Major Works Project Management Office
Highways Department of HKSAR

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Route 11 (Section between Yuen Long and North Lantau) - Investigation

Sediment Sampling and Testing Plan

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1 Introduction

1.1 Project Background

1.1.1 The objective of the Project is to enhance the connectivity between the North West New Territories (NWNT) and the North Lantau to meet the future traffic demands generated by the future developments in both regions. The Project will be a strategic highway to support the proposed developments in the NWNT. It will also provide the third vehicular access to Lantau in addition to the existing Tsing Ma and Kap Shui Mun Bridges and the Tuen Mun-Chek Lap Kok Link (TM-CLKL).

1.1.2 A layout plan for the tentative alignment of the Project is shown in **Figure 1.1**, which is subject to changes during the course of Environmental Impact Assessment (EIA) study. It stretches from Lam Tei to North Lantau and comprises sections of tunnels, viaducts, at-grade roads and a long span suspension bridge (i.e., Tsing Lung Bridge). It connects to several strategic routes such as Kong Sham Western Highway and Yuen Long Highway at its northern end, Tuen Mun Road (TMR) at So Kwun Wat and Tsing Lung Tau and North Lantau Highway, Lantau Link, the proposed Tsing Yi - Lantau Link (TYLL) (under separate project), the proposed Hong Kong Island - Northeast Lantau (HKI-NEL Link) (under separate project) and the proposed Road P1 (under separate project) along the northern coast of Lantau. The suspension bridge spans across Ha Pang Fairway, connecting Tsing Lung Tau to North Lantau.

1.2 Site Area

1.2.1 The tentative alignment of the Project is shown on **Figure 1.1**. Based on the current design scheme, The Project will have a total length of approximately 20km, covering areas in Lam Tei, So Kwun Wat, Tai Lam, Tsing Lung Tau, and North Lantau.

1.3 Objective of this Report

1.3.1 To support the EIA studies, it is necessary to identify and quantify the dredging/excavation, transportation and impact due to dredging of sediment from the Project. This Sediment Sampling and Testing Plan (SSTP) is prepared to seek agreement from Environmental Protection Department (EPD) prior to the commencement of the testing works which include:

- The proposed locations and schedule of sediment sampling;
- The specification of chemical test and biological toxicity test of sediment samples for the evaluation of waste management under the EIAO process; and
- Specification of elutriate test and pore water test of sediment samples for water quality modelling under the EIAO process.

1.3.2

A separate SSTP/Sediment Quality Report in accordance with ETWB TC(W) No. 34/2022 – Management of Dredged/Excavated Sediment would be prepared when applying for the dumping permit under the Dumping at Sea Ordinance (DASO). The rationale for sediment removal/disposal would be agreed with Marine Fill Committee (MFC) of CEDD.

2 Project Description

2.1 Project Scope

2.1.1 The scope of the Project is to provide connection roads (in form of open roads, tunnels, viaducts, and a bridge) to enhance the connectivity between NWNT and North Lantau. The scope of the Project comprises the following key elements:

a) construction of Lam Tei Quarry Interchange, which comprises slip roads and viaducts, connecting the proposed Lam Tei Tunnel to Kong Sham Western Highway and Yuen Long Highway;

b) construction of Lam Tei Tunnel by drill-&-blast, which is an approx. 4.0 km long dual 3-lane carriageway tunnel, connecting the proposed Lam Tei Quarry Interchange and So Kwun Wat Interchange;

c) construction of So Kwun Wat Interchange, which comprises slip roads and viaducts, connecting the proposed Lam Tei Tunnel, So Kwun Wat Link Road and the Tai Lam Chung Tunnel;

d) construction of So Kwun Wat Link Road, which comprises an approx. 1.3 km long dual 2-lane carriageway tunnel and associated slip roads and viaducts, connecting TMR and the proposed So Kwun Wat Interchange;

e) construction of Tai Lam Chung Tunnel, which is an approx. 1.6 km long dual 4- lane carriageway tunnel, a viaduct crossing Tai Lam Chung River and another tunnel to the west of Tai Lam Chung River, which is an approx. 285 m long dual 4-lane carriageway tunnel, connecting the proposed So Kwun Wat Interchange and Tsing Lung Tau Interchange;

f) construction of Tsing Lung Tau Interchange, which comprises slip roads, viaducts and tunnel, connecting the proposed Tai Lam Chung Tunnel and Tsing Lung Bridge to TMR;

g) construction of Tsing Lung Bridge, which is an approx. 1.4 km long dual 3-lane carriageway suspension bridge, crossing over the Ha Pang Fairway and connecting the proposed Tsing Lung Tau Interchange and North Lantau Interchange, with reclamation for construction of bridge towers;

h) construction of North Lantau Interchange, which comprises slip roads, viaducts and tunnels, connecting Tsing Lung Bridge to North Lantau Highway, Lantau Link and the proposed Road P1 (under separate project);

i) construction of slip roads and viaducts to connect the proposed Tsing Lung Bridge to the proposed TYLL (under separate project) and the proposed Hong Kong Island - Northeast Lantau (HKL-NEL) Link (under separate project) at the proposed North Lantau Interchange, subject to the implementation of such projects;

j) re-alignment of an approx. 1.7 km long section of TMR at Tsing Lung Tau;

k) modification / realigning of the existing interchanges / roundabouts / junctions / roads, where appropriate;

l) reprovisioning / modification of existing bridges, underpasses, footbridges and crossings affected;

m) construction of associated administration buildings, ventilation buildings, toll collection facilities; and

n) associated geotechnical works, drainage works, sewerage works, traffic aids, directional signs, street lightings, Traffic Control and Surveillance System (TCSS), Electrical and Mechanical (E&M) works, environmental mitigation measures, landscaping works, Vessel Impact Protection System (VIPS), dehumidification systems for cables and decks, and services systems for inspection, maintenance, structural health monitoring and management of the suspension bridge.

2.1.2 The alignment shown in **Figure 1.1** is tentative only, and subject to changes during the course of EIA study with reference to the engineering practicability, traffic constraint and the latest statutory and Government requirements, etc.

2.2 Review of Existing Quality

2.2.1 Sediment sampling and testing has been conducted in Tai Lam Kok as shown in the EIA of Improvement to Castle Peak Road between Ka Loon Tsuen and Siu Lam (AEIAR-047/2001). The sampling location in Tai Lam Kok (i.e. VB1A-VB9A) were located 1.5 km from the proposed Tsing Lung Bridge, as shown in **Appendix 2.1** and **Figure 2.1**. The laboratory testing results and the determined contamination categories and disposal types are extracted in **Appendix 2.2**. The results indicated that these samples were mostly Category L, with 1 sample classified as Category M and another as Category H.

2.2.2 Sediment sampling and testing has been conducted in Pearl Island as shown in Marine Water Quality in Hong Kong 2020. The sampling location in Pearl Island (i.e. NS2) were located 5.9 km from the proposed Tsing Lung Bridge, as shown in **Appendix 2.3** and **Figure 2.1**. The laboratory testing results, the determined contamination categories and disposal types are extracted in **Appendix 2.4**. The results indicated that these samples were mostly Category L, with some samples exceeding the LCEL and none exceeding the UCEL thus Category M.

2.3 Estimation of Volume of Marine Deposit to be Generated

2.3.1 The alignment of the Project and Tsing Lung Bridge is subject to change. Based on the latest design of the Tsing Lung Bridge, there will be possible reclamation area near Tsing Lung Tau, its indicative location is shown in **Figure 1.1**. Based on current design, non-dredged reclamation method will be adopted. The marine deposit would only be generated during the piling works for the construction of bridge tower. Land-based sediment is also anticipated to be generated through mucking out activity during piling works. The estimated volume of marine-based sediment and land-based sediment to be generated are about 46,000 m^3 and about 250 m^3 respectively.

3 Legislative Requirements

3.1 Legislation and Guidelines

3.1.1 The Environment, Transport and Works Bureau Technical Circular (Works) No. 34/2002 "Management of Dredged / Excavated Sediment" (ETWB TC(W) No. 34/2002) sets out the procedure for seeking approval to dredge/ excavate sediment and the management framework for marine disposal of such sediment. It outlines the requirements for sediment quality assessment and provides guidelines for the classification of sediment based on their contaminant levels. It also explains the disposal arrangement for the classified sediment.

3.2 Methodology for Sediment Quality Assessment

3.2.1 The management framework of dredged/excavated sediment in Hong Kong is implemented under a three-tiered approach as illustrated in **Appendix 3.1** in accordance with the ETWB TC(W) No. 34/2002; this also sets out the guidelines for the assessment, sampling, testing and classification of sediment. **Table 3.1** summarises the sediment quality criteria for sediment classification under ETWB TC(W) No. 34/2002.

Table 3.1 Sediment quality criteria for classification of sediment under ETWB TC(W) No. 34/2002

Contaminants	Lower Chemical Exceedance Level (LCEL)	Upper Chemical Exceedance Level (UCEL)
Metals (mg/kg dry wt.)		
Cadmium (Cd)	1.5	4
Chromium (Cr)	80	160
Copper (Cu)	65	110
Mercury (Hg)	0.5	1
Nickel (Ni) [1]	40	40
Lead (Pb)	75	110
Silver (Ag)	1	2
Zinc (Zn)	200	270
Metalloid (mg/kg dry wt.)		
Arsenic (As)	12	42
Organic-PAHs (µg/kg dry wt.) [2]		
Low Molecular Weight PAHs	550	3160
High Molecular Weight PAHs	1700	9600
Organic-non-PAHs (µg/kg dry wt.) [2]		
Total PCBs [3]	23	180
Organometallics (µg TBT/L in Interstitial water) [4]		
Tributyltin [1]	0.15	0.15

Notes:
[1] The contaminant level is considered to have exceeded the UCEL if it is greater than the value shown.
[2] PAHs: Polycyclic Aromatic Hydrocarbons
[3] PCBs: Polychlorinated Biphenyls
[4] TBT: Tributyltin

3.2.2 The sediment is classified into 3 categories based on its contaminant levels:

Category L Sediment with all contaminant levels not exceeding the LCEL. The material must be dredged, transported and disposed of in a manner which minimises the loss of contaminants either into solution or by resuspension.

Category M Sediment with any one or more contaminant levels exceeding the LCEL and none exceeding the UCEL. The material must be dredged and transported with care, and must be effectively isolated from the environment upon the final disposal unless appropriate biological tests demonstrate that the material will not adversely affect the marine environment.

Category H Sediment with any one or more contaminant levels exceeding the UCEL. The material must be dredged and transported with great care, and must be effectively isolated from the environment upon the final disposal.

3.2.3 **Tier I Screening** is a desktop screening process to review the available information and determine whether the sediment of concern belonging to Category L material is suitable for open sea disposal. If there is insufficient information to arrive at such conclusion, Tier II chemical screening shall be proceeded accordingly.

3.2.4 **Tier II Screening** is a chemical screening process to categorise sediment based on its chemical contaminant levels and to determine whether the sediment is suitable for open sea disposal without further testing. Upon Tier II screening, the sediment shall be classified as Category L, M or H material. There are three types of disposal options: namely Type 1 for open sea disposal, Type 2 for confined marine disposal and Type 3 for special treatment/disposal respectively. Category L material is suitable for open sea disposal, but Categories M and Category H with one or more contaminant levels exceeding 10 × LCEL will require Tier III screening to further determine the disposal option.

3.2.5 **Tier III Screening** is a biological screening process to identify the most appropriate disposal option for Category M (either Type 1 or 2) and certain Category H sediment (either Type 2 or 3). Sediment classified as Category M shall be subjected to the following three toxicity tests:

- A 10-day burrowing amphipod toxicity test;
- A 20-day burrowing polychaete toxicity test; and
- A 48-96 hours larvae (bivalve or echinoderm) toxicity test.

3.2.6 **Table 3.2** summarises the details of the test endpoints and failure criteria of the three toxicity tests. Sediment classified as Category H and with one or more contaminant levels exceeding 10 times LCEL shall also be subjected to the above three toxicity tests but in a diluted manner (dilution test). In case failure of biological test on Category M material, Type 2 disposal will be required. Similarly, Type 3 disposal will be required for Category H material if biological test is failed.

Table 3.2 Test endpoints and decision criteria for Tier III biological screening under ETWB TC(W) No. 34/2002

Toxicity Test	Endpoints Measured	Failure Criteria
10-day amphipod	Survival	Mean survival in test sediment is significantly different ($p \leq 0.05$)[1] from mean survival in reference sediment **and** mean survival in test sediment <80% of mean survival in reference sediment.
20-day polychaete worm	Dry Weight[2]	Mean dry weight in test sediment is significantly different ($p \leq 0.05$)[1] from mean dry weight in reference sediment **and** mean dry weight in test sediment <90% of mean dry weight in reference sediment.
48-96 hour larvae (bivalve or echinoderm)	Normality Survival[3]	Mean normality survival in test sediment is significantly different ($p \leq 0.05$)[1] from mean normality survival in reference sediment **and** mean normality survival in test sediment <80% of mean normality survival in reference sediment.

Notes:
[1] Statistically significant differences should be determined using appropriate two-sample comparisons (e.g., t-tests) at a probability of $p \leq 0.05$.
[2] Dry weight means total dry weight after deducting dead and missing worms.
[3] Normality survival integrates the normality and survival end points, and measures survival of only the normal larvae relative to the starting number.

4 Proposed Marine Sediment Sampling & Testing

4.1 Marine-based Sediment Sampling Locations

4.1.1 As discussed in **Section 2.2**, the sediment sampling and testing results under the EIA of Improvement to Castle Peak Road between Ka Loon Tsuen and Siu Lam and Marine Water Quality in Hong Kong 2020 indicated that the majority of the samples collected were Category L, with only one Category M sample and one Category H sample out of 30 sediment samples. Although the expected contamination level is not very high at the tentative piling locations for the construction of bridge tower, Category M and Category H sediment may still be expected, a 200m x 200m sampling grid arrangement with reference to paragraph 4(a) of memo issued by Development Bureau on 6 October 2010 – *Control Measures for Management of Dredged/Excavated Contaminated Sediment (ref: 0 in DevB(W) 515/83/04)* was therefore adopted to determine the number of environmental sampling locations required. The memo is presented in **Appendix 4.1**. A total number of 8 sampling locations are proposed based on the tentative piling locations for the construction of bridge tower for Tsing Lung Bridge. The proposed sampling locations are shown in **Figure 4.1** and their coordinates are given in **Table 4.1**. The sediment sampling and testing is targeted to commence in Q3/Q4 Year 2022, upon the agreement of this SSTP.

Table 4.1 Proposed marine-based marine sediment sampling locations

Sampling Locations	Sampling Method	Sampling Depth	Coordinates	
			Easting	Northing
TLB/VC1	Grab & Vibrocore Sample	Seabed Level, 0.9m, 1.9m, 2.9m, thereafter every 3m to the bottom of marine sediment	822048	824306
TLB/VC2			822205	824204
TLB/VC3			821904	824245
TLB/VC4			822026	824116

4.1.2 Grab and vibrocore samples are proposed for collecting sediment samples at TLB/VC1 to TLB/VC4 with the aid of barges. Modified Van Veen grab (or equivalent) of capacity of ~2L will be deployed from vessel to collect approximately 30L of sediment at each grab sampling location. Vibrocore samples will be collected continuously at 0m, 0.9m, 1.9m, 2.9m depths, and thereafter every 3m to the bottom of the marine deposit. The aforesaid sediment quantities to be collected by vibrocores shall be confirmed with the testing laboratory.

4.1.3 Prior to sampling, the laboratory responsible for analysis will be consulted for the particular sample size for chemical/ biological testing as well as the preservation procedures that are necessary for each chemical analysis. According to ETWB TC(W) No. 34/2002, the recommended sample sizes for each parameter and test are shown in **Table 4.2**. The actual sample size would however be subject to agreement with the designated laboratory.

Table 4.2 Recommended sediment sample size

Parameters to be tested	Sample Size
Metals and metalloid	0.5L
Organic	0.5L
Biological response	6L

4.1.4 All vibrocores will be labelled with the station number, sample length, diameter and depth, sampling date and time, together with full description of the sample. For vibrocore sample, both cut ends of each sub-sample will be clearly labelled "top" and "bottom". If the contents are hazardous, this will be clearly marked on the container and precautions taken during transport. The samples will be stored in dark at 4 ^{o}C but never frozen. Samples will be delivered to laboratory within 24 hours of the samples being collected and analyzed within 14 days from sampling for chemical testing.

4.1.5 It should be noted that based on the sediment information collected at this feasibility stage, strategy for the next round of sediment sampling and testing exercise to be conducted at a later stage of the Project under the DASO application process will be recommended in accordance with ETWB TC(W) No. 34/2002.

4.2 Land-based Sediment Sampling Locations

4.2.1 As mentioned in **Section 2.3**, it is anticipated that land-based marine sediment would be generated through mucking out activity during piling at the tentative piling locations for the construction of bridge tower for Tsing Lung Bridge. In accordance with ETWB TC(W) No. 34/2002, the recommended sampling grid size for marine sediment with low expected contamination level is 200m x 200m with samples to be taken from top marine sediment layer. 1 sampling location is proposed based on the tentative piling locations for the construction of bridge tower for Tsing Lung Bridge. The proposed sampling location is shown in **Figure 4.1** and their coordinates are given in **Table 4.3**. The sediment sampling and testing is targeted to commence in Q3/Q4 Year 2022, upon the agreement of this SSTP.

Table 4.3 Proposed land-based marine sediment sampling locations

Sampling Locations	Sampling Method	Sampling Depth	Coordinates	
			Easting	Northing
TLB/BH1	U100/U76	Top level of the marine sediment of each drillhole, the 0.9m down, 1.9m down, 2.9m down, thereafter every 3m to the bottom of marine sediment layer or the piling depth	822612	822519

4.2.2 Sediment samples will be collected continuously with vertical profile at 0.9m, 1.9m, 2.9m depths, and thereafter every 3m to the bottom of the marine sediment layer or the piling depth. During borehole drilling, an on-site Environmental Specialist will be responsible for supervising the sampling works and identifying suitable sampling depth based on the changes in material characteristics, visual appearance, etc.

4.2.3 Drillholes would be constructed by means of rotary drilling method as far as practicable. For safety reason, an inspection pit will be excavated down to 1.5m below ground to inspect the presence of underground utilities at the proposed drillhole locations. Boring using drill rig will then be performed for depth from 1.5m to the base of marine sediment layer. U100/U76 sediment samples (stainless steel) will be collected at the marine sediment layer.

4.2.4 Strata logging for drillholes will be undertaken during the course of drilling/digging and sampling by a qualified geologist. The logs will include the

general stratigraphic descriptions, depth of sampling, sample notation and level of groundwater (if encountered). The presence of rocks/boulders/cobbles and foreign materials such as metals, wood and plastics will be recorded.

4.2.5 All equipment in contact with the ground will be thoroughly decontaminated between each excavation, drilling and sampling event to minimize the potential for cross-contamination. The equipment (including drilling pit, digging tools and samplers) will be decontaminated by steam cleaning/high-pressure hot water jet, then washed by phosphate-free detergent and finally rinsed by distilled/deionized water. A clean area immediately adjacent to the sample location will be established, using a clean plastic sheet, on which all cleaned, and foil wrapped equipment will be placed.

4.2.6 Prior to sampling, the laboratory responsible for analysis will be consulted for the particular sample size for chemical/ biological testing as well as the preservation procedures that are necessary for each chemical analysis. According to ETWB TC(W) No. 34/2002, the recommended sample sizes for each parameter and test are shown in **Table 4.4**. The actual sample size would however be subject to agreement with the designated laboratory.

Table 4.4 Recommended sediment sample size

Parameters to be tested	Sample Size
Metals and metalloid	0.5L
Organic	0.5L
Biological response	6L

4.2.7 All sampling bottles will be labelled with the station number, sample length, diameter and depth, sampling date and time, together with full description of the sample. If the contents are hazardous, this will be clearly marked on the container and precautions taken during transport. The samples will be contained in laboratory cleaned high-density polyethylene bottles or wide mouth borosilicate glass bottles with Teflon lined lids in accordance with the recommendations of ETWB TC(W) No. 34/2002. The samples will be stored in dark at 4 ^{o}C but never frozen. Samples will be delivered to laboratory within 24 hours of the samples being collected and analysed within 14 days from sampling for chemical testing.

4.2.8 It should be noted that based on the sediment information collected at this feasibility stage, strategy for the next round of sediment sampling and testing exercise to be conducted at a later stage of the Project under the DASO application process will be recommended in accordance with ETWB TC(W) No. 34/2002.

4.3 Chemical and Biological Test

4.3.1 Sediment quality will be assessed through laboratory analyses of sediment samples for the chemical and/or biological parameters. The reference sediment (clean sample) (see **Section 4.4** for details) will also be tested for comparison. Based on the chemical contaminant levels, sediment will be classified into either Category L, M or H sediment according to the criteria stated in ETWB TC(W) No. 34/2002. Tier III biological screening test will be implemented for Category M sediment. Sediment classified as Category H and with one or more contaminant levels exceeding 10 × LCEL will also undergo the biological screening test but in a diluted manner (dilution test). The chemical and biological screening parameters

are summarised in **Table 4.5** and **Table 4.6** respectively, and the preparation method for biological screening tests is presented in **Table 4.7.**

Table 4.5 Chemical screening parameters for sediment quality assessment

Parameters	Preparation Method *U.S. EPA Method* (i)	Determination Method *U.S. EPA Method* (i)	Reporting Limit (ii)
Metals (mg/kg dry wt.)			
Cadmium (Cd)	3050B	6020A or 7000A or 7131A	0.2
Chromium (Cr)	3050B	6010C or 7000A or 7190	8
Copper (Cu)	3050B	6010C or 7000A or 7210	7
Mercury (Hg)	7471A	7471A	0.05
Nickel (Ni)	3050B	6010C or 7000A or 7520	4
Lead (Pb)	3050B	6010C or 7000A or 7420	8
Silver (Ag)	3050B	6020A or 7000A or 7761	0.1
Zinc (Zn)	3050B	6010C or 7000A or 7950	20
Metalloids (mg/kg dry wt.)			
Arsenic (As)	3050B	6020A or 7000A or 7061A	1
Organic-PAHs (µg/kg dry wt.)			
Low Molecular Weight PAHs+	3550B or 3540C and 3630C	8260B or 8270C	55
High Molecular Weight PAHs++	3550B or 3540C and 3630C	8260B or 8270C	170
Organic-non- PAHs (µg/kg dry wt.)			
Total PCBs+++	3550B or 3540C and 3665A	8082	3
Organometallics (µg TBT/L in interstitial water)			
Tributyltin	Krone *et al.* (1989)* - GC/MS UNEP/IOC/IAEA**	Krone *et al.* (1989)* - GC/MS UNEP/IOC/IAEA**	0.015

Notes:
(i) The preparation and determination methods shown in this table are practicable as confirmed by the testing laboratory.
(ii) The reporting limits shown in this table are the most stringent limits and are practicable as confirmed by the testing laboratory.
(iii) Any methodology for which the laboratory is accredited that will produce equivalent or better results/reporting limits as required may be used subject to approval by DEP.
\+ Low molecular weight PAHs include acenaphthene, acenaphthylene, anthracene, fluorene, naphthalene, and phenanthrene
++ High molecular weight PAHs include benzo[a]anthracene, benzo[a]pyrene, chrysene, dibenzo[a,h]anthracene, fluoranthene, pyrene, benzo[b]fluoranthene, benzo[k] fluoranthen, indeno[1,2,3-c,d]pyrene and benzo[g,h,i]perylene
+++ The reporting limit is for individual PCB congeners. Total PCBs include 2,4' diCB, 2,2',5 triCB, 2,4,4' triCB, 2,2',3,5' tetraCB, 2,2',5,5' tetraCB, 2,3',4,4' tetraCB, 3,3',4,4' tetraCB, 2,2',4,5,5' pentaCB, 2,3,3',4,4' pentaCB, 2,3',4,4',5 pentaCB, 3,3',4,4',5 pentaCB, 2,2',3,3',4,4' hexaCB, 2,2',3,4,4',5' hexaCB, 2,2',4,4',5,5' hexaCB, 3,3',4,4',5,5' hexaCB, 2,2',3,3',4,4',5 heptaCB, 2,2',3,4,4',5,5' heptaCB, 2,2',3,4',5,5',6 heptaCB (ref: the "summation" column of Table 9.3 of Evaluation of Dredged Material Proposed for Discharge in Waters of the U.S. - Testing Manual (The Inland Testing Manual) published by U.S. EPA).
* Krone *et al.* (1989), A method for analysis of butyltin species and measurement of butyltins in sediment and English Sole livers from Puget Sound, Marine Environmental Research 27 (1989) 1-18. Interstitial water to be obtained by centrifuging the sediment and collecting the overlying water.
** UNEP/ICO/IAEA refers to IAEA's Marine Environment Laboratory reference methods. These methods are available free of charge from UNEP/Water or Marine Environmental Studies Laboratory at IAEA's Marine Environment Laboratory. Interstitial water to be obtained by centrifuging the sediment and collecting the overlying water.

Table 4.6 Biological screening* parameters for sediment quality assessment

Toxicity Test	Test Method	Endpoints Measured	Failure Criteria
10-day amphipod	U.S. EPA 600/R-94/025 June 1994 Test Method 100.4	Survival	Mean survival in test sediment is significantly different (p≤ 0.05)** from mean survival in reference sediment **and** mean survival in test sediment < 80% of mean survival in reference sediment.
20-day polychaete worm	Recommended Guidelines for Conducting Laboratory Bioassays on Puget Sound Sediments, PSEP, July 1995	Dry weight***	Mean dry weight in test sediment is significantly different (p≤ 0.05)** from mean dry weight in reference sediment **and** mean dry weight in test sediment <90% of mean dry weight in reference sediment.
48-96 hour larvae (bivalve or echinoderm)	Recommended Guidelines for Conducting Laboratory Bioassays on Puget Sound Sediments, PSEP, July 1995	Normality survival****	Mean normality survival in test sediment is significantly different (p≤ 0.05)** from mean normality survival in reference sediment **and** mean normality survival in test sediment <80% of mean normality survival in reference sediment.

Notes:
* Ancillary testing parameters to be analysed for all sediment samples include Moisture Content, Grain Size (%<63 µm), Total Organic Carbon, Ammonia (as mg N/L), and Salinity in pore water.
** Statistically significantly differences should be determined using appropriate two-sample comparisons (e.g. t-tests) at a probability of p≤ 0.05.
*** Dry weight means total dry weight after deducting dead and missing worms.
**** Normality survival integrates the normality and survival end points, and measures survival of only the normal larvae relative to the starting number.

Table 4.7 Preparation method for biological screening tests

Sediment Characteristics	Preparation Method
Category H sediment (> 10 × LCEL)	Sample to be mixed with 9 portions of reference sediment
Category M sediment or Category H sediment (> 10 × LCEL) suspected of ammonia contamination	Additional set of sample (after dilution for Category H sediment) to be purged# for ammonia removal (for amphipod test only).

Note:
\# If the ammonia concentration in the overlaying water of the test system is ≥20mg/L, purging of sediment is required. This is performed by replacing the overlying water at a rate of 6 volume replacement / 24 h for 24 hours, and repeated once only if the ammonia level still exceeds 20mg/L.

4.3.2 Only ecologically relevant species should be used for carrying out the biological screening tests. The species to be used for each type of test are summarised in **Table 4.8**.

Table 4.8 Species to be used for biological screening test

Test Type	Species	Reference Test Conditions*
10-day burrowing amphipod toxicity test	*Ampelisca abdita* *Leptocheirus plumulosus* *Eohaustorius estuarius*	U.S. EPA(1994)/PSEP(1995) U.S. EPA(1994) U.S. EPA(1994)/PSEP(1995)
20-day burrowing polychaete toxicity test	*Neanthes arenaceodentata*	PSEP(1995)
48-96 hour larvae (bivalve or echinoderm) toxicity test	Bivalve: *Mytilus* spp. *Crassostrea gigas*	 PSEP(1995) PSEP(1995)
	Echinoderm: *Dendraster excentricus* *Strongylocentrotus* spp.	 PSEP(1995) PSEP(1995)

Note:
* U.S. EPA 1994. Methods for assessing the toxicity of sediment-associated contaminants with estuarine and marine amphipods. Office of Research and Development. U.S. EPA, Cincinnati, OH. EPA/600/R94/025. PSEP (Puget Sound Estuary Program) 1995. Recommended guidelines for conducting laboratory bioassays on Puget Sound Sediments.

4.4 Elutriate Test

4.4.1 Preparation of elutriate will be conducted in accordance with the Evaluation of Dredged Material proposed for Discharge in Waters of the US – Testing Manual (Inland Testing Manual), USEPA and USACE, 1998. The reference sediment and marine water samples will also be tested for comparison. Analytical methods and reporting limits are given in **Table 4.9**.

4.4.2 TLB/VC2 and TLB/VC3 are proposed for elutriate testing due to their representative locations. For the samples which are subject to elutriate testing, 6L of marine water sample will be required for each sample for the elutriate test as well as the blank test. The water samples will be collected from 1m below the surface, mid-depth and 1m above the seabed at each environmental sampling location. The sampling locations for elutriate testing will be the same as the sediment sampling location, shown in **Figure 4.1** and their coordinates are given in **Table 4.1**.

4.4.3 Elutriate samples will be prepared by sub-sampling approximately 1L of sediment sample combined with unfiltered marine water collected on-site in a sediment-to-water ratio of 1:4 by volume in a pre-cleaned container in the laboratory. The mixture will be stirred for 30 minutes on a platform shaker. After the 30 minutes, the mixture will be allowed to settle for 1 hour and the supernatant will then be siphoned off without disturbing the settled material. The decanted solution will be centrifuged to remove particulates prior to chemical analysis (approximately 2000 rpm for 30 min, until visually clear).

4.5 Pore Water Test

4.5.1 Similarly, TLB/VC2 and TLB/VC3 are also proposed for pore water testing due to their representative locations. Preparation of pore water from the grab sediment sample collected will be conducted in accordance with "Methods for Collection, Storage and Manipulation of Sediments for Chemical and Toxicological Analyses:

Technical Manual, USEPA 2001" (or equivalent). The reference sediment will also be tested for comparison.

4.5.2 All seawater being trapped inside the grab during sampling should be drained out carefully before any further process. After draining out all the seawater, individual grabs will be composited on-site and split into portions for packing for laboratory pore water testing. The sampling locations for pore water testing will be the same as the sediment sampling location, shown in **Figure 4.1** and their coordinates are given in **Table 4.1**.

4.5.3 Pore water samples will be prepared by sub-sampling approximately 1L of sediment in a pre-cleaned container in the laboratory and centrifuged at rotation speed at 3,000 rpm for 10 minutes. After that, the supernatant will be decanted without disturbing the sediment material. The pore water testing parameters and assessment criteria will be the same as those for elutriate samples. Analytical methods and reporting limits are given in **Table 4.9**.

Table 4.9 Chemical Parameters for Sediment Elutriate and Pore Water Testing

Contaminant of Concern	Instrumentation	Determination Method	Reporting Limit
Cadmium (Cd)	ICP-MS	USEPA 6020A	0.2 µg/L
Chromium (Cr)	ICP-MS	USEPA 6020A	1 µg/L
Copper (Cu)	ICP-MS	USEPA 6020A	1 µg/L
Mercury (Hg)	ICP-AES / CVAAS	USEPA 6010B /APHA3112B	0.05 µg/L
Nickel (Ni)	ICP-MS	USEPA 6020A	1 µg/L
Lead (Pb)	ICP-MS	USEPA 6020A	1 µg/L
Silver (Ag)	ICP-MS	USEPA 6020A	1 µg/L
Zine (Zn)	ICP-MS	USEPA 6020A	1 µg/L
Arsenic (As)	ICP-MS	USEPA 6020A	1 µg/L
Ammonia	FIA	APHA 4500-NH3 H	0.01 mg/L
Nitrite as N	FIA	APHA 4500-NO2 I	0.01 mg-N/L
Nitrate as N	FIA	APHA 4500-NO3 I	0.01 mg-N/L
TKN as N	Kjeldahl	APHA 4500-Norg + NH3 C	0.1 mg-N/L
Total P	Colorimetric	APHA 4500-P B&E	0.1 mg-P/L
Reactive P	FIA	APHA 4500-P G	10 µg-P/L
PAHs [1]	GC-MSD	USEPA 3510C USEPA 3630C USEPA 8270C	0.1 µg/L (individually)
Total PCBs	GC-ECD/GCMSD	USEPA 3510C USEPA 3620B USEPA 8082/8270	0.01 µg/L (for each PCB congener)
Tributyltin (TBT)	GC-MSD	UNEP/IOC/IAEA [2]	0.015 µg/L
Chlorinated Pesticides: Alpha-BHC Beta- BHC Gamma-BHC Delta-BHC Heptachlor Aldrin (individually) Heptachlor epoxide Endosulfan 1 p,p'-DDE p,p'-DDD	GC-MSD/GCECD	USEPA 3510C USEPA 3620B USEPA 8270C USEPA 8081A	0.1 µg/L (individually)

Contaminant of Concern	Instrumentation	Determination Method	Reporting Limit
p,p'-DDT Endosulfan sulfate			

Notes:

[1] Low Molecular Weight PAHs shall include acenaphthene, acenaphthylene, anthracene, fluorene, naphthalene and phenanthrene. High Molecular Weight PAHs shall include benzo[a]anthracene, benzo[a]pyrene, chrysene, dibenzo[a,h]anthracene, fluoranthene, pyrene, benzo[b]fluoranthene, benzo[k]fluoranthene, indeno[1,2,3-c,d]pyrene and benzo[g,h,i]perylene.

[2] UNEP/ICO/IAEA refers to IAEA's Marine Environment Laboratory reference methods.

4.6 Sample Handling and Storage

4.6.1 All sediment samples will be stored at 4°C during transportation and at the laboratory prior to testing. The sampling bottles and pre-treatment methods will follow the recommendation stipulated in Section 2 (b)(i) of Appendix B of ETWB TC(W) No. 34/2002. All sampling bottles will be labelled with the station number, sampling date and time, together with a full description of the sample. The recommended types of sampling bottle and pre-treatment methods are summarized in **Table 4.10**.

Table 4.10 Recommended types of sampling bottle and pre-treatment methods

Parameters to be tested	Sampling Bottle	Pre-treatment Procedure#
Metals and metalloid	High density polyethylene bottles*	U.S. EPA SW-846+ Chapter 3
Organic	Wide mouth Borosilicate glass bottles with Teflon lined lid	U.S. EPA SW-846 Chapter 4
Biological response	Wide mouth Borosilicate glass bottles with Teflon lined lid or high density polyethylene bottles *	U.S. EPA SW-846 Chapter 3 or Chapter 4 as appropriate.

Notes:

* Heavy duty plastic bags may be used for the storage of sediment sample for testing metals, metalloid and biological response.

\# Other equivalent methods may be used subject to the approval of Director of Environmental Protection (DEP).

\+ Test methods for evaluating solid waste: physical/chemical methods, SW-846, 3rd edition, U.S. EPA.

4.6.2 All sediment samples will be extracted in the laboratory and placed in the appropriate containers directly after the sampling. All samples will be double-bagged and labelled internally and externally with indelible ink. Samples for biological testing (if any) will be stored in the same manner as described above (including for ancillary parameters).

4.6.3 Samples for chemical testing will be extracted and analysed within 2 weeks to ensure a Tier III Biological Testing Programme (where required) can be developed and commenced within 8 weeks from the date of sampling.

4.7 Reference Samples

4.7.1 Based on the data from EPD's Annual Marine Water Quality Report - *Marine Water Quality in Hong Kong in 2020*, one of the EPD reference marine sampling points at Outer Port Shelter (PS6, E850234, N820057) is proposed to be used as the reference station for the Project. The most recent available test results from EPD on the recovered sediments at sampling point PS6 indicated that the sediments are with all contaminant levels not exceeding the LCEL as defined in ETWB TC(W) No. 34/2002, which means the sediment could be classified as Category L. The location of reference sample and excerpts of the published marine sediment testing results at PS6 are given in **Appendix 4.2**.

4.7.2 Modified Van Veen grab (or equivalent) of capacity ~2L will be deployed from vessel and reference sediment (surface grab) will be collected at Port Shelter, of which the quantity will be advised by designated laboratory. Marine water of ~15L shall also be collected at the same time for the preparation of elutriate sample and blank test. Individual grabs will be composited on-site and split into portions for packing. The samples will be stored at 4°C during transportation and at the laboratory prior to testing.

4.8 QA/QC Requirements

4.8.1 Field logs and site diary will be maintained for all on-site sampling works with date, equipment used, site activities and observations, undertaken as far as possible. Any deviation from the standard procedures and reasons will be recorded in the logs.

4.8.2 Laboratory QA/QC requirements will be strictly complied. All tests will be conducted by laboratories accredited by Hong Kong Laboratory Accreditation Scheme (HOKLAS) or, in case of overseas laboratories, by equivalent national accreditation for these tests.

4.8.3 For chemical screening, the following QC plan would be implemented for the laboratory testing:

- Method Blank;
- Duplicate (at 5% level, i.e. one for every 20 samples); and
- Matrix Spike (at 5% level, i.e. one for every 20 samples).

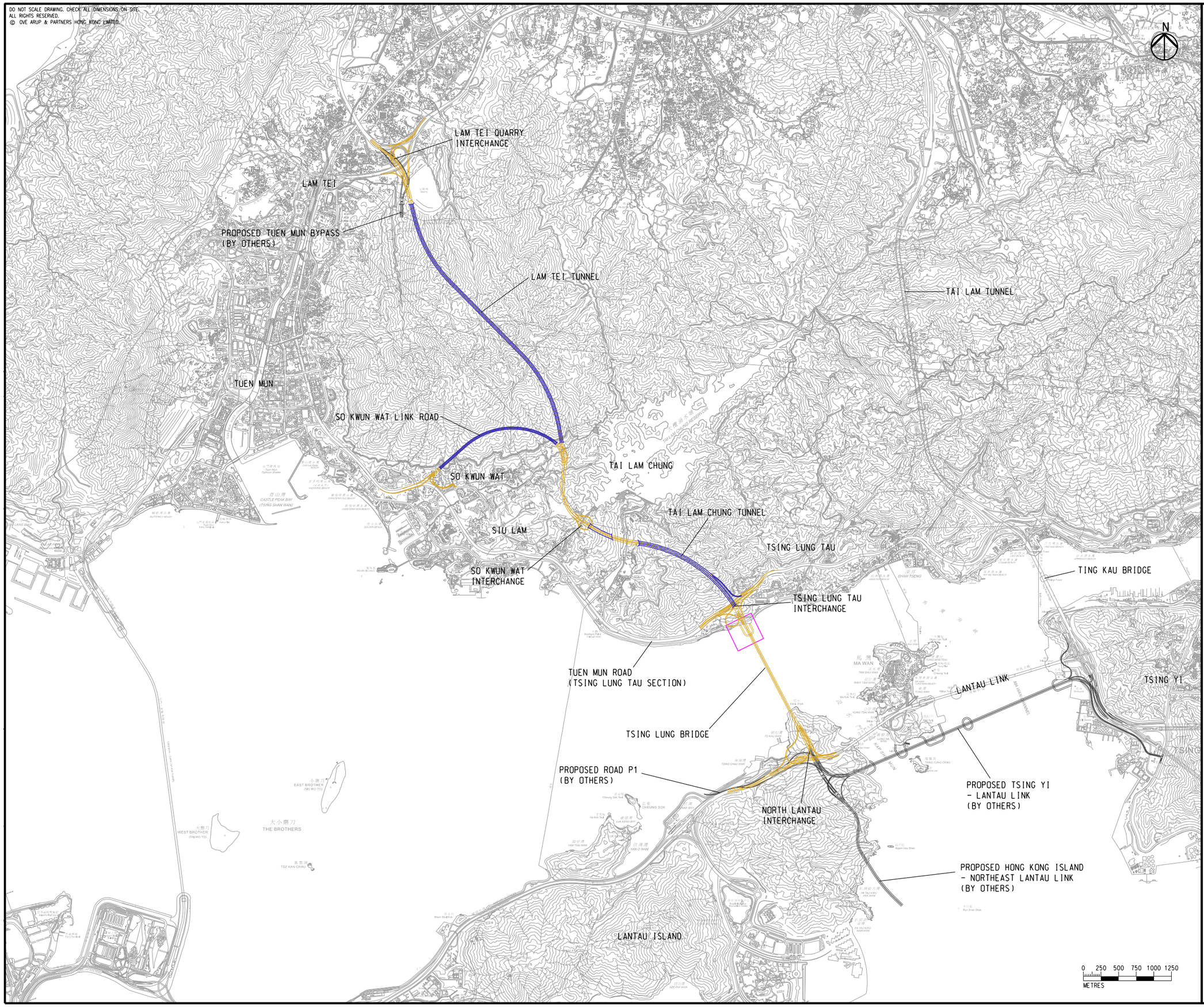
4.8.4 The proposed data quality objectives are shown in **Table 4.11**.

Table 4.11 Data Quality Objectives for the Laboratory Testing

Quality Controls	Acceptance Criteria
Method Blank	Less than method detection limit (MDL)
Duplicate	Agree within ±25% of the mean of duplicate results
Matrix Spike	Agree within ±25% of the recovery of spike concentration

For biological testing, all biological tests must be conducted by laboratories with appropriate accreditation; The QA/QC control in biological testing will be based on the application of the negative and positive control.

Figure



LEGEND

- PROPOSED ELEVATED/ AT-GRADE ROAD (TENTATIVE ALIGNMENT)
- PROPOSED TUNNEL (TENTATIVE ALIGNMENT)
- PROPOSED ROAD NETWORK (BY OTHERS)
- POSSIBLE RECLAMATION AREA

Rev	Description	By	Date
A	FIRST ISSUE	GL	03/22

Consultant

ARUP

Project Title

ROUTE 11

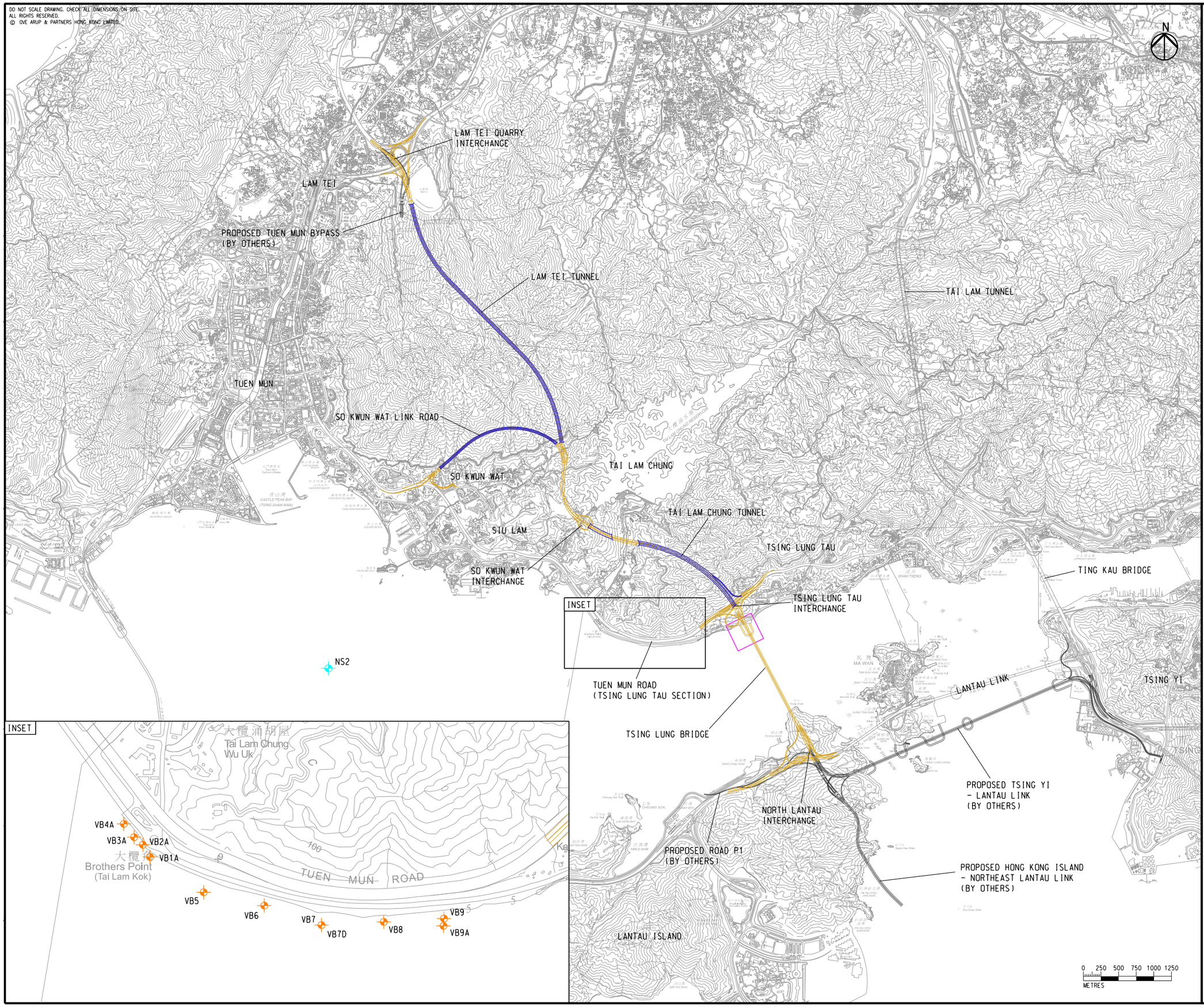
(SECTION BETWEEN YUEN LONG AND NORTH LANTAU) - INVESTIGATION

Drawing title

LOCATION OF PROJECT

Drawing no.			Rev.
FIGURE 1.1			A
Drawn: GL	Date: 03/22	Checked: TL	Approved: FC
Scale: 1:50000 @ A3		Status: PRELIMINARY	

路政署
HIGHWAYS DEPARTMENT



LEGEND

- PROPOSED ELEVATED/ AT-GRADE ROAD (TENTATIVE ALIGNMENT)
- PROPOSED TUNNEL (TENTATIVE ALIGNMENT)
- PROPOSED ROAD NETWORK (BY OTHERS)
- POSSIBLE RECLAMATION AREA
- SEDIMENT SAMPLING LOCATION AT TAI LAM KOK
- SEDIMENT SAMPLING LOCATION AT PEARL ISLAND

Rev	Description	By	Date
A	FIRST ISSUE	GL	03/22

Consultant

ARUP

Project Title

ROUTE 11

(SECTION BETWEEN YUEN LONG AND NORTH LANTAU) - INVESTIGATION

Drawing title

REFERENCED LOCATIONS FOR EXISTING SEDIMENT QUALITY

Drawing no.			Rev.
FIGURE 2.1			A
Drawn: GL	Date: 03/22	Checked: TL	Approved: FC
Scale: 1:50000 @ A3		Status: PRELIMINARY	

路政署 HIGHWAYS DEPARTMENT

N

LAM TEI QUARRY INTERCHANGE

LAM TEI

PROPOSED TUEN MUN BYPASS (BY OTHERS)

LAM TEI TUNNEL

TAI LAM TUNNEL

TUEN MUN

SO KWUN WAT LINK ROAD

SO KWUN WAT

TAI LAM CHUNG

TAI LAM CHUNG TUNNEL

SIU LAM

TSING LUNG TAU

SO KWUN WAT INTERCHANGE

TING KAU BRIDGE

TSING LUNG TAU INTERCHANGE

FIGURE 4.1a

TUEN MUN ROAD (TSING LUNG TAU SECTION)

TSING LUNG BRIDGE

LANTAU LINK

TSING YI

PROPOSED ROAD P1 (BY OTHERS)

NORTH LANTAU INTERCHANGE

PROPOSED TSING YI - LANTAU LINK (BY OTHERS)

PROPOSED HONG KONG ISLAND - NORTHEAST LANTAU LINK (BY OTHERS)

LANTAU ISLAND

0 250 500 750 1000 1250
METRES

LEGEND

- PROPOSED ELEVATED/ AT-GRADE ROAD (TENTATIVE ALIGNMENT)
- PROPOSED TUNNEL (TENTATIVE ALIGNMENT)
- PROPOSED ROAD NETWORK (BY OTHERS)
- POSSIBLE RECLAMATION AREA

Rev	Description	By	Date
A	FIRST ISSUE	GL	03/22

Consultant

ARUP

Project Title

ROUTE 11

(SECTION BETWEEN YUEN LONG AND NORTH LANTAU) - INVESTIGATION

Drawing title

PROPOSED SEDIMENT SAMPLING LOCATIONS

Drawing no.			Rev.
FIGURE 4.1			A
Drawn: GL	Date: 03/22	Checked: TL	Approved: FC
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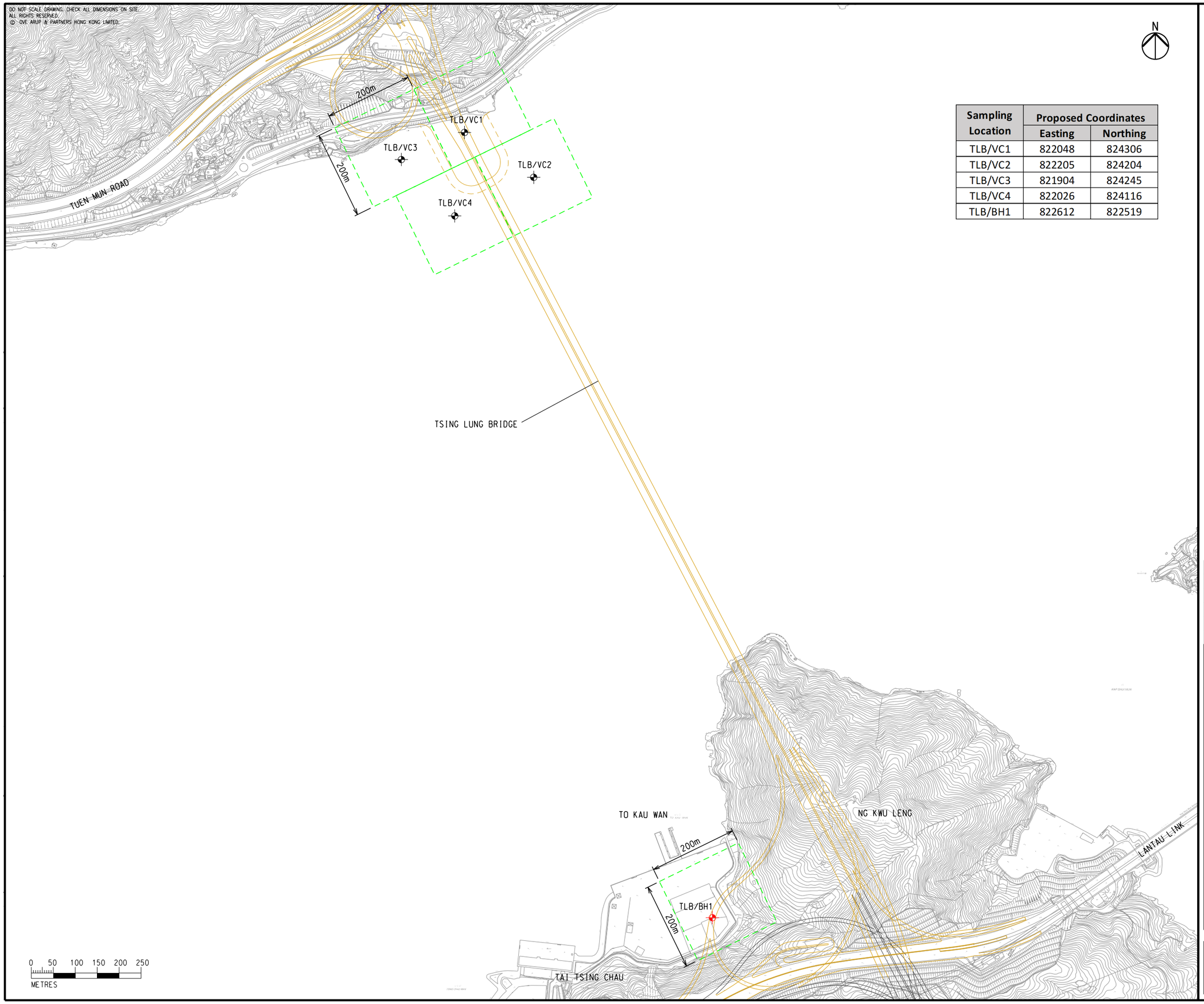
路政署
HIGHWAYS DEPARTMENT



Sampling Location	Proposed Coordinates	
	Easting	Northing
TLB/VC1	822048	824306
TLB/VC2	822205	824204
TLB/VC3	821904	824245
TLB/VC4	822026	824116
TLB/BH1	822612	822519

LEGEND

- PROPOSED ELEVATED/ AT-GRADE ROAD (TENTATIVE ALIGNMENT)
- PROPOSED TUNNEL (TENTATIVE ALIGNMENT)
- PROPOSED ROAD NETWORK (BY OTHERS)
- SAMPLING GRID
- PROPOSED MARINE-BASED SEDIMENT SAMPLING LOCATIONS
- PROPOSED LAND-BASED SEDIMENT SAMPLING LOCATIONS

Rev	Description	By	Date
B	FIRST ISSUE	GL	06/22
A	FIRST ISSUE	GL	03/22

Consultant

ARUP

Project Title

ROUTE 11

(SECTION BETWEEN YUEN LONG AND NORTH LANTAU) - INVESTIGATION

Drawing title

PROPOSED SEDIMENT SAMPLING LOCATIONS

Drawing no.			Rev.
FIGURE 4.1a			B
Drawn: GL	Date: 06/22	Checked: TL	Approved: FC
Scale: AS SHOWN		Status: PRELIMINARY	

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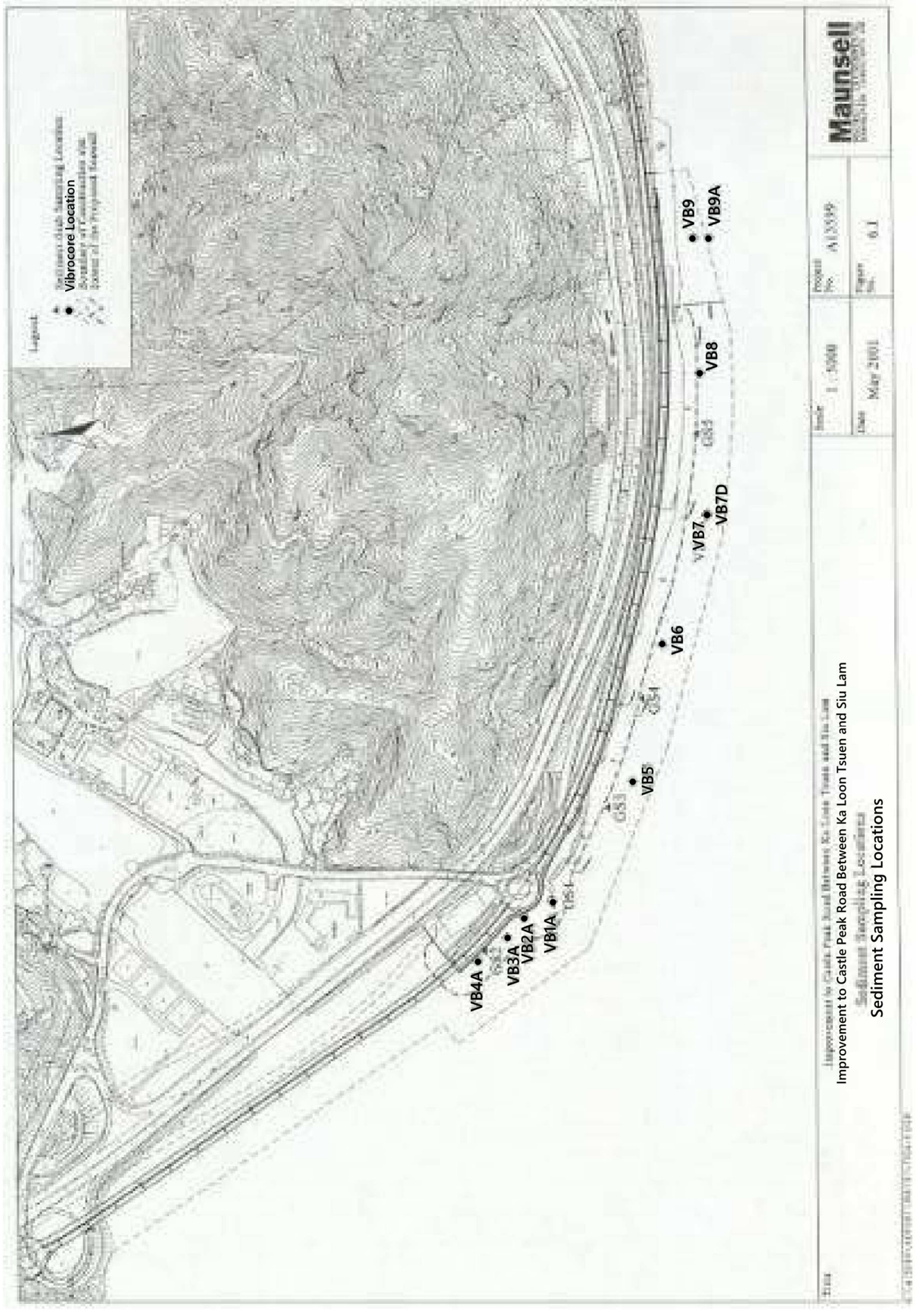
HIGHWAYS DEPARTMENT

Appendix 2.1

Sampling Location in Tai Lam Kok



Appendix 2.2

Sediment Quality in Tai Lam Kok

Table 6.2 Sediment Quality Analysis Results from Marine Ground Investigation Works

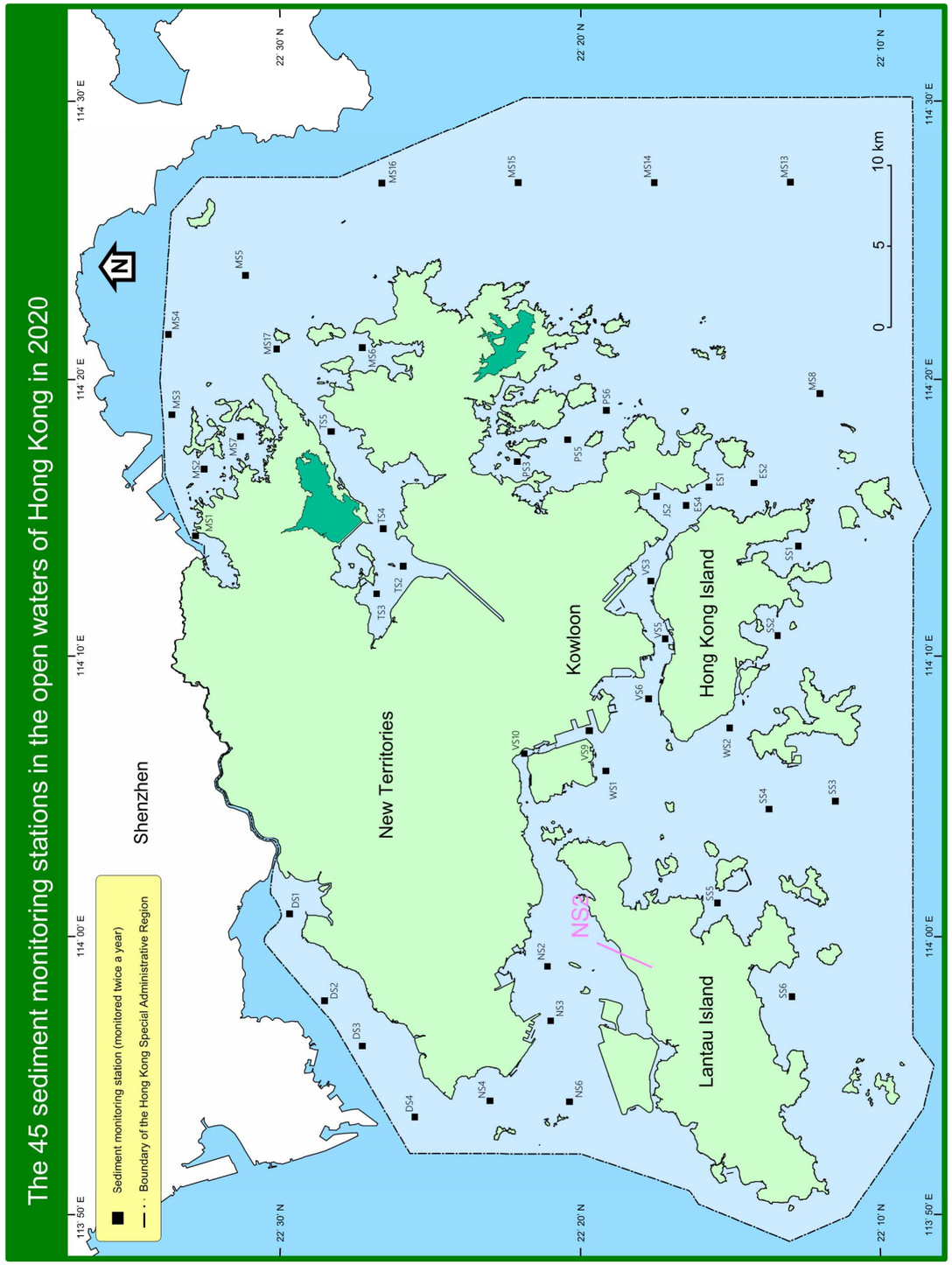
Vibrocore	Sampling Depth	Metals and Metalloid Content (mg/kg)									ug/kg				Overall Classification
		Ag	As	Cd	Cr	Cu	Ni	Pb	Zn	Hg	Total PCBs	PAHs Low (1)	PAH High (2)	TBT in Sediment	
VB1A	0-0.9m	0.2	3	<0.2	13	10	6	16	35	<0.1	<2	<35	<50	<0.5	Category L
	0.9-1.9m	<0.1	2	<0.2	7	2	5	13	17	<0.1	<2	<35	<50	<0.5	Category L
	1.9-2.9m	<0.1	<1	<0.2	3	3	<1	36	29	<0.1	<2	<35	<50	<0.5	Category L
VB2A	0-0.9m	0.1	3	<0.2	14	11	8	15	39	<0.1	<2	<35	<50	2	Category L
	0.9-1.9m	0.2	3	<0.2	14	11	7	15	40	<0.1	<2	<35	<50	<0.5	Category L
VB3A	0-1.37m	<0.1	3	<0.2	9	4	4	41	22	<0.1	<2	<35	<50	<0.5	Category L
	1.37-2.37m	<0.1	4	<0.2	7	2	7	10	21	<0.1	<2	<35	<50	<0.5	Category L
VB4A	0-0.9m	0.1	3	<0.2	14	13	9	16	47	<0.1	<2	<35	<50	6	Category L
	0.9-1.9m	<0.1	2	<0.2	11	3	6	10	26	<0.1	<2	<35	<50	1	Category L
	1.9-2.9m	<0.1	4	<0.2	14	5	10	13	36	<0.1	<2	<35	<50	<0.5	Category L
	2.9-3.9m	<0.1	4	<0.2	6	2	3	9	19	<0.1	**	**	**	**	Category L
VB5	0-0.9m	<0.1	<1	<0.2	4	3	1	14	31	<0.1	<2	<35	<50	2	Category L
	0.9-1.9m	<0.1	3	<0.2	13	6	7	20	26	<0.1	<2	<35	<50	<0.5	Category L
	1.9-2.1m	<0.1	14	<0.2	12	6	11	30	47	<0.1	<2	<35	<50	<0.5	Category M
	2.9-3.9m	<0.1	<1	<0.2	4	1	<1	23	17	<0.1	**	**	**	**	Category L
	3.9-4.87m	<0.1	<1	<0.2	4	<1	2	33	17	<0.1	**	**	**	**	Category L
VB6	0-0.9m	<0.1	3	<0.2	10	6	6	19	26	<0.1	<2	<35	<50	<0.5	Category L
	0.9-1.9m	<0.1	1	<0.2	4	2	3	11	16	0.2	<2	<35	<50	<0.5	Category L
	1.9-2.9m	<0.1	2	<0.2	7	1	2	9	11	<0.1	<2	<35	<50	<0.5	Category L
VB7	0-1.2m	<0.1	2	<0.2	7	4	4	35	19	<0.1	<2	<35	<50	<0.5	Category L
VB7D	0-0.9m	<0.1	7	<0.2	16	20	9	45	48	<0.1	<2	<35	<50	2	Category L
	0.9-1.8m	<0.1	6	<0.2	13	13	8	48	35	<0.1	<2	<35	<50	<0.5	Category L
VB8	0.25-1.25m	<0.1	4	<0.2	8	9	5	48	24	<0.1	<2	<35	<50	1	Category L
	1.25-2.25m	<0.1	1	0.3	4	10	1	41	13	<0.1	<2	<35	<50	<0.5	Category L
	2.25-3.15m	0.2	<1	<0.2	2	9	<1	44	11	<0.1	<2	<35	<50	<0.5	Category L
VB9	0-0.9m	0.2	3	<0.2	12	15	8	57	69	<0.1	9	<35	305	1	Category L
	0.9-1.9m	0.2	<1	1.7	3	2	<1	**185**	11	<0.1	<2	<35	<50	<0.5	Category H
	1.9-2.1m	<0.1	<1	<0.2	2	2	<1	11	16	<0.1	<2	<35	<50	<0.5	Category L
VB9A	0-0.9m	<0.1	4	<0.2	9	3	2	13	14	<0.1	<2	<35	<50	<0.5	Category L
	0.-9-1.9m	<0.1	3	<0.2	8	2	2	10	14	<0.1	<2	<35	<50	<0.5	Category L

Notes:
1. Low molecular weight PAHs i.e. acenaphthene, acenaphthylene, anthracene, fluorene, naphthalene and phenanthrene
2. High molecular weight PAHs i.e. benzo[a]anthracene, benzo[a]pyrene, chrysene, dibenzo[a,h]anthracene, fluoranthene, pyrene, benzo[b]fluoranthene, benzo[k]fluoranthene, ideno[1,2,3-c,d]pyrene and benzo[g,h,I]perylene.
3. Value in underline indicate Category M sediment under WBTC No. 3/2000
4. Value in bold indicate Category H sediment under WBTC No. 3/2000

Appendix A

Appendix 2.3

Sampling Location in Pearl Island



Appendix 2.4

Sediment Quality in Pearl Island

Summary statistics for bottom sediment quality in the North Western and Western Buffer WCZs, 2016 - 2020

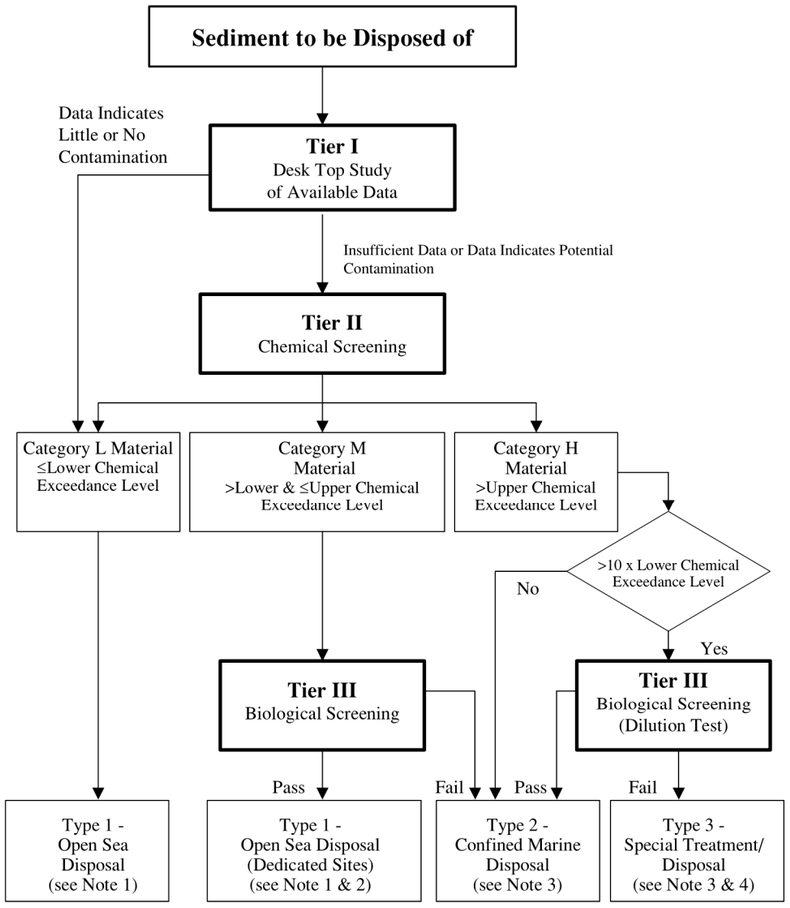
Parameter	Pearl Island NS2	Pillar Point NS3	Urmston Road NS4	Chek Lap Kok (North) NS6	Tsing Yi (South) WS1	Hong Kong Island (West) WS2
Number of samples	10	10	10	10	10	10
Particle Size Fractionation <63μm (%w/w)	59 (20 - 97)	66 (25 - 96)	54 (28 - 89)	69 (13 - 99)	74 (17 - 94)	74 (26 - 91)
Electrochemical Potential (mV)	-135 (-173 - -59)	-161 (-217 - -125)	-157 (-186 - -118)	-136 (-161 - -107)	-202 (-346 - -109)	-188 (-343 - -102)
Total Solids (%w/w)	52 (39 - 63)	51 (44 - 59)	57 (50 - 64)	53 (41 - 64)	45 (38 - 52)	47 (38 - 54)
Total Volatile Soilds (%TS)	6.5 (4.8 - 7.8)	6.7 (5.3 - 8.5)	5.8 (4.2 - 7.5)	6.6 (4.6 - 8.2)	7.6 (6.2 - 9.1)	7.3 (5.9 - 9.8)
Chemical Oxygen Demand (mg/kg)	11510 (6900 - 15000)	13600 (11000 - 16000)	13400 (11000 - 17000)	11340 (8700 - 15000)	15270 (8700 - 21000)	13080 (9800 - 16000)
Total Carbon (%w/w)	0.7 (0.5 - 1.0)	0.7 (0.6 - 0.9)	0.6 (0.4 - 0.8)	0.7 (0.4 - 1.2)	0.7 (0.5 - 1.1)	0.7 (0.6 - 1.2)
Ammonical Nitrogen (mg/kg)	4.14 (0.05 - 9.30)	6.43 (0.18 - 18.00)	4.74 (0.17 - 24.00)	6.84 (0.05 - 45.00)	13.85 (1.40 - 27.00)	4.91 (0.65 - 8.90)
Total Kjeldahl Nitrogen (mg/kg)	430 (280 - 540)	460 (380 - 530)	450 (330 - 740)	420 (340 - 570)	580 (500 - 770)	490 (370 - 600)
Total Phosphorus (mg/kg)	220 (170 - 280)	230 (180 - 240)	220 (180 - 250)	220 (160 - 310)	230 (200 - 270)	220 (170 - 250)
Total Sulphide (mg/kg)	27.6 (0.9 - 100.0)	56.0 (1.6 - 230.0)	20.9 (4.3 - 51.0)	11.5 (0.2 - 56.0)	146.8 (52.0 - 320.0)	28.2 (0.2 - 81.0)
Total Cyanide (mg/kg)	0.1 (0.1 - 0.2)	0.1 (0.1 - 0.2)	0.1 (0.1 - 0.2)	0.1 (0.1 - 0.2)	0.1 (0.1 - 0.2)	0.1 (0.1 - 0.2)
Arsenic (mg/kg)	11.5 (7.7 - 23.0)	12.4 (9.7 - 16.0)	10.8 (8.3 - 13.0)	15.7 (12.0 - 22.0)	9.7 (7.5 - 12.0)	9.5 (7.6 - 13.0)
Cadmium (mg/kg)	<0.1 (0.1 - <0.1)	0.1 (0.1 - 0.2)	<0.1 (0.1 - <0.1)	<0.1 (0.1 - <0.1)	0.1 (0.1 - 0.2)	0.1 (0.1 - 0.3)
Chromium (mg/kg)	33 (21 - 48)	30 (22 - 45)	24 (17 - 32)	32 (22 - 38)	35 (26 - 46)	31 (25 - 34)
Copper (mg/kg)	32 (17 - 48)	29 (17 - 51)	26 (16 - 44)	24 (13 - 34)	50 (26 - 100)	30 (18 - 63)
Lead (mg/kg)	46 (29 - 90)	39 (33 - 53)	34 (25 - 39)	42 (34 - 52)	40 (33 - 52)	37 (30 - 44)
Mercury (mg/kg)	0.10 (0.07 - 0.12)	0.10 (0.06 - 0.14)	0.08 (0.06 - 0.11)	0.10 (0.06 - 0.17)	0.16 (0.10 - 0.25)	0.14 (0.07 - 0.32)
Nickel (mg/kg)	20 (13 - 30)	18 (13 - 27)	15 (10 - 26)	20 (15 - 25)	20 (17 - 26)	20 (18 - 22)
Silver (mg/kg)	0.2 (0.2 - 0.4)	0.2 (0.2 - 0.4)	<0.2 (0.2 - <0.2)	<0.2 (0.2 - <0.2)	0.6 (0.3 - 1.7)	0.4 (0.2 - 0.9)
Zinc (mg/kg)	140 (79 - 220)	120 (92 - 160)	110 (78 - 150)	110 (82 - 180)	150 (94 - 300)	130 (86 - 180)
Total Polychlorinated Biphenyls (PCBs) (μg/kg) [3]	18 (18 - 18)	18 (18 - 18)	18 (18 - 18)	18 (18 - 18)	18 (18 - 18)	18 (18 - 19)
Low Molecular Weight Polycylic Aromatic Hydrocarbons (PAHs) (μg/kg) [4] [6]	110 (90 - 150)	110 (90 - 220)	99 (90 - 140)	100 (90 - 200)	120 (90 - 320)	120 (90 - 220)
High Molecular Weight Polycylic Aromatic Hydrocarbons (PAHs) (μg/kg) [5] [6]	63 (38 - 100)	76 (30 - 140)	89 (28 - 220)	54 (24 - 130)	190 (91 - 400)	360 (29 - 1500)

Note:
1. Data presented are arithmetic means ; data in brackets indicate ranges.
2. All data are based on the analyses of bulk (unsieved) sediment and are reported on a dry weight basis unless stated otherwise.
3. Total PCBs results are derived from the summation of 18 congeners. If the concentration of a congener is below report limit (RL), the result will be taken as 0.5xRL in the calculation.
4. Low molecular weight polyaromatic hydrocarbons (PAHs) include 6 congeners of molecular weight below 200, namely : Acenaphthene, Acenaphthylene, Anthracene, Flourene, Naphthalene and Phenanthrene.
5. High molecular weight polyaromatic hydrocarbons (PAHs) include 10 congeners of molecular weight above 200, namely : Fluoranthene, Pyrene, Benzo(a)anthracene, Chrysene, Benzo(b)fluoranthene, Benzo(k)fluoranthene, Benzo(a)pyrene, Dibenzo(a,h)anthracene, Benzo(g,h,i)perylene and Indeno(1,2,3-cd)pyrene.
6. Low and high molecular weight PAHs results are derived from the summation of the corresponding congeners. If the concentration of a congener is below report limit (RL), the result will be taken as 0.5xRL in the calculation.

Appendix 3.1

Framework for Dredged/ Excavated Sediment

Management Framework for Dredged/Excavated Sediment



Notes

(1) Most open sea disposal sites are multi-user facilities and as a consequence their management involves a flexibility to accommodate varying and unpredictable circumstances. Contract documents should include provisions to allow the same degree of flexibility should it be necessary to divert from one disposal site to another during the construction period of a contract.

(2) Dedicated Sites will be monitored to confirm that there is no adverse impact.

Appendix 4.1

Memo issued by Development Bureau on Control Measures for Management of Dredged Excavated Contaminated Sediment

MEMO

From	Secretary for Development	*To*	Distribution
Ref	( ) in DEVB(W) 515/83/04	*(Attn :*	
Tel. No.	2848 2704	*Your Ref.*	
Fax No.	2536 9299	*dated*	
Email	wwchui@devb.gov.hk	*Fax No.*	
Date	6 October 2010	*Total Pages*	4 + Encl.

RECEIVED ON
- 6 OCT 2010
Fill Management Division

TM/COM/21

Control Measures for Management of
Dredged/Excavated Contaminated Sediment

This memo is to promulgate control measures about management of dredged/excavated contaminated sediment.

2. Dredged/excavated contaminated sediment has been disposed of at mud pits at East of Sha Chau since 1992. However, with environmental, marine traffic and development constraints, the mud pits now under construction at East of Sha Chau and the mud pits being planned at South of the Brothers are the last mud pits available in Hong Kong.

3. To ensure maximum effort is made by the project proponent to reduce the consumption of the very limited mud pit capacity, it is necessary to tighten the control on management of dredged/excavated contaminated sediment, including the stepping up of sampling requirement at early stage of project planning, the exhaustive examination of options to reduce sediment generation and disposal, the requirement for cross-boundary disposal of Category Mp sediment and the enhancement of accountability of sediment disposal proposal.

4. The control measures to tighten up the control on management of dredged/excavated contaminated sediment are as follows:

(a) To enable a more accurate estimate of mud disposal volume be made available for consideration when provisional agreement for sediment disposal allocation is sought for projects involving dredging and excavation in areas where the expected contamination level is Category M/H, Marine Fill Committee (MFC) requires that the project proponent should take sediment samples at a 200m x 200m grid. The samples should be continuous and with a vertical profile. The top level of the sub-samples should be at seabed, 0.9m down, 1.9m

down, 2.9m down and then every 3m to the bottom of the dredged layers. The project proponent should as early as practicable submit the proposed sampling plan to the Dumping At Sea Ordinance (DASO) Team of the Environmental Protection Department (EPD) for comment.

(b) The project proponent is required to carry out an assessment on sediment management as outlined on the "Flow Chart for Management of Contaminated Sediment" at **Appendix A**. This requirement ensures that the project proponent has exhausted all management options to keep the sediment in place and explored in details all possible ex-situ treatment, disposal and beneficial reuse options before a decision is made to remove the sediment off site. Reference should be made to the consultancy study – FM01/2007 by the Civil Engineering and Development Department (CEDD) on various management options. A copy of the report is available on CEDD's website.

(c) Project proponents should apply for cross-boundary disposal of Category Mp sediment generated from their projects in accordance with the Agreement on Cross-boundary Marine Dumping and the Implementation Scheme on the Management of Cross-boundary Marine Dumping unless the genuinely estimated quantity of Category Mp sediment is less than 100,000 m^3. Other non-mud pit options for Category Mp sediment should also be examined. In case the application is not successful and there is no other feasible non-mud pit options, the project proponent should liaise with the Secretary of MFC about fall-back options.

(d) To enhance the accountability of the sediment disposal proposal, endorsement by the appropriate directorate officer of the works departments or the Authorized Person (AP) of the private project as indicated on the attached Flow Chart at **Appendix A** is required to be obtained prior to submission of the disposal option to the Secretary of MFC. Project proponents may seek advice from the Secretary of MFC, if necessary.

FM									
	CE	SE/P1	SE/P2	SE/P3		SE/BP	SE/HF	SE/S1	SE/S2
Initial									
Date									
E/			GR			CIR			
PS II			FM / /			BU			

(e) Project proponents are required to exhaust all management options and work out the estimated quantities of contaminated sediments to be disposed of based on the results of the sampling carried out as early as practicable according to (a) above and seek provisional agreement from MFC on allocation of disposal space at mud pit. Such allocation will have to be re-confirmed after the sediment quality report (SQR) is completed and approved by DASO team of EPD during the detailed design stage. During construction, a project proponent should review from time to time the estimated final quantity of contaminated sediment disposal and advise MFC of any changes in advance before the actual disposed quantity has reached 80% of the approved quantity. If the latest estimated final quantity **exceeds** the approved quantity by 5,000 m^3 (or 5% of the approved quantity, whichever is more), the project proponent should seek further approval from MFC as a new application with appropriate endorsement as follows:

Scenario		Endorsement
(I) Public Works Projects		
(i)	The estimated final quantity **does not exceed** the approved quantity by 100,000m^3 (or 5% of the approved quantity, whichever is more)	By a D2 officer for MFC's approval
(ii)	The estimated final quantity **exceeds** the approved quantity by 100,000m^3 (or 5% of the approved quantity, whichever is more)	By a D3 officer for MFC's approval
(II) Private Projects		Endorsement by the AP for MFC's approval

Examples illustrating how the threshold quantities are determined and how the requirements of new applications and endorsements apply are shown in **Appendix B**.

(f) If a public project proponent disposes a quantity of 5,000 m^3 (or 5% of the approved quantity, whichever is more) more

than the approved quantity without the prior approval of MFC, or a quantity less than the approved quantity by more than 5,000 m^3 (or 5% of the approved quantity, whichever is more) without prior notification to MFC, the respective Director should personally provide an explanation to MFC and copy it to the Permanent Secretary for Development (Works).

5. This memo should be read in conjunction with ETWB TCW No. 34/2002 - Management of Dredged/Excavated Sediment.

6. This memo takes immediate effect. Paragraph 4 (c) should only apply to those projects for which provisional agreement of MFC for allocation of sediment disposal space has not yet been granted.

7. If you require further information, please contact Mr M Y Tang, AS(WP)6, at 2848 2585.

(W W CHUI)
for Secretary for Development

Distribution:

SDEV(PL)	(Attn: Miss Amy YUEN)	Fax No. : 2848 3489
STH	(Attn: Mr M K CHAN)	Fax No. : 2523 0030
DEP	(Attn: Mr Sam WONG)	Fax No. : 2591 0558
D of Hy	(Attn: Mr James S O CHAN)	Fax No. : 2714 5216
D of Lands	(Attn: Ms Rita LAI)	Fax No. : 2511 9861
D of Marine	(Attn: Mr Y W LAI)	Fax No. : 2581 1765
D of Plan	(Attn.: Miss Helen L M SO)	Fax No. : 2868 4497
D of DS	(Attn.: Mr Yam-tat SO)	Fax No. : 2802 9006
DAFC	(Attn: Mr Dick CHOI)	Fax No. : 2377 4427
DWS	(Attn: Mr K W CHAN)	Fax No. : 2824 0578

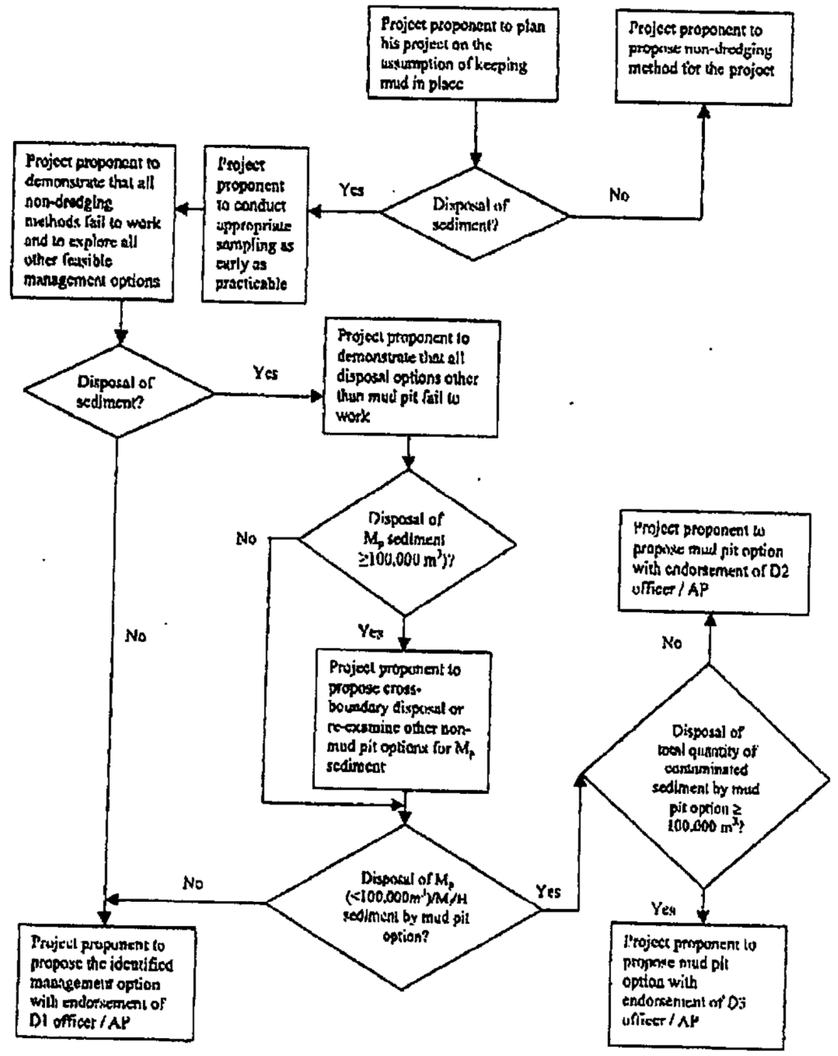
c.c.

Director of Buildings	(Attn: Mr L C SHUM)	Fax No. : 2845 1559
Secretary, MFC	(Attn: Mr Raymond CHENG)	Fax No. : 2714 0113

I:\WP\EA(WP1)\contaminated sediment\Memo_Control Measures for Mgt of Dreged ExcavatedCS.version 8.DOC

Appendix A

Flow Chart for Management of Contaminated Sediment#



This flow chart shall be read in conjunction with Appendix C of ETWB TC(W) No. 34/2002. M_p and M_H sediment refer to Category M sediment passing and failing respectively the biological screening.

Note: The volume refers to bulk volume.

Appendix B

Examples to illustrate how the threshold quantities are determined and how the requirements of new applications and endorsement apply

	Example	Threshold quantity for requirement of new application	Threshold quantity for requirement of endorsement by a D2/D3 Officer
		5,000m^3 or 5% of the approved quantity, whichever is more	**100,000m^3** or 5% of the approved quantity, whichever is more
(a)	Project with **large** quantity of contaminated sediment Approved Quantity: 2,500,000m^3 Estimated Quantity: 2,750,000m^3 (i.e. increase by 250,000m^3)	**125,000m^3** because 5% of approved quantity, i.e.125,000m^3 is more than 5,000m^3. A new application is required because the increased quantity i.e. 250,000m^3 exceeds 125,000m^3.	**125,000m^3** because 5% of the approved quantity, i.e. 125,000 m^3 is more than 100,000m^3. The new application shall be endorsed by a D3 officer because the increased quantity exceeds 125,000m^3.
(b)	Project with **medium** quantity of contaminated sediment Approved Quantity: 120,000m^3 Estimated Quantity: 132,00 m^3 (i.e. increase by 12,000m^3)	**6,000m^3** because 5% of approved quantity, i.e.6,000m^3 is more than 5,000m^3. A new application is required because the increased quantity i.e. 12,000m^3 exceeds 6,000m^3.	**100,000m^3** because 100,000m^3 is more than 5% of the approved quantity, i.e. 6,000 m^3. The new application shall be endorsed by a D2 officer because the increased quantity does not exceed 100,000m^3.
(c)	Project with **small** quantity of contaminated sediment Approved Quantity: 10,000m^3 Estimated Quantity: 11,000m^3 (i.e. increase by 1,000m^3)	**5,000m^3** because 5,000m^3 is more than 5% of approved quantity, i.e.500m^3. A new application is <u>not</u> required because the increased quantity, i.e. 1,000m^3 does not exceed 5,000m^3.	NA

* The threshold quantities determined for the respective example cases are shown in bold.

Appendix 4.2

Relevant EPD's Sediment Monitoring Results

Summary statistics for bottom sediment quality in the Port Shelter and Mirs Bay WCZs, 2016 - 2020

	Inner Port Shelter	Outer Port Shelter		Starling Inlet	Crooked Island		Port Island	Mirs Bay (North)
Parameter	PS3	PS5	PS6	MS1	MS2	MS7	MS17	MS3
Number of samples	10	10	10	10	10	10	10	10
Particle Size Fractionation <63µm (%w/w)	80 (10 - 97)	58 (9 - 96)	68 (9 - 89)	86 (26 - 98)	89 (4 - 99)	80 (2 - 99)	84 (6 - 99)	79 (7 - 94)
Electrochemical Potential (mV)	-276 (-395 - -103)	-212 (-387 - -88)	-224 (-399 - -126)	-248 (-383 - -139)	-328 (-401 - -194)	-337 (-415 - -214)	-241 (-383 - -58)	-251 (-386 - -108)
Total Solids (%w/w)	36 (30 - 39)	51 (40 - 64)	50 (44 - 54)	42 (38 - 47)	34 (30 - 38)	29 (27 - 36)	35 (32 - 39)	42 (36 - 49)
Total Volatile Soilds (%TS)	12.0 (11.0 - 13.0)	8.6 (6.4 - 12.0)	8.5 (7.6 - 9.4)	7.4 (6.4 - 8.1)	9.3 (7.6 - 10.0)	10.8 (8.5 - 12.0)	9.8 (7.6 - 11.0)	7.7 (6.4 - 9.0)
Chemical Oxygen Demand (mg/kg)	15400 (11000 - 19000)	13400 (12000 - 17000)	13400 (11000 - 16000)	13700 (11000 - 16000)	16000 (13000 - 21000)	16700 (13000 - 21000)	15700 (14000 - 18000)	13530 (8300 - 20000)
Total Carbon (%w/w)	1.1 (0.8 - 1.3)	1.7 (1.2 - 2.4)	1.4 (1.0 - 1.8)	0.6 (0.3 - 0.8)	0.6 (0.5 - 0.7)	0.7 (0.6 - 0.8)	0.7 (0.5 - 0.9)	0.7 (0.4 - 0.9)
Ammonical Nitrogen (mg/kg)	7.78 (1.10 - 12.00)	4.83 (0.57 - 8.10)	4.73 (0.92 - 5.90)	8.49 (5.30 - 19.00)	10.27 (8.50 - 17.00)	9.90 (7.20 - 18.00)	7.86 (5.50 - 9.50)	7.68 (2.20 - 15.00)
Total Kjeldahl Nitrogen (mg/kg)	730 (630 - 1000)	570 (440 - 730)	620 (570 - 770)	520 (390 - 740)	620 (450 - 710)	680 (520 - 770)	690 (590 - 770)	550 (400 - 780)
Total Phosphorus (mg/kg)	200 (190 - 230)	200 (150 - 240)	230 (190 - 270)	190 (170 - 230)	190 (150 - 220)	180 (160 - 230)	210 (180 - 250)	200 (150 - 310)
Total Sulphide (mg/kg)	37.8 (4.2 - 65.0)	20.0 (2.1 - 43.0)	25.6 (3.5 - 54.0)	38.6 (4.3 - 170.0)	59.0 (26.0 - 140.0)	63.7 (17.0 - 100.0)	23.9 (5.7 - 55.0)	26.2 (2.9 - 65.0)
Total Cyanide (mg/kg)	<0.1 (0.1 - <0.1)	<0.1 (0.1 - <0.1)	<0.1 (0.1 - <0.1)	0.1 (0.1 - 0.2)	0.2 (0.1 - 0.2)	0.1 (0.1 - 0.2)	0.1 (0.1 - 0.2)	<0.1 (0.1 - <0.1)
Arsenic (mg/kg)	7.1 (5.5 - 8.6)	6.2 (4.3 - 10.0)	6.9 (5.2 - 9.4)	10.3 (7.7 - 13.0)	9.5 (6.4 - 11.0)	7.6 (4.0 - 9.7)	8.5 (6.5 - 11.0)	8.0 (6.3 - 9.8)
Cadmium (mg/kg)	<0.1 (0.1 - <0.1)	0.1 (0.1 - 0.2)	<0.1 (0.1 - <0.1)	0.1 (0.1 - 0.2)	0.3 (0.2 - 0.4)	0.4 (0.2 - 0.5)	<0.1 (0.1 - <0.1)	<0.1 (0.1 - <0.1)
Chromium (mg/kg)	26 (22 - 30)	21 (14 - 30)	24 (19 - 30)	32 (26 - 34)	36 (30 - 41)	31 (25 - 40)	32 (26 - 37)	28 (22 - 34)
Copper (mg/kg)	23 (19 - 32)	15 (7 - 46)	11 (9 - 16)	20 (14 - 25)	25 (21 - 29)	22 (18 - 28)	18 (15 - 20)	14 (10 - 17)
Lead (mg/kg)	41 (37 - 44)	29 (22 - 38)	34 (28 - 38)	41 (31 - 49)	47 (36 - 54)	44 (38 - 51)	43 (38 - 45)	33 (26 - 38)
Mercury (mg/kg)	0.09 (0.07 - 0.12)	0.06 (0.05 - 0.13)	0.05 (0.05 - 0.07)	0.05 (0.05 - 0.07)	0.06 (0.05 - 0.09)	0.07 (0.05 - 0.11)	0.06 (0.05 - 0.10)	0.05 (0.05 - 0.06)
Nickel (mg/kg)	17 (15 - 19)	14 (10 - 20)	17 (14 - 22)	20 (16 - 22)	24 (20 - 27)	22 (17 - 28)	24 (19 - 27)	19 (15 - 24)
Silver (mg/kg)	0.2 (0.2 - 0.3)	<0.2 (0.2 - <0.2)	<0.2 (0.2 - <0.2)	0.3 (0.2 - 0.4)	0.3 (0.2 - 0.3)	0.2 (0.2 - 0.3)	<0.2 (0.2 - <0.2)	<0.2 (0.2 - <0.2)
Zinc (mg/kg)	110 (97 - 130)	87 (46 - 170)	79 (62 - 94)	110 (82 - 130)	120 (110 - 140)	110 (94 - 140)	110 (94 - 120)	82 (66 - 100)
Total Polychlorinated Biphenyls (PCBs) (µg/kg) [3]	18 (18 - 18)	18 (18 - 18)	18 (18 - 18)	18 (18 - 18)	18 (18 - 18)	18 (18 - 18)	18 (18 - 18)	18 (18 - 18)
Low Molecular Weight Polycylic Aromatic Hydrocarbons (PAHs) (µg/kg) [4] [6]	110 (90 - 230)	100 (90 - 140)	120 (90 - 330)	120 (90 - 210)	120 (90 - 290)	140 (90 - 320)	91 (90 - 96)	120 (90 - 340)
High Molecular Weight Polycylic Aromatic Hydrocarbons (PAHs) (µg/kg) [5] [6]	52 (34 - 79)	29 (16 - 47)	29 (20 - 43)	36 (17 - 78)	37 (16 - 76)	74 (19 - 270)	49 (21 - 140)	32 (16 - 66)

Note:
1 Data presented are arithmetic means ; data in brackets indicate ranges.
2 All data are based on the analyses of bulk (unsieved) sediment and are reported on a dry weight basis unless stated otherwise.
3 Total PCBs results are derived from the summation of 18 congeners. If the concentration of a congener is below report limit (RL), the result will be taken as 0.5xRL in the calculation.
4 Low molecular weight polyaromatic hydrocarbons (PAHs) include 6 congeners of molecular weight below 200, namely : Acenaphthene, Acenaphthylene, Anthracene, Flourene, Naphthalene and Phenanthrene.
5 High molecular weight polyaromatic hydrocarbons (PAHs) include 10 congeners of molecular weight above 200, namely : Fluoranthene, Pyrene, Benzo(a)anthracene, Chrysene, Benzo(b)fluoranthene, Benzo(k)fluoranthene, Benzo(a)pyrene, Dibenzo(a,h)anthracene, Benzo(g,h,i)perylene and Indeno(1,2,3-cd)pyrene.
6 Low and high molecular weight PAHs results are derived from the summation of the corresponding congeners. If the concentration of a congener is below report limit (RL), the result will be taken as 0.5xRL in the calculation.