








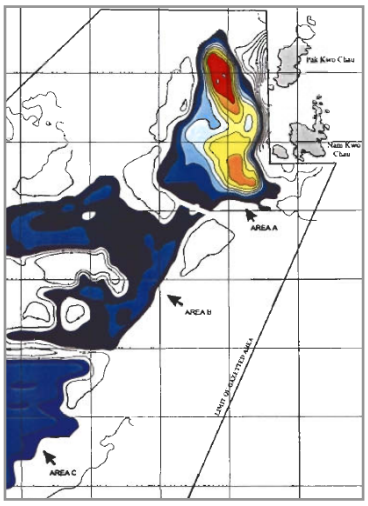

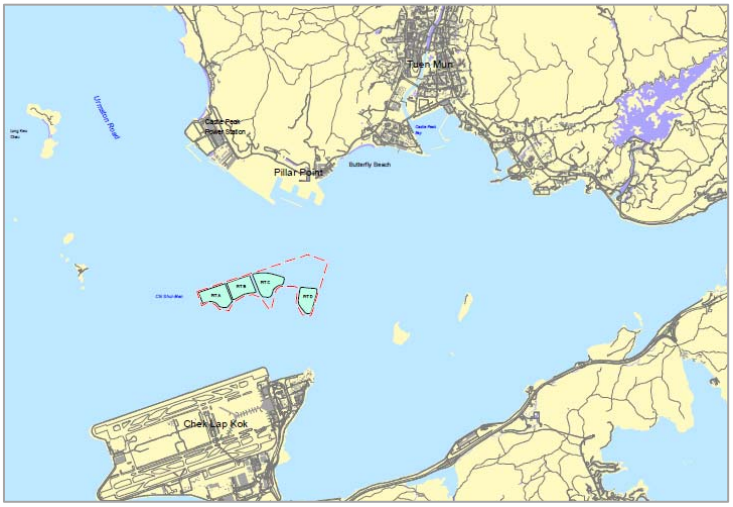

土木工程拓展署
Civil Engineering and Development Department

Environmental Monitoring and Audit for Contaminated Mud Pit at Sha Chau (2009-2013) – Investigation

Agreement No. CE 4/2009(EP)

Environmental Monitoring and Audit (EM&A) Manual

Final Second Review

17 November 2010

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Distribution

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1 INTRODUCTION

1.1 PURPOSE OF THE MANUAL

This Environmental Monitoring and Audit (EM&A) Manual ("the Manual") has been prepared by ERM-Hong Kong, Limited (ERM) on behalf of the Civil Engineering and Development Department (CEDD) of the Hong Kong Special Administrative Region (HKSAR) Government.

The purpose of the Manual is to provide information, guidance and instruction to personnel charged with environmental duties and those responsible for undertaking EM&A work during the operation of Contaminated Mud Pit IV and V (CMP IV and CMP V) at East of Sha Chau. It provides systematic procedures for monitoring and auditing of potential environmental impacts that may arise from the works.

EM&A works relating to CMP V have been prepared in accordance with the Environmental Permit (EP-312/2008/A) (EP) for Disposal of Contaminated Sediment – Dredging, Management and Capping of Sediment Disposal Facility at Sha Chau (hereafter referred as "the Project") and the *Technical Memorandum of the Environmental Impact Assessment Process (EIAO TM)*.

1.2 REVIEW OF EM&A MANUAL

The EM&A Manual is an evolving document that should be updated to maintain its relevance as the Project progresses. The primary focus for reviews of the EM&A Manual will be to ensure the impacts predicted and the recommended mitigation measures remain consistent and appropriate to the manner in which the works are to be carried out.

This second review of the EM&A Manual has been made to integrate the EM&A requirements of both the existing (CMP IV) and new (CMP V) disposal facilities at Sha Chau in order to facilitate the subsequent implementation of the respective EM&A works. This includes suitable provisions for the monitoring requirements of CMP IV after the pits are filled and capped. This EM&A Manual incorporates the requirements for the second review. Further reviews and subsequent updates will be undertaken whenever necessary to take into account the findings obtained during the Assignment as the works progress and will be presented in separate documents.

1.3 PROJECT DESCRIPTION

1.3.1 Background to the Study

Since December 1992, the East of Sha Chau area has been the site of a series of dredged CMPs designed to provide confined marine disposal capacity for

contaminated mud arising from the HKSAR's dredging and reclamation projects. The latest group of pits, CMP IVa, b & c began receiving contaminated mud from construction projects on 1 December 1997. CMP IVa was full by March 2000 (7.0 Mm^3 of contaminated mud) and CMP IVb was full by May 2002 (12.5 Mm^3 of contaminated mud). CMP IVc is presently in operation for backfilling by contaminated sediments.

As required by the Environment Protection Department (EPD), an environmental monitoring and audit programme was carried out to monitor the operation of the CMP IV under the Project "Management and Capping of Contaminated Mud Pit IV at East of Sha Chau". In this connection, an environmental monitoring and audit programme which encompassed water and sediment chemistry, fisheries assessment, tissue and whole body analysis, sediment toxicity and benthic recolonisation studies have been continuously carried out since the operation of CMP IV. A review of the collection and analysis of such environmental data from the monitoring programme demonstrated that there had not been any adverse environmental impacts resulting from disposal activities (1)(2)(3)(4).

Capacity to dispose of contaminated mud is currently predicted to be exhausted by 2010 with the completion of backfilling of CMP IVc at East of Sha Chau. When CMP IVc is full, a new environmentally acceptable disposal capacity for essential arisings will be required. A capacity of 8 Mm^3 has been estimated as being needed to provide disposal capacity up to 2015. The assignment *Strategic Assessment and Site Selection Study for Contaminated Mud Disposal (Agreement CE 105/98)* recommended a Contained Aquatic Disposal facility (CAD - capped seabed pit such as those already used at East of Sha Chau) at Airport East (5). The results and recommendations of CE 105/98 were presented to the Advisory Council on the Environment (ACE) on 23 July 2001 (ACE Paper 4/2001). The study recommended that an EIA be carried out.

The results of the EIA indicated that a series of four seabed pits be constructed at East of Sha Chau to meet continuing contaminated sediment demands (6). This recommendation and the EIA supporting it were endorsed by ACE on 11 July 2005 and the EIA was subsequently approved by the Director of Environmental Protection (DEP) without conditions on 1 September 2005 (AEIAR-089/2005).

(1) ERM – Hong Kong, Ltd (2002) Environmental Monitoring and Audit for Contaminated Mud Pit IV at East of Sha Chau. Final Report. For the Civil Engineering Department, Hong Kong SAR Government..

(2) ERM (2007b) Environmental Monitoring and Audit for Contaminated Mud Pit IV at East of Sha Chau (2005 - 2008). Final First Annual Review Report. For CEDD.

(3) ERM (2008d) Environmental Monitoring and Audit for Contaminated Mud Pit IV at East of Sha Chau (2005 - 2008). Final Second Annual Review Report. For CEDD.

(4) ERM (2009c) Environmental Monitoring and Audit for Contaminated Mud Pit IV at East of Sha Chau (2005 - 2008). Final Third Annual Review Report. For CEDD.

(5) ERM - Hong Kong, Ltd (1999) Strategic Assessment and Site Selection Study for Contaminated Mud Disposal. Final Report. For the Civil Engineering Department, Hong Kong SAR Government.

(6) ERM (2005) New Contaminated Mud Marine Disposal Facility at Airport East / East Sha Chau Area: EIA Report.(AEIAR-089/2005). Approved without conditions on 1 Sep 2005

An Environmental Permit (EP-312/2008) was issued by the Environmental Protection Department (EPD) to the CEDD, the Permit Holder, on 9 September 2008 and varied on 28 November 2008 (EP-312/2008/A) for CMP V.

Under the requirements of *Condition 3* of the EP (EP-312/2008) for CMP V, an EM&A programme as set out in the Manual is required to be implemented. EM&A programmes have been continuously carried out during the operation of the previous mud pits. The proposed monitoring and audit programme for CMP V is a continuation of the existing monitoring and audit programme. The monitoring and audit arrangement will integrate the monitoring requirements for CMP IV and CMP V. In this regard, the programme will assess the impacts resulting from disposal and capping of CMP IV and from dredging, disposal and capping of CMP V.

1.3.2 Contaminated Mud Disposal Operations at East of Sha Chau

The dredging, backfilling and capping of CMP V is classified as a Designated Project by virtue of Item C (Reclamation, Hydraulic and Marine Facilities, Dredging and Dumping), Item C.10 (A Marine Dumping Area) and C.12 (A Dredging Operation Exceeding 500,000 m^3) of Part I of Schedule 2 under the *Environmental Impact Assessment Ordinance (Cap. 499) (EIAO).*

The key components of the construction and operation of CMP V include the following:

i. Dredging of a series of seabed pits at CMP V within the proposed facility boundaries at East of Sha Chau (*Figure 1.1*);

ii. Backfilling each dredged pit at CMP V with contaminated mud that has been classified as requiring Type 2 disposal in accordance with ETWBTC 34/2002 (1); and,

iii. Capping each backfilled pit at CMP V with uncontaminated mud effectively isolating the contaminated mud from the surrounding marine environment.

The key components for the operation of CMP IV include the following:

i. Disposal of contaminated mud into Pit IVc that has been classified as requiring Type 2 disposal in accordance with ETWBTC 34/2002 (2); and,

ii. Capping backfilled CMP IV with uncontaminated mud, effectively isolating the contaminated mud from the surrounding marine environment.

(1) ETWBTC (2002). *Op cit.*

(2) ETWBTC (2002). Management of Dredged/Excavated Sediment. Environment, Transport and Works Bureau Technical Circular 34/2002.

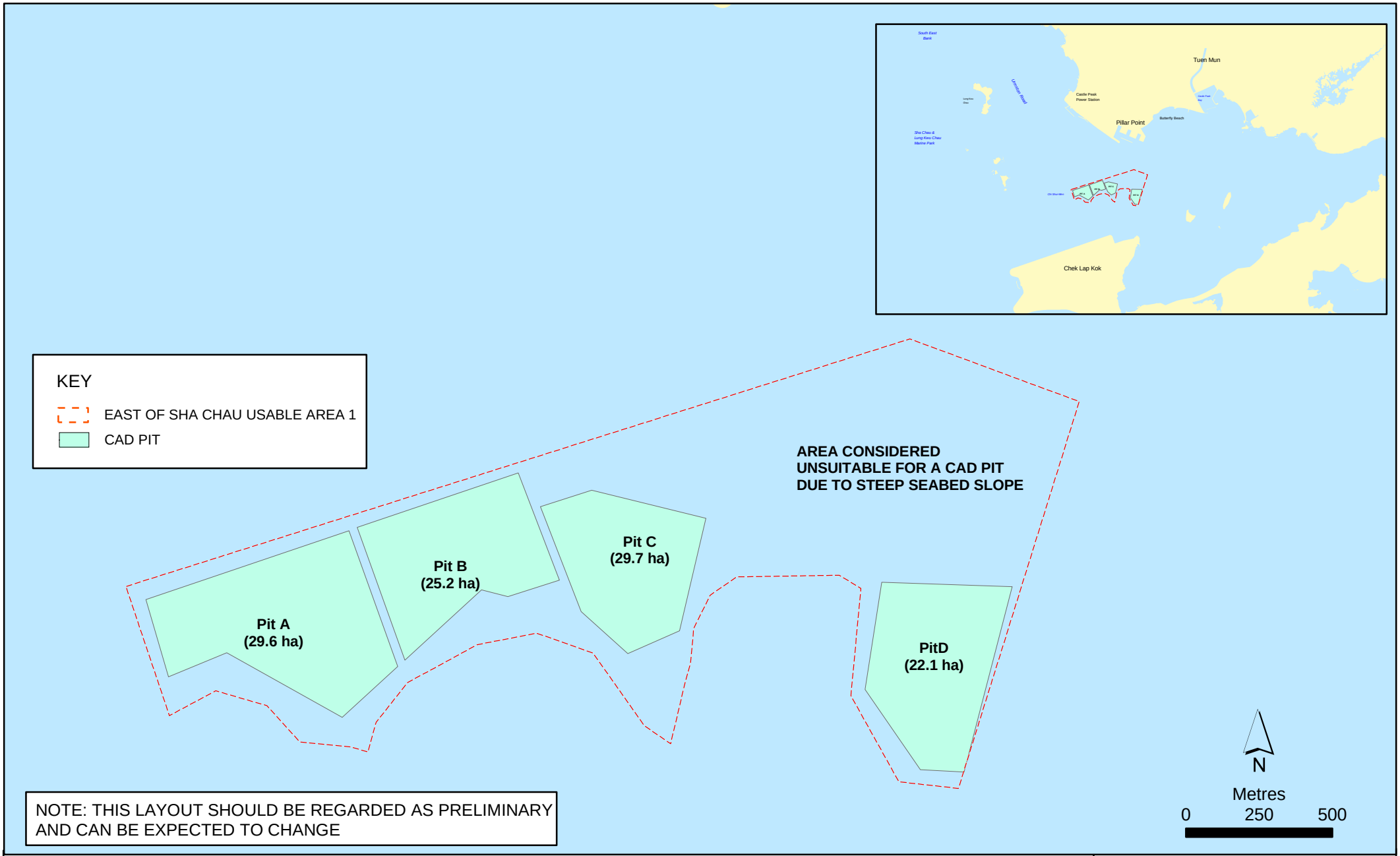

Figure 1.1

Preliminary Layout for a Multi-Pit Contained Aquatic Disposal (CAD) Facility in the East of Sha Chau Area

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1.3.3 Construction Programme

It is expected that CMP IVc will be active until March 2011 and capping will start in April 2011. Dredging for the first pit at CMP V commenced in September 2009 in order to be ready to receive contaminated mud in mid 2011. According to the arising estimates, the fourth pit of CMP V (CMP Vd) at the East of Sha Chau Facility will be backfilled and capped during the first half of 2015. It should be noted that should the rate at which contaminated mud arises change (either increasing or decreasing) then CMP Vd may be capped earlier or later.

1.4 BACKGROUND TO THE EM&A PROGRAMME

The construction and operational impacts resulting from the implementation of CMP IV and V are specified in the respective EIA Reports. The EIA Report also specifies mitigation measures that need to be implemented to ensure compliance with the required environmental criteria. These mitigation measures and their implementation requirements are presented in the Implementation Schedule (*Annex A).* The EIAs recommend that environmental monitoring will be necessary to assess the effectiveness of measures implemented to mitigate potential water quality, marine ecology and fisheries impacts during the construction and operation of the proposed facility. Regular environmental auditing is also recommended to ensure that potential impacts from other sources are adequately addressed through the implementation of the mitigation measures defined in the EIA Reports.

This Manual provides the EM&A requirements that have been recommended in the EIA Reports for CMP IV and V in order to ensure compliance with the specified mitigation measures.

1.5 THE SCOPE OF THE EM&A PROGRAMME

The scope of this EM&A programme is to:

- establish baseline water quality levels at specified locations prior to dredging operations for the construction of CMP V at Sha Chau;
- implement monitoring and inspection requirements for water quality monitoring programme during backfilling and capping of CMP IV and during dredging, backfilling and capping operations of CMP V;
- implement monitoring and inspection requirements for sediment quality monitoring programme during backfilling operations at CMP IV and CMP V;
- implement monitoring and inspection requirements for sediment toxicity monitoring programme during backfilling operations at CMP IV and CMP V;

- implement monitoring and inspection requirements for the body burden (marine biota) monitoring programme during backfilling operations at CMP IV and CMP V;

- liaise with, and provide environmental advice (as requested or when otherwise necessary) to site staff on the comprehension and consequences of the environmental monitoring data;

- identify and resolve environmental issues and other functions as they may arise from the works;

- check and quantify the Contractor's overall environmental performance, implementation of Event and Action Plans (EAPs), and remedial actions taken to mitigate adverse environmental effects as they may arise from the works;

- conduct monthly reviews of monitored impact data as the basis for assessing compliance with the defined criteria and to ensure that necessary mitigation measures are identified and implemented, and to undertake additional *ad hoc* monitoring and auditing as required by special circumstances;

- evaluate and interpret all environmental monitoring data to provide an early indication should any of the environmental control measures or practices fail to achieve the acceptable standards, and to verify the environmental impacts predicted in the EIA;

- manage and liaise with other individuals or parties concerning other environmental issues deemed to be relevant to the construction and operation process; and,

- conduct regular site inspections of a formal or informal nature to assess:

  – the level of the Contractor's general environmental awareness;

  – the Contractor's implementation of the recommendations in the EIA;

  – the Contractor's performance as measured by the EM&A;

  – the need for specific mitigation measures to be implemented or the continued usage of those previously agreed;

  – to advise the site staff of any identified potential environmental issues; and,

  – submit regular EM&A reports which summarise project monitoring and auditing data, with full interpretation illustrating the acceptability or otherwise of any environmental impacts and identification or assessment of the implementation status of agreed mitigation measures.

1.5.1 Environmental Management Plan (EMP)

To ensure effective implementation and reporting on compliance with the stated mitigation measures, as well as the monitoring and auditing requirements and remedial actions defined in the EIA, an appropriate contractual and supervisory framework needs to be established. The basis of the framework within which implementation should be managed overall is through the preparation of EMPs by the Contractor(s).

An EMP is similar in nature to a quality plan and provides details of the means by which the Contractor (and all subcontractors working to the Contractor) will implement the recommended mitigation measures and achieve the environmental performance standards defined in Hong Kong environmental legislation, the contract and in the EIA documentation. The primary reason for adopting the EMP approach is to make the Contractor aware of his environmental responsibilities and to be pro-active about the commitment to achieve the standards specified, rather than relying on the EM&A programme.

The EMP also provides opportunities for the Contractor to draw upon the strength of other institutional processes such as ISO 9000/14000 to ensure that the achievement of the required standards and fulfilment of commitments are documented.

The contractual requirement for an EMP would generally comprise appropriate extracts from (and references to) the EIA Report and EM&A Manual, and include such typical elements as the relevant statutory environmental standards, general environmental control clauses and specific environmental management clauses, as well as an outline of the scope and content of the EMP. In drafting the documentation, due consideration should be given to the predictive nature of the EIA process and the consequent need to manage and accommodate the actual impacts arising from the construction process. In particular, the Contractor must be placed under a clear obligation to identify and control any implications arising from changes to the working methods assumed in the EIA, or to the progress rates and other estimates made during the preliminary design phase.

1.6 OBJECTIVES OF THE EM&A PROGRAMME

The objectives of the EM&A programme are as follows:

1. To monitor and report on the environmental impacts of the dredging operations associated with the construction of the disposal pits at CMP V.

2. To monitor and report on the environmental impacts due to capping operations of the exhausted pits at CMP IV and V.

3. To monitor and report on the environmental impacts of the disposal of contaminated marine sediments in the active pits at CMP IV and V, specifically to determine:

- changes/trends caused by disposal activities in the concentrations of contaminants in sediments adjacent to the pits;
- changes/trends caused by disposal activities in the toxicity of sediment adjacent to the pits;
- changes/trends caused by disposal activities in the concentrations of contaminants in tissues of demersal marine life adjacent to and remote from the pits;
- impacts on water quality and benthic ecology caused by the disposal activities; and
- the risks to human health and dolphin of eating seafood taken in the marine area around the active pits.

4. To monitor and report on the environmental impacts of the disposal operation at CMP IV and V and specifically to determine whether the methods of disposal are effective in minimising the risks of adverse environmental impacts.

5. To monitor and report on the benthic recolonisation of the capped pits at CMP IV and V and specifically to determine the difference in infauna between the capped pits and adjacent sites.

6. To assess the impact of a major storm (Typhoon Signal No. 8 or above) on the containment of any uncapped or partially capped pits at CMP IV and V.

7. To design and continually review the operation and monitoring programme and:
   - to make recommendations for changes to the operation that will rectify any unacceptable environmental impacts; and
   - to make recommendations for changes to the monitoring programme that will improve the ability to cost effectively detect environmental changes caused by the disposal activities.

8. To establish numerical decision criteria for defining impacts for each monitoring component.

9. To provide supervision on the field works and laboratory works to be carried out by contractors/laboratories.

The specific objectives of each component are discussed in the relevant sections of this EM&A Manual.

1.7 ORGANISATION AND STRUCTURE OF THE EM&A

1.7.1 General

The Civil Engineering and Development Department (CEDD) will appoint an Environmental Team (ET) to conduct the monitoring and auditing works and to provide specialist advice on the undertaking and implementation of environmental responsibilities.

The ET will have previous relevant experience with managing similarly sized EM&A programmes and the Environmental Team Leader (ET Leader) will be a recognised environmental professional, preferably with a minimum of seven years relevant experience in impact assessments and impact monitoring programmes.

To maintain strict control of the EM&A process, the ET will also appoint independent auditor(s) to verify and validate the environmental performance of the Contractor and the ET.

1.7.2 Project Organisation

The roles and responsibilities of the various parties involved in the EM&A process are further expanded in the following sections. The ET Leader will be responsible for, and in charge of, the Environmental Team; and will be the person responsible for executing the EM&A requirements.

Contractor

Reporting to CEDD, the Contractor will:

- work within the scope of the construction contract and other tender conditions;
- provide assistance to the ET in conducting the required environmental monitoring;
- participate in the site inspections undertaken by the ET, as required, and undertake any corrective actions instructed by CEDD;
- provide information/advice to the ET regarding works activities which may contribute, or be contributing to the generation of adverse environmental conditions;
- implement measures to reduce impact where Action and Limit levels are exceeded; and
- take responsibility and strictly adhere to the guidelines of the EM&A programme and complementary protocols developed by their project staff.

Civil Engineering and Development Department (CEDD)

CEDD will:

- monitor the Contractor's compliance with contract specifications, including the effective implementation and operation of environmental mitigation measures and other aspects of the EM&A programme;
- comply with the agreed Event and Action Plan in the event of any exceedance; and
- instruct the Contractor to follow the agreed protocols or those in the Contract Specifications in the event of exceedances or complaints.

Environmental Team

The duties of the Environmental Team (ET) and Environmental Team Leader (ET Leader) are to:

- monitor the various environmental parameters as required by this or subsequent revisions to the EM&A Manual;
- assess the EM&A data and review the success of the EM&A programme determining the adequacy of the mitigation measures implemented and the validity of the EIA predictions as well as identify any adverse environmental impacts before they arise;
- conduct regular site inspections and to investigate and inspect the Contractor's equipment and work methodologies with respect to pollution control and environmental mitigation, monitor compliance with the environmental protection specifications in the Contract, and to anticipate environmental issues that may require mitigation before the problem arises;
- audit the environmental monitoring data and report the status of the general site environmental conditions and the implementation of mitigation measures resulting from site inspections;
- review Contractor's working programme and methodology, and comment as necessary;
- investigate and evaluate complaints, and identify corrective measures;
- advice to the Contractor on environmental improvement, awareness, enhancement matters, etc, on site;
- employ an Independent Auditor(s) to audit the results of the EM&A works carried out by the ET;
- report on the environmental monitoring and audit results and the wider environmental issues and conditions to the Contractor, CEDD and the EPD; and

- adhere to the agreed protocols or those in the Contract Specifications in the event of exceedances or complaints.

The ET will be led and managed by the ET leader. The ET leader will have relevant education, training, knowledge, experience and professional qualifications subject to the approval of the Director of Environmental Protection. Suitably qualified staff will be included in the ET, and ET should not be in any way an associated body of the Contractor.

1.8 STRUCTURE OF THE EM&A MANUAL

The remainder of the Manual is set out as follows:

- *Section 2* sets out the EM&A general requirements;
- *Section 3* details the methodologies, parameters to be tested and the requirements for the marine water quality monitoring for the dredging, backfilling and capping operations at the active pits;
- *Section 4* details the methodologies, parameters to be tested and the requirements for sediment quality monitoring for the backfilling activities at the active pits;
- *Section 5* details the methodologies, parameters to be tested and the requirements for sediment toxicity quality monitoring for the backfilling activities at the active pits;
- *Section 6* details the methodologies, parameters to be tested and the requirements for marine biota monitoring for the backfilling activities at the active pits;
- *Section 7* details the requirements for Human Health and Dolphin Risk Assessment;
- *Section 8* details the requirements for benthic re-colonisation assessment;
- *Section 9* details the methodologies, parameters to be tested and the requirements for the assessment of impacts due to major storms; and
- *Section 10* details the EM&A reporting requirements.

2 EM&A GENERAL REQUIREMENT

2.1 INTRODUCTION

In this section, the general requirements of the EM&A programme are presented with reference to the EIA Study findings that have formed the basis of the scope and content of the programme.

2.2 EM&A

Key environmental issues associated with the construction and operation of the Project will be addressed through monitoring and controls specified in the EM&A Manual. Water and sediment quality, marine ecology and fisheries issues will be subject to EM&A, the details of which are outlined in *Sections 3* to *9*.

2.2.1 Action and Limit Levels

Action and Limit (A/L) Levels are defined levels of impact recorded by the environmental monitoring activities which represent levels at which a prescribed response is required. These levels only relate to CMP V. This processes by which these levels should be quantitatively defined are presented in the relevant sections of this manual and described in principle below:

- *Action Limits:* beyond which there is a clear indication of a deteriorating ambient environment for which appropriate remedial actions are likely to be necessary to prevent environmental quality from falling outside the *Limit Levels*, which would be unacceptable; and

- *Limit Levels:* statutory and/or agreed contract limits stipulated in the relevant pollution control ordinances, HKPSG or *Environmental Quality Objectives* established by the EPD. If these are exceeded, works should not proceed without appropriate remedial action, including a critical review of plant and working methods.

2.2.2 Event and Action Plan

The purpose of an Event and Action Plan (EAP) is to provide, in association with the monitoring and audit activities, procedures for ensuring that if any significant environmental incident (either accidental or through inadequate implementation of mitigation measures on the part of the Contractor) does occur, the cause will be quickly identified and remediated, and the risk of a similar event recurring is reduced. This also applies to the exceedances of A/L criteria to be identified in the EM&A programme. As with the Action and Limit Levels, the Event and Action Plan only relates to CMP V.

2.2.3 Enquiries, Complaints and Requests for Information

Enquiries, complaints and requests for information can be expected from a wide range of individuals and organisations including members of the public, Government departments, the press and television media and community groups.

All enquiries concerning the environmental effects of the Project (CMP IV and V), irrespective of how they are received, will be reported to CEDD and directed to the ET Leader who will set up procedures for handling, investigation and storage of such information. The following steps will then be followed:

1) The ET Leader will notify CEDD of the nature of the enquiry.

2) An investigation will be initiated to determine the validity of the complaint and to identify the source of the problem.

3) The ET Leader will undertake the following steps, as necessary:

   - investigate and identify source of the problem;
   - if considered necessary by CEDD undertake additional monitoring to verify the existence and severity of the alleged complaint;
   - liaise with EPD to identify remedial measures;
   - liaise with CEDD and the Contractor to identify remedial measures;
   - implement the agreed mitigation measures;
   - repeat the monitoring to verify effectiveness of mitigation measures; and
   - repeat review procedures to identify further possible areas of improvement if the repeat monitoring results continue to substantiate the complaint.

4) The outcome of the investigation and the action taken will be documented on a complaint proforma (*Annex B*). A formal response to each complaint received will be prepared by the ET Leader within a maximum of five working days and submitted to CEDD, in order to notify the concerned person(s) that action has been taken.

5) All enquiries which trigger this process will be reported in the EM&A reports which will include results of inspections undertaken by the ET Leader, and details of the measures taken, and additional monitoring results (if deemed necessary). It should be noted that the receipt of complaint or enquiry will not be, in itself, a sufficient reason to introduce additional mitigation measures.

In all cases the complainant will be notified of the findings, and audit procedures will be put in place to ensure that the problem does not recur.

2.2.4 Reporting

Monthly, Quarterly and Annual reports for CMP IV and V will be submitted to CEDD, EPD and AFCD and will be prepared by the ET. The reports will be prepared and submitted within a specified period. Additional details on reporting protocols are presented in *Section 10*.

3 WATER QUALITY

3.1 INTRODUCTION

This Section provides details of the water quality monitoring to be undertaken during the construction and operation of the active pits. Water quality modelling carried out for the EIA indicates that the potential water quality impacts associated with the backfilling and capping works at CMP IV and dredging, backfilling and capping works at CMP V will be within acceptable levels and no adverse water quality impacts are expected. However, the monitoring programme is designed to verify the predictions of the EIA and ensure compliance with the WQOs.

3.2 MONITORING ACTIVITIES

Water quality monitoring for the Project can be divided into the following stages:

- Dredging Activities for CMP V;
- Backfilling Activities for CMP IV and V; and
- Capping Activities for CMP IV and V.

Each of these is discussed in turn below.

3.3 MONITORING FOR DREDGING ACTIVITIES OF CMP V

Water quality monitoring will be conducted during dredging of four seabed pits for CMP V at Sha Chau. Monitoring will consist of the collection of baseline water quality data for the purposes of the development of Action and Limit Levels, as well as impact monitoring of actual dredging activities.

3.3.1 *Baseline Monitoring for Dredging Activities of CMP V*

Baseline monitoring for dredging activities will be conducted in the vicinity of the new facility at Sha Chau and in reference areas (EPD Water Quality Monitoring Stations NM1, 2, 3, 5 and 6) for a period of four weeks prior to the commencement of marine dredging works in order to gather representative water quality data for the EM&A. Locations of the baseline monitoring stations are shown in *Figure 3.1* and the coordinates are shown in *Table 3.1.*

The baseline water quality monitoring will be undertaken three days per week at all stations within a 3 hour window of 1.5 hours before or after mid-flood and mid-ebb tides for four weeks prior to construction works commencing. The interval between two sampling surveys will not be less than 36 hours. A sampling survey will include the collection of all water samples and

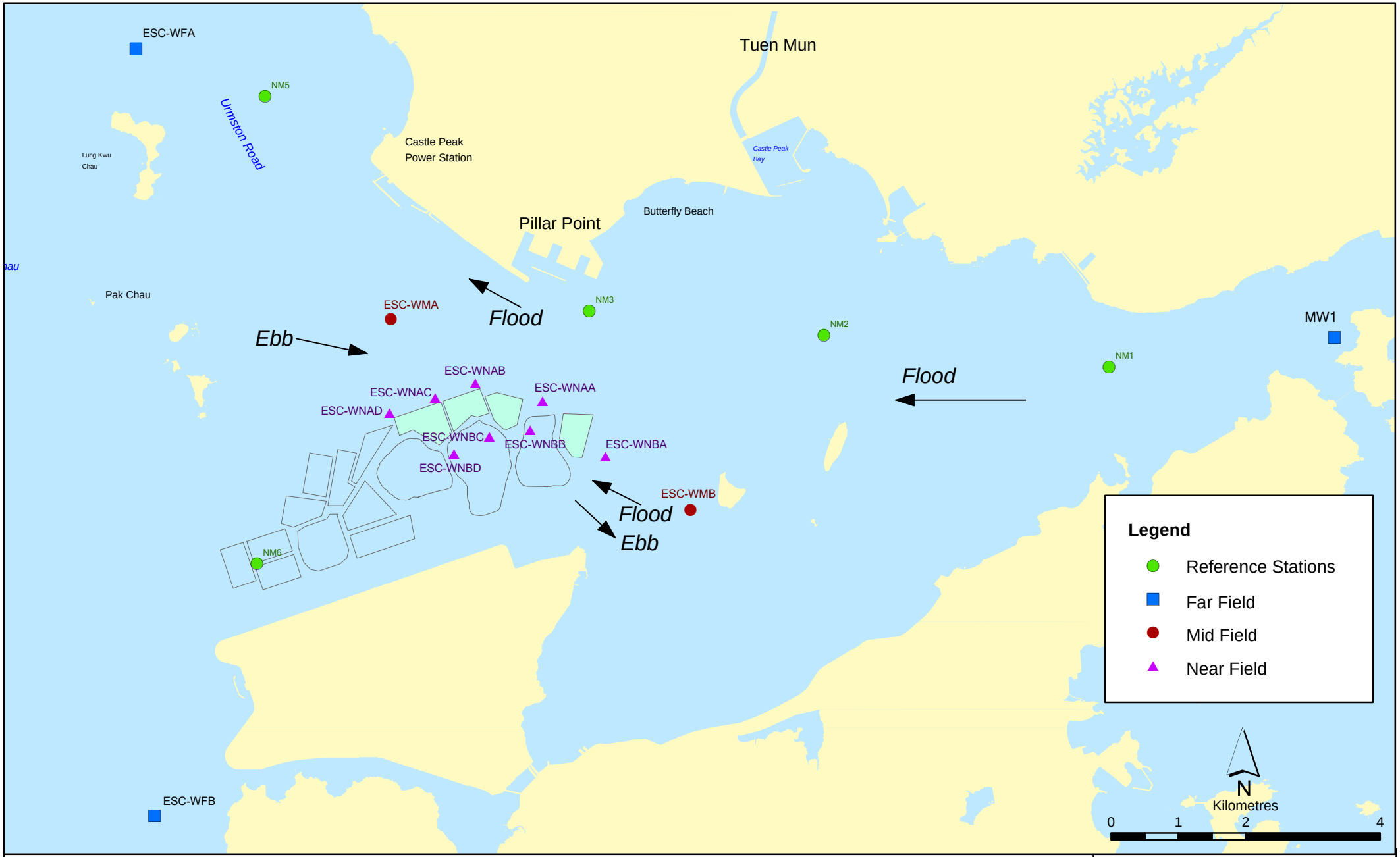

Figure 3.1

Baseline Water Quality Monitoring Stations for Dredging Activities

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measurement of all *in situ* parameters during both mid-flood and mid-ebb tides at all stations on the same day.

Table 3.3.1 Coordinates of Water Quality Monitoring Stations for Baseline Water Quality Monitoring for Dredging Activities

Monitoring Stations	Eastings	Northings
Far Field Stations		
ESC-WFA	805787	827951
ESC-WFB	806066	816537
MW1	823604	823654
Near Field Stations		
ESC-WNAA	811830	822706
ESC-WNAB	810833	822965
ESC-WNAC	810235	822756
ESC-WNAD	809557	822527
ESC-WNBA	812767	821889
ESC-WNBB	811651	822278
ESC-WNBC	811043	822178
ESC-WNBD	810514	821919
Mid Field Stations		
ESC-WMB	814033	821082
ESC-WMA	809577	823922
Reference Stations		
NM1	820256	823214
NM2	816015	823686
NM3	812527	824049
NM5	807707	827244
NM6	807584	820286

Each station will be sampled and measurements will be taken at three depths, 1 m below the sea surface, mid depth and 1 m above the seabed. Where the water depth is less than 6 m the mid-depth station may be omitted. If the water depth is less than 3 m, only the mid-depth station will be monitored.

The following suite of parameters should be measured as part of the baseline monitoring:

- Dissolved Oxygen (mg L^{-1}) (*in situ*);
- Salinity (ppt) (*in situ*);
- pH *(in situ*);
- Turbidity (NTU) (*in situ*);
- Temperature (°C) (*in situ*);
- Current Velocity and Direction (ms^{-1}) (*in situ*);
- Suspended Solids (mg L^{-1}) (laboratory analysis);
- Ammonia (mg L^{-1}) (laboratory analysis);
- Total Inorganic Nitrogen (TIN mg L^{-1}) (laboratory analysis);

- 5-Day Biochemical Oxygen Demand (BOD) (mg L^{-1}) (laboratory analysis);
- Cadmium (mg L^{-1}) (laboratory analysis);
- Chromium (mg L^{-1}) (laboratory analysis);
- Copper (mg L^{-1}) (laboratory analysis);
- Lead (mg L^{-1}) (laboratory analysis);
- Mercury (mg L^{-1}) (laboratory analysis);
- Nickel (mg L^{-1}) (laboratory analysis);
- Silver (mg L^{-1}) (laboratory analysis);
- Zinc (mg L^{-1}) (laboratory analysis); and,
- Arsenic (mg L^{-1}) (laboratory analysis).

In addition to the water quality parameters, other relevant data will also be measured and recorded in Water Quality Monitoring Logs, including the location of the sampling stations, water depth, time, weather conditions, sea conditions, tidal stage, special phenomena and work activities undertaken around the monitoring and works area that may influence the monitoring results.

Four hard copies and one electronic copy of the Baseline Monitoring Report will be submitted to EPD at least two weeks before commencement of construction of the Project.

3.3.2 Impact Monitoring for Dredging Activities of CMP V

Impact monitoring for the dredging activities to form CMP V will be conducted at mobile stations around the dredging area. Currently the impact monitoring is conducted for three times per week and the monitoring frequency may be revised upon agreement with the EPD. Monitoring will be carried out during both mid-flood and mid-ebb tides on each monthly monitoring day. The location of the mobile stations is dependent on the location of the dredging activities. These mobile stations will be located at an appropriate distance between each other along the up-current and down-current transect for the dredging area. The following methodology will be adopted to determine the precise location of the mobile stations on each sampling occasion:

- Contact the CEDD barge one day before the survey day for every sampling occasion to determine the dredging schedule for that particular survey day and to determine the likely location of dredging at the proposed time of sampling;
- Determine current direction at mid-depth at one station upstream and one station downstream of the new facility during both mid-flood and

mid-ebb tide. Upstream station will be 100 m upstream and the downstream station will be 100 m downstream of the dredging area of CMP V;

- Determine a suitable location for the station transect (the first down-current station will be located on the down current edge, and first up-current station will be located on the up-current edge, of the CMP V according to the current direction and the position of dredging at the time of sampling); and,

- Collect samples from the stations located on a transect running up-current and down-current of the dredging area.

There will be two stations located up-current and five stations down-current of CMP V on the transect. A 500 m separation distance will be adopted between adjacent stations except between adjacent upstream and downstream stations which are located on the pit edge. In addition, water samples will be collected from the station MW1 as shown in *Figure 3.2*. Locations of upstream and downstream stations are illustrated in *Figure 3.2* based on assumed current direction and dredging position during monitoring.

Each station will be sampled and measurements will be taken at three depths, 1 m below the sea surface, mid depth and 1 m above the seabed. Duplicate water samples and measurements will be taken at each depth. Where water depth is less than 6m the mid-depth station may be omitted. If water depth is less than 3m, only the mid-depth station will be monitored.

The following suite of parameters should be measured as part of the impact monitoring for dredging:

- Dissolved Oxygen (mg L^{-1}) (*in situ*);
- Salinity (ppt) (*in situ*);
- pH (*in situ*);
- Turbidity (NTU) (*in situ*);
- Temperature (°C) (*in situ*)
- Current Velocity and Direction (ms^{-1}) (*in situ*); and,
- Suspended Solids (mg L^{-1}) (laboratory analysis).

In addition to the water quality parameters, other relevant data will also be measured and recorded in Water Quality Monitoring Logs, including the location of the sampling stations, water depth, time, weather conditions, sea conditions, tidal stage, special phenomena and work activities undertaken around the monitoring and works area that may influence the monitoring results.

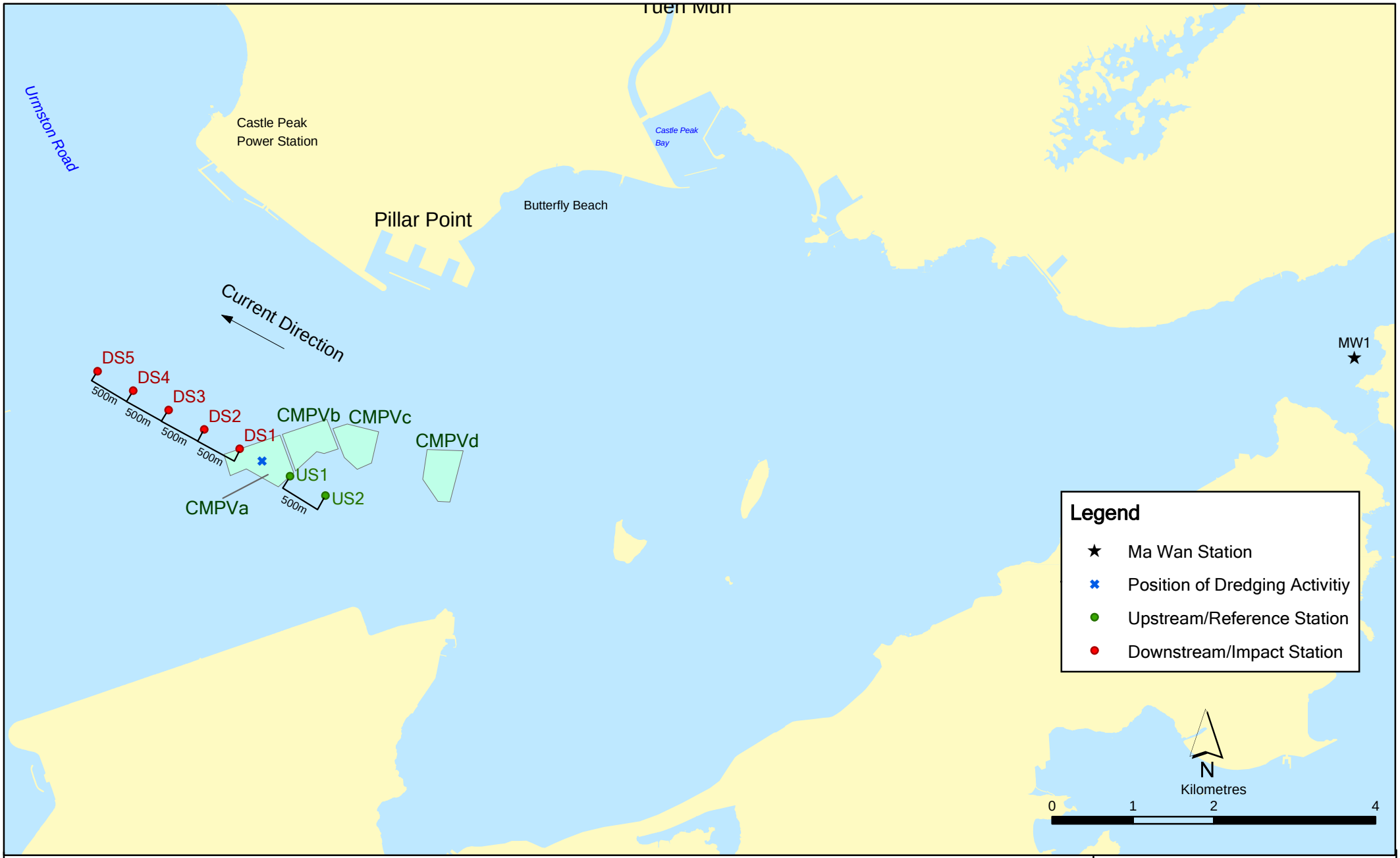

Figure 3.2

Indicative Dredging Impact Sampling Stations for CMPV

Note: The locations of sampling stations will be determined on site based on current direction and position of dredging activities.

File: CMPV\0103262_modelling stations2.mxd
Date: 28/09/2009

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3.3.3 Water Quality Compliance and Event & Action Plan

Impact monitoring for dredging activities of CMP V will be evaluated against Action and Limit Levels. The key assessment parameters are dissolved oxygen (DO) and suspended sediment (SS) and thus Action and Limit Levels based on the assessment criteria are identified for these parameters. However, turbidity can also provide valuable instantaneous information on water quality and thus an Action Limit is measured for this parameter to facilitate quick responsive action in the event of any apparent unacceptable deterioration attributable to the works.

The Action and Limit Levels for DO, turbidity and SS were determined in the *Baseline Monitoring Report* (1) according to the criteria shown in *Table 3.1*. The Action and Limit Levels of DO, turbidity and SS were derived from the baseline monitoring data (1) and they are presented in *Table 3.2*.

Action and Limit levels are used to determine whether modifications are necessary to mitigate impacts to water quality. In the event that the levels are exceeded, appropriate actions in Event and Action Plan (*Table 3.3)* should be undertaken.

(1) ERM - Hong Kong, Ltd (2009) Baseline Monitoring Report. For the Civil Engineering Department, Hong Kong SAR Government.

Table 3.1 ***Determination of Action and Limit Level of Water Quality for Dredging, Capping and Backfilling Activities of CMP V***

Parameter	Action Level	Limit Level
Dissolved Oxygen		
Surface and Middle Depth Averaged	The depth average of the impact station readings are <5%ile of baseline data and Significantly less than the reference stations mean DO (at the same tide of the same day)	The average of the impact station readings are <4mg/L and Significantly less than the reference stations mean DO (at the same tide of the same day)
Bottom	The average of the impact station readings are <5%ile of baseline data and Significantly less than the reference stations mean DO (at the same tide of the same day)	The average of the impact station readings are <2mg/L and Significantly less than the reference stations mean DO (at the same tide of the same day)
Suspended Solids		
Depth Averaged	The depth average of the impact station readings are >95%ile of baseline data and 120% or more of the reference stations SS (at the same tide of the same day)	The depth average of the impact station readings are >99%ile of baseline data and 130% or more of the reference stations SS (at the same tide of the same day)
Turbidity		
Depth Averaged	The depth average of the impact station readings are >95%ile of baseline data and 120% or more of the reference stations turbidity (at the same tide of the same day)	The depth average of the impact station readings are >99% of baseline data and 130% or more of the reference stations turbidity (at the same tide of the same day)

Table 3.2 ***Action and Limit Levels of Water Quality for Dredging, Capping and Backfilling Activities of CMP V.***

Parameter	Action Level	Limit Level
Dissolved Oxygen (DO) (1)		
Surface and Middle Depth Averaged (2)	5%-ile of baseline data for surface and middle layer = 3.76 mg L^{-1} and Significantly less than the reference stations mean DO (at the same tide of the same day)	1%-ile of baseline data for surface and middle layer = 3.11 mg L^{-1} (3) and Significantly less than the reference stations mean DO (at the same tide of the same day)
Bottom	5%-ile of baseline data for bottom layers = 2.96 mg L^{-1} and Significantly less than the reference stations mean DO (at the same tide of the same day)	The average of the impact station readings are <2 mg/L and Significantly less than the reference stations mean DO (at the same tide of the same day)
Depth-averaged Suspended Solids (SS) (4) (5)	95%-ile of baseline data for depth average = 37.88 mg L^{-1} and 120% of control station's SS at the same tide of the same day	99%-ile of baseline data for depth average = 61.92mg L^{-1} and 130% of control station's SS at the same tide of the same day
Depth-averaged Turbidity (Tby) (4) (5)	95%-ile of baseline data = 28.14 NTU and 120% of control station's turbidity at the same tide of the same day	99%-ile of baseline data = 38.32 NTU and 130% of control station's turbidity at the same tide of the same day

Notes:

(1) For DO, non-compliance of the water quality limits occurs when monitoring result is lower than the limits.

(2) The Action and Limit Levels for DO for Surface & Middle layers were calculated from the combined pool of baseline surface layer data and baseline middle layer data.

(3) Given the Action Level for DO for Surface & Middle layers has already been lower than 4 mg L^{-1}, it is proposed to set the Limit Level at 3.11 mg L^{-1} which is the first percentile of the baseline data.

(4) "Depth-averaged" is calculated by taking the arithmetic means of reading of all three depths.

(5) For turbidity and SS, non-compliance of the water quality limits occurs when monitoring result is higher than the limits.

Table 3.3 Water Quality Event and Action Plan during Dredging Operations

Event	Environmental Team (ET)	Contractor
Action Level		
Exceedance for one sample	• Repeat *in-situ* measurement to confirm findings; • Identify the source(s) of impact; • Inform contractor and contractor informs CEDD, EPD and AFCD and confirm notification of the non-compliance in writing; • Check monitoring data; • Discuss potential mitigation measures if exceedance is attributed to the works with contractor.	• Discuss potential mitigation measures with ET and agree on mitigation measures to be implemented if exceedance is attributed to the works; • Ensure mitigation measures are implemented; • Assess the effectiveness of the implemented mitigation measures.
Limit Level		
Limit level for one occasion	• Repeat *in-situ* measurement to confirm findings; • Identify source(s) of impact; • Inform contractor and contractor informs CEDD, EPD and AFCD; • Discuss further mitigation measures if exceedance is attributed to the works with contractor; • Increase the monitoring frequency to daily if exceedance is attributed to the works until no exceedance of the Limit Level.	• Critical review of working methods; • Check plant, equipment and working methods; • Discuss further mitigation measures with ET to be implemented if exceedance is attributed to the works; • Ensure mitigation measures are being implemented; • Assess the effectiveness of the implemented mitigation measures.
Limit Level exceeded on two or more occasions	• Identify source(s) of impact; • Inform contractor and contractor informs, CEDD, EPD and AFCD.	• If exceedance is attributed to the works consider and if necessary reduce works until no exceedance of Limit Level.
Impacts attributable to works	• Inform contractor and contractor informs, CEDD, EPD and AFCD.	• Comprehensive review of works; • Reduce works; and • Suspension of works.

3.4 MONITORING FOR BACKFILLING ACTIVITIES

3.4.1 Objective

The main objective of this component is to determine the impacts, if any, of backfilling activities at CMP IV and V on water quality. Two separate components of water quality monitoring are necessary during backfilling:

- *Routine Water Quality Monitoring* - Conducted to examine the impacts of disposal activities on the level of inorganic metal contaminants in marine waters; and,

- *Water Column Profiling* - conducted to examine *in situ* the effects of backfilling operations on water quality parameters within the water column.

3.4.2 Hypotheses

The impact hypothesis for this work component has been defined based on the predictions from the EIA regarding impacts from the contaminated mud disposal operations and the objectives for the study.

Backfilling operations do not result in any exceedances of Northwestern Water Quality Control Zone (NWQCZ) Water Quality Objectives (WQO).

As a consequence of performing two separate tasks for assessing the impacts of disposal operations on water quality, two null hypotheses will be tested:

Routine Water Quality Monitoring

H_0 There are no differences in the levels of contaminants in water samples in the plume arising from the disposal works and background levels in the vicinity of the backfilling.

Water Column Profiling

H_0 There is no change in the level of compliance with the NWWCZ WQOs of samples taken from the plume arising from backfilling activities (EIA predicted location).

3.4.3 Sampling Design

Routine Water Quality Monitoring

Routine water quality monitoring will be undertaken during backfilling activities at mid-ebb or mid-flood tide. Water samples will be collected at specific stations at fixed location, which should be located in three areas at increasing distances from the active facility; Reference, Intermediate and Impact stations/areas. The design for this component of the programme allows impacts, if any, to water quality as a result of the backfilling activities in the vicinity of CMP IV and V to be assessed.

The number of monitoring stations sampled depends on the state of the tide. During the ebb tide, water samples are collected from five up-current Reference Stations, five down-current Impact Stations and five down-current Intermediate Stations. During the flood tide, water samples are collected from three up-current Reference Stations, three down-current Impact Stations and three down-current Intermediate Stations. The approach will ensure that the impact of temporal changes on the hydrodynamic conditions in the area is considered in the sampling.

The following suite of parameters should be measured as part of routine water quality monitoring operations:

- Dissolved Oxygen (mg L^{-1}) (*in situ*);
- Salinity (ppt) (*in situ*);
- pH *(in situ*);
- Turbidity (NTU) (*in situ*);
- Temperature (°C) (*in situ*)
- Current Velocity and Direction (ms^{-1}) (*in situ*);
- Suspended Solids (mg L^{-1}) (laboratory analysis);
- Ammonia (mg L^{-1}) (laboratory analysis);
- Total Inorganic Nitrogen (TIN mg L^{-1}) (laboratory analysis);
- 5-Day Biochemical Oxygen Demand (BOD_5) (mg L^{-1}) (laboratory analysis)
- Cadmium (mg L^{-1}) (laboratory analysis);
- Chromium (mg L^{-1}) (laboratory analysis);
- Copper (mg L^{-1}) (laboratory analysis);
- Lead (mg L^{-1}) (laboratory analysis);
- Mercury (mg L^{-1}) (laboratory analysis);
- Nickel (mg L^{-1}) (laboratory analysis);
- Silver (mg L^{-1}) (laboratory analysis);
- Zinc (mg L^{-1}) (laboratory analysis); and
- Arsenic (mg L^{-1}) (laboratory analysis).

In addition to the water quality parameters, other relevant data will also be measured and recorded in Water Quality Monitoring Logs, including the location of the sampling stations, water depth, time, weather conditions, sea conditions, tidal stage, special phenomena and work activities undertaken around the monitoring and works area that may influence the monitoring results.

Sampling for CMP IV

For CMP IV the locations of stations during ebb and flood tides are shown in *Figures 3.3* and *3.4*, respectively, and the coordinates are shown in *Table 3.4*. Sampling should be undertaken at each station for two times per year, once in

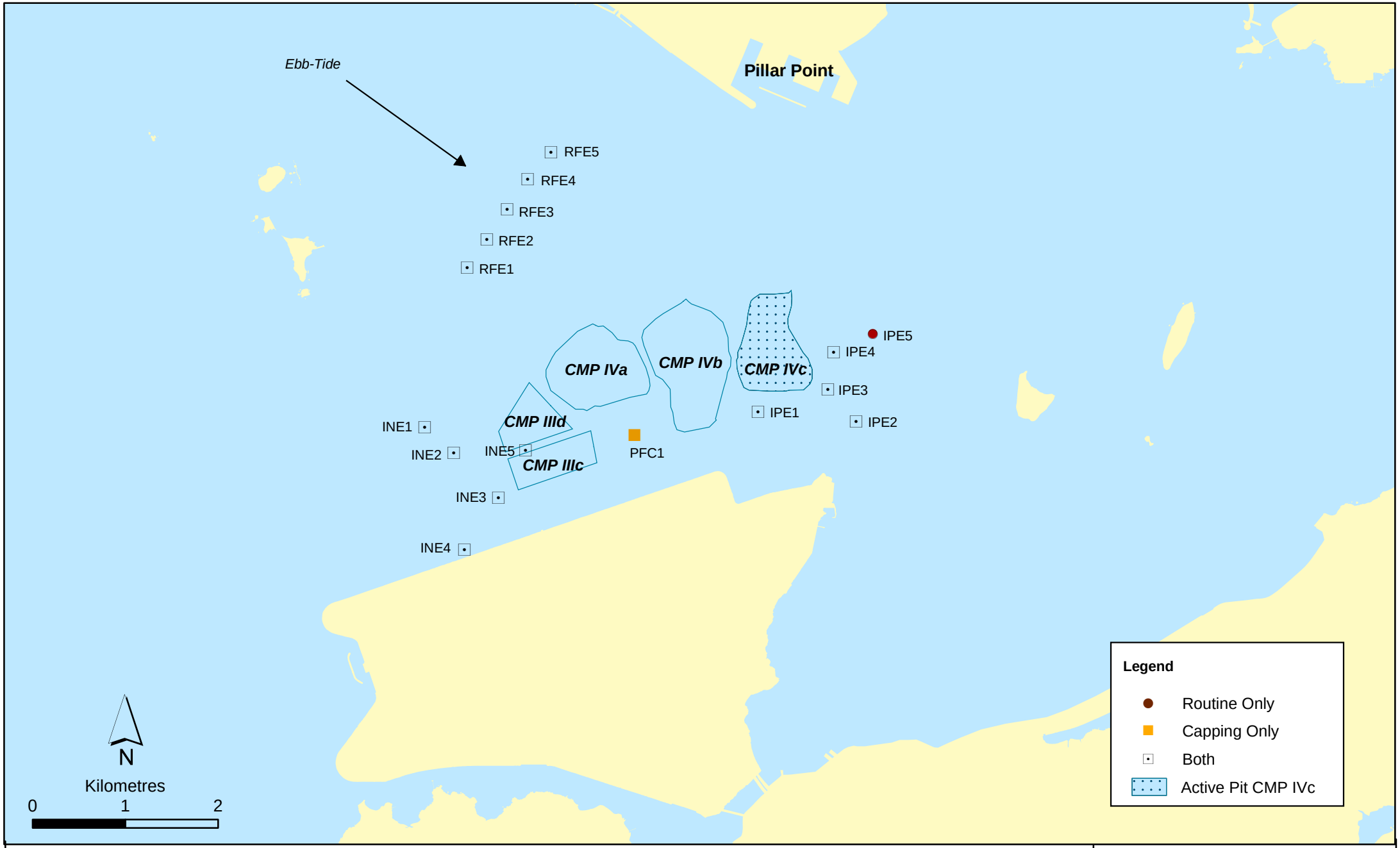

Figure 3.3

Routine & Capping Water Quality Sampling Stations (Ebb-Tide) for CMPIV

File: CMPIV\0103262_ WQsampling station.mxd
Date: 20/10/2009

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Figure 3.4

Routine & Capping Water Quality Sampling Stations (Flood Tide) for CMPIV

File: CMPIV\0103262_WQsampling station_flood.mxd
Date: 20/10/2009

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the dry season and once in the wet season. For a given sampling event water samples and *in situ* measurements should be taken at mid-depth of all stations during the same tidal state (ie mid-ebb or mid-flood tide). The *Long-term Review of Environmental Monitoring for Contaminated Mud Pits* (1) determined that this sampling frequency is adequate to track potential changes in contaminant concentrations of seawater which may take a long time to appear, while at the same time addressed the potential seasonal difference in seawater quality.

Table 3.4 ***Coordinates of Water Quality Monitoring Stations for Capping and Routine Water Quality Monitoring for CMP IVc***

Monitoring Stations	Eastings	Northings
Ebb		
Reference Stations		
RFE1	808527	822762
RFE2	808736	823066
RFE3	808956	823390
RFE4	809176	823715
RFE5	809427	824008
Impact Stations		
IPE1	811658	821212
IPE2	812716	821107
IPE3	812412	821453
IPE4	812475	821851
IPE5	812894	822050
PFC1	810328	820961
Intermediate Stations		
INE1	808066	821045
INE2	808380	820772
INE3	808862	820280
INE4	808495	819725
INE5	809155	820793
Flood		
Reference Stations		
RFF1	807608	820633
RFF2	812126	821111
RFF3	813233	821127
• **Impact Stations**	•	•
IPF1	809104	822250
IPF2	809721	822598
IPF3	810860	823706
PFC1	810623	823484
• **Intermediate Stations**	•	•
INF1	808775	823012
INF2	809096	823328
INF3	809571	823816
PFC2	810109	824272

Note: Coordinates are based on Hong Kong 1980 GRID Coordinate System.

(1) ERM– Hong Kong, Ltd (2008) Review of Past Monitoring Results for Contaminated Muds Pits. Environmental Monitoring and Audit for Contaminated Mud Pit IV at East of Sha Chau (2005-2008) - Investigation Agreement No. CE 19/2004 (EP) For the Civil Engineering Department, Hong Kong SAR Government.

Three replicate samples for Zinc and BOD_5, and two replicate samples for all other metals, Ammonia (NH_3), TIN and SS will be collected from each of the monitoring stations during each sampling event. This number of replicate samples for CMP IVc was determined from a power analyses that evaluated the cost efficiency and effectiveness of this EM&A programme (1).

Routine water quality monitoring will be undertaken for CMP IVc which will be active until March 2011 based on current predictions. Details on the *Sampling Programme* for CMP IV are shown in *Table C1* of *Annex C*.

Sampling for CMP V

The locations of stations during ebb and flood tides for CMP V are shown in *Figures 3.5* and *3.6*, respectively, and the coordinates are shown *Table 3.5*. An additional monitoring station at Ma Wan will be sampled for CMP V. Eight replicate samples should be collected from each monitoring station for eight times per year, twice in the dry season, twice during the wet season and twice in each of the two transitional seasons. The sampling frequency and number of replicates are the same as those used at the start of CMP IV monitoring (1) and will initially be used for CMP V monitoring as a consistent and conservative approach. For a given sampling event water samples and *in situ* measurements should be taken at mid-depth of all stations during the same tidal state (ie mid-ebb or mid-flood tide). Sampling frequency and number of replicates for CMP V will be reviewed and adjusted accordingly based on power analyses in each *Annual Review Report*.

Routine water quality monitoring for CMP V will be undertaken during its backfilling activities, which is currently predicted to begin in March 2011. Details on the *Sampling Programme* for CMP V are shown in *Table C2* of *Annex C*.

Table 3.5 Coordinates of Water Quality Monitoring Stations for Capping and Routine Water Quality Monitoring for CMP V

Monitoring Stations	Eastings	Northings
Ebb		
Reference Stations		
ESC-RFE1	808527	822762
ESC-RFE2	808736	823066
ESC-RFE3	808956	823390
ESC-RFE4	809176	823715
ESC-RFE5	809427	824008
Impact Stations		
ESC-IPE1	810121	821674
ESC-IPE2	810814	822136
ESC-IPE3	811763	821931
ESC-IPE4	812430	821717
ESC-IPE5	812894	822050
Intermediate Stations		
ESC-INE1	808066	821045

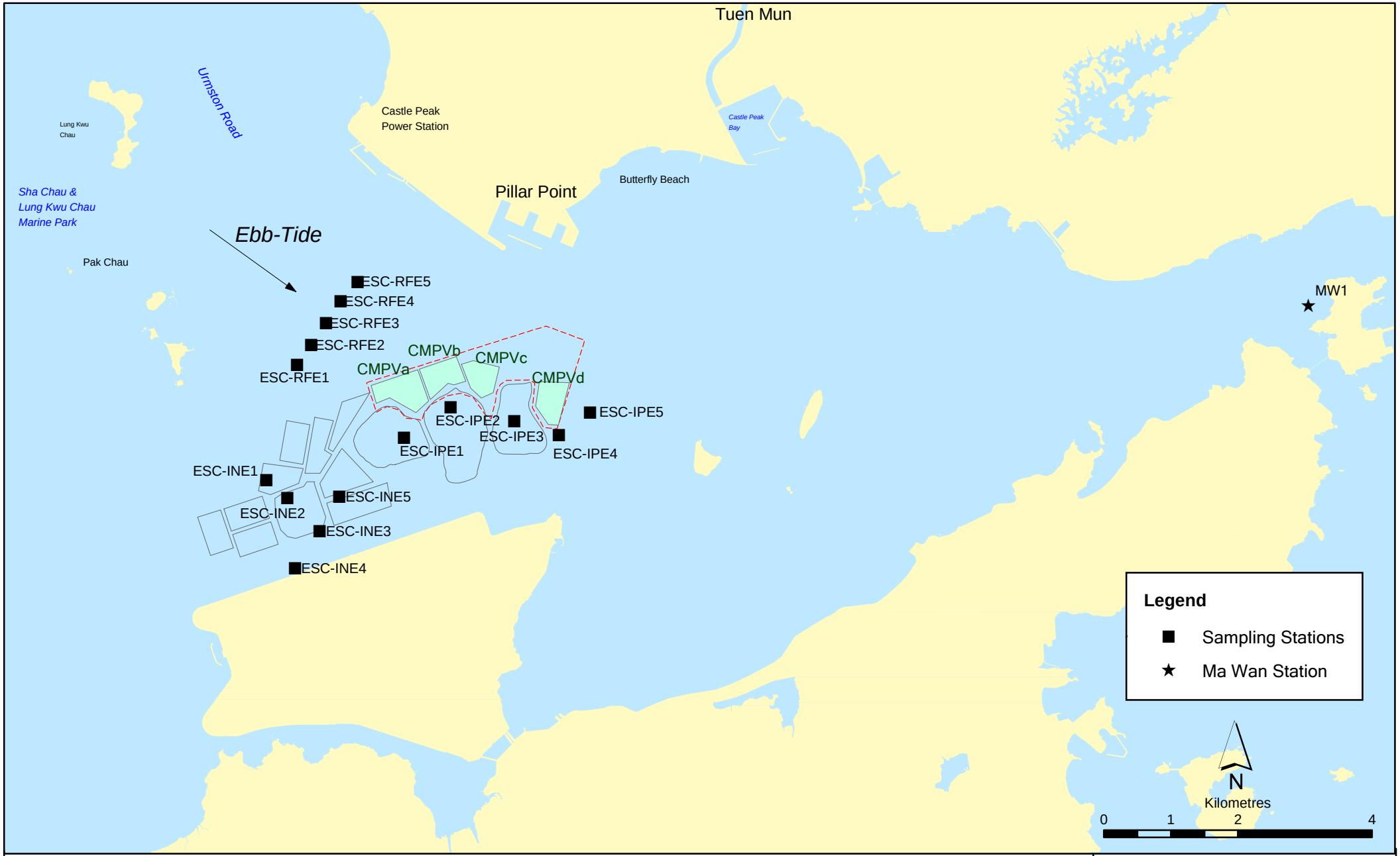

Figure 3.5

Routine & Capping Water Quality Sampling Stations (Ebb-Tide) for CMPV

File: CMPV\0103262_R_C_WQMS_ebb.mxd
Date: 29/10/2009

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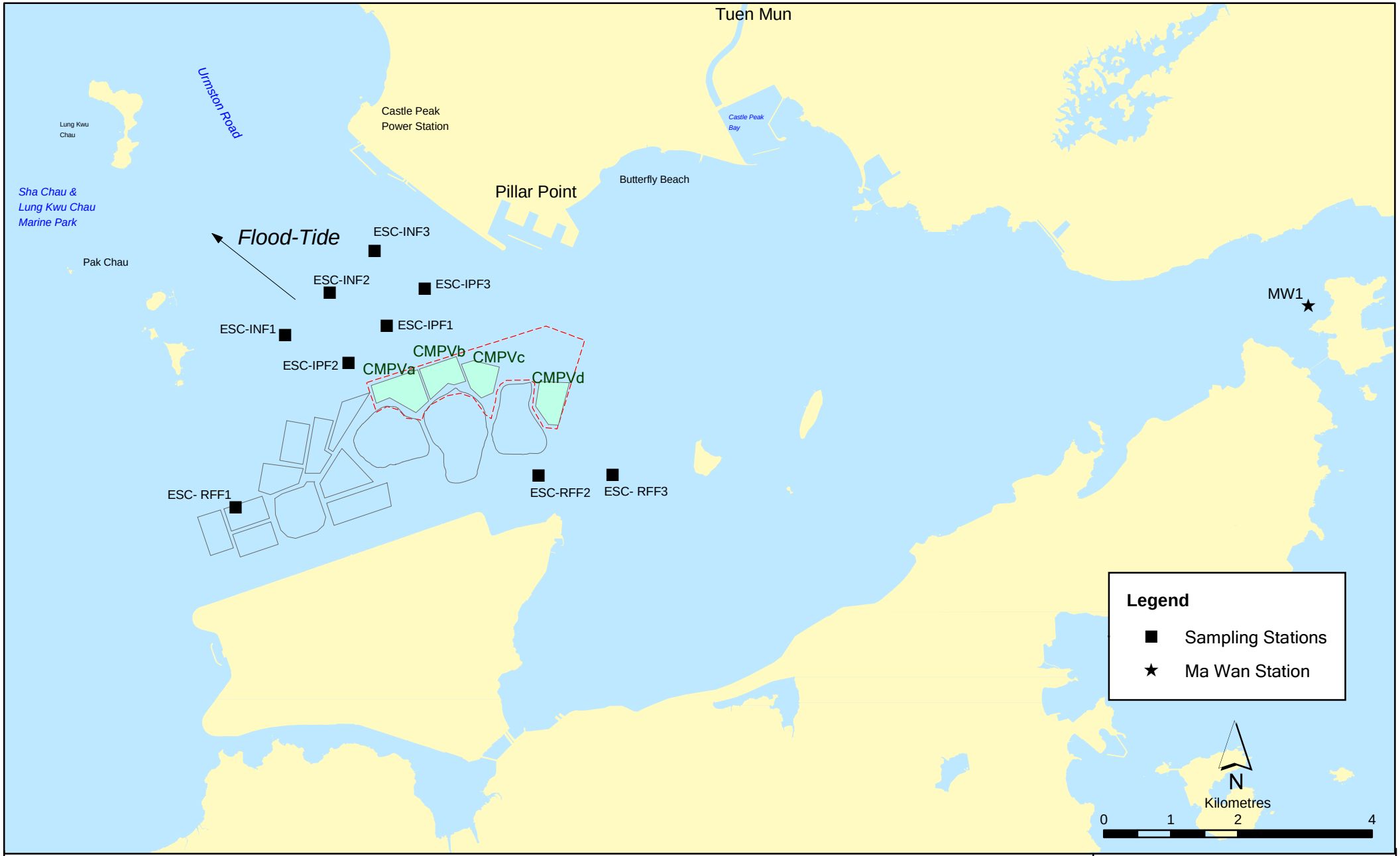

Figure 3.6

Routine & Capping Water Quality Sampling Stations (Flood-Tide) for CMPV

File: CMPV\0103262_R_C_WQMS_flood.mxd
Date: 29/10/2009

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Monitoring Stations	Eastings	Northings
ESC-INE2	808380	820772
ESC-INE3	808862	820280
ESC-INE4	808495	819725
ESC-INE5	809155	820793
Ma Wan Station		
MW1	823604	823654
Flood		
Reference Stations		
ESC-RFF1	807608	820633
ESC-RFF2	812126	821111
ESC-RFF3	813233	821127
Impact Stations		
ESC-IPF1	809862	823353
ESC-IPF2	809293	822799
ESC-IPF3	810432	823907
Intermediate Stations		
ESC-INF1	808346	823213
ESC-INF2	809013	823843
ESC-INF3	809680	824473
Ma Wan Station		
MW1	823603	823653

Note: Coordinates are based on Hong Kong 1980 GRID Coordinate System.

Water Column Profiling

Water column profiling will be undertaken during backfilling activities. For both CMP IV and V, there are two monitoring stations for Water Column Profiling. Their locations are mobile, and will be dependent on the position of the disposal barge at the time of monitoring. The two mobile monitoring stations will be approximately 100 m upstream and downstream of the disposal area, respectively.

The following suite of parameters should be measured as part of the water column profiling:

- Salinity (ppt) (*in situ*);
- Dissolved Oxygen (mg L^{-1}) (*in situ*);
- Turbidity (NTU) (*in situ*);
- Temperature (°C) (*in situ*)
- Current Velocity and Direction (ms^{-1}) (*in situ*)
- pH *(in situ*); and
- Suspended Solids (mg L^{-1}) (laboratory analysis).

In addition to the water quality parameters, other relevant data will also be measured and recorded in Water Quality Monitoring Logs, including the location of the sampling stations, water depth, time, weather conditions, sea conditions, tidal stage, special phenomena and work activities undertaken

around the monitoring and works area that may influence the monitoring results.

Sampling for CMP IV

Water Column Profiling for CMP IVc will be conducted six times per year, three times during the wet season and three times during the dry season. Two replicate samples for SS will be collected at mid-depth from each of the monitoring stations during each sampling event. This level of replication for CMP IV was found to be sufficient in power analyses that evaluated the cost efficiency and effectiveness of the EM&A programme (1). In addition, during each sampling event i*n situ* measurements should be taken at 1 m depth intervals through the water column for a period of one hour at each station. All water samples and *in situ* measurements should be taken during the same tidal state (ie mid-ebb or mid-flood tide) of a given sampling event. Details on the *Sampling Programme* for CMP IV are shown in *Table C1* of *Annex C*.

Sampling for CMP V

Water Column Profiling for CMP V will be conducted monthly. Four replicate samples for SS will be collected at mid-depth from each of the monitoring stations during each sampling event. This is the same number of replicates as those used at the start of CMP IV monitoring (1) and will be initially used for CMP V monitoring as a consistent and conservative approach. During each sampling event i*n situ* measurements should be taken at 1 m depth intervals through the water column for a period of one hour at each station. All water samples and *in situ* measurements should be taken during the same tidal state (ie mid-ebb or mid-flood tide) of a given sampling event. Sampling frequency and the number of replicates for CMP V will be reviewed and adjusted accordingly based on power analyses in each *Annual Report*. Details on the *Sampling Programme* for CMP V are shown in *Table C2* of *Annex C*.

3.4.4 Statistical Treatment of Data

Routine Water Quality Monitoring

The hierarchy of sampling design should allow for the application of nested analysis of variance to statistically test any changes or trends in the dataset. Under the nested design, differences will be tested between stations in a particular area and between the three areas (ie Impact, Intermediate and Reference). Once a time series of data has been gathered temporal changes in water quality parameters can be analysed for significant differences. In addition, the data gathered will be examined against the water quality objectives for the NWWCZ to determine if the relevant water quality objectives have been exceeded.

Water Column Profiling

The data gathered will be examined graphically against the water quality

objectives for the NWWCZ to determine if the relevant water quality objectives have been exceeded for any apparent impacts arising from the backfilling activities.

3.4.5 Use of Data

Should increases be detected in the level of contaminants or exceedances of the NWWCZ WQOs be detected, a review of the other monitoring parameters will be undertaken. This will focus on sampling stations in the vicinity of the water quality stations where increases are detected to see if these can be attributed to contaminant spread from the active pits. If so, consideration will be given to revising the facility operations plan and backfilling activities to reduce the spread of contaminants in the plume and achieve compliance with WQOs.

3.5 MONITORING FOR CAPPING ACTIVITIES

The design for this component of the programme allows impacts to water quality as a result of the overall capping activities of CMP IV and V to be assessed. Replicate water samples will be collected at specific stations, which should be located in three discrete areas: Impact, Intermediate and Reference. The number of monitoring stations sampled depends on the state of the tide. During the ebb tide, water samples will be collected from five up-current Reference Stations, five down-current Impact Stations and five down-current Intermediate Stations. During the flood tide, water samples will be collected at three up-current Reference Stations, three down-current Impact Stations and three down-current Intermediate Stations.

The following suite of parameters should be measured as part of the impact monitoring for capping:

- Dissolved Oxygen (mg L^{-1}) (*in situ*);
- Salinity (ppt) (*in situ*);
- pH *(in situ*);
- Turbidity (NTU) (*in situ*);
- Temperature (°C) (*in situ*)
- Current Velocity and Direction (ms^{-1}) (*in situ*); and,
- Suspended Solids (mg L^{-1}) (laboratory analysis).

In addition to the water quality parameters, other relevant data will also be measured and recorded in Water Quality Monitoring Logs, including the location of the sampling stations, water depth, time, weather conditions, sea conditions, tidal stage, special phenomena and work activities undertaken around the monitoring and works area that may influence the monitoring results.

Sampling for CMP IV

For CMP IV the locations of stations during ebb and flood tides are shown in *Figures 3.3* and *3.4*, respectively, and the coordinates are shown *Table 3.4*. Replicate samples will be collected from each station four times per year, twice in the dry season and twice during the wet season. Three replicate samples of SS will be collected from mid-depth at each of the monitoring station during each sampling event. In addition, *in situ* measurements should be taken at 1 m depth intervals through the water column at each station during a sampling event. All water samples and *in situ* measurements should be taken during the same tidal state (ie mid-ebb or mid-flood tide) of a given sampling event. Sampling will be undertaken during capping activities for CMP IV as detailed in the *Sampling Programme* for CMP IV shown in *Table C1* of *Annex C*. Capping monitoring for CMP IV will cease once capping monitoring for CMP V has been started as the capping monitoring for CMP V is designed to track the potential plumes arise from concurrent CMP IV and V capping activities.

Sampling for CMP V

The locations of stations during ebb and flood tides for CMP V are shown in *Figures 3.5* and *3.6*, respectively, and the coordinates are shown *Table 3.5*. For CMP V, samples will be collected from an additional station at Ma Wan, for both ebb and flood tides. Samples should be collected four times per year, twice in the dry season and twice during the wet season. Three replicate samples of SS will be collected from mid-depth at each monitoring station during each sampling event. In addition, *in situ* measurements should be taken at 1 m depth intervals through the water column at each station during a sampling event. All water samples and *in situ* measurements should be taken during the same tidal state (ie mid-ebb or mid-flood tide) of a given sampling event. Sampling will be undertaken during capping activities for CMP V as detailed in the *Sampling Programme* for CMP V shown in *Table C2* of *Annex C*. Sampling frequency and number of replicates for CMP V will be reviewed and adjusted accordingly based on power analyses in each *Annual Report*.

3.6 SAMPLING PROCEDURE FOR WATER QUALITY MONITORING

In situ water quality monitoring (salinity, temperature, current velocity and direction) will be conducted using the equipment listed in *Section 3.6.1* and following the testing protocols detailed in *Section 3.6.2*. In order to ensure the reliability and quality of the data, the measuring instrument will be calibrated prior to each sampling cruise and the probe of the measuring instrument will be maintained at a suitable distance from the seabed to avoid re-suspension of bottom sediments from skewing the results.

Water quality profiling will be conducted continuously for a one-hour period from a fixed point. After deployment, the probe of the measuring equipment will be allowed to equilibrate with the surrounding seawater for

approximately 30 seconds. Subsequently, average readings will be taken every few seconds to minimise sampling noise arising from the sensitivity of the equipment.

In addition to *in situ* water quality monitoring, water samples will be collected in a water sampler. Samples will be stored in sealed sampling bottles and chilled, and on completion of the survey will be transported to the laboratory for immediate analysis. Samples not for immediate analysis will be stored at 4 ± 2°C.

3.6.1 Equipment

The following equipment will be supplied and used by the contractor for the water quality monitoring:

- ***Positioning Device*** - Horizontal positioning will be used and determined by a differential Global Positioning System (dGPS) with the differential signal being provided by a UHF differential transmitter. The UHF system should provide an accuracy of better than 3m at the 95% confidence level to ensure the survey vessel is in the correct location before taking measurements. The dGPS will be calibrated daily before each survey period or results reported. And all data will be printed and logged on disc.

- ***Electronic data logging device*** - A data logging device capable of storing measurement data will be used. The device will be able to read and store the output from all electronic meters used for this project and will record time and location as measured by the GPS.

- ***Dissolved Oxygen and Temperature Measuring Equipment*** - The instrument will be a portable, weatherproof dissolved oxygen measuring instrument complete with cable, sensor, comprehensive operation manuals, and will be operable from a DC power source. It will be capable of measuring: dissolved oxygen levels in the range of 0 - 20 mg L^{-1} and 0 - 200% saturation; and a temperature of 0 - 45 degrees Celsius.

  It will have a membrane electrode with automatic temperature compensation complete with a cable of not less than 20 m in length. Sufficient stocks of spare electrodes and cables will be available for replacement where necessary (for example, YSI model 59 metre, YSI 5739 probe, YSI 5795A submersible stirrer with reel and cable or an approved similar instrument).

- ***Turbidity Measurement Equipment*** - Turbidity within the water will be measured *in situ* by the nephelometric method. The instrument will be a portable, weatherproof turbidity-measuring unit complete with cable, sensor and comprehensive operation manuals. The equipment will be operated from a DC power source, it will have a photoelectric sensor capable of measuring turbidity between 0 - 1000 NTU and will be

complete with a cable with at least 20 m in length (Hach 2100P or an approved similar instrument).

- ***Salinity Measurement Instrument*** - A portable salinometer capable of measuring salinity in the range of 0 - 40 ppt will be provided for measuring salinity of the water at each monitoring location.

- ***pH meter*** – A portable pH meter capable of measuring a range between 0.0 and 14.0 will be provided to measure pH in marine waters.

- ***Suspended Solid Measurement Equipment*** - A water sampler (eg Kahlsico Water Sampler), which is a PVC cylinder (capacity not less than 2 litres) which can be effectively sealed with latex cups at both ends, will be used for sampling. The sampler will have a positive latching system to keep it open and prevent premature closure until released by a messenger when the sampler is at the selected water depth. Water samples for suspended solids measurement will be collected in high density polythene bottles, packed in ice (cooled to 4^{o}C without being frozen), and delivered to the laboratory in the same day as the samples were collected.

- ***Water Depth Gauge*** - A portable, battery-operated echo sounder (Seafarer 700 or a similar approved instrument) will be used for the determination of water depth at each designated monitoring station. This unit will either be hand-held or affixed to the bottom of the work boat if the same vessel is to be used throughout the monitoring programme.

- ***Water Sampling Equipment*** - A water sampler, consisting of a transparent PVC or glass cylinder of not less than two litres which can be effectively sealed with cups at both ends, will be used (Kahlsico Water Sampler 13SWB203 or an approved similar instrument). The water sampler will have a positive latching system to keep it open and prevent premature closure until released by a messenger when the sampler is at the selected water depth.

- ***Current Velocity Measuring Equipment*** – An NE Sensortec A/S UCM-60 current meter or Valeport 108 MKIII current meter or a similar approved instrument will be used for measuring current direction. Current velocity is measured by ADCP. Calibration of ADCP is not likely to be necessary for these instruments as they are calibrated for the life of the instrument.

3.6.2 Sampling / Testing Protocols

The position of the survey vessel will be positioned to within 3 m of the designated coordinates at each monitoring station using a differential Global Positional System (GPS).

All *in situ* monitoring instruments will be checked, calibrated and certified by a laboratory accredited under HOKLAS or any other international accreditation scheme before use, and subsequently re-calibrated at three

month intervals throughout the stages of the water quality monitoring. Responses of sensors and electrodes will be checked with certified standard solutions before each use.

On-site calibration of field equipment will follow the "*Guide to Field and On-Site Test Methods for the Analysis of Waters*", BS 1427: 1993. Sufficient stocks of spare parts will be maintained for replacements when necessary. Backup monitoring equipment will also be made available so that monitoring can proceed uninterrupted even when equipment is under maintenance, calibration etc.

Water samples for SS measurements will be collected in high density polythene bottles, packed in ice (cooled to 4° C without being frozen), and delivered to a HOKLAS laboratory as soon as possible after collection.

At least two replicate samples should be collected from each of the monitoring events for *in situ* measurement and lab analysis.

3.6.3 Laboratory Procedures

Using chain of custody forms, collected water samples will be transferred directly to laboratory for immediate processing of suspended solids, ammonia, nutrients and BOD_5. Water samples will be analysed for pH and BOD within 4 hours of their arrival at the laboratory. All other parameters will be analysed within 48 hours of arrival. During this period samples will be held at $4 \pm 2^{o}C$. Prior to subjecting the sample to metals analysis, samples will be filtered to remove solids and colloidal matter. Filtration will be accomplished using acid washed, single-use 0.45 micron membrane filters within a maximum of 8 hours from sample collection. Where necessary, samples will undergo further preparation involving preconcentration which allows lower method detection limits to be achieved and removes some of the possible sources of interference.

3.7 QA/QC

3.7.1 Field Logs

Field logs will be maintained for all survey work, noting the date of the survey, equipment used, survey manager and a record of all activities and observations. Field logs will be retained for the duration of the Project and archived on completion.

In-situ measured data will be digitally recorded from the instruments and converted into Microsoft Excel format, or manually noted. Both disc copy and hard copy will be retained for the file records. Any deviation from the standard procedure will be noted in the log and the reason for the deviation recorded. In addition, field logs will contain notes of events or activities in the vicinity of the monitoring location which might give rise to anomalous data being recorded.

3.7.2 Sampling

The sampling, collection, storage and identification procedures are described in *Section 3.6* of this Manual and the Contractor will record all data from *in situ* testing and from any analysis carried out on the boat in a Field Log. All samples will be identified with a unique date/time/location/depth/sample-type code which will be attached to the sample container or written in indelible ink directly on the container. In order to avoid contamination of the samples, all containers will be new and unused and of analytical grade quality. Sources of contamination will be isolated from the working area (for example, vessel fuel and exhaust fames) and any sample contaminated by local material (such as printed circuit boards) will be discarded and the sampling repeated. Low level metal analysis in seawater is easily contaminated through inappropriate handling and sampling techniques. Site staff involved in seawater sample collection intended for dissolved metal analysis will ensure that they wear non-contaminating disposable gloves if they have previously been operating or have handled metallic equipment.

3.7.3 Measurement Procedures

All *in situ* monitoring instruments will be checked, calibrated and certified and subsequently re-calibrated at three monthly intervals throughout all stages of the water quality monitoring, or as required by the manufactures specification. Certificate(s) of Calibration specifying the instrument will be attached to the monitoring reports.

3.7.4 Transport of Samples

All samples transferred from one sub-contractor to another will be accompanied by Chain of Custody (COC) forms. Any missing or damaged samples require notification to ET Leader following logging in the laboratory QA system. The number of samples, the parameters to be tested and the time of delivery should be clearly stated on the COC forms to ensure that samples are analysed for the correct parameters and suitable time is provided to the analytical laboratory for provision of resources required in the analyses.

3.7.5 Laboratory Procedures

For details of the contaminants to be tested, the methods to be used, the accreditation status of laboratory analytical methods, instruments and procedures to be used, sample preparation information, method detection limits (MDLs), QA/QC protocols and turnaround times, contractor should refer to the previous monitoring programme for the ESC CMPIV (1) (2)(3).

(1) ERM (2001) Environmental Monitoring and Audit for Contaminated Mud Pit IV at East of Sha Chau: Monitoring and Audit Manual. Submitted to CED, February 2001.

(2) Mouchel (2001) Consultancy for Environmental Monitoring and Audit for Contaminated Mud Pit IV at East of Sha Chau (2000-2005): Monitoring and Audit Manual. Submitted to CED, May 2001.

(3) ERM (2005) Environmental Monitoring and Audit for Contaminated Mud Pit IV at East of Sha Chau (2005-2008): Monitoring and Audit Manual. Submitted to CED, May 2005.

The analytical techniques to be adopted for this Project must conform to HOKLAS (or similar overseas) accreditation.

3.7.6 Data Quality Objectives

Data Quality Objectives (DQOs) have been developed in the previous monitoring programme for ESC CMPIV (1) (2) to address precision, accuracy and analyte recovery. The Contractor is recommended to follow the DQOs developed for data analysis.

Inorganic Analyses

Details of quality control specifications for inorganic testing should be included in the updated EM&A Manual prior to commencement of disposal activities.

Precision

Duplicates (1 in every 20 samples) will be used to monitoring the precision of the analysis. Results should be flagged for reference when:

- In water samples, for metals with a concentration >4x MDL, the duplicate results have more than a 15% RPD
- For all analytes with concentration <4x MDL, the duplicate results will be reported as analysed and no bounds should be quoted

Accuracy

Standard and certified reference material (CRM) will be used to monitor accuracy and precision within and between batches: Results should be flagged for reference if:

- The variation of the standard from its true value is more than ± 15% (for mercury: ± 20%).

Recovery

Post digest spikes will be used to determine the recovery of determinants in complex sample matrices. Results should be rejected if:

- Spike recoveries are more than ± 25% from the theoretical recovery for water samples. An exceptional case would be if the sample concentration is greater than four times the spike value, the spike may be disregarded.

(1) ERM (2001) *Op cit.*

(2) Mouchel (2001) *Op cit.*

4 SEDIMENT QUALITY

4.1 INTRODUCTION

In accordance with the recommendations of the EIA for the present Project, a monitoring programme examining sediment quality will be instituted to verify the EIA predictions and ensure that there is no build-up in contamination adjacent to the pits. Sediment chemistry has long been an important component of monitoring programmes at the East of Sha Chau mud disposal complex. A comprehensive list of Contaminants of Concern (COCs) has been used since 1997, comprising eight heavy metals and one metalloid, polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), organochlorine pesticides (eg DDT) and Tributyltin (TBT). These contaminants (which correspond to the list of COCs in *ETWBTC(W) 34/2002*) in sediments should be measured in the present monitoring programme and changes over time and distance should also be examined.

4.2 OBJECTIVE

The main objective of this task is to determine if there are any changes and/or trends in the concentrations of contaminants in sediments adjacent to the pits caused by disposal activities at CMP IV and V. This objective is most appropriately addressed through two separate but intrinsically linked sub-tasks:

- *Pit Specific Monitoring of Sediment Quality* - conducted to examine near field impacts of backfilling operations at CMP IV and V on the spread of contaminants from the pits and to allow for rapid detection of any adverse environmental impacts and, if necessary, changes to the operations plan.

- *Cumulative Impact Monitoring of Sediment Quality* - conducted to analyse the ambient conditions in the North Lantau region and to investigate whether any impacts to marine sediments are occurring due to the dispersion of contaminants from the active pits at CMP IV and V.

4.3 HYPOTHESES

The impact hypothesis for this task is as follows:

There is no increase in sediment contaminant concentrations over time at individual stations or a trend of increasing concentrations with proximity to the active pit.

As a result of the separation of this programme into two sub-tasks, two sets of null hypotheses should be tested:

Pit Specific Monitoring of Sediment Quality

H_0 There is no increase in sediment contaminant concentration in the area adjacent to the pits during contaminated mud disposal works.

Cumulative Impact Monitoring of Sediment Quality

H_0 There is no increase in sediment contaminant concentration over time in the area of contaminated mud disposal activity.

H_0 There is no increase in sediment contaminant concentration with proximity to the active pits.

4.4 SAMPLING DESIGN

The designs for assessing the impacts of disposal of contaminated mud in the active pits at CMP IV and V on the sediment chemistry of remote and adjacent areas take into account the following factors:

- The null hypotheses being tested;
- Background levels of contaminants in the region;
- Predictions on sediment plume locations;
- Spatial variability in sediment chemistry;
- Temporal variability in sediment chemistry; and,
- Expected statistical treatment of the data.

As mentioned in *Section 1. 2,* this EM&A Manual is an evolving document that should be updated to maintain its relevance as the Project progresses. This includes the relocation of monitoring stations to best suit the requirements of the monitoring programme and to take into account other work that is occurring in the direct vicinity of the active facility.

4.4.1 Data Collection Parameters

The parameters that should be measured in sediments collected during the two sub-tasks and the rationale for each are given below. Some of the contaminants listed are the "Contaminants of Concern" for which Lower and Upper Chemical Exceedance Limits (LCEL/UCEL) exist.

(a) **Total Organic Carbon (TOC)** - an indicator of organic load and the impact on bottom layer dissolved oxygen. TOC is an important factor influencing the chemical partitioning and toxicity of hydrophobic organic compounds such as PAHs, PCBs and pesticides. High TOC often infers that hydrophobic contaminants are less bioavailable;

(b) **Inorganic Contaminants** - metals and metalloids present in the disposed sediments which may be bioaccumulated;

(c) **Polycyclic Aromatic Hydrocarbons (PAH)** - a class of organic compounds some of which are persistent and carcinogenic. These compounds may be bioaccumulated and stored in the fatty body tissues of mammals;

(d) **Total Polychlorinated Biphenyls (PCB)** - a class of persistent man-made chemicals which tend to bioaccumulate through the food chain and can cause reproductive failure and cancer;

(e) **Organochlorine Pesticides (DDE & DDT)** - contaminants which are persistent, highly lipophilic (can be accumulated and stored in fat), have high bioaccumulation and biomagnification potential, and high toxicity to aquatic organisms; and,

(f) **Tributyltin (TBT) (in sediment and interstitial water)** - moderately persistent toxic compound found in marine sediments which may be bioaccumulated and cause growth abnormalities and reproductive failure.

(g) **Percentage of Silt/Clay (% < 63μm) –** measured in Cumulative Impacts Monitoring only. Organic contaminants and metals bind more readily to finer particles than coarser particles due to their larger surface area and consequent larger number of binding sites;

4.4.2 Pit Specific Monitoring of Sediment Quality

Pit specific monitoring of sediment quality will be undertaken during backfilling activities. For both CMP IV and V, sediment samples will be collected from two stations in the active pit, two stations on the edge of the active pits and two stations in close proximity to the pits. For pit specific monitoring, parameters *(a)* to *(g)* in *Section 4.4.1* will be analysed.

Sampling for CMP IV

For CMP IV the locations of stations are shown in *Figure 4.1* and the coordinates are shown *Table 4.1*. Sampling should be undertaken at each station for three times per year. The long-term review of environmental monitoring for contaminated mud pits (1) determined this sampling frequency to be adequate to track potential changes in contaminant concentrations of sediments.

(1) ERM– Hong Kong, Ltd (2008) Review of Past Monitoring Results for Contaminated Muds Pits. Environmental Monitoring and Audit for Contaminated Mud Pit IV at East of Sha Chau (2005-2008) - Investigation Agreement No. CE 19/2004 (EP) For the Civil Engineering Department, Hong Kong SAR Government.

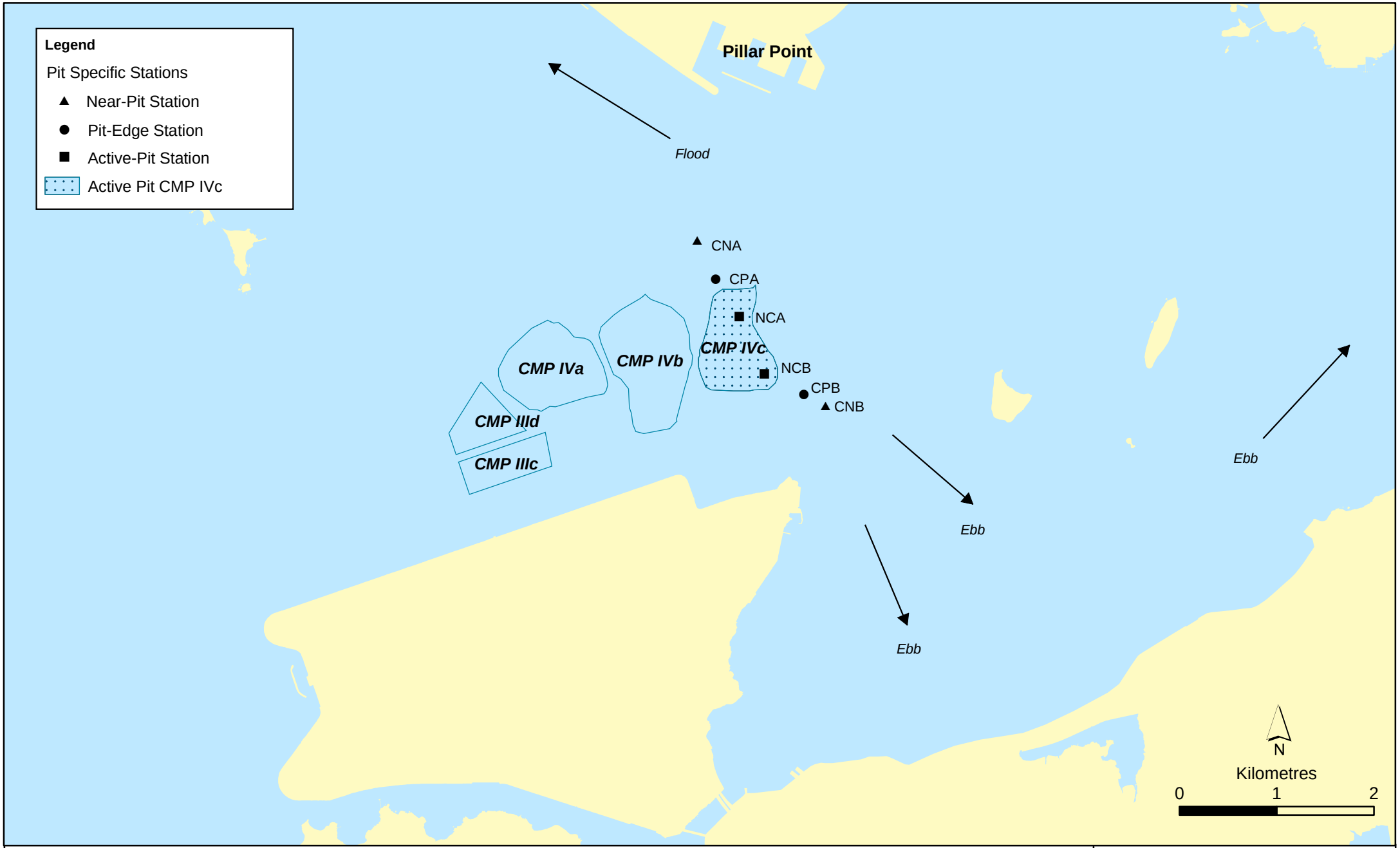

Figure 4.1

Pit-Specific Sediment Quality Monitoring Stations for CMPIV

File: CMPIV\0103262_Sed_pit specific.mxd
Date: 20/10/2009

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Table 4.1 ***Coordinates of Pit Specific Sediment Monitoring Stations for CMP IVc***

Monitoring Stations	Eastings	Northings
Near-Pit		
CNA	811414	822982
CNB	812734	821281
Pit-Edge		
CPA	811607	822579
CPB	812514	821393
Active-Pit		
NCA	811849	822198
NCB	812106	821608

Note: Coordinates are based on Hong Kong 1980 GRID Coordinate System.

Two replicate sampleswill be collected for each parameter from each of the monitoring stations. The number of replicate samples for CMP IV was determined from a power analyses which showed this sampling was cost effective and sufficient for the environmental monitoring programme (1). Details on the *Sampling Programme* for CMP IV are shown in *Table C1* of *Annex C*.

Sampling for CMP V

Sediment samples will be collected on a monthly basis from any of the six stations shown in *Figure 4.2* and *Table 4.2*. Locations of the six sampling stations will be dependent on the location of the active pit and will be adjusted accordingly. For example when CMP Va is active, stations ESC-NNDA-B, ESC-NEDA-B and ESC-NPDA-B will be monitored. Twelve replicates of composite samples (i.e. 5 grab samples obtained using a cluster grab) will be collected from each of the stations. Sampling frequency and the number of replicates for CMP V will be reviewed and adjusted accordingly based on power analyses in each *Annual Report*.

Table 4.2 ***Coordinates of Pit Specific Sediment Monitoring Stations for CMP V***

Monitoring Stations	Eastings	Northings
CMP Va active		
Near-Pit		
ESC-NNDA	809547	822778
ESC-NNDB	810636	821839
Pit-Edge		
ESC-NEDA	809748	822606
ESC-NEDB	810398	822031
Active-Pit		
ESC-NPDA	809976	822414
ESC-NPDB	810203	822206
CMP Vb active		
Near-Pit		
ESC-NNCA	810110	822994
ESC-NNCB	811003	822185
Pit-Edge		
ESC-NECA	810288	822825
ESC-NECB	810792	822364
Active-Pit		

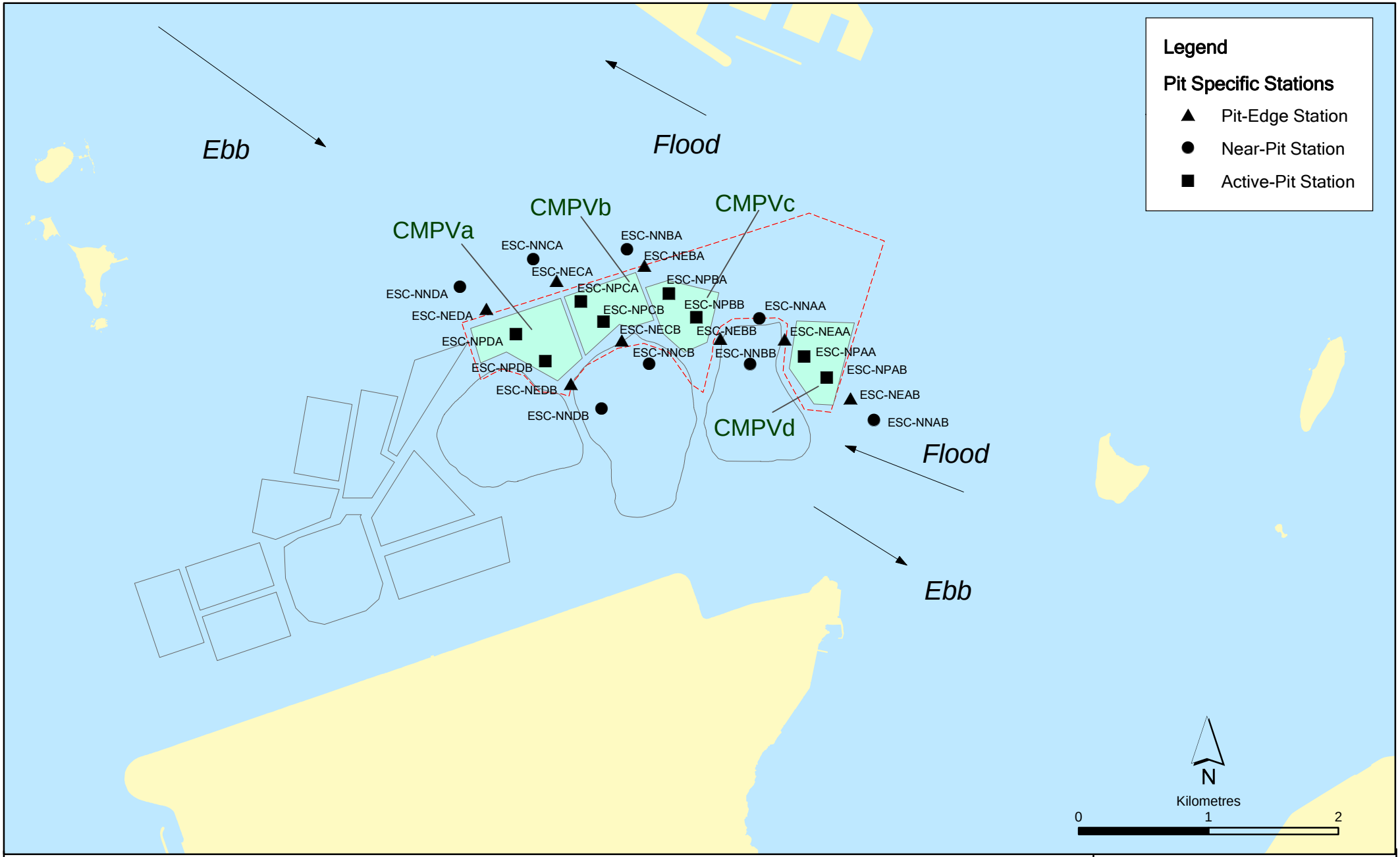

Figure 4.2

Pit Specific Sediment Quality Monitoring Stations for CMPV

File: CMPV\0103262_SQMS_pit specific.mxd
Date: 29/10/2009

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Monitoring Stations	Eastings	Northings
ESC-NPCA	810477	822665
ESC-NPCB	810652	822509
CMP Vc active		
Near-Pit		
ESC-NNBA	810831	823066
ESC-NNBB	811780	822183
Pit-Edge		
ESC-NEBA	810965	822939
ESC-NEBB	811549	822378
Active-Pit		
ESC-NPBA	811156	822726
ESC-NPBB	811367	822544
CMP Vd active		
Near-Pit		
ESC-NNAA	811851	822535
ESC-NNAB	812735	821751
Pit-Edge		
ESC-NEAA	812046	822372
ESC-NEAB	812553	821917
Active-Pit		
ESC-NPAA	812196	822239
ESC-NPAB	812371	822080

Note: Coordinates are based on Hong Kong 1980 GRID Coordinate System.

4.4.3 Cumulative Impacts Monitoring of Sediment Quality

For both CMP IVc and V, sediment samples should be collected from stations located in four discrete areas, with two stations in each area. The areas should be located at increasing distances from the disposal operations (ie. Near Field, Mid Field, Capped Pits and Far Field). For CMP V, sediment samples should also be collected from the Ma Wan station MW1. For cumulative impacts monitoring parameters (a) to (g) in *Section 4.4.1* will be analysed**.**

Sampling for CMP IV

The locations of stations for CMP IV are shown in *Figure 4.3* and the coordinates are presented *Table 4.3*. Sampling should be undertaken at each station twice per year. The long-term review of environmental monitoring for contaminated mud pits (1) determined this sampling frequency to be adequate to track potential changes in contaminant concentrations of sediments.

(1) ERM– Hong Kong, Ltd (2008) Review of Past Monitoring Results for Contaminated Muds Pits. Environmental Monitoring and Audit for Contaminated Mud Pit IV at East of Sha Chau (2005-2008) - Investigation Agreement No. CE 19/2004 (EP) For the Civil Engineering Department, Hong Kong SAR Government.

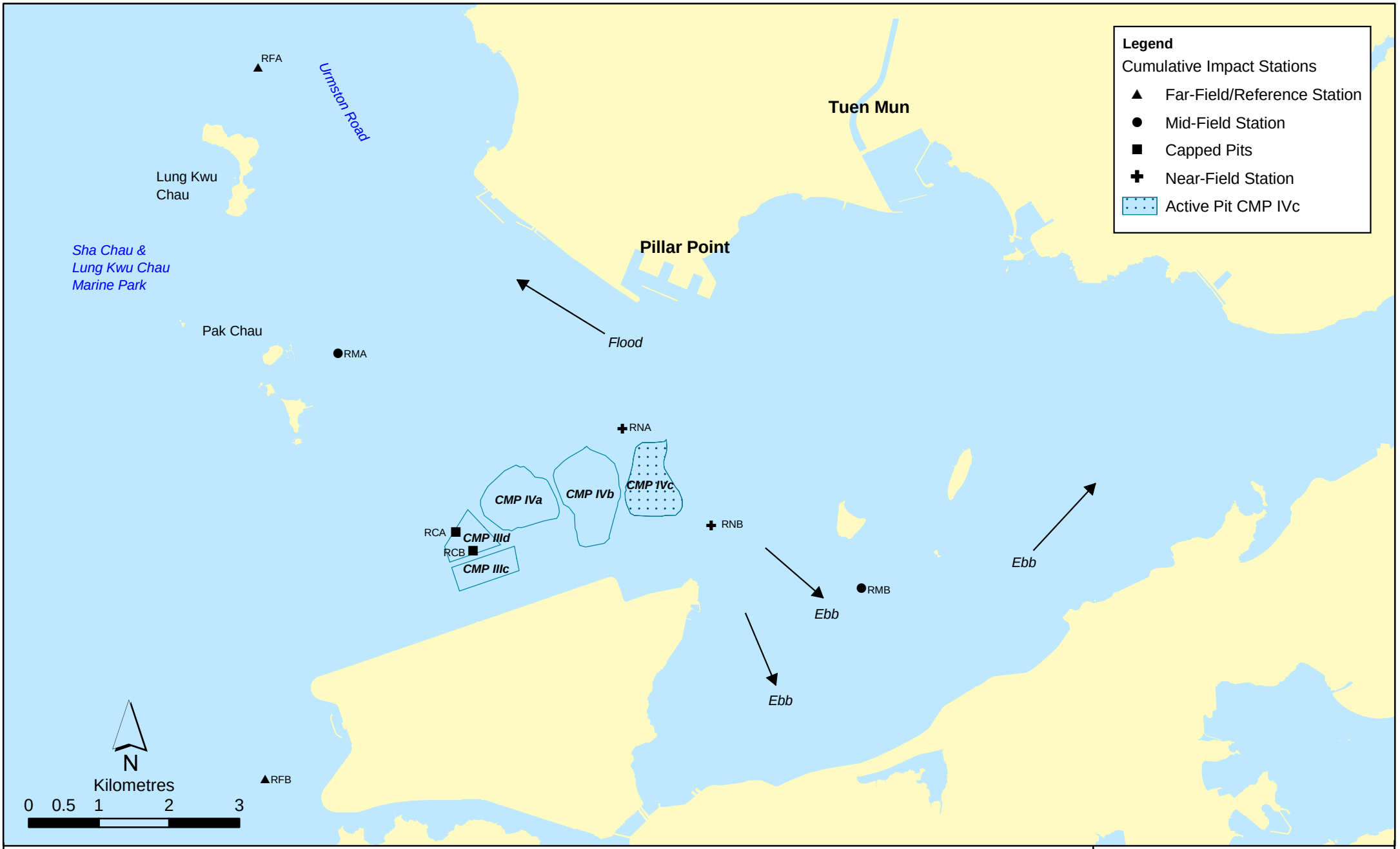

Figure 4.3

Cumulative Impact Sediment Quality Monitoring Stations for CMPIV

File: CMPIV\0103262_Sed_cum impact.mxd
Date: 20/10/2009

Environmental Resources Management

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Table 4.3 ***Coordinates of Cumulative Impact Sediment Monitoring Stations for CMP IVc***

Monitoring Stations	Eastings	Northings
Near-field		
RNA	811414	822982
RNB	812734	821281
Mid-field		
RMA	807351	823745
RMB	814793	820405
Far-field		
RFA	806207	827812
RFB	806307	817693
Capped Pits		
RCA	809024	821205
RCB	809268	820942

Note: Coordinates are based on Hong Kong 1980 GRID Coordinate System.

Two replicate samples for all organic contaminants and six replicate samples for metals and PSD will be collected from each of the monitoring stations. The number of replicate samples for CMP IV was determined from a power analyses which showed that this replication was adequate to monitor any potential impacts while remaining cost effective (1). Details on the Sampling Programme for CMP IV are shown in Table C*1* of Annex C.

Sampling for CMP V

Sediment samples should be collected four times per year, twice during the dry season and twice during the wet season at stations indicated on *Figure 4.4* and the coordinates are shown in *Table 4.4*. Twelve replicates of composite samples (i.e. 5 grab samples obtained using a cluster grab) will be collected from each station. Sampling frequency and number of replicates for CMP V will be reviewed and adjusted accordingly based on power analyses in each *Annual Report*.

Table 4.4 ***Coordinates of Cumulative Impact Sediment Monitoring Stations for CMP V***

Monitoring Stations	Eastings	Northings
Near-field		
ESC-RNA	809547	822778
ESC-RNB	810636	821839
Mid-field		
ESC-RMA	807797	825010
ESC-RMB	813278	820968
Far-field		
ESC-RFA	806207	827812
ESC-RFB	806307	817693
Capped Pits		
ESC-RCA	809152	821238
ESC-RCB	809313	820987
Ma Wan Station		
MW1	823603	823653

Note: Coordinates are based on Hong Kong 1980 GRID Coordinate System.

Figure 4.4

Cumulative Impacts Sediment Quality Monitoring Stations for CMPV

File: 0103262_SQMS_cum impact.mxd
Date: 29/10/2009

Environmental Resources Management

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4.5 STATISTICAL TREATMENT OF DATA

4.5.1 Pit Specific Monitoring of Sediment Quality

Observed differences in the levels of contaminants should be tested using analysis of variance (ANOVA) with factors area and station, followed by Student Newman Keuls (SNK) multiple comparison procedures to isolate which treatments differ from others.

For all of the analysis of variance techniques performed during the monitoring programme, initial analyses should be performed to ensure that the data complies with the specific assumptions of analysis of variance. These assumptions state:

- the data within and among samples must be independent of each other;
- the variance within samples must be equal (tested through the use of tests such as Levene's median test); and,
- the data among the samples must be normally distributed (tested through the use of tests such as the Kolgomorov-Smirnov test).

Should the data not comply with these assumptions then the appropriate transformation should be applied to the data (eg, arc-sin for percentage data, log $^{(x+1)}$ for abundance data, or rank transformation if necessary). If, after transformation, the data are still non-compliant then non-parametric equivalents to ANOVA such as Kruskal-Wallis tests should be used.

4.5.2 Cumulative Impacts of Sediment Quality

The design of the monitoring programme should allow nested analysis of variance techniques to be employed. These techniques will be used to analyse the data at different spatial and temporal scales of replication. Statistical differences should be tested at the following levels: between areas and between sampling times. An advantage of this sampling design is that it removes the possibility of detecting differences simply due to inherent variation over spatial scales in the active area and thus facilitates clearer attribution to disposal operations. By replicating within each area, ie by sampling two stations in one area, any statistically significant differences detected between areas are more likely to be due to factors other than spatial variation (eg disposal operations). This approach is now an internationally recommended technique for use in monitoring programmes [(1)]. Multidimensional scaling ordination techniques will also be applied to the data, if deemed necessary.

(1) AJ Underwood (1997) Experiments in Ecology: their logical design and interpretation using analysis of variance.

4.6 USE OF DATA

Should significant increases be detected in the level of contaminants in sediment samples, a review of the other monitoring parameters should be undertaken. This review will focus on sampling stations in the vicinity of the sediment quality monitoring stations where increases are detected to see if these can be attributed to contaminant migration from the active pits. Assessment of the statistical significance of the data, confidence in the data and the presence of supporting data from other components of the monitoring programme should be jointly assessed. If appropriate, changes to the operations plan should be considered.

4.7 SAMPLING PROCEDURE AND EQUIPMENT

All samples should be collected by an experienced sampling team, deployed on a survey boat equipped with fully calibrated sampling equipment and precision navigational instruments. All vessel positioning should be accomplished with a calibrated Differential Global Positioning System (DGPS), ensuring station location accuracy to $< \pm 1$ m (95% confidence), with sample position automatically logged and mapped by the navigation computer. Where sample stations are located in close proximity to the pit area, positioning should be further validated by use of an echo sounder to detect whether the vessel is within the boundaries of the pit.

At each sampling station the top 5 cm of seabed sediment should be collected using a 5-component cluster grab sampler which collects surface sediments with a minimal disruption to the surface layer and is designed to work effectively in soft sediment such as those found in the area. The cluster grab should be deployed once at each of the stations located within each sampling area (eg Pit-Edge). The grabs can be customised and a fine mesh lid added, which ensures that the fine fluid sediments on the surface of the seabed are retained in the sample. Utilisation of this cluster sampler allows a large volume of sediment to be collected in a single deployment. Other similar samplers (eg Petit-ponar) collect less sediment in each deployment may have difficulty in collecting adequate samples in soft sediments, such as those within the study area, thereby reducing efficiency and increasing collection time. The five-cluster grab should be collected and combined, and the sample, labelled, double-bagged and stored in an ice chest cooled to a temperature of 4^{o}C with ice packs. The sediment sampler and all other utensils should be rinsed with seawater after each sample has been collected to avoid cross contamination between samples. On completion of the survey, all samples should be promptly transported, in chilled containers, to the testing laboratory for analysis.

4.8 QA/QC

A broad range of contaminants should be analysed in sediment samples including metals, metalloids, PAHs, PCBs, pesticides and Tributyltin in both

sediment and interstitial water. The method detection limits should be consistent with previous monitoring programmes at East of Sha Chau. Other QA/QC procedures to be implemented for marine sediment analyses include:

- *Laboratory blanks* - an analyte free matrix to which all reagents will be added in the same volumes or proportions as used in the standard sample preparation to monitor contamination introduced in the laboratory (organics and inorganics);
- *Batch duplicates* - an intralaboratory split sample randomly selected from the sample batch to monitor method precision (intrabatch) in a given sample matrix (inorganics only);
- *Certified Reference Materials* - analysis of a material with a known concentration of contamination to determine the accuracy of results in a given matrix (inorganics only);
- *Single Control Samples* - a known, interference-free matrix spiked with target analytes used to monitor laboratory preparation techniques (organics only);
- *Duplicate Control Samples* - multiple single control samples designed to monitor preparation technique reproducibility (organics).

4.9 DATA QUALITY OBJECTIVES

Data Quality Objectives (DQOs) have been developed to address precision, accuracy and analyte recovery.

4.9.1 Inorganic Analyses

Precision

Duplicates (1 in every 20 samples) should be used to monitoring the precision of the analysis. Results should be flagged for reference when:

- For all analytes, except metals, with concentration >4x Method Detection Limit (MDL), the duplicate results have more than a 20% Relative Percentage Deviation (RPD)
- In water samples, for metals with a concentration >4x MDL, the duplicate results have more than a 15% RPD
- In sediment and biota samples, for metals with a concentration >4x MDL, the duplicate results have more than a 25% RPD
- For all analytes with concentration <4x MDL, the duplicate results should be reported as analysed and no bounds should be quoted

Accuracy

Standard and certified reference material (CRM) will be used to monitor accuracy and precision within and between batches: Results should be flagged for reference if:

- The variation of the standard from its true value is more than ± 15% (for mercury: ± 20%).

Recovery

Post digest spikes should be used to determined the recovery of determinants in complex sample matrices. Results should be rejected if:

- Spike recoveries are more than ± 25% from the theoretical recovery for waters, sediment and marine biota. An exceptional case would be if the sample concentration is greater than four times the spike value, the spike may be disregarded.

4.9.2 Organic Analyses

Samples should be analysed in lots of less than 20. In order to measure the laboratory performance within each batch of samples, a single control sample (SCS), a duplicate control sample (DCS) and a method blank (MB) should be processed concurrently with the samples. A SCS or DCS consists of an interference free control matrix that is spiked with a group of target compounds representative of the method analytes.

Method blanks, also known as reagent, analytical, or preparation blanks, should be analysed to assess the level of contamination that exist in the analytical system and which might lead to the reporting of elevated concentration levels or false positive data. For organic analyses, the concentration of target analytes in the blank must be below the reporting limit for that analyte in order for the blank to be considered acceptable.

Accuracy is expressed as the average percent recovery for the SCS and precision is expressed as the relative percent difference (RPD) for the DCS pair. For control limits that are not established due to insufficient data sets, the QC Acceptance Criteria of US EPA Method 8080 and 8270A should be used as a supplement. Once enough data are collected, the in-house control limits should then be calculated.

The accuracy and precision data for SCS and DCS should be evaluated against laboratory established control limits. QC results falling outside the control limits should be automatically flagged. The acceptance criterion is that 100 percent of the precision and accuracy values must fall within the control limits. If this criterion is not met, corrective action must be taken. This may include repeat sample analysis.

The average percent recovery of the SCS should be compared to the limit set for each compound being monitored (*Table 4.1*). For DCS, an RPD of less than 20% is deemed to be acceptable in normal instances.

For multianalyte organic tests, if greater than 20% of the accuracy or precision results for the SCS/DCS are outside of the control limits, the data are considered suspect and the samples associated with the unacceptable DCS are reprepared and/or reanalysed.

Table 4.1 Quality Control Acceptance Criteria for Organic Analyses

Target Analytes	Percent Recovery Measured
Naphthalene	74 - 126
Acenaphthalene	69 - 125
Acenaphthene	73 - 119
Fluorene	81 - 129
Phenanthrene	74 - 131
Anthracene	63 - 116
Fluoranthene	73 - 134
Pyrene	59 - 129
Benzo(a)anthracene	77 - 136
Chrysene	53 - 130
Benzo(a)pyrene	51 - 103
Dibenzo(a,h)anthracene	78 - 126
DDE	73 - 121
DDT	87 - 120
Total PCBs	79 - 127
Tributyltin	80 - 115

Result must be greater than zero

5 SEDIMENT TOXICITY

5.1 INTRODUCTION

The ecotoxicological testing programme will feature a suite of tests that include three phylogenetically distinct species that interact with bedded sediments in different ways. Unacceptable impacts may have occurred if the levels of contaminants in the sediments collected in the adjacent area of the active pits are shown to have caused toxicity to marine fauna. The findings of the sediment toxicity tests will be compared to the results of the sediments chemistry.

5.2 OBJECTIVE

The objective of this task is to determine if there are any changes and/or trends caused by disposal activities in the toxicity of sediments adjacent to the pits as a result of disposal activities.

5.3 HYPOTHESIS

In accordance with the objectives of the Study, the impact hypothesis for this task will be as follows:

There is no increase in sediment toxicity over time at individual stations or a trend of increasing toxicity with proximity to the pit.

The null hypothesis which should be statistically tested is as follows:

H_0 There are no differences in the toxicity of sediments collected at stations adjacent to the active pits when compared with reference sediments.

5.4 SAMPLING DESIGN

In order to determine whether contaminated sediment placed in the active pits represents an ecological risk to biota in areas adjacent to the mud pit, ecotoxicological evaluations will be performed on sediment collected from these surrounding areas.

The toxicological testing programme should feature a suite of tests that includes phylogenetically distinct species which interact with sediments in different ways. The testing programme will include whole-sediment, or solid-phase toxicity tests. The following three international species should be tested:

- Burrowing amphipod (*Leptocheirus plumulosus*, *Ampelisca abdita*, *Eohaustorius estuarius* or other equivalent species);

- Burrowing polychaete (*Neanthes arenaceodentata* or other equivalent species); and,
- Free swimming larvae of bivalves (*Crassostrea gigas*, *Mytilus* spp. or other equivalent species).

In addition, two of the following local species should also be tested:

- Amphipod *Melita longidactyla*;
- Polychaete *Capitella capitata*;
- Juvenile shrimp *Metapenaeus ensis* or *Penaeus* (*Litopenaeus*) *vannamei*; and,
- Barnacle larvae *Balanus amphitrite*.

The experimental designs for assessing the impacts of disposal of contaminated mud in the East of Sha Chau facility on the toxicity of sediments in remote and adjacent areas take into account the following factors:

- The null hypotheses being tested;
- Location of other potential sources of contaminants in the North Lantau region, eg, Pearl River;
- Predictions taken from the EIA on sediment plume locations; and,
- Expected statistical treatment of the data.

Once the pit is active (ie receiving contaminated mud), sediment toxicity testing will be performed only when the level(s) of sediment contaminant(s) in the Near-field station(s) exceed the LCELs as measured by the *Cumulative Impact Monitoring of Sediment Quality*. Sampling stations will be sampled not more than twice per year (once in each of the wet and dry seasons).

5.4.1 Sampling for CMP IV

Sediment samples will be collected from two treatment areas. The first treatment is represented by samples taken from two stations in an area close to the active pits (Near-Field) and the second treatment is represented by samples collected from stations in a reference area (Far-Field). The locations of stations are shown in *Figure 5.1* and the coordinates are presented in *Table 5.1*. At each of the stations, three replicate composite grab samples will be taken and used for the sediment toxicity tests.

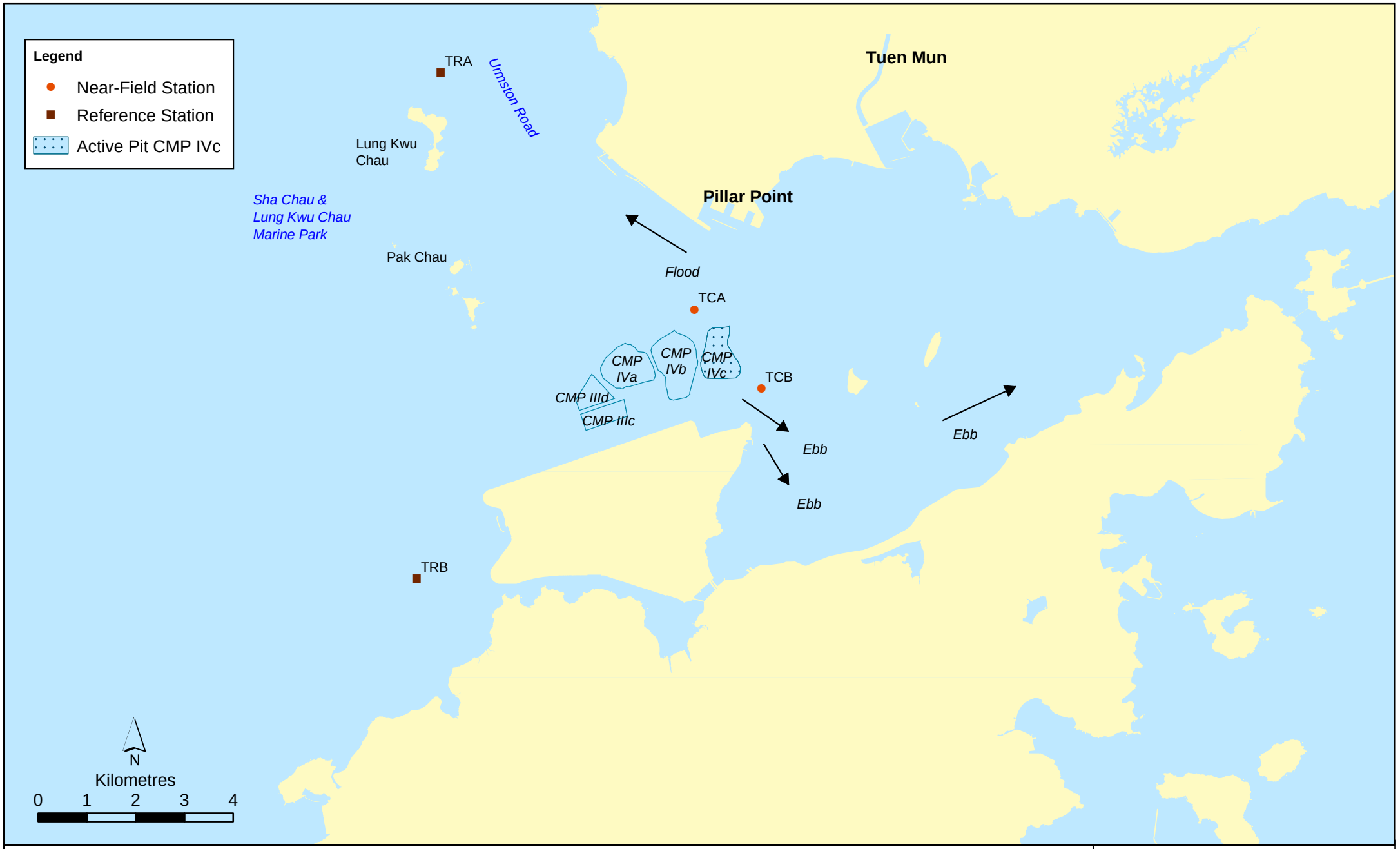

Figure 5.1

Sediment Toxicity Monitoring Stations for CMPIV

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Table 5.1 ***Sediment Toxicity Testing Sampling Stations for CMP IVc***

Station	Eastings	Northings
Reference		
TRA	806207	827812
TRB	806307	817693
Near-Field		
TCA	811414	822982
TCB	812734	821281

Note: Coordinates are based on Hong Kong 1980 GRID Coordinate System

5.4.2 Sampling for CMP V

Sediment samples for CMP V should be collected from two treatment areas as well as at the Ma Wan station. The first treatment area is represented by samples taken from two stations in an area close to the active pits (Near-Field) and the second treatment area is represented by samples collected from stations in a reference area (Far-Field). The locations of stations are shown in *Figure 5.2* and the coordinates are presented in *Table 5.2*. Five replicates of composite samples will be collected from each of the stations and used for the sediment toxicity tests. Sampling frequency and number of replicates for CMP V will be reviewed and adjusted accordingly based on power analyses in each *Annual Report*. In addition, locations of sampling stations will be amended based on location of the active facility.

Table 5.2 ***Sediment Toxicity Testing Sampling Stations for CMP V***

Station	Eastings	Northings
Reference		
ESC-TRA	806207	827812
ESC-TRB	806307	817693
Near-Field		
ESC-TDA	809547	822778
ESC-TDB	810636	821839
Ma Wan Station		
MW1	823603	823653

Note: Coordinates are based on Hong Kong 1980 GRID Coordinate System.

5.5 STATISTICAL TREATMENT OF DATA

Each of the toxicological tests will be evaluated for statistically significant increases in toxicity. Statistically significant toxicity will be determined by performing an analysis of variance (ANOVA) test that compares the responses observed in the test treatments with those of the reference treatments. At the end of the monitoring programme changes in the toxicity of the sediments over time will be evaluated through the use of two-factor ANOVA incorporating both spatial and temporal scales of variation.

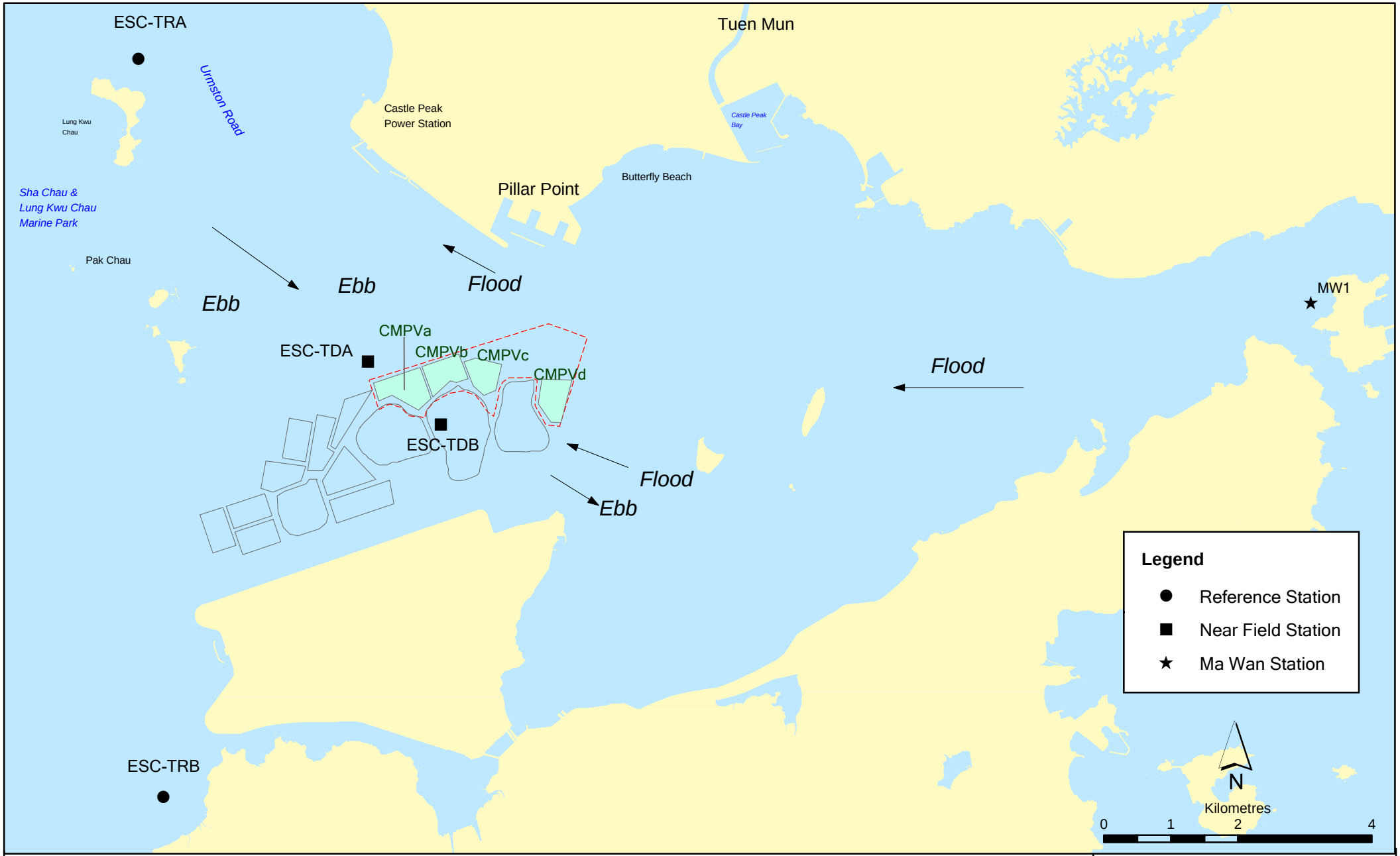

Figure 5.2

Sediment Toxicity Monitoring Stations for CMPV

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5.6 USE OF DATA

Once the data have been evaluated for significance, it is important to identify potential causes of toxicity and the biological significance of the observed effects. The cause of the observed effects needs to be distinguished between 1) non-persistent contaminants, 2) persistent contaminants, and 3) physical factors. It is most important to determine if the cause of the toxicity is due to persistent contaminants that are derived from the contaminated sediment placed in the pits (eg metals, pesticides, PAHs, TBT), to non-persistent contaminants (eg sulfides, ammonia, salinity) or to physical factors (eg grain size).

If the toxicity is due to persistent contaminants that are associated with disposal operations, the operations plan for the active pits may not be effective enough at managing the containment of contaminated sediment to acceptable levels and thus should be modified. If the observed toxicity is due to non-persistent contaminants, the effects may be due to the pit but they are transient. The toxicity of these types of contaminants can be assimilated by the environment in relatively short time periods, and are thus less harmful. If the effects are related to physical factors, they are again of less concern and would not likely require changes in the facility operations plan.

As non-contaminant factors and physical factors can confound toxicity test interpretation, the ET will monitor ammonia, sulfides, interstitial salinity, and sediment-grain size. Each of these factors has been observed to elicit a toxic response in test organisms, however, they are not factors related to persistent contaminants of concern. This information will be used to investigate any observed toxicity responses and determine whether the response is due to persistent contaminants or to more transient factors.

5.7 DATA COLLECTION PARAMETERS

The amphipod toxicity test with burrowing amphipod (*Leptocheirus plumulosus*, *Ampelisca abdita*, *Eohaustorius estuarius* or other equivalent species as agreed with EPD/AFCD prior to conduct of the toxicity test) will evaluate survival following a 10-day exposure to test sediment. Procedures will follow those outlined in PSEP (1995) (1) and/or USEPA (1994) (2), depending on the species used for the test, and CEDD's Environmental Laboratory Guidance Document (1996) (2). The amphipod benthic test will be conducted as a static test and will be performed with 175 ml of sediment and 800 ml of overlying seawater placed in a 1-L glass jar. At test initiation, each of five replicate test chambers will be seeded with 20 amphipods. Test chambers will be maintained at 20°C and will be checked daily throughout the test to establish

(1) Puget Sound Estuary Program (PSEP) (1995). Recommended guidelines for conducting laboratory bioassays on Puget Sound sediments. Prepared for the US EPA.

(2) U.S.EPA (U.S. Environmental Protection Agency) (1994). Methods for assessing the toxicity of sediment-associated contaminants with estuarine and marine amphipods. Office of Research and Development. U.S. Environmental Protection Agency, Cincinnati, OH. EPA/600/R94/025

(3) EVS (1996). Testing of Dredged material for Marine Disposal: Environmental Laboratory Guidance Document. Prepared for CED.

trends in sediment avoidance. After the 10-day exposure, the benthic tests will be terminated by sieving the sediments and enumerating the live and dead amphipods.

The test on *Neanthes arenaceodentata* (or a equivalent species as agreed with EPD/AFCD prior to conduct of the toxicity test) will evaluate polychaete survival and growth following a 20-day exposure to test sediment. Test methods will follow those outlined in PSEP (1995) (3). The test will be conducted as a static test, performed in 175 ml of sediment and 800 ml of overlying seawater in 1-L glass jars. At test initiation, each of five replicate test chambers will be seeded with five polychaetes. Test chambers will be maintained at 20°C and will be checked daily to record mortality and sediment avoidance. To promote growth, worms will be fed TetraMarin[8] every third day throughout the test. After 20 days, the *N. arenaceodentata* test will be terminated by sieving each test chamber and enumerating both live and dead organisms. Surviving polychaetes will be dried and weighed for each test chamber. Average dry weight will be compared to initial biomass to determine mean growth for each test chamber.

The larval-development toxicity test will be performed with fertilized bivalve embryos (*Crassostrea gigas, Mytilus galloprovincialis* or a equivalent species as agreed with EPD/AFCD prior to conduct of the toxicity test) will evaluate larval survival and development following a 48 to 96-hour exposure to test sediments. This procedure will follow those outlined in PSEP (1995) (1). This test will be conducted in 20 mg of test sediment with 800 ml of seawater in 1-L glass jars. At test initiation, test jars will be seeded with 20 to 40 embryos per ml. Test chambers will be maintained at 16°C. At termination, overlying water will be decanted and subsamples drawn from the supernatant. Survival and normal larval development will then be determined under an inverted compound microscope.

In each of the sediment tests, a sediment/seawater control (consisting of clean sediment for amphipod and polychaete or clean seawater for the bivalve larval test) will be tested concurrently with the test sediments. The control treatment should be included to determine the health of the test organisms. Sediments collected from the reference stations will also be tested concurrently with test sediments to provide a basis for statistical comparison. For the larval tests, grain-size controls will be tested concurrently with the test sediments to discern any effects related to sediment grain size. Additionally, a water-only reference toxicant test using cadmium (from $CdCl_2$) or copper (from $CuNO_3$) will be conducted with each batch of test organisms. This reference-toxicant test provides a measure of relative sensitivity for each group of test organisms. All toxicity tests will be completed and reported within four months from collection of the samples.

(1) PSEP (1995) *op cit.*
(2) PSEP (1995) *op cit*

5.8 SAMPLING PROCEDURE AND EQUIPMENT

Procedures for sampling will be as for the sediment chemistry for Sediment Quality Monitoring as detailed in *Section 4.8* of this Manual. Shipments of the sediments will be packaged in ice-boxes in order to maintain the sediments at a constant temperature of 4°C and dispatched by express courier for immediate testing.

5.9 QA/QC

To ensure the quality and integrity of the ecotoxicological data and subsequent analyses, a QA/QC control program will be followed that meets or exceeds the QA/QC program outlined in Chapter 4 of CEDD's Environmental Laboratory Guidance Document (1996) (2). The QA/QC program for the facility ecotoxicological program is described below.

5.9.1 Sediment Handling and Chain-Of-Custody

Upon sample receipt, samples will be held at 4° ± 2° C in the dark until required for testing. Sediment holding times for biological testing begin the day of sample collection and will be kept at a minimum. The holding time for sediment intended for biological testing will be eight weeks. Chain-of-custody forms will accompany each batch of samples to track samples and to provide temperature data before and after shipping.

5.9.2 Bioassay Seawater

Clean seawater for holding test organisms will be sand-filtered seawater piped directly into the testing laboratory. Seawater used for test water and control water should be additionally gravity-feed filtered through a 0.45 -μm filter before use for all test species. Bioassay seawater should be continually monitored for water quality and the presence of algal blooms.

5.9.3 Instrument Maintenance and Calibration

Procedures for calibration and maintenance of water quality equipment will follow *Measurement Standards Laboratory* (MSL) protocols. All measuring and testing equipment used on this Project should be traceable to the data collected and should be calibrated before use.

The pH meters used for obtaining water quality data must be calibrated daily before use according to MSL-M-045, Calibration and Use of pH Meters. The calibration will be documented on the pH Meter Calibration Record sheet. Maintenance on pH meters will be performed monthly. Maintenance should include visual inspection, cleaning probes in 0.1 M HCl, and cleaning any corroded contacts.

(1) EVS (1996). Testing of Dredged material for Marine Disposal: Environmental Laboratory Guidance Document. Prepared for CED.

Refractometers used for obtaining water quality data will be calibrated monthly using IAPO Standard Seawater according to MSL-M-048, Calibration and Use of Refractometers. The calibration should be documented on the Refractometer Calibration Record sheet. Refractometers should be inspected visually and cleaned monthly.

Digital thermometer calibrations will be performed monthly by comparison to a certified mercury thermometer as specified in MSL-M-047, Calibration and Use of Thermometers. The calibration will be documented on a Thermometer Calibration Record. Maintenance should include visual inspection and cleaning of salt and corrosion from connectors and contacts.

Dissolved oxygen meters should be calibrated daily before use according to MSL-M-046, Calibration and Use of Dissolved Oxygen Meters. The calibration should be documented on the Dissolved Oxygen Meter Calibration Record. Maintenance should be performed once monthly and should include visual inspection, cleaning the probe, and replacing of probe membrane.

The Fisher Accumet 1003 pH/selective ion electrode meter with ammonia electrode should be maintained according to manufacturer's instructions. The meter should be calibrated on each day of use with three concentrations of NH_4Cl standards bracketing the expected test concentrations of ammonia. The ammonia probe should be stored in 0.02 M NH_4Cl when not in use.

5.9.4 Data Review and Validation

In addition to QA/QC mentioned above, a series of reviews by qualified laboratory personnel should be implemented to ensure that the data generated for this Project meets the data quality objectives. These reviews should include the following:

- Data should be reviewed periodically by laboratory personnel to ensure that sample testing activities are completely and adequately documented.

- Sample holding times, sample integrity, test animal handling and acclimation, equipment calibration, water quality measurements, reference toxicity results, observations, and control survival will be reviewed by qualified laboratory personnel. The results of QC measurements will be compared to pre-established criteria as a measure of data acceptability.

- A final data audit by the Quality Assurance Officer will be performed prior to submission of the data and report. This audit will ensure that the data are accurate, traceable, defensible, and complete, as compared to the Manual. The audit procedure (MSL-Q-005, Quality Assurance Data Audits) is a statistical, randomized check which involves comparing selected reported values to the original data. This procedure is designed to ensure a 95 percent chance of detecting whether one percent or more reported values disagree with the original data.

The overall quality assurance objective for this Project is to implement procedures that will ensure the collection of representative data that is of acceptable and defensible quality. The data quality objectives for the ecotoxicological tests will be devised with reference to the previous data quality objectives established for the previous monitoring programmes for the East of Sha Chau CMPs.

A negative control provides a measure of test organism health. Negative control treatment will be running concurrent to each toxicity test as a measure of the test organism's health. For the amphipod (eg *Ampelisca* sp) and polychaete (eg *Neanthes* sp) toxicity tests, the negative control should consist of clean, native sediment that is to be collected from the test organism's natural habitat. For the bivalve larval test, the negative control should consist of clean seawater. Acceptable limits for the negative controls will be defined with reference to the limits established for the East of Sha Chau CMP monitoring programmes. If survival or normal development do not meet the acceptability criteria, all data should be evaluated and the test may need to be repeated.

Water quality measurements provide documentation of environmental conditions within the test chambers during the exposure. Temperature, dissolved oxygen, pH, and salinity will be measured daily throughout the test. Conditions that are acceptable to maintain the health of the test organisms will be defined with reference to the acceptable conditions defined for the East of Sha Chau CMP monitoring programmes. If test conditions are outside the acceptability criteria, the data will need to be qualified.

The positive control provides a relative measure of test organism sensitivity. For each of the bioassays for the active pits, a separate reference-toxicant test should be performed with each batch of test organisms. The results of the reference-toxicant tests will be compared with control charts generated by the testing laboratory for that species and toxicant. Those results within two standard deviations of the cumulative mean are considered to be similar in sensitivity to previous test populations. For amphipods (eg *A. abdita)* the reference-toxicant test will be performed with cadmium in the form of cadmium chloride; for polychaetes (eg *N. arenaceodentata*) and bivalve larvae reference-toxicant tests will be performed with copper as copper nitrate. If the test results are outside the control limits, the data will need to be qualified.

6 MARINE BIOTA

6.1 INTRODUCTION

The bioaccumulation of contaminants by prey organisms and consequent biomagnification of contaminants up the food chain has long been an issue of concern for the disposal of contaminated mud at East of Sha Chau. Although the public at large may not appreciate the technical details of a biomonitoring programme, especially concerning mobile populations, they are well aware of the potential for contaminated mud disposal to taint seafood products. In recognition of these issues, a comprehensive biomonitoring programme which will address public concerns about contamination of seafood in the area through use of the data in a risk assessment framework should be undertaken for the disposal activities at the active pits.

6.2 OBJECTIVE

As well as examining the influence of contaminated sediment disposal on contaminant levels in demersal fisheries resources, the impact of disposal on the abundance and structure of demersal fisheries should also be assessed. Consequently, there are two objectives for this task:

- *Biomonitoring of Contaminants* - To identify any increases in the concentrations of contaminants in tissues and whole body burdens of demersal marine life adjacent to and remote from the active pits.

- *Trawling, Sorting & Analysis* - To assess the impact of contaminated mud disposal at the active pits on the fisheries resources of the North Lantau area.

6.3 HYPOTHESIS

In accordance with the predictions of the EIA and the objectives for the Study, the impact hypothesis for this task is as follows:

There is no increase in tissue or whole body contaminant concentration over time in selected target species.

In order to reflect the dual workstreams under this task, two sets of null hypotheses should be tested:

Biomonitoring of Contaminants

H_0 The concentrations of contaminants in tissue and whole body samples of demersal marine life adjacent to the active pits are not greater than contaminant concentrations from samples collected at stations remote from the active pits.

H_0 The concentrations of contaminants in tissue and whole body samples of demersal marine life do not increase over time.

Trawling, Sorting & Analysis

H_0 There are no differences in the composition or abundance of demersal fisheries resources near to and remote from the active pits.

H_0 There are no differences in the composition or abundance of demersal fisheries resources over time.

6.4 SAMPLING DESIGN

6.4.1 Biomonitoring of Contaminants

Samples for biomonitoring of contaminants will be selected from trawl samples described in *Section 6.4.2*. Samples of the target species should be collected twice per year (July/August in the wet season and January/February in the dry seasons) specifically from six stations. The reference stations will comprise of two stations located near Lung Kwu Chau and two stations to the south west of the airport (*Figures 6.1*-2). These reference stations are the same as those sampled in the ongoing monitoring programme (*Agreements No. CE 64/*99 and *CE 19/2004*). The other two stations will be impact stations, located on the edge of active pits. However, in order to obtain sufficient tissue and whole body samples from impact and reference stations, samples collected at different impact and reference stations will be combined where necessary.

Due to concerns regarding the collection of sufficient quantities of target species, catch from the first trawl survey of each season (trawl for catch characterisation) should be retained in a frozen state for joint processing with the biomonitoring samples in the following month.

Five replicate tows (each with six nets) should be conducted at each station and composite samples prepared from all nets and tows at each station during each of the sampling events. Replicate data points should be obtained whenever the abundance of target species allows laboratory analysis of more than one tissue/whole body sample for each target species at each station. The design to be developed should address the following key issues:

- Rigour of the dataset to allow for statistical testing of observed differences;
- Data required for the risk assessment;
- Composite samples to minimise the variance between fish and improve the reliability of detecting any significant trends; and,
- Analysing replicate samples, whenever possible, to provide cost effective

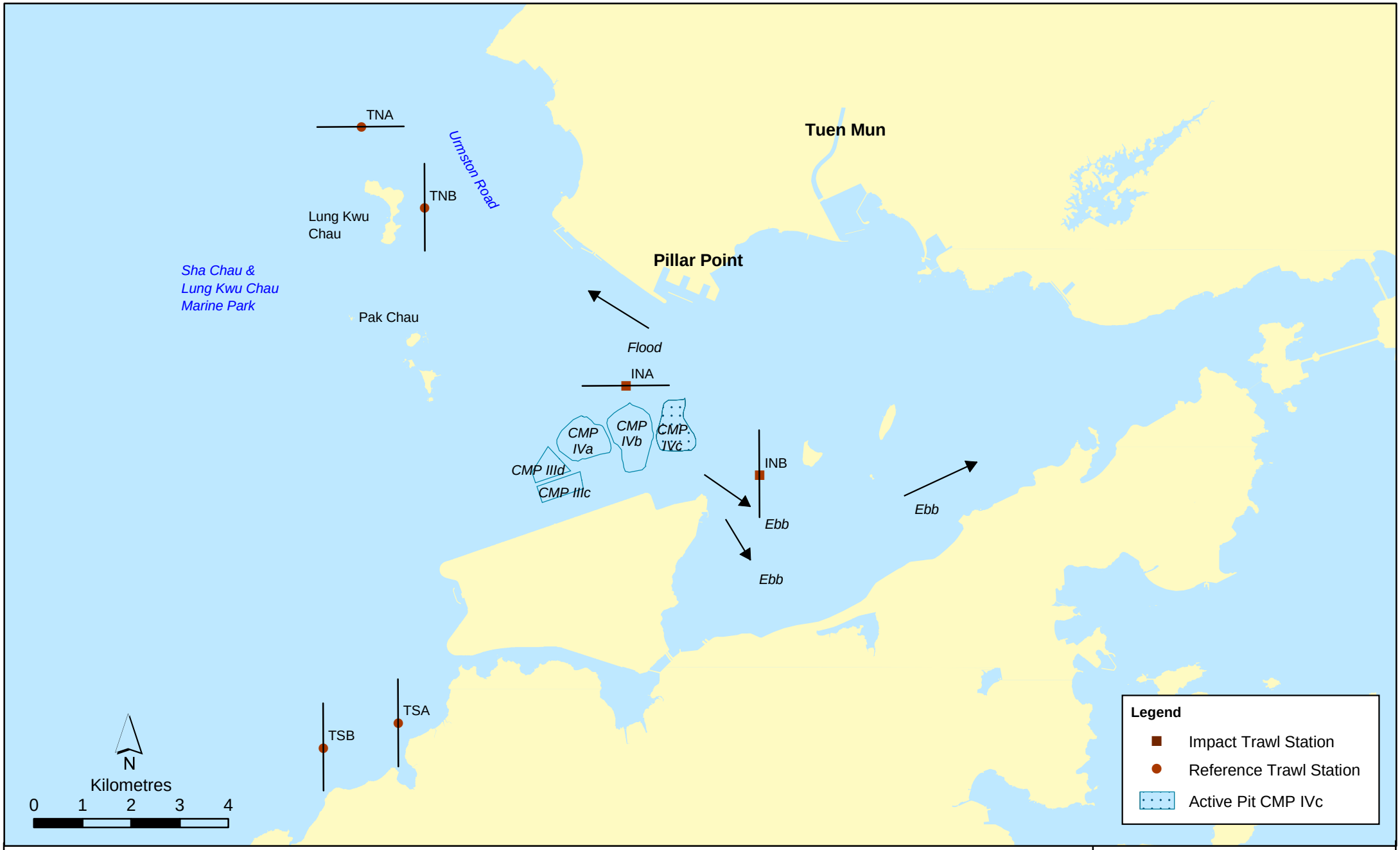

Figure 6.1

Marine Biota Monitoring Stations for CMPIV

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Date: 20/10/2009

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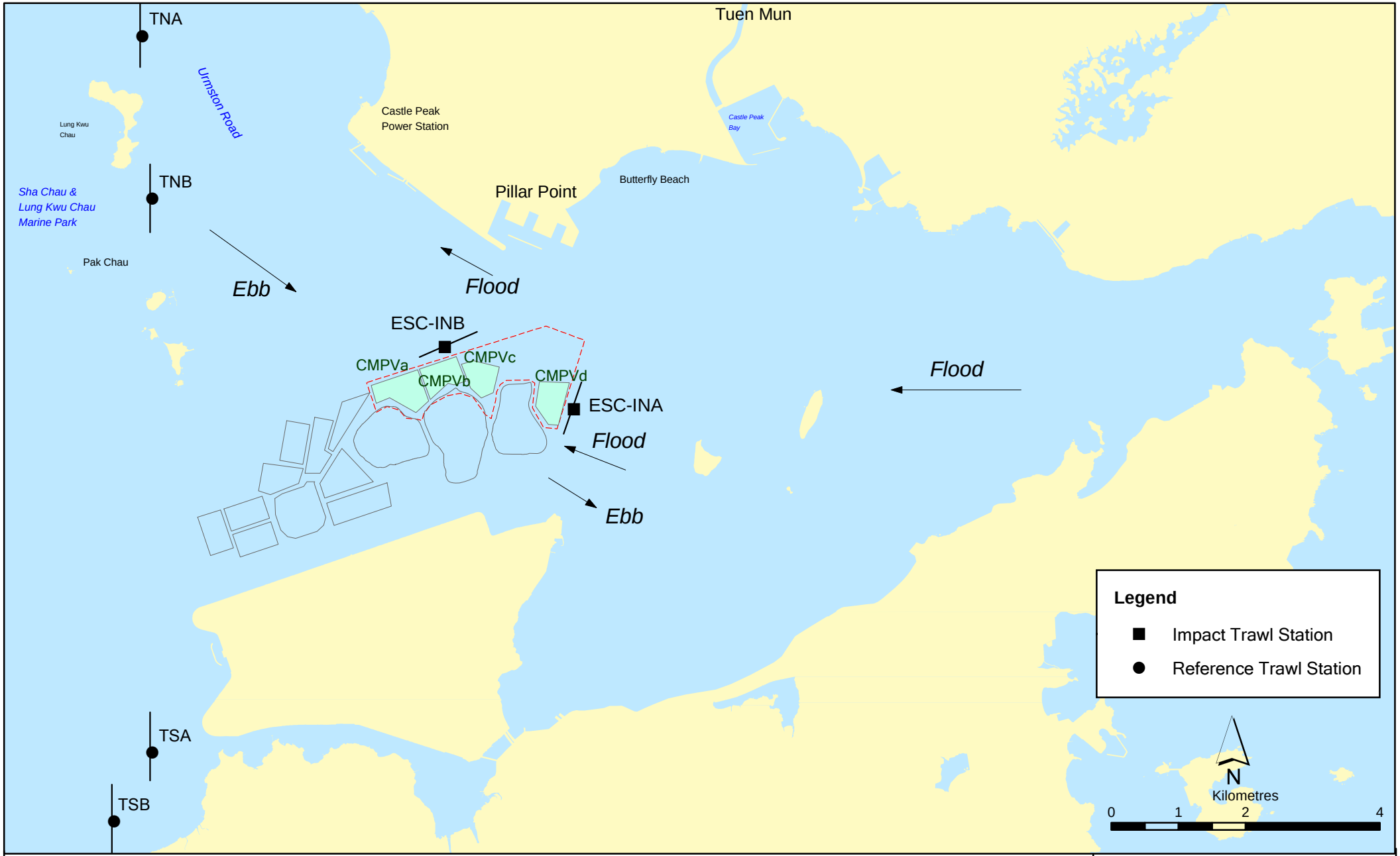

Figure 6.2

Marine Biota Monitoring Stations for CMPV

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statistical rigour.

Sampling for CMP IV

For CMP IV, the locations of stations for biota monitoring are shown in *Figure 6.1* and the coordinates are shown *Table 6.1*. Details on the *Sampling Programme* for CMP IV are shown in *Table C1* of *Annex C*. For CMP IV, a long term review of the monitoring program showed that PAHs were rarely recorded above detection limits and consequently these parameters will not be measured in the monitoring programme for CMP IV.

Table 6.1 Demersal Trawl Sampling Station Coordinates (centre of the transect) for CMP IVc

Station	Eastings	Northings
Impact		
INA	810808	822779
INB	813561	820935
Reference		
TNA	805353	828111
TNB	806655	826440
TSA	806115	815824
TSB	804567	815308

Note: Coordinates are based on Hong Kong 1980 GRID Coordinate System.

Sampling for CMP V

The locations of biota monitoring stations for CMP V are shown in *Figure 6.2* and the coordinates are shown *Table 6.2*. Details on the *Sampling Programme* for CMP V are shown in *Table C2* of *Annex C*.

Table 6.2 Demersal Trawl Sampling Station Coordinates (centre of the transect) for CMP V

Station	Eastings	Northings
Impact		
ESC-INA	812651	822106
ESC-INB	810730	823034
Reference North		
TNA	806220	827674
TNB	806366	825248
Reference South		
TSA	806366	816977
TSB	805796	815951

Note: Coordinates are based on Hong Kong 1980 GRID Coordinate System.

6.4.2 Trawling, Sorting & Analysis

The design of the sampling programme should encompasses the following key issues:

- Temporal variation in fisheries assemblages; and,

- Spatial variation of mobile assemblages of demersal fisheries resources.

Samples should be collected for analysis four times each year (twice in the dry season and twice in the wet season) to account for temporal variation in the fisheries assemblages. The samples should be collected from 5 replicate trawls (each with 6 nets) undertaken along a transect at each of the six stations, in which two stations are located at the impact area while four stations are located at the two reference areas (*Figure 6.1* and *6.2*, for CMP IV and CMP V, respectively). Samples for biomonitoring of contaminants will be selected from the trawl samples.

6.5 STATISTICAL TREATMENT OF DATA

6.5.1 Biomonitoring of Contaminants

The data should be analysed using analysis of variance (ANOVA) techniques to test for differences between the two sampling sites (Impact and Reference). Once a time series of data (sequential sampling events) has been gathered, differences should be tested between sites and between the different sampling events to examine any temporal trends in contaminant levels in the target species.

6.5.2 Trawling, Sorting & Analysis

Catch composition should be analysed using partially nested analysis of variance (ANOVA) techniques to account for changes in catches between and within sites in the North Lantau region and between different sampling times.

6.6 USE OF DATA

If significant increases are detected in the levels of contaminants in fisheries resources in this programme it will indicate that bioaccumulation is occurring. However, as demersal fisheries resources are generally mobile (except burrowing species such as the gobies *Trypauchen* and *Oxyurichthys*), increases may not necessarily be due to disposal at the disposal facility. Other contaminant sources such as discharges from the Pearl River, the local sewage outfalls or non point source pollution may cause such increases. To account for these confounding effects, the results from this Project's sediment and water quality monitoring programmes along with the most recent sediment toxicity test results will be examined so that the sources of any increases can be identified. Should there be evidence that effects are due to the active facility, the monitoring and disposal programmes will be reviewed and revised where necessary as agreed with CEDD and EPD.

6.7 DATA COLLECTION PARAMETERS

6.7.1 Biomonitoring of Contaminants

The contaminants of concern for this project should be measured separately, firstly in tissue samples (soft tissue) and secondly in whole body samples obtained from the species list established for this project. The species to be examined should be chosen based on two criteria:

- The degree to which the organisms are exposed to contaminants in the sediments; and,
- The position of the organisms in the food chain and the trophic level of their predators (ie, humans or Indo-Pacific Humpback Dolphin).

The species list (*Table 6.3*) has been devised with reference to the previous biomonitoring programmes for the East of Sha Chau CMP's. Comparing to the monitoring programme from February 2006 to April 2009, the analysis of whole body samples of Cephalopods is suggested to be removed from the present monitoring programme as according to Jefferson and Hung (2004) (1), there is little evidence that Indo-Pacific Humpback Dolphin consumed Cephalopods as a major prey item. Therefore, it is considered unnecessary to analyze Cephalopods for the risk assessment of Indo-Pacific Humpback Dolphin (please refer to *Section 7* for details of risk assessment).

Table 6.3 List of Target Species for Tissue and Whole Body Analysis

Type	Tissue Analysis Target Species (2)	Alternative Species (3)	Whole Body Analysis Target Species (1)	Alternative Species (2)
Prawn	*Metapenaeus ensis* *Metapenaeus affinis*	*Metapenaeus joyneri* *Metapenaeopsis* spp.	*Metapenaeus* spp.	*Metapenaeopsis* spp.
Mantis Shrimp	*Oratosquilla oratoria*	*Oratosquilla nepa* *Oratosquilla anomala*	*Oratosquilla* spp.	
Swimming Crab	*Charybdis cruciata*	*Portunus sanguinolentus* *Scylla serrata* *Portunus pelagicus* *Portunus trituberculatus*		
Flat Fish	*Cynoglossus macrolepidotus*	*Cynoglossus trigrammus* and *Solea ovata*		

(1) Jefferson TA and Hung SK (2004) *Op. cit.*

(2) In case sufficient samples of the target species cannot be obtained, analysis of the alternative species should be carried out.

(3) The alternative species are listed in order of priority.

Type	Tissue Analysis Target Species (2)	Alternative Species (3)	Whole Body Analysis Target Species (1)	Alternative Species (2)
Burrowing Fish	*Trypauchen vagina*	*Oxyurichthys tentacularis*		
Demersal/Pelagic Fish	*Leiognathus brevirostris*	*Collichthys lucida*	*Leiognathus* spp.	
			Collichthys lucida	*Johnius belengeri* Other Sciaenidae
			Mugil spp. *Thryssa* spp.	
Gastropod Non-Commercial Crab	*Turritella terbra*		*Charybdis* spp.	

In the laboratory, each trawl sample should be sorted for target species and target species selection should be based on the abundance and potential sample mass available for each species captured. In preparing composite samples for analysis, different species will not be mixed. Each composite sample for laboratory analysis should consist of three or more organisms, with priority given to larger individuals with no more than 2 fold difference in length. Length and weight of all individual organisms represented by the composite sample will be recorded and individuals for tissue sample analysis dissected with a sterilised (with hexane) titanium knife and a composite sample prepared. Care should be taken not to cross contaminate any tissue samples with gut contents. For fish, the axial muscle should be extracted for analysis. For prawn/shrimp and crab, abdominal and claw/leg muscle should be used, respectively. For gastropods, tissue samples should be taken from the soft body tissue.

The analytical parameters for tissue and whole body testing for both CMP IVc and CMP V are given below:

- Inorganic Arsenic;
- Cadmium;
- Chromium;
- Copper;
- Lead;
- Mercury
- Nickel;
- Silver;
- Zinc
- Total Polychlorinated Biphenyls (PCBs);

- Organochlorine Pesticides (DDE & DDT);
- Tributyltin (TBT); and,
- Moisture content.

Polycyclic Aromatic Hydrocarbons (PAHs) will be measured for CMP V only.

For CMP IVc, for each of the target species a total of two replicates from each station should be analyzed for each analytical parameter for tissue and whole body analysis, respectively, except for Copper, Silver, Zinc and TBT in which five replicates should be analyzed instead.

For CMP V, for each of the target species a total of five replicates from each station should be analyzed for each analytical parameter for tissue and whole body analysis, respectively.

Tissue Pooling and Preparation

In past monitoring programmes at CMP IV there have been times when insufficient biota are collected in the trawl samples for chemical analysis of contaminants. In the event of a low catch, it is possible to pool samples using the procedures shown in *Table 6.4* and in the text below.

Table 6.4 Methodology for Pooling Samples to Obtain Sufficient Tissue/Whole Body Samples for Analysis

Step	Stations to Be Combined	Decision Criteria (1)
1	Impact (INA) + Impact (INB) = Impact Reference (TNA) + Reference (TNB) = Reference	Proceed to step 2 unless tissue and whole body samples are adequate for analysis
2	Above + previous months Impact (INA) = Impact Above + Reference (TSA) + Reference (TSB) = Reference	Proceed to step 3 unless Proceed to step 2 unless tissue and whole body samples are adequate for analysis
3	Above + previous months Impact (INB) = Impact Above + previous months Reference (TNA) = Reference	Proceed to step 4 unless Proceed to step 2 unless tissue and whole body samples are adequate for analysis
4	Above + previous months Reference (TSB) = Reference	Proceed to step 5 unless Proceed to step 2 unless tissue and whole body samples are adequate for analysis
5	Above + Reference (TSA) and Reference (TSB) = Reference	N/A

(1) Note that inter-seasonal pooling is not permitted.

The pooling of Reference and Impact biota is not permitted. Pooling biota from station in the same area should only be done as a last measure.

Wherever possible, samples from the same station and of the same species should be pooled together ie pooling together *Species X* from TNA Trawl 1 January 2009 with TNA Trawl 2 January 2009 would be preferable to pooling samples from TNA and TNB, this can sometimes be unavoidable due to low catch rates. Pooling of totally different taxa is not permitted, however,

similar taxa can sometimes be pooled when using 'Alternative Species' e.g *Oratosquilla nepa* and *Oratosquilla anomala* to form *Oratosquilla* spp.

If insufficient material is obtained following pooling then, material should be kept and used in 'Alternative Species' pooling if they are of a similar group (e.g. if not enough *Charybdis cruciata* are available after the pooling of stations it is possible to pool with other *Charybdis* sp.). Contaminant uptake is dependent on the salinity of the water, which is seasonal. Typically greater uptake occurs during the wet season when salinity is lower than in the dry season (1). For this reason, the pooling of samples between different seasons should not be conducted.

6.7.2 Trawling, Sorting & Analysis

Catches from the trawl vessel should be processed to record the abundance and biomass of individuals of commercial fisheries resources as well as the number of species (or to the lowest possible taxonomic level) present.

6.8 SAMPLING PROCEDURE AND EQUIPMENT

Trawl sampling should be conducted by a shrimp trawler equipped with a GPS system to ensure accurate positioning of each trawl. Five replicate trawls, with six nets deployed in each, should be conducted for 10 minutes at each station. If more than one of the six nets are retrieved in a damaged condition, the samples should be rejected and the trawl repeated. To ensure the maximum quality of the benthic trawl samples, several control measures have been incorporated into the sampling programme, including:

- no more than three consecutive trawls should be conducted at a station and resampling should only occur after a minimum of two hours has elapsed;
- subsequent trawls at each station should be shifted to avoid repetitive sampling over the same area of seabed; and,
- the first station sampled in each survey should be selected at random to minimise the diurnal influences on catches.

Catches from all six nets in each trawl should be combined to form one sample. Each sample should be immediately washed and stored in sterilised (with hexane) glass jars. All samples should be chilled to 4^{o}C and transported to the laboratory for further sorting and analysis.

(1) Mouchel (2003). *Op cit.*

7.1 INTRODUCTION

The waters north of Lantau have historically been important fishing grounds. These fishermen's catches comprise mainly shrimps and crabs, as well as fish species of relatively low commercial value such as pony fish, puffer fish and gobies (1). The North of Lantau area also is recognized as the primary habitat of the Indo-Pacific Humpback Dolphin (*Sousa chinensis*) within Hong Kong waters. This species, which is listed as Near Threatened on International Trade in Endangered Species (CITES), has a limited distribution in Hong Kong waters due to its preference for shallow, coastal estuarine habitat and is thought to be threatened by continuing development in the Pearl River Delta.

Disposal operations at the facility will be designed to minimize the dispersion of contaminated sediments during disposal and to prevent the long-term migration of contaminants through placement of a clean sand and mud cap. However, as losses of contaminated sediment will nevertheless occur during placement, and as the area serves as habitat for marine species which may be consumed by humans and/or the Indo-Pacific Humpback Dolphin, the risk of adverse impacts must be addressed by the monitoring programme. Pathways of contaminant release to sensitive receivers (ie humans and dolphins) include ingestion of contaminated sediment, ingestion of dissolved and suspended contaminants in water, and ingestion of organisms with contaminant residues.

Consequently, a risk assessment will be performed on an annual basis to verify that no unacceptable risk are occurring to either human health or marine mammals as a result of consuming prey species from the waters in the vicinity of the pits of North Lantau. The details of the EM&A programme for assessing hazard to health of humans and marine mammals are presented below.

7.2 OBJECTIVE

The objective of the risk assessment component of the monitoring programme is to determine whether disposal operations at the active pits are posing an unacceptable risk to humans and dolphins through consumption of seafood/marine prey species from the North Lantau area. This objective should be addressed through a standardized risk assessment methodology which cost effectively builds on existing risk assessment methodologies and databases and overcomes some of the previous studies' limitations.

(1) ERM (1997) Fisheries Resources and Fishing Operations in Hong Kong Waters. Draft Final Report prepared AFD.

7.3 *HYPOTHESIS*

Given the above discussion of objectives, the impact hypotheses for this component of the monitoring programme are defined as follows:

For Human Health:

IH_1: Risks to human health from consumption of commercial species captured adjacent to the active pits are no greater than risks associated with consumption of species remote from the active pits;

AND

IH_2: Risks to human health from consumption of commercial species captured adjacent to the active pits are below the screening risk criterion (see Section 7.5).

For Dolphins:

IH_1: Risks to dolphins from consumption of prey species captured adjacent to the active pits are no greater than risks associated with consumption of prey species remote from the active pits;

AND

IH_2: Risks to dolphins from consumption of prey species captured adjacent to the active pits are below the screening risk criterion (see Section 7.5).

7.4 *SAMPLING DESIGN*

Data required for the risk assessment should consist of:

- contaminant concentrations in commercial/prey species collected from stations adjacent to and remote from the active pits;
- toxicology data for humans and dolphins;
- literature-derived human consumption rates and patterns for seafood;
- literature-derived data on exposure of humans from other food groups;
- literature-derived data on contaminant levels in marine mammals;
- data collected by AFCD on contaminant levels in stranded *Sousa chinensis* carcasses; and,
- existing natural history information for the Indo-Pacific Humpback Dolphin and related species (eg diet composition and feeding range).

The primary data input to the risk assessment should derive from the bi-annual trawl (ie tissue samples for human populations and whole body

samples for dolphins) monitoring events. The risk assessment will be performed on an annual basis.

7.5 USE OF DATA

The risk assessment will follow the guidelines of the US Environmental Protection Agency [1] [2] and will incorporate a four-step approach involving problem formulation, estimation of exposure, characterization of ecological or human health effects (injury), and risk characterization. Each of these steps is described below with reference to how each applies to both human health and ecological risk assessment.

Problem Formulation: Also known as hazard definition [3], the problem formulation will describe the sensitive populations (eg the general Hong Kong population, subsistence fishermen, the Indo-Pacific Humpback Dolphin) and identify biological effects of concern potentially associated with the CMP operations at the active facility. Identification of these effects should include a discussion of contaminants of concern, measurement endpoints and a conceptual model embodying the mechanisms of contaminant migration.

Estimation of Exposure: The purpose of the exposure estimation is to determine the intake of each contaminant of concern by potentially exposed individuals. This step will consider the various routes of contaminant release and their migration from the site to sensitive receivers. Factors such as fate and transport processes, the concentrations in the ambient environment, and the maximum short-term or average lifetime doses should be assessed.

For human populations exposure factors presented in previous reports [1] [2] will be critically evaluated to determine if further modification is necessary. These factors, which include amounts of seafood consumed, origin of seafood products, and methods of preparation (eg raw versus cooked, whole body vs tissue only) will be evaluated for the general population and any sensitive subpopulations (eg subsistence fishermen fishing in the East of Sha Chau area).

Characterization of Effects: The effects assessment is designed to quantify the relationship between the degree of exposure to a substance and the extent of toxic injury or disease. This step in the assessment will use data derived from dose response studies on laboratory animals or, less frequently, on exposed human populations and clinical trials. For non-carcinogenic

(1) U.S. Environmental Protection Agency. 1992. Framework for Ecological Risk Assessment. EPA/630/R-92/001. Risk Assessment Forum, U.S. EPA, Washington, DC.

(2) U.S. Environmental Protection Agency. 1996. Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments (Draft). U.S. EPA.

(3) Suter, G W II. (1993). Ecological Risk Assessment. Lewis Press, Boca Raton, FL, 538 pp.

(4) Shaw, B (1995) Evaluation of risks to human health in Hong Kong from consumption of chemically contaminated seafood: A risk assessment approach, MSc thesis, Environmental Management Programme, University of Hong Kong.

(5) EVS (1996) Contaminated Mud Disposal at East of Sha Chau: Comparative Integrated Risk Assessment. Prepared for CED.

substances, once the relationship between doses and responses is established, a threshold which represents the highest contaminant concentration that is not expected to result in an adverse effect, ie the reference dose (RfD) or a No Observed Adverse Effect Level (NOAEL) can be established. This threshold will then compare to the dose derived from the exposure assessment above to produce the risk characterization.

For humans, dose-response relationships must be considered separately for carcinogens and non-carcinogens. When dealing with carcinogens, a cancer potency factor (CPF) or Slope Factor (SF) for each contaminant of concern will be used. For non-carcinogens, the NOAEL or LOAEL (lowest observed adverse effect level) will be used as the threshold value. Data on CPFs and NOAEL/LOAEL values are available through the U.S. EPA's IRIS (Integrated Risk Information System) and HEAST (Health Effects Assessment Summary Tables) databases. The relationship between contaminant concentrations in toothed cetacean tissues and the concentrations in their prey items will be assessed in this programme.

Risk Characterization: The risk characterization will integrate the results of the exposure and effects assessments to estimate the risks and consequences of contaminant exposures. In this step, the estimated exposure should be divided by the threshold value to obtain a Hazard Quotient (HQ). Generally HQ values below 1 are considered to represent a very low risk of adverse effects, whereas HQ values above 10 indicate a moderate to high level of risk.

For human populations, the general approach to evaluating HQs can be applied to this Project. However, the human health risk characterization produced for this Project should be updated through the use of continually collected tissue and other environmental monitoring data to reflect current conditions. This Study's human health risk assessment will improve the robustness of previous studies through a careful reconsideration of all exposure and effects parameters, with particular focus on background doses and seafood consumption patterns.

8 BENTHIC RECOLONISATION

8.1 INTRODUCTION

The EIAs conducted for CMP IV and V have indicated that benthic fauna are expected to recolonise the pits following capping with uncontaminated mud. It is expected that recolonisation of the natural benthic assemblage will occur and eventually the benthic assemblage will resemble that of the surrounding areas. Recolonisation may be achieved by larval recruitment, influx of juveniles or adults carried in water currents, or through the active swimming or crawling of individuals. However, other natural (eg storm events, hypoxia, salinity fluctuations) or anthropogenic (eg pollution, dredging activities and fisheries operations) activities may hinder recolonisation of capped pits. As a result, the factors contributing to the composition of the benthic assemblage may be difficult to determine. It is also important for any recolonisation studies to be aware of any cap maintenance (or "topping up") activities which may also impact the resident benthic assemblages.

In order to verify the recolonisation of marine biota on the capped pits, a benthic recolonisation programme is recommended. The full details of the EM&A programme for benthic recolonisation are presented in the following sections.

8.2 OBJECTIVE

The objective for this component of the Study is to monitor and report on the benthic recolonisation of the capped pits including the previous ones and specifically to determine the difference in infauna between the capped pits and adjacent sites.

8.3 HYPOTHESIS

The impact hypothesis for this task is as follows:

Recolonisation is occurring at the capped pits such that assemblages at the capped pits become more similar to reference assemblages as time since capping increases.

The null hypothesis to be tested for this work component is as follows:

H_0 There is no difference in the structure of benthic infaunal assemblages found at the capped pits at the active facility and adjacent reference areas.

H_0 Similarity of assemblage structures between impact and reference stations does not change over time.

8.4 SAMPLING DESIGN

The sampling design of this task involves two treatments: capped pits and reference areas. The capped pit treatment will involve collection of samples from the capped mud pits at the active facility. The second treatment will involve sampling at different reference sites, which are chosen to improve the balanced nature of the design. Using multiple controls is an effective way of ensuring that the extremely variable nature of Hong Kong's marine benthos from one site to another does not overly influence or alter the results. Current ecological theory suggests that the use of multiple control sites in sampling designs are statistically more robust and hence the conclusions more reliable (1) (2).

The benthic sediment samples collected during this task will be analysed for the following parameters:

- Percentage of silt/clay in the sediments;
- Faunal Abundance;
- Faunal Biomass;
- Species Composition; and,
- Trophic Structure

Sampling for CMP IIId

For CMP IIId the locations of impact and reference stations are shown in *Figure 8.1* and the coordinates are shown in *Table 8.1*. Three replicate samples will be collected from each station twice per year, once in the dry season and once during the wet season. Sampling will be undertaken as detailed in the *Sampling Programme* in *Table C1* of *Annex C*.

Table 8.1 Coordinates of Benthic Monitoring Stations for CMP IIId

Station	Easting	Northing
Reference		
RBA	806252	821271
RBB	807405	821963
RBC	807232	821165
Capped Pit		
CPA	809144	821271
CPB	809009	820963
CPC	809336	820992

Note: Coordinates are based on Hong Kong 1980 GRID Coordinate System.

(1) RJ Schmitt & CW Osenberg(1996) Detecting Ecological Impacts: concepts and applications in coastal habitats. Academic Press.

(2) AJ Underwood (1997) *op cit.*

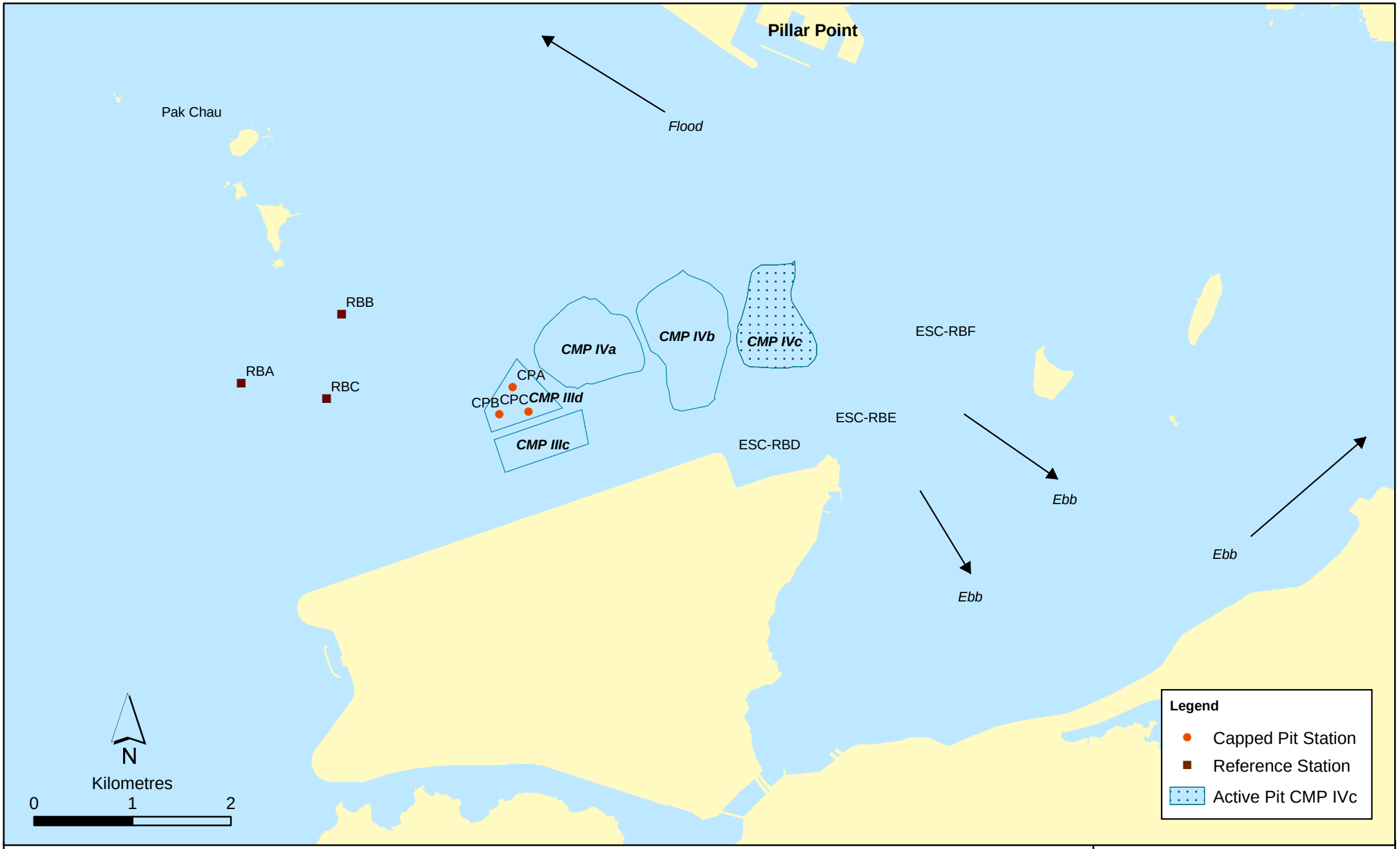

Figure 8.1

Benthic Monitoring Stations for CMP IIId

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Sampling for CMP IV

The locations of impact and reference stations for CMP IV are shown in *Figure 8.2* and the coordinates are shown *Table 8.2*. For standardisation purposes, the reference stations are at the same locations as CMP IIId [(1)] (refer to *Figure 8.1*). Samples should be collected twice per year, once in the dry season, once during the wet season. Twelve replicate samples will be collected from each of the monitoring stations. Sampling will be undertaken after capping completed at CMP IV as detailed in the *Sampling Programme* in *Table C2* of *Annex C*. Sampling frequency and number of replicates for CMP IV will be reviewed and adjusted accordingly based on power analyses in each *Annual Review Report*.

Sampling for CMP V

The sampling design for benthic recolonisation study of CMP V will be incorporated into this Manual and commenced once capping at CMP V is completed.

Table 8.2 Coordinates of Benthic Monitoring Stations for CMP IV

Station	Easting	Northing
Reference		
RBA	806399	821682
RBB	808206	822708
RBC	806171	819354
Capped Pit		
CPA	809899	821634
CPB	811006	821780
CPC	811788	821878

Note: Coordinates are based on Hong Kong 1980 GRID Coordinate System.

8.5 STATISTICAL TREATMENT OF DATA

The data collected during the monitoring programme will be analysed using two different but complementary approaches as detailed below.

8.5.1 Univariate Analyses

ANOVA & MANOVA: Simple, univariate measures will be tested using an Analysis of Variance (ANOVA), and multivariate measures of community structure will be tested using the Multiple Analysis of Variance (MANOVA). Both ANOVA and MANOVA test the same null hypothesis using similar methods. The method is essentially a comparison of the variability within a site to the variability between sites. If the ratio of these two variances (that is, the between-group-variance over the within-group-variance) is large enough, then any differences observed are due to true differences that exist between

(1) Mouchel (2003). Consultancy for Environmental Monitoring and Audit for Contaiminated Mud Pit IV at East of Sha Chau (200-2005). Final Monitoring and Audit Manual .

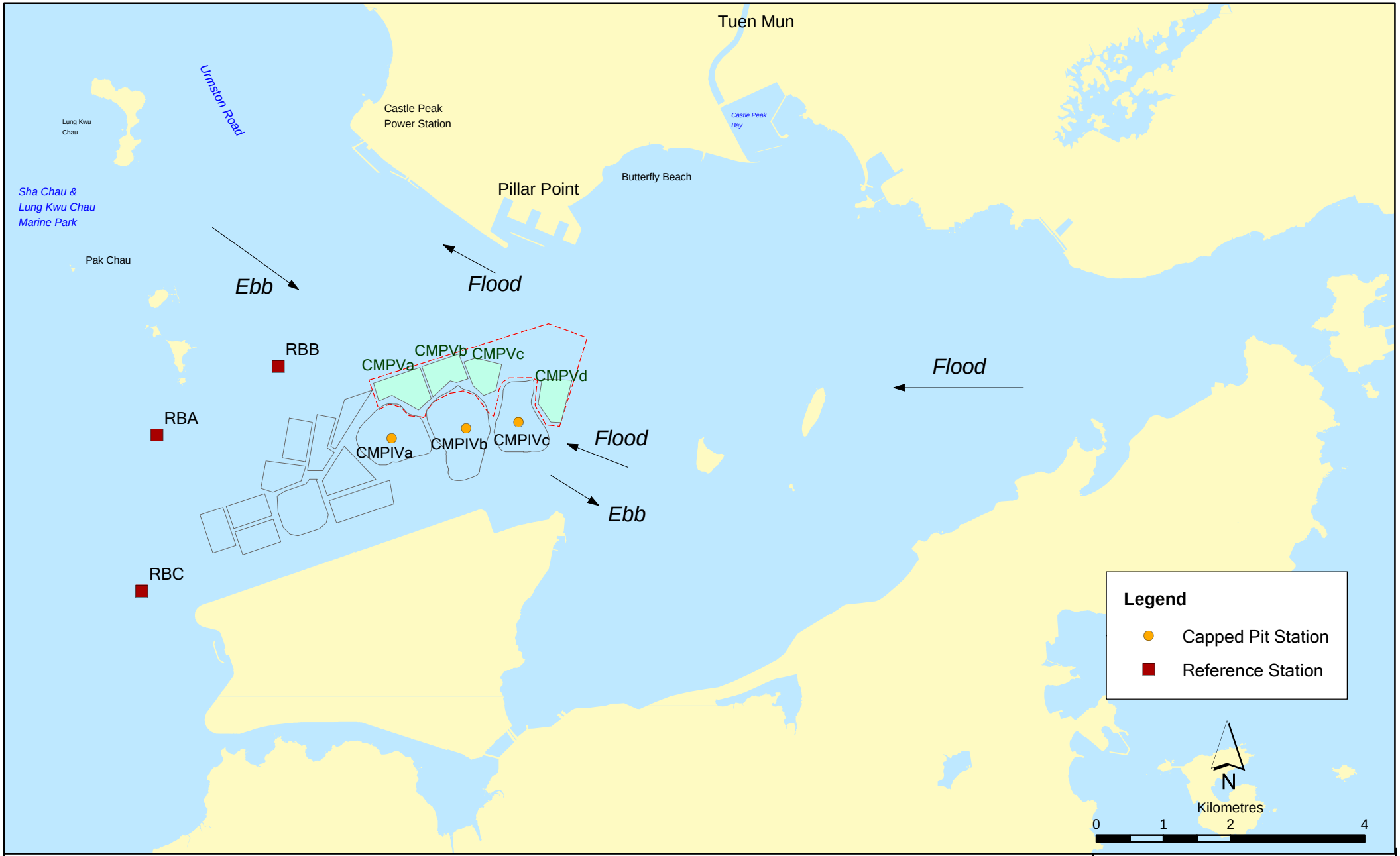

Figure 8.2

Benthic Monitoring Stations for CMPIV

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the groups and not just to random variation. ANOVA and MANOVA tests are based on several assumptions related to the underlying distribution of the data being analysed (ie normality, homogeneity of variances). If the data deviate significantly from these assumptions, then these tests are considered to be inappropriate. If this situation arises, alternative procedures (ie parametric tests with rank transformed data or nonparametric analogues such as Kruskal Wallis) which address similar hypotheses but do not require such stringent assumptions will be adopted. Observed differences between the sites and/or areas will be tested using multiple comparison procedures such as the Student Newman Keuls (SNK) or Tukey test.

8.5.2 Multivariate Analyses

Multi Dimensional Scaling (MDS): Multi dimensional scaling (MDS) will also be used to depict the similarities between stations based on their benthic assemblages. MDS is a method for creating a low dimensional picture of the relationships between stations in a complex, multi dimensional problem. The Bray-Curtis distance metric will be used for both the clustering techniques and the MDS. The dendrogram from the cluster analysis and the MDS ordination plot will provide complementary views of the same similarity information. The data for MDS and cluster analyses should be standardised prior to analysis, to ensure that bias resulting from including data in different forms (eg percent data for silt clay composition, numerical data for abundances and biomass data in mg) does not occur.

8.6 USE OF DATA

The detailed statistical analyses described above will be used to comprehensively explore the benthic assemblage patterns in the area of the active pits. This exploration should lead to conclusions regarding the effectiveness of the cap material in promoting post-dredging benthic assemblages.

8.6.1 Sampling Procedure and Equipment

The sampling team and vessel will be deployed and accurate positioning attained as described in *Section 4*. The vessel will be equipped with adequate fixed sieve stations to facilitate rapid processing of samples and ensure the maximum number of samples are collected in each survey. At each of the designated benthic sampling stations, seafloor sampling will be carried out with a modified Van Veen grab sampler (dimensions 30 cm H 30 cm H 15 cm) or similar instrument approved by EPD/AFCD. One subsample of approximately 1 kg sediment will be collected from each sample for analysis of particle size. The remaining sediment from each sample will be used for sorting. Samples will be labelled and sieved through a 1 mm and 0.5 mm sieve and all residues and organisms retained, double-bagged and preserved in 4% buffered formalin in seawater. A vital stain (eg Rose bengal) will be added to distinguish organic materials and organisms from other non-living residues. The grab and utensils will be washed thoroughly with seawater

after each deployment to avoid cross-contamination between samples. On completion of the survey all samples will be transferred to the laboratory for sorting and identification. All sediment sieving will be conducted by qualified marine scientists who will oversee and coordinate all field operations.

8.7 LABORATORY PROCEDURES

Upon arrival at the laboratory, all benthic samples should be re-inventoried and checked against chain-of-custody forms. Sample rescreening should be performed after the samples have been held in formalin for a minimum of 24 hours to ensure adequate fixation of the organisms. Individual samples from the 500 μm and 1 mm^2 mesh sieves will be gently rinsed with fresh water into a 250 μm sieve to remove the formalin from the sediments. Sieves will be partially filled while rinsing a specific sample to maximize washing efficiency and prevent loss of material. All material retained on the 250μm sieve is placed in small fractions into a labelled petri dish and preserved with 70% ethanol. The material is lightly agitated to ensure complete mixing of the alcohol with the sediments. The sediment is then sorted to remove all animals and fragments. Original labels will remain with the rescreened sample material.

Standard and accepted techniques will be used for sorting organisms from the sediments (1). Small fractions of a sample will be placed in a petri dish under a 10-power magnification dissecting microscope. The petri dish will be scanned systematically and all animals and fragments removed using forceps. Each petri dish will be sorted at least twice to ensure removal of all animals. Organisms representing major taxonomic groups including Polychaeta, Arthropoda, Mollusca, and miscellaneous taxa will be sorted into separate, labelled vials containing 70 percent ethanol. All sorted samples will be systematically checked to ensure compliance with QA/QC program requirements before proceeding to the taxonomic identification, enumeration, and biomass determination phases of the analysis.

Taxonomic identifications will be performed by regional taxonomic experts using stereo dissecting and high-power compound microscopes, to the family level except for dominants, which will be identified, where possible, to species. The careful sampling procedure employed in the Study will minimise fragmentation of organisms, however should breakage of soft-bodied organisms occur, only anterior portions of organism fragments will be counted. All fragments will be retained and weighed during biomass determinations, described below. Rare or questionable taxa will be compared against reference collection specimens for confirmation and consistency of identification. The nomenclature used in all reference collections referred to in this study should be cross checked and differences or

(1) Holme, N. A. and A. D. McIntyre (eds) (1984) Methods for the study of marine benthos. Blackwell Scientific Publications, Oxford (UK).

discrepancies should be noted. Biomass determinations will be made by taking the blotted wet mass of each taxonomic fraction.

8.8 BENTHIC MACRO-INFAUNA AND TAXONOMIC IDENTIFICATION

Sorting QA/QC will be performed using 25-power magnification by someone other than the original sorter. Twenty percent of each sorted sample should be resorted to ensure 95 percent sorting efficiency. A sample passes QA/QC if the number of organisms found during the QA/QC check does not represent more than 5 percent of the total number of organisms found in the entire sample. If the number of organisms found is greater than 5 percent of the total number, the entire sample will be resorted. Any samples where the identification of taxa is questionable will be sent out for independent reidentification by a qualified regional expert. Reference collections developed during previous seabed and benthic studies in Hong Kong should be consulted as necessary.

9 IMPACTS OF MAJOR STORMS

9.1 INTRODUCTION

Based on the previous experience with the development and approval for CMPs at East of Sha Chau for use as a confined disposal facility for contaminated mud, monitoring of the dispersion of uncapped sediments during major storm events, such as typhoons of signal 8 or higher, is an important objective of the study. It is therefore considered necessary to include this post-storm monitoring as part of the EM&A programme for the mud disposal facility.

9.2 SAMPLING DESIGN

The post-storm monitoring programme will mobilise within one week of a major storm event (Typhoon Signal Number 8 or above) in order to determine whether the pits retain disposed sediments during storms and whether there are any detectable changes in sediment quality adjacent to the pits. Sediment samples will be collected within one week of a major storm at stations of the cumulative impact sediment quality monitoring programme (*Section 4.4.3*). Locations of the sampling stations are depended on the location of the active pit; when CMP IVc is active for disposal operations sediment samples will be taken from sampling stations illustrated in *Figure 4.2* while stations shown in *Figure 4.4* will be monitored if CMP V is the active pit. Only inorganic contaminants and particle size distribution (organic contaminants are not measured as inorganics can provide a more cost-effective indicator of any sediment quality change) will be analysed in the storm assessment.

The field, laboratory and QA/QC procedures for sediment sample collection after major storm events will be identical to those used for the Cumulative Impact Sediment Quality Monitoring Programme (*Section 4*).

10 REPORTING

10.1 GENERAL

Reports will be provided in both hard copy and electronic version upon agreeing the format with EPD. This would enable a transition from a paper/historic and reactive approach to an electronic/real time proactive approach. All the monitoring data should also be submitted on CD / DVD.

10.2 REPORTS

The following documents will be submitted to CEDD for the EM&A programme:

- Inception Report;
- Environmental Monitoring and Audit Manual;
- Operations Manual;
- Tender Documents;
- Contract Documents;
- Reports on Dredging and Capping Operations;
- Monthly Progress Reports;
- Quarterly EM&A Reports;
- Annual Review Report;
- Annual Risk Assessment Report;
- Draft Final Report;
- Executive Summary Report; and
- Final Report.

Monthly Progress Reports will be required for the duration of the programme period and will be submitted to CEDD by the 10th working day of each month. Each report will contain:

- A list of the activities, tests, analyses and assessments performed in the month according to that detailed in the Monitoring and Audit Manual for the purpose of reporting any significant findings resulting from monitoring and audit activities;

- a list of outstanding activities, tests, analyses and assessments as well as the schedule for completing these outstanding items; and,

- a list of previously outstanding activities, tests, analyses and assessments that are completed in the month.

Quarterly EM&A Reports will be required for the duration of the programme period and will be submitted within 30 days from the end of every quarterly monitoring period. Each report will:

- confirm that all activities, tests, analyses, assessments etc. have been carried out as stated in this EM&A Manual;
- report on the auditor's findings on the field events and laboratory tests and analysis;
- report on any trends resulting from disposal, dredging and capping activities at the active facility.

An **Annual Review Report** will be submitted within 60 days from the end of every yearly monitoring period. Each report will:

- make a clear statement on the acceptability of environmental impacts by reference to the impact hypotheses;
- state how successful the monitoring programme has been in addressing the objectives of the Assignment;
- make recommendations for revisions to the monitoring programme and disposal operation, as necessary, to ensure that the objectives are fully met in a cost effective manner; and
- summarise the monitoring results to illustrate whether any change or trend resulting from the disposal, dredging and capping activities is detected or not.

A **Risk Assessment Report** will be prepared within 60 days from the end of every yearly monitoring period. Each report will address the risk to the human health and dolphin of eating seafood taken in the marine area around North Lantau area due to disposal of contaminated marine sediments in the active pits.

A **Draft Final Report** will be prepared within 90 days from the end of the monitoring period for this Assignment. It will address how each objective of the assignment has been met and should will included a final version of the EM&A Manual as an appendix.

A **Final Report** will be prepared within 3 weeks after the agreed revisions on the Draft Final Report.

An English and Chinese **Executive Summary Report** will be prepared within 3 weeks of receipt of comments on the Draft Final Report. It should highlight any issues of concern and the acceptability of the operations at the active pits.

Annex A

Implementation Schedule

1 IMPLEMENTATION SCHEDULE

This *Annex* provides a consolidation of the mitigation measures recommended for the Project. The Implementation Schedule has the following column headings:

EIA Ref

This denotes the section number or reference from the EIA Report Main text.

EM&A Log Ref

This denotes the sequential number of each of the recommended mitigation measures specified in the Implementation Schedule.

Environmental Protection Measures

This denotes the recommended mitigation measures, courses of action or subsequent deliverables that are to be adopted, undertaken or delivered to avoid, minimise or ameliorate predicted environmental impacts.

Objectives

This denotes the objectives of the recommended mitigation measures and main concerns to address.

Location/Duration of Measures/Timing of Completion of Measures

This indicates the spatial area in which the recommended mitigation measures are to be implemented together with details of the programming or timing of their implementation.

Implementation Agent

This denotes where the responsibility lies for the implementation of the recommended mitigation measures.

Implementation Stage

This denotes the stage at which the recommended mitigation measures are to be implemented either during the Design, Construction, Operation or Decommissioning.

Relevant Legislation

This section defines the controlling legislation that is required to be compiled with.

IMPLEMENTATION SCHEDULE

EIA* Ref.	EM&A Log Ref	Environmental Protection Measures	Objectives	Location/Duration of Measures/Timing of Completion of Measures	Implementation Agent	Implementation Stage**				Relevant Legislation & Guidelines
						Des	C	O	Dec	
		WATER QUALITY								
Section 2.4 of Part 3	1	Although there is no requirement for constraints on timing or sequencing apparent from the assessment, as all scenarios have been demonstrated to be acceptable with the required mitigation measures in place. The following operational constraints shall be implemented to ensure no unacceptable water quality impacts.								
Section 2.4 of Part 3		• Dredging operations within the East of Sha Chau Facility do not exceed 100,000 m^3 $week^{-1}$.	To avoid unacceptable water quality impacts during dredging	At the East of Sha Chau work site, throughout the whole duration of the construction period	Contractor		✓			*Water Pollution Control Ordinance*
Section 2.4 of Part 3		• Backfilling operations within the East of Sha Chau Facility do not exceed a disposal rate of 26,700 m^3 day^{-1}.	To avoid unacceptable water quality impacts during backfilling	At the East of Sha Chau work site, throughout the whole duration of backfilling	Contractor			✓		*Water Pollution Control Ordinance*
Section 2.4 of Part 3		• Capping operations within the East of Sha Chau Facility do not exceed a disposal rate of 26,700 m^3 day^{-1}.	To avoid unacceptable water quality impacts during capping	At the East of Sha Chau Facility work site, throughout the whole duration of capping	Contractor			✓		*Water Pollution Control Ordinance*
Section 2.4 of Part 3		• No overflow is permitted from the trailer suction hopper dredger but the Lean Mixture Overboard (LMOB) system will be in operation at the beginning and end of the dredging cycle when the drag head is being lowered and raised.	To avoid unacceptable water quality impacts during dredging	At the East of Sha Chau work site, throughout the whole duration of the construction period	Contractor		✓			*Water Pollution Control Ordinance*

EIA* Ref.	EM&A Log Ref	Environmental Protection Measures	Objectives	Location/Duration of Measures/Timing of Completion of Measures	Implementation Agent	Implementation Stage**				Relevant Legislation & Guidelines
Section 2.4 of Part 3		• Dredged marine mud shall be disposed of in a gazetted marine disposal area in accordance with the *Dumping at Sea Ordinance* (*DASO)* permit conditions.	To avoid unacceptable water quality impacts during dredging	At the East of Sha Chau work site, throughout the whole duration of the construction period	Contractor		✓			*Water Pollution Control Ordinance*
Section 2.4 of Part 3	2	The following good practice measures shall apply at all times: • All disposal vessels should be fitted with tight bottom seals in order to prevent leakage of material during transport.	To prevent leakage of material during transport	At the East of Sha Chau work site, throughout the whole duration of the disposal period	Contractor			✓		*Water Pollution Control Ordinance*
Section 2.4 of Part 3		• All barges should be filled to a level, which ensures that material does not spill over during transport to the disposal site and that adequate freeboard is maintained to ensure that the decks are not washed by wave action.	To ensure that material does not spill over during transport and the decks are not washed by wave action	At the East of Sha Chau work site, throughout the whole duration of the construction and operation period	Contractor		✓	✓		*Water Pollution Control Ordinance*
Section 2.4 of Part 3		• After dredging, any excess materials should be cleaned from decks and exposed fittings before the vessel is moved from the dredging area.	To avoid potential adverse water quality impacts associated with dredging	At the East of Sha Chau dredging sites, throughout the dredging period	Contractor		✓			*Water Pollution Control Ordinance*
Section 2.4 of Part 3		• The contractor(s) should ensure that the works cause no visible foam, oil, grease, litter or other objectionable matter to be present in the water within and adjacent to the dredging site.	To avoid potential adverse water quality impacts associated with dredging	At the East of Sha Chau dredging sites, throughout the dredging period	Contractor		✓			*Water Pollution Control Ordinance*
Section 2.4 of Part 3		• If installed, degassing systems should be used to avoid irregular cavitation within the pump.	To avoid adverse water quality impacts due to irregular cavitation within the pump	At the East of Sha Chau work site, throughout the whole duration of the construction and operation period	Contractor		✓			*Water Pollution Control Ordinance*

EIA* Ref.	EM&A Log Ref	Environmental Protection Measures	Objectives	Location/Duration of Measures/Timing of Completion of Measures	Implementation Agent	Implementation Stage**				Relevant Legislation & Guidelines
Section 2.4 of Part 3		• Monitoring and automation systems should be used to improve the crew's information regarding the various dredging parameters to improve dredging accuracy and efficiency.	To improve dredging accuracy and efficiency	At the East of Sha Chau dredging site, throughout the dredging period	Contractor		✓			*Water Pollution Control Ordinance*
Section 2.4 of Part 3		• Control and monitoring systems should be used to alert the crew to leaks or any other potential risks.	To alert the crew to leaks or any other potential risks	At the East of Sha Chau work site, throughout the whole duration of the construction and operation period	Contractor		✓	✓		*Water Pollution Control Ordinance*
Section 2.4 of Part 3		• When the dredged material has been unloaded at the disposal areas, any material that has accumulated on the deck or other exposed parts of the vessel should be removed and placed in the hold or a hopper. Under no circumstances should decks be washed clean in a way that permits material to be released overboard.	To prevent release of dredged materials overboard	At the East of Sha Chau dredging sites, throughout the dredging period	Contractor		✓			*Water Pollution Control Ordinance*
Section 2.4 of Part 3		• All dredgers should maintain adequate clearance between vessels and the seabed at all states of the tide and reduce operations speed to ensure that excessive turbidity is not generated by turbulence from vessel movement or propeller wash.	To ensure that under-vessel turbidity is not generated by turbulence from vessel movement or propeller wash	At the East of Sha Chau dredging sites, throughout the dredging period	Contractor		✓			*Water Pollution Control Ordinance*
Section 3 of Part 4	3	Water quality monitoring will be required for the following activities at the East of Sha Chau Facility: • Dredging of each pit; • Backfilling of each pit with contaminated mud; and • Capping of each pit with uncontaminated Mud.	To avoid impacts to water quality during dredging, backfilling and capping	At the East of Sha Chau work sites, throughout the dredging, backfilling and capping period	Contractor		✓			*Water Pollution Control Ordinance*

EIA* Ref.	EM&A Log Ref	Environmental Protection Measures	Objectives	Location/Duration of Measures/Timing of Completion of Measures	Implementation Agent	Implementation Stage**				Relevant Legislation & Guidelines
Section 3 of Part 4	4	Sediment quality monitoring will be required for the backfilling activities at the East of Sha Chau Facility.	To avoid impacts to water quality during backfilling	At the East of Sha Chau work sites, throughout the backfilling period	Contractor		✓			*Water Pollution Control Ordinance*
		MARINE ECOLOGY								
Section 3 of Part 3	5	In accordance with the guidelines in the *EIAO-TM*, the general policy for mitigating impacts to marine ecological resources shall be applied in order of the following priority: • **Avoidance:** Potential impacts should be avoided to the maximum extent practicable by adopting suitable alternatives; • **Minimisation:** Unavoidable impacts should be minimised by taking appropriate and practicable measures such as constraints on the intensity of works operations (eg dredging rates) or timing of works operations; and • **Compensation:** The loss of important species and habitats may be provided for elsewhere as compensation. Enhancement and other conservation measures should always be considered whenever possible.	To avoid potential impacts to marine ecology	During project planning and design	Design Team	✓				*EIAO-TM*
Section 3 of Part 4	6	Sediment toxicity monitoring will be conducted to assess the potential toxicity impacts to marine life due to disposal activities.	To avoid impacts to marine life due to disposal activities	At the East of Sha Chau Facility, throughout the backfilling period	Contractor			✓		

EIA* Ref.	EM&A Log Ref	Environmental Protection Measures	Objectives	Location/Duration of Measures/Timing of Completion of Measures	Implementation Agent	Implementation Stage**				Relevant Legislation & Guidelines
	7	Benthic recolonisation monitoring will be required to assess the recolonisation status of benthic fauna on capped pits.	To assess the recolonisation status of benthic fauna on capped pits	At the East of Sha Chau Facility, after capping of mud pits	Contractor			✓		
		HAZARD TO HEALTH								
Section 3 of Part 4	8	A risk assessment to verify that no unacceptable risk are occurring to either human health or marine mammals as a result of consuming prey species from the waters in the vicinity of the pits will be required.	To assess hazard to health of humans and marine mammals	In the vicinity of the East of Sha Chau Facility, throughout the disposal period	Contractor			✓		

Annex B

Complaints Proforma

COMPLAINTS PROFORMA

REPORT FORM FOR COMPLAINTS `	SHEET ____ OF ____ UNIT REFERENCE _____

RECIPIENT

NAME: LOCATION: TEL.:

COMPLAINANT

NAME: TEL.: FAX:

ADDRESS:

COMPLAINT

TYPE: Water Quality/Other

DATE: TIME: Location:

DESCRIPTION:

COPY FAX TO: DATE:	ORIGINAL TO: DATE:

REVIEW RESULTS

SIGNED: DATE:

RECOMMENDATIONS

SIGNED: DATE:

ATTACHMENTS

COPY TO: DATE/TIME:

CED: DATE: TIME:

INDEPENDENT ENVIRONMENTAL CHECKER DATE: TIME.:

Annex C

Sampling Programme

Table C1 - East of Sha Chau Environmental Monitoring and Audit Sampling Schedule for CMP IVc (February 2010 - March 2011)

			2010											2011		
Pit Specific Sediment Chemistry	**Code**	**Frequency**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**	**J**	**F**	**M**
Active-Pit																
	NCA	3 times per year			*				*				*			
	NCB	3 times per year			*				*				*			
Pit-Edge																
	CPA	3 times per year			*				*				*			
	CPB	3 times per year			*				*				*			
Near-Pit																
	CNA	3 times per year			*				*				*			
	CNB	3 times per year			*				*				*			

Cumulative Impact Sediment Chemistry			**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**	**J**	**F**	**M**
Near-field Stations																
	RNA	2 times per year							*				*			
	RNB	2 times per year							*				*			
Mid-field Stations																
	RMA	2 times per year							*				*			
	RMB	2 times per year							*				*			
Capped Pit Stations																
	RCA	2 times per year							*				*			
	RCB	2 times per year							*				*			
Far-Field Stations																
	RFA	2 times per year							*				*			
	RFB	2 times per year							*				*			

Sediment Toxicity Tests			**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**	**J**	**F**	**M**
Near-Pit Stations																
	TCA	2 times per year							3				3			
	TCB	2 times per year							3				3			
Reference Stations																
	TRA	2 times per year							3				3			
	TRB	2 times per year							3				3			

Tissue/ Whole Body Sampling			**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**	**J**	**F**	**M**
Near-Pit Stations																
	INA	2 times per year	*						*						*	
	INB	2 times per year	*						*						*	
Reference North																
	TNA	2 times per year	*						*						*	
	TNB	2 times per year	*						*						*	
Reference South																
	TSA	2 times per year	*						*						*	
	TSB	2 times per year	*						*						*	

Demersal Trawling			**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**	**J**	**F**	**M**
Near Pit Stations																
	INA 1-5	4 times per year	5					5	5					5	5	
	INB 1-5	4 times per year	5					5	5					5	5	
Reference North																
	TNA 1-5	4 times per year	5					5	5					5	5	
	TNB 1-5	4 times per year	5					5	5					5	5	
Reference South																
	TSA 1-5	4 times per year	5					5	5					5	5	
	TSB 1-5	4 times per year	5					5	5					5	5	

Capping			**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**	**J**	**F**	**M**
Ebb Tide																
Impact Station Downcurrent																
	IPE1	4 times per year	3				3		3				3		3	
	IPE2	4 times per year	3				3		3				3		3	
	IPE3	4 times per year	3				3		3				3		3	
	IPE4	4 times per year	3				3		3				3		3	
	PFC1	4 times per year	3				3		3				3		3	
Intermediate Station Downcurrent																
	INE1	4 times per year	3				3		3				3		3	
	INE2	4 times per year	3				3		3				3		3	
	INE3	4 times per year	3				3		3				3		3	
	INE4	4 times per year	3				3		3				3		3	
	INE5	4 times per year	3				3		3				3		3	
Reference Station Upcurrent																
	RFE1	4 times per year	3				3		3				3		3	
	RFE2	4 times per year	3				3		3				3		3	
	RFE3	4 times per year	3				3		3				3		3	
	RFE4	4 times per year	3				3		3				3		3	
	RFE5	4 times per year	3				3		3				3		3	
Flood Tide																
Impact Station Downcurrent																
	IPF1	4 times per year	3				3		3				3		3	
	PFC1	4 times per year	3				3		3				3		3	
	IPF2	4 times per year	3				3		3				3		3	
Intermediate Station Downcurrent																
	INF1	4 times per year	3				3		3				3		3	
	PFC2	4 times per year	3				3		3				3		3	
	INF3	4 times per year	3				3		3				3		3	
Reference Station Upcurrent																
	RFF1	4 times per year	3				3		3				3		3	
	RFF2	4 times per year	3				3		3				3		3	
	RFF3	4 times per year	3				3		3				3		3	

Routine Water Quality Monitoring			**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**	**J**	**F**	**M**
Ebb Tide																
Impact Station Downcurrent																
	IPE1	2 times per year	*						*						*	
	IPE2	2 times per year	*						*						*	
	IPE3	2 times per year	*						*						*	
	IPE4	2 times per year	*						*						*	
	IPE5	2 times per year	*						*						*	
Intermediate Station Downcurrent																
	INE1	2 times per year	*						*						*	
	INE2	2 times per year	*						*						*	
	INE3	2 times per year	*						*						*	
	INE4	2 times per year	*						*						*	
	INE5	2 times per year	*						*						*	
Reference Station Upcurrent																
	RFE1	2 times per year	*						*						*	
	RFE2	2 times per year	*						*						*	
	RFE3	2 times per year	*						*						*	
	RFE4	2 times per year	*						*						*	
	RFE5	2 times per year	*						*						*	
Flood Tide																
Impact Station Downcurrent																
	INF1	2 times per year	*						*						*	
	INF2	2 times per year	*						*						*	
	INF3	2 times per year	*						*						*	
Intermediate Station Downcurrent																
	IPF1	2 times per year	*						*						*	
	IPF2	2 times per year	*						*						*	
	IPF3	2 times per year	*						*						*	
Reference Station Upcurrent																
	RFF1	2 times per year	*						*						*	
	RFF2	2 times per year	*						*						*	
	RFF3	2 times per year	*						*						*	

Water Column Profiling			**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**	**J**	**F**	**M**
Plume Stations	WCP1	6 times per year	2				2	2	2				2	2	2	
	WCP2	6 times per year	2				2	2	2				2	2	2	

Benthic Recolonisation Studies			**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**	**J**	**F**	**M**
Capped Contaminated Mud Pit IIId																
	CPA	2 times per year							3				3			
	CPB	2 times per year							3				3			
	CPC	2 times per year							3				3			
Reference Stations																
	RBA	2 times per year							3				3			
	RBB	2 times per year							3				3			
	RBC	2 times per year							3				3			

Note: Assuming CMP IVc is active until March 2011 (according to current disposal schedule)

"*" = Number of replicates depends on parameters

Table C2 - East of Sha Chau Environmental Monitoring and Audit Sampling Schedule for CMP V (February 2010 - February 2014)

			2010											2011												2012												2013												2014	
Pit Specific Sediment Chemistry	**Code**	**Frequency**	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F
Active-Pit																																																				
	ESC-NPDA	Monthly															12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12
	ESC-NPDB	Monthly															12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12
Pit-Edge																																																			
	ESC-NEDA	Monthly															12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12
	ESC-NEDB	Monthly															12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12
Near-Pit																																																			
	ESC-NNDA	Monthly															12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12
	ESC-NNDB	Monthly															12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12
Cumulative Impact Sediment Chemistry			F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F
Near-field Stations																																																			
	ESC-RNA	4 times per year																	12		12				12		12				12		12				12		12				12		12				12		12
	ESC-RNB	4 times per year																	12		12				12		12				12		12				12		12				12		12				12		12
Mid-field Stations																																																			
	ESC-RMA	4 times per year																	12		12				12		12				12		12				12		12				12		12				12		12
	ESC-RMB	4 times per year																	12		12				12		12				12		12				12		12				12		12				12		12
Capped Pit Stations																																																			
	ESC-RCA	4 times per year																	12		12				12		12				12		12				12		12				12		12				12		12
	ESC-RCB	4 times per year																	12		12				12		12				12		12				12		12				12		12				12		12
Far-Field Stations																																																			
	ESC-RFA	4 times per year																	12		12				12		12				12		12				12		12				12		12				12		12
	ESC-RFB	4 times per year																	12		12				12		12				12		12				12		12				12		12				12		12
Ma Wan Station																																																			
	MW1	4 times per year																	12		12				12		12				12		12				12		12				12		12				12		12
Sediment Toxicity Tests			F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F
Near-Pit Stations																																																			
	ESC-TDA	2 times per year																			5						5						5						5						5						5
	ESC-TDB	2 times per year																			5						5						5						5						5						5
Reference Stations																																																			
	ESC-TRA	2 times per year																			5						5						5						5						5						5
	ESC-TRB	2 times per year																			5						5						5						5						5						5
Ma Wan Station																																																			
	MW1	2 times per year																			5						5						5						5						5						5
Tissue/ Whole Body Sampling			F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F
Near-Pit Stations																																																			
	INA	2 times per year																			*						*						*						*						*						*
	INB	2 times per year																			*						*						*						*						*						*
Reference North																																																			
	TNA	2 times per year																			*						*						*						*						*						*
	TNB	2 times per year																			*						*						*						*						*						*
Reference South																																																			
	TSA	2 times per year																			*						*						*						*						*						*
	TSB	2 times per year																			*						*						*						*						*						*
Demersal Trawling			F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F
Near Pit Stations																																																			
	INA 1-5	4 times per year																		5	5					5	5					5	5					5	5					5	5					5	5
	INB 1-5	4 times per year																		5	5					5	5					5	5					5	5					5	5					5	5
Reference North																																																			
	TNA 1-5	4 times per year																		5	5					5	5					5	5					5	5					5	5					5	5
	TNB 1-5	4 times per year																		5	5					5	5					5	5					5	5					5	5					5	5
Reference South																																																			
	TSA 1-5	4 times per year																		5	5					5	5					5	5					5	5					5	5					5	5
	TSB 1-5	4 times per year																		5	5					5	5					5	5					5	5					5	5					5	5
Capping			F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F
Ebb Tide																																																			
Impact Station Downcurrent																																																			
	IPE1	4 times per year																	3		3				3		3				3		3				3		3				3		3				3		3
	IPE2	4 times per year																	3		3				3		3				3		3				3		3				3		3				3		3
	IPE3	4 times per year																	3		3				3		3				3		3				3		3				3		3				3		3
	IPE4	4 times per year																	3		3				3		3				3		3				3		3				3		3				3		3
	PFC1	4 times per year																	3		3				3		3				3		3				3		3				3		3				3		3
Intermediate Station Downcurrent																																																			
	INE1	4 times per year																	3		3				3		3				3		3				3		3				3		3				3		3
	INE2	4 times per year																	3		3				3		3				3		3				3		3				3		3				3		3
	INE3	4 times per year																	3		3				3		3				3		3				3		3				3		3				3		3
	INE4	4 times per year																	3		3				3		3				3		3				3		3				3		3				3		3
	INE5	4 times per year																	3		3				3		3				3		3				3		3				3		3				3		3
Reference Station Upcurrent																																																			
	RFE1	4 times per year																	3		3				3		3				3		3				3		3				3		3				3		3
	RFE2	4 times per year																	3		3				3		3				3		3				3		3				3		3				3		3
	RFE3	4 times per year																	3		3				3		3				3		3				3		3				3		3				3		3
	RFE4	4 times per year																	3		3				3		3				3		3				3		3				3		3				3		3
	RFE5	4 times per year																	3		3				3		3				3		3				3		3				3		3				3		3
Ma Wan Station																																																			
	MW1	4 times per year																	3		3				3		3				3		3				3		3				3		3				3		3
Flood Tide																																																			
Impact Station Downcurrent																																																			
	IPF1	4 times per year																	3		3				3		3				3		3				3		3				3		3				3		3
	PFC1	4 times per year																	3		3				3		3				3		3				3		3				3		3				3		3
	IPF2	4 times per year																	3		3				3		3				3		3				3		3				3		3				3		3
Intermediate Station Downcurrent																																																			
	INF1	4 times per year																	3		3				3		3				3		3				3		3				3		3				3		3
	PFC2	4 times per year																	3		3				3		3				3		3				3		3				3		3				3		3
	INF3	4 times per year																	3		3				3		3				3		3				3		3				3		3				3		3
Reference Station Upcurrent																																																			
	RFF1	4 times per year																	3		3				3		3				3		3				3		3				3		3				3		3
	RFF2	4 times per year																	3		3				3		3				3		3				3		3				3		3				3		3
	RFF3	4 times per year																	3		3				3		3				3		3				3		3				3		3				3		3
Ma Wan Station																																																			
	MW1	4 times per year																	3		3				3		3				3		3				3		3				3		3				3		3
Routine Water Quality Monitoring			F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F
Ebb Tide																																																			
Impact Station Downcurrent																																																			
	IPE1	8 times per year															8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8
	IPE2	8 times per year															8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8
	IPE3	8 times per year															8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8
	IPE4	8 times per year															8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8
	IPE5	8 times per year															8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8
Intermediate Station Downcurrent																																																			
	INE1	8 times per year															8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8
	INE2	8 times per year															8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8
	INE3	8 times per year															8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8
	INE4	8 times per year															8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8
	INE5	8 times per year															8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8
Reference Station Upcurrent																																																			
	RFE1	8 times per year															8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8
	RFE2	8 times per year															8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8
	RFE3	8 times per year															8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8
	RFE4	8 times per year															8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8
	RFE5	8 times per year															8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8
Ma Wan Station																																																			
	MW1	8 times per year															8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8
Flood Tide																																																			
Impact Station Downcurrent																																																			
	INF1	8 times per year															8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8
	INF2	8 times per year															8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8
	INF3	8 times per year															8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8
Intermediate Station Downcurrent																																																			
	IPF1	8 times per year															8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8
	IPF2	8 times per year															8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8
	IPF3	8 times per year															8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8
Reference Station Upcurrent																																																			
	RFF1	8 times per year															8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8
	RFF2	8 times per year															8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8
	RFF3	8 times per year															8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8
Ma Wan Station																																																			
	MW1	8 times per year															8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8
Water Column Profiling			F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F
Plume Stations	WCP1	Monthly	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
	WCP2	Monthly	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
Benthic Recolonisation Studies			F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F
Capped Contaminated Mud Pits IVa-b																																																			
	CPA	2 times per year																			12				12								12				12								12				12		
	CPB	2 times per year																			12				12								12				12								12				12		
	CPC	2 times per year																			12				12								12				12								12				12		
Reference Stations																																																			
	RBA	2 times per year																			12				12								12				12								12				12		
	RBB	2 times per year																			12				12								12				12								12				12		
	RBC	2 times per year																			12				12								12				12								12				12		
Impact Monitoring for Dredging			F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F
Upstream Stations																																																			
	US1	Monthly	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6										
	US2	Monthly	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6										
Downstream Stations																																																			
	DS1	Monthly	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6										
	DS2	Monthly	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6										
	DS3	Monthly	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6										
	DS4	Monthly	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6										
	DS5	Monthly	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6										
Ma Wan Station																																																			
	MW1	Monthly	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6										

Note: Assuming CMP IVc is active until March 2011 and CMP Va will be active in April 2011 (according to current disposal schedule)
"*" = Number of replicates depends on parameters
Naming of stations are tentative only and will be subjected to changes