5.3.2.3 Highest PCB levels were recorded in KTTS (VS14) in five consecutive years. The PAHs in the sediments of the two typhoon shelters were in very high levels (>50 μg/kg dry weight).

5.4 Assessment Methodology

5.4.1 *Sediment Chemical Quality Assessment Criteria*

5.4.1.1 The proposed reclamation is planned to commence in about 2003. The guidelines specified in the *WBTC No. 3/2000* will therefore be adopted for dredging and disposal of sediments for the whole development.

5.4.1.2 As specified in the *WBTC No. 3/2000*, sediments are classified into three categories based on their contaminant levels with reference to the Chemical Exceedance Levels (CEL). The classification is defined 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, which minimizes the loss of contaminants either into solution or by resuspension.

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 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 Upper Chemical Exceedance Level (UCEL). The material must be dredged and transported with great care, and must be effectively isolated from the environment upon the final disposal.

5.4.1.3 The sediment quality criteria for the classification of sediment are shown in **Table 5.2**. Sediment can be classified into Category L, Category M or Category H material after carrying out Tier II screening test. There are three types of disposal options. Types 1, 2 and 3 represent open sea disposal, confined marine disposal and special treatment/disposal respectively. Category L material is suitable for open sea disposal. Tier III screening test is required to determine the disposal option (Type 1 open sea disposal or Type 2 confined marine disposal) for Category M material. For Category H material with one or more contaminant levels 10 times higher than the LCEL, Tier III screening test (dilution test) is required to determine whether the sediment is suitable for Type 2 confined marine disposal or Type 3 special treatment/disposal. If contaminant levels are lower than 10 x LCEL, Type 2 confined marine disposal should be adopted.

Table 5.2 Sediment Quality Criteria for the Classification of Sediment (WBTC No. 3/2000)

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) Note 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 (mg/kg dry wt.)		
Low Molecular Weight PAHs	550	3160
High Molecular Weight PAHs	1700	9600
Organic-non-PAHs (µg/kg dry wt.)		
Total PCBs	23	180
Organometallics (µg TBT/L in Interstitial water)		
Tributyltin Note 1	0.15	0.15

Note:
1. The contaminant level is considered to have exceeded the UCEL if it is greater than the value shown.

5.4.1.4 Comparisons with the sediment classification defined in *TC No. 1-1-92* were also made in this assessment. The classification comprises of three levels and is defined as follows:

Class A Uncontaminated material, for which no special dredging, transport or disposal methods are required beyond those which would normally be applied for the purpose of ensuring compliance with EPD's Water Quality Objectives, or for protection of sensitive receptors near the dredging or disposal areas.

Class B Moderately contaminated material, which requires special care during dredging and transport, and which must be disposed of in a manner which minimizes the loss of pollutants either into solution or by re-suspension.

Class C Seriously contaminated material, which must be dredged and transported with great care, which cannot be dumped in the gazetted disposal grounds and which must be effectively isolated from the environment upon final disposal.

5.4.1.5 The classification criteria for contamination levels are shown in **Table 5.3**. It is defined that it is necessary for the concentration of only one metallic element to be exceeded for sediments to be identified as falling within a particular case.

Table 5.3 Classification Criteria for Contamination Levels (TC No. 1-1-92)

	Cd	Cr	Cu	Hg	Ni	Pb	Zn
Class A	0.0-0.9	0-49	0-54	0.0-0.7	0-34	0-34	0-140
Class B	1.0-1.4	50-79	55-64	0.8-0.9	35-39	65-74	150-190
Class C	1.5 or more	80 or more	65 or more	1.0 or more	40 or more	75 or more	200 or more

Note: All units in mg/kg dry wt.

5.4.2 *Biogas Assessment Criteria*

5.4.2.1 Methane gas is colourless and odourless but it is flammable and asphyxiating. It has the potential to cause fire, explosion or asphyxiation under the following conditions:

- The methane concentration in air is between 5 – 15% (v/v) (the Lower Explosive Limits and Upper Explosive Limit respectively);
- The gas is in a confined or semi-confined space; and

- A source of ignition is present.

5.4.2.2 A reference guidance for biogas assessment is the *Landfill Gas Hazard Assessment Guidance Note*. It is recommended in the guidance note that methane gas should be monitored periodically in all excavations, manholes and chambers and any confined spaces during construction. If the monitored methane concentration exceeds 20% Lower Explosive Limit or 1.0% methane gas (v/v), no works and no entry to the construction site should be allowed and the personnel on-site should be evacuated.

5.4.2.3 In the *Waste Management Paper No. 26A: Landfill Completion* by the UK Department of the Environment (1993), the methane emission rate of less than 0.015 m^3/hr from any boreholes drilled into the waste was recommended.

5.4.2.4 In the *Green Island Development Study*, the maximum safe rate of gas emission was 10 $L/m^2/d$. It was recommended in the study that the maximum safe rate of gas emission provides a guide for determining whether the methane emission rate poses an unacceptable risk to the development in where methane is likely to be generated. It has been agreed with EPD that this maximum safe rate of gas emission (10 $L/m^2/d$) is an acceptable guide for assessment of the potential risk of methane emission in the present study.

5.4.2.5 There are different methods for estimation of the biogas generation rate. The total organic carbon (TOC) and sediment oxygen demand (SOD) tests were adopted in a number of reclamation projects in Hong Kong to estimate biogas generation from contaminated sediment. The tests, which measure biologically degradable organic matter, are considered suitable for this purpose. The parameters of TOC and SOD are therefore used in this study for estimation of biogas generation from the sediments.

5.4.2.6 Use of TOC for biogas assessment is based on the assumptions that the organic matter in the sediments is readily degradable and there is no consideration of biological oxidation under aerobic conditions in the upper sediment layer. The assumptions for estimation of biogas generation based on SOD are that the oxygen demand is assumed to be entirely carbonaceous oxygen demand and there is no consideration of nitrogenous oxygen demand. Comparing these two methods, the rate of biogas generation estimated based on TOC would be higher than that estimated based on SOD. It is because TOC is a measure of the total organic carbon, however, some of the total organic carbon may not be biodegradable. Therefore, estimation of biogas generation based on TOC would give higher end results and would be more conservative. By assuming all organic matter is convertible to biogas, estimation based on TOC represents a worst case scenario.

5.4.3 *Sediment Sampling and Analysis*

5.4.3.1 Site investigation (SI) was carried out to determine the sediment chemical quality and potential biogas generation from the SEKD reclamation. A simple grid system (220 m) was used to allocate the sediment sampling points. A total of seven sampling points (AC1 to AC7) were selected for the KTAC. There were four sampling points in KTTS (KT1 to KT4) and seven sampling points in Hoi Sham/Kowloon Bay (KB1 to KB7). **Drawing No. 22936/EN/021** shows the distribution of sampling points for the whole SEKD.

5.4.3.2 It should be noted that in accordance with the *WBTC No. 3/2000*, instead of a 220m x 220m grid system proposed for the SI, a 50m x 50m grid is required for areas near outfalls or nullahs for the preparation of Sediment Quality Report. The number of samples is thus substantially less than those required by *WBTC No. 3/2000* but are deemed adequate for environmental impact assessment purpose. The methodology for sediment sampling, assessment of sediment chemical quality and biogas generation was agreed with EPD.

Screening Test

5.4.3.3 Two recent studies on biogas assessment including *In-situ Treatment of Kai Tak Nullah Approach Channel Sediments – Future Methane Generation Potential* and *Northshore Lantau Development Feasibility Study* indicated that a short incubation period for the SOD test may affect the final SOD result, hence the accuracy of the estimated methane generation. The SOD value of sediment is higher when the sediment is incubated for a longer period.

5.4.3.4 A SI screening test was carried out before the SI in order to determine the appropriate incubation period for the SOD test. **Table 5.4** lists the sampling points for the SI screening test.

Table 5.4 Sampling Points for the SI Screening Test

Location	Sampling Point
Kai Tak Approach Channel	AC2 and AC5
Kwun Tong Typhoon Shelter and the proposed typhoon shelter	KT2
Hoi Sham	KB5 and KB6

5.4.3.5 Grab samples were collected at the five sampling points presented in **Table 5.4** for the SI screening test. During the laboratory analysis, the SOD results were measured after the sediment samples were incubated for 1, 2, 3, 4, 7, 9, 10, 12, 15, 17 and 20 days. A sample size of 0.2g was used in the test. A plot in **Figure 5A** below shows the increase in SOD values with increasing incubation period. As shown in the figure, the SOD values increased rapidly in the first few days of incubation. The 10-day SOD values were approximately 80% of the 20-day SOD values. The last 10 days of extended incubation only provides the remaining 20% of the SOD values. The overall results indicate that the longer the incubation period the higher the SOD values. It has been agreed with EPD that the 20-day incubation period should be used for the SOD test in the SI.

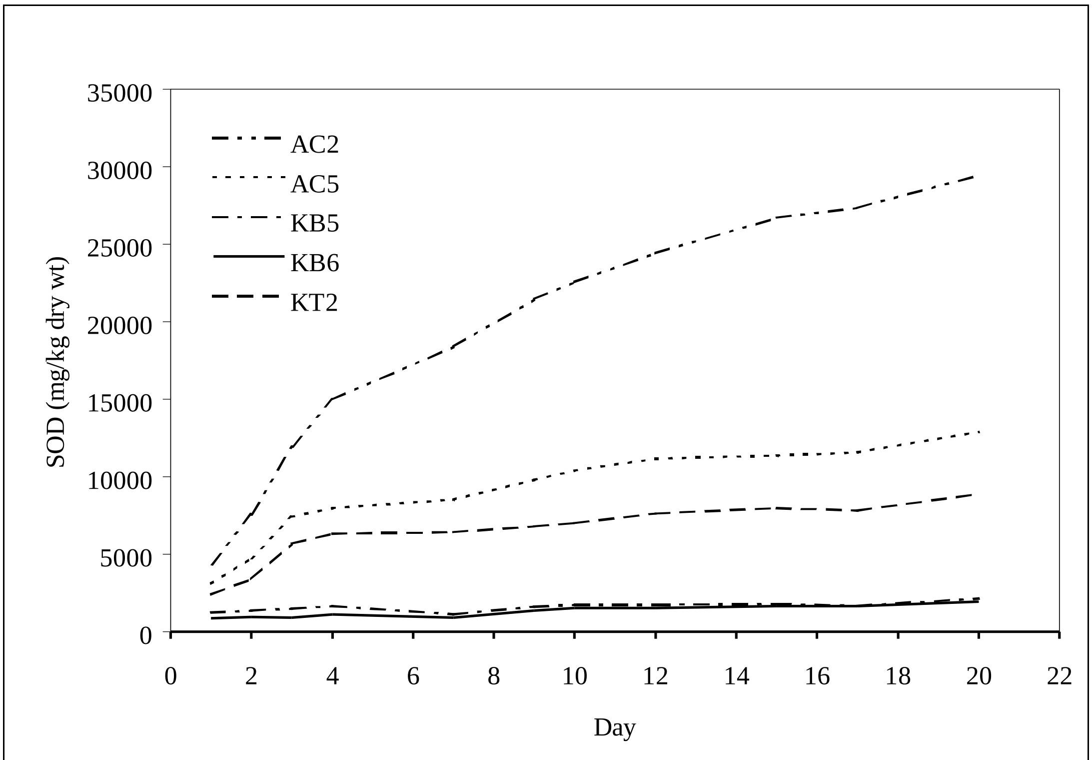

Figure 5A SOD Results for the SI Screening Test

5.4.3.6 The SI was carried in phases to cover the areas of KTAC, KTTS and Hoi Sham. **Table 5.5** summarizes the sampling locations for the SI.

Table 5.5 Locations of Sampling Points for the SI

Location	Sampling Point
Kai Tak Approach Channel	AC1, AC2, AC3, AC4, AC5, AC6 and AC7
Kwun Tong Typhoon Shelter and the Proposed Typhoon Shelter	KT1, KT2, KT3 and KT4
Hoi Sham	KB1, KB2, KB3, KB4, KB5, KB6 and KB7

Collection of Sediment Samples

5.4.3.7 Vibrocore samples were collected at the sampling points. The vibrocore penetrated into the unconsolidated mud layer until the more compact consolidated sand layer was encountered. This could easily be distinguished by the different penetration rates of the two different layers during vibrocoring. The sediment depth was further checked by visual observation of the collected vibrocore sample.

5.4.3.8 Vertical profile of the sediment core was taken at each sampling point. Three sediment samples were collected at the top 1 m layer, middle 1 m layer and bottom 1 m layer of each vibrocore sample when the sediment length was greater than 3 m. For sediment length between 900 mm and 3 m, three equal sections were divided from the top of the vibrocore samples. For sediment length less than 900 mm, three equal sections of 300 mm were divided from the top of vibrocore samples. Each sample was split into aliquots for both inorganic and organic analyses. The size of aliquots collected for inorganic and organic analyses was as follows:
Metals and metalloid: 0.5 litre
Organic: 0.5 litre

Laboratory Analysis of Sediment

5.4.3.9 The collected vibrocore samples were analyzed for the following parameters:

- Total organic carbon (TOC), sediment oxygen demand (SOD), total sulphide and acid volatile sulphide (AVS);
- Heavy metals and metalloid including cadmium (Cd), chromium (Cr), copper (Cu), mercury (Hg), nickel (Ni), lead (Pb), zinc (Zn), silver (Ag) and arsenic (As); and
- Organic micro-pollutants including polychlorinated biphenyls (PCB), tributyltin (TBT) and polyaromatic hydrocarbons (PAHs).

5.4.3.10 In order to estimate the percentage of biodegradable TOC, three grab samples of the upper layer sediment collected at the KTAC were analyzed for carbon compound fractionation using Gas Chromatography – Flame Ionization Detector (GC-FID).

5.4.3.11 Analytical methods in accordance with the *Standards Methods for the Examination of Water and Wastewater by APHA* and relevant testing methods (e.g. USEPA) were adopted in analyzing the above listed parameters.

5.5 Identification, Prediction and Evaluation of Potential Impacts

5.5.1 *Sediment Contamination*

5.5.1.1 The chemical characteristics of the sediments collected at KTAC, KTTS and Hoi Sham were determined for the SI. The average depths of the contaminated sediments in the KTAC, KTTS, Hoi Sham and near Cha Kwo Ling were 2.9m, 1.63m, 1.81m, 3.75m respectively. The