

## 7 Sediment Quality Impact

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### 7.1 Legislation and Standards

7.1.1 Relevant legislation and guidelines for the disposal of contaminated sediments at marine disposal sites are listed below.

- Annexes 7 and 15 of the TM-EIAO, Criteria and Guidelines for Evaluating and Assessing Waster Management Implications;
- Dumping at Sea Ordinance (DASO) (Cap.466);
- Environment, Transport and Works Bureau Technical Circular (Works) No. 34/2002 “Management of Dredged/Excavated Sediment” (ETWB TC(W) No. 34/2002); and
- Works Bureau Technical Circular (WBTC) No. 12/2000 Fill Management.

7.1.2 The DASO is the principal statutory legislation to control dumping of sediment at sea. It safeguards the water quality and ecology of Hong Kong waters.

7.1.3 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 covers the approval of dredging/excavation proposals and marine disposal of dredged/excavated sediment. ETWB TC(W) No. 34/2002 also provides guidelines for the classification of sediment based on their contaminant levels. Sediment quality criteria for classification include:

- Metals (cadmium, chromium, copper, mercury, nickel, lead, silver and zinc);
- Metalloid (arsenic); and
- Organic micro-pollutants (PAHs, PCBs and TBT).

7.1.4 Based on the criteria, sediment is classified into Category L (low contamination level), Category M (medium contamination level) or Category H (high contamination level).

7.1.5 This technical circular also stipulates a three-tier screening for sediment assessment for determining the disposal options. Details of this three-tier approach are given in **Section 7.2.3 – 7.2.5**.

## 7.2 Methodology for Sediment Quality Assessment

**7.2.1** The management framework of dredged/excavated sediment in Hong Kong is implemented under a three-tiered approach as illustrated in **Appendix 7.1** in accordance with the ETWBTC (Works) No. 34/2002. Sediment will be classified as 3 categories as follows:

- Category L** Sediment with all contaminant levels not exceeding the Lower Chemical Exceedance Level (LCEL). The material must be dredged, transported and disposed of in a manner that minimises the loss of contaminants either into solution or by suspension.
- Category M** Sediment with any one or more contaminant levels exceeding the Lower Chemical Exceedance Level (LCEL) and none exceeding the Upper Chemical Exceedance Level (UCEL). The material must be dredged and transported with care, and must be effectively isolated from the environment upon 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 Upper Chemical Exceedance Level (UCEL). The material must be dredged and transported with great care, and must be effectively isolated from the environment upon final disposal.

**7.2.2** **Table 7.1** summarises the guidelines for the assessment, sampling, testing and classification of sediment. Detailed description of the three-tier approach stipulated in the ETWB TC(W) No. 34/2002 is described below.

**Table 7.1 Test endpoints and decision criteria for Tier III biological screening under ETWBTC (Works) No. 34/2002**

Contaminants	Lower Chemical Exceedance Level (LCEL)	Upper Chemical Exceedance Level (UCEL)
<b>Heavy Metal (mg/kg dry weight)</b>		
Cadmium (Cd)	1.5	4
Chromium (Cr)	80	160
Copper (Cu)	65	110
Mercury (Hg)	0.5	1
Nickel (Ni) <sup>(1)</sup>	40	40
Lead (Pb)	75	110
Silver (Ag)	1	2

Zinc (Zn)	200	270
<b>Metalloid (mg/kg dry weight)</b>		
Arsenic	12	42
<b>Organic-PAHs (µg/kg dry weight)</b>		
PAHs (Low Molecular Weight)	550	3160
PAHs (High Molecular Weight)	1700	9600
<b>Organic-non-PAHs (µg/kg dry weight)</b>		
Total PCBs	23	180
<b>Organometallics (µg-TBT L-1 in interstitial water)</b>		
Tributyltin <sup>(1)</sup>	0.15	0.15

Note:

- (1) The contaminant level is considered to have exceeded the UCEL if it is greater than the value shown.

### ***Tier I Screening***

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

### ***Tier II Screening***

- 7.2.4 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 Type II screening, the sediment shall be classified as Category L, M or H material. Category L material is suitable for Type 1 disposal - Open Sea Disposal, but Categories M and H will require Tier III screening to further determine the disposal option.

### ***Tier III Screening***

- 7.2.5 Tier III screening is a biological screening process for further analysis of Category M and certain Category H sediment (contaminant levels exceed 10 times Lower Chemical Exceedance Level). 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 hour larvae (bivalve or echinoderm) toxicity test.

**7.2.6** **Table 7.2** summarizes 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). If the Category M material passes the biological test (i.e. Mp material), Type 1 disposal - Open Sea Disposal (Dedicated Sites) is required. In case of failure of biological test on Category M material (i.e. Mf material), Type 2 disposal - Confined Marine Disposal shall be required. For Category H material which passes the biological test (i.e. Hp material), Type 2 disposal - Confined Marine Disposal shall be required. However, Type 3 disposal - Special Treatment/Disposal shall be required for Category H material if biological test is failed (i.e. Hf material).

**Table 7.2 EPD sediment quality data between 2005 and 2009 at Junk Bay**

Toxicity Test	Endpoints Measured	Test Methods	Failure Criteria
10-day amphipod	Survival	USEPA Standard Methods for Assessing the Toxicity of Sediment-associated Contaminants with Estuarine and Marine Amphipods	Mean survival in test sediment is significantly different ( $p \leq 0.05$ ) <sup>(1)</sup> 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 <sup>(2)</sup>	PSEP Standard Recommended Guidelines for Conducting Laboratory Bioassays on the Pudget Sound Sediments – Juvenile Polychaete Sediment Bioassay, 1995	Mean dry weight in test sediment is significantly different ( $p \leq 0.05$ ) <sup>(1)</sup> 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 <sup>(3)</sup>	PSEP Standard Recommended Guidelines for Conducting Laboratory Bioassays on the Pudget Sound Sediments – Bivalve Larvae Sediment Bioassay, 1995	Mean normality survival in test sediment is significantly different ( $p \leq 0.05$ ) <sup>(1)</sup> from mean normality survival in reference sediment and mean normality survival in test sediment <80% of mean normality survival in reference sediment

Note:

- (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.

## 7.3 Review of Previous Sediment Quality Data

### *EPD's Monitoring Data*

**7.3.1** EPD conducts routine monitoring of bottom sediment quality at 45 stations within the territory of Hong Kong waters, in which the nearest station is located at Junk Bay approximately 1km to the south of the proposed CBL.

**7.3.2** **Table 7.3** summarizes the sediment contaminant levels (mean values of data collected between 2005 and 2009, data in brackets indicate ranges) and their classification. The measurement parameters include heavy metals (cadmium, chromium, copper, mercury, nickel, lead, silver, zinc, arsenic) and organic contaminants (PAHs and PCBs). Measurement of TBT was not provided. Based on the data, "Copper" and "Silver" exceeded the LCEL, and therefore the sediment shall be classified as Category M.

**Table 7.3 EPD sediment quality data between 2005 and 2009 at Junk Bay**

Contaminant	Unit	Mean Concentration (between 2005 and 2009)	Sediment Classification under ETWB TC(W) No. 34/2002
Silver (Ag)	mg/kg	2.0 (1.6 – 3.0)	Category M
Arsenic (As)	mg/kg	7.4 (6.7 – 8.5)	Category L
Cadmium (Cd)	mg/kg	0.2 (0.1 – 0.2)	Category L
Chromium (Cr)	mg/kg	46 (39 – 52)	Category L
Copper (Cu)	mg/kg	96 (73 – 120)	Category M
Nickel (Ni)	mg/kg	24 (19 – 31)	Category L
Lead (Pb)	mg/kg	50 (41 – 54)	Category L
Zinc (Zn)	mg/kg	150 (110 – 160)	Category L
Mercury (Hg)	mg/kg	0.26 (0.17 – 0.41)	Category L

Contaminant	Unit	Mean Concentration (between 2005 and 2009)	Sediment Classification under ETWB TC(W) No. 34/2002
Total PCB	µg/kg	18 (18 – 20)	Category L
Low Molecular Weight PAHs	µg/kg	97 (90 – 110)	Category L
High Molecular Weight PAHs	µg/kg	250 (90 – 420)	Category L

7.3.3 The elevated levels of heavy metals detected in the sediments of Junk Bay could often be attributed to previous industrial pollution sources in the 1960s to 1980s before pollution control legislation was introduced (EPD, 2009).

#### ***EIA for Further Development of TKO***

7.3.4 Sediment sampling works for the EIA of Further Development of TKO were conducted in March 2003. Vibrocore samples were collected at 6 locations. In these 6 locations, 2 (i.e. VC5 and VC13) of them are lying on the proposed alignment of CBL. The locations of these 2 sediment samples are presented in **Drawing no. 209506/EIA/SQ/001**.

7.3.5 **Appendix 7.2** presents a summary of the measurement results at these 2 locations. All sub-samples of these 2 locations were classified as Category L, except the following:

- VC5, depth 0.12 – 0.9m, heavy metal “Copper” exceeded the LCEL and is therefore classified as Category M.
- VC13, depth 0.9 – 1.9m, heavy metal “Mercury” exceeded the LCEL and is therefore classified as Category M.

7.3.6 No sample was classified as Category H. The concentrations of PAH and TBT of both samples were reported to be very low. No Tier III Biological Screening Test was carried out for the Category M sediment samples.

## 7.4 Sample Collection and Laboratory Analysis

### *Objectives*

- 7.4.1 The purpose of ground investigation for CBL is to obtain relevant information for the geo-chemical characteristics of the seabed sediment to be excavated from the Study Area through identification of the geological conditions, presence of contaminants and their levels, so that the subsequent decision for the sediment disposal arrangement could be made. The SI works were accomplished by collecting vibrocore, grabs sediment and in-situ samples for the subsequent laboratory analyses.

### *Sediment Sampling*

- 7.4.2 The locations of the grab and vibrocore sediments were selected with a view to obtain information for the excavation works. A summary of these sampling locations is given below and illustrated in **Drawing no. 209506/EIA/SQ/002**. The sampling work was carried out between March and April 2010 by the Term Contractor of Geotechnical Engineering Office (GEO) of CEDD.

- Grab and Vibrocore sediment samples
  - 12 sampling Locations:
    - VB1 to VB9, VB11 and VB12 for three CBL alignment options
    - VB10 for the saltwater main partly submarine alignment
- Grab sample only
  - 1 sample at Reference Location in Port Shelter (PS6)

- 7.4.3 It should be noted that the proposed saltwater main has been excluded from the scope of this EIA Study (refer to **Section 1.3**). Therefore, the testing results of VB10 are not presented in this EIA Report.

- 7.4.4 Sediment samples were retrieved by vibrocore in the marine deposit layer. Vibrocore of 100mm in diameter and 4m long was deployed from marine vessels. The sediment samples were collected at seabed level (i.e. grab sampling) and then at 0.9m, 1.9m, 2.9m below the seabed, thereafter 3m depth intervals. The depth of sediment sampling was terminated at base of marine deposits.

- 7.4.5 Grab samples of the upper deposits of seabed were collected for pore water testing at all vibrocore locations. Modified van Veen grab (or equivalent) of capacity ~2L was deployed from marine vessels and ~20L of sediment at each location was collected. All seawater trapped inside the grab during sampling was drained out carefully before any further process. After draining of seawater, individual grabs were composited on-site and split into portions for packing for laboratory pore water testing.
- 7.4.6 All sediment samples were kept at 4°C during transportation and at the laboratory prior to testing. The sampling bottle and pre-treatment methods followed the recommendation stipulated in ETWB TC(W) No. 34/2002. Sediment samples were extracted in the laboratory and placed in the appropriate containers directly after the sampling. All samples were double bagged and labelled internally and externally with indelible ink. The sample holding time for chemical and biological testing was 2 weeks and 8 weeks respectively.
- 7.4.7 The sub-samples for biological testing were stored in the same manner as described above (including for ancillary parameters). The composite samples for biological testing (where required) comprised of up to 5 sub-samples of the same category (i.e. sediment classified under the ETWB TC(W) No. 34/2002 as Categories M or H), and continuous in a vertical or horizontal profile.
- 7.4.8 Marine water of ~5L was required for preparation of elutriate testing in the laboratory for each sediment sub-sample. Sufficient quantity of marine water was collected at one location during each day of vibrocoreing. The sample holding time for elutriate samples was 1 week. Additional 10L of marine water was collected for each sampling location column for blank test. The locations for collecting water samples for the elutriate test and blank test were the same as the vibrocoreing.
- 7.4.9 Reference sediment (surface grab) of ~30L was collected at Port Shelter (PS6, E850234, N820057). Modified Van Veen grab (or equivalent) of capacity ~2L was deployed from marine vessel and ~30L of sediment was collected. Individual grabs were composited on-site and split into portions for packing, of which ~4L for elutriate testing, ~20L for pore water testing, and ~6L for biological testing respectively. Sediment sample was stored at 4°C during transportation and at the laboratory prior to testing. Marine water of



~5L was collected at the same time for preparation of elutriate samples.

### ***Laboratory Testing***

#### **Testing for Sediment Quality Assessment**

- 7.4.10 The sediment quality was assessed through laboratory analyses of sediment samples at all vibrocore locations (as in **Table 7.1**) for the chemical and/or biological parameters listed in ETWB TC(W) No. 34/2002. The reference sediment (clean sample) was also tested for comparison.
- 7.4.11 Chemical screening parameters include:
- 9 metals/metalloid: cadmium, chromium, copper, mercury, nickel, lead, silver, zinc and arsenic for all grab samples and vibrocore sub-samples; and
  - 3 organic micro-pollutants: polyaromatic hydrocarbons (PAHs) (low and high molecular weights), polychlorinated biphenyls (PCBs) (total), tributyltin (TBT) (in pore water) for all grab samples and vibrocore sub-samples.
- 7.4.12 Biological screening parameters include:
- 10-day burrowing amphipod toxicity test,
  - 20-day burrowing polychaete toxicity test, and
  - 48-96 hours larvae (bivalve or echinoderm) toxicity test.
- 7.4.13 Based on the chemical test results, the necessity and arrangement of biological tests were concluded. For every sample which required biological test based on the chemical test results and subsequent classification in accordance with the ETWBTC (Works) No. 34/2002, biological test of each sample was conducted. All analytical methods were based on the U.S. Environmental Protection Agency (U.S. EPA) or equivalent.
- 7.4.14 Details of the chemical and biological testing parameters, methodology and reporting limits for sediment quality assessment are summarised in **Tables 7.4** and **7.5**. Ancillary testing parameters including moisture content, grain size (>2000µm, 63-2000µm, and <63µm), total organic carbon, ammonia (as mg N/L), and salinity in pore water were analysed for those samples undergoing biological testing.

**Table 7.4 Chemical screening parameters for sediment quality**

Parameters	Instrumentation	Analytical Method	Reporting Limit
Cadmium (Cd)	ICP-ES & ICP-MS	<u>ICP-ES</u> APHA 3030F 3b APHA 3120B ASTM D3976-92 <u>ICP-MS</u> APHA 3030F 3b APHA 3125 A & B ASTM D3976-92 USEPA 3005A USEPA 6020A	0.05 mg/kg
Chromium (Cr)	ICP-ES & ICP-MS		0.1 mg/kg
Copper (Cu)	ICP-ES & ICP-MS		0.2 mg/kg
Mercury (Hg)	ICP-MS		0.05 mg/kg
Nickel (Ni)	ICP-ES & ICP-MS		0.2 mg/kg
Lead (Pb)	ICP-ES & ICP-MS		0.1 mg/kg
Silver (Ag)	ICP-ES & ICP-MS		0.1 mg/kg
Zinc (Zn)	ICP-ES & ICP-MS		0.2 mg/kg
Arsenic (As)	ICP-ES & ICP-MS		0.1 mg/kg
Total PAHs (Low MW)	GC-MSD	USEPA 3546, 3660B, 8630C & 8270C	55 µg/kg <sup>(1)</sup>
Total PAHs (High MW)	GC-MSD		55 µg/kg <sup>(1)</sup>
Total PCBs	GC-MSD	USEPA 3546, 3660B, 3665A, 8082 & 8270C	2 µg/kg <sup>(2)</sup>
Tributyltin <sup>(3)</sup> (TBT)	GC-MSD	UNEP/IOC/IAEA	0.015 µg/L

Note:

- (1) Reporting limit for each low and high molecular weight PAH.
- (2) Reporting limit for each PCB.
- (3) In interstitial water

**Table 7.5 Biological screening<sup>(1)</sup> parameters for sediment quality**

Toxicity Test	Test Method	Endpoints Measured	Failure Criteria
10-day amphipod	USEPA Standard Methods for Assessing the Toxicity of Sediment-associated Contaminants with Estuarine and Marine Amphipods	Survival	Mean survival in test sediment is significantly different ( $p \leq 0.05$ ) <sup>(2)</sup> from mean survival in reference sediment and mean survival in test sediment < 80% of mean survival in reference sediment.
20-day polychaete worm	PSEP Standard Recommended Guidelines for Conducting Laboratory Bioassays on the Puget Sound Sediments – Juvenile Polychaete Sediment Bioassay, 1995	Dry weight <sup>(3)</sup>	Mean dry weight in test sediment is significantly different ( $p \leq 0.05$ ) <sup>(2)</sup> from mean dry weight in reference sediment and mean dry weight in test sediment < 90% of mean dry weight in reference sediment.

Toxicity Test	Test Method	Endpoints Measured	Failure Criteria
48-96 hour larvae (bivalve or echinoderm)	PSEP Standard Recommended Guidelines for Conducting Laboratory Bioassays on the Pudget Sound Sediments – Bivalve Larvae Sediment Bioassay, 1995	Normality survival <sup>(4)</sup>	Mean normality survival in test sediment is significantly different ( $p \leq 0.05$ ) <sup>(2)</sup> from mean normality survival in reference sediment and mean normality survival in test sediment $< 80\%$ of mean normality survival in reference sediment.

Note:

- (1) Ancillary testing parameters to be analysed for all sediment samples include moisture content, grain size ( $>2000\mu\text{m}$ ,  $63\text{-}2000\mu\text{m}$ , and  $<63\mu\text{m}$ ), total organic carbon, ammonia (as mg N/L), and salinity in porewater.
- (2) Statistically significant differences should be determined using appropriate two-sample composite (e.g. t-tests) at a probability of  $p \leq 0.05$ .
- (3) Dry weight means total dry weight after deducting dead and missing worms. \
- (4) Normality survival integrates the normality and survival end points, and measures survival of only the normal larvae relative to the starting number.

#### **Elutriate and Pore Water Testing for Water Quality Assessment**

**7.4.15** Preparation of elutriate for vibrocore sediment sub-samples was 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 were also tested for comparison.

**7.4.16** Elutriate samples were prepared by sub-sampling approximately 1L of sediment sub-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 was stirred for 30 minutes on a platform shaker. After 30 minutes, the mixture was allowed for settling for 1 hour and the supernatant was then siphoned off without disturbing the settled material. The decanted solution was centrifuged to remove particulates prior to chemical analysis (approximately 2000rpm for 30 min, until visually clear). The elutriate testing parameters include:

- 9 metals/metalloid: cadmium, chromium, copper, mercury, nickel, lead, silver, zinc and arsenic;
- 3 organic micro-pollutants: PAHs (low and high molecular weights), total PCBs and TBT; and

- Ammonia, Nitrite, Nitrate, Total Kjeldahl Nitrogen, Total Phosphorus, Reactive Phosphorus and Chlorinated Pesticides.

**7.4.17** Preparation of pore water from all grab sediment samples was 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 was also tested for comparison.

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

**7.4.19** All analytical methods were based on U.S. EPA or equivalent. The details of elutriate and pore water testing parameters for water quality assessment are summarised in **Table 7.6** (including the reporting limits for the respective analytical methods).

**Table 7.6 Chemical parameters for sediment elutriate and pore water testing**

Parameters	Instrumentation	Analytical Method	Reporting Limit
Cadmium (Cd)	ICP-ES & ICP-MS	<u>ICP-ES</u> APHA 3030F 3b APHA 3120B ASTM D3976-92	0.1 µg/L
Chromium (Cr)	ICP-ES & ICP-MS		0.2 µg/L
Copper (Cu)	ICP-ES & ICP-MS		0.2 µg/L
Mercury (Hg)	ICP-MS		0.1 µg/L
Nickel (Ni)	ICP-ES & ICP-MS	<u>ICP-MS</u> APHA 3030F 3b APHA 3125 A & B USEPA 3005A USEPA 6020A	0.2 µg/L
Lead (Pb)	ICP-ES & ICP-MS		0.2 µg/L
Silver (Ag)	ICP-ES & ICP-MS		0.2 µg/L
Zinc (Zn)	ICP-ES & ICP-MS		0.4 µg/L
Arsenic (As)	ICP-ES & ICP-MS		0.2 µg/L
PAHs	GC-MSD	USEPA 3546, 3660B, 8630C & 8270C	0.1 µg/L <sup>(1)</sup>
Total PCBs	GC-MSD	USEPA 8082 & 8270C	0.01 µg/L <sup>(2)</sup>
Tributyltin (TBT)	GC-MSD	UNEP/IOC/IAEA	0.015 µg TBT/L
Ammonia	FIA	APHA 4500-NH <sub>3</sub> H	0.01mg NH <sub>3</sub> -N/L
Nitrite as N	FIA	APHA 4500-NO <sub>2</sub> B	0.01mg NO <sub>2</sub> <sup>-</sup> -N/L
Nitrate as N	FIA	APHA 4500-NO <sub>3</sub> F	0.01 NO <sub>3</sub> <sup>-</sup> -mg/L
TKN as N	FIA	APHA 4500-N <sub>org</sub> A, B & D	0.5mg N/L

Parameters	Instrumentation	Analytical Method	Reporting Limit
Total Phosphorus	FIA	APHA 4500-P B, E, F & H	0.02 mg-P/L
Reactive Phosphorus	FIA	APHA 4500-P A, F & G	0.005 mg PO <sub>4</sub> <sup>3-</sup> /L
Chlorinated Pesticides: Alpha-BHC Beta- BHC Gamma-BHC Delta-BHC Heptachlor Aldrin Heptachlor epoxide Endosulfan 1 p,p'-DDE p,p'-DDD p,p'-DDT Endosulfan sulphate	GC-MSD	USEPA 8270C	0.05 µg/L <sup>(3)</sup>

Note:

- (1) Reporting limit for both low and high molecular weights PAHs.
- (2) Reporting limit for each PCB.
- (3) Reporting limit for each Chlorinated Pesticides.

## QA/QC Requirements

**7.4.20** Field logs and site diary were 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 were recorded in the logs.

**7.4.21** Laboratory QA/QC requirements, including analyses by HOKLAS accredited laboratory, certified reference materials, spike recovery, blank samples, duplicate samples (for every 20 samples), negative/positive control for biological test, etc. were strictly followed.

## 7.5 Sediment Quality and Classification

### *Chemical screening test*

**7.5.1** There were in total 90 sub-samples from 11 vibrocore and 11 grab samples from each of the vibrocore sampling locations (i.e. the

sampling location VB10 is excluded). The detailed results of chemical screening test of the sediment samples are summarised in **Table 7.7**.

**7.5.2** The levels of cadmium, chromium, mercury, nickel, and silver were all below LCELs with concentration ranged from:

- Cadmium : <0.05 - 1.4 mg/kg,
- Chromium: 4.4 - 50 mg/kg,
- Mercury: <0.05 - 0.23 mg/kg,
- Nickel: 2.5 - 25 mg/kg,
- Silver: <0.1 - 0.1 mg/kg

**7.5.3** The concentrations of PAHs, PCBs, TBT were all below the LCELs.

**7.5.4** The levels of copper, lead, zinc, and arsenic have exceeded LCELs in some of the sub-samples including most of the grab samples. On the other hand, the level of zinc in 2 sub-samples VB3 (0.2-0.9m) and VB11 (1.9-2.9m) have exceeded the UCEL. The maximum concentrations of these metals were 106mg/kg for copper, 105mg/kg for lead, 400mg/kg for zinc and 15mg/kg for arsenic.

**7.5.5** Based on the chemical test results, 78 vibrocore sub-samples with no exceedance of LCELs were classified as Category L, whilst the 2 sub-samples VB3 (0.2-0.9m) and VB11 (1.9-2.9m) which each have an exceedance of UCEL was classified as Category H. The remaining 10 sub-samples with levels of contaminants exceeded LCELs were classified as Category M and were further tested on the biological screening tests.

**Table 7.7 Sediment Chemical Quality Data and Proposed Biological Tests**

Sampling Location	Sampling Depth (meter below seabed level)	Metals and Metalloid (mg/kg in dry wt. basis)									Organics (µg/kg in dry wt. basis)			Organo-metallic (µg TBT/L)	Overall Classification under ETWB TC(W) No. 34/2002	Biological Test
		Cd	Cr	Cu	Hg	Ni	Pb	Ag	Zn	As	Total PCB	LMW PAHs	HMW PAHs	Tributyltin - Soluble		
VB1	Grab Sample	0.13	31	73	0.11	15	40	0.1	106	4.3	All PCB congeners are <2 µg/kg	<330	<550	<0.015	M	√
	0.0-0.9	0.28	32	85	0.11	13	61	<0.1	160	3.6		<330	<550	<0.015	M	√
	0.9-1.9	<0.05	37	57	0.14	19	41	<0.1	128	4.3		<330	<550	<0.015	L	-
	1.9-2.9	<0.05	24	4.8	0.15	18	14	<0.1	60	1.7		<330	<550	<0.015	L	-
	4.9-5.9	<0.05	26	6.3	0.09	18	18	<0.1	58	2.3		<330	<550	<0.015	L	-
	7.9-8.9	<0.05	28	7.9	<0.05	20	24	<0.1	64	3.8		<330	<550	<0.015	L	-
	10.9-11.9	<0.05	29	8.3	<0.05	21	31	<0.1	66	6.3		<330	<550	<0.015	L	-
	13.9-14.9	<0.05	9.2	4.6	<0.05	2.8	8.0	<0.1	11	2.6		<330	<550	IS	L	-
	16.3-17.3	<0.05	23	8.9	<0.05	16	23	<0.1	54	6.8		<330	<550	IS	L	-
VB2	Grab Sample	<0.05	28	58	0.08	15	34	<0.1	62	5.1	All PCB congeners are <2 µg/kg	<330	<550	<0.015	L	-
	0.1-0.9	<0.05	5.8	18	<0.05	8.1	21	<0.1	26	2.5		<330	<550	<0.015	L	-
	0.9-1.9	<0.05	7.8	3.9	<0.05	6.3	17	<0.1	22	2.1		<330	<550	<0.015	L	-
	1.9-2.9	<0.05	27	7.9	<0.05	21	21	<0.1	64	3.6		<330	<550	<0.015	L	-
	4.9-5.9	<0.05	29	8.4	<0.05	22	28	<0.1	64	2.8		<330	<550	<0.015	L	-
	7.9-8.9	<0.05	33	10	<0.05	25	30	<0.1	71	3.9		<330	<550	<0.015	L	-
	10.9-11.9	<0.05	25	8.2	<0.05	18	34	<0.1	58	7.4		<330	<550	<0.015	L	-
	12.0-13.0	<0.05	24	5.9	<0.05	8.7	18	<0.1	24	9.8		<330	<550	IS	L	-
VB3	Grab Sample	0.13	35	63	0.09	18	59	0.1	124	4.9	All PCB congeners are <2 µg/kg	<330	<550	<0.015	L	-
	0.2-0.9	1.4	50	106	0.13	17	105	<0.1	400	4.2		<330	<550	<0.015	H	-
	0.9-1.9	0.16	25	31	0.10	13	56	<0.1	84	2.7		<330	<550	<0.015	L	-
	1.9-2.9	<0.05	25	8.5	<0.05	19	20	<0.1	83	1.2		<330	<550	<0.015	L	-

Sampling Location	Sampling Depth (meter below seabed level)	Metals and Metalloid (mg/kg in dry wt. basis)									Organics (µg/kg in dry wt. basis)			Organo-metallic (µg TBT/L)	Overall Classification under ETWB TC(W) No. 34/2002	Biological Test
		Cd	Cr	Cu	Hg	Ni	Pb	Ag	Zn	As	Total PCB	LMW PAHs	HMW PAHs	Tributyltin - Soluble		
	4.9-5.9	<0.05	29	8.3	<0.05	21	20	<0.1	66	1.6		<330	<550	<0.015	L	-
	7.9-8.9	<0.05	29	10	<0.05	21	23	<0.1	70	2.6		<330	<550	<0.015	L	-
	10.9-11.9	<0.05	27	8.7	<0.05	20	29	<0.1	62	5.6		<330	<550	<0.015	L	-
	13.9-14.9	<0.05	5.2	2.8	<0.05	2.5	14	<0.1	22	2.6		<330	<550	IS	L	-
VB4	Grab Sample	0.17	40	86	0.17	19	49	0.1	126	5.3	All PCB congeners are <2 µg/kg	<330	<550	<0.015	M	√
	0.0-0.9	<0.05	29	58	0.23	13	41	<0.1	101	4.3		<330	<550	<0.015	L	-
	0.9-1.9	<0.05	24	13	0.21	17	32	<0.1	76	2.6		<330	<550	<0.015	L	-
	1.9-2.9	<0.05	24	5.5	0.20	18	15	<0.1	58	1.8		<330	<550	<0.015	L	-
	4.9-5.9	<0.05	24	6.5	0.20	17	17	<0.1	54	1.1		<330	<550	<0.015	L	-
	7.9-8.9	<0.05	28	7.4	0.10	19	21	<0.1	60	2.1		<330	<550	<0.015	L	-
	10.9-11.9	<0.05	28	8.5	<0.05	21	27	<0.1	64	5.6		<330	<550	<0.015	L	-
	13.9-14.9	<0.05	21	6.4	<0.05	6.7	22	<0.1	23	2.1		<330	<550	IS	L	-
	15.9-16.7	<0.05	34	8.2	<0.05	11	13	<0.1	28	9.6		<330	<550	IS	L	-
VB5	Grab Sample	0.18	29	76	<0.05	13	45	0.1	97	4.1	All PCB congeners are <2 µg/kg	<330	<550	<0.015	M	√
	01-0.9	0.21	16	35	0.10	11	74	<0.1	93	4.7		<330	<550	<0.015	L	-
	0.9-1.9	<0.05	41	44	<0.05	21	56	<0.1	119	5.6		<330	<550	<0.015	L	-
	1.9-2.9	<0.05	26	7.2	<0.05	20	19	<0.1	61	4.1		<330	<550	<0.015	L	-
	4.9-5.9	<0.05	24	7.2	<0.05	18	20	<0.1	56	2.3		<330	<550	<0.015	L	-
	7.9-8.9	0.05	25	8.5	<0.05	19	31	<0.1	53	3.0		<330	<550	<0.015	L	-
	10.9-11.9	<0.05	24	8.6	<0.05	19	32	<0.1	57	7.2		<330	<550	<0.015	L	-
	12.8-13.8	<0.05	10	6.1	<0.05	6.6	26	<0.1	36	7.6		<330	<550	IS	L	-



Sampling Location	Sampling Depth (meter below seabed level)	Metals and Metalloid (mg/kg in dry wt. basis)									Organics (µg/kg in dry wt. basis)			Organo-metallic (µg TBT/L)	Overall Classification under ETWB TC(W) No. 34/2002	Biological Test
		Cd	Cr	Cu	Hg	Ni	Pb	Ag	Zn	As	Total PCB	LMW PAHs	HMW PAHs	Tributyltin - Soluble		
VB6	Grab Sample	0.19	33	85	0.09	14	45	0.2	103	4.7	All PCB congeners are <2 µg/kg	<330	<550	<0.015	M	√
	0.1-0.9	<0.05	43	54	0.06	20	40	<0.1	114	3.9		<330	<550	<0.015	L	-
	0.9-1.9	<0.05	37	38	<0.05	18	48	<0.1	117	4.1		<330	<550	<0.015	L	-
	1.9-2.9	<0.05	22	5	<0.05	16	14	<0.1	55	2.0		<330	<550	<0.015	L	-
	4.9-5.9	<0.05	24	6.8	<0.05	18	19	<0.1	55	1.6		<330	<550	<0.015	L	-
	7.9-8.9	<0.05	29	8.5	<0.05	21	23	<0.1	62	1.7		<330	<550	<0.015	L	-
	10.9-11.9	<0.05	29	9.1	<0.05	21	27	<0.1	62	3.7		<330	<550	<0.015	L	-
	13.9-14.9	<0.05	24	8.1	<0.05	18	30	<0.1	55	7.0		<330	<550	IS	L	-
	14.9-15.7	<0.05	11	1.9	<0.05	3.7	39	<0.1	26	15		<330	<550	IS	M	√
	0.1-0.9	<0.05	23	8.5	0.16	16	17	<0.1	55	2.5		<330	<550	<0.015	L	-
VB7	Grab Sample	0.33	36	96	0.11	19	66	0.1	230	7.1	All PCB congeners are <2 µg/kg	<330	<550	<0.015	M	√
	0.9-1.9	<0.05	42	58	0.11	19	48	<0.1	121	5.5		<330	<550	<0.015	L	-
	1.9-2.9	<0.05	21	3.7	<0.05	16	14	<0.1	53	1.3		<330	<550	<0.015	L	-
	4.9-5.9	<0.05	22	5.3	<0.05	17	15	<0.1	53	1.7		<330	<550	<0.015	L	-
	7.9-8.9	<0.05	28	6.8	<0.05	20	22	<0.1	63	1.7		<330	<550	<0.015	L	-
	10.9-11.9	<0.05	29	7.7	<0.05	21	24	<0.1	64	2.8		<330	<550	<0.015	L	-
	13.9-14.9	<0.05	25	7.4	<0.05	18	29	<0.1	59	7.7		<330	<550	IS	L	-
VB8	Grab Sample	<0.05	25	54	0.09	11	34	<0.1	97	5.2	All PCB congeners are <2 µg/kg	<330	<550	<0.015	L	-
	0.2-0.9	<0.05	30	39	<0.05	16	41	<0.1	132	3.6		<330	<550	<0.015	L	-
	0.9-1.9	<0.05	23	6.2	<0.05	17	17	<0.1	59	2.1		<330	<550	<0.015	L	-
	1.9-2.9	<0.05	23	5.2	<0.05	17	15	<0.1	58	1.3		<330	<550	<0.015	L	-

Sampling Location	Sampling Depth (meter below seabed level)	Metals and Metalloid (mg/kg in dry wt. basis)									Organics (µg/kg in dry wt. basis)			Organo-metallic (µg TBT/L)	Overall Classification under ETWB TC(W) No. 34/2002	Biological Test
		Cd	Cr	Cu	Hg	Ni	Pb	Ag	Zn	As	Total PCB	LMW PAHs	HMW PAHs	Tributyltin - Soluble		
	4.9-5.9	<0.05	25	6.9	<0.05	18	18	<0.1	57	1.2		<330	<550	<0.015	L	-
	7.9-8.9	<0.05	27	7.9	<0.05	20	26	<0.1	60	3.2		<330	<550	<0.015	L	-
	10.9-11.9	<0.05	23	7.8	<0.05	17	34	<0.1	56	7.0		<330	<550	<0.015	L	-
	12.3-13.3	<0.05	7.9	3.8	<0.05	4	58	<0.1	26	3.2		<330	<550	IS	L	-
VB9	Grab Sample	0.15	34	73	0.10	16	55	0.1	192	5.0	All PCB congeners are <2 µg/kg	<330	<550	<0.015	M	√
	0.5-0.9	0.18	26	64	0.08	12	54	<0.1	119	4.0		<330	<550	IS	L	-
	0.9-1.9	<0.05	23	12	<0.05	17	25	<0.1	68	3.6		<330	<550	<0.015	L	-
	1.9-2.9	<0.05	24	6.8	<0.05	18	17	<0.1	60	2.6		<330	<550	<0.015	L	-
	4.9-5.9	<0.05	23	6.9	<0.05	17	19	<0.1	53	1.8		<330	<550	<0.015	L	-
	7.9-8.9	<0.05	29	8.5	<0.05	21	25	<0.1	62	3.4		<330	<550	<0.015	L	-
	10.9-11.9	<0.05	24	8.7	<0.05	18	36	<0.1	59	7.4		<330	<550	<0.015	L	-
	13.9-14.9	<0.05	5.3	2.8	<0.05	1.6	18	<0.1	7.9	5.2		<330	<550	IS	L	-
VB11	Grab Sample	0.20	37	73	0.17	19	70	0.1	159	5.5	All PCB congeners are <2 µg/kg	<330	<550	<0.015	M	√
	0.5-0.9	0.13	26	38	0.09	11	48	<0.1	85	3.0		<330	<550	IS	L	-
	0.9-1.9	0.47	45	90	0.21	16	67	<0.1	317	3.7		<330	<550	<0.015	<u>H</u>	-
	1.9-2.9	<0.05	31	18	<0.05	23	35	<0.1	93	4.3		<330	<550	<0.015	L	-
	4.9-5.9	<0.05	30	8.9	<0.05	23	24	<0.1	69	3.4		<330	<550	<0.015	L	-
	7.9-8.9	<0.05	30	11	<0.05	23	31	<0.1	68	4.5		<330	<550	<0.015	L	-
	10.9-11.9	<0.05	4.4	7.6	<0.05	2.9	38	<0.1	17	7.1		<330	<550	IS	L	-
VB12	Grab Sample	0.12	37	69	0.14	18	60	0.1	130	5.0	All PCB congeners	<330	<550	<0.015	M	√
	0.1-0.9	<0.05	17	16	<0.05	11	27	<0.1	58	7.2		<330	<550	<0.015	L	-

Sampling Location	Sampling Depth (meter below seabed level)	Metals and Metalloid (mg/kg in dry wt. basis)									Organics (µg/kg in dry wt. basis)			Organo-metallic (µg TBT/L)	Overall Classification under ETWB TC(W) No. 34/2002	Biological Test
		Cd	Cr	Cu	Hg	Ni	Pb	Ag	Zn	As	Total PCB	LMW PAHs	HMW PAHs	Tributyltin - Soluble		
	0.9-1.9	0.16	44	56	0.35	18	68	<0.1	124	4.7	are <2 µg/kg	<330	<550	<0.015	L	-
	1.9-2.9	<0.05	28	6.5	<0.05	23	20	<0.1	70	3.4		<330	<550	<0.015	L	-
	4.9-5.9	<0.05	28	8.4	<0.05	21	23	<0.1	64	3.5		<330	<550	<0.015	L	-
	7.9-8.9	<0.05	32	10	<0.05	25	33	<0.1	71	4.2		<330	<550	<0.015	L	-
	10.9-11.9	<0.05	27	9	<0.05	21	35	<0.1	64	11		<330	<550	<0.015	L	-
	12.6-13.6	<0.05	5.6	1.4	<0.05	2.5	21	<0.1	15	1.9		<330	<550	IS	L	-
Port Shelter	Grab Sample (Reference Sediment Sample)	<0.05	20	9.8	0.1	14	26	<0.1	59	5.6	All PCB congeners are <2 µg/kg	<330	<550	<0.015	--	--

Note:

1. IS: Insufficient interstitial water for TBT analysis
2. Bold value denotes contaminate level exceeds the Lower Chemical Exceedance Level (LCEL)
3. Italic value denotes contaminate level exceeds the Upper Chemical Exceedance Level (UCEL)
4. Low molecular weight PAHs includes naphthalene, acenaphthylene, acenaphthene, fluorene, phenanthrene and anthracene; high molecular weight PAHs include chrysene, benzo(a)anthracene, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(a)pyrene, dibenzo(a,h.)anthracene, fluoranthene, indeno(1.2.3-cd)pyrene, pyrene and benzo(g,h,i)perylene; and
5. Total PCBs include 2,4' dichlorobiphenyl, 2,2',5 trichlorobiphenyl, 2,4',4 trichlorobiphenyl, 2,2',3,5 tetrachlorobiphenyl, 2,2',5,5' tetrachlorobiphenyl, 2,3',4,4' tetrachlorobiphenyl, 3,3',4,4' tetrachlorobiphenyl, 2,2',4,5,5' pentachlorobiphenyl, 2,3,3',4,4' pentachlorobiphenyl, 2,3',4,4',5' pentachlorobiphenyl, 3,3',4,4,5' pentachlorobiphenyl, 2,2',3,3',4,4' hexachlorobiphenyl, 2,2',3,4,4',5' hexachlorobiphenyl, 2,2',4,4',5,5' hexachlorobiphenyl, 3,3',4,4',5,5' hexachlorobiphenyl, 2,2',3,3',4,4',5 heptachlorobiphenyl, 2,2',3,4,4',5,5' heptachlorobiphenyl and 2,2',3,4',5,5',6 heptachlorobiphenyl.

### ***Biological screening test***

- 7.5.6** Biological screening tests are required for the 10 Category M sediments. **Table 7.8** summarises the samples requiring biological screening tests.
- 7.5.7** The results of 10-day burrowing amphipod toxicity test, 20-day burrowing polychaete toxicity test, and 48-hour bivalve larvae toxicity test are summarised in **Tables 7.9 – 7.11**. The results of ancillary parameters including grain size, moisture content, total organic carbon (TOC), ammonia, and salinity are summarised in **Table 7.12**.
- 7.5.8** The results showed that all the samples passed the biological tests except the Composite Sample VB1 (i.e. composited of VB1 Grab Sample & VB1 (0.0-0.9m)), VB6 Grab Sample and VB6 (14.9-15.7m) which failed in the 48-hour bivalve larvae test, as the mean normality survival percentage in these samples were more than 80% in relation to the reference and were significantly different from that of the reference sediment.
- 7.5.9** The levels of moisture content and TOC content ranged from 44 - 65% and from 0.13 - 0.45%, respectively. Levels of interstitial salinity were all found to be 32ppt except for VB6 (14.9-15.7m) and VB7 (grab sample) which were 31ppt. The levels of interstitial ammonia was between <0.05 and 0.06 mgNH<sub>3</sub>/L. The size spectrum of >2000 µm, 63-2000 µm, and <63 µm ranges from 0.6 - 2.3%, 13 - 24%, and 56 - 86.1%, respectively.

**Table 7.8 Sediment samples requiring biological screening tests**

Sampling Location	Sampling Depth (meter below seabed level)	Composite Sample
VB1	Composite of VB1 Grab Sample and VB1 (0.0-0.9m)	--
VB1	0.0-0.9	Yes
VB4	Grab Sample	
VB5	Grab Sample	--
VB6	Grab Sample	--
VB6	14.9-15.7	--
VB7	Grab Sample	--
VB9	Grab Sample	--
VB11	Grab Sample	--
VB12	Grab Sample	--

**Table 7.9 Amphipod survival in relation to reference sediment**

Sampling Location	Sampling Depth (meter below seabed level)	Mean Survival (%)	Survival in relation to reference (%) <sup>(1)</sup>	Results
Reference	-	92.0	-	-
VB1	Composite of VB1 Grab Sample and VB1 (0.0-0.9m)	93.0	101.1	Pass
VB4	Grab sample	91.0	98.9	Pass
VB5	Grab sample	87.0	94.6	Pass
VB6	Grab sample	88.0	95.7	Pass
VB6	14.9-15.7	89.0	96.7	Pass
VB7	Grab sample	89.0	96.7	Pass
VB9	Grab sample	85.0	92.4	Pass
VB11	Grab sample	85.0	92.4	Pass
VB12	Grab sample	92.0	100.0	Pass

**Table 7.10 Total dry weight of polychaete in relation to reference sediment**

Sampling Location	Sampling Depth (meter below seabed level)	Mean Total Dry Weight (mg)	Total dry weight in relation to reference (%) <sup>(1)</sup>	Results
Reference	-	86.9	-	-
VB1	Composite of VB1 Grab Sample and VB1 (0.0-0.9m)	96.7	111.3	Pass
VB4	Grab sample	99.5	114.5	Pass
VB5	Grab sample	87.8	101.0	Pass
VB6	Grab sample	88.9	102.3	Pass
VB6	14.9-15.7	101.5	116.8	Pass
VB7	Grab sample	107.9	124.2	Pass
VB9	Grab sample	100.5	115.7	Pass
VB11	Grab sample	90.8	104.5	Pass
VB12	Grab sample	88.2	101.5	Pass

Note:

- (1) As the average total dry weight of polychaete for test sediment was greater than 90% of that of the reference sediment, statistical analysis was not required.

**Table 7.11 Normality survival bivalve larvae in relation to reference sediment**

Sampling Location	Sampling Depth (meter below seabed level)	Mean Normality Survival (%)	Normal survival in relation to reference (%)	Results
Reference	-	84.3	-	-
VB1	Composite of VB1 (0.0-0.9m) and grab sample	67.1	79.6 <sup>(1)</sup>	<b>Fail</b>
VB4	Grab sample	79.0	93.7	Pass
VB5	Grab sample	74.8	88.7	Pass
VB6	Grab sample	53.4	63.3 <sup>(1)</sup>	<b>Fail</b>
VB6	14.9-15.7	61.5	73.0 <sup>(1)</sup>	<b>Fail</b>
VB7	Grab sample	76.9	91.2	Pass
VB9	Grab sample	76.6	90.9	Pass
VB11	Grab sample	80.0	94.9	Pass
VB12	Grab sample	80.6	95.6	Pass

Note:

- (1) Mean normality survival in test sediment is <80% in relation to reference sediment and is significantly different ( $p < 0.05$ ) from that in reference sediment

**Table 7. 12 Ancillary test results**

Sampling Location	Sampling Depth (meter below seabed level)	Interstitial Ammonia (mgNH <sub>3</sub> /L)	Interstitial Salinity (ppt)	Size Spectrum (percentage of sand/silt/clay, >2000µm), %	Size Spectrum (63-2000µm), %	Size Spectrum (<63µm) ,%	Moisture Content (%)	Total Organic Carbon (%)
VB1	Composite of VB1 (0.0-0.9m) and grab sample	0.05	32	2.1	24	73.9	44	0.31
VB4	Grab Sample	0.06	32	1.2	16	82.8	55	0.45
VB5	Grab Sample	<0.05	32	0.9	13	86.1	55	0.44
VB6	Grab Sample	0.05	32	0.9	22	77.1	49	0.33
VB6	14.9-15.7	<0.05	31	11	33	56.0	24	0.13
VB7	Grab Sample	0.06	31	2.3	19	78.7	65	0.37
VB9	Grab Sample	0.05	32	0.6	19	80.4	65	0.45
VB11	Grab Sample	0.06	32	1.2	16	82.8	61	0.43
VB12	Grab Sample	0.05	32	1.3	21	77.7	61	0.34

### *Elutriate Samples*

- 7.5.10** Elutriate tests were conducted for the purpose of water quality assessment (see **Section 8**) to test the extent of contaminant release when excavation activities take place. The testing parameters included heavy metals (cadmium, chromium, copper, mercury, nickel, lead, zinc and silver), metalloid (arsenic) and organic micro-pollutants (PCB, PAH and TBT), chlorinated pesticides and nutrients including  $\text{NH}_3\text{-N}$ ,  $\text{NO}_2\text{-H}$ ,  $\text{NO}_3\text{-N}$ , TKN,  $\text{PO}_4\text{-P}$ , and total phosphorus.
- 7.5.11** The elutriate test results are summarised in **Tables 7.3** and **7.14**. In general, the levels of PAHs, PCBs and TBT were all below the reporting limits.

### *Pore Water Samples*

- 7.5.12** Pore water tests were conducted (i.e. for grab samples only) also for the purpose of water quality assessment (see **Section 8**) of the potential of contaminant release when filling activities take place. The testing parameters included heavy metals (cadmium, chromium, copper, mercury, nickel, lead, zinc and silver), metalloid (arsenic) and organic micro-pollutants (PCB, PAH and TBT), chlorinated pesticides and nutrients including  $\text{NH}_3\text{-N}$ ,  $\text{NO}_2\text{-H}$ ,  $\text{NO}_3\text{-N}$ , TKN,  $\text{PO}_4\text{-P}$ , and total phosphorus.
- 7.5.13** The pore water test results of this investigation are summarised in **Tables 7.15** and **7.16**. In general, the levels of PAHs, PCBs and TBT were all below the reporting limits.



**Table 7.13 Elutriate test results (Metals, Metalloid and PAHs)**

Sampling Location	Sampling Depth (meter below seabed level)	Metals (µg/L)								Metalloid (µg/L)	Organic-PAHs (µg/L)	
		Cd	Cr	Cu	Hg	Ni	Pb	Ag	Zn	As	LMW PAH	HMW PAH
VB1	Ambient water	<0.1	4.8	37	<0.1	2.3	33	<0.2	41	21	<0.1	<0.1
	0.0-0.9	<0.1	12.0	57	<0.1	4.6	41	<0.2	65	16	<0.1	<0.1
	0.9-1.9	<0.1	6.7	35	<0.1	2.7	38	<0.2	29	21	<0.1	<0.1
	1.9-2.9	<0.1	21	32	<0.1	12.0	31	<0.2	34	33	<0.1	<0.1
	4.9-5.9	<0.1	7.3	33	<0.1	3.0	35	<0.2	30	14	<0.1	<0.1
	7.9-8.9	<0.1	22	36	<0.1	13	32	<0.2	80	13	<0.1	<0.1
	10.9-11.9	<0.1	6.5	33	<0.1	3.1	35	<0.2	25	12	<0.1	<0.1
	13.9-14.9	<0.1	6.7	34	<0.1	1.2	28	<0.2	20	13	<0.1	<0.1
	16.3-17.3	<0.1	5.3	34	<0.1	2.4	38	<0.2	17	12	<0.1	<0.1
VB2	Ambient water	<0.1	2.8	43	<0.1	7.0	55	<0.2	7.2	34	<0.1	<0.1
	0.1-0.9	<0.1	1.5	43	<0.1	4.4	57	<0.2	7.8	40	<0.1	<0.1
	0.9-1.9	<0.1	1.3	42	<0.1	5.3	52	<0.2	7.0	41	<0.1	<0.1
	1.9-2.9	<0.1	2.0	42	<0.1	4.8	51	<0.2	6.4	35	<0.1	<0.1
	4.9-5.9	<0.1	2.0	43	<0.1	4.4	52	<0.2	6.2	33	<0.1	<0.1
	7.9-8.9	<0.1	1.8	44	<0.1	5.4	61	<0.2	6.5	36	<0.1	<0.1
	10.9-11.9	<0.1	1.3	44	<0.1	4.0	52	<0.2	8.1	31	<0.1	<0.1
	12.0-13.0	<0.1	1.7	43	<0.1	6.2	53	<0.2	8.7	32	<0.1	<0.1
VB3	Ambient water	<0.1	4.7	35	<0.1	0.4	32	<0.2	18	13	<0.1	<0.1
	0.2-0.9	<0.1	5.1	34	<0.1	3.7	34	<0.2	32	19	<0.1	<0.1
	0.9-1.9	<0.1	4.4	34	<0.1	2.3	33	<0.2	85	22	<0.1	<0.1
	1.9-2.9	<0.1	8.0	33	<0.1	2.9	37	<0.2	20	20	<0.1	<0.1
	4.9-5.9	<0.1	6.0	71	<0.1	2.4	32	<0.2	16	26	<0.1	<0.1
	7.9-8.9	<0.1	6.6	37	<0.1	2.6	36	<0.2	21	21	<0.1	<0.1

Sampling Location	Sampling Depth (meter below seabed level)	Metals (µg/L)								Metalloid (µg/L)	Organic-PAHs (µg/L)	
		Cd	Cr	Cu	Hg	Ni	Pb	Ag	Zn	As	LMW PAH	HMW PAH
	10.9-11.9	<0.1	8.6	36	<0.1	2.9	48	<0.2	35	6.9	<0.1	<0.1
	13.9-14.9	<0.1	6.2	34	<0.1	2.9	36	<0.2	17	18	<0.1	<0.1
VB4	Ambient water	<0.1	5.2	41	<0.1	1.6	32	<0.2	17	8.1	<0.1	<0.1
	0.0-0.9	<0.1	6.8	38	<0.1	2.9	38	<0.2	28	16	<0.1	<0.1
	0.9-1.9	<0.1	4.7	31	<0.1	1.2	34	<0.2	7.9	37	<0.1	<0.1
	1.9-2.9	<0.1	7.4	33	<0.1	3.3	35	<0.2	42	24	<0.1	<0.1
	4.9-5.9	<0.1	6.3	34	<0.1	1.9	35	<0.2	13	18	<0.1	<0.1
	7.9-8.9	<0.1	4.9	33	<0.1	1.8	29	<0.2	13	23	<0.1	<0.1
	10.9-11.9	<0.1	4.0	32	<0.1	0.8	34	<0.2	8.6	15	<0.1	<0.1
	13.9-14.9	<0.1	5.5	33	<0.1	0.5	37	<0.2	12	17	<0.1	<0.1
	15.9-16.7	<0.1	5.8	35	<0.1	1.8	36	<0.2	61	12	<0.1	<0.1
VB5	Ambient water	<0.1	1.0	40	<0.1	7.1	51	<0.2	0.8	33	<0.1	<0.1
	0.1-0.9	<0.1	1.4	39	<0.1	3.7	50	<0.2	0.8	36	<0.1	<0.1
	0.9-1.9	<0.1	2.1	38	<0.1	5.0	55	<0.2	1.3	32	<0.1	<0.1
	1.9-2.9	<0.1	2.0	39	<0.1	5.7	53	<0.2	2.4	36	<0.1	<0.1
	4.9-5.9	<0.1	2.4	39	<0.1	5.2	50	<0.2	2.4	38	<0.1	<0.1
	7.9-8.9	<0.1	2.1	39	<0.1	4.8	51	<0.2	2.5	36	<0.1	<0.1
	10.9-11.9	<0.1	2.2	42	<0.1	6.9	58	<0.2	8.4	36	<0.1	<0.1
	12.8-13.8	<0.1	1.3	43	<0.1	3.6	54	<0.2	2.8	29	<0.1	<0.1
VB6	Ambient water	<0.1	1.4	42	<0.1	5.3	58	<0.2	1.2	40	<0.1	<0.1
	0.1-0.9	<0.1	1.9	40	<0.1	6.1	51	<0.2	<0.4	34	<0.1	<0.1
	0.9-1.9	<0.1	1.3	40	<0.1	6.2	55	<0.2	<0.4	41	<0.1	<0.1
	1.9-2.9	<0.1	1.3	40	<0.1	4.1	57	<0.2	0.6	38	<0.1	<0.1

Sampling Location	Sampling Depth (meter below seabed level)	Metals (µg/L)								Metalloid (µg/L)	Organic-PAHs (µg/L)	
		Cd	Cr	Cu	Hg	Ni	Pb	Ag	Zn	As	LMW PAH	HMW PAH
	4.9-5.9	<0.1	1.7	41	<0.1	4.9	56	<0.2	0.5	39	<0.1	<0.1
	7.9-8.9	<0.1	1.8	41	<0.1	5.0	50	<0.2	0.9	36	<0.1	<0.1
	10.9-11.9	<0.1	2.1	43	<0.1	4.1	57	<0.2	1.6	30	<0.1	<0.1
	13.9-14.9	<0.1	2.7	42	<0.1	5.6	55	<0.2	0.4	39	<0.1	<0.1
	14.9-15.7	<0.1	2.1	42	<0.1	6.0	54	<0.2	2.1	43	<0.1	<0.1
VB7	Ambient water	<0.1	4.9	36	<0.1	1.2	33	<0.2	31	15	<0.1	<0.1
	0.1-0.9	<0.1	9.4	40	<0.1	3.1	39	<0.2	36	14	<0.1	<0.1
	0.9-1.9	<0.1	6.7	36	<0.1	2.6	35	<0.2	14	27	<0.1	<0.1
	1.9-2.9	<0.1	7.5	32	<0.1	3.1	34	<0.2	18	34	<0.1	<0.1
	4.9-5.9	<0.1	4.3	32	<0.1	1.1	34	<0.2	21	5.0	<0.1	<0.1
	7.9-8.9	<0.1	4.5	32	<0.1	0.5	35	<0.2	12	18	<0.1	<0.1
	10.9-11.9	<0.1	5.1	33	<0.1	3.3	38	<0.2	24	29	<0.1	<0.1
	13.9-14.9	<0.1	5.7	32	<0.1	1.6	33	<0.2	24	17	<0.1	<0.1
VB8	Ambient water	<0.1	1.9	40	<0.1	5.1	54	<0.2	1.6	31	<0.1	<0.1
	0.2-0.9	<0.1	2.5	41	<0.1	4.8	59	<0.2	3.2	26	<0.1	<0.1
	0.9-1.9	<0.1	2.4	42	<0.1	3.8	57	<0.2	3.4	34	<0.1	<0.1
	1.9-2.9	<0.1	1.6	41	<0.1	4.9	53	<0.2	0.2	26	<0.1	<0.1
	4.9-5.9	<0.1	1.6	40	<0.1	6.5	53	<0.2	0.8	38	<0.1	<0.1
	7.9-8.9	<0.1	2.8	42	<0.1	4.2	55	<0.2	2.0	29	<0.1	<0.1
	10.9-11.9	<0.1	2.8	40	<0.1	5.5	61	<0.2	0.9	48	<0.1	<0.1
	12.3-13.3	<0.1	2.6	40	<0.1	5.6	51	<0.2	<0.4	20	<0.1	<0.1
VB9	Ambient water	<0.1	1.3	38	<0.1	3.2	57	<0.2	1.7	42	<0.1	<0.1
	0.5-0.9	<0.1	1.9	42	<0.1	5.6	50	<0.2	2.6	34	<0.1	<0.1

Sampling Location	Sampling Depth (meter below seabed level)	Metals (µg/L)								Metalloid (µg/L)	Organic-PAHs (µg/L)	
		Cd	Cr	Cu	Hg	Ni	Pb	Ag	Zn	As	LMW PAH	HMW PAH
	0.9-1.9	<0.1	2.3	41	<0.1	4.5	54	<0.2	2.5	43	<0.1	<0.1
	1.9-2.9	<0.1	2.6	41	<0.1	4.3	54	<0.2	3.2	39	<0.1	<0.1
	4.9-5.9	<0.1	2.0	41	<0.1	6.3	56	<0.2	2.3	38	<0.1	<0.1
	7.9-8.9	<0.1	1.0	42	<0.1	4.3	57	<0.2	1.4	35	<0.1	<0.1
	10.9-11.9	<0.1	2.4	41	<0.1	5.7	50	<0.2	1.3	28	<0.1	<0.1
	13.9-14.9	<0.1	2.1	41	<0.1	4.9	56	<0.2	1.3	37	<0.1	<0.1
	0.5-0.9	<0.1	1.2	41	<0.1	4.9	57	<0.2	<0.4	44	<0.1	<0.1
VB11	Ambient water	<0.1	0.8	40	<0.1	5.6	55	<0.2	<0.4	28	<0.1	<0.1
	0.9-1.9	<0.1	1.8	40	<0.1	4.5	48	<0.2	<0.4	31	<0.1	<0.1
	1.9-2.9	<0.1	1.8	41	<0.1	4.5	54	<0.2	<0.4	32	<0.1	<0.1
	4.9-5.9	<0.1	1.8	41	<0.1	5.1	53	<0.2	<0.4	42	<0.1	<0.1
	7.9-8.9	<0.1	1.2	43	<0.1	4.6	52	<0.2	<0.4	24	<0.1	<0.1
	10.9-11.9	<0.1	1.8	45	<0.1	5.2	53	<0.2	<0.4	32	<0.1	<0.1
VB12	Ambient water	<0.1	1.9	40	<0.1	3.8	57	<0.2	2.0	32	<0.1	<0.1
	0.1-0.9	<0.1	1.1	42	<0.1	5.9	57	<0.2	2.7	28	<0.1	<0.1
	0.9-1.9	<0.1	1.2	44	<0.1	4.0	57	<0.2	3.4	35	<0.1	<0.1
	1.9-2.9	<0.1	0.8	43	<0.1	5.3	54	<0.2	2.9	29	<0.1	<0.1
	4.9-5.9	<0.1	1.5	42	<0.1	6.9	50	<0.2	1.2	39	<0.1	<0.1
	7.9-8.9	<0.1	1.7	41	<0.1	5.5	62	<0.2	1.0	29	<0.1	<0.1
	10.9-11.9	<0.1	1.4	40	<0.1	5.5	54	<0.2	0.9	43	<0.1	<0.1
	12.6-13.6	<0.1	2.8	41	<0.1	4.7	56	<0.2	1.8	37	<0.1	<0.1
Reference	Ambient water	<0.1	2.6	31	<0.1	3.1	27	<0.2	8.8	14	<0.1	<0.1

**Table 7.14 Elutriate test results (PCBs, TBT, Chlorinated Pesticides and Nutrients)**

Sampling Location	Sampling Depth (meter below seabed level)	Organic-non-PAHs (µg/L)	Organo-metallics (µg/L)	Chlorinated Pesticides (µg/L)	TKN (mg/L)	NH <sub>3</sub> -N (mg/L)	NO <sub>3</sub> -N (mg/L)	NO <sub>2</sub> -N (mg/L)	Total P (mg/L)	Ortho-P (mg/L)
		Total PCBs	TBT							
VB1	Ambient water	<0.01	<0.015	<0.05	<0.5	0.15	0.08	0.01	0.17	0.036
	0.0-0.9	<0.01	<0.015	<0.05	1.5	1.2	0.49	0.01	0.39	0.029
	0.9-1.9	<0.01	<0.015	<0.05	2.2	1.3	1.3	0.02	0.34	0.11
	1.9-2.9	<0.01	<0.015	<0.05	1.5	1.3	0.07	0.02	0.26	0.094
	4.9-5.9	<0.01	<0.015	<0.05	1.2	1.1	0.15	0.02	0.32	0.088
	7.9-8.9	<0.01	<0.015	<0.05	0.6	0.5	0.19	0.02	0.21	0.072
	10.9-11.9	<0.01	<0.015	<0.05	2.2	1.3	0.08	0.01	0.33	0.048
	13.9-14.9	<0.01	<0.015	<0.05	2.4	1.7	0.7	0.02	0.23	0.022
	16.3-17.3	<0.01	<0.015	<0.05	4.1	3.8	0.26	0.01	0.25	0.02
VB2	Ambient water	<0.01	<0.015	<0.05	<0.5	0.08	0.03	0.03	0.23	0.026
	0.1-0.9	<0.01	<0.015	<0.05	<0.5	0.07	0.05	<0.01	0.21	0.026
	0.9-1.9	<0.01	<0.015	<0.05	<0.5	0.15	0.03	0.02	0.21	0.027
	1.9-2.9	<0.01	<0.015	<0.05	<0.5	0.09	0.03	0.02	0.22	0.026
	4.9-5.9	<0.01	<0.015	<0.05	<0.5	0.08	0.04	0.02	0.20	0.027
	7.9-8.9	<0.01	<0.015	<0.05	<0.5	0.11	0.04	0.02	0.20	0.028
	10.9-11.9	<0.01	<0.015	<0.05	<0.5	0.11	0.03	0.03	0.22	0.025
	12.0-13.0	<0.01	<0.015	<0.05	<0.5	0.07	0.04	0.02	0.23	0.028
VB3	Ambient water	<0.01	<0.015	<0.05	<0.5	0.08	0.19	0.02	0.14	0.036
	0.2-0.9	<0.01	<0.015	<0.05	0.8	0.7	0.05	0.02	0.24	0.041
	0.9-1.9	<0.01	<0.015	<0.05	2.1	2.1	0.03	0.02	0.33	0.055
	1.9-2.9	<0.01	<0.015	<0.05	0.8	0.76	0.09	0.02	0.31	0.038
	4.9-5.9	<0.01	<0.015	<0.05	2.1	2.0	0.08	0.02	0.33	0.061
	7.9-8.9	<0.01	<0.015	<0.05	2.0	2.0	0.08	0.02	0.34	0.068

Sampling Location	Sampling Depth (meter below seabed level)	Organic-non-PAHs (µg/L)	Organo-metallics (µg/L)	Chlorinated Pesticides (µg/L)	TKN (mg/L)	NH <sub>3</sub> -N (mg/L)	NO <sub>3</sub> -N (mg/L)	NO <sub>2</sub> -N (mg/L)	Total P (mg/L)	Ortho-P (mg/L)
		Total PCBs	TBT							
	10.9-11.9	<0.01	<0.015	<0.05	2.2	1.7	0.1	0.02	0.30	0.037
	13.9-14.9	<0.01	<0.015	<0.05	1.6	1.4	0.07	0.02	0.31	0.04
VB4	Ambient water	<0.01	<0.015	<0.05	<0.5	0.12	0.09	0.02	0.38	0.037
	0.0-0.9	<0.01	<0.015	<0.05	1.2	1.0	0.13	0.02	0.22	0.11
	0.9-1.9	<0.01	<0.015	<0.05	1.3	1.2	0.11	0.02	0.20	0.074
	1.9-2.9	<0.01	<0.015	<0.05	0.7	0.67	0.21	0.01	0.32	0.048
	4.9-5.9	<0.01	<0.015	<0.05	1.2	1.1	0.13	0.02	0.31	0.061
	7.9-8.9	<0.01	<0.015	<0.05	1.6	1.5	0.1	0.01	0.21	0.071
	10.9-11.9	<0.01	<0.015	<0.05	3.6	2.7	0.09	0.02	0.15	0.059
	13.9-14.9	<0.01	<0.015	<0.05	2.5	2.3	0.09	0.01	0.13	0.029
	15.9-16.7	<0.01	<0.015	<0.05	1.7	1.4	0.18	0.01	0.13	0.035
VB5	Ambient water	<0.01	<0.015	<0.05	<0.5	0.07	0.04	0.03	0.20	0.028
	0.1-0.9	<0.01	<0.015	<0.05	<0.5	0.08	0.04	0.03	0.26	0.021
	0.9-1.9	<0.01	<0.015	<0.05	<0.5	0.1	0.04	0.03	0.25	0.027
	1.9-2.9	<0.01	<0.015	<0.05	<0.5	0.08	0.04	0.03	0.26	0.025
	4.9-5.9	<0.01	<0.015	<0.05	<0.5	0.12	0.03	0.02	0.24	0.023
	7.9-8.9	<0.01	<0.015	<0.05	<0.5	0.07	0.04	0.02	0.22	0.027
	10.9-11.9	<0.01	<0.015	<0.05	<0.5	0.1	0.03	0.02	0.26	0.026
	12.8-13.8	<0.01	<0.015	<0.05	<0.5	0.08	0.03	0.02	0.26	0.024
VB6	Ambient water	<0.01	<0.015	<0.05	<0.5	0.09	0.04	0.03	0.26	0.027
	0.1-0.9	<0.01	<0.015	<0.05	<0.5	0.08	0.04	0.02	0.25	0.028
	0.9-1.9	<0.01	<0.015	<0.05	<0.5	0.13	0.04	0.03	0.25	0.025
	1.9-2.9	<0.01	<0.015	<0.05	<0.5	0.09	0.03	0.03	0.24	0.024

Sampling Location	Sampling Depth (meter below seabed level)	Organic-non-PAHs (µg/L)	Organo-metallics (µg/L)	Chlorinated Pesticides (µg/L)	TKN (mg/L)	NH <sub>3</sub> -N (mg/L)	NO <sub>3</sub> -N (mg/L)	NO <sub>2</sub> -N (mg/L)	Total P (mg/L)	Ortho-P (mg/L)
		Total PCBs	TBT							
	4.9-5.9	<0.01	<0.015	<0.05	<0.5	0.1	0.04	0.03	0.25	0.027
	7.9-8.9	<0.01	<0.015	<0.05	<0.5	0.08	0.06	0.03	0.26	0.023
	10.9-11.9	<0.01	<0.015	<0.05	<0.5	0.12	0.04	0.03	0.26	0.021
	13.9-14.9	<0.01	<0.015	<0.05	<0.5	0.1	0.03	0.02	0.33	0.022
	14.9-15.7	<0.01	<0.015	<0.05	<0.5	0.07	0.03	0.03	0.22	0.024
VB7	Ambient water	<0.01	<0.015	<0.05	<0.5	0.32	0.22	0.02	0.65	0.034
	0.1-0.9	<0.01	<0.015	<0.05	<0.5	0.37	0.75	0.04	0.14	0.11
	0.9-1.9	<0.01	<0.015	<0.05	1.3	1.3	0.17	0.02	0.3	0.12
	1.9-2.9	<0.01	<0.015	<0.05	0.8	0.71	0.08	0.02	0.26	0.09
	4.9-5.9	<0.01	<0.015	<0.05	<0.5	0.42	0.19	0.01	0.21	0.033
	7.9-8.9	<0.01	<0.015	<0.05	<0.5	0.11	0.77	0.01	0.12	0.034
	10.9-11.9	<0.01	<0.015	<0.05	3.8	3.7	0.08	0.02	0.27	0.13
	13.9-14.9	<0.01	<0.015	<0.05	4.1	4.1	0.15	0.04	0.21	0.078
VB8	Ambient water	<0.01	<0.015	<0.05	<0.5	0.08	0.03	0.03	0.26	0.023
	0.2-0.9	<0.01	<0.015	<0.05	<0.5	0.08	0.04	0.03	0.25	0.026
	0.9-1.9	<0.01	<0.015	<0.05	<0.5	0.07	0.04	0.03	0.26	0.023
	1.9-2.9	<0.01	<0.015	<0.05	<0.5	0.1	0.03	0.02	0.24	0.024
	4.9-5.9	<0.01	<0.015	<0.05	<0.5	0.1	0.04	0.02	0.26	0.024
	7.9-8.9	<0.01	<0.015	<0.05	<0.5	0.08	0.04	0.03	0.21	0.021
	10.9-11.9	<0.01	<0.015	<0.05	<0.5	0.06	0.03	0.03	0.26	0.022
	12.3-13.3	<0.01	<0.015	<0.05	<0.5	0.07	0.03	0.03	0.26	0.024
VB9	Ambient water	<0.01	<0.015	<0.05	<0.5	0.08	0.03	0.03	0.26	0.024
	0.5-0.9	<0.01	<0.015	<0.05	<0.5	0.06	0.04	0.03	0.24	0.026

Sampling Location	Sampling Depth (meter below seabed level)	Organic-non-PAHs (µg/L)	Organo-metallics (µg/L)	Chlorinated Pesticides (µg/L)	TKN (mg/L)	NH <sub>3</sub> -N (mg/L)	NO <sub>3</sub> -N (mg/L)	NO <sub>2</sub> -N (mg/L)	Total P (mg/L)	Ortho-P (mg/L)
		Total PCBs	TBT							
	0.9-1.9	<0.01	<0.015	<0.05	<0.5	0.08	0.04	0.03	0.24	0.024
	1.9-2.9	<0.01	<0.015	<0.05	<0.5	0.08	0.13	0.03	0.24	0.022
	4.9-5.9	<0.01	<0.015	<0.05	<0.5	0.07	0.04	0.03	0.23	0.024
	7.9-8.9	<0.01	<0.015	<0.05	<0.5	0.09	0.04	0.03	0.21	0.02
	10.9-11.9	<0.01	<0.015	<0.05	<0.5	0.11	0.04	0.03	0.22	0.024
	13.9-14.9	<0.01	<0.015	<0.05	<0.5	0.08	0.03	0.03	0.22	0.025
VB11	Ambient water	<0.01	<0.015	<0.05	<0.5	0.16	0.03	0.03	0.54	0.024
VB11	0.5-0.9	<0.01	<0.015	<0.05	<0.5	0.13	0.04	0.03	0.48	0.025
	0.9-1.9	<0.01	<0.015	<0.05	<0.5	0.08	0.04	0.02	0.52	0.025
	1.9-2.9	<0.01	<0.015	<0.05	<0.5	0.22	0.03	0.02	0.53	0.025
	4.9-5.9	<0.01	<0.015	<0.05	<0.5	0.11	0.03	0.03	0.43	0.023
	7.9-8.9	<0.01	<0.015	<0.05	<0.5	0.12	0.04	0.03	0.42	0.026
	10.9-11.9	<0.01	<0.015	<0.05	<0.5	0.06	0.03	0.03	0.38	0.023
VB12	Ambient water	<0.01	<0.015	<0.05	<0.5	0.07	0.03	0.02	0.21	0.025
	0.1-0.9	<0.01	<0.015	<0.05	<0.5	0.1	0.03	0.02	0.22	0.022
	0.9-1.9	<0.01	<0.015	<0.05	<0.5	0.12	0.03	0.02	0.2	0.026
	1.9-2.9	<0.01	<0.015	<0.05	<0.5	0.08	0.03	0.02	0.41	0.027
	4.9-5.9	<0.01	<0.015	<0.05	<0.5	0.1	0.03	0.03	0.44	0.026
	7.9-8.9	<0.01	<0.015	<0.05	<0.5	0.13	0.04	0.02	0.57	0.026
	10.9-11.9	<0.01	<0.015	<0.05	<0.5	0.25	0.03	0.02	0.56	0.023
	12.6-13.6	<0.01	<0.015	<0.05	<0.5	0.1	0.03	0.02	0.56	0.024
Reference	Ambient water	<0.01	<0.015	<0.05	<0.5	0.06	0.03	<0.01	0.39	0.017



**Table 7.15 Pore water test results for grab samples (Metals, Metalloid and PAHs)**

Sampling Location	Metals (µg/L)								Metalloid (µg/L)	Organic-PAHs (µg/L)	
	Cd	Cr	Cu	Hg	Ni	Pb	Ag	Zn	As	LMW PAH	HMW PAH
VB1	<0.1	4.4	34	<0.1	0.6	40	<0.2	13.2	14	<0.1	<0.1
VB2	<0.1	2.1	47	<0.1	4.9	57	<0.2	9.8	26	<0.1	<0.1
VB3	<0.1	4.5	83	<0.1	0.2	36	<0.2	22.5	8	<0.1	<0.1
VB4	<0.1	4.8	42	<0.1	2.1	38	<0.2	34.3	19	<0.1	<0.1
VB5	<0.1	2.7	41	<0.1	5.8	50	<0.2	5.2	32	<0.1	<0.1
VB6	<0.1	1.4	40	<0.1	5.4	54	<0.2	0.5	38	<0.1	<0.1
VB7	<0.1	4.7	33	<0.1	1.4	34	<0.2	34.4	16	<0.1	<0.1
VB8	<0.1	1.1	42	<0.1	5.6	56	<0.2	3.4	26	<0.1	<0.1
VB9	<0.1	1.8	40	<0.1	3.9	57	<0.2	3.5	32	<0.1	<0.1
VB11	<0.1	1.3	40	<0.1	5.2	51	<0.2	<0.4	26	<0.1	<0.1
VB12	<0.1	2.1	40	<0.1	5.2	54	<0.2	3.1	35	<0.1	<0.1
Reference	<0.1	2.8	30	<0.1	2.1	25	<0.2	6.2	14	<0.1	<0.1

**Table 7.16 Pore water test results for grab samples (PCBs, TBT, Chlorinated Pesticides and Nutrients)**

Sampling Location	Organic-non-PAHs (µg/L)	Organo-metallics (µg/L)	Chlorinated Pesticides (µg/L)	TKN (mg/L)	NH <sub>3</sub> -N (mg/L)	NO <sub>3</sub> -N (mg/L)	NO <sub>2</sub> -N (mg/L)	Total P (mg/L)	Ortho-P (mg/L)
	Total PCBs	TBT							
VB1	<0.01	<0.015	<0.05	<0.5	0.10	2.00	0.02	0.12	0.034
VB2	<0.01	<0.015	<0.05	<0.5	0.07	0.03	0.03	0.22	0.024
VB3	<0.01	<0.015	<0.05	<0.5	0.16	0.53	0.02	0.16	0.04
VB4	<0.01	<0.015	<0.05	<0.5	0.13	0.10	0.01	0.15	0.036
VB5	<0.01	<0.015	<0.05	<0.5	0.06	0.03	0.02	0.26	0.027
VB6	<0.01	<0.015	<0.05	<0.5	0.09	0.04	0.03	0.26	0.026
VB7	<0.01	<0.015	<0.05	<0.5	0.16	0.43	0.02	0.18	0.034
VB8	<0.01	<0.015	<0.05	<0.5	0.12	0.04	0.03	0.26	0.023
VB9	<0.01	<0.015	<0.05	<0.5	0.10	0.04	0.03	0.24	0.024
VB11	<0.01	<0.015	<0.05	<0.5	0.17	0.03	0.02	0.54	0.024
VB12	<0.01	<0.015	<0.05	<0.5	0.06	0.03	0.02	0.24	0.025
Reference	<0.01	<0.015	<0.05	<0.5	0.06	0.03	<0.01	0.38	0.026

## 7.6 Classification of Sediment

7.6.1 Based on the chemical and biological test results, the classification of samples according to ETWBTC (Works) No. 34/2002 is summarised in **Table 7.17**. 10 sediment samples were classified as Category M of which 6 were Category Mp (Type 1 open sea disposal at dedicated sites) and 4 were Category Mf (Type 2 confined marine disposal); 2 Category H sediments were also identified. All remaining sediment samples belong to Category L (Type 1 open sea disposal).

**Table 7.17 Classification of sediment**

Sampling Location	Sampling Depth (meter below seabed level)	Sediment Category				Proposed Disposal Option (according to ETWB TC(W) No. 34/2002)
		L	Mp	Mf	H	
VB1	Grab Sample			#		Type 2 (Confined Marine Disposal)
	0.0-0.9			#		Type 2 (Confined Marine Disposal)
	0.9-1.9	#				Type 1 (Open Sea Disposal)
	1.9-2.9	#				Type 1 (Open Sea Disposal)
	4.9-5.9	#				Type 1 (Open Sea Disposal)
	7.9-8.9	#				Type 1 (Open Sea Disposal)
	10.9-11.9	#				Type 1 (Open Sea Disposal)
	13.9-14.9	#				Type 1 (Open Sea Disposal)
	16.3-17.3	#				Type 1 (Open Sea Disposal)
VB2	Grab Sample	#				Type 1 (Open Sea Disposal)
	0.1-0.9	#				Type 1 (Open Sea Disposal)
	0.9-1.9	#				Type 1 (Open Sea Disposal)
	1.9-2.9	#				Type 1 (Open Sea Disposal)
	4.9-5.9	#				Type 1 (Open Sea Disposal)
	7.9-8.9	#				Type 1 (Open Sea Disposal)
	10.9-11.9	#				Type 1 (Open Sea Disposal)
	12.0-13.0	#				Type 1 (Open Sea Disposal)
VB3	Grab Sample	#				Type 1 (Open Sea Disposal)

Sampling Location	Sampling Depth (meter below seabed level)	Sediment Category				Proposed Disposal Option (according to ETWB TC(W) No. 34/2002)
		L	Mp	Mf	H	
	0.2-0.9				#	<b>Type 2 (Confined Marine Disposal)</b>
	0.9-1.9	#				Type 1 (Open Sea Disposal)
	1.9-2.9	#				Type 1 (Open Sea Disposal)
	4.9-5.9	#				Type 1 (Open Sea Disposal)
	7.9-8.9	#				Type 1 (Open Sea Disposal)
	10.9-11.9	#				Type 1 (Open Sea Disposal)
	13.9-14.9	#				Type 1 (Open Sea Disposal)
VB4	Grab Sample		#			<b>Type 1<sup>#</sup> Open Sea Disposal (Dedicated Sites)</b>
	0.0-0.9	#				Type 1 (Open Sea Disposal)
	0.9-1.9	#				Type 1 (Open Sea Disposal)
	1.9-2.9	#				Type 1 (Open Sea Disposal)
	4.9-5.9	#				Type 1 (Open Sea Disposal)
VB4	7.9-8.9	#				Type 1 (Open Sea Disposal)
	10.9-11.9	#				Type 1 (Open Sea Disposal)
	13.9-14.9	#				Type 1 (Open Sea Disposal)
	15.9-16.7	#				Type 1 (Open Sea Disposal)
VB5	Grab Sample		#			<b>Type 1<sup>#</sup> Open Sea Disposal (Dedicated Sites)</b>
	01-0.9	#				Type 1 (Open Sea Disposal)
	0.9-1.9	#				Type 1 (Open Sea Disposal)
	1.9-2.9	#				Type 1 (Open Sea Disposal)
	4.9-5.9	#				Type 1 (Open Sea Disposal)
	7.9-8.9	#				Type 1 (Open Sea Disposal)
	10.9-11.9	#				Type 1 (Open Sea Disposal)
	12.8-13.8	#				Type 1 (Open Sea Disposal)
VB6	Grab Sample			#		<b>Type 2 (Confined Marine Disposal)</b>
	0.1-0.9	#				Type 1 (Open Sea Disposal)

Sampling Location	Sampling Depth (meter below seabed level)	Sediment Category				Proposed Disposal Option (according to ETWB TC(W) No. 34/2002)
		L	Mp	Mf	H	
	0.9-1.9	#				Type 1 (Open Sea Disposal)
	1.9-2.9	#				Type 1 (Open Sea Disposal)
	4.9-5.9	#				Type 1 (Open Sea Disposal)
	7.9-8.9	#				Type 1 (Open Sea Disposal)
	10.9-11.9	#				Type 1 (Open Sea Disposal)
	13.9-14.9	#				Type 1 (Open Sea Disposal)
	14.9-15.7			#		<b>Type 2 (Confined Marine Disposal)</b>
VB7	Grab Sample		#			<b>Type 1<sup>#</sup> Open Sea Disposal (Dedicated Sites)</b>
	0.1-0.9	#				Type 1 (Open Sea Disposal)
	0.9-1.9	#				Type 1 (Open Sea Disposal)
	1.9-2.9	#				Type 1 (Open Sea Disposal)
	4.9-5.9	#				Type 1 (Open Sea Disposal)
	7.9-8.9	#				Type 1 (Open Sea Disposal)
	10.9-11.9	#				Type 1 (Open Sea Disposal)
	13.9-14.9	#				Type 1 (Open Sea Disposal)
VB8	Grab Sample	#				Type 1 (Open Sea Disposal)
	0.2-0.9	#				Type 1 (Open Sea Disposal)
	0.9-1.9	#				Type 1 (Open Sea Disposal)
	1.9-2.9	#				Type 1 (Open Sea Disposal)
	4.9-5.9	#				Type 1 (Open Sea Disposal)
	7.9-8.9	#				Type 1 (Open Sea Disposal)
	10.9-11.9	#				Type 1 (Open Sea Disposal)
	12.3-13.3	#				Type 1 (Open Sea Disposal)
VB9	Grab Sample		#			<b>Type 1<sup>#</sup> Open Sea Disposal (Dedicated Sites)</b>
	0.5-0.9	#				Type 1 (Open Sea Disposal)
VB9	0.9-1.9	#				Type 1 (Open Sea Disposal)

Sampling Location	Sampling Depth (meter below seabed level)	Sediment Category				Proposed Disposal Option (according to ETWB TC(W) No. 34/2002)
		L	Mp	Mf	H	
	1.9-2.9	#				Type 1 (Open Sea Disposal)
	4.9-5.9	#				Type 1 (Open Sea Disposal)
	7.9-8.9	#				Type 1 (Open Sea Disposal)
	10.9-11.9	#				Type 1 (Open Sea Disposal)
	13.9-14.9	#				Type 1 (Open Sea Disposal)
VB11	Grab Sample		#			<b>Type 1<sup>#</sup> Open Sea Disposal (Dedicated Sites)</b>
	0.5-0.9	#				Type 1 (Open Sea Disposal)
	0.9-1.9				#	<b>Type 2 (Confined Marine Disposal)</b>
	1.9-2.9	#				Type 1 (Open Sea Disposal)
	4.9-5.9	#				Type 1 (Open Sea Disposal)
	7.9-8.9	#				Type 1 (Open Sea Disposal)
	10.9-11.9	#				Type 1 (Open Sea Disposal)
VB12	Grab Sample		#			<b>Type 1<sup>#</sup> Open Sea Disposal (Dedicated Sites)</b>
	0.1-0.9	#				Type 1 (Open Sea Disposal)
	0.9-1.9	#				Type 1 (Open Sea Disposal)
	1.9-2.9	#				Type 1 (Open Sea Disposal)
	4.9-5.9	#				Type 1 (Open Sea Disposal)
	7.9-8.9	#				Type 1 (Open Sea Disposal)
	10.9-11.9	#				Type 1 (Open Sea Disposal)
	12.6-13.6	#				Type 1 (Open Sea Disposal)

## 7.6.2

The classification of sediment samples given in **Table 7.17** above was used to estimate the quantities of different category of marine deposit to be excavated and disposed from CBL. This information is vital to determine the disposal options of excavated marine deposit in accordance with ETWB TC(W) No. 34/2002.

### *Estimation of quantities of excavated marine deposit*

- 7.6.3 In accordance with the proposed CBL alignment and preliminary bridge design, there are total 12 piers along the alignment. The four Western Approach Piers are numbered 1 to 4 and the six Eastern Approach Piers are numbered 5 to 10. The two piers of the main bridge are named as Pylon A and Pylon B. Among the 11 sediment sampling locations, VB3 to VB7 are located along the recommended alignment. Therefore, the testing results of these sampling locations are applied to each pier as illustrated in **Drawing no. 209506/EIA/SQ/003** based on the proximity.
- 7.6.4 Classification of sediment samples given in **Table 7.17** and the design details of the foundations at each pier and pylon, together with the data from geotechnical investigations are used to estimate the quantities of different category of marine deposit to be excavated and disposed. A summary of the estimation is provided in **Table 7.18**. Detailed calculations are given in **Appendix 7.3**. It is estimated that a total of approximately 4,300m<sup>3</sup> marine deposit is required to be excavated. Amongst the excavated volume, approximately 96.7% is Category L sediment. Category Mp, Mf, and H sediments contribute to about 3.3% of the total volume.

**Table 7.18 Estimated quantities of different categories of excavated marine deposit**

Sampling Location	Pier	Estimated quantities of excavated marine sediment (m³)				Total estimated quantities of excavated marine sediment (m³)
		Category L	Category Mp	Category Mf	Category H	
Western Approach Piers						
VB3	1	254.5	0.0	0.0	9.4	263.9
VB3	2	254.5	0.0	0.0	9.4	263.9
VB3	3	273.3	0.0	0.0	9.4	282.7
VB4	4	256.4	7.5	0.0	0.0	263.9
Main Bridge Piers						
VB4	Pylon A	688.0	18.8	0.0	0.0	706.9
VB5	Pylon B	735.1	18.8	0.0	0.0	754.0
Eastern Approach Piers						
VB6	5	256.4	0.0	7.5	0.0	263.9
VB6	6	256.4	0.0	7.5	0.0	263.9
VB6	7	273.3	0.0	28.3	0.0	301.6
VB7	8	312.9	7.5	0.0	0.0	320.4
VB7	9	284.6	7.5	0.0	0.0	292.2
VB7	10	275.2	7.5	0.0	0.0	282.7
Total estimated quantities of each category (m³)		4120.5	67.9	43.4	28.3	4260.0
Total estimated quantities of each disposal options to the nearest digit (percentage,%)		Type 1	Type 1 <sup>#</sup>	Type 2		
		4120.5 (96.7)	67.9 (1.6)	71.7 (1.7)		4260.0 (100.0)

Note:

1. Type 1 - Open sea disposal (applicable to Category L).
2. Type 1<sup>#</sup> - Open sea disposal (Dedicated sites) (applicable to Category Mp).
3. Type 2 - Confined marine disposal (applicable to Category Mf & H).



## 7.7 Conclusion

- 7.7.1 This section reviewed the sediment quality data and summarised the findings of the site investigation for sediment quality in relation to the proposed alignment of CBL. The sediment was classified in accordance with ETWB TC(W) No. 34/2002. The corresponding disposal methods were also proposed.
- 7.7.2 Classification of the sediment samples based on the chemical and biological test results, estimation of the quantities of different Categories of marine deposit to be excavated from the marine works of CBL and the corresponding disposal options are provided in this section.
- 7.7.3 Sediment quality been assessed according to the requirements of Annex 15, Guidelines for Assessment of Waste Management Implications, of the TM-EIAO. It is concluded that in respect of the marine sediment to be excavated and disposed at sea during the construction of the CBL, Annex 7, Criteria for Evaluating Waste Management Implications, of the TM-EIAO would be complied with.