08	-5.20E+06	2.66%	-1.89E+08	-1.80E+08	9.21E+06	-4.87%	-1.92E+07	-2.06E+07	-1.39E+06	7.24%	**-4.55E+08**	**-4.53E+08**	**1.62E+06**	**-0.36%**
Wet Season																						
Spring Tide	Flood Phase	7/26/2025 4:30	3.92E+07	3.90E+07			1.63E+09	1.63E+09			-2.12E+09	-2.12E+09			5.75E+08	5.75E+08						
		7/26/2025 8:30	1.10E+08	1.11E+08			2.02E+09	2.04E+09			-1.84E+09	-1.87E+09			6.33E+08	6.36E+08						
		Difference	7.06E+07	7.17E+07	1.09E+06	1.55%	3.93E+08	4.12E+08	1.91E+07	4.86%	2.79E+08	2.52E+08	-2.63E+07	-9.44%	5.74E+07	6.04E+07	3.05E+06	5.32%	**8.00E+08**	**7.97E+08**	**-3.06E+06**	**-0.38%**
	Ebb Phase	7/26/2025 10:45	9.99E+07	1.01E+08			2.04E+09	2.06E+09			-1.81E+09	-1.84E+09			6.32E+08	6.34E+08						
		7/26/2025 16:00	-2.58E+07	-2.79E+07			1.54E+09	1.54E+09			-2.38E+09	-2.37E+09			6.15E+08	6.12E+08						
		Difference	-1.26E+08	-1.28E+08	-2.79E+06	2.22%	-4.95E+08	-5.17E+08	-2.24E+07	4.53%	-5.69E+08	-5.31E+08	3.81E+07	-6.69%	-1.68E+07	-2.22E+07	-5.40E+06	32.14%	**-1.21E+09**	**-1.20E+09**	**7.51E+06**	**-0.62%**
Neap Tide	Flood Phase	7/31/2025 20:30	1.05E+08	9.31E+07			3.22E+09	3.16E+09			-4.12E+09	-3.98E+09			1.03E+09	9.92E+08						
		8/1/2025 0:45	1.65E+08	1.52E+08			3.49E+09	3.43E+09			-3.98E+09	-3.84E+09			1.07E+09	1.03E+09						
		Difference	6.02E+07	5.84E+07	-1.82E+06	-3.02%	2.71E+08	2.74E+08	2.91E+06	1.08%	1.45E+08	1.37E+08	-7.45E+06	-5.15%	3.62E+07	3.84E+07	2.19E+06	6.05%	**5.12E+08**	**5.07E+08**	**-4.17E+06**	**-0.82%**
	Ebb Phase	8/1/2025 3:30	1.62E+08	1.48E+08			3.50E+09	3.44E+09			-3.97E+09	-3.84E+09			1.07E+09	1.03E+09						
		8/1/2025 6:00	9.74E+07	8.18E+07			3.34E+09	3.27E+09			-4.15E+09	-4.00E+09			1.07E+09	1.03E+09						
		Difference	-6.45E+07	-6.63E+07	-1.77E+06	2.74%	-1.58E+08	-1.69E+08	-1.11E+07	7.07%	-1.84E+08	-1.66E+08	1.78E+07	-9.66%	-1.74E+06	-3.30E+06	-1.56E+06	89.66%	**-4.08E+08**	**-4.04E+08**	**3.29E+06**	**-0.81%**

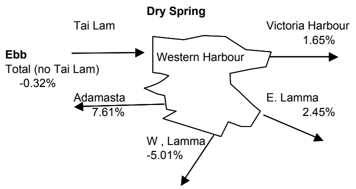
Convention : -ve means flow leaving the control voulme bounded by Victoria Harbour, East & West Lamma, Adamasta and Tai Lam Channel.

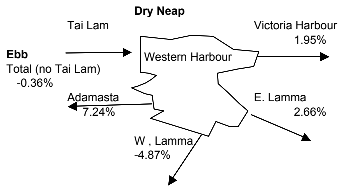


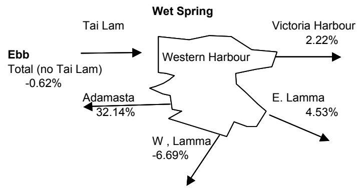












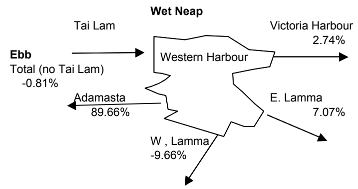


Table 4 Changes in Accumulated Flow through Deep Bay Due to Site M1

Table 4			Inner Deep Bay				Outer Deep Bay			
			Accumulated Flow (m^3)				Accumulated Flow (m^3)			
			Baseline Scenario	Operational Scenario	Difference	Relative Difference	Baseline Scenario	Operational Scenario	Difference	Relative Difference
Dry Season										
Spring Tide	Flood Phase	2/11/2025 16:15	1.55E+07	1.50E+07			-2.01E+07	-1.91E+07		
		2/11/2025 19:00	4.54E+07	4.43E+07			6.06E+07	5.59E+07		
		Difference	2.99E+07	2.92E+07	-6.20E+05	-2.08%	8.07E+07	7.50E+07	-5.66E+06	-7.02%
	Ebb Phase	2/11/2025 22:00	6.95E+07	6.93E+07			1.20E+08	1.13E+08		
		2/12/2025 2:15	2.00E+07	2.00E+07			-2.51E+07	-2.16E+07		
		Difference	-4.95E+07	-4.93E+07	1.81E+05	-0.37%	-1.45E+08	-1.35E+08	9.67E+06	-6.68%
Neap Tide	Flood Phase	2/18/2025 8:00	1.58E+07	1.39E+07			-6.13E+07	-5.82E+07		
		2/18/2025 10:45	3.90E+07	3.71E+07			7.27E+06	6.12E+06		
		Difference	2.33E+07	2.32E+07	-4.40E+04	-0.19%	6.86E+07	6.43E+07	-4.21E+06	-6.14%
	Ebb Phase	2/18/2025 14:00	5.78E+07	5.69E+07			5.06E+07	4.89E+07		
		2/18/2025 19:30	3.70E+07	3.59E+07			-9.23E+06	-7.73E+06		
		Difference	-2.08E+07	-2.09E+07	-1.85E+05	0.89%	-5.98E+07	-5.66E+07	3.21E+06	-5.37%
Wet Season										
Spring Tide	Flood Phase	7/26/2025 5:30	-1.76E+07	-1.80E+07			7.12E+06	6.80E+06		
		7/26/2025 8:30	2.11E+07	2.00E+07			1.15E+08	1.07E+08		
		Difference	3.87E+07	3.80E+07	-6.90E+05	-1.78%	1.07E+08	1.00E+08	-7.46E+06	-6.95%
	Ebb Phase	7/26/2025 10:45	4.68E+07	4.78E+07			1.81E+08	1.73E+08		
		7/26/2025 16:00	-2.20E+07	-2.07E+07			-1.76E+07	-1.29E+07		
		Difference	-6.88E+07	-6.85E+07	3.13E+05	-0.45%	-1.98E+08	-1.86E+08	1.28E+07	-6.43%
Neap Tide	Flood Phase	7/31/2025 20:30	-4.70E+07	-4.71E+07			-3.37E+07	-3.20E+07		
		8/1/2025 0:45	-1.71E+07	-1.72E+07			5.29E+07	4.94E+07		
		Difference	2.98E+07	2.99E+07	1.70E+04	0.06%	8.66E+07	8.14E+07	-5.12E+06	-5.91%
	Ebb Phase	8/1/2025 3:30	-7.72E+06	-7.54E+06			7.65E+07	7.27E+07		
		8/1/2025 6:00	-2.23E+07	-2.20E+07			3.43E+07	3.34E+07		
		Difference	-1.46E+07	-1.45E+07	1.03E+05	-0.71%	-4.22E+07	-3.93E+07	2.92E+06	-6.92%

Convention : -ve means flow leaving Deep Bay