DRAINAGE SERVICES DEPARTMENT
LAND DRAINAGE DIVISION

Agreement No. CE 27/94

TERRITORIAL LAND DRAINAGE & FLOOD CONTROL STRATEGY STUDY - PHASE III

SEDIMENTATION STUDY

TASK 6, EIA

EXECUTIVE SUMMARY

May 1997

Hyder Consulting Limited

in association with
Delft Hydraulics • Dredging Research Limited
University of Strathclyde • Hyder Environmental Limited

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1. INTRODUCTION

1.1 Background

The Territorial Land Drainage and Flood Control Strategy Study Phase III Sedimentation Study is to generate a maintenance dredging strategy for the major tidal drainage channels in the Territory. The objective is to determine an appropriate methodology for maintenance dredging and sediment disposal so as to maintain or improve the channels in terms of flood protection. This study identifies appropriate dredging, sediment disposal methods and management procedures for the following thirteen drainage channels:

- River Silver;
- Shing Mun River and its tributaries including Siu Lek Yuen Nullah, Fo Tan Nullah and Tai Shui Hang Channel;
- River Indus Channel and its tributaries;
- San Tin Main Drainage Channels;
- So Kwun Wat Drainage Channel;
- Sham Tseng Nullah;
- Staunton Creek Nullah;
- Tai Po/Lam Tsuen River Channel and its tributaries;
- Yuen Long /Kam Tin / Ngau Tam Mei River Channels;
- Tin Shui Wai Western and Eastern Drainage Channels;
- Kai Tak Nullah;
- Tuen Mun River;
- Tai Lam Chung River Channel.

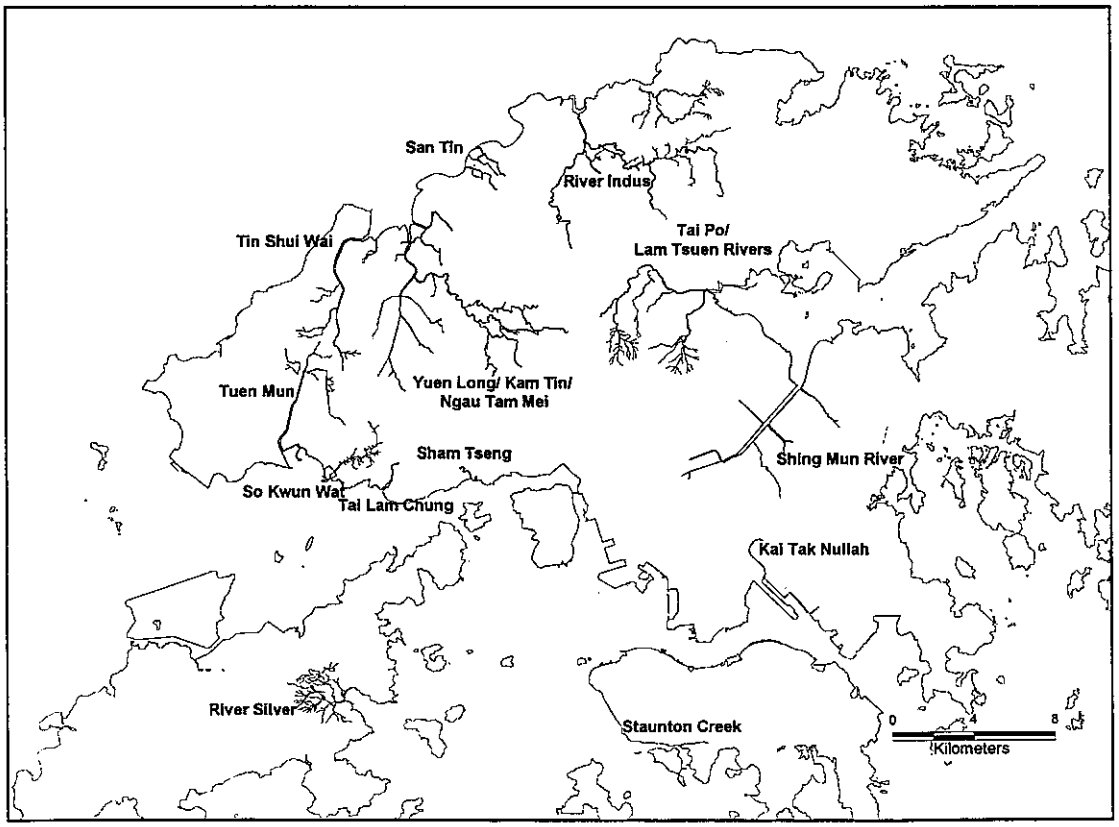


Figure 1.1 Location of the study channels.

The tasks that make up the Sedimentation Study include the following:

Task 1: Literature Review and Data Collection;

Task 2: Sediment Balance;

Task 3: Morphological Modelling;

Task 4: Maintenance Dredging Requirements;

Task 5: Dredging Operation and Sediment Disposal;

Task 6: Environmental Impact Assessment/Study;

Task 7: Contractual Arrangements and Resources Requirements; and

Task 8: Erosion Control and Maintenance Provisions.

1.2 Approach of the Environmental Impact Assessment (EIA)

The objective of the EIA has been to describe the maintenance dredging requirements and associated works and to assess and evaluate the impacts on the environment.

The EIA has evaluated the potential impacts of the proposed dredging strategy including access, transport, dredging methods and disposal options for each channel in detail and assessed the significance of impacts. Early in the study an integrated approach had been adopted with respect to the identification of dredging requirements (Task 4), the methodology for dredging and disposal (Task 5) and the EIA. The Initial Assessment Report (IAR) and Key Issues Report (KIR) were issued as the study progressed and provided environmental input to the development of dredging strategies under Tasks 4 and 5. As such, the EIA was undertaken concurrently with the development of the dredging strategy as part of an iterative design process. The dredging strategy was therefore able to incorporate environmental concerns at an early stage of the study.

Initially the potential impacts were identified through a scoping exercise utilising existing data and data collected from site visits. A Geographic Information System (GIS) was set up to handle the vast amount of data collated during the project. The initial findings were presented in the IAR *(September 1995)*, and the KIR *(August 1996)*. The key issues were found to be: sediment disposal, water quality, ecological impacts, noise and air quality.

To support the impact assessment of the proposed works field surveys were undertaken to gather baseline noise, air quality, ecological, water quality and sediment quality data. International dredging practice and sediment contamination criteria were reviewed with the aim of identifying best practice applicable to local conditions. The most efficient and environmentally acceptable dredging plant, equipment, working methods and disposal options were defined in conjunction with Task 5 and formed the basis for this assessment of environmental impacts.

2. MAINTENANCE DREDGING STRATEGY

2.1 Dredging Requirements

Flooding occurs because a channel does not have sufficient flow capacity to accommodate flood waters. Maintaining the hydraulic, or flow, capacity of a channel requires the cross-sectional area to be maintained and blockages removed. Ideally, it is preferred to control sedimentation at the source. However, if sedimentation does occur, dredging may be required to prevent an unacceptable increase in flood risk.

The two key sources of sediment in the channels are catchment derived and marine sediments transported by tidal action. Anticipated dredging requirements are more strongly influenced by catchment derived material, due to its tendency to accumulate.

Behaviour of Marine Sediments: A balance, or equilibrium, is usually established, whereby over the long term and in the absence of other influences, the river bed remains at a fairly constant level. Task 4 determined that the majority of channels in Hong Kong were at or close to their equilibrium level for marine sediments.

Behaviour of Catchment Derived Sediments: Generally, the most important sources of catchment derived sediment in Hong Kong are erosion of hill slopes, construction or quarry sites. Unlike marine sediment the coarse fraction is not in equilibrium and will tend to accumulate in areas of reduced flow velocity. Since it is primarily catchment derived sediment which results in continuous accretion it is desirable to minimise the quantity of material entering the channel from this route.

Predicted Dredging Volumes and Locations: The accumulation of catchment or marine derived sediment in areas of low flow, may ultimately decrease the cross-sectional channel area and increase the flood risk. Hydraulic modelling was carried out to assess the performance of each channel with simulated dredging and sedimentation respectfully.

The hydraulic modelling identified the need for two types of dredging operations; recurrent and restoration dredging. **Recurrent dredging** has been defined as the volume of material to be removed annually, or at a stated frequency, to maintain the channel at or below the critical bed level. **Restoration dredging** has been defined as the removal of existing accumulations of sediment which reduce the cross-section to below that defined by the dredging trigger level, or which cause significant blockage of incoming pipes and culverts. The forecast restoration dredging requirements were primarily determined from the comparison of existing bed levels with the trigger levels and levels of incoming pipes and culverts. Only the Shing Mun and Tuen Mun channels were identified as requiring restoration dredging.

Recurrent dredging volumes are based on both the estimated dredged material volume anticipated for each dredging event and the frequency with which dredging is expected. The annual average dredged volume is 57,816m^3 based on the present situation and is anticipated to increase marginally to 60,296m^3 following the implementation of the river training and flood protection works in the N and NW New Territories. Table 2.1 details the recurrent and restoration dredging requirements for each channel.

2.2 Dredging Methodologies

The preferred options were determined based on the physical and environmental constraints at the dredging locations. Tasks 4 and 5 concluded that improvements in the existing practices could be achieved through plant operation and adoption of improved instrumentation to assist accurate dredging.

Together the study tasks have developed an approach to maintenance dredging that improves operational procedures, addresses flood risk and gives due consideration to identified environmental constraints. Maintenance dredging will only be initiated when sediment bed levels rise above defined flood trigger levels. To facilitate this routine monitoring of sediment bed levels and sediment quality has been recommended. Thus, as a consequence of this approach over dredging will be avoided and dredging events will typically be less than 10,000m^3 and confined to short stretches of channel.

2.3 Disposal Strategy

Based on EPD *Technical Circular TC 1-1-92* less than 10% of the sediment to be dredged annually will be uncontaminated material (Class A). The remaining 90% would be classified as moderately contaminated, Class B, requiring open sea disposal or seriously contaminated Class C, requiring confined marine disposal. It should be noted that although the Technical Circular defines three classes of dredged sediments based on analysis of heavy metals, operation of the classification scheme has simplified and, *de facto* dredged material is classified as suitable for open sea disposal if metals are present in concentrations lower than the Class C criteria.

Treatment techniques to facilitate acceptance of sediments at disposal facilities have also been considered under Task 5. The main constraint is to meet the requirement for solid content and no free draining water for disposal to landfill. This can be resolved by the addition of lime which is both efficient and cost effective.

Following cost evaluations and extensive evaluation of environmental impacts, this study concluded that the following potential disposal options are considered viable, (depending on the classification system in operation):

- East Sha Chau;
- Open sea disposal;
- Strategic landfill;
- Public dumps;
- Beneficial uses;
- Shoreline enclosure.

The preferred disposal options are summarised in Table 2.1 and discussed further in section 7 of this summary.

2.4 Good Dredging Practice

Good dredging practice is recommended in the Task 5 Report with the objective of reducing the volume of material to be dredged. Three main components of volume minimisation are:

- use dredging methods which do not result in an excessive increase of the volume of material;
- dredging only as much as is necessary;
- dredging only when necessary.

Careful and accurate operation is required in order to minimise the addition of water and to ensure accurate removal of material. Minimising the addition of water requires grab and excavator buckets to be completely filled during ordinary operation. Grabs and excavators should be fitted with depth and position indicators to ensure the operator knows the exact dredging location in relation to the required levels. The Contractor is also encouraged to work accurately by, in addition to the Specification of appropriate instrumentation and methods of working, the incorporation of penalties for necessary overdredging.

TABLE 2.1 SUMMARY OF CHANNEL SPECIFIC DREDGING AND DISPOSAL STRATEGIES

Channel	Sediment quantity Recurrent requirement (Restoration)	Location of dredging	Preferred dredging equipment	Preferred Disposal Option	
				Short-Term	Long -Term
River Silver	1,300m^3 every two years	Catchment derived from the confluence of the upstream tributaries	Bulldozer, crane grab, trucks	Local Beneficial use - agricultural land/ habitat creation	N. Lantau Port Public Dump[1]/Beneficial use
Staunton Creek	5,000m^3 every 15 years	Downstream of Ap Lei Chau bridge	Pontoon mounted grabs and backhoes, small barges	East Sha Chau / SENT Landfill	East Sha Chau/Strategic landfill
Kai Tak Nullah	2,000m^3 per year	Upstream of airport, rubbish and catchment derived sediment	Manual work	SENT Landfill	Strategic Landfill
Shing Mun Main Channel	(148,000m^3 restoration) 20,000m^3 per year	Between Lion Rock road bridge and Banyan bridge	Pontoon mounted grabs/excavators, small barges	East Sha Chau Open sea disposal Pak Shek Kok[1]	Strategic landfill/East Sha Chau Local Beneficial use
Fo Tan Nullah	320m^3 per year	Catchment derived in lower reaches of the nullah	Tyred mini excavators, manual methods	East Sha Chau SENT/NENT Landfill	Strategic landfill /East Sha Chau
Siu Lek Yuen Nullah	7,000m^3 per year	Head of the nullah/ confluence with the main channel	Pontoon mounted grabs, backhoes, medium sized barges	Pak Shek Kok[1] / East Sha Chau /open sea disposal	Beneficial use / open sea disposal/East Sha Chau/ Strategic landfill
Tai Shui Hang	460m^3 per year	Downstream area	Backhoes and excavators with hydraulic buckets	Pak Shek Kok[1] / Local Beneficial use	Local Beneficial use
Tai Po	4,050m^3 every 3 years	Between Tai Po Road and Plover Cove Road	Pontoon mounted grabs, backhoes, small sized barges	Pak Shek Kok[1] / East Sha Chau	Strategic Landfill / East Sha Chau
Lam Tsuen	3,600m^3 every 2 years	Near the channel mouth	Pontoon mounted grabs, backhoes, small sized barges	Pak Shek Kok[1]/ East Sha Chau	As above (if clean -Beneficial use)
River Indus - Present	5,000m^3 per year	Upstream of the confluence	Pontoon mounted grabs, backhoes, long reach excavator, trucks	Landfill NENT - East Sha Chau	Strategic Landfill / Beneficial use/ ESC
River Indus - Future	8,100m^3 every 3 years	To be determined	Pontoon mounted grabs, backhoes, long reach excavator, trucks	Lanfill NENT/East Sha Chau	Strategic Landfill/East Sha Chau/Open Sea disposal

Channel	Sediment quantity Recurrent requirement (Restoration)	Location of dredging	Preferred dredging equipment	Preferred Disposal Option	
				Short-Term	Long -Term
San Tin - Present	4,200m^3 every 3 years	Over general area	Pontoon mounted grabs, backhoes, long reach excavator, trucks	Local Beneficial use/ NENT/WENT/ESC/Open Sea disposal	Local Beneficial use/Open Sea disposal/ /Strategic landfill/East Sha Chau
San Tin - Future	4,200m^3 every 10 years	To be determined	Pontoon mounted grabs, backhoes, long reach excavator, trucks	Landfill NENT - East Sha Chau / Local Beneficial use	Strategic Landfill / East Sha Chau
Yuen Long/Kam Tin/Ngau Tau Mei - Main Channel	22,000m^3 every 10 years	Upstream end of catchment	Pontoon mounted grabs, backhoes, medium sized barges	WENT/East Sha Chau	Strategic Landfill / East Sha Chau
Kam Tin	14,500m^3 every 5 years	To be determined	Pontoon mounted grabs, backhoes, medium sized barges	East Sha Chau/WENT	Strategic Landfill / East Sha Chau
Ngau Tam Mei	3,000m^3 every 5 years	To be determined	Pontoon mounted grabs, backhoes, medium sized barges	WENT/East Sha Chau	Strategic Landfill / East Sha Chau
Wo Sang Wai	17,600m^3 every 10 years	To be determined	Pontoon mounted grabs, backhoes, medium sized barges	East Sha Chau / WENT	Strategic landfill /East Sha Chau
Tin Shui Wai	7,000m^3 every 10 years	Upstream of the fabridam + monitoring of bed levels downstream	Pontoon mounted grabs, backhoes, trucks	Local Beneficial use/ ESC/WENT	Strategic landfill /East Sha Chau/Local Beneficial use
Tuen Mun	10,000m^3 every year (7,000m^3 restoration dredging)	Adjacent to Area 19	Pontoon mounted grabs, medium sized barges	East Sha Chau / WENT	Strategic landfill /East Sha Chau
So Kwun Wat	4,650m^3 every 4 years	Upstream of castle peak road	Pontoon mounted grabs, backhoes, trucks	Tuen Mun Area 38 Public Dump[1]/ Local Beneficial use/Open sea disposal	Open Sea disposal/ Local Beneficial use
Tai Lam Chung	1,400m^3 every 10 years	Upstream of castle peak road	Pontoon mounted grabs, backhoes, trucks	Tuen Mun Area 38 Public Dump[1]/ Local Beneficial use/Open sea disposal	Open Sea disposal/ Local Beneficial use
Sham Tseng	No dredging	-	_	WENT/Landfill/ESC	Strategic Landfill/ESC

1 Pak Shek Kok is a preferred option subject to further study on the potential water quality impacts. This applies to other public dump facilities specified above.

3. KEY ISSUES - WATER QUALITY

3.1 Introduction

The extent and significance of the potential impacts is dependant upon the existing water quality, the physical characteristics and pollutant concentrations in the sediment, the type, volume and location of the dredging and the environmental sensitivity of the dredging location. The primary concern relates to short term impacts from the release of sediment and associated pollutants during dredging and from the release of polluted water during handling of dredged material.

The objective of the EIA was to determine the extent of dredging effects in order to assess and evaluate water quality related impacts against standards specified in the Water Pollution Control Ordinance, (Cap 358).

3.2 Methodology and Criteria

The Shing Mun, Tai Po/Lam Tsuen and the Tuen Mun Rivers which represent almost 60% of the anticipated annual dredging requirements were selected for modelling. The predicted impacts in these channels assisted in identifying potential effects in other channels unsuitable for modelling.

The assessment was undertaken using the hydraulic model used in Task 4 in association with a water quality model. The hydraulic model is capable of simulating unsteady hydraulic flows, salt intrusion, sediment transport, morphology and water quality. The water quality model is a generalised model package with tools for calculating both the transportation of substances and the active water quality processes.

Due to scarce pollutant load data, the water quality models were configured with available monitoring data from routine EPD surveys, additional monitoring undertaken for this study and pollutant load information contained in the *River Water Quality in Hong Kong for 1994 (Ref. EPD/TR4/95)* report by EPD. Dredging operations were assumed to occur for ten hours over the eight day simulation period, during which the tidal range reduced from spring to neap. A worst case dredging scenario has been assumed for modelling the restoration dredging required in Shing Mun River. This is based on two dredgers operating simultaneously with a combined dredging rate of approximately $40m^3/hr$. Comparisons were made between the model predictions for the various scenarios in order to assess the potential effect of the proposed dredging and to determine the significance of any predicted impact.

Laboratory tests were undertaken to assess the potential for release of contaminants from sediments. Although these tests tend to overstate the concentrations they assist in identifying the key contaminants. Ammonia was produced at high levels in relation to background values, which could have impacts in the immediate vicinity of the dredging site although dilution will minimise the impact. Mitigation has been recommended to minimise the release of water during dredging and monitoring to assess its effectiveness.

3.3 Assessment Findings and Mitigation

The results of the modelling exercise indicated that suspended solid levels would increase significantly over an area of up to 500m from the dredging site. Limited impacts on DO are predicted by the modelling, however, impact monitoring has been recommended as DO is considered a key water quality indicator. Although direct mitigation using silt curtains was considered, it was found to be impractical due to operational constraints. Therefore

mitigation has been recommended in the form of improved dredging accuracy as an effective way to minimise potential impacts.

Contractual procedures that define good dredging practice were defined in Task 5 and summarised in section 2.4 of this summary. In addition, standard environmental specifications have been drafted which are applicable to all maintenance events and are presented in Section 9 of this summary.

3.4 Environmental Monitoring and Audit

The monitoring and audit programme has been categorised for each dredging event based on the quantity of sediment to be dredged, the size of the channel, and the environmental sensitivity of the dredging site. The three categories are as follows:

- Category A: No monitoring and audit required;
- Category B: Practical in-situ monitoring required; and
- Category C: Extensive monitoring including sampling and in-situ measurement.

4. KEY ISSUE - ECOLOGY

4.1 Impact Assessment

Channelisation continues to result in the removal of aquatic plants, marginal vegetation and species typical of the riparian zone. This habitat loss reduces significantly the ecological value of Hong Kong's river channels. Thus, particular ecological concerns have related to further habitat loss and disturbance to bird populations. Bird surveys were conducted in San Tin and Tin Shui Wai, channels known to support diverse/ abundant avifauna as well as providing habitat of importance for migratory, wintering or breeding birds.

Impact on Protected Areas -Deep Bay

The most significant environmental resource of the study area was the mudflat/mangrove/gei wai/fishpond habitat in Inner Deep Bay and the internationally significant bird populations supported there. The area has been designated as a Ramsar site within which works and development are excluded. In the channels around Deep Bay i.e. San Tin, Tin Shui Wai and Yuen Long Channels, potential impacts may arise from recurrent dredging for flood alleviation purposes. Mitigation and monitoring and audit has been recommended based on the ecological sensitivity of the dredging area.

Localised Impacts

There is potential for loss of small areas of foraging habitat for wading birds, however, this loss will be minimised through the controlled bed-level monitoring programme which will restrict dredging to small areas where there is a demonstrated flood risk.

Typically the faunal diversity of the channels is low and pollutant tolerant organisms are dominant. Direct impacts of sediment removal and secondary impacts such as contaminant release from sediment are not predicted to cause adverse ecological impact. However, to afford greater protection to channels with high ecological sensitivity a comprehensive water quality monitoring and audit programme has been recommended.

4.2 Mitigation

Maintenance works will generally be completed in a four to six week period and will be confined to those areas exceeding the flood trigger levels. Thus, the potential ecological

impacts are minimal provided that good practice is observed as laid out in the dredging contract manuals. The objective is to avoid unnecessary clearance of vegetation, minimise bankside damage, minimise water quality impacts and to control noise and dust emissions. Provided that these measures are implemented, no significant ecological impacts are anticipated and no ecological monitoring is required.

For channels draining into Deep Bay, *The Deep Bay Guidelines* should be followed to minimise disturbance to both migratory and local birds. This EIA has recommended reduced working hours within Buffer Zone 1 to reduce bird disturbance during dawn and dusk.

5. KEY ISSUE - NOISE

5.1 Introduction

Based on the methodology stipulated in the Technical Memorandum on Noise From Construction Work other Than Percussive Piling (TM), the noise levels at each NSR were predicted and compared to the relevant daytime assessment criteria for establishing noise mitigation measures. Having identified the need for mitigation, practical solutions were proposed.

5.2 Impact Assessment

Noise impacts were identified as a potential concern at all channels where dredging had been proposed. The assessment indicated that unmitigated noise levels at the worst affected NSR exceeded the daytime assessment criteria in some of the channels as listed in Table 5.1. The assessment presents a worst case scenario based on a static dredging operation with conservative estimates of the noise emitted by each item of plant and equipment.

5.3 Mitigation Measures

Mitigated noise levels are summarised in Table 5.1 below. The channels show exceedance in the worst-case scenario largely due to the limited distance between the plant and the sensitive receivers. For this reason the EIA has recommended that dredging works be confined to normal daytime hours 0700-1900 hours. However, in some circumstances the daytime noise guideline of 75dB(A) would be exceeded for the short duration when works are close to specific sensitive receivers. Practical mitigation measures have been explored and recommended, however the daytime noise criteria will still be exceeded for some of the channels due to the proximity of the works.

The approach to noise mitigation is to enforce "good practice" through the inclusion of standard specifications that apply to all maintenance dredging events, (see Section 9).

TABLE 5.1 UNMITIGATED AND MITIGATED NOISE LEVELS

Channel	Noise Exceedance without Mitigation (dB(A))	Noise Exceedance after mitigation (dB(A))	Proposed Mitigation/Comments
River Silver	2	0	No idling of equipment will be permitted, the use of plant will therefore be phased to avoid cumulative noise.
Shing Mun River and Tributaries	1	0	No idling of equipment will be permitted, the use of plant will therefore be phased to avoid cumulative noise.
Tai Po/Lam Tsuen	7 for School i.e. 70dB(A)	7	This represents a worst case scenario based on calculations for traditional dredging equipment. Actual exceedance at school likely to be lower. Dredging during examinations should be avoided.
San Tin	4 for Buffer Zone 1 i.e. 60dB(A)	4	Only small scale dredging equipment should be used to reduce SPL and bring noise levels to within guidelines. Dredging should be restricted to between 0800-1700hrs within Buffer zone 1.
Wo Sang Wai	4 for Buffer Zone 1 i.e. 60 dB(A)	4	Dredging should be restricted to between 0800-1700hrs within Buffer zone 1.
Tuen Mun	1 for Schools i.e. 70 dB(A)	0	Exceedance of guideline unlikely if small scale equipment used. Liaison with head teacher of school necessary to avoid examinations.
So Kwun Wat	13	13	No idling of equipment will be permitted.
Tai Lam Chung	8	6	No idling of equipment will be permitted, the use of plant will therefore be phased to avoid cumulative noise.

5.4 Environmental Monitoring and Audit

Impact monitoring has not been recommended except where works occur within 50m of a Noise Sensitive Receiver (based on calculated exceedance of the daytime 75dB(A) criteria) and are scheduled for 2 weeks or more. However, in the event that noise is the subject of local complaints during the dredging period, the EIA recommends that the Contractor be required to undertake performance monitoring.

6. KEY ISSUE - AIR QUALITY

6.1 Introduction

Air Quality impacts were initially identified as a potential area of concern due to an anticipated requirement for access roads, stockpiling and handling of significantly larger quantities of sediment than are now predicted. Since the study now forecasts much lower sediment volumes, air quality impacts are not predicted to be of significance.

6.2 Impact Assessment

Baseline monitoring data was gathered from key sites where dredging was predicted to occur in the vicinity of sensitive receivers. A qualitative assessment of potential dust impacts was undertaken based on knowledge of the dredging process, the channel specific conditions and professional judgement. The focus of the study has been to devise mitigation measures which are both cost effective and practical to implement. Potential for dust impacts is considered to be low provided that the recommended standard specifications are followed.

Odour is not predicted to be a problem for the small works required for typical maintenance events. However, a localised odour impact is anticipated for the restoration works on the Shing Mun River. Odour modelling indicated that there would be limited impacts at the ASRs. In particular, recreational users of the channel and promenade may be subjected to short term odour releases grater than those already experienced at low tide.

6.3 Mitigation Measures

In addition to the procedures defining good dredging practice, mitigation measures have been proposed to mitigate potential dust and odour impacts. These are presented as standard specifications in Section 9.

6.4 Environmental Monitoring and Audit

Given that maintenance dredging has little potential to generate dust, a specific monitoring programme is not recommended. Alternatively, standard specifications are proposed which ensure that the contractor adopts "good practice" and avoids dust generation. Monitoring and audit is considered appropriate in the event that complaints are received and substantiated. On receipt of complaints relating to dust and odour standard procedures (detailed in the EM&A manual) will be followed involving liaison with EPD, the Contractor and the complainant to resolve the issue.

7. MANAGEMENT OF DREDGED MATERIAL

7.1 Introduction

The objective of this EIA study was to assess the environmental impacts associated with disposal of dredged material as dictated by the current legislative framework. In addition, the EIA has considered the effect of possible new guidelines for sediment classification and testing (proposed by EVS Consultants) on the most environmentally acceptable disposal options. However, since there are many unknowns associated with the potential new disposal criteria the study has focused on the existing classification system, EPD TC-1-1-92.

7.2 Methodology

Sediment core and grab surveys were undertaken to determine the chemical and physical characteristics of the sediment. The objective was to assess the potential for environmental pollution arising from the dredging, handling and transportation of the sediment. Tests were also conducted to predict the potential for contaminant loss and based on these results disposal options and treatment technologies were evaluated to identify practical procedures for handling, transportation and disposal of dredged material.

As mentioned above, the impact of new assessment criteria and guidelines proposed by EVS Consultants were considered, since they may require extended testing for additional parameters in future. The EVS Consultants' proposed sediment quality values have been

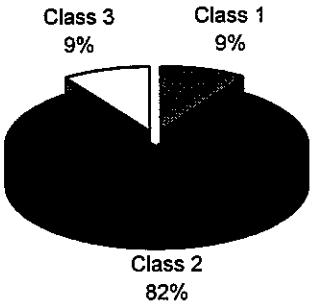
termed as Interim Sediment Quality Values (ISQV). Sediment with parameters exceeding the $ISQV_{low}$ values will be considered as moderately contaminated and those exceeding the $ISQV_{high}$ values will be considered highly contaminated. The decision making process is based on a four tiered system, the first tier involves a review of available information on potential contamination. If this is inconclusive or indicative of contamination then tier II chemical testing follows. Material exceeding the $ISQV_{low}$ value will then be subject to Tier III biological toxicity testing resulting in one of the following outcomes:

- the sediment has no effect on the selected "benchmark" organisms and can be considered safe for open marine disposal (Class 1);
- the material is found to have sub-lethal effects and confined disposal at East Sha Chau is necessary (Class 2); and
- the material has lethal effects and is subject to further Tier IV testing to determine if it is unsuitable for marine disposal (Class 3).

Classification of Channel sediment

Material was classified under the existing classification system (EPD, TC-1-1-92) and it was found that 80% of the cores contained Class C material at varying depths. This was however, attributable to one or two exceedances of the standards and typically for the metals copper, zinc and/or lead.

Figure 7.1 Potential classification of dredged sediment under EVS guidelines



To consider the standards proposed by EVS an additional sediment survey was undertaken in August 1996, locations selected were those found to be most contaminated in previous surveys and/or most likely to be dredged. None of the samples exceeded the provisional $ISQV_{high}$ values, however additional testing by EVS on up to 200 individual compounds found that 3 of the samples from the Fo Tan Nullah, River Indus and the Tuen Mun River would likely be considered as Class 3, highly polluted sediment subject to Tier IV biological testing which is yet to be defined.

7.3 Impact Assessment of Disposal Options

East Sha Chau: Currently, disposal to East Sha Chau (ESC) is the only acceptable option for highly contaminated sediments (Class C) which will be removed from the channels. ESC is a Government approved disposal site, subject to rigorous environmental monitoring and controls. Since disposal operations in the past have not had any detectable impacts on the marine environment around ESC, in the short term, continued disposal of class C material in this location is considered acceptable on environmental grounds.

In the event that the EVS study recommendations are endorsed, material which is unpolluted (Class 1) or highly polluted (Class 3) will be excluded from the mud pits.

Public dumps: Although currently not an approved disposal route, this EIA recommends that disposal of moderately contaminated material arising from the Shing Mun and the Tai Po Lam Tsuen Rivers to the Pak Shek Kok Public Dump site be considered. It is not anticipated that this material will affect the overall stability of the reclamation nor lead to increased water pollution. However, before this option could be pursued it should be subject to further study.

Landfill: In the event that a new classification system is implemented based on the current EVS Consultants' recommendations, some dredged material would be prohibited from marine disposal due to its toxicity. For polluted material which cannot easily be rendered harmless, a practical option would be disposal to landfill. The potential volume of material is small, predicted to be approximately 6,000 m^3 per annum for recurrent dredging.

The only constraint is the need to comply to the standard of at least 30% solids content and the absence of free draining water. Potential impacts on leachate treatment systems have been assessed and leachate test results indicate that the undiluted leachate from the most contaminated material would fall within the concentration ranges currently measured at the three strategic landfills. Thus, the most contaminated material arising from the study channels should be acceptable for landfill disposal.

Lime stabilisation is the favoured treatment to reduce free flowing water due to its efficiency and cost. Lime treatment of sediments stabilises contaminants through either physical or chemical treatment. A relatively small land-take would be required near to the landfill site.

Shoreline Disposal Facility: Dedicated shoreline facilities have been considered, but were rejected on economic grounds due to the small volumes of sediment likely to be disposed. However, if the disposal volumes increase dramatically reconsideration of this option is warranted.

7.4 Summary of Preferred Disposal Options

Under the current legislative framework the disposal routes recommended in this study are as follows:

- Class A sediments are recommended for local beneficial use such as reclamations, fill material, habitat creation etc.;
- Class B for open sea disposal. Disposal to Pak Shek Kok or other public dump facilities is also an option which should be subject to further study;
- Class C sediments for disposal to East Sha Chau Contaminated Mud Pits.

In the event that new guidelines are imposed based on the EVS recommendations there are two main effects:

i) Contaminated material may become suitable for open water disposal - subject to biological testing;

ii) Contaminated material may become unsuitable for marine disposal and strategic landfill is the recommended alternative.

Table 2.1 summarises the preferred disposal options in the short term and longer term.

8. ENVIRONMENTAL MONITORING AND AUDIT

8.1 Introduction

Environmental monitoring and audit (EM&A) is required to ensure that impacts from the works are minor as predicted. The proposed EM&A programme has been designed based on the quantities of sediment likely to be removed per dredging event.

In addition to the monitoring recommended under the EM&A programme, routine sediment and water quality monitoring is recommended. It is necessary that sediment be monitored on a continual basis and that this should be linked to EPD's current water quality monitoring. Such monitoring will enable Government to classify channels and determine suitable disposal routes in advance of the works. The data will facilitate an efficient and well managed maintenance programme which can be implemented at short notice.

8.2 Monitoring and Audit Schedules

Water Quality Monitoring and Audit

The main monitoring recommended by Task 6 is for water quality. In order to consider the channel size, the quantity of sediment to be removed and the environmental sensitivity of the channel, three categories have been defined as follows:

Category A: dredging events of <7000m^3 on the small channels and <10,000m^3 on the large channels do not require monitoring given the small volumes and the short duration of the works. (Unless within 500m of a water quality sensitive receiver or an SSSI/Ramsar site then category B would apply).

Category B: Between 7,000 - 20,000m^3 for the small channels **category B** water monitoring is required and between 10,000 - 30,000m^3 **category B** is required for the large channels. (If located within 500m of a designated Site of Special Scientific Interest SSSI, then Category C monitoring would apply).

Category C: Above 20,000m^3 **category C** monitoring is required for the small channels and above 30,000m^3 for the large channels. This is a consequence of both the quantity and the duration of the works and is likely to apply only to the large channels.

'Small' channels are: River Silver; Staunton Creek; Kai Tak Nullah; San Tin MDC (present); So Kwun Wat Drainage Channel; Tai Lam Chung; Sham Tseng Nullah; tributaries to Shing Mun River, Indus and Shan Pui River; and, Eastern Drainage Channel at Tin Shui Wai.

'Large' channels are: Shing Mun River Main Channel; Tai Po and Lam Tsuen River Channels; River Indus; Yuen Long Main section; Tin Shui Wai Western Drainage Channel; and, Tuen Mun River Channel and future San Tin MDC.

Sediment Monitoring: To carefully manage the need for sediment removal, a monitoring strategy has been developed involving:

i) regular survey's to establish bed levels, areas and rates of sedimentation;

ii) sampling and testing of sediments to establish their physical characteristics; and

iii) sampling and testing of sediments to monitor the extent and degree of chemical contamination.

Noise Monitoring and Audit: As a general rule, noise monitoring is not considered necessary for small scale maintenance dredging operations. However, if the Contractor proposes to work outside normal hours a construction noise permit will be required and appropriate impact monitoring undertaken. Similarly, in the event that complaints arise from noise generated by the dredging works, the Contractor shall undertake performance monitoring. To cover for extreme events, noise monitoring will be required for dredging works of two weeks or more within 50m of a noise sensitive receiver.

Air Quality Monitoring and Audit: No physical monitoring of air quality parameters is recommended for maintenance dredging works. However, a series of standard specifications are recommended to encourage and enforce "good practice" and prevent unacceptable air quality impacts. As with noise, if complaints are received; the Contractor will be required to undertake monitoring works in accordance with the requirements set out in the EM&A manual.

Ecological Monitoring and Audit: No ecological monitoring and audit has been recommended by this EIA. The standard specifications are considered to be sufficient and these have been incorporated into the dredging manuals to ensure good dredging practice and protect ecological resources.

9. STANDARD SPECIFICATIONS FOR ENVIRONMENTAL PROTECTION

9.1 Water Quality Standard Specification

i) The Contractor shall undertake water quality monitoring at locations upstream and downstream of the dredging area and at a designated control station and in accordance with the categorisation system as set out in the EM&A manual.

ii) The Contractor/Engineer shall ensure that dredging activities shall not commence when dissolved oxygen levels are below 2mg/l at mid-depth, (with the exception of water with annual averages below these values for which revised limits will be used).

iii) The Contractor shall ensure that all large solid debris such as construction waste, bicycles etc., shall be cleared away manually prior to mechanical dredging to minimise loss from partially closing grabs;

iv) The Contractor shall pay due attention to the accuracy of barge loading, including transhipment operations to minimise loss of sediment to the marine environment;

v) The Contractor shall ensure that grabs close tightly and that hoist speeds are suitably low to minimise sediment loss;

vi) The Contractor shall plan his works with due regard to sensitive receivers in close proximity.

9.2 Noise Control Standard Specifications

i) The Contractor shall restrict dredging works to the normal working hours 0700 - 1900, unless there are sound operational or environmental reasons for working outside of these times.

ii) The Contractor shall ensure that all plant and equipment used is well maintained and not excessively noisy.

iii) The Contractor shall consider noise as a constraint to his work in locating plant and equipment and arranging methods of working. The works shall be phased to avoid unnecessary cumulative plant operation and idle equipment shall be switched off .

iv) In ecologically sensitive areas (i.e. Deep Bay Buffer zone 1 and designated conservation areas e.g. SSSI sites), the Contractor shall confine works to 0800-1700 hrs.

v) Whilst planning works adjacent to sensitive receivers such as temples, schools and colleges, the Contractor shall plan his works to avoid unnecessary disturbance during examination periods, religious festivals etc.

vi) In the event that complaints are registered relating to noise generated by the dredging works, the Contractor shall employ (or the Engineer shall undertake or employ) suitable qualified staff to undertake performance monitoring. This shall continue until such time that the source of the complaint has been identified and mitigated to the satisfaction of the EPD or until the complaint is found to be unsubstantiated.

vii) In the event that dredging for two weeks or more is required at a distance of less than 50m from a noise sensitive receiver, the contractor shall undertake noise monitoring as detailed in the EM&A manual.

9.3 Air Quality Control Standard Specifications

i) The Contractor shall ensure that dredged materials are handled as efficiently as possible to avoid the generation of dust or odours.

ii) The Contractor shall ensure that there shall be no storage or drying of contaminated dredged material in the immediate vicinity of the channel. Temporary storage will be permitted where necessary provided that it is controlled and within a truck/container.

iii) The Contractor shall ensure that dredged material is kept moist at all times to prevent dust and to reduce odour.

iv) During road transportation the Contractor shall ensure that there is no discharge of dredged sediments along the route nor cause a nuisance from dust or odour pollution.

v) The Contractor shall select appropriate routing for transporting of dredged material, minimising travel through densely populated areas.

vi) In the event that complaints are registered relating to air quality arising from the dredging works, the Contractor shall employ (or the Engineer shall undertake or employ) suitably qualified staff to undertake recommended monitoring of performance, as set out in the EM&A manual. This shall continue until such time that the source of the complaint has been identified and mitigated to the satisfaction of the EPD or until the complaint is found to be unsubstantiated.

9.4 Ecological Standard Specifications

i) The Contractor shall ensure that in gaining access to the channel there is no unnecessary clearance or damage to bankside vegetation.

ii) Site remedy for any access constructed will be the responsibility of the Contractor.

iii) When working in Deep Bay Buffer Zone 1 and designated conservation areas the Contractor shall confine works to 0800 - 1700 hours.

iv) In the event that vegetation is unavoidably cleared, the Contractor shall be responsible for undertaking compensation planting based on a similar mix of native species to those removed.

v) For works within designated conservation areas or Deep Bay Buffer Zone 1 the Contractor shall liaise the WWF team at Mai Po Nature Reserve or AFD as appropriate, to determine the most appropriate working methods and programme to minimise ecological impacts.

10. CONCLUSIONS

The Sedimentation Study has defined a practical and environmentally sensitive approach to maintenance dredging. The annual quantities of sediment predicted to be dredged, not including the restoration dredging in the Shing Mun River, are small and consequently the potential environmental impacts are minor. The amount of dredging will be controlled by a routine bed level monitoring programme and initiated only when the bed levels exceed defined flood trigger levels and where there is a feasible depth of sediment (0.5m) to facilitate dredging. This is likely to be on relatively short stretches of the channels, for example, on river bends and confluence's, and the dredging period will typically be four to six weeks duration.

Given that much of the sediment is contaminated it requires careful removal, handling and disposal to avoid contamination of the environment. Dredging manuals have been prepared defining an approach based on best practice which is contractually enforced.

The environmental mitigation has been presented in the form of standard specifications applicable to all channels subject to maintenance dredging. To ensure that the recommended environmental controls are implemented, a framework for environmental monitoring and audit has been provided.

Potential Impacts and Mitigation

The main potential impact relates to a short term impact on water quality due to an increase in suspended solid levels and reductions in dissolved oxygen. The modelling has demonstrated that this impact will be confined to a relatively short length of channel, (within 500m of the dredging site) and that the impact will be short lived. However, given the potential for impacts as a result of short term DO depletion a flexible monitoring programme has been defined with a focus on this issue. Water quality monitoring and audit has been defined on a categorisation basis in order to consider the size of the dredging event, the size of the channel and the environmental sensitivity of the dredging site. Furthermore it has been recommended that the Engineer/Contractor works within the constraints of the assessment criteria i.e no greater than a combined $40m^3/hr$ production rate for two dredgers working simultaneously. With time however, monitoring results may indicate that this production rate can be increased marginally without causing a detrimental environmental impact.

Noise impacts have been assessed and in the majority of cases can be mitigated readily. However, for dredging events predicted at So Kwun Wat and Tai Lam Chung the works are expected to be particularly close to residential areas. All practical mitigation measures have been explored and recommended. However, the day time assessment criteria would still be exceeded at some NSRs. Noise barriers to keep noise levels within the 75dB(A) day time assessment criteria are not recommended. Since their installation and very presence will have a greater impact on local residents than would a short period of noise disturbance. Prior consultation with institutions such as schools to explain the works and potential impacts should be undertaken and monitoring is recommended on the receipt of complaints and extreme events likely to result in noise disturbance.

Residual air quality impacts are limited to short term odour impacts on recreational activities on or beside the Shing Mun River during restoration dredging. Mitigation measures for example covering of material during transport, no stockpiling of material, keeping material damp etc. are included in standard specifications which will be included in contractual clauses. The on-going EPD study on the Shing Mun River, which will provide more information on the environmental improvement of the river in a wider perspective, is expected to be completed by July-August 1997. Appropriate recommendations from this

study, when available, will also be taken into account in planning the restoration dredging works in Shing Mun River.

The key potential ecological impacts relate to habitat loss and disturbance to bird populations. For dredging works in sensitive ecological areas extensive water monitoring has been recommended to prevent secondary impacts on ecology together with restrictions on working hours. Standard specifications address the issue of habitat loss and are aimed at protecting all forms of bankside vegetation whether they alone have a specific ecological value or not.

Sediment Disposal

Practical and environmentally acceptable disposal routes have been defined for sediment under both the current legislation and possible new guidelines based on proposals drafted by EVS Consultants. East Sha Chau continues to be the most feasible option for disposing of contaminated material. The EIA recommends that public dump sites be subject to further study and considered for Class B sediment disposal. If this is found to be unacceptable then open sea disposal continues to be the preferred option. In the future, if marine disposal is unacceptable for highly polluted sediments, then strategic landfill is the recommended disposal option together with lime stabilisation to meet the requirement for solid content and no free draining water.