DRAINAGE SERVICES DEPARTMENT
LAND DRAINAGE DIVISION

Agreement No. CE 27/94

TERRITORIAL LAND DRAINAGE & FLOOD CONTROL STRATEGY STUDY - PHASE III

SEDIMENTATION STUDY

FINAL REPORT - TASK 6
ENVIRONMENTAL IMPACT ASSESSMENT
(VOLUME A)

May 1997

Hyder Consulting

Hyder Consulting Limited

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

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INTRODUCTION

1. INTRODUCTION

1.1 Background

The Territorial Land Drainage and Flood Control Strategy Study Phase III (TELADFLOCOSS III) Sedimentation Study is concerned with identifying the need for maintenance dredging to maintain or improve flood protection levels, together with the appropriate dredging and spoil disposal methods, and management procedures, for thirteen flood route drainage channels across the Territory, namely:

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

Figure 1.1 indicates the general location of each of the study channels.

The EIA is Task 6 of the Sedimentation Study. Task 1 involved the collation of existing information and undertaking surveys to provide supplementary data. Task 2 assessed the sediment budget in the channels for both terrestrial and marine sourced material. Task 3 involved the development of a specific morphological model for the Tai Po/Lam Tsuen river channel. Task 4 involved hydraulic modelling for all of the channels to identify the need for dredging to maintain or improve the flooding characteristics of the channel and generated recommended dredging volumes and locations. Task 5 produced recommended dredging methods and disposal routes, recognising the physical constraints which exist to the production of channel specific Dredging Manuals. Task 5 and 6 involved extensive co-operation to investigate both local and international dredging and disposal practice in order to develop appropriate overall strategies. This Task 6 EIA report assesses the impact of the recommended dredging and disposal strategy and identifies operational constraints and requirements. Task 7 addresses the optimisation of contractual arrangements for undertaking the work and Task 8 considers erosion control and maintenance provision.

1.2 Objectives of Task 6

The Environmental Impact Assessment (EIA) has been undertaken concurrently with the development of the recommended dredging strategy, with extensive collaboration and discussion of alternative approaches which mitigate impacts. The process of finalisation of the dredging strategy has involved continual feedback between the two tasks in the light of comments on the draft Task reports.

The objective of the EIA is to describe the maintenance dredging works and associated works together with the requirements for carrying out the work. The EIA should describe the sensitive elements of the community and environment which are likely to be affected by the dredging works; quantify impacts; and develop cost effective mitigation measures. Following this, residual, cumulative and secondary impacts should be quantified. Finally, an environmental monitoring and audit programme should be developed to ensure that environmental protection measures are implemented.

The specific requirements of the brief are summarised below and are set out in detail in section 6 of Appendix D of the brief:

- Establishment of baseline conditions for the study area of each subject channel;
- Identification of all environmentally sensitive uses likely to be affected both beneficially and adversely by the dredging and disposal of sediments for each channel;
- Identification of various options for dredging and disposal of sediment from each of the channels and identification of beneficial and adverse impacts arising from these operations; and
- Recommendations for environmental monitoring and audit.

1.3 Approach

There are established procedures for identifying and assessing environmental impacts which have been utilised for this study. Initially the project was scoped to provide the focus for the study. The findings of the scoping stage are presented in the Initial Assessment Report (IAR) September 1995. The IAR also identified possible impacts, forming the basis for the Key Issues report (Acer Consultants, August 1996), which detailed the anticipated impacts based on the information available at the time. This report further quantifies the potential impacts, wherever possible, assesses their significance and proposes mitigation measures and environmental monitoring and audit (EM&A) requirements.

For this multidisciplinary study, potential concerns and sensitive receivers were identified through site visits and reviews of existing information. As much information as possible was stored spatially on the Geographical Information System (GIS) and once dredging locations were known, these were placed on the GIS. The layers on the GIS allow the assessor to utilise the overlay technique, a formal technique whereby potential impacts on water quality and noise/air impacts arising from the dredging can be related to the location of sensitive sites such as residential areas and sites of ecological importance. This relatively simple technique allowed the team to identify the key issues for each channel.

Where options or alternatives were to be considered then the following two approaches were adopted. Firstly the GIS was used to compare spatial advantages and disadvantages of options. For example, disposal options were plotted on the GIS and the optimum location found for each channel based on distance and transport routes/options. Secondly matrices were used to compare options. For example, environmental advantages and disadvantages were compared for the disposal options using this approach. Matrices are a useful way of displaying the outcome of an assessment which has compared various options and these have therefore been included in this report.

Team discussions were a valuable tool in both identifying and minimizing impacts. Close liaison between Task 5 and 6, for example, ensured that the proposed dredging strategy had considered the environmental constraints associated with each channel so that from the outset the strategy would aim to minimize environmental impacts.

Although the dredging strategy sought to minimise environmental impacts it was only in draft form at the time of writing and the finalisation of the strategy depends in part upon the outcome of this EIA. This report, therefore, considers the proposed dredging strategy including access, transport, dredging methods and disposal options for each channel in more detail and assesses the significance of any impacts. Impact significance is determined through the use of standard techniques and assessment criteria for the prediction of air, noise and water quality impacts based on the relevant legislation and guidelines currently applied in Hong Kong.

1.4 Report Format

This report is presented in two volumes due to the large quantity of factual data provided. Volume A presents the background to the study, the approach and the main conclusions and recommendations, Volume B provides the channel specific data and assessments. The conclusions and recommendations in Volume B are summarised in Volume A and the reader need only refer to Volume B for channel specific details.

Following this introduction Section 2 describes the proposed project, that is, the maintenance dredging strategy based on the information derived from the other tasks in this study and from previous studies undertaken as part of the Territorial Land Drainage and Flood Control Strategy Study (TELADFLOCOSS). Sections 3, 4, 5, 6, and 7 focus on the impacts arising from the proposed strategy. Each section is issue specific and considers key issues such as water, ecology, air, noise and waste management. The aim of these sections is to provide the reader with an overview of the EIA methods and findings at an early stage of the report. The sections provide a description of the legislation, methodology for assessment, areas of concern and an evaluation of impacts from maintenance dredging and their significance before and after proposed mitigation. Section 8 details the recommended monitoring and audit requirements for noise, air, water quality and ecology. In addition, Section 8 provides details on general mitigation clauses which have been recommended for all the channels subjected to maintenance dredging works.

Volume B of the report (sections 10-22) presents the findings of the detailed, channel specific assessment. Each chapter includes baseline data, key issues and sensitive receivers, predicted impacts and mitigation measures.

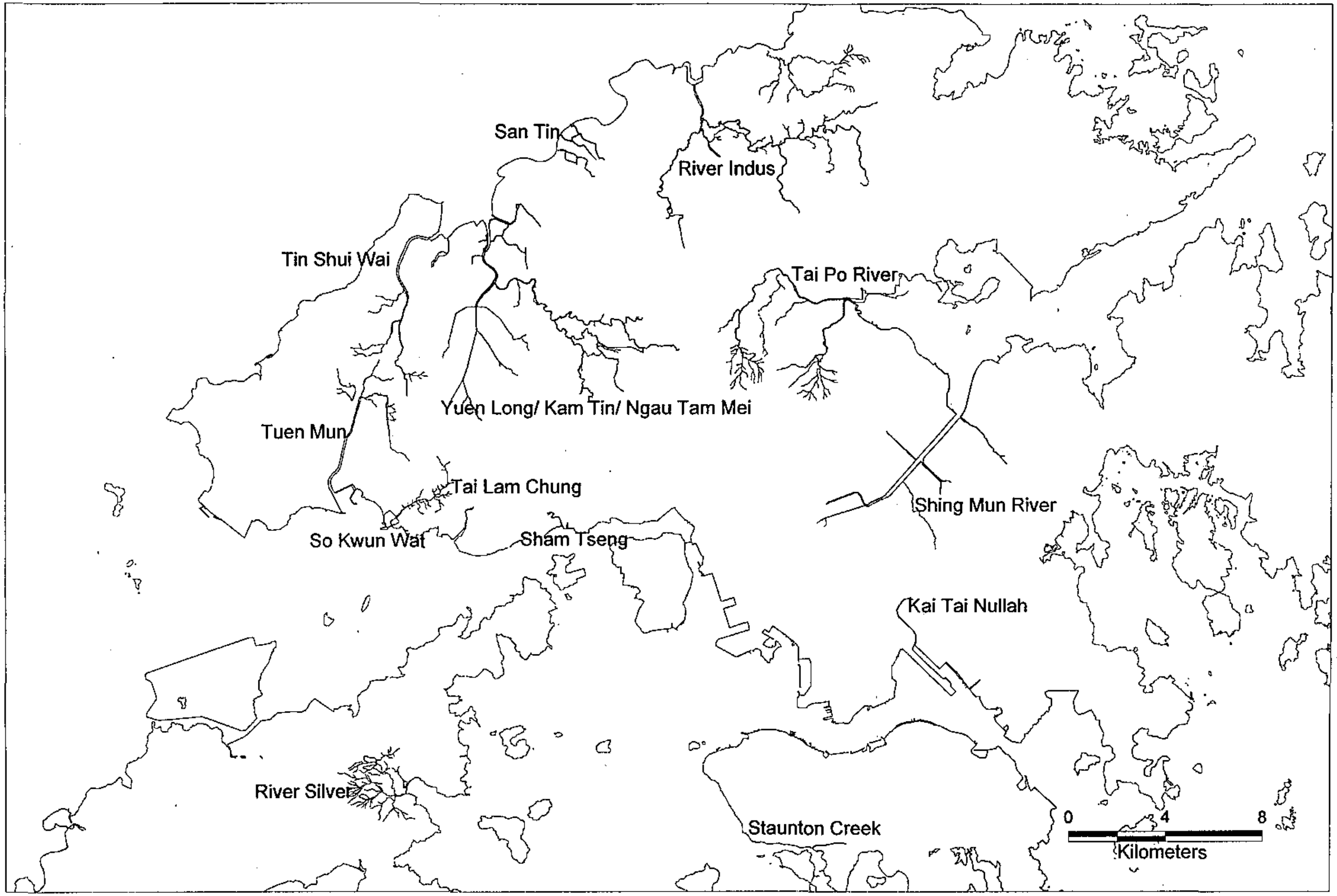

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Figure 1.1 Channel location

SECTION 2

MAINTENANCE DREDGING STRATEGY

2. MAINTENANCE DREDGING STRATEGY

2.1 Introduction

This section describes the anticipated dredging works derived from the assessments undertaken in other tasks in the Study, in particular Tasks 4 and 5, which have determined the anticipated dredging locations and quantities, together with the preferred dredging methods and disposal options for each of the channels. Detailed information on the modelling work and dredging and disposal option assessment can be found in the Task 4 and Task 5 reports and working papers.

2.2 Identified Flood Risk Areas

The fundamental objective of the TELADFLOCOSS Phase III Sedimentation Study is to identify areas where dredging is required to maintain or improve flood drainage capacity and thereby reduce the risk of flooding in sensitive areas. Flooding has been a common occurrence in the Territory since records were kept, primarily as a consequence of extreme rainfall events. Table 2.1 details some of the maximum rainfall figures recorded between 1884 - 1939 and 1947 - 1991 and total average rainfall recorded between the years 1961 - 1990.

The official average rainfall in the Territory is about 2200 mm, some 50% of the area receives on average between 2100 and 2400 mm of precipitation per year, while only 1% of the area is subject to rainfall between 2900-3000 mm (Task 8 Report). Typhoons and troughs of low pressure frequently bring intense rainstorms to Hong Kong between May - October where intensities of more than 250 mm in 24 hours occur frequently (Greenway, 1987).

TABLE 2.1 EXTREME RAINFALL EVENTS RECORDED AT THE ROYAL OBSERVATORY HEADQUARTERS

Month	Total Average Rainfall (mm)	Maximum Hourly (mm)	Maximum Daily (mm)	Maximum Monthly (mm)
January	23	21	99	214
February	48	31	86	241
March	66	50	126	428
April	161	92	190	492
May	316	109	520	1241
June	376	108	382	962
July	323	100	534	1,147
August	391	82	334	872
September	299	84	325	844
October	145	71	292	718
November	35	44	149	224
December	27	51	177	206

(Source: The Royal Observatory, Hong Kong)

Note:

Extreme events recorded between 1884-1939 and 1947- 1994
Total average rainfall for 1961-1990

Such extreme events mean that many areas in the Territory are prone to flooding particularly during the wettest months from May through to October. Such high intensity storms are also very erosive resulting in relatively high sediment yields in the channels from their catchments during this period.

The major flood risk areas were identified in Phase I as being the Northern and North West New Territories. Four of the basins which were studied in detail in TELADFLOCOSS II (Binnie Consultants, 1993), due to their high susceptibility to flooding, are relevant to this study:

- Yuen Long / Kam Tin / Ngau Tam Mei;
- River Indus;
- San Tin; and
- Tin Shui Wai.

Flood risk and planned flood protection schemes for these key areas were outlined in the EIA IAR based on the findings of the TELADFLOCOSS II Study.

2.3 Dredging Requirements

2.3.1 Sedimentation in Channels

The current study is focused on dredging associated with the minimisation of flooding risk and has not explicitly considered issues such as the maintenance of water depth for commercial or recreational purposes, such as rowing in Shing Mun River, or the minimisation of nuisance such as odour control, which may generate additional dredging requirements.

Flooding occurs because a channel does not have sufficient hydraulic capacity to accommodate the flood water volume. The hydraulic capacity is dependant on the gradient and cross-sectional area of the channel and the bank heights relative to the downstream water level. Since all of the channels considered are tidal, the downstream water level is also subject to extreme heights. Task 4 considered the effect of combinations of extreme rainfall and high tide events and concluded that in several channels (such as San Tin) the bank heights were too low to prevent flooding under extreme tidal conditions alone, irrespective of rainfall.

Maintaining the hydraulic capacity of a channel requires that the cross-sectional area be maintained and that blockages are removed. It is therefore desirable to control sedimentation in the channel by reducing the sediment input, preferably through control at source. In the event that sedimentation does occur, dredging may be required to remove it in order to prevent an unacceptable increase in flood risk.

There are two key sources of sediment in the channels: catchment derived sediments which comprise natural sediment inputs, inputs from discharges to the channel and inputs from construction sites; and marine sediments transported into the channel by tidal action and deposited there. Task 2 estimated that only 5-10% of the sediment currently in the channels is derived from catchment sources. However, as described below, because of its characteristics, the anticipated dredging requirements are more strongly influenced by this catchment derived material than by the marine material.

<u>Behaviour of Marine Sediments</u>

The marine environment contributes soft, fine-grained sediment which is re-suspended from the seabed offshore by a combination of wave action and tidal currents and is transported into the channel through tidal action. Under low river flow conditions, some of this material may be deposited over slack water periods and not re-eroded during succeeding tides, leading to the accumulation of a layer of soft, unconsolidated marine sediments. Over a period of several months, providing the river flow remains low and the tidal currents do not re-erode it, this material may consolidate to form a layer of firmer material, which will be more resistant to erosion.

As the sediment accumulates, the cross-sectional area of the channel will reduce, resulting in increased velocities in the channel during rainfall. As the velocity increases, so does the potential for erosion, leading to the soft sediment and, under extreme rainfall events, the upper portion of the consolidated material being re-suspended and transported downstream out of the channel. A dynamic equilibrium is therefore established, whereby over the long term and in the absence of other influences, the river bed remains at a fairly constant level.

The river bed level is considered to be the upper surface of the consolidated marine sediment, since any overlying soft marine sediments would be eroded under only moderate river flow conditions and transported out of the channel. Task 4 determined that the majority of channels in Hong Kong were at or close to their equilibrium level for the marine sediments. The actual bed level will vary depending on the recent rainfall conditions and at any one time may be above or below the dynamic equilibrium level, but over the long-term the bed level should remain around the equilibrium level in the absence of other sediment inputs. This has been discussed in detail under Task 4.

Behaviour of Catchment Derived Sediments

Unlike the marine sediment, the coarse fraction of catchment derived sediment is not in equilibrium and tends to accumulate in the channels. This will occur in areas where the flow velocity, even under high river flow conditions, is insufficient to re-suspend the material and transport it further along the channel. This will occur in areas where the channel slope reduces, the cross-sectional area increases, or at bends or confluences where 3-D flow structures may lead to areas of reduced current velocity.

Generally, the most important sources of catchment derived sediment in Hong Kong are erosion of hill slopes and construction or quarry sites. The importance of livestock waste as a source of sediment has decreased considerably in recent years as a result of the reduction in agricultural activity and the implementation of livestock waste control schemes in the majority of the catchments.

Since it is primarily the catchment derived sediment which results in continuous accretion it is clearly desirable to minimise the quantity of material entering the channel from this route. Task 8a addresses this issue in detail and sets out cost benefit assessments for various strategies to reduce the amount of catchment derived material entering the channels. Recommendations from the Task 8a and 8b draft reports are incorporated into the channel specific assessments as mitigation measures.

2.3.2 Predicted Dredging Volumes and Locations

The accretion of catchment derived sediment or consolidated marine sediment in areas of low flow, may ultimately result in the cross-sectional area of the channel being reduced sufficiently to increase the flood risk unacceptably. As described in the Task 4 reports, hydraulic modelling was carried out for each channel using the SOBEK 1-D model, to assess the performance of each channel with the current bed levels and the effect of increasing the bed level (simulating sedimentation) and reducing the bed level (simulating dredging).

Based on the modelled scenarios severe flooding is possible for current conditions in the River Silver, Kai Tak Nullah, Shing Mun River, River Indus (present), So Kwun Wat and Sham Tseng Nullah. Minor to moderate flooding is also likely in the remaining study channels. Even with dredging, severe flooding is still likely in sections of the River Silver, Shing Mun River, River Indus (present) and the Sham Tseng Nullah during extreme rainfall events. However, dredging can mitigate flood risk to a certain extent through reducing the length over which flooding occurs in the River Silver northern and southern tributaries, Lam Tsuen River and the San Tin East Drainage Channel. Also, dredging can prevent the already adverse situation from further deterioration.

For each channel the critical bed level was identified. The critical bed level defines a minimum acceptable cross-sectional area for the channel, below which the risk of flooding is increased beyond either the design standard or, for channels where the design standard could not be achieved by dredging, current levels. The critical bed level was proposed as the trigger level at which dredging should be initiated. Task 4 then determined the anticipated rate and location for accumulation of either marine or catchment derived sediment, in order to determine which of the channels were at risk from sediment accumulating to a level in excess of the critical bed level.

In addition to the modelling work, the forecast dredging volumes were assessed through a detailed comparison of existing bed levels with historical sounding records and a review of dredging records from both DSD and CED. This information was used to supplement and cross-check the modelling predictions.

The outcome of Task 4 was that two types of dredging operations were necessary; recurrent and restoration dredging. Task 4 defined **recurrent dredging** 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 . Table 2.2 contains the predicted dredging volumes quantified by Task 4 and locations for recurrent dredging which result from both natural sediment input and inputs from construction sites.

Restoration dredging was 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 currently requiring restoration dredging work. Table 2.3 summarises the Task 4 findings from this exercise.

Annual Dredging Requirements

Task 5 considered the practical approach to undertaking the proposed dredging and determined the likely dredging frequency for each of the channels at the anticipated dredging locations. Table 2.2 indicates both the estimated dredged material volume, which is anticipated from a single dredging event, and the frequency with which the dredging is expected to be necessary.

The estimated average annual dredging requirement for each channel is also given in Table 2.2. The annual average dredged volume is circa 57,000-60,000 m^3. Whilst for any individual year the dredging volume will vary from this figure, depending on the rainfall distribution and the results of routine bed level monitoring identifying areas of concern, over the long term the dredging volumes are predicted to be of this order.

TABLE 2.2 ESTIMATED RECURRENT DREDGING REQUIREMENT

River Name	Natural Sediment Input			Input from Construction Work			Total Annual Requirement
	Dredging Volume [m³]	Dredging Frequency [year]	Dredging Location [chainage]	Dredging Volume [m³]	Dredging Frequency [year]	Dredging Location [chainage]	Dredging Volume (m³)
River Silver	1,300	2 years	confluence of upstream tributaries	negligible			650
Staunton Creek	3,600	15 years	ch 1300-1450	1,400	15 years	ch 1300-1450	333
Kai Tak	negligible			negligible			2,000
Shing Mun	negligible			negligible			20,000
Fo Tan	320	1 year	ch 700-800	negligible			320
Siu Lek Yuen	negligible			negligible			7,000
Tai Shui Hang	460	1 year	ch 650-1050	negligible			460
Lam Tsuen	2,400	2 years	ch 3100-3200	1,200	2 years	ch 3100-3200	1,800
Tai Po	3,000	3 years	ch 700-1000	1,050	3 years	ch 700-1000	1,350
River Indus (present)	5,000	1 year	upstream of confluence	Dredging activities to follow from yearly inspection of river confluences			5,000
BEAS (future)	6,000	6 years	ch 1000-1300	dredging to follow from inspection of drainage locations of construction sites			1,000
Sutlej (future)	4,000	10 years	ch 300-500				400
Indus main channel (future)	8,100	3 years	ch 1000-1500				2,700
San Tin (present)	3,000-6,000 (4,500 Average)	yearly	entire length	Note: this contains marine sediment and some fluviatile sediment			4,500
San Tin East (future)	2,100	10 years	ch 1600-1900	negligible			210
San Tin West (future)	2,100	10 years	ch 200-600	negligible			210
Yuen Long	22,000	10 years	ch 800-1500	negligible			2,200
(future)	14,500	5 years	ch 1200-1400	negligible			2,900
Kam Tin			ch 3000-3200	negligible			
	3,000	5 years	ch 900-1100	negligible			600
Ngau Tam Mei							
Wo Sang Wai	negligible			17,600	10 years	ch 600-1600	1,760
Tin Shui Wai	7,000	10 years	ch 500-600	diffusive input of 2400 m³/yr: monitoring			3,100
Tuen Mun	negligible			negligible			10,000
So Kwun Wat	3,000	4 years	ch 320-520	1,650	4 years	ch 320-520	1,163
Tai Lam Chung	1,400	10 years	around ch 1100	negligible			140
Sham Tseng	negligible			negligible			0
Total Present Annual Volume	14,960			3,856			57,816
Total Future Annual Volume	15,680			5,616			60,296

Source Task 4 Final Report

TABLE 2.3 ESTIMATED REQUIREMENT FOR RESTORATION DREDGING

Channels No.	Channel Tributary Name	Maintenance Quantities (m^3)	Location of Dredging	Assessment of Side Channels/Culverts
A	River Silver	Nil	N/A	Not affected
B	Staunton Creek Nullah	Nil	N/A	Not affected
C	Kai Tak Nullah	Nil	N/A	Not affected
D	Shing Mun River Main Channel	147,980	ch. 1400 to 3300 ch. 4700 to 5000	Affected
	Siu Lek Yuen Nullah	Nil	N/A	Affected
E	Tai Po River Channel	Nil	N/A	Affected
	Lam Tsuen River Channel	Nil	N/A	
F	River Indus Channel and Its Tributaries	Nil	N/A	No side channels/culverts of concern
G	San Tin Main Drainage Channels	Nil (included in yearly requirements)	N/A	Polder outfall at ch. 400
H	Yuen Long/Kam Tin/Ngau Tam Mei River Channels	Nil (included in yearly requirements)	N/A	Clearance of side culverts will be needed
I	Tin Shui Wai Drainage Channels	Nil	N/A	No side channels/culverts of concern
J	Tuen Mun River Channel	7,470	ch. 2200 to 2300	Affected
K	So Kwun Wat Drainage Channel	Nil	N/A	No side channels/culverts of concern
L	Tai Lam Chung River Channel	Nil	N/A	No side channels/culverts of concern
M	Sham Tseng Nullah	Nil	N/A	Not affected
TOTAL VOLUME	155,450			

2.4 Dredging Methodologies

Task 5 identified the preferred dredging methodologies for each channel and the duration of the dredging given the types of equipment likely to be used. The preferred options were determined based on the physical and environmental constraints at the dredging locations determined by Task 4.

Task 5 reviewed current local dredging practices and concluded that they were broadly in line with international practice, subject to the particular constraints of the tidal channels in Hong Kong, so that no fundamental changes in approach were required.

Dredging is typically undertaken locally using small grab dredgers which are often de-mountable and transportable by road. The relatively sophisticated, purpose-built equipment frequently used overseas was considered unlikely to be financially viable in Hong Kong due to the high cost and limited demand. Hydraulic dredgers or hybrids which incorporate hydraulic excavation or transport systems are not widely used due to problems with debris, access to the site and distance from the disposal site. Hydraulic dredging is also considered unsuitable in the channels given that it invariably results in a substantial dilution of the sediment and a consequent increase of volume for disposal. In view of the costs of transport and disposal this is not considered desirable.

Task 5 concluded that improvements in the existing practices could be achieved both in the manner in which the plant is operated and, particularly, through the adoption of improved instrumentation to assist accurate dredging and thereby reduce the material volumes for transport and disposal. Task 5 has categorised the channels into four groups to aid development of the dredging strategy:

1. Large engineered channels in urban areas where marine access is possible over most of the channel length e.g. Shing Mun, Tuen Mun and Lam Tsuen/Tai Po. Sediment tends to be muddy and contaminated
2. Channels where no or only restricted marine access is possible and where sediments have variable composition and contamination status
3. Short and steep predominately natural channels with granular, uncontaminated material
4. Fully engineered channels with mixed sediment often containing significant quantities of rubbish and construction site run off.

Simplified, there are two broad categories of dredging operations proposed for the works in the study channels:

- Marine operations - generally associated with dredging works where direct marine access is possible but also include some operations in channels where there is no direct marine access and dredging is undertaken from floating plant which are transported to site by road.
- Land based operations - essentially those where the dredged material is put ashore in the primary stages of operation, irrespective of the final destination of the dredged material.

In section 6 of the Task 5 Report, good dredging practice is recommended. In particular the strategy must be directed towards reducing the volume to be dredged and disposal kept to an absolute minimum. There are three main components of volume minimisation:

- 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 the removal of material which needs to be removed. Minimising the addition of water requires grab and excavator buckets are of size appropriate to the thickness of the layer being removed, i.e. they can be completely filled during ordinary operation. Grabs and excavators should be fitted with depth and position indicators as well, to ensure the operator knows exactly where he is dredging in relation to the required levels. The Contractor could be encouraged to work accurately by, in addition to the Specification of appropriate instrumentation and methods of working, the incorporation of penalties for unnecessary overdredging.

Access is also a key consideration in terms of the development of the dredging strategy. Bridges and shallow water constrain access in the channel for much marine based equipment. Land based plant may access channels via roads and ramps where available. Table 2.4 summarises the access proposed for each of the channels in Task 5. Generally, both land and marine access is possible for the majority of channels but marine plant can only be used in the downstream sections of the channel and is restricted by water depth and bridges. Where land access has been proposed this will be either via existing ramps, temporary earth ramps or using cranes to lower equipment onto the channels from bridges.

Dredging strategies including access, transport, equipment and duration have been developed in full under Task 5. Each of the strategies for the channels at the dredging locations identified by Task 4 is summarised below in Section 2.6 and assessed in greater detail in the channel specific sections of this report.

2.5 Disposal Strategy

Based on the forecast dredging requirements and the results of sediment quality analyses undertaken for the study and reported in Task 1, it has been estimated that less than 10% of the sediment to be dredged annually will be uncontaminated according to the existing classification system - Works Branch Technical Circular TC 1-1-92.

Extensive consideration has been given to disposal options, including a review of existing local and international practice and a detailed assessment of the potential to introduce new disposal options. Potential disposal options were initially described in the Task 6 Key Issues Report. These were considered further, including a cost analysis based on the forecast volumes, in the Task 5 report.

Table 2.5 lists the range of disposal options which have been considered.

TABLE 2.4 SUMMARY OF PROPOSED ACCESS FOR MAINTENANCE DREDGING OF CHANNELS

Channel		Proposed Access		Comments
		Land	Marine	
A	River Silver	✓	✓	Only channel mouth accessible by marine based equipment.
B	Staunton Creek	✓	✓	Use of ramps and cranes to access channel upstream of Ap Lei Chau Bridge.
C	Kai Tak Nullah	✓	X	Access ramps in upper reaches; restricted access to airport; cranes required in airport sections.
D	Shing Mun River (Main Channel)	✓	✓	Small craft only for marine access; Crane to lower equipment from Che Kung Mui Road; Access Ramps. Land based only for upper reaches.
	Tai Shui Hang	✓	✓	Only lower section likely to be dredged which involves marine access.
	Siu Lek Yuen	X	✓	Restricted marine access towards Tate's Cairn Highway. Land access not possible.
	Fo Tan Nullah	✓	✓	Only lower reaches accessible by barge, much of the dredging further upstream, will be by land access only.
E	Tai Po River	✓	✓	Ramps/crane for access from Nam Wan Rd. Only lower reaches accessible by barge.
	Lam Tsuen River	✓	✓	Only lower reaches accessible by barge. Crane to lower equipment from Nam Wan Rd Bridge/Access ramps.
F	River Indus (Present & Future)	✓	X	All equipment brought in by road; use of long reach excavators/floating plant.
G	San Tin MDC (Present & Future)	✓	X	Access along Border Fence Road. Land based equipment/de-mountable floating plant.
H	Yuen Long/Kam Tin/Ngau Tam Mei	✓	✓	Only tidal restrictions in upper reaches length of channel - dredged with pontoon mounted excavators. Access via Ramsar site is costly.
I	Tin Shui Wai E&W Drainage Channels	✓	✓	Marine access up to fabridam through Ramsar Site (costly). Wheeled excavators upstream of dam, ramps for access.
J	Tuen Mun River Channel	✓	✓	Marine access downstream; Access ramps will be used upstream by trucks to remove stockpiled material.
K	So Kwun Wat River Channel	✓	✓	Marine access at mouth only (downstream of Castle Peak Road Bridge). Upstream of bridge only land based plant - access from right bank. Temporary earth ramps to be constructed.
L	Tai Lam Chung River Channel	✓	✓	Marine access at low water to channel mouth. Land based track excavators accessing via earth banks in upper reaches.
M	Sham Tseng Nullah	✓	✓	Generally only land access via access ramp on right bank north of Tuen Mun Road.

TABLE 2.5 DISPOSAL OPTIONS CONSIDERED

Offshore Disposal	• Unconfined Disposal in Licensed disposal areas • Confined disposal by controlled bottom dumping into sea-bed depressions or redundant sand borrow pits • Confined disposal between underwater dykes constructed on the seabed • Formation of islands
Onshore Disposal	• Unconfined disposal in thin layers on land • Construction of silt hills • Coastal lagoons - with low cost enclosures to retain solids • Coastal lagoons - high integrity enclosure designed to retain contaminants • Disposal to fishponds • Confined disposal to landfill • Disposal to public dumps/reclamation sites
Beneficial Uses	• Habitat creation e.g. mudflats • Aquaculture • Bank stabilisation • Noise barriers/earth berms etc. • Reclamation • Improvement of agricultural land/ use as topsoil • Composting

2.5.1 Treatment

Given the potential advantages of beneficial use disposal options and recognising that the capacity of any disposal site is finite, specific consideration has been given to the potential to apply treatment techniques to improve the quality and characteristics of material. Treatment of dredged material is also necessary in some instances to improve the condition of the material to make it acceptable for certain disposal sites such as landfills. The techniques considered are described in the draft Task 5 report and are listed below:

- Dewatering (air drying/mechanical/thermal)
- Slurry injection (addition of polymers/flocculants/microbes)
- Separation (screening/settling/hydrocyclones/magnetic/electrostatic separators)

2.5.2 Recommended Disposal Strategy

Following a review of the potential options, Task 5 undertook a cost assessment of the available and potential disposal options. Clean materials are relatively inexpensive to dispose of or re-use and for all options considered; re-use, public dumps, redundant marine borrow areas and disposal to private land, the costs are approximately the same and a notional $10 charge per cubic metre was assumed for these options.

Initially it had been anticipated that significantly larger volumes of contaminated material might be dredged from the channels. In such circumstances, disposal to a shore line enclosure constructed specifically for this purpose was considered to be the cheapest option. However small enclosures, appropriate to the volumes expected under this study, are not considered to be economical.

Landfills, particularly WENT landfill, are an expensive option and, given the restricted capacity of the landfills, relatively unattractive. This is exacerbated by the existing requirement to treat the sediment to reduce water content prior to disposal. Once the Sludge Treatment and Disposal Strategy Study (CE 5/96) currently underway has been completed, it may be found that the restriction on water content can be relaxed without any adverse impact on slope stability, working area, leachate or leachate treatment system at the sites.

For sediments removed using marine plant, it is generally more practical to take material to East Sha Chau Contaminated Mud Pits (ESC). However, the ongoing review of guidelines for the control of marine disposal of sediments by consultants appointed by the Fill Management Committee, may result in certain highly contaminated materials being classified as unsuitable for marine disposal.

Public dumps provide a potential disposal route, although currently a specific restriction exists precluding the disposal of marine mud at these sites. Of particular interest is the site at Pak Shek Kok because of its proximity to the Shing Mun and Tai Po channels, which represents a major future source of dredged sediment.

Overall, the following potential disposal options are considered viable:

- ESC is expected to be the most cost effective option for contaminated sediments, both from marine operations and from land operations with trans-shipment
- Strategic landfill for highly contaminated sediment or coarse sediments from land operations in the upper reaches of channels (initial dewatering where necessary)
- Public dumps for clean or moderately contaminated material subject to the lifting of the restriction on disposal of marine mud
- Beneficial uses - local uses for clean material and moderately contaminated material for strategic uses such as the shoreline enclosure or agricultural use

Given the cost of disposal to shoreline enclosures and landfill, ESC is currently the preferred disposal option in terms of cost. ESC is considered to be one of the most sophisticated, best controlled and demonstrably successful operations of its kind and provides an environmentally sound means of managing contaminated material. It is recommended that all material which is currently class C should be disposed of at ESC, including material which is removed by land operations and requires trans-shipment to barge for transport to ESC.

2.6 Channel Specific Dredging Strategies

The conclusions and recommendations of the Task 4 and Task 5 reports are summarised here for convenience. The environmental issues associated with the proposed approach for each channel is considered in detail in Volume B.

2.6.1 River Silver

The anticipated dredging requirement is approximately 1,300m^3 every two years, primarily of catchment derived material which will accumulate at the confluence of the upstream tributaries. The dredging will be undertaken using a small bulldozer running on the main channel bed, placing material in bankside stockpiles. A crane grab would then load trucks for transportation by land to a suitable beneficial use.

2.6.2 *Staunton Creek*

Only limited and infrequent dredging is likely in Staunton Creek Nullah in the downstream section of the channel where approximately 5,000m^3 would be removed every 15 years in order to alleviate flood risk. To remove this volume in one dredging campaign would take approximately 4 - 6 weeks.

Downstream of Ap Lei Chau Bridge dredging would be undertaken using pontoon mounted grabs and backhoes which would load dredged material onto small barges to take material to East Sha Chau. The lower reaches of the channel would have to be dredged at high tide due to restrictions with water depths.

In addition, upstream of Ap Lei Chau Bridge a nominal 50m^3 per year of material will be removed using rubber tyred loaders which would load into skips. This work would be restricted by tidal conditions and generally undertaken in the dry season.

2.6.3 *Kai Tak Nullah*

Approximately 2,000m^3 per year of general rubbish and construction derived sediment is required to be removed from the channel in the area upstream of the airport. The material will consist largely of rubbish and will be removed manually in dry conditions. Material will be contained in plastic bags and transported by road to strategic landfill (SENT) for disposal.

2.6.4 *Shing Mun River*

Main Channel

It is estimated that approximately 148,000m^3 of restoration dredging is required in the short term, followed by an annual 20,000m^3 of sediment to maintain clearance for culverts and pipes and to deal with areas of accumulation near the mouths of side channels.

The bulk of the dredging will be undertaken between Lion Rock Tunnel Road Bridge and Banyan Bridge (Fo Tan Road). The section above Lion Bridge that is unlined requires the use of marine plant such as pontoon-mounted grabs/excavators loading into small barges. Works here will be subject to tidal restrictions, material being trans-shipped downstream for transport to East Sha Chau or SENT landfill.

The area downstream of Lion Bridge where most dredging will take place is more readily accessible by marine plant. Small backhoes, grabs or auger dredgers could be used. The bulk of the sediment is in this area and the dredging operations will take approximately 13 weeks per year.

Fo Tan Nullah

Approximately 320m^3 per year of primarily catchment derived sediment will need to be removed from the mid to lower reaches of the channel. Tidal conditions in the proposed dredging area will severely restrict the use of pontoon-mounted grabs and it is anticipated that most of the dredging will be undertaken using tyred mini excavators and manual methods working at low tide. Material would be loaded into skips and transported by truck to SENT prior to which dewatering may be required to eliminate free draining water.

Siu Lek Yuen Nullah

An annual dredging requirement of approximately 7,000m^3 per year has been identified, primarily based on practice to date. This is split between an estimated 4,000m^3 per year of natural catchment derived sediment which accumulates at the head of the nullah, and 3,000m^3 per year of construction related catchment derived sediment which accumulates at the junction with the main channel.

Marine access to most of the channel is possible and relatively unhindered except in the upper reaches of the nullah. Most of the material will be removed using pontoon mounted grabs and backhoes and loaded into medium sized barges for transport to a transfer site, and either into larger barges for passage to East Sha Chau or into watertight trucks for transfer to SENT with dewatering as necessary.

Tai Shui Hang Stream

The anticipated dredging requirement is approximately 460m^3 per year, primarily of natural catchment derived material which will accumulate in the downstream area of this tributary. A single dredging campaign would take no more than one month, using marine plant such as backhoes and excavators with hydraulic buckets. Dredged material will be loaded into small barges, then transferred to larger barges for marine transport. This material is not likely to be contaminated and disposal at Pak Shek Kok Public Dump, to an approved beneficial use or placing the disposal responsibility on the dredging Contractor (as is currently the case), are all potential options.

2.6.5 *Tai Po and Lam Tsuen River Channels*

Tai Po

Approximately 4,000m^3 of catchment derived material (roughly 75% natural and 25% construction site) will need to be removed every three years from the area between Tai Po Road and Plover Cove Road.

Dredging will be undertaken using pontoon mounted grabs and backhoes loading into small barges and transported to an area for transfer either into larger barges for passage to East Sha Chau or into watertight trucks for transfer to SENT with dewatering as necessary.

Lam Tsuen

Approximately 3,600m^3 of catchment derived material (roughly 66% natural and 33% construction site) will need to be removed every two years from the area near the channel mouth. Dredging will be undertaken using pontoon mounted grabs and backhoes loading into small barges and transported to an area for transfer either into larger barges for passage to East Sha Chau or into watertight trucks for transfer to SENT with dewatering as necessary.

2.6.6 *River Indus*

Present

Approximately 5,000m^3 of natural catchment derived material is estimated to need to be removed every year from the area upstream of the confluence, subject to the results of yearly inspections. Pontoon mounted grabs and backhoes will be used in combination with long reach excavators from the channel bank. The material is likely to be contaminated, therefore disposal options include landfill and East Sha Chau.

Future

Following the construction of the proposed flood protection works, it is estimated that the total dredging requirements will be approximately 6,000m^3 per year. The material will continue to be natural catchment derived sediment, although the level of contamination will depend on the effectiveness of local discharge controls.

The anticipated requirements for each of the channels are:

- ***Main channel:*** 8,100m^3 removed every three years
- ***Beas:*** 6,000m^3 removed every six years
- ***Sutlej:*** 4,000m^3 removed every ten years

Inputs from construction work will depend on local control procedures and the sediment bed level monitoring results will be used to identify the requirement for increased dredging activity.

As for the existing situation, pontoon mounted grabs and backhoes will be used in combination with long reach excavators from the channel bank. If the material is contaminated it is anticipated that it will be taken to landfill and dewatered prior to disposal. If uncontaminated the material will be suitable for beneficial use.

2.6.7 *San Tin Main Drainage Channels (present and future scenario)*

Present

There is significant uncertainty about the present dredging requirement. This is due in part to the sparseness of the data and the problems inherent in collecting soundings data in a channel completely overgrown with water hyacinth, necessitating that soundings are taken manually with a probe to determine the thickness of the soft mud deposits present during the survey.

The best estimate possible is that 3,000-6,000m^3 per year of primarily marine derived sediment is currently accumulated due to the poor flushing in the overgrown channel and distributed along the entire length of the channels. In order to optimise flood risk protection, it is proposed that material accumulating above the flood trigger level is removed as indicated by the sediment bed level monitoring, although some flooding will still occur due to the low bank heights in the area.

The water hyacinth presents a particular challenge to any dredging work and Task 5 proposes that it is removed prior to specific dredging events using long reach excavators fitted with rakes to gather the water hyacinth, working from the bank or on pontoons brought in by road. The accumulated sediment would be dredged using long reach excavators. It is proposed that the sediment be disposed of to landfill rather than East Sha Chau given the remoteness of the site and the use of land based equipment, although it may be possible to develop an alternative beneficial disposal route for the vegetation removed.

Future

Following the construction of the new flood channels proposed, it is anticipated that the channels will achieve equilibrium in terms of marine sediments within five years. After this time only the catchment derived sediments will need to be removed and it is anticipated that this will amount to approximately 2,100m^3 of material to be removed every 10 years from each of the two new channels, eastern and western. In addition, the culvert from the poldered village will also require annual maintenance dredging to prevent it from becoming blocked and it is estimated that approximately 60m^3 of material will need to be removed each year.

The lack of marine access limits the choice of equipment and land based operations are anticipated. Similarly, disposal is expected to continue to be to landfill.

2.6.8 Yuen Long/Kam Tin/Ngau Tam Mei

The Yuen Long Channel is currently being retrained therefore the study has focused on the future scenario. It is anticipated that a total of approximately 7,500m^3 per year of catchment derived sediment will need to be removed from the new channels, comprising:

- ***Main channel:*** 22,000m^3 removed every ten years
- ***Kam Tin:*** 14,500m^3 removed every five years
- ***Ngau Tam Mei:*** 3,000m^3 removed every five years
- ***Wo San Wei:*** 17,600m^3 removed every ten years

The channel can be accessed by both land and marine plant. The preferred disposal option depends on the availability of an access channel from Deep Bay which would be constrained by the Ramsar Site in this area. If this channel exists, then marine disposal is proposed for both contaminated and uncontaminated sediments. Clean material could be disposed of to an approved open water disposal site, whereas contaminated material would be disposed of at East Sha Chau. Highly contaminated material could be taken by barge and disposed of at WENT landfill. If there is no marine access to the channel anticipated, transport by road is preferred to Tuen Mun and then transfer to barges for disposal at East Sha Chau.

2.6.9 Tin Shui Wai Western and Eastern Channels

The anticipated dredging requirement is for 7,000m^3 of catchment derived sediment to be removed every 10 years from the channel just upstream of the fabridam. It is proposed that wheeled excavators would be used to remove sediment from the channel which would load into tucks for road transport to landfill or transfer to barge to East Sha Chau.

Potentially more significantly, in the area downstream of the fabridam approximately 2,400m^3 per year of sediment arising from construction sites enters the channel through various diffuse inputs. This may need to be periodically dredged if routine monitoring indicates that the dredging trigger bed level has been exceeded. Marine access is possible for the western channel but not the eastern channel, although land access to both channels is relatively easy. As for the material from upstream of the fabridam, disposal will either be to East Sha Chau or landfill.

2.6.10 Tuen Mun Channel

The Tuen Mun channel is not yet thought to have reached dynamic equilibrium with respect to marine sediments, and is not anticipated to do so within a period of 10 years. During this period slow accretion of marine and catchment derived sediment will continue, but is considered unlikely to result in bed levels exceeding the dredging trigger level over that time period. Hence it is not anticipated that dredging will be required to prevent flood protection standards being compromised in the foreseeable future.

Historically CED have removed approximately 10,000m^3 per year of coarse sediments, primarily derived from natural slope eroded materials from Area 19 (CED,1997). Removal of these coarse sediments is likely to be necessary to maintain flood protection standards. This would be undertaken using pontoon mounted grabs and backhoes loading into medium sized barges. The sediment, which is expected to be contaminated, will be transferred into larger barges for transport to East Sha Chau. Heavily contaminated sediments are also anticipated which under the proposed EVS guidelines will require land disposal. This could be taken by barge and disposed of at WENT landfill, following dewatering to eliminate free draining water.

The routine monitoring programme will be used to monitor the requirement for dredging to maintain free flows in culverts and drains in the downstream section of the channel, where marine sediments may accumulate and cause blocking.

2.6.11 So Kwun Wat

It is anticipated that approximately 4,650m^3 of catchment derived material (roughly 65% natural and 35% construction site) will need to be removed every 4 years from the area just upstream of the Castle Peak Road Bridge. It is proposed that low ground pressure tracked excavators, possibly fitted with dozer blades, would be used to move the material to a stockpile area adjacent to the Castle Peak Road for subsequent loading into trucks. The material is relatively coarse and uncontaminated and is considered suitable for local beneficial use or disposal at a public dump. Special care would have to be taken when dredging due to the large amounts of rubbish and debris in the channel, which require manual clearance.

2.6.12 Tai Lam Chung

It is anticipated that approximately 1,400m^3 of natural catchment derived material will need to be removed every 10 years from the area upstream of Castle Peak Road adjacent to the container storage area. Land based tracked excavators and manual methods are likely to be used in this section of the channel. The material is relatively coarse and unlikely to be contaminated and is therefore likely to be suitable for disposal at public dump or used for local beneficial uses.

2.6.13 Sham Tseng

No dredging has been predicted for this channel for flood alleviation but there is likely to be a nominal amount of dredging for clearance operations (50m^3 per year). It is likely that small land based plant will be used above the Castle Peak Road and the channel will be accessed via a ramp. Material is likely to be contaminated and will be transported to WENT landfill. It is unlikely that any material will be removed from the channel mouth, if it is then marine plant will be used and material taken to East Sha Chau.

SECTION 3

KEY ISSUE - WATER QUALITY

3. KEY ISSUE - WATER QUALITY

3.1. Introduction

The potential for the proposed dredging works to impact on the water quality of the channels has been recognised since the start of the study. (Water Quality impacts arising from disposal operations are discussed in Section 7). Impacts may arise from a number of sources, including:

i) release of sediment and associated pollutants during dredging;

ii) release of polluted water during handling of dredged material;

iii) changes in hydraulic characteristics of channels due to change in bed levels; or

iv) changes in physical characteristics or pollutant concentrations of the channel bed sediment.

Of these, the primary concern relates to the short term effects of items i and ii and the potential impacts which may result from these effects. The longer term effects associated with items iii and iv may arise from both the accretion of sediment and from its removal during dredging. The changes in water quality resulting from the natural accretion of sediment provide a baseline water quality impact against which the effect of dredging may be assessed.

In addition to the flood protection benefits, there are potential environmental benefits associated with dredging. For example, the removal of contaminated sediment, which may act as a reservoir of pollutants. However, any potential improvement in water quality is dependant on the pollutant loading and whether the sediment itself is a significant source of pollutants.

The extent and significance of the effects of dredging depend on: the existing water quality within the channels; the physical characteristics and pollutant concentrations in the sediment, the type and location of the dredging operations and more importantly, on beneficial use of the channel water and presence of sensitive receivers. Based on the recommendations from Task 5, the majority of routine dredging work will be scheduled to occur during the dry season when base river flows are extremely low. For many of the channels, sediment removal operations can therefore be scheduled to take place in the dry season, minimising the potential for water quality impacts. Most of the dredging works will be undertaken from a floating pontoon i.e. in wet conditions.

The objective of the water quality impact assessment is to determine the likely degree and spatial extent of the effect of dredging and to assess this effect against the natural variability of the water quality in the area in order to determine the potential impact on sensitive receivers. In addition, proposed monitoring and audit requirements are recommended to ensure that the dredging operations are effectively controlled.

3.2. Methodology and Criteria

3.2.1. Controlling Legislation

In Hong Kong impacts on water quality are controlled through the Water Pollution Control Ordinance (Cap. 358) (WPCO). The WPCO allows the Government to declare Water Control Zones (WCZ) and to set water quality objectives (WQO) which apply within the WCZ or parts thereof. The WQO describe the water quality that will promote the conservation and best use of the waters in the public interest. The existing designated Water Control Zones in Hong Kong are shown in Figure 3.1.

Discharges into drainage and sewerage systems, inland and coastal waters are controlled under the Technical Memorandum issued under section 21 of the WPCO. The Technical Memorandum classifies inland waters into four groupings according to their recognised beneficial use:

- Group A: abstraction for potable water supply;
- Group B: irrigation;
- Group C: pond fish culture; and
- Group D: general amenity and secondary contact recreation (including streams which enter the sea at gazetted beaches).

Specific effluent standards apply for each group of channels and vary according to the rate of discharge. Where a user abstracts water and then returns it to the channel, different standards may be applied although the discharger will not be required to return water cleaner than that abstracted.

Dredging is specifically excluded under the Technical Memorandum, although it may be considered to apply to discharges arising from the drainage of stored materials. Nor does the Technical Memorandum apply to discharges or deposits of waste that are controlled by the Waste Disposal (Livestock Waste) Regulations (Cap. 354 sub. Leg.), a subsidiary regulation to the Waste Disposal Ordinance (Cap. 354) (WDO).

3.2.2. Existing Situation

EPD undertake routine monitoring of watercourses within the WCZ on a monthly or bi-monthly frequency according to the specific sampling location. The measured data is used to determine the Water Quality Index (WQI) for each monitoring location, which is in turn used to determine the water quality ranking as Excellent, Good, Fair, Bad or Very Bad. The WQI is based on the observed dissolved oxygen (DO), 5-day Biochemical Oxygen Demand (BOD_5) and ammoniacal nitrogen (NH_4-N) concentrations and is primarily an indicator of organic pollution. Figure 3.2a indicates the 1995 rankings for the monitoring sites on the Study channels. Five of the study channels are excluded from the EPD routine monitoring programme, namely Staunton Creek, San Tin, Tai Lam Chung, So Kwun Wat and Sham Tseng.

All of the proposed dredging is within the tidal reach of the channels. Since the EPD routine monitoring is randomly scheduled, there is no direct assessment of tidal effects within the data set. A specific baseline monitoring exercise was scheduled under Task 1 of the study to provide monitoring over a thirteen hour period for those channels where dredging was originally anticipated: River Silver, Shing Mun, Tai Po/Lam Tsuen, Indus, Tin Shui Wai, Tuen Mun and Sham Tseng. Monitoring locations are shown in Figure 3.2b. All of the monitoring took place during 15th April 1996 to 18th April 1996 depending on the specific channel, with five samples taken at mid-depth at roughly three hourly intervals over a thirteen hour period for each site, see Appendix A3.

The results of the additional monitoring are included in Appendix A1. Generally the water quality was poorer than the average EPD results for the nearest routine monitoring site. The mean water quality over the period at each location was used to calculate the WQI, based on the standard EPD methodology, and the water quality ranking, see Figure 3.2b. Although not strictly comparable to the EPD reported WQI, which is based on an annual average, it provides a useful comparative measure.

Overall, the EPD monitoring indicates that there has been a steady improvement in the percentage of monitoring stations with a WQI of Fair or better, and in the percentage compliance with WQO. These improvements are the result of significant reductions in BOD load which have been achieved through the implementation of WPCO and WDO controls. The effectiveness of the controls is indicated in Table 3.1 which shows the changes achieved in the study channels.

TABLE 3.1 REDUCTION IN BOD LOAD IN STUDY CHANNELS

Watercourse	BOD load reduction		BOD load (1994)	Controls
	Kg/day	%	Kg/day	Introduced
Mui Wo (Silver)	192	99	1	August 1988
Shing Mun	6,450	78	1,850	April 1987
Tai Po / Lam Tsuen	4,170	65	2,246	April 1987
Indus / Beas	16,588	74	5,705	December 1990
Yuen Long / Kam Tin	23,961	61	15,329	December 1990
Tin Shui Wai	8,388	73	3,146	December 1990
Tuen Mun	13,955	90	1,590	April 1992

Source: River Water Quality in Hong Kong for 1994, EPD

All of the study channels listed in Table 3.1, with the exception of Tin Shui Wai, are designated by the Hong Kong Government as "priority watercourses" and targeted for investment and increased controls in order to improve water quality.

The reduction in waste load has resulted in an improvement in water quality in many of the channels monitored, in particular:

- Mui Wo (Silver)
- Shing Mun (excluding upper Fo Tan)
- Tai Po / Lam Tsuen
- Tuen Mun

Although the water quality in the Indus / Beas has improved slightly, it is still classified as Bad or Very Bad and there is no evidence of improvement in the Yuen Long / Kam Tin channels which are classified as Very Bad. WQO compliance in 1994 for DO, BOD_5 and COD were less than 50% for the following channels:

- Indus / Beas
- Tin Shui Wai

- Yuen Long / Kam Tin
- Tuen Mun

Although there are exceptions (most notably Tuen Mun) the general trend is for the water quality to deteriorate from the upper catchment, where the WQI is Fair or better, to the lower reaches, where it is generally Fair or worse.

3.2.3. *Numerical Modelling*

Channel Selection

A range of criteria were adopted to determine for which channels it was viable to undertake water quality modelling, these included:

- significance and method of proposed dredging;
- hydraulic characteristics and model;
- water quality, sediment quality and pollutant load information; and
- susceptibility to adverse impact.

Table 3.2 summarises the forecast dredging requirements, both in terms of volume of material and as a percentage of the total anticipated dredged volume. It is clear that the forecast dredging is heavily influenced by the estimated volumes for the Shing Mun and tributaries and the Tuen Mun, which together represent almost 60% of the total anticipated dredging requirement.

The channels in the N and NW New Territories (Indus, San Tin, Yuen Long and Tin Shui Wai) collectively represent 30% of the forecast requirements given the existing channels, reducing to around 25% following the implementation of the planned river training works. Of the remaining channels, only Tai Po / Lam Tsuen represents 5% or more of the anticipated annual dredging volume.

TABLE 3.2 ANTICIPATED ANNUAL DREDGING REQUIREMENTS

Watercourse	Anticipated Annual Dredging Requirements	
	m3/year	% of total
Mui Wo (Silver)	650	1
Staunton	330	<1
Kai Tak	2,000	3
Shing Mun and tributaries	27,780	42
Tai Po / Lam Tsuen	3,400	5
Indus (present / future)	5,000 / 5,900	8 / 10
San Tin (present / future)	4,500 / 420	7 / <1
Yuen Long drainage channels (future)	7,460	11
Tin Shui Wai	3,100	5
Tuen Mun	10,000	15
So Kwun Wat	1,150	2
Tai Lam Chung	140	<1
Sham Tseng Nullah	negligible	N/A

The basic approach to dredging in all of the channels is similar, using mechanical grab or backhoe to pick up the material and transfer it to a container for transport to a disposal site. In the smaller channels and particularly in the upper reaches or where marine access is restricted, the majority of the dredging can take place in dry conditions. Careful site management can effectively prevent any impact on water quality from occurring. This approach can be used in the River Silver, Staunton Creek, Kai Tak nullah, Tin Shui Wai western channel (above fabridam) and for the upper reaches of most of the channels.

Hydraulic models were developed using the SOBEK 1-D software under Task 4 of the study, in order to assess the effects of sedimentation and dredging on the flood characteristics of the channels under extreme tidal and storm flow conditions. Since the dredging will take place under dry season conditions, the hydraulic models must be stable under low flow conditions. For channels with a low base flow the water in the channels is primarily a function of the tidal exchange, resulting in low current speeds throughout the tidal cycle and extremely shallow water depths at low water. This is a problem for all of the channels, but particularly affects the smaller channels with the lowest base flows.

The available information on pollutant loads in all of the channels is a critical constraint. The lack of point discharge emission data means that water quality models can only be configured using the observed upstream and downstream water quality as input boundary conditions. The lack of available information describing the existing water quality in several of the channels further restricts the number of channels for which models can be configured. The limited sediment quality information in some of the smaller channels also limits the potential for assessing water quality impacts using a numerical modelling approach.

Those channels where the water quality has shown improvement since livestock waste controls were implemented and now have water quality rated as Fair or better are considered at most risk from impacts due to the proposed dredging activities. In those channels where the existing water quality is rated as Bad or Very Bad, the potential to model any incremental impact due to the dredging activities is extremely restricted as the effect of any modelled processes will be masked. In the smaller channels, the lack of water depth resulted in highly artificial concentrations in the area and were therefore unsuitable for modelling.

Due to these restrictions, water quality models were developed for the Shing Mun, Tai Po/Lam Tsuen and Tuen Mun channels only i.e. the three larger channels which have shown improving water quality as a consequence of the introduction of the WPCO and WDO controls and which represent the majority of the anticipated dredging. The intention was to use predicted impacts from these channels as an indication of potential effects in the other smaller channels. If impacts on water quality were not considered significant in the modelled channels then the same could be assumed for smaller channels where dredging requirements are significantly lower.

Model Description

The assessment is being undertaken using the SOBEK 1-D hydraulic model and the DELWAQ water quality model, both developed by Delft Hydraulics. The SOBEK software is used to output specific hydrodynamic information which is required for use in DELWAQ.

SOBEK is a one-dimensional open-channel dynamic modelling system which is capable of solving equations which describe unsteady flow, salt intrusion, sediment transport, morphology and water quality (*Ref. - SOBEK User's Guide and Technical Reference Guide, Delft Hydraulics, January 1996*). It enables the simulation and solving of problems in river management, flood protection, design of canals, irrigation systems, water quality, navigation and dredging. The software was developed by Delft Hydraulics in full partnership with the Institute for Inland Water Management and Waste Water Treatment (RIZA) of the Netherlands Government.

The modelling software requires a description of the river channel including cross-sectional profiles, structures on the river and any flow inputs at boundaries and other locations within the river network. Models of the study channels have already been developed in Tasks 3 and 4 to assess flooding, sedimentation and dredging issues.

The DELWAQ modelling software was developed by Delft Hydraulics (*Ref. - DELWAQ User's Guide and Technical Reference, Version 4.2, Delft Hydraulics, November 1995*). The software is a generalised package containing tools for calculating both the transportation of substances and the water quality processes which act on the substances, based on hydrodynamics supplied by 1-D, 2-D or 3-D hydraulic models.

Model Configuration

The basic hydrodynamic model input is the cross-sectional information at key locations along the branches on the channel network. In order to reduce numerical dispersion in the water quality model, the branches of the hydrodynamic model network were sub-divided into segments of 100m to 200m length. The hydraulic boundary input time series data was produced for representative model tidal boundary elevations and low river flow conditions.

The dry weather upstream boundary flow condition was taken from the Task 2 analysis of flow records from the surveys undertaken between August and October 1995 as part of Task 1. Table 3.3 shows a comparison of the low river flows identified from the observed data and the predicted 95%ile exceedance values based on the flow duration curves. Based on this data, the measured low flow values were used for the low flow river inputs at the upper boundaries. No dredging has been proposed in the channels under high flow conditions.

TABLE 3.3 LOW FLOW BOUNDARY CONDITIONS

Upstream River Boundary	Predicted 95%ile Flow Value (m3/s)	Measured Low Flow Approx. Value (m3/s)
Shing Mun	0.178	0.060
Fo Tan Nullah		0.005
Siu Lek Yuen Nullah		0.075
Tai Shui Hang		0.005
Tuen Mun	0.014	0.015
Tai Po	0.048	0.040
Lam Tsuen		0.040

In the absence of average spring and neap tidal data, tidal constituents have been taken for both the Tai Po Kau and Quarry Bay Tidal Stations and used to predict tidal curves of one year duration. An eight day period has been selected as representative of an average tidal condition, from mid-spring to mid-neap (7th to 14th January 1996). This tidal data has then been used as a tidal elevation boundary at the downstream end of the Tuen Mun (Quarry Bay) and Shing Mun and Tai Po / Lam Tsuen (Tai Po Kau) river networks.

The water quality model was configured to simulate changes in suspended solids (SS), biological oxygen demand (BOD), dissolved oxygen (DO), ammoniacal nitrogen (NH_4), cadmium (Cd) (a contaminant which partitions into the dissolved phase) and lead (Pb) (a contaminant which adsorbs to suspended sediment).

Due to the paucity of pollutant load data, the water quality models were configured with upstream boundary conditions based on the available monitoring data from the routine EPD surveys, additional monitoring undertaken for this study and the pollutant load information contained in the *River Water Quality in Hong Kong for 1994 (Ref. EPD/TR4/95)* report by EPD. Downstream boundary conditions were based on the *Marine Water Quality in Hong Kong for 1994 (Ref. EPD/TR5/95)* report by EPD, using data for Tolo Harbour and offshore of Tuen Mun. Such an approach is suitable for providing an indicative measure of the impact of a specific activity such as the proposed dredging, but not for the wider environmental management issues such as assessing the specific impact of individual discharges.

<u>Model Simulations</u>

For each river model, three sets of simulations were undertaken:

- baseline scenario;
- bed levels at dredging trigger levels; and
- dredging with bed levels as per baseline scenario.

The baseline simulation was run for each river to check that the predicted water quality was within the range observed during the EPD routine monitoring and the additional data collection undertaken for the study. Peak values for each channel were used to determine inputs at boundaries and for loads. Dredging load was determined by multiplying dredging release rate by the mass per unit volume of contaminant in the dredged material (kg/s x mg/kg). Where necessary, changes were made to the upstream boundary condition to ensure that the predictions were within the range of observations. Details of the boundary conditions used are given in Appendix A2.

In order to determine the effect of changing the bed level, the cross-sections used in the river network defined for the hydraulic model were changed to reflect the recommended dredging trigger bed levels. These levels are described in the draft Task 4 report and illustrated in Figures 3.3 (a and b), 3.4 and 3.5 for the Shing Mun and tributaries, Tai Po/Lam Tsuen and Tuen Mun channels respectively. All boundary conditions remained the same as the baseline conditions.

In order to simulate the dredging, the models were run with additional pollutant sources defined at the upstream end of anticipated dredging areas. In order to consider the worst case scenario, where more than one area is anticipated to be dredged it was assumed that dredging would be concurrent. Sediment release rates were provided by the Task 5 team on the basis of their experience of the anticipated dredging method and size of plant. 'S-factors' representing the loss of sediment (in kg per cubic metre dredged) for a variety of sizes and types of dredger working in fine sediments were defined. The S-factor for a small grab-dredger working with an open grab bucket and no silt curtain was estimated to be typically 25kg/m^3.

For the input to the modelling , the S-factor was used, in conjunction with estimated dredging production rates to derive a loss rate in kg/sec. The rate of production varied from channel to channel depending on the channel characteristics and the degree of difficulty of working. For the Shing Mun River, restoration dredging, a worst case was assumed for two dredgers working simultaneously with a total rate of production of approximately 40m^3/hr.

The sediment release rates are detailed in Table 3.4 below:

TABLE 3.4 SEDIMENT RELEASE RATES DURING DREDGING

River Stretch	Sediment Release Rate (Kg/s)
Shing Mun	
upstream of Lion Bridge	0.097
downstream of Lion Bridge	0.194
Fo Tan Nullah	Done in the dry
Siu Lek Yuen Nullah	0.175
Tai Shui Hang	0.175
Tai Po	0.194
Lam Tsuen	0.194
Tuen Mun	0.194

The dredging was represented as a pollutant source discharging at the pollutant load derived from the sediment release rate and the pollutant concentration. The maximum sediment contaminant concentrations identified from the grab and core sample testing undertaken through Task 1 were adopted as representative of worst case conditions.

Dredging operations were assumed to occur over a ten hour period during daylight hours over the entire eight day simulation period, during which the tidal range reduced from spring to neap tide. 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.

3.2.4. *Results and Discussion*

Graphs of all model predictions are presented in Appendix 2 of this report. When interpreting the model results, the following points were borne in mind:

i) The lack of detailed pollutant load information restricts the robustness of the modelling so that the results are only indicative of sign and order of magnitude of effect, but this is considered adequate for assessing the potential impact of dredging.

ii) The channels are generally steep in the upper reaches but almost flat over an extended tidal reach. One of the controlling effects on water quality is therefore the residence time associated with the tidal exchange. Increasing the bed levels reduces the residence time, effectively increasing the flushing of the channels and therefore improving the predicted water quality. Dredging would therefore have the opposite effect, increasing the exchange volume and the residence time. This could potentially cause a deterioration in water quality after the dredging operations are completed, although this clearly depends on the extent of the pollutant loading and characteristics of the newly dredged channel bottom sediments.

Modelling results indicate the following:

i) The dredging will result in a significant increase in suspended solids concentrations in the area of the dredging. The concentration will drop relatively quickly and is expected to reduce to no more than 10mg/l above background within 500m of the dredging site. The actual concentration will depend heavily on the sediment release rate, which will in turn depend on the dredging and material handling methods adopted.

ii) Modelling indicated that an increase in bed level results in an improvement in water quality, most notably as an increase in 0.5mg/l in dissolved oxygen concentrations over much of the length of Shing Mun River due to reduced exchange volume and residence time. The predicted decrease in DO due to the dredging works (shown in the graphs in Appendix 2) is minimal and is significantly less than the predicted increase in DO levels due to an increase in bed levels. However, the high BOD levels observed in some of the channels suggests that there may be areas of sediment with higher organic content, which would result in a greater adverse impact than that modelled. Given the potential for such impacts and subsequent effects of DO depletion, this will be a key parameter for impact monitoring and will therefore be included in the EM&A Programme.

iii) The water quality effects associated with the increase in suspended solids concentration are a reflection on the nature and degree of the contamination of the sediment being dredged.

The model looked at lead, considered to be a key metal due to high levels found in the sediments and also cadmium due to its toxicity at very low concentrations. Typical increases in metal concentrations predicted by the model runs are:

Channel	Lead (mg/l)	Cadmium (μg/l)
Shing Mun River	0.01	0.03
Tai Po / Lam Tsuen	0.02	0.10
Tuen Mun	0.10	0.10

The high levels of certain metals in some of the sediments sampled indicates that the impact monitoring for the larger dredging events should include measurement of appropriate metals potentially released during dredging. These will be dependent upon the sediment quality data and identified parameters of concern.

3.3. Elutriate Tests

The modelling used sediment quality data obtained from site surveys and based metal partitioning between the particulate and dissolved phase on common literature coefficients. Elutriate tests were also undertaken to assist in identifying potential disposal options and to provide a comparison with the potential impacts identified by the modelling. It should be noted that elutriate tests can over state predicted contaminant concentrations and therefore the results should be interpreted with caution.

The elutriate tests were undertaken on 11 samples taken from 3 channels as part of an additional sediment survey to look at key contaminants in more detail. The samples were taken from Tuen Mun River channel, Tai Po/Lam Tsuen and Shing Mun Rivers (including Fo Tan Nullah). One sample of water was taken for the tests from each channel. The loss of contaminants to the river water during tests is presented in Table 3.5 together with the water quality of the river water used in the tests. Table 3.6 shows net increases in contamination in the water i.e the difference between the final elutriate concentration and the river water. Again, the river water quality is shown for comparison. Full results are attached as Appendix A10 and are described below.

3.3.1. Results and Discussion

The results represent a worst case scenario as the channels considered contained some of the most contaminated sediments identified in the core sample. Also, as stated above, elutriate tests, by their very nature, overstate the potential impact. The accuracy of the tests is limited and only provide an indication of contaminants likely to be of concern during dredging.

In the absence of water quality objectives for specific metals in inland waters in Hong Kong, data was compared to Standards for Effluents Discharged into Group D Inland Waters which have also been provided in Table 3.5. The channels for which elutriate tests were undertaken were the Group D water bodies, i.e. those that permit secondary contact recreation.

Ammonia

From the results, the final elutriate concentration exceeds the TM standard for ammonia in three of the river water samples. Since ammonia was not determined in the river water, total Kjedahl nitrogen (TKN) can be used as an indication of original ammonia levels since TKN comprises total organic nitrogen and total ammoniacal nitrogen. Background TKN levels were very low so it can be assumed that background levels of ammonia were even lower. Results for TKN and ammonia in the final elutriate are very similar (Table 3.5) and it can therefore be deduced that total organic nitrogen levels were low and TKN is representative of ammoniacal nitrogen levels. Net increases in TKN shown in Table 3.6 are therefore representative of net increases in ammonia. Net increases in Shing Mun River samples were at worst 11 mg/l above the original channel concentration, 7.7 mg/l above the original TKN value in Tai Po and nearly 39mg/l above the original river water concentration for TKN in Tuen Mun. Despite this, net increases only exceed the TM standard (20mg/l for TKN and ammonia) in Tuen Mun.

These findings contradict with modelling results which show an increase of less than 0.25 mg/l in ammoniacal nitrogen levels during dredging in Tuen Mun River, and a maximum of 0.1mg/l in Shing Mun and 0.08 in Tai Po/Lam Tsuen.. Given this and the recognised potential to over predict the dissolved chemical concentrations by more than an order of magnitude using data from elutriate tests, following mixing in the water body, ammonia is unlikely to cause significant adverse impacts for most of the dredging events. However, for the larger dredging operations (>30,000m^3), particularly restoration dredging works in the Shing Mun, it is considered necessary to monitor ammonia to ensure that there are no significant increases in ammonia and secondary impacts on fish. For large events, comprehensive Category C monitoring would be required and will include ammonia, as described in Section 8.3. Ecological impacts are discussed further in Section 4.4.3.

Metals

Net increases in nickel were found in two Shing Mun River samples, as shown in Table 3.6. Although the net increases were up to one and a half times greater than original water quality, concentrations remained significantly lower than the TM Standard. One sample in the Tai Po river indicated that lead release was up to nine times the original river water lead concentration. Concentrations for lead for all samples were well below TM Standards for metals, especially considering that elutriate results may over predict chemical concentrations by an order of magnitude.

Generally, in terms of other contaminants, zinc and arsenic appeared to be elevated in the river water elutriate but this was due to high concentrations in the actual river water used in the tests. No net increase resulted during the elutriate test and it can therefore be assumed that dredging will not add to levels of these contaminants in the water column. This is in agreement with EVS' study who have stated in their report on the classification of dredged material for marine disposal (EVS Draft Final Report, 1996) that although sediment bound arsenic can be released into the water column, it is usually relatively stable for 100's of years. Toxicity of arsenic increases with solubility in water and arsenic is included in Annex II of the London Convention.

Both modelling and elutriate tests have indicated that there is a potential for contaminant release following sediment disturbance such as dredging. For small dredging events these releases will be insignificant but again, where volumes to be dredged are large such as in the Shing Mun River Restoration dredging then metal sampling is recommended as part of the category C water quality monitoring to ensure increases are detected and impacts prevented. Mitigation is described below.

3.4. Mitigation

The water quality modelling reflects worst case conditions for dredging production and considers rates of up to 40m^3/hr based on two dredgers operating in the case of the Shing Mun River. Without any mitigation the potential water quality impacts are confined to a 500m zone of influence and are not predicted to be significant. However, the potential for the release of contaminants such as ammonia and lead has been indicated in elutriate results. Although these tests only provide an indication of likely impacts, the results support the need for a well managed dredging operation subject to environmental monitoring and audit.

Direct mitigation such as the case of silt curtains has been considered. However, due to the low water depths and tidal fluctuations over a typical dredging day, their use is considered impracticable. The mitigation recommended includes both improvements to current dredging practice, as well as direct controls imposed on the dredging operation.

The dredging manuals will incorporate mitigation to minimise the volume of material dredged and to encourage accurate dredging. Examples include, the fitting of depth and position indicator, so that the operator knows the precise dredging location. The also allows the operator to install the correct size grab or excavator bucket, so that they are completely filled during normal operation, thereby eliminating excessive water loss. In addition, the dredging manuals incorporate penalties for unnecessary overdredging.

Direct mitigation in the form of standard specifications is also proposed. These are presented in the form of contractual clauses in Section 8.3.3. and include the following controls:

- a requirement for water quality monitoring in accordance with the categorisation system A, B and C, ranging from no monitoring to comprehensive monitoring including laboratory analysis, as described in section 8 of this EIA and the EM&A manual;
- the planning of dredging works during the dry season;
- restrictions on the commencement of dredging operations during periods of critically low DO levels;
- separate removal of large objects that might affect the closing of grab buckets;
- accurate barge loading;
- the use of tightly closing grabs and hoist speeds that minimise sediment loss; and

- the planning of the dredging works with due regard to sensitive receivers.

3.5. Conclusions

The data collection, sediment testing and numerical modelling work has provided an indication of the effects likely to result from the proposed dredging works, as well as an indication of the constraints in attempting to quantify these effects. Modelling of the larger channels in the study in which the majority of dredging will take place has indicated only marginal effects in terms of sediment release and subsequent impacts. For the smaller channels and where only small volumes of material are to be dredged, impacts will therefore be minimal and monitoring is not considered necessary. For the larger channels and/or larger dredging events releases of suspended solids could potentially cause depletion in dissolved oxygen and release contaminants and nutrients into the water column, depending on existing sediment and water quality.

Allowing bed levels to increase, while offering the potential for improvements in dissolved oxygen due to increased flushing, also increases flood risk. Dredging has only small negative impacts on dissolved oxygen levels in the channel and offers the significant benefits of reducing flood risk and removing contaminated material which has the potential to release contaminants during periods of disturbance such as storm events etc. With controls on pollutants entering the channels, potential for contaminant releases during future dredging events is likely to be significantly lower.

Releases of sediment will be controlled as far as possible through good dredging practice as detailed above.

Since the significance and degree of impact are dependent on water and sediment quality prior to dredging, monitoring will provide the key to controlling impacts. Monitoring will be dependent upon channel size, dredged volume and sediment quality. EM&A for water quality has been described in detail in section 8.3. Event contingency plans have also been devised for occasions when Action or Limit levels are exceeded.

A summary of proposed mitigation is presented in Table 3.7.

TABLE 3.5 RESULTS OF ELUTRIATE TESTS UNDERTAKEN WITH RIVER WATER

Analysis description	Shing Mun River water	D2	D4	D6	D9	Tai Po River Water	E1	E4	E5	Tuen Mun River water	J1	J2	J3	J4	Standard of TM*
Arsenic (µg/l)	60	50	50	50	50	40	40	40	50	30	30	30	30	20	n/a
Cadmium (µg/l)	<0.2	0.2	0.2	0.4	0.2	<0.2	0.2	<0.2	<0.2	<0.2	<0.2	<0.2	0.2	<0.2	1
Chromium (µg/l)	7	11	4	3	2	1	3	2	1	<1	<1	<1	<1	<1	200
Copper (µg/l)	10	10	8	9	7	8	7	6	9	7	5	5	4	5	200
Lead (µg/l)	<1	2	<1	<1	<1	<1	<1	2	9	<1	<1	<1	<1	<1	200
Nickel (µg/l)	9	16	5	5	20	8	6	9	6	8	8	9	9	9	200
Zinc (µg/l)	40	30	40	40	30	60	40	20	40	60	30	30	20	30	200
pH Value	8.1	7.4	7.7	7.8	7.5	7.7	7.5	7.6	7.7	8.1	9.5	7.8	7.9	8.0	6-10
Total Kjeldahl Nitrogen as N (mg/l)	0.8	10.3	8.3	11.9	5.5	1.2	8.9	<0.1	0.4	1.3	0.5	20.9	40.2	38.1	20
Total Phosphorus as P (mg/l)	<0.01	0.07	<0.01	<0.01	0.09	0.1	0.10	0.04	<0.01	<0.01	0.04	0.08	0.08	<0.01	5
Ammonia (mg/l)	-	10	7.7	11.8	5.2	-	8.3	<0.1	0.2	-	0.5	20.6	38.5	37.3	20

- Source: Table 6, Standards for effluents discharged into Group D inland waters, *Standards for Effluents Discharged into Drainage and Sewerage Systems, Inland and Coastal Waters.* EPD Technical Memorandum, 1991

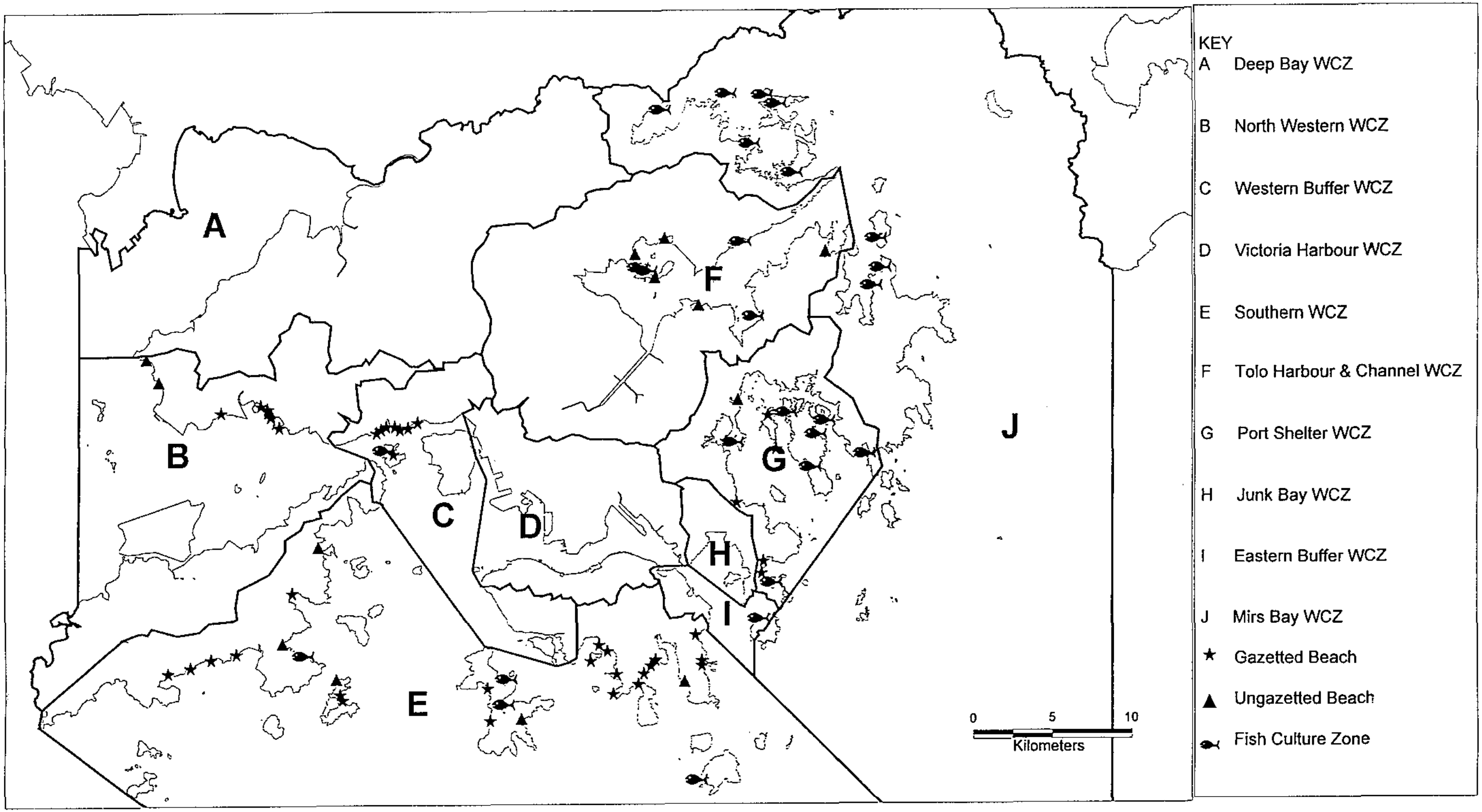
TABLE 3.6 RIVER WATER QUALITY AND NET INCREASES IN CONTAMINANTS AFTER ELUTRIATION.

Analysis description	Shing Mun River water	D2	D4	D6	D9	Tai Po River Water	E1	E4	E5	Tuen Mun River water	J1	J2	J3	J4
Arsenic (µg/l)	**60**	0	0	0	0	**40**	0	0	10	**30**	0	0	0	0
Cadmium (µg/l)	**<0.2**	0	0-0.2	0.2-0.4	0-0.2	**<0.2**	0-0.2	0	0	**<0.2**	0	0	0.2	0
Chromium (µg/l)	**7**	4	0	0	0	**1**	2	1	0	**<1**	0	0	0	0
Copper (µg/l)	**10**	0	0	0	0	**8**	0	0	1	**7**	0	0	0	0
Lead (µg/l)	**<1**	1-2	0	0	0	**<1**	0	0-2	0-9	**<1**	0	0	0	0
Nickel (µg/l)	**9**	7	0	0	11	**8**	0	1	0	**8**	1	1	1	1
Zinc (µg/l)	**40**	-	-	-	-	**60**	0	0	0	**60**	0	0	0	0
pH Value	**8.1**	dec 0.7	dec 0.4	dec 0.3	dec 0.6	**7.7**	dec 0.1	dec 0.1	0	**8.1**	inc 1.4	dec 0.3	dec 0.2	dec 0.1
Total Kjeldahl Nitrogen as N (mg/l)	**0.8**	9.5	7.5	11.1	4.7	**1.2**	7.7	0	0	**1.3**	0	19.6	38.9	36.8
Total Phosphorus as P (mg/l)	**<0.01**	0.07	0	0	0.09	**0.1**	0	0	0	**<0.01**	0.04	0.08	0.08	0

TABLE 3.7 SUMMARY OF WATER QUALITY MITIGATION:

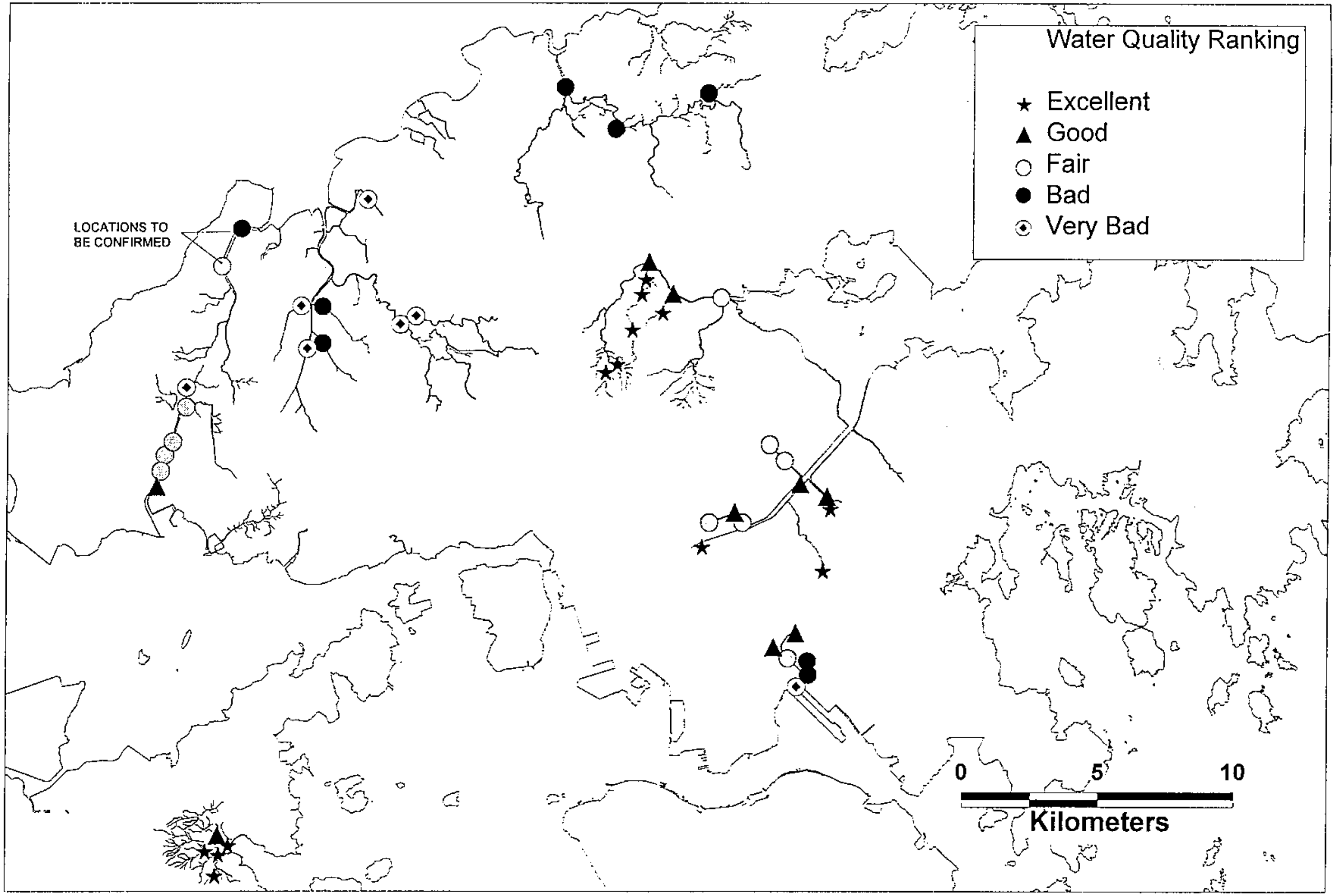
Channel	Mitigation	Mechanism to Implement	Environmental Acceptability
River Silver	Standard Mitigation. Avoid bathing season	Contract Clauses	✓
Staunton Creek	Standard Mitigation Sediment should not be sprayed down in dried areas as this disperses contaminants and contributes to odour generation.	Contract Clauses	✓
Kai Tak nullah	Standard Mitigation Overalls, gloves and face protection should be used during manual clearance as a precaution against skin-contact or inhalation related health impacts. Sediment should not be sprayed down in dried areas as this disperses contaminants and contributes to odour generation.	Contract Clauses	✓
Shing Mun River	Standard Mitigation*. Schedule dredging in early dry season to avoid dragon boat races in April-June etc. Category C monitoring for restoration works.	Contract Clauses	✓
Tai Po Lam Tsuen	Standard Mitigation*.	Contract Clauses	✓
River Indus	Standard Mitigation*	Contract Clauses	✓
San Tin	Standard Mitigation*	Contract Clauses	✓
Yuen Long/Kam Tin	Standard Mitigation*	Contract Clauses	✓
Tin Shui Wai	Standard Mitigation*	Contract Clauses	✓
Tuen Mun	Standard Mitigation.*	Contract Clauses	✓
So Kwun Wat	Standard Mitigation*	Contract Clauses	✓
Tai Lam Chung	Standard Mitigation*	Contract Clauses	✓
Sham Tseng	Standard Mitigation*	Contract Clauses	✓

**Standard Mitigation refers to measures included in standard specifications listed in Section 8*



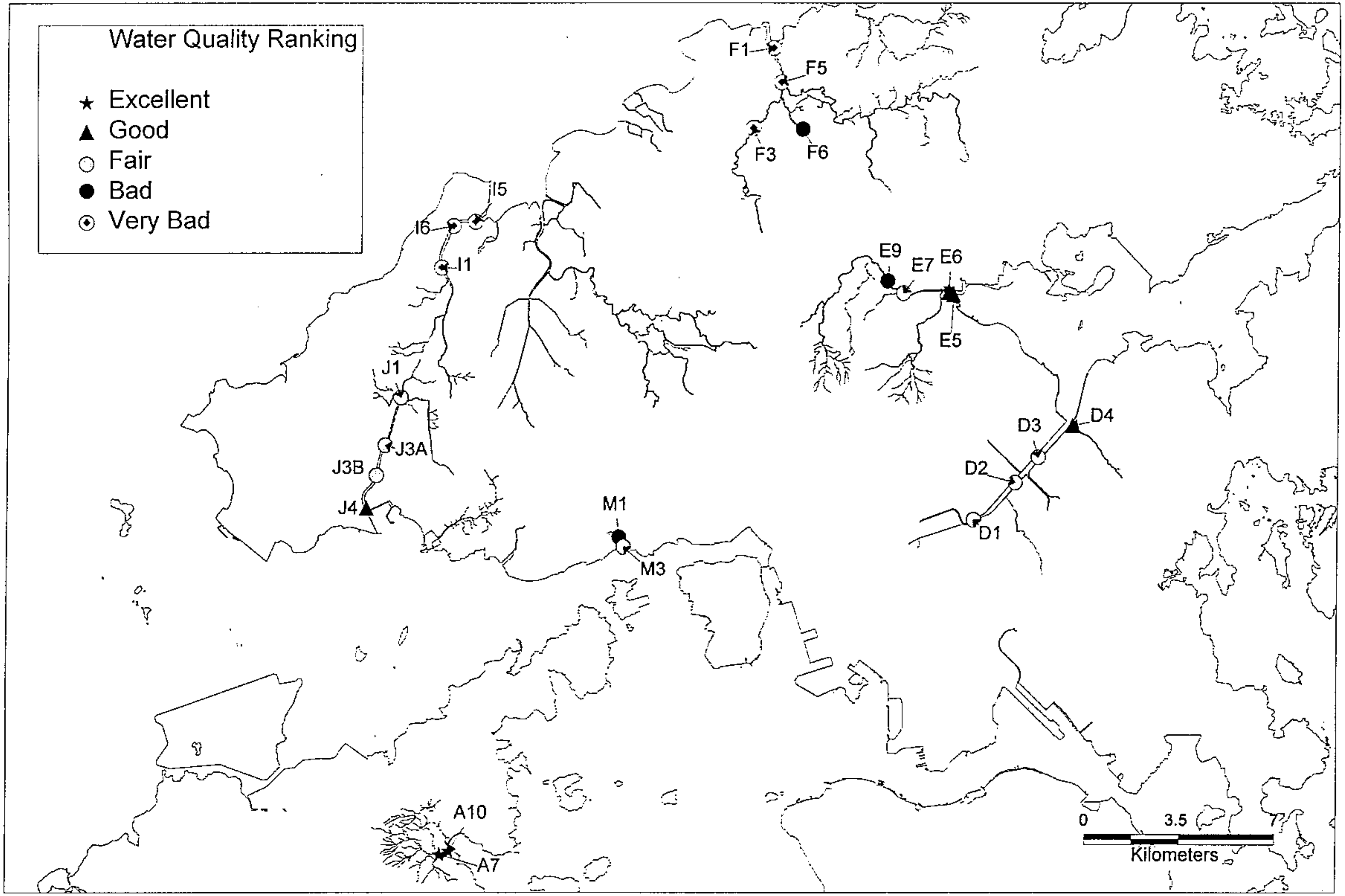
Hyder Consulting

Figure 3.1 Location of Gazetted Beaches, Ungazetted Beaches, Fish Culture Zones and Water Control Zones



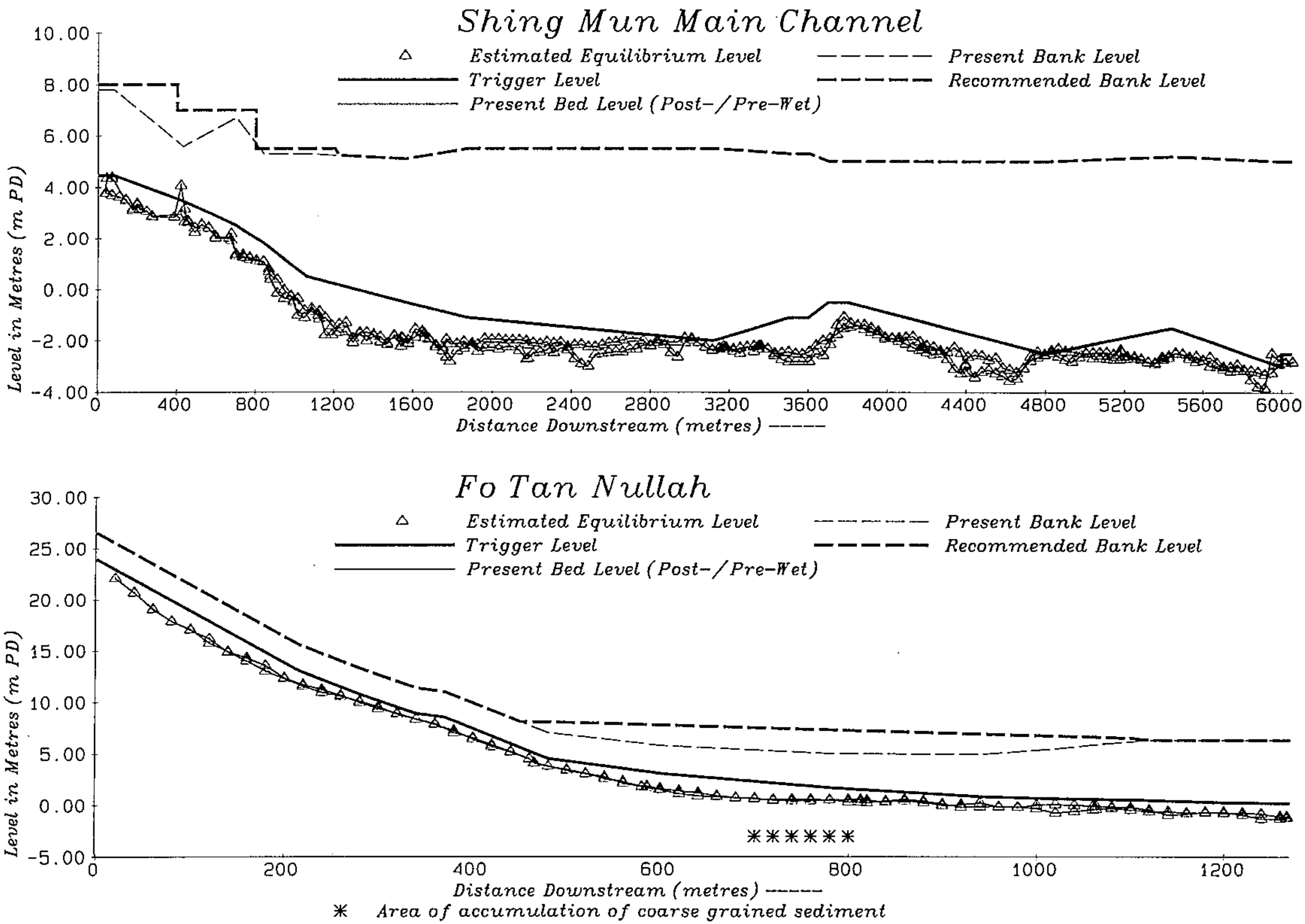
Hyder Consulting

Figure 3.2a EPD 1995 Water Quality Ranking for Routine Monitoring Sites in Study Channels



Hyder Consulting

Figure 3.2b Locations of Baseline Water Quality Monitoring Sites and Water Quality Ranking based on monitoring results



SEDIMENTATION STUDY

Shing Mun Main Channel and Fo Tan Nullah
Estimated equilibrium level, trigger level for dredging and present bed level for consolidated layer

SOBEK

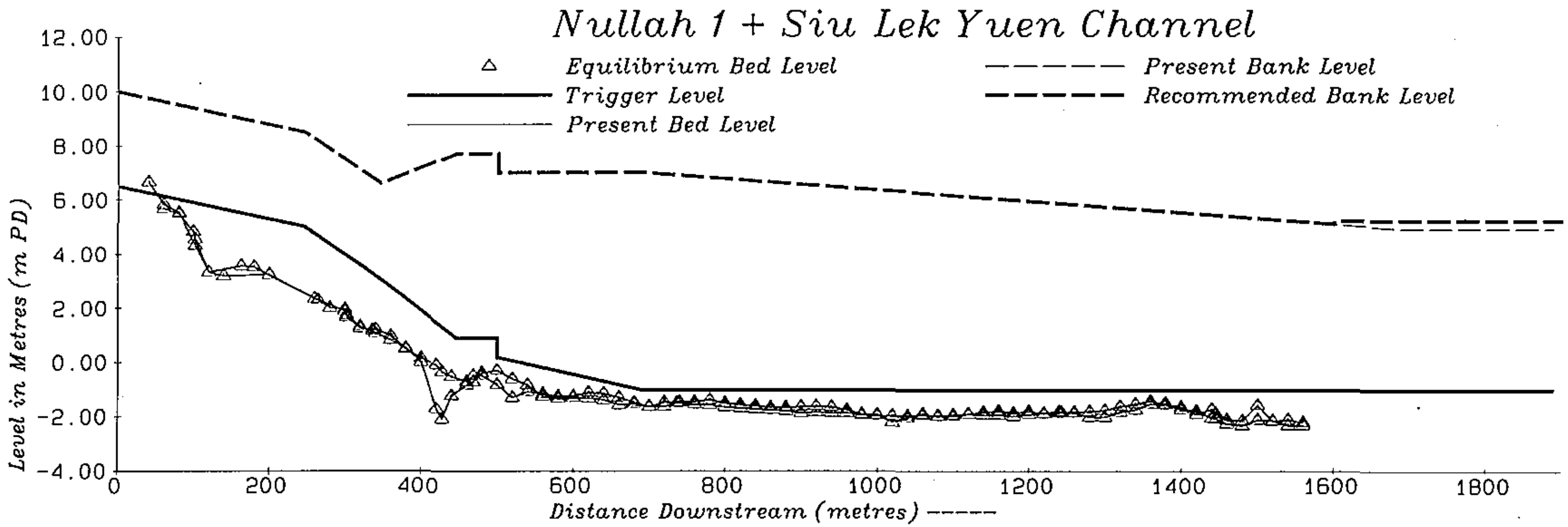
Shing Mun Model

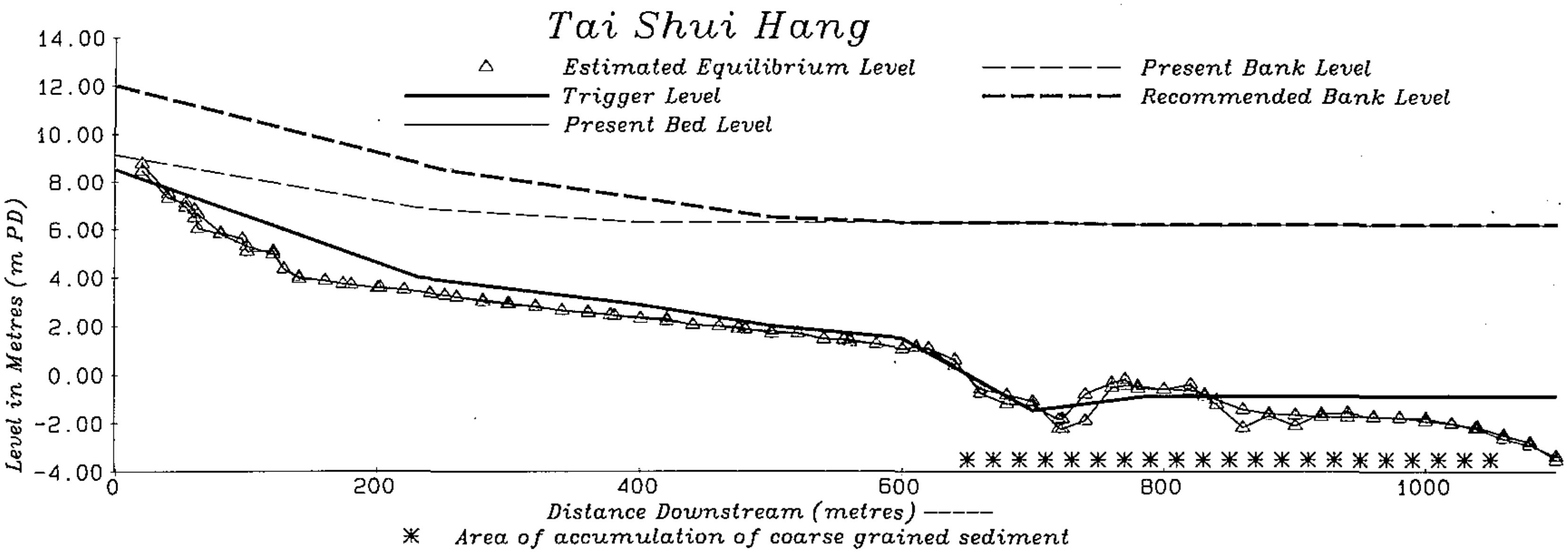
22-11-96

Fig. 3.3A

SEDIMENTATION STUDY

Siu Lek Yuen and Tai Shui Hang
Estimated equilibrium level, trigger level for dredging and present bed level for consolidated layer





Shing Mun Model

SOBEK

22-11-96

Fig. 3.3B

SEDIMENTATION STUDY

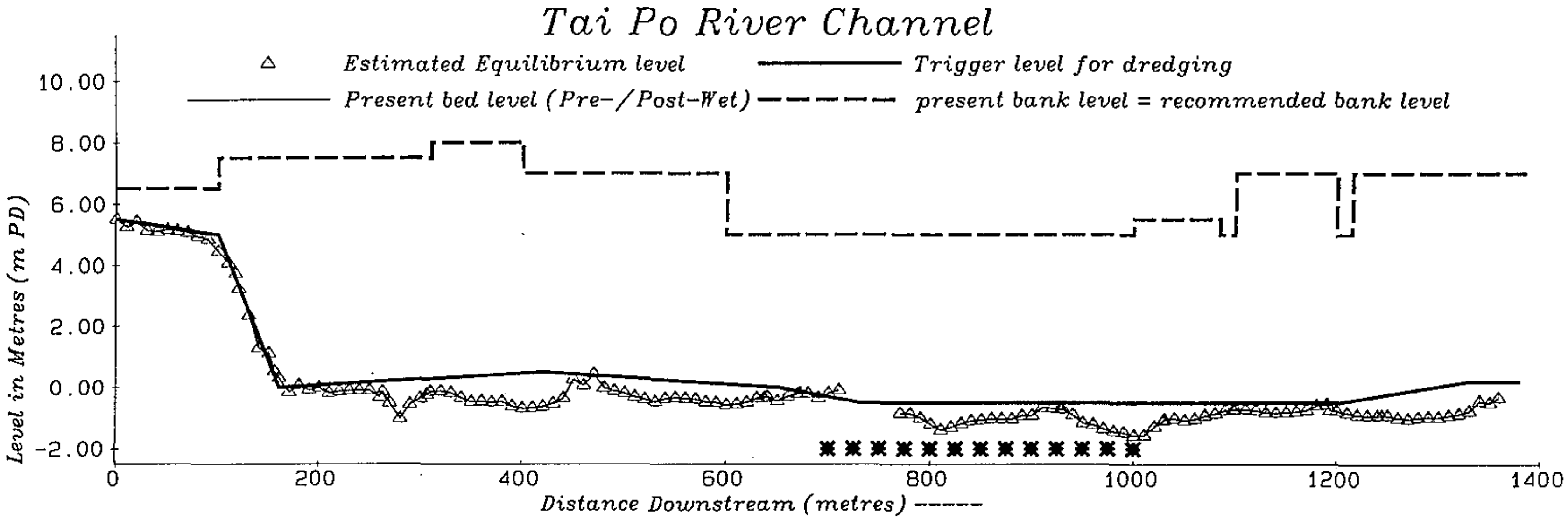
Tai Po and Lam Tsuen River Channels
Estimated Equilibrium level, trigger level for dredging and present bed level for consolidated layer.

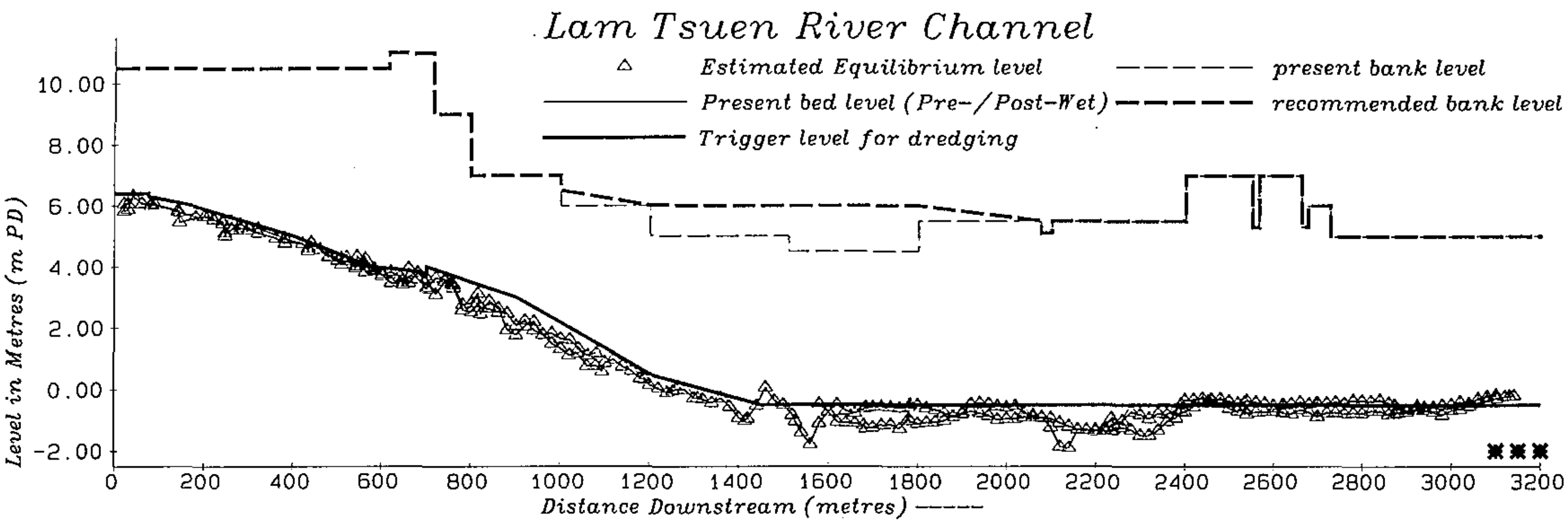
S O B E K

22-11-96

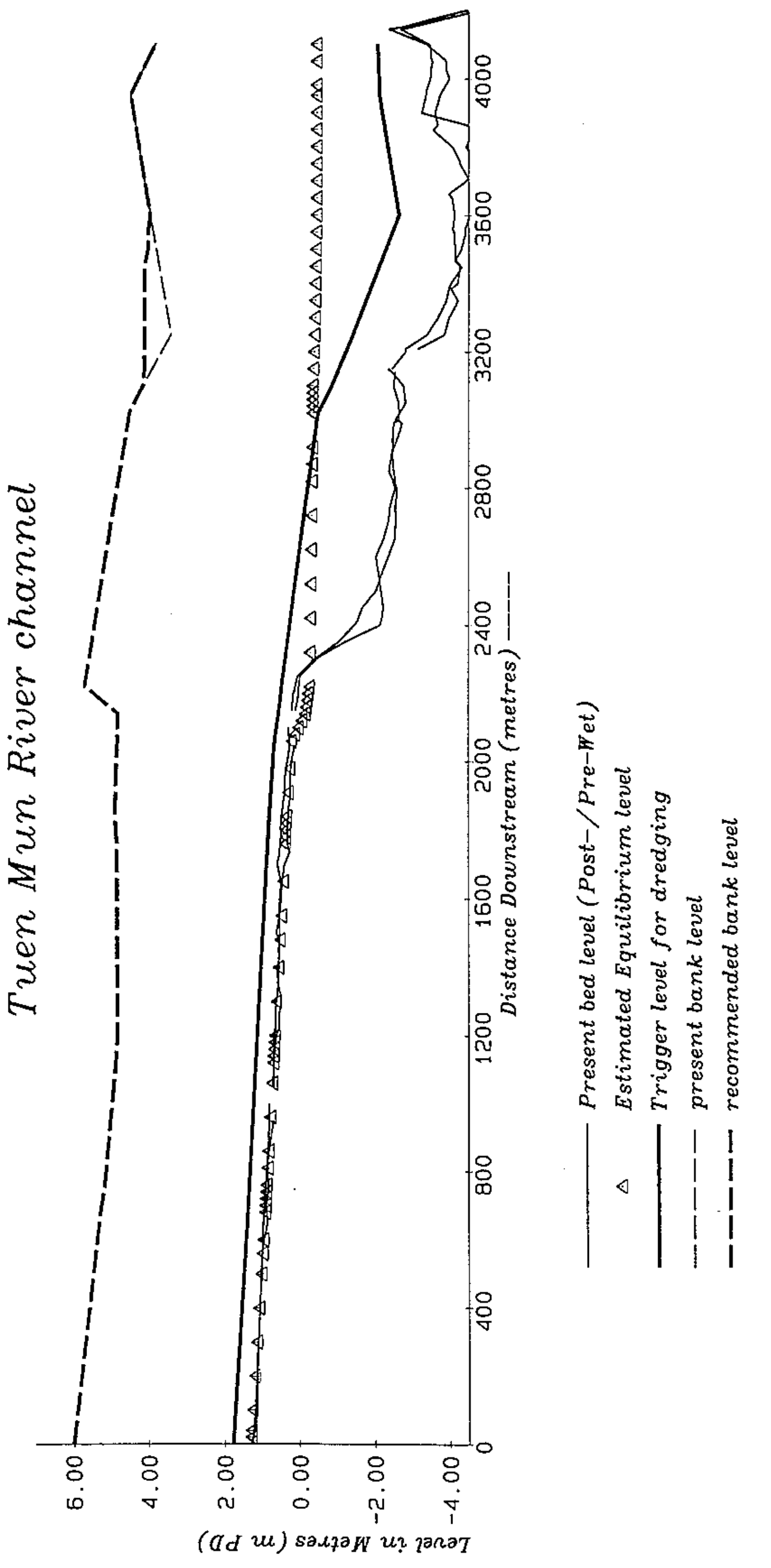
Tai Po/Lam Tsuen Channels

Fig. 3.4





* area of accumulation of coarse grained sediment



Tuen Mun River Channel *Estimated Equilibrium level, trigger level for dredging and present bed level for consolidated layer.*	*S O B E K*	*22–11–96*
	Tuen Mun River Channel	
SEDIMENTATION STUDY		*Fig. 3.5*

SECTION 4

KEY ISSUE - ECOLOGY

4. KEY ISSUE - ECOLOGY

4.1 Introduction

The Key Issues Report identified ecology as an area requiring further assessment, particularly regarding potential habitat loss and disturbance to bird populations. However, the potential significance of impacts has been reduced considerably since the Key Issues Report was prepared given that predicted dredged volumes are now reduced to an average of 60,000m^3 of sediment per annum for all 13 channels.

In-stream ecology can be impacted upon both directly and indirectly in the short term by dredging operations. Loss of substrate can have impacts on fauna living or feeding in or on the sediment deposits, while release of contaminants can directly affect aquatic life and potentially have long-term effects on the food chain. It should, however, also be noted that dredging may in the long term help to improve the river water and sediment quality and encourage a more diverse ecological community.

Outlined below is the legislation protecting Hong Kong's ecological resources together with the methodology used to assess ecological impacts and a summary of the detailed impact assessment. Practical mitigation measures have also been outlined below but will be discussed in greater detail in the channel specific sections.

4.2 Assessment Methodology and Criteria

4.2.1 Hong Kong Government Regulations

The Hong Kong Government Regulations relevant to the maintenance dredging work include the following:

- the Forests and Countryside Ordinance (CAP 96) which protects both natural and planted forests, including mangroves;
- the Forestry Regulations which protect specific local wild plant species; and
- the Wild Animals Protection Ordinance (CAP 170) which protects specific species of wild animals (excluding fish and marine invertebrates) by prohibiting the disturbance, taking or removal of such animals, their nests and eggs.

The Town Planning Ordinance (Cap. 131), Section 3(1)(a) states the Town Planning Board shall undertake systematic preparation of draft plans for the layout of such areas of Hong Kong as the Governor may direct, as well as for the types of building suitable therein. Moreover the ordinance also makes provision under section 4(1)(g) that the Board's draft plans prepared under section 3(1)(a) for the layout of any such area may show or make provision for country parks, coastal protection areas, Sites of Special Scientific Interest (SSSIs), green belts or other specified uses that promote conservation or protection of the environment.

Hong Kong Government guidelines relevant to ecological aspects of the study are the following:

- Hong Kong Planning Standards and Guidelines which address protection of ecological resources.
- Deep Bay Guidelines for Dredging, Reclamation, and Drainage Works which address geographic, seasonal, temporal, technological, and methodological restrictions on such works in the Deep Bay area.

International treaties and conventions relevant to Hong Kong, through the United Kingdom, which relate to the ecological aspects of the study are the following:

- The Convention on Wetlands of International Importance Especially as Waterfowl Habitat (the Ramsar Convention) which allows designation of important wetlands as Ramsar Sites (Mai Po Marshes Nature Reserve and portions of surrounding buffer zones were approved for nomination to the Ramsar Committee as Hong Kong's first Ramsar site in March 1995) and requires wise use of Territorial wetlands from a conservation perspective.
- The Convention on the Conservation of Migratory Species of Wild Animals (the Bonn Convention) which requires protection of species (mainly of migratory water birds) which seasonally occupy or migrate through the Territory.

The significance of potential ecological impacts is dependant on a number of factors for example; whether any designated sites of ecological importance are affected; if long-term residual impacts are predicted; or if there is a cumulative impact on similar ecological resources. Furthermore, it has been recognised from the outset of Task 6 that consideration of ecological impacts should not be confined to those particularly sensitive areas. Equal attention should be paid to the preservation of the natural environment generally, e.g. natural earth river banks and associated vegetation.

Hong Kong Environmental Impact Assessment Bill

The Hong Kong Environmental Impact Assessment Bill was enacted on 29 January 1997. The forthcoming Technical Memorandum will set down criteria and guidelines for project proponents to follow for scheduled projects including maintenance dredging works. Generally only dredging work exceeding 500,000m^3 of sediment will be controlled by the Technical Memorandum. However, works within 500m of an area of ecological importance will require an Environmental Permit. In particular, maintenance work in channels in the vicinity of the Inner Deep Bay Ramsar site i.e San Tin MDC, Yuen Long and Tin Shui Wai channels, may in the future require an Environmental Permit.

4.2.2 Ecological Assessment Methodology

Site visits proved valuable for scoping the project area in terms of ecological importance. It was apparent from initial visits that ecological concerns were minimal in a number of the channels where water was evidently highly polluted and the channels engineered structures. A conceptual, qualitative ecological model (Figure 4.1) was developed as a tool for directing the assessment of energetic and trophic relationships between groups of organisms which may be subject to impacts of dredging. Channel specific models were then produced to describe the potential range of impacts which could result from dredging related disturbances.

The only field surveys required under Task 6 have been bird surveys in those channels known to support diverse or abundant avifauna or which provide habitat of seasonal importance for migratory, wintering or breeding birds. The channels studied included:

i) San Tin Nullahs

ii) Tin Shui Wai Western and Eastern Channels

Bird belt transects were conducted on both sides of the channel extending no more than 500 m on each side. The length of channel surveyed was approximately 1 km in each case. The surveys were undertaken on three days per quarter in order to cover a full 12 month period. The results are presented in the channel specific sections in Volume B.

Following a review of available data from previous studies and discussions held with AFD relating to the poor water quality of the channels, additional benthic sampling was not considered appropriate. The channels support a low diversity community of pollutant-tolerant organisms which would readily re-establish in the channels following dredging. On-going studies in Tin Shui Wai, Yuen Long and San Tin were also identified to provide additional information for channels of greater ecological concern. Generally a loss of such species would not be of ecological significance particularly as observations during the avifauna surveys did not indicate that bird populations were dependant on benthic organisms as a food source.

4.3 Areas of Concern

In terms of potential impacts of concern, channels in close proximity to SSSIs, the Mai Po Ramsar Site and respective buffer zones; Fish Culture Zones; fish ponds and water bodies known to be of ecological value are vulnerable to primary and secondary impacts caused by dredging. Primary impacts being disturbance, loss of habitat and noise, secondary impacts being effect of water quality impacts on the ecology e.g pollutant release.

On a localised scale loss of benthos; impacts on aquatic organisms in the channel and receiving water; disturbance; loss of feeding areas; impacts on the food chain; and damage to vegetation whether aquatic, marginal or bankside vegetation are potential impacts arising from dredging works. In terms of vegetation, the study has not identified any potential impacts on protected species and impacts are not species specific, rather the emphasis has been on protection of local habitats.

Those channels considered most sensitive ecologically are as follows:

- The Tin Shui Wai, Yuen Long / Kam Tin and San Tin MDC which lie close to or within the Buffer Zone area of the designated Ramsar Site, area of International Importance for wetland birds. Tin Shui Wai channel is important for migratory waterfowl such as teal and widgeon as well as waders, including herons and egrets. Its proximity to Deep Bay encourages use by many of the water bird species which feed primarily on the mud flats of inner Deep Bay. The same is true for San Tin nullahs although they tend to support species which feed individually or in small groups;

- The Shing Mun and Tai Po rivers which drain into Tolo Harbour, an area of significant ecological resource in terms of marine ecology;
- The present River Indus channel, River Silver, So Kwun Wat and Tai Lam Chung rivers where access for dredging could result in damage to bankside vegetation and in the case of River Indus potential damage to adjacent fishponds.

Ecology is not considered to be a key issue in the following channels in this study:

- Kai Tak Nullah - this channel is engineered and has a concrete bed and contains water of poor quality and contaminated sediment. Ecological impacts of dredging are therefore not a key issue in this channel.
- Staunton Creek Nullah - again this channel is engineered and contains contaminated sediment. Bankside vegetation and in stream ecology are not considered to be of special or common value therefore potential ecological impacts are not a key issue.
- Tuen Mun River - is engineered with little bankside vegetation; marine access is likely for dredging work; and the current river water quality does not support an ecologically diverse aquatic ecosystem.
- Sham Tseng - proposed works are insignificant and involve removal of rubbish which is more likely to have a positive effect on in-stream ecology which is presently very poor; mid to lower reaches have no bankside vegetation of interest; Upper reaches would only require manual work.

4.4 Impact Assessment

4.4.1 Introduction

Channelisation in the past has led to the removal of aquatic plants, marginal vegetation and species typical of the riparian zone. Past livestock farming and industrial development of the catchments has resulted in poor water quality in a number of the channels such as the Tuen Mun, Shing Mun, Tai Po/Lam Tsuen, River Indus and Tin Shui Wai. Consequently, these rivers no longer support a diverse range of aquatic species. In some of these channels Government enforcement actions are resulting in marked improvements in water quality. Fish were observed in nearly every channel, but were generally the same species, mainly mullet *Mugil cephalus* and *Tilapia* sp. In terms of benthic ecology, (potentially affected by both the chemical and physical impacts of dredging), only pollution tolerant benthos are present in the sediments but these do represent secondary food source for wading birds.

4.4.2 Impact on Protected Areas

The most significant environmental resource in Deep Bay is the mudflat/mangrove/gei wai/fish pond habitat in the Inner Deep Bay and the internationally significant bird population it supports. Deep Bay is of importance for birds because the area supports a significant number of both resident and migratory birds. Over 39,000 birds were counted in January 1988 - a number which is increasing possibly due to declining habitat elsewhere in the Region. Over 320 different species have been recorded in the area over a number of years (Young, 1992). Amongst these are seven rare or endangered species, four of which are classified as globally threatened such as the Oriental White Stork and the Black Faced Spoonbill. The Deep Bay Guidelines state that no works will be permitted within this envelope of land designated as the Special Measures Zone (SMZ) which follows the Buffer Zone 1 boundary (Figure 4.2). Deep Bay is also a wintering ground for a diverse range of local and migratory birds. In the Deep Bay area there are five SSSIs including Mai Po Marshes, Inner Deep Bay, Tsim Bei Tsui, Tsim Bei Tsui Egretry and Mai Po Egretry. These sites are recognised for the importance of their habitats, in particular as a feeding ground for large numbers of wetland birds and their locations are shown in Figure 4.2.

In the San Tin, Tin Shui Wai and Yuen Long Channels there will be no capital restoration dredging. Possible ecological impacts in these channels would therefore be the result of recurrent dredging for flood alleviation purposes. The potential impacts arise from noise disturbance and water quality deterioration.

In Tin Shui Wai the majority of dredging will take place up-stream of the fabridam and will require land access. This upper area is not of ecological significance and downstream impacts are unlikely to have significant impacts given that the fabridam affords a degree of protection. No dredging requirement has been identified downstream of the fabridam in the area of the channel which has greater ecological value. Any dredging works within 500m of the Ramsar or SSSI will be subject to a more detailed water quality monitoring programme to afford appropriate protection to ecological resources.

It is unlikely that the channels entering Deep Bay can be accessed from the marine side, and this is preferred from an environmental perspective as it minimises the potential disturbance to either breeding or migratory birds. This is consistent with the Task 5 strategy of reducing dredged volumes through the avoidance of dredging and channel access maintenance in Deep Bay.

The Shing Mun and Tai Po/ Lam Tsuen Rivers drain into Tolo Harbour which is considered to be of ecological importance in terms of marine life, such as corals. Tolo Harbour has one SSSI, Centre Island which is just over 2 km from the mouths of the channels draining into the harbour. Water quality modelling has demonstrated that impacts on water quality will not extend beyond a 500m radius and will be short-term in nature. Thus, there will not be significant or long term cumulative impacts arising from the recurrent dredging programme. For restoration dredging a more detailed water quality programme is recommended, including heavy metal and ammoniacal nitrogen sampling and analysis, to ensure against unacceptable water quality impacts which might have downstream ecological impacts.

4.4.3 Localised Impacts

Accumulated sediment in channels has been observed to provide a foraging habitat for wading birds such as egrets and herons. Loss of this foraging area through dredging was highlighted as an issue for consideration in the Key Issues Report. However, now that the maintenance dredging is defined by the exceedance of flood trigger levels, it is unlikely that large stretches of any channel will be dredged at any one time. Thus, the impact on benthic fauna and hence bird feeding grounds would be minimal.

Furthermore, the engineered drainage channels have been designed for the purpose of maintaining certain prescribed levels of hydraulic capacity to protect safety, property as well as the surrounding natural environment from flood events. Thus, the positive impacts of dredging i.e reduction of flood risk, removal of contaminated sediment etc., outweigh the minor impacts associated with the loss in foraging area for birds.

Direct ecological impacts considered were the potential loss of benthic fauna along the lower reaches of the river channels. Benthic communities in the channels were not considered to be of high diversity or ecological value themselves due to pollution of both sediments and water. However the benthos in channels in the NW New Territories in the vicinity of the Ramsar site, particularly the mouths of the Tin Shui Wai, Yuen Long and San Tin MDC, is foraged by migratory birds, which use this area as a supplement to their main food source at Mai Po. Impacts on this protected area have been discussed above and the mitigation recommended is more stringent for works in these areas.

Contaminant Release from Dredging

Water Quality modelling and elutriate tests have investigated contaminant release during dredging. Water quality modelling has indicated that impacts from ammonia during dredging would not be significant (appendix A2) but contaminants such as lead and cadmium may increase following dredging. As described in Section 3.3, elutriate tests indicated that elevated levels of nutrients, particularly ammonia, and in some samples lead and nickel were released following disturbance. Net releases were not however thought to be significant in the context of the proposed recurrent dredging volumes. Elevated levels of zinc and arsenic were found in the final elutriate but this was due to their presence in river water used in the test rather than from sediment releases during elutriation.

If pollutant loading into channels is not controlled then sediment quality may deteriorate in the future, increasing releases of contaminants during dredging. The resultant contaminant releases could impact upon ecological resources either directly or through depletion of dissolved oxygen levels. The following assesses potential impacts of contaminant release.

Reviews of past studies on the ecological character of the study areas, together with site visits for the Key Issues Report (Acer Consultants, 1996), concluded that the faunal diversity of the channels tends to be low and that pollutant tolerant organisms are dominant. Therefore, it is considered unlikely that the potential releases of ammonia during typical maintenance dredging events will be sufficient to cause significant ecological impacts. Monitoring will be necessary for larger dredging events (defined in section 8.3) to ensure that this is the case this will be achieved through water quality monitoring and site inspections.

Restoration dredging on the Shing Mun River is by far the most significant dredging event and it is recommended that ammonia release is monitored carefully throughout the works, particularly as the ongoing Shing Mun River Improvement Study has indicated the presence of high levels of ammonia. This monitoring regime together with the general mitigation measures recommended to ensure good dredging practice, is considered adequate to protect the ecological resources potentially affected by the works.

4.5 Mitigation

Mitigation of Impacts in Deep Bay Area

For work in the channels which drain into Deep Bay, the Deep Bay Guidelines for Dredging, Reclamation and Drainage Work (ERM 1991) should be followed to minimise general disturbance and form the basis for mitigation for the channels within the North West New Territories. The requirements extend over the entire time frame of a project and spatially over the off shore, near shore, in shore tidal and upper reaches of the drainage channels, including natural and man made watercourses, where the project's influence may lead to adverse environmental impact on Deep Bay.

Dredging works have been proposed by Tasks 4 and 5 to take place during the dry season, thus, potentially clashing with the nesting and breeding season for migratory birds (November to March). However, in line with recommendations made for the EIA Study on the Shenzhen River Regulation Project, 'dredging in the dry season during low flow conditions is preferable to minimise water quality impacts which might have secondary impacts on ecological resources in the Deep Bay area.

Impacts can be greatly reduced by accessing these channels from the land side allowing the particularly sensitive ecological areas to remain undisturbed. This, according to the Task 5 assessment is generally a cheaper option than marine access due to the additional dredging that would otherwise be required.

In order to minimise disturbance to birds, and in line with Shenzhen River EIA recommendations, restricting working hours to 0800-1700hrs avoids dawn and dusk when birds are roosting. Erection of noise barriers is not considered appropriate given the nature of the proposed works and impacts can be better minimised through liaison with the WWF team at Mai Po Nature Reserve to determine sensitivity of the area with respect to birds at the time of dredging. If necessary, manual methods of excavation may have to be employed in areas of San Tin MDC within Buffer Zone 1 if the timing of the works is considered to cause significant disturbance to birds.

Mitigation of Loss of Bankside Vegetation

Removal of bankside habitat, although there is an absence of protected species and it is not of Territory wide importance, can have localised habitat impacts and should therefore be avoided or mitigated. The loss of local habitat presents the most significant potential ecological impact of the dredging operations. Task 6 has recommended that compensation planting is enforced contractually so that cleared areas are re-established quickly with an appropriate mix of native species. Such planting schemes will be determined on a case by case basis by the Engineer/EM&A team. Recommended native species are listed in Tables 4.1 and 4.2 below and it is suggested that a similar mix of species be used as it is not always possible to obtain the exact species. Species recommended by the AFD include, *Cerbera manghas, Cleistocalyx operculata, Hibiscus tiliaceus, and Litsea glutinosa* (AFD, 1997).

The species listed below include those considered to be of value for frugivorous (fruit eating) birds in Hong Kong and have a mixed fruiting period to provide a food source all year round. In addition, those species found along the Yuen Long channel are recommended for replanting in estuarine habitats.

TABLE 4.1 NATIVE PLANTS RECOMMENDED FOR REPLANTING ON UPPER REACHES OF CHANNEL BANKS

Species	Habitat	Relative Attraction for Birds	Period of fruiting
Celtis sinensis	tree	XXX	Jun - Aug
Cinnamomum camphora	large tree	XXX	Nov - Jan
Ficus microcarpa	tree	XX	irregular
Ficus superba	tree	XX	irregular
Ficus virens	tree	XX	irregular
Sapium discolor	tree	XXXX	Oct - Dec
Sapium sebiferum	tree	XX	Nov - Jan
Schefflera octophylla	tree	XXXX	Jan - Mar
Scolopia saeva	tree	XX	Dec - Jan
Sterculia lanceolata	tree	XXXX	Jul - Sep

Source: Memoirs of the Hong Kong Natural History Society 1992 (19) 115 - 116

TABLE 4.2 RECOMMENDED SPECIES FOR REPLANTING IN RIPARIAN COASTAL HABITATS

Riparian and coastal Species	
Aegiceras corniculatum	Sapium sebiferum
Kandelia candel	Melia azedarach
Avicennia marina	Cyperus malaccensis
Derris trifoliata	Clerodendrum inerme
Acrostichum aureum	Phragmites communis
Acanthus ilicifolius	Canavalia maritima
Eichhornia crassipes	Mikania guaco
Excoecaria agallocha	Hibiscus tiliaceus
Lantana camara	Eucalyptus citriodora
Macaranga tanarius	Parsiflora foetida

Generally the construction of ramps is relatively expensive especially when remediation costs (i.e. replanting) are considered. It is therefore preferable to use cranes to lower equipment into the channel and ensure that equipment does not damage bankside vegetation. Inspections of the channels can assist in the avoidance of damage to bankside vegetation. There are areas in all of the channels where the banks are clear of vegetation or have suitable direct access points or areas for lowering equipment into the channel.

Mitigation of secondary impacts arising from water quality impacts

Task 5 has made a number of recommendations to refine the dredging operations and to eliminate unnecessary over dredging. The water quality modelling under task 6 has demonstrated that the impacts of recurrent dredging on water quality are likely to be short lived and the area affected close to the dredging operations. For small dredging operations and for works in small channels impacts are not expected to be significant. Despite this, Task 6 has recommended additional controls to enforce good dredging practice and these should be enforced contractually and through site inspections. For example, the use of water tight grabs is highly recommended to minimise the release of suspended solids and contaminants into the channel and prevent secondary adverse impacts on both in-stream ecology and marine ecology. Section 8 details general contractual clauses to be enforced through the dredging contract manuals for all the maintenance dredging required.

4.6 Monitoring and Audit

No ecological monitoring is recommended for the maintenance works, however, general mitigation clauses have been drafted to enforce good practice. The Engineer will be responsible for ensuring that contractual conditions are implemented.

The aim is to ensure that unnecessary damage to ecological resources of the channels are avoided through:

- Confirming the agreement of channel access points with the EM&A team/Engineer before dredging to prevent damage of bankside vegetation;
- Using carefully planned land access to the channels in the NW New Territories rather than marine access;
- Maintaining an appropriate programme of water quality impact monitoring including dissolved oxygen, ammonia and suspended solids to ensure secondary impacts on aquatic and marine fauna are avoided;
- Minimising noise disturbance to birds during breeding and nesting seasons and liaising with WWF/AFD when sensitive areas are to be dredged within the Buffer Zone 1 boundary;
- Avoiding bank side storage of material to prevent damage to adjacent fishponds etc. In the event of damage to fishponds, e.g alongside the River Indus, bunds should be repaired and the water quality of the ponds should be restored through refilling with fresh water.

The proposed monitoring and audit programme is detailed in Section 8 along with the proposed mitigation measures for the specific channels in the form of clauses for inclusion in the dredging contract manual. Table 4.3 below summaries the ecological mitigation on a channel by channel basis.

TABLE 4.3 SUMMARY OF ECOLOGICAL MITIGATION:

Channel	Mitigation	Mechanism to Implement	Environmental Acceptability
River Silver	Standard Mitigation.* Works in upstream area should be confined to manual methods to minimise damage to vegetation.	Contact Clauses	✓
Staunton Creek	Non Required		✓
Kai Tak nullah	Manual Works - Non Required		✓
Shing Mun River	Standard Mitigation.*	Contract Clauses	✓
Tai Po Lam Tsuen	Standard Mitigation*	Contract Clauses	✓
River Indus	Standard Mitigation*	Contract Clauses	✓
San Tin	Standard Mitigation* Restriction on working hours 0800 - 1700 in buffer zone 1; Water hyacinth removal should be restricted to sections of channel where trigger levels are exceeded.	Contract Clauses	✓
Yuen Long/Kam Tin	Standard Mitigation* Dredging in areas in/close to Inner Deep Bay e.g Wo San Wai should be restricted to 0800-1700 hrs. Channels should be accessed from the land side.	Contract Clauses	✓
Tin Shui Wai	Standard Mitigation Downstream of the fabridam works should be restricted to 0800-1700 Channel should be accessed from land.	Contract Clauses	✓
Tuen Mun	Standard Mitigation*	Contract Clauses	✓
So Kwun Wat	Standard Mitigation*	Contract Clauses	✓
Tai Lam Chung	Standard Mitigation*	Contract Clauses	✓
Sham Tseng	Standard Mitigation*	Contract Clauses	✓

**Standard Mitigation refers to mitigation included in standard specifications listed in Section 8*

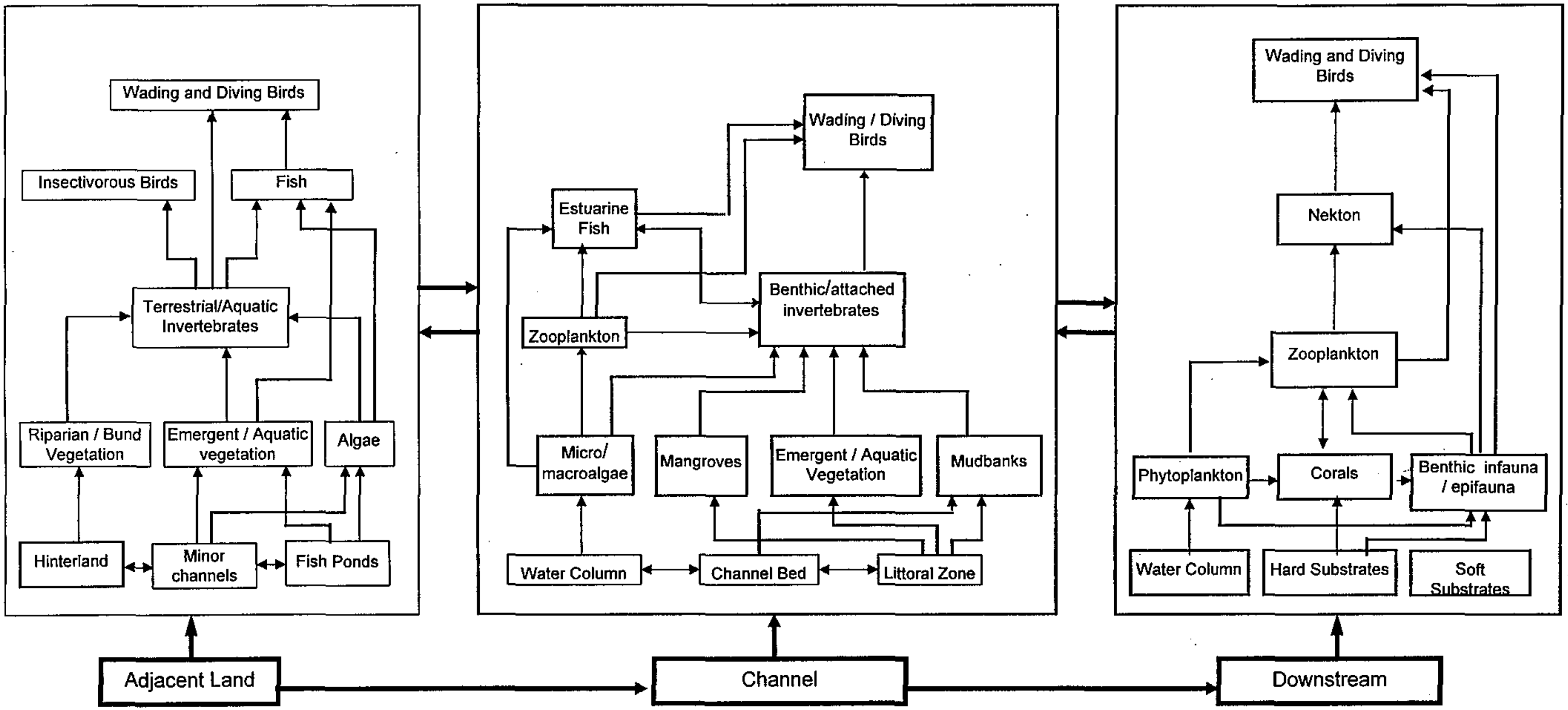
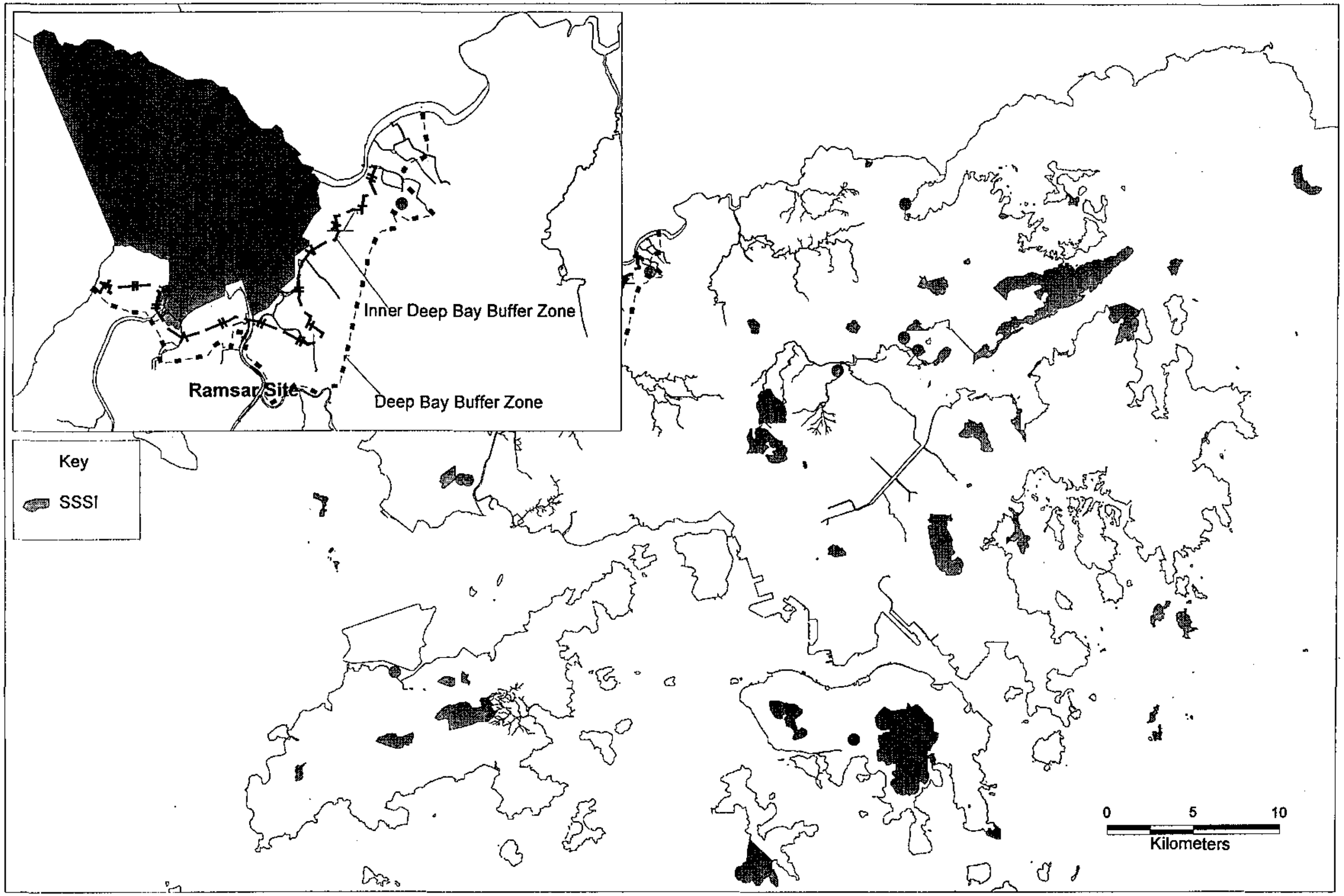


Figure 4.1 A Conceptual, Qualitative Ecological Model

Hyder Consulting



Hyder Consulting

Figure 4.2 Location of Sites of Special Scientific Interest (SSSI)

SECTION 5

KEY ISSUE - NOISE

5. KEY ISSUE - NOISE

5.1 Introduction

The Task 6 Key Issues Report identified noise from dredging works as being an area for further assessment, particularly for those channels in urban areas or for those channels close to areas of ecological importance in the inner Deep Bay area. Noise levels for these works are controlled under and limited by the *Noise Control Ordinance (Cap 400) including its subsidiary regulations and the Technical Memoranda* (TM). The following section outlines the methodology used for the assessment, key areas of concern, sensitive receivers and the outcome of the detailed assessment.

5.2 Methodology and Criteria

Assessment of noise impacts was conducted according to the standard procedures set out in the *Technical Memorandum on Noise from Construction Work other than Percussive Piling*, (Environmental Protection Department, July 1991). Construction noise is controlled during restricted hours (19.00 - 23.00) and (23.00 - 07.00) and on general holidays. Outside of these hours construction works are not subject to the Noise Control Ordinance (NCO) requirements. There are however additional requirements, or interpretations used as a guideline in order to control noise, (EPD guidelines recommend a daytime assessment criteria of 75 dB(A)). This EPD assessment criteria applies to noise from equipment and activities (other than percussive piling) during the time period from 0700 to 1900 hours on any day not being a general holiday. The above standards and criteria were therefore used for this assessment of dredging works.

Operational noise from the sediment handling and disposal operations should observe the HKPSG noise limits and EPD assessment criteria as well as complying with the statutory requirements stipulated in the NCO. For those channels which lie within the Inner Deep Bay Special Measures Zone (applicable to Hong Kong side only) then the more restrictive Deep Bay Guidelines also apply. These guidelines would affect dredging works in the mouth of the Tin Shui Wai, Yuen Long and San Tin MDC. Works have been recommended by Tasks 4 and 5 to be undertaken in the dry season. This period is sensitive since it overlaps with the migratory season (November to March) when there is the potential to disturb breeding and nesting birds. However in accordance with the recommendations of the EIA Study for Shenzhen River Regulation Project, noise from small scale works such as the proposed maintenance dredging is unlikely to have any significant impacts on birds (Shenzhen River Regulation Office of Municipal Government, 1995).

The following points were assumed:

- The noise level measured at 1 m from the most affected external facade of the nearby Noise Sensitive Receivers (NSR)s during any 30-minute period, on normal weekly daytime periods (0700 to 1900 hours) should not exceed an equivalent sound level (L_{Aeq}) of 75 dB(A) at residential NSRs or 70 dB(A) for schools(or 65 dB(A) during examination). In the Inner Deep Bay Special Measures Zone noise levels during the day should not exceed 60 dB(A) (0700-2300 hrs) and 45 dB(A) during the night.
- Construction should not be undertaken during the restricted period (1900-0700 hrs), without the existence of the relevant Construction Noise Permit (CNP).
- If the work is unlikely to take longer than 14 days, a positive correction of 3 dB(A) shall be applied to the Acceptable Noise Levels (ANLs).

The general methodology for noise assessment was, therefore, as follows. Details of any amendments due to special conditions or guidelines are given in the channel specific sections:

- Activities to be undertaken were identified based on the potential options for dredging strategies set out in the Task 5 Report. The works area was based on the revised Recurrent and Restoration dredging locations specified in the Task 4 Report - Maintenance Dredging Requirements. The duration of the works was based on a best estimate provided by members of the Task 5 team.
- In accordance with the TM, the area around the proposed dredging location has an Area Sensitivity Rating (ASR) A, B or C depending on the nature of the surrounding area and any Influencing Factors (IF) such as major roads. Adjustments were made where necessary for considering factors such as areas where works would not exceed 14 days duration. The methodology for the baseline survey, sub-contracted to Materialab Ltd. is attached as Appendix A4.
- The noise contribution of the plant was determined by assuming that they are located at the Notional Source Position (NSP) which is defined as the mid way point between the approximate geographical centre of the site and the site boundary nearest to the NSR. In the case of an oblong area, having a length to width ratio of 5:1 or more, then only the closest portion to the NSR has been considered, as defined in the TM. The sound power levels of the equipment used in this assessment are derived from the TM. A total sound power level of the dredging operation is obtained by summing all the individual sound power levels of the associated equipment.
- The total noise level at the NSRs were calculated assuming that all the plant was operational at the same time in the absence of any noise mitigation measures and assumes that the dredger is static. A typical mix of equipment was taken from the potential options outlined in the Task 5 Report. The noise levels at each NSR are predicted by the following equation:

  Predicted noise level = Total sound power level - 20 log$_{10}$D - 8 dB(A)

  where D is distance between the NSR and the notional noise source

  A positive correction of (3 dB(A) is made to each predicted noise level due to all concurring activities to account for the facade reflection at the NSR. A detailed calculation spreadsheet is attached in Appendix A5.

- By comparison with the noise limits set out in the NCO and identified assessment criteria and also based on a ranking of the noise contribution from individual plant, the need for mitigation was identified and proposed.

5.3 Areas of Concern

In recent times the predicted noise from dredging operations has resulted in the postponement of the works. A number of the channels are in urban locations and noise sensitive receivers are located adjacent to the channel. NSRs are defined in the TM as "*any domestic premise, hotel, hostel, temporary housing accommodation, hospital, medical clinic, educational institution, place of public worship, library, court of law or performing arts centre*". Generally, most uses other than Industrial or Commercial are considered to be a NSR. Potential NSRs were identified through site inspections in a 300m buffer area either side of the works site. The results are presented under channel specific issues, Volume B.

Noise impacts were identified as a potential concern for all channels where dredging would take place. The significance of the noise impact however is largely related to the extent and duration of the dredging operations. On this basis, eight locations covering seven of the study areas were selected for baseline noise monitoring:

- River Silver
- Fo Tan Nullah and Tai Shui Hang Nullah
- Tai Po / Lam Tsuen
- San Tin Main Drainage Channels.
- Tin Shui Wai;
- Tuen Mun;
- So Kwun Wat;

Selection of monitoring locations was based on the nearest NSR to the proposed dredging works and represented a worst case scenario, with all equipment operating and a static dredger. In the event that the owner of the premises was reluctant for the monitoring to take place, the next best site was chosen as an alternative. Baseline data is summarised in the channel specific chapters and was used in the assessment of the noise impacts, particularly for the determination of the Area Sensitivity Rating for the channel. The full Baseline Noise data is presented in Appendix A6.

5.4 Impact Assessment

The noise assessment for each channel where dredging had been proposed indicated that unmitigated noise levels exceeded permitted noise levels during restricted hours and assessment criteria for day time noise set in guidelines issued by the EPD in certain channels. Channels for which there is likely to be an exceedance of daytime assessment criteria have been summarised in Table 5.1.

TABLE 5.1 EXCEEDANCES OF DAYTIME NOISE GUIDELINES AT MOST AFFECTED NSRs ALONG THE CHANNELS

Channel	Guideline (dB(A))	Exceedance (dB(A))	Comments
River Silver	75	2	Exceedance at residential NSR
Shing Mun & Tributaries	75 70 for school (65 during examination)	1 3 (during examinations only)	Exceedance at 2 residential NSRs Exceedance at 3 schools
Tai Po/Lam Tsuen	75 70 for School (65 during examinations)	7 (12 during examinations)	Exceedance at school
San Tin MDC	Buffer Zone 1 - 60 Buffer Zone 2 - 75 Outside Deep Bay - 75	4	Exceedance for works in Buffer Zone 1
Tuen Mun	75 70 for school, 65 during examinations	1 (6 during examinations)	Exceedance at school
Wo Sang Wai	Buffer Zone 1 - 60	4	Exceedance for works in Buffer Zone 1
So Kwun Wat	75	13	Exceedance at village housing along channel banks
Tai Lam Chung	75	8	Exceedance at residential NSR

Assessments would indicate that noise is an issue of concern in seven of the study channels at identified Sensitive Receivers. In reality the extent of impact will depend on the duration of the dredging and the proximity to sensitive receivers. Given that the duration is dredging is low and the dredger is a moving noise source, practical mitigation measures are deemed sufficient in most cases. These have been drafted for incorporation into the dredging contract manuals under task 7.

It should be noted that Kai Tak Nullah has in the past been dredged using manual methods and this practice will continue, thus noise impacts are not expected to occur. Mechanical operations, which could have a noise impact on local schools, have not been addressed in the EIA.

5.5 Mitigation Measures

In the majority of cases practical mitigation measures as detailed in Section 8 are sufficient to ensure compliance with the 75dB(A) day time guideline. Furthermore, it is a recommendation of this EIA that maintenance works are confined to normal day time hours unless special operational circumstances apply.

In extreme cases where dredgers are working very close to sensitive receivers there are very few mitigation measures that can feasibly be used for such short term works. Erection of permanent noise barriers or insulation of NSRs are not cost effective nor appropriate for this type of work. Temporary noise barriers which can include solid objects such as containers are not considered to be practical given the noise related to moving these objects along the channel as the works progress, the inconvenience caused to people using the channel sides as a recreational resource and the visual impacts of barriers. However, it is recommended that institutions such as schools are consulted in areas where EPD's guideline value of 75dB(A) cannot be met over very short time spans and reasons for not using barriers are explained to them prior to the commencement of works. With such consultation, sensitive periods such as school examinations can be avoided.

Generally the preferred approach to mitigation is to enforce "good practice" through the inclusion of standard specifications in the contract documents. Examples include the following:

- Use of well maintained, quiet equipment;
- Phasing of the work to ensure that the minimum number of noisy equipment is in operation at any one time;
- requiring lorries to turn off engines when idling to minimise noise emissions;
- For channels in the Deep Bay Special Measures Zone (taken to be within the Buffer Zone 1 Boundary), works should be restricted to between 0800-1700 hrs.

Idle equipment should be switched off at all times and should bring the noise levels at the key NSRs down to within the guideline values. Such phasing of equipment typically permits only one activity at any one time, so that noise emissions can be reduced. For example, trucks would not be operating at the same time as excavators, therefore material could only be taken off site when the dredgers are not operating.

Recommendations for appropriate equipment have been made in Tasks 5 and 7 and it is likely that noise emissions from this smaller sized equipment will be lower than those calculated using Sound Power Levels quoted in the TM which are used traditionally for much larger scale dredging projects in Hong Kong. The results therefore represent a worst case scenario.

As noted above, unless there are special circumstances or benefits to be derived from dredging during restricted hours, the works will be restricted to day time hours 0700 to 1900, with the exception of works within Deep Bay Buffer Zone 1 (applying to San Tin, Yuen Long and Tin Shui Wai) where restricting dredging hours 0800 - 1700 hours are recommended.

Mitigated noise levels are summarised in Table 5.2 below.

TABLE 5.2 MITIGATED NOISE LEVELS

Channel	Exceedance of guideline* at worst affected NSR (dB(A)) after mitigation	Proposed Mitigation/Comments
River Silver	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	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 schools)	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)	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)	Dredging should be restricted to between 0800-1700hrs within Buffer zone 1.
Tuen Mun	1 (for school)	Exceedance of guideline unlikely if small scale equipment used. Liaison with school necessary to avoid examination periods.
So Kwun Wat	13	No idling of equipment will be permitted, the use of plant will therefore be phased to avoid cumulative noise.
Tai Lam Chung	6	No idling of equipment will be permitted, the use of plant will therefore be phased to avoid cumulative noise.

** Guideline values are given in Table 5.1*

Of the channels showing exceedances in Table 5.1 (Unmitigated), three channels still exceed the day time EPD noise guideline with mitigation in all cases due to the minimal distance between the noise source and the sensitive receiver. The River Silver and Shing Mun River and tributaries meet the noise guideline when the phasing of equipment is included in the noise calculations eliminating cumulative noise impact.

Tai Po/ Lam Tsuen

The noise guideline of 70 dB(A) applying to schools is exceeded by 7 dB(A). Given that the proposed dredging equipment is smaller than that for which Sound Power Levels are available in the TM, it is likely that in reality noise levels will be significantly reduced. However, in such circumstance where works are located very close to schools noise monitoring is recommended. Such extreme events are defined as: *dredging works taking place within 50m of a sensitive receiver for a continuous period of two weeks or more*. This will not be a typical case due to the movement of the dredger along the channel. Furthermore, in the case of schools works should be avoided during examination periods which will be identified through liaison with the head teacher.

So Kwun Wat

With the placement of a noise barrier the noise at the nearest sensitive facade exceeds the 75 dB(A) guideline by 3 dB(A). Given that the calculations consider a worst case scenario and that the duration of the dredging is very short (estimated by Task 5 to be 1-2 weeks, and therefore less than this affecting any one NSR since the dredging plant is moving). Given the lack of space at the channel sides it is considered that the nuisance/general disturbance and visual impact of the noise barrier would be greater than the short period of noise impact. Alternative measures have been explored and practical solutions recommended. The residual noise impact will therefore be an exceedance above the daytime assessment criteria in the vicinity of 13dB(A). With small scale equipment it is likely that this noise exceedance can be reduced by several dB(A) but it is recommended that the affected institutions such as schools, be consulted prior to commencement of works and explanations given as to why noise barriers are not considered appropriate. As indicated above, noise monitoring will be required if the dredging works take place within 50m of a sensitive receiver for a continuous period of two weeks or more.

Tai Lam Chung

A similar situation exists here due to the proximity of the nearest sensitive facades to the works area. Noise levels exceed the 75 dB(A) assessment criteria by 6 dB(A) when phasing of equipment is included in the noise calculations. Again, SPLs are likely to be lower than those used in the assessment. Although noise barriers would achieve an anticipated noise reduction of about 10 dB(A) the associated impacts of installation of temporary barriers is considered to be greater the potential short lived noise impacts of the proposed works.

San Tin/Wo Sang Wai

Outside of the Deep Bay Special Measures Zone noise impacts are not an issue of concern during day time hours. However, daytime noise guidelines are exceeded within Buffer Zone 1. Since only a small part of the existing channels lie within Buffer Zone 1, impacts will be very short lived and are therefore should not have detrimental impacts on birds in Deep Bay. However, it is recommended that working hours be restricted to those recommended in the EIA for the Shenzhen River Regulation Project, 0800 - 1700 hrs.

5.6 Monitoring and Audit

The recommended EM&A for the proposed works is outlined in section 8 of the report and in the EM&A Manual. Auditing will ensure that the contractor implements the recommended channel specific mitigation measures and standard specifications for control of noise described above and in Section 8 of this report.

The assessment has concluded that dredging during restricted hours will cause unacceptable residual impacts, breaching the requirements of the Noise Control Ordinance. The focus of the mitigation and subsequently the monitoring and audit programme, therefore, is to meet the relevant daytime assessment criteria for establishing noise mitigation measures. In the event that a complaint is received relating to noise disturbance during the works then performance monitoring will be required to resolve the complaint.

Based on the results of the detailed noise calculations in Appendix 5, dwellings within 45m and schools within 50m from the dredging locations are likely to be affected by noise exceeding the daytime assessment criteria. Therefore, the EIA recommends that noise monitoring should be performed for works which are within 50m of the nearest NSR and scheduled for two weeks or more.

Noise mitigation and a summary of the environmental acceptability of works is provided in Table 5.3.

TABLE 5.3 SUMMARY OF NOISE MITIGATION:

Channel	Mitigation	Mechanism to Implement	Environmental Acceptability
River Silver	Standard Mitigation.*	Contract Clauses	✓
Staunton Creek	Standard Mitigation*	Contract Clauses	✓
Kai Tak nullah	Manual Works - No mitigation required	Contract Clauses	✓
Shing Mun River	Standard Mitigation.*	Contract Clauses	✓
Tai Po Lam Tsuen	Standard Mitigation* Avoid school examination periods, for works in close proximity to the Fung Leung Kit secondary school. Liaison with institutions/ schools likely to be affected.	Contract Clauses	✓
River Indus	Standard Mitigation*	Contract Clauses	✓
San Tin	Restrict dredging hours in Deep Bay Buffer Zone 1 0800-1700hrs. Standard Mitigation.	Contract Clauses	✓
Yuen Long/Kam Tin	Restrict dredging hours in Deep Bay Buffer Zone 1. Standard Mitigation	Contract Clauses	✓
Tin Shui Wai	Standard Mitigation* Restrict dredging hours in Deep Bay Buffer Zone 1.	Contract Clauses	✓
Tuen Mun	Avoid school examination periods. Standard Mitigation.*	Contract Clauses	✓
So Kwun Wat	Standard Mitigation.*	Contract clauses. Liaison with affected institutions	Residual impact of short duration.
Tai Lam Chung	Standard Mitigation. * Liaison with the affected institutions is required.	Contract clauses. Liaison with affected institutions	Residual impact of short duration.
Sham Tseng	None Required		✓

**Standard Mitigation refers to mitigation measures included in the standard specifications listed in Section 8*

SECTION 6

KEY ISSUE - AIR QUALITY

6. KEY ISSUE - AIR QUALITY

6.1 Introduction

Air Quality impacts were initially identified as an area of concern in the event that access roads were to be constructed to the channels, or if stockpiling of significant quantities of dredged materials was to be required. Both of these activities have the potential to generate dust and odour. However, based on the Task 5 proposed dredging strategies, it is unlikely that any access ramps or roads will be constructed due to their cost and stockpiling of material close to the channels for any length of time is not supported.

A further issue of concern is the potential for odour generation as a result of dredging works. Odour impacts were initially highlighted as a key issue due to the predicted volumes of sediment to be removed. However, since the dredging volumes have decreased dramatically, the potential for significant odour impacts has declined for the recurrent dredging programme. However, potential odour impact is still a key issue for Shing Mun River restoration dredging. A odour baseline survey has recently been completed as part of the EPD Shing Mun River Improvement Study by Aspinwall Consultants. Hydrogen suphide has been identified as the main cause of odour impacts and the potential odour impact during dredging has been modelled as outlined below.

The sensitive receivers to odour and dust are essentially the same and are discussed further in Section 6.3 of this report and in the channel specific sections.

6.2 Methodology and Criteria

6.2.1 Dust (TSP)

A qualitative assessment has been made of potential air quality impacts in terms of Total Suspended Particulates (TSP) and comparison made with the Hong Kong Air Quality Objectives guidelines for average 1 hr TSP concentrations from construction. Baseline monitoring data has been gathered from key sites where dredging is likely to occur in the vicinity of sensitive receivers. These were defined as the following channels based on the current dredging forecasts at the time:

- River Silver
- Fo Tan Nullah and Tai Shui Hang Nullah
- Tai Po / Lam Tsuen
- San Tin
- Tin Shui Wai
- Tuen Mun
- So Kwun Wat

The methodology adopted for the baseline survey is attached as Appendix A4 and the results are summarised in the channel specific sections of this report and are presented in full in Appendix A7.

A qualitative assessment of potential dust impacts has been undertaken based on knowledge of the dredging process, the channel specific conditions and experience and professional judgement.

6.2.2 *Odour*

Classification of odourous compounds is complex and in the US the EPA classify odour as non-criteria pollutants. Chemicals which cause odours can be detected by the human olfactory system at very low concentrations. For example, hydrogen sulphide gas is detectable as a "rotten egg" smell at concentrations as low as 0.5ppb and chlorine, which has a pungent, irritating odour can be detected at 0.314ppm. Algae can also have distinctive odours which have been defined in the literature as ranging from "fishy" to "spicy" when abundant. Modified air dispersion models can be used to determine the impact of odour emissions on the surrounding area. The method is based on modelling the dispersion of a determined emission factor over a specified duration given the local meteorological conditions and topography.

Due to the volume of material to be removed for restoration dredging odour impacts have been modelled for the Shing Mun River. For the typical maintenance dredging the potential odour impact is low and the focus of the study has been to devise mitigation measures which are both cost effective and practical to implement.

6.3 Areas of Concern

Generally sensitive receivers for dust and odour are the same and can be classed as Air Sensitive Receivers (ASRs). In the Hong Kong Planning Standards and Guidelines (HKPSG), nullahs/drainage channels are classed as a common air pollution source and ASRs are given as residential areas, nurseries, homes for the aged, hospitals and clinics, schools and active recreational activities. The precise locations of key ASRs are identified and discussed in more detail under the channel specific sections of this report. Odour is only identified to be a key issue for the Shing Mun River restoration dredging.

6.4 Impact Assessment

6.4.1 *Dust*

Dredging has the potential to generate impacts on ASRs as dredging is likely to be undertaken in the dry season when there is the potential for dust and suspended particulates to be released if there is any bank side storage. Dust impacts can be mitigated through adopting standard dust suppression measures. Stockpiled materials should be covered and all trucks transporting material should be covered appropriately according to the condition of the material they are transporting.

Given the proposed dredging strategy it is unlikely that any construction of roads or access ramps will be necessary. In terms of stockpiling, the material should be enclosed sufficiently to avoid wind dispersion and should be kept wet. Observing, good practice is recommended to ensure that risk of dust generation is minimised. Any potential stockpiling area should be reviewed by the EM&A team and should be located away from ASRs, particularly residential areas.

6.4.2 *Odour Impacts*

Given the small dredging volumes for the recurrent dredging programme, odour impacts are predicted to be limited in the majority of channels provided that the practical mitigation included in the standard specifications is enforced as recommended. Odour impacts may however be worse for channels where promenades run along the length of the proposed dredging area as the number of people affected can be increased.

Potential odour impacts were identified for Air Sensitive Receivers (ASRs) in the vicinity of the Shing Mun River for the predicted restoration dredging of contaminated sediments. Odour is a problem under normal circumstances and is worsened during dredging operations, which were suspended partly due to complaints from local residents. However, it is known that the dredging practices used previously generated unnecessary impacts due to the dispersal of sediments. This situation will be improved as the dredging methods will be controlled by the proposed contractual clauses recommended under Task 5 of the Sedimentation Study.

Baseline odour surveys indicated that the main odour problems are associated with the upper reaches of the Main channel, particularly during low tide conditions when the sediments are exposed. The initial findings of the EPD Shing Mun River study have indicated that Hydrogen Sulphide gas is the main agent causing odour problems.

Preliminary odour modelling using the standard ISCST2 air quality model was undertaken to investigate potential odour impacts of Hydrogen Sulphide during dredging operations. Results indicated that there would be limited odour impacts at the ASRs. In particular, recreational users of the channel and promenade may be subjected to short term odorous releases greater than those already experienced at low tide.

6.5 Mitigation

Dust - Total Suspended Particulates (TSP)

The emphasis of TSP mitigation is on the enforcement of good dredging practice and site control. The potential for significant dust impacts from the works is considered to be low provided that standard procedures are followed. If vehicles work in the channel itself then a wheel wash facility should be provided to minimise the transfer of potentially dusty material off the site. Standard mitigation measures to be included as general contractual clauses are listed in Section 8 of this report. In addition, mitigation measures are included in the channel specific sections, incorporating any additional localised controls considered appropriate.

Odour

The emphasis of the odour mitigation is also on the enforcement of good dredging practice through contractual conditions. The generation of odour can be minimised by reducing exposure time and by keeping the dredging sediments wet to prevent the release of odorous gases, both during temporary storage and transportation. Dredging will take place during the dry season when temperatures are lower, this is beneficial as cool conditions can reduce odour impacts. Sediment should be taken off site as quickly as possible and during temporary storage or transport material should be kept in covered, watertight trucks. In the event that loading of the sediments is necessary this should be away from sensitive receivers.

Standard specifications incorporating mitigation measures to be included as general contractual clauses are listed in Section 8 of this report and where appropriate additional measures have been included under the channel specific sections. In addition, the Task 5 - Dredging Operations and Sediment Disposal, Task Report, has recommended particular dredging methodologies and contract requirements designed to minimise dredged volumes. Such controls will also serve to minimise the potential environmental impacts of the works. A summary of mitigation measures is provided on a channel by channel basis in Table 6.1 below.

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.

6.6 Monitoring and Audit

From the baseline survey we have learnt that there are large discrepancies in the day to day Total Suspended Particulate (TSP) levels recorded. This is dependent on the prevailing winds and activities on local construction sites. Thus, combined with the fact that the maintenance dredging proposed (with the appropriate mitigation) has little potential to generate dust, we do not propose to recommend a monitoring and audit programme. Alternatively, a standard list of specifications to be included in contractual clauses are recommended which will ensure that the engineer follows "good practice" and avoids dust generation. These are included in detail in Section 8.6 of this report. This section also includes a general clause to the effect that, should dust become the subject of local complaints during the dredging period then the Engineer would be required to undertake performance/impact monitoring. Monitoring and audit schedules and procedures are detailed in the Task 6 Environmental Monitoring and Audit Manual. This also address appropriate responses to complaints received regarding dust or odour related impacts.

TABLE 6.1 SUMMARY OF AIR QUALITY MITIGATION

Channel	Mitigation For Dust and Odour	Mechanism to Implement	Environmental Acceptability
River Silver	Standard Mitigation *	Contract Clauses	✓
Staunton Creek	Standard Mitigation* Removal of odorous material from the concrete section of the Creek should be undertaken in dry/cool conditions, and give due consideration to the prevailing wind direction.	Contract Clauses	✓
Kai Tak nullah	Standard Mitigation* for dust and odour	Contract Clauses	✓
Shing Mun River[x]	Standard Mitigation* In the dry areas of Fo Tan Nullah removal of sediment should be undertaken in dry/cool conditions to minimise odour. Sprayed water should not be used in this process as it only serves to disperse contaminants and generate odour.	Contract Clauses	✓
Tai Po Lam Tsuen	Standard Mitigation*	Contract Clauses	✓
River Indus	Standard Mitigation*	Contract Clauses	✓
San Tin	Standard Mitigation*	Contract Clauses	✓
Yuen Long/Kam Tin	Standard Mitigation*	Contact Clauses	✓
Tin Shui Wai	Standard Mitigation*	Contract Clauses	✓
Tuen Mun	Standard Mitigation*	Contract Clauses	✓
So Kwun Wat	Standard Mitigation*	Contract Clauses	✓
Tai Lam Chung	Standard Mitigation*	Contract Clauses	✓
Sham Tseng	Standard Mitigation*	Contract Clauses	✓

* *Standard Mitigation refers to measures included in standard specifications listed in Section 8*

x *For Shing Mun River restoration dredging reference should be made to the recommendations of the EPD Shing Mun River Improvement Study if available*

SECTION 7

MANAGEMENT OF DREDGED MATERIAL

7. MANAGEMENT OF DREDGED MATERIAL

7.1 Introduction

Tasks 5 and 6 reviewed disposal practise in Hong Kong and overseas concluding that practise in Hong Kong differs because on shore disposal is restricted by land supply and therefore capacity at disposal sites is limited. Disposal can be split into two main categories; offshore disposal and onshore disposal options which have been outlined in Section 2. In order to avoid repetition these options have not been further discussed in detail in this report. Rather, the aim of this report is to assess the environmental impact of selected disposal options which are considered appropriate for Hong Kong and to develop suitable mitigation, monitoring and criteria for these disposal sites.

7.2 Methodology

The assessment of disposal options has involved additional sediment testing and a cost benefit analysis which has been presented in the Task 5 Report. The analysis showed that the transport and disposal of sediment accounts for the majority of the costs of maintenance dredging works. The volumes of sediment dredged from the channels must therefore be kept to a minimum and the productivity of the dredging operations is a secondary consideration as it has a relatively minor impact on overall costs. Retaining as much of the sediment in-situ, particularly with respect to highly contaminated sediment is also considered to be in line with the London Convention. Accurate dredging is thus a greater priority in terms of general improvement techniques.

Those disposal options and treatment technologies considered most suitable for this study are assessed in detail below. A cost comparison was undertaken in task 5 and is taken further in this report to look at cost benefit in relationship to environmental impacts. In the determination of suitable options several key questions had to be answered:

- Is the disposal option/site already established in Hong Kong and therefore available in the short term?
- Is the site accessible from land or sea or both?
- Does the site accept contaminated material or clean material or both?
- Does the site have sufficient capacity to be considered a long term option (5-10 years)?
- Is there potential to develop the option in the long term?
- Does the option/site have environmental merits/ can environmental impacts be controlled?
- Is the disposal option considered cost effective (based on Task 5 assessment)?
- What frequency of maintenance dredging is necessary?

iii) On any land other than crown land without the consent of the owner or occupier.

- The Water Pollution Control Ordinance.

Currently, proponents of projects involving the marine disposal of dredged mud should follow the procedures stipulated in the Works Branch Technical Circular No 22/92. The EPD Technical Circular TC-1-1-92 currently provides the standards for sediment quality. On determination of sediment quality, the proponent must obtain allocation of marine disposal ground capacity from the Fill Management Committee. The existing framework for managing Dredged Material in Hong Kong is summarised in Figure 7.1 and Criteria are set out in TC No. 1-1-92, Appendix A8.

EPD Technical Circular No (TC)1-1-92 - Classification of Dredged Sediments for Marine Disposal defines three classes of dredged sediments based on the analysis of seven heavy metals. Since issue of the circular in 1992, operation of the classification scheme has been simplified and, *de facto*, dredged material is classified as suitable for open sea disposal if contaminants are lower than the original class C criteria. The classification scheme for sediment is currently under review and the new guidelines are considered below.

7.2.2 Future Criteria and Guidelines

New assessment criteria and guidelines have been proposed by EVS consultants for the Fill Management Committee which if/when accepted will eventually result in extended testing for additional parameters such as silver, man-made organics (PAHs, PCBs), pesticides (DDT, TBT) and metalloids (As). The proposed new guidelines and criteria aim to refine the existing practice in Hong Kong and to add to the process rather than to change parameters and criteria currently in use. Following an international review of criteria, guidelines and sediment chemistry in Hong Kong, EVS identified 24 Category 1 Contaminants of Concern (COCs) and 17 Category 2 COCs. Category 1 COCs were then proposed for incorporation in efforts to update the present Hong Kong sediment quality values. These COCs have potential to cause adverse biological effects and are specific to Hong Kong sediments. The new list of parameters to be analysed in sediments is given in Table 7.1. Those that are additional parameters to current criteria are indicated in this table.

The study went on to recommend criteria for determining whether the material is uncontaminated, moderately contaminated or highly contaminated. The sediment quality values have been termed as Interim Sediment Quality Values (ISQV) which will be reviewed once more region-specific synoptic sediment chemistry data is available (Classification of dredged material for marine disposal, EVS consultants, October 1996). Ultimately there will be two sets of sediment quality values, $ISQV_{low}$ and $ISQV_{high}$ Sediment which exceeds the $ISQV_{low}$ values will be considered as moderately contaminated. Sediment exceeding the $ISQV_{high}$ values will be considered highly contaminated. $ISQV_{low}$ values are based on Effects Range Low (ERL) values below which effects on benthic organisms are unlikely and $ISQV_{high}$ values are based on Effects Range Medium (ERM) levels above which effects on benthic communities are probable.

Under the existing system in Hong Kong, material currently classed as Class C, "highly contaminated" would be disposed to East Sha Chau and this decision would be based on chemical contamination alone and is conservative in that it does not consider biological effects. Under the new framework, such material would be subject to Tier III biological screening and this may have significant implications to the disposal of channel sediment. If the biological testing indicates that the sediment has no effect on the selected "benchmark" organisms, then the material can be considered safe for open marine disposal (Class 1). It is possible, therefore, that a proportion of the channel sediment currently earmarked for East Sha Chau would not require confined disposal in the future. Alternatively, the material may be found to have sub lethal effects on the organisms, in which case confined marine disposal at East Sha Chau would still be necessary (Class 2). Finally, the material may be observed to have lethal effects on the benchmark organisms during the toxicity tests. Under this scenario the material would not be suitable for marine disposal unless further testing (Tier IV) indicated otherwise. Details of the biological testing are presented in Appendix A9 and have been extracted from the experimental design outlined in the EVS study.

Tier IV testing allows for a more in depth investigation into the toxicity of the material. For example, sediment containing compounds such as ammonia or hydrogen sulphide cause lethal effects on benchmark organisms. However lethal effects caused by such compounds are often short lived and can be rapidly rendered harmless if lost in small quantities into the marine environment during contained marine disposal. Tier IV testing may therefore investigate the presence of these gases and look for appropriate ways to oxidise the material which may render the material harmless and then be considered safe for marine disposal. If the material is causing lethal effects on marine organisms due to the presence of elevated levels of other chemicals then extended biological testing including field trials would be undertaken to investigate the impact of the material. It is very likely for the riverine sediments under consideration here that the majority of sediment which exceeds ISQV-low could be demonstrated to be safe for confined marine disposal and it is only in exceptional circumstances that the material would have to be sent to a non marine disposal site as a Class 3 material.

It is apparent that the only feasible option for non marine disposal at present is the strategic landfills. Therefore, some of the sediment to be removed from the channels in the future, which would currently be accepted at East Sha Chau, may, after extensive testing have to be disposed of to one of the landfills. Should the material require landfilling then under the current requirements, a small proportion of the material may have to be pre-treated to reduce water content before it can be accepted (maximum 70% water content and no free draining water). Section 7.2.3 indicates the proportion of channel sediment which would be classified as contaminated under the existing and future classification system.

7.2.3 Classification of Channel sediment

Sediment has been sampled and analysed from the channels under this study and the Final Key Issues Report (Acer Consultants, 1996) described the outcome of the core analysis undertaken in the dry season of 1995/1996. Material was classified under the existing classification system (TC-1-1-92) and it was found that a significant number

7. MANAGEMENT OF DREDGED MATERIAL

7.1 Introduction

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7.2 Methodology

The assessment of disposal options has involved additional sediment testing and a cost benefit analysis which has been presented in the Task 5 Report. The analysis showed that the transport and disposal of sediment accounts for the majority of the costs of maintenance dredging works. The volumes of sediment dredged from the channels must therefore be kept to a minimum and the productivity of the dredging operations is a secondary consideration as it has a relatively minor impact on overall costs. Retaining as much of the sediment in-situ, particularly with respect to highly contaminated sediment is also considered to be in line with the London Convention. Accurate dredging is thus a greater priority in terms of general improvement techniques.

Those disposal options and treatment technologies considered most suitable for this study are assessed in detail below. A cost comparison was undertaken in task 5 and is taken further in this report to look at cost benefit in relationship to environmental impacts. In the determination of suitable options several key questions had to be answered:

- Is the disposal option/site already established in Hong Kong and therefore available in the short term?
- Is the site accessible from land or sea or both?
- Does the site accept contaminated material or clean material or both?
- Does the site have sufficient capacity to be considered a long term option (5-10 years)?
- Is there potential to develop the option in the long term?
- Does the option/site have environmental merits/ can environmental impacts be controlled?
- Is the disposal option considered cost effective (based on Task 5 assessment)?
- What frequency of maintenance dredging is necessary?

7.2.1 Legislation, Criteria and Guidelines

Guidance for management of dredged material in Hong Kong is found under the following categories:

a) Marine Pollution

Hong Kong, through the United Kingdom is a signatory to the London Convention which aims to regulate those wastes which contribute to marine pollution, develop a legal framework for controlling disposal of wastes at sea and establish overall global policies which can provide guidance for regional agreements.

The requirements of the London Convention are implemented through the Dumping at Sea Ordinance and Cap. 466 sets out the legislation "to control the disposal of substances and articles at sea and the dumping of substances and articles in the sea and under the sea bed". The Ordinance provides the requirements for the designation of marine dumping areas and permits for marine dumping together with provisions for marine pollution controls.

b) Marine Disposal Grounds

The HKPSG state that,

"if dredged material is not required as fill then it may normally be transported to and deposited at the gazetted spoil dumping grounds or sites approved by the EPD. Considerations should be given to ensure that the dredged material to be disposed of should not overstress the available capacity of the existing, committed or planned spoil dumping grounds. On no account should any material be dumped directly into an inland watercourse. Particular care must be taken in cases where the dredged material may be contaminated in any way". (HKPSG Chapter 9, Environment)

c) Onshore Disposal

Guidelines discussed in this report relating to land disposal options include the following:

- Works Branch Technical Circular No. 16/96, wet soil in public dumps;
- The dredged materials disposal criteria at the NENT, SENT and WENT landfills are the same. This type of waste is classified as type 2 waste, the acceptance of which will require specific instruction from the DEP to the landfill contractors.
- EPD standard for dredged material acceptance at landfills i.e. that material should have a moisture content no greater than 70% and the material must be contaminated to prevent using capacity unnecessarily.
- The Waste Disposal Ordinance (CAP. 354-1980). This ordinance permits disposal without any regulation as long as the material is not placed:
    - i) In a public place;
    - ii) On crown land; and

iii) On any land other than crown land without the consent of the owner or occupier.

- The Water Pollution Control Ordinance.

Currently, proponents of projects involving the marine disposal of dredged mud should follow the procedures stipulated in the Works Branch Technical Circular No 22/92. The EPD Technical Circular TC-1-1-92 currently provides the standards for sediment quality. On determination of sediment quality, the proponent must obtain allocation of marine disposal ground capacity from the Fill Management Committee. The existing framework for managing Dredged Material in Hong Kong is summarised in Figure 7.1 and Criteria are set out in TC No. 1-1-92, Appendix A8.

EPD Technical Circular No (TC)1-1-92 - Classification of Dredged Sediments for Marine Disposal defines three classes of dredged sediments based on the analysis of seven heavy metals. Since issue of the circular in 1992, operation of the classification scheme has been simplified and, *de facto*, dredged material is classified as suitable for open sea disposal if contaminants are lower than the original class C criteria. The classification scheme for sediment is currently under review and the new guidelines are considered below.

7.2.2 Future Criteria and Guidelines

New assessment criteria and guidelines have been proposed by EVS consultants for the Fill Management Committee which if/when accepted will eventually result in extended testing for additional parameters such as silver, man-made organics (PAHs, PCBs), pesticides (DDT, TBT) and metalloids (As). The proposed new guidelines and criteria aim to refine the existing practice in Hong Kong and to add to the process rather than to change parameters and criteria currently in use. Following an international review of criteria, guidelines and sediment chemistry in Hong Kong, EVS identified 24 Category 1 Contaminants of Concern (COCs) and 17 Category 2 COCs. Category 1 COCs were then proposed for incorporation in efforts to update the present Hong Kong sediment quality values. These COCs have potential to cause adverse biological effects and are specific to Hong Kong sediments. The new list of parameters to be analysed in sediments is given in Table 7.1. Those that are additional parameters to current criteria are indicated in this table.

The study went on to recommend criteria for determining whether the material is uncontaminated, moderately contaminated or highly contaminated. The sediment quality values have been termed as Interim Sediment Quality Values (ISQV) which will be reviewed once more region-specific synoptic sediment chemistry data is available (Classification of dredged material for marine disposal, EVS consultants, October 1996). Ultimately there will be two sets of sediment quality values, $ISQV_{low}$ and $ISQV_{high}$ Sediment which exceeds the $ISQV_{low}$ values will be considered as moderately contaminated. Sediment exceeding the $ISQV_{high}$ values will be considered highly contaminated. $ISQV_{low}$ values are based on Effects Range Low (ERL) values below which effects on benthic organisms are unlikely and $ISQV_{high}$ values are based on Effects Range Medium (ERM) levels above which effects on benthic communities are probable.

Generally it can be seen that the $ISQV_{low}$ values for parameters already tested in Hong Kong are equivalent to the lower limit for Class C material or the upper limit for Class B except for mercury, which now has a much more conservative value in accordance with international criteria. $ISQV_{high}$ data have been proposed as working numbers only to provide a basis for future development. Implementation of these values will require incorporation of biological screening and biological assessment to provide adequate severe effects data. EVS have stated that these $ISQV_{high}$ values should not be used until such data is available for local species as it may lead to misinterpretation of data and therefore these have not been considered further in this study.

TABLE 7.1 CONTAMINANTS OF CONCERN AND $ISQV_{LOW}$ VALUES PROPOSED BY EVS

Contaminant	$ISQV_{low}$ (Metals mg/kg; Organics µg/kg)	TC-1-192 Class C(mg/kg)
Metals		
Cadmium	1.5	>1.5
Chromium	80	>80
Copper	65	>65
Mercury	0.15	>1.0
Nickel	40	>40
Lead	75	>75
Silver*	1.0	
Zinc	200	>200
Metalloids		
Arsenic*	8.2	
Organics - PAHs		
Total PAHs*	4022	
Organics - non-PAHs		
Total PCBs*	22.7	
Total DDT*	1.58.	
TBT*	??	

** indicates new parameters*

The proposed decision making framework is based on a four-tiered testing system (EVS, October 1996), (Figure 7.2) which is in line with the requirements of the Dredged Material Assessment Framework of the London Convention and builds upon the framework currently in use in Hong Kong. Future development in dealing with highly contaminated material is also indicated in Figure 7.2.

The first tier involves a review of existing information to determine whether there is sufficient evidence that the material is not a carrier of pollutants. If there is not explicit evidence that the material is uncontaminated then chemical testing (Tier II) is undertaken to determine whether material is uncontaminated, moderately contaminated or highly contaminated. This is based on comparison of analytical results to the $ISQV_{low}$ values. Any material exceeding the $ISQV_{low}$ values can be considered contaminated and will be subject to Tier III testing. The third tier investigates biological toxicity, i.e. the effects of the contaminants on benthic organisms to determine whether the material is unpolluted, moderately polluted or highly polluted.

Under the existing system in Hong Kong, material currently classed as Class C, "highly contaminated" would be disposed to East Sha Chau and this decision would be based on chemical contamination alone and is conservative in that it does not consider biological effects. Under the new framework, such material would be subject to Tier III biological screening and this may have significant implications to the disposal of channel sediment. If the biological testing indicates that the sediment has no effect on the selected "benchmark" organisms, then the material can be considered safe for open marine disposal (Class 1). It is possible, therefore, that a proportion of the channel sediment currently earmarked for East Sha Chau would not require confined disposal in the future. Alternatively, the material may be found to have sub lethal effects on the organisms, in which case confined marine disposal at East Sha Chau would still be necessary (Class 2). Finally, the material may be observed to have lethal effects on the benchmark organisms during the toxicity tests. Under this scenario the material would not be suitable for marine disposal unless further testing (Tier IV) indicated otherwise. Details of the biological testing are presented in Appendix A9 and have been extracted from the experimental design outlined in the EVS study.

Tier IV testing allows for a more in depth investigation into the toxicity of the material. For example, sediment containing compounds such as ammonia or hydrogen sulphide cause lethal effects on benchmark organisms. However lethal effects caused by such compounds are often short lived and can be rapidly rendered harmless if lost in small quantities into the marine environment during contained marine disposal. Tier IV testing may therefore investigate the presence of these gases and look for appropriate ways to oxidise the material which may render the material harmless and then be considered safe for marine disposal. If the material is causing lethal effects on marine organisms due to the presence of elevated levels of other chemicals then extended biological testing including field trials would be undertaken to investigate the impact of the material. It is very likely for the riverine sediments under consideration here that the majority of sediment which exceeds ISQV-low could be demonstrated to be safe for confined marine disposal and it is only in exceptional circumstances that the material would have to be sent to a non marine disposal site as a Class 3 material.

It is apparent that the only feasible option for non marine disposal at present is the strategic landfills. Therefore, some of the sediment to be removed from the channels in the future, which would currently be accepted at East Sha Chau, may, after extensive testing have to be disposed of to one of the landfills. Should the material require landfilling then under the current requirements, a small proportion of the material may have to be pre-treated to reduce water content before it can be accepted (maximum 70% water content and no free draining water). Section 7.2.3 indicates the proportion of channel sediment which would be classified as contaminated under the existing and future classification system.

7.2.3 Classification of Channel sediment

Sediment has been sampled and analysed from the channels under this study and the Final Key Issues Report (Acer Consultants, 1996) described the outcome of the core analysis undertaken in the dry season of 1995/1996. Material was classified under the existing classification system (TC-1-1-92) and it was found that a significant number of cores contained Class C material at varying depths. Figure 7.3 shows the sediment quality based on core samples obtained from the dry season survey and Figure 7.4 presents the corresponding data from the wet season Grab sampling survey, the full data is included in Volume B of this report.

Of the core samples taken 17% of the locations were Class A, 3% Class B and 80% Class C based on one or more exceedance of the criteria from any sub sample within the core. If we take a closer look at the 118 core sub samples we can further appreciate the sediment quality as follows:

i) 47% Class A

ii) 4% Class B

iii) 49% Class C

Thus, approximately half of the sub samples contain metal contaminants at Class C levels and approximately half could be classified as uncontaminated. In the majority of Class C sub samples the metal contaminants are one or more of Copper, Zinc and Lead.

All samples that are classified as Class C would also exceed the $ISQV_{low}$ values and would therefore be subject to Tier III biological screening. Based on the metals data alone, 59 of the 118 sub samples analysed from the cores exceeded one or more of the $ISQV_{low}$ values and would therefore require Tier III testing. Data was also compared to $ISQV_{high}$ values for interest and 14 samples in six of the channels (Staunton Creek, Fo Tan Nullah, River Indus, San Tin MDC, Tin Shui Wai and Tuen Mun) were highly contaminated with metals. Subject to biological testing it may be the case that some of the material from these channels could not be disposed at East Sha Chau due to metal pollution. It is also possible that the high metal levels may not contribute to the toxicity of the material, depending on the form of the metals in the material. Should the material have lethal effects on test organisms then further investigation would be required to determine whether the toxic effects were only short lived effects of ammonia etc. rather than the effects of the metals themselves.

Some of the samples classified as Class A or B under the existing system would also exceed the $ISQV_{low}$ values for the additional parameters proposed by EVS. For example, the sediment may contain PAHs, PCBs or Arsenic. Based on metals alone, approximately 50% (i.e. 59 samples) of the sub samples did not exceed $ISQV_{low}$ values and may not require Tier III testing. It is likely that the majority of Class A or B sediment would be considered uncontaminated and could therefore be subject to open marine disposal. Figure 7.5 presents the proposed new classification of the sediment core samples.

<u>Additional Sediment Survey</u>

In order to look at some of the COCs in more detail, an additional sediment survey was undertaken in August 1996. Since the FMC study findings were not available at the time of testing, silver was not included neither were DDT and TBT. It is however unlikely that the sediments would have contained detectable levels of TBT given that this is largely found in the environment as a result of loss from ship's hulls over 25m in length.

Organic analysis looked at the USA EPA range of PAHs at lower detection levels than had previously been used in the initial wet season survey (July 1995) when grab samples had been taken. Arochlor mixture of PCB congeners, metals and arsenic were also analysed in the sediments.

Locations selected for re-sampling were those found to be most contaminated (Class C) in previous surveys and/or most likely to be dredged. Eleven samples from 3 channels (Shing Mun (including Fo Tan), Tai Po and Tuen Mun) were tested and all samples except two in Tai Po/Lam Tsuen channel were still found to be seriously contaminated i.e. Class C. When compared to the new $ISQV_{low}$ values all samples exceeded the values and were therefore at least moderately contaminated. It is interesting to note that in Tai Po where existing classification criteria would have ranked the sediment as Class A, investigation into additional parameters indicated that Arsenic and organics (notably PAHs) were present in sufficiently high levels to classify the material as contaminated. It is also of note that none of the samples exceeded the provisional $ISQV_{high}$ values.

EVS undertook detailed chemical analysis (of 200 individual compounds) and biological testing for sub lethal and lethal effects of 5 riverine sediments relevant to this study. The results indicated that 3 of the samples from the Fo Tan Nullah, River Indus and the Tuen Mun River would be likely to be considered as Class 3, highly polluted sediment and would be subject to Tier IV biological testing.

More recently, the Environmental Improvement of Shing Mun River Main Channel and associated Nullahs Study for EPD by Aspinwall Clouston Ltd has indicated that sediment in the Shing Mun channel is capable of exerting a lethal effect on certain marine organisms. Tier III testing indicated the mean response (i.e. growth and survival) of marine organisms to the test sediment was over 25% lower than for the reference sediment. The study team have, however, indicated that sediments may be giving a lethal toxicity response due to the presence of sulphides, particularly hydrogen sulphide which is known to be present in high concentrations and to be causing the odour in the channel rather than metals. Ammonia is also present in the sediment in high concentrations and the EPD study is currently investigating ways to remove these compounds to determine whether sediment can be rendered suitable for marine disposal. (Letter sent to EPD ref. EP 540/S8/1 V, 7/3/97)

Table 7.2 provides a summary of potential classification, based on grab, core and EVS sediment surveys and an indication of potential annual volumes of sediment to be removed for flood alleviation:

TABLE 7.2 SUMMARY OF POTENTIAL CLASSIFICATION BASED ON SURVEY DATA

Channel	Potential Annualised Recurrent Dredged Volume (m^3)
Channels where Class 1 uncontaminated sediments are likely:	
River Silver (all data indicates uncontaminated sediment)	650
Tai Shui Hang (tributary of Shing Mun)	460
Upper reaches of Lam Tsuen River	1,800-2,300
Northern MDC in San Tin	1,500

Channel	Potential Annualised Recurrent Dredged Volume (m^3)
Upper reaches of Tuen Mun River (based on grab samples)	-
So Kwun Wat (above CPR Bridge)	1,150
Upper reaches of Tai Lam Chung	140
Downstream section of Sham Tseng	-
Total (figure may increase subject to outcome of Tier III testing on material from channels listed below)	**5,700 - 6,200**
Channels where Tier III biological screening would be required (Potential Class 2):	
Staunton Creek	330
Kai Tak Nullah	2,000
Shing Mun River	20,000
Lower reaches of Siu Lek Yuen	7,000
Tai Po River	1,350
River Beas/Sutlej (future)	1,000
Southern San Tin MDC	3,000
Yuen Long/Kam Tin	7,460
Tin Shui Wai Drainage channels	3,100
Tuen Mun River (mid - lower reaches)	7,000
Mouth of So Kwun Wat	-
Total (Subject to outcome of Tier III and Tier IV testing)	**52,240**
Channels for which Tier IV testing is likely to be required (Potential Class 3):	
Fo Tan Nullah	320
River Indus (future)	2,700
Tuen Mun River (downstream of Industrial area)	3,000
Total (Worst case as proportion of material will be considered class 2 following Tier IV testing)	**6,020**

Note: The total present volume = 57,816 m^3
The total future volume = 60,296 m^3

7.3 Impact Assessment of Disposal Options

7.3.1 East Sha Chau

<u>Introduction</u>

The locations of existing and potential future disposal sites are presented in Figure 7.6.

East Sha Chau has been confirmed by government as an acceptance site for the disposal of contaminated muds. At present disposal to East Sha Chau (ESC) is the most economical option for the majority of the contaminated sediments which will be removed from the channels. Under EVS Consultants' recommendations, all material which is classified as Class 2 after biological testing will in the future be disposed of in ESC contaminated mudpits. However, in the event that the recommendations of EVS' latest study are incorporated into the management of dredged sediment, material which is both unpolluted (Class 1) and highly polluted (Class 3) will be excluded from the mud pits. With the new EVS guidelines in place it is generally thought that the volumes of material requiring disposal at ESC will be reduced, thus prolonging the lifetime of the mud pits. The new pit has an anticipated life span of about five years and some other form of disposal or treatment may therefore be necessary for contaminated sediment in the future.

Capital Restoration Dredging

The most significant dredging campaign will occur before the new guidelines are fully considered and will be the capital restoration dredging in the Shing Mun River. This will undoubtedly produce wet contaminated sediment unsuitable for any of the land based disposal options without treatment of one form or another. Since marine access is possible to the majority of this channel it is preferable that all of this and capital restoration sediments from Tuen Mun be disposed of at ESC. Since disposal operations in the past have not had any detectable impacts on the marine environment around ESC and sediment surveys indicate only small volumes of highly contaminated material, it is considered that disposal of capital restoration dredging is acceptable on environmental grounds. Should the works take place after the guidelines have been implemented then additional testing (Tier III) will be required.

The remainder of the disposal options therefore focus on disposal of material from recurrent dredging operations.

Recurrent Dredging

Channels where disposal to ESC has been proposed in the dredging strategy are those where contaminated material is to be removed by marine plant:

- Staunton Creek;
- Shing Mun Main and Siu Lek Yuen;
- Tai Po/Lam Tsuen;
- Tuen Mun

Or, where transfer from road plant to marine plant is considered suitable such as in Tin Shui Wai. Material from the Yuen Long/Kam Tin channels is also likely to be moved off site by road and then transferred into barges on the southern coast of the NWNT due to cost implications identified in task 5 of accessing the channels through Deep Bay.

Generally, the relatively small volumes involved in recurrent dredging mean that there will be no significant impact at the disposal site. Of this volume, it is also possible in the future that biological screening will indicate that open marine disposal is feasible, in which case the same plant can be used but cost savings can be achieved in terms of disposal. The potential future disposal of Class 2 material at ESC has been subject to the detailed assessment undertaken by EVS and the continuing monitoring programme undertaken at the mudpits and is therefore considered to have no residual environmental impact.

Impacts may arise upon transhipment to larger barges for transfer to ESC. There is the potential for loss of "moderately contaminated" material to either the channel or the marine environment. If uncontrolled this may result in short term increases in suspended solids and the release of contaminants previously bound in the sediments.

Alternatives

For channels in the Eastern New Territories, i.e. in the Shing Mun and Tai Po/Lam Tsuen catchments, ESC is not considered to be the optimum disposal option in terms of potential environmental impact. The distance over which material has to be transported before disposal is considerable and would have to be via the areas in Hong Kong which, in terms of coral and marine life, are probably most diverse and sensitive ecologically. Such areas include Hoi Ha Wan, Kei Ling Ha Hoi and Tai Long Wan. In the event of an accident, the loss of contaminated material could therefore have an undesirable impact on the marine environment. Transport and disposal costs could also be reduced if disposed options in closer proximity are considered.

The preferred option for these channels is disposal at the Public Dump area in Pak Shek Kok. Volumes involved in terms of recurrent dredging for flood alleviation are approximately 10,500 m^3 p.a. excluding the Fo Tan Nullah which is considered too contaminated at present. Pak Shek Kok is discussed under "Public Dumps" below.

7.3.2 Public dumps

Public dumping is described in the HKPSG as a disposal method for dredged and excavated spoil (Hong Kong, Planning, Standards and Guidelines, EPD/Planning Department, April 1991, Appendix 6.2, Chapter 9). Existing and potential public dump sites are indicated in Figure 7.6. The Task 5 dredging strategy has recommended disposal at public dumps for material removed from Tai Shui Hang tributary of the Shing Mun River, So Kwun Wat drainage channel and Tai Lam Chung river channel.

Suitability of Material

In August 1996 Works Branch Technical Circular No 16/96 "Wet Soil in Public Dumps" was issued. The circular states that wet soil can routinely be accepted for use at public dumps below water and not present a management problem for reclamation contracts. However, wet soil can pose engineering problems, though not insurmountable, when placed above water level. Due to problems associated with acceptance or rejection of material at the entrance of the public dump, and problems associated with the waste producer not being able to plan in advance where to take material, the circular states that it is necessary to require all reclamation works involving public dumping to accept wet soil by including a particular specification in their contracts.

As in previous dumping licences for public dumps, the wet soil should be free of marine mud, refuse, plastic and metal, animal and vegetable matter and industrial and chemical waste. If space is not immediately available for wet soil then the contractor is asked by the WBTC to mix the wet soil and render it suitable for use in permanent work as fill material. Wet material that cannot be mixed and used in the fill must be disposed of properly by the contractor in an environmentally acceptably manner.

There is some difficulty in determining the acceptability of the riverine sediments at public dumps. Chapter 2 established that the material in the channels consisted of a significant proportion of marine sediment. Marine mud typically contains greater than 80% particles less than 63 μm. The PSD data for the sediment cores indicates that in some of the channels the percentage of clay is considerably lower than marine muds, but in certain cores such as the San Tin MDC the sediment was comparable to marine mud. However, as stated in the Task 5 draft final report, small volumes such as occasional truck loads could be well distributed throughout the dump, in-filling interstitial spaces and consolidating rapidly due to short drainage path lengths.

In many of the channels, the sediments are contaminated in the proposed dredging locations. In terms of the impact of contaminated material on the leachate from the site it was necessary to look at the sediment chemistry in more detail and determine availability of the contaminants.

The USEPA Toxic Characteristic Leachate Procedure (TCLP) is a test undertaken to look at the suitability of the material for landfill disposal. The test looks at the mobility of both organic and inorganic substances present in liquid, solid and multiphasic wastes. This test was undertaken on 11 of the samples taken in the additional sediment survey in August 1996. Samples were analysed for metals, nutrients, ammonia and Arsenic. More details on the methodology for these tests and the results are presented in Appendix A10. In addition to these tests, elutriate tests were undertaken which looked at loss of material when dredging and loss of contaminants to distilled water.

There are few criteria to which the results of the TCLP can be compared. In Germany guidelines exist for the disposal of dredged material and their classification system includes guidelines for elutriate. Based on the data from the additional sediment tests (river water, distilled water and TCLP elutriate tests) restricted open placement would be permitted to geologically and hydrologically suitable areas. Also, the data were compared to the Standards for Effluents Discharged into Drainage and Sewerage Systems in Inland and Coastal Waters.

As an example, it was assumed that material from the Tai Po and Shing Mun River were dumped in the Pak Shek Kok Reclamation which lies in the Tolo Harbour Water Control Zone. The proposed Pak Shek Kok reclamation covers an area of approximately 68 hectares of seabed and is expected to have a life span of 7-8 years. The initial years of the operation will be subject to an EM&A programme. Effects of the dump on the water quality are a concern due to the proximity of the Marine Science Laboratory of the Chinese University of Hong Kong. Thus, although Pak Shek Kok is a preferred option the acceptability of the proposal in terms of water quality impacts would need to be subject to further study.

The maximum volume per annum of material from recurrent flood alleviation and restoration dredging in the Shing Mun and Tai Po/ Lam Tsuen channels is 31,130m^3. It is assumed that material from the Fo Tan Nullah is too contaminated for disposal to Pak Shek Kok and therefore the volume is reduced slightly to 30,810m^3 p.a. The TCLP results for the Shing Mun and Tai Po sediments indicate that the leachate would have at worst the composition set out in Table 7.3.

Section 2 provided some information on the annual rainfall figures. Assuming 2,400 mm of rainfall occur on average per annum then over the Pak Shek Kok reclamation there would be a volume of 1,632,000 m^3 of water a year. Per day this potentially produces a discharge of 4,471 m^3 of water. This value was then used to find appropriate effluent control guidelines i.e. the standards under a flow rate of >4,000 and <5,000 can be used from Table 7 of the Technical Memorandum. Total toxic metals is given as 0.1 mg/L. If all of the material in the dump was the contaminated sediment then total toxic metals would be approximately 0.24 mg/L, Total nitrogen 22.1 mg/L as opposed to a guideline of 10 mg/L and Total phosphorus 0.04 mg/L compared to a standard of 5.

For much of the year the flow rate would be significantly lower and as little as <10m^3 a day during the dry season. In this case toxic metals permissible in effluent are greater (2 mg/L) and total permissible nitrogen is 20 mg/L. It can be seen therefore that even if all of the material in Pak Shek Kok was contaminated to the degree of the sediment in Shing Mun and Tai Po Channels, (depending on the flow rate of leachate from the dump) it is expected that the leachate would be within the effluent standards. Given that only 30,180m^3 of material p.a. would be dumped there and a total of 211,000m^3 over the 7 year life of the dump, this is a small fraction (3.5%) of the proposed 6 million m^3 capacity. It should also be noted that a over 10% of this material would be from the upper reaches of Siu Lek Yuen and Tai Shui Hang tributaries which is considered to be uncontaminated.

TABLE 7.3 TCLP RESULTS

Parameter	Units	LOR	D2	D4	D6	E4	E5	*WORST CASE*
Date			9/8/96	9/8/96	9/8/96	9/8/96	9/8/96	
pH Value	µg/L	0.1	5.7	5.4	5.5	5.2	5.4	*5.4*
Arsenic	µg/L	10	20	10	10	<10	<10	*20*
Cadmium	µg/L	0.2	<0.2	<0.2	<0.2	<0.2	<0.2	*<0.2*
Chromium	µg/L	1	<1	<1	<1	<1	<1	*<1*
Copper	µg/L	1	2	3	2	1	2	*3*
Nickel	µg/L	1	110	88	84	29	33	*110*
Lead	µg/L	1	2	3	1	2	<1	*3*
Zinc	µg/L	10	30	20	40	110	70	*110*
Total Kjeldahl Nitrogen as N	mg/L	0.1	10.9	8.1	12.6	1.2	1.2	*10.9*
Total Phosphorus as P	mg/L	0.01	<0.01	0.08	<0.01	<0.01	0.04	*0.04*
Ammonia	mg/L	0.1	10.3	7.3	12.1	0.8	0.8	***12.1***

There are both cost and environmental benefits to disposing of material in public dumps where they are considered to be the closest and most convenient disposal option, since volumes are not great.

Apart from Shing Mun River and Tai Po channels, public dumping has only been proposed for relatively clean and coarse material. Such material is unlikely to be very wet and should not affect the overall stability of the reclamation. Thus, in long-term strategic planning of sediment disposal we recommend that public dump sites are considered as viable disposal options. Prior to such disposal, it is recommended that a more in depth study of potential marine water quality impacts be undertaken, such a study extends beyond the scope of this EIA.

Alternatives

A proportion of the cleaner material proposed for public dumping can be disposed to open water but may be subject to biological screening once all of the Contaminants of Concern have been tested. The equivalent of Class 1 material may be used beneficially for example, on land for channel maintenance or natural earth bund formation for noise mitigation.

7.3.3 Landfill

Introduction

Three strategic landfills WENT, NENT and SENT are currently operated in Hong Kong, the locations of which are indicated in Figure 7.6. Of the three landfills, WENT has the largest remaining capacity, approximately 58 Mm^3 as of mid 1996. Despite available capacity at the three landfills, a key policy is to reduce volumes of waste and conserve capacity for municipal waste and sewage sludge. A second key feature of the landfills is to minimise the moisture content of materials accepted at the landfill to preserve the stability of the landfill and to prevent adverse effects on the leachate treatment system. Material should have a moisture content of no greater than 70% and should contain no free draining water. Material can only be disposed of to landfill if contaminated and considered unsuitable for marine disposal in order to prevent unnecessary use of capacity. There is however a need to prevent the disposal of large volumes of severely contaminated material which could have adverse impacts on the leachate treatment system of the landfills.

Dredged material from the following channels could, potentially, be disposed of in one of the landfills as an alternative to East Sha Chau and the preferred landfill depends on proximity to the channel (this has been indicated in brackets):

- Kai Tak Nullah (SENT)
- Upper reaches of Shing Mun River (SENT)
- Fo Tan Nullah (SENT)
- Siu Lek Yuen (SENT)
- Tai Po/Lam Tsuen (SENT)
- Indus - Present and future (NENT/WENT)
- San Tin MDC (WENT)
- Yuen Long (WENT)
- Tin Shui Wai (WENT)
- Sham Tseng (WENT)

EPD have indicated that the cost to Government of disposal to landfill is HK$120 per tonne for NENT and SENT and HK$221 for WENT (Fax sent from EPD 12/12/96). This figure includes all capital, aftercare, operating cost and administrative cost to Government (but does not include hidden costs such as land and opportunity costs). Clearly, it is preferable to dispose of sediment to NENT or SENT on a cost basis.

Suitability of Material

Recently EPD have revised the standards for dredged material acceptable to landfills. Whereas previously material should not exceed the maximum water content of 30%, the revised figure is a maximum water content of 70%. It is considered that the majority of dredged material requiring landfill disposal will meet the revised standard. There may however be free draining water present in the dredged material which will require removal prior to landfill disposal.

A further relevant issue is the current quality of leachate in the strategic landfills. EPD have advised that the quality of leachate in the landfills has not yet been stabilised. Only in several years time will the majority of leachate generated be in the methanogenic stage with BOD/COD concentrations at the lower end of the range and high ammoniacal nitrogen levels. Also co-disposal of contaminated dredged materials with municipal waste may leach out excessive heavy metal concentrations.

The first issue of concern is impact of contaminants found in the leachate from the sediment. The TCLP results for the three channels tested are presented in Appendix 10. Two of the sample locations from Fo Tan Nullah and Tuen Mun River have consistently been found to be highly contaminated with metals. The TCLP results for these two most contaminated sites are set out in Table 7.4 below:

TABLE 7.4 TCLP ELUTRIATE RESULTS FOR FO TAN NULLAH AND TUEN MUN RIVER

Analysis description	Units	LOR	D9	J4
			9/8/96	13/8/96
pH Value	µg/L	0.1	5.6	5.9
Arsenic	µg/L	10	<10	<10
Cadmium	µg/L	0.2	<0.2	<0.2
Chromium	µg/L	1	<1	<1
Copper	µg/L	1	1	2
Nickel	µg/L	1	230	78
Lead	µg/L	1	19	<1
Zinc	µg/L	10	260	50
Total Kjeldahl Nitrogen as N	mg/L	0.1	3.7	42.2
Total Phosphorus as P	mg/L	0.01	<0.01	<0.01
Ammonia	mg/L	0.1	3.6	39.5

Results would indicate that the leachate produced by TCLP would be within the range of contaminants currently found within the raw leachate produced from the three strategic landfills as shown in Table 7.5 below.

TABLE 7.5 UNTREATED LEACHATE QUALITY

Parameter	RANGE		
	WENT Dec 94 - Dec 95	NENT Oct 95 - Mar 96	SENT Dec 94 - Dec 95
pH	5.9 - 8.1	6.0 - 7.7	5.37 - 7.81
BOD	3400 - 70000	12000 - 48000	220 - 46000
COD	9200 - 90000	25000 - 74000	1600 - 66000
TOC	1400 - 60000	7900 - 28000	520 - 37000
SS	160 - 84000	230 - 2500	N.A.
NH	2200 - 6000	910 - 4300	1.6 - 1800
Cd	0.03 - 15	N.A.	N.A.
Cu	0.1 - 1000	0.08 - 0.1	N.A.
Hg	<1 - 20	N.A.	N.A.
Ni	0.3 - 1.4	0.39 - 0.72	N.A.
Zn	0.7 - 220	1.6 - 3.5	0.38 - 4.5
Fe	7.5 - 440	42 - 200	2.1 - 440
Cr	0.2 - 4	N.A.	N.A.
Sn	<10 - 89	N.A.	N.A.

All units are given in mg/l except pH. Sources: (EPD, correspondence by fax dated 28/3/96 and 29/4/96)

A concern relating to raw leachate production is the potential impact of organic contaminants on the operation of the biological leachate treatment system. Table 7.5 does not show any organic compounds amongst its parameters as they are not routinely tested for.

The TCLP test results do not take into account dilution effects and therefore present a worst case scenario. Where parameters have been tested and enable a comparison to be made it can be assumed that where results from TCLP are within ranges displayed in Table 7.5 then there will be no significant impact on the landfill operation. The most contaminated material from the channels should therefore be acceptable for landfilling. Dewatering of material will however be required. There are several methods which can be employed to reduce water content, some of which have the added benefit of stabilising the material both chemically and physically as explained below under lime stabilisation.

<u>Dewatering</u>

In the future Class 3 material as defined under the EVS guidelines and any other material for which landfill disposal has been identified as being a potential disposal option, if the 70% water content/no free draining water criteria cannot be met then dewatering will be necessary. Based on a cost comparison of the disposal options alone it is likely that volumes disposed to landfill will be minimised and the focus for dewatering will be for the highly contaminated materials. Task 5 Report indicates that 10% of the total dredged volume will be landfilled, i.e. approximately 6,000 m^3 a year. Of this it is considered that as a worst case scenario 10% by volume will be free water i.e. 600m^3 per annum. If two landfill sites are used (e.g. WENT and SENT) then this means that only an average of 300m^3 of water per annum will require removal per site.

Table 3.1 of the Task 5 Draft Final Report presents the principal methods for dewatering and the percentage solids achievable under ideal conditions. These are summarised in Table 7.6. Several of these methods are unable to produce the desired reduction in water content to make the output suitable for reception at a landfill site.

TABLE 7.6 DEWATERING METHODS AND THEIR EFFICIENCY

Dewatering method	Percentage solids achievable (%)
Settling Pond	up to 60
Belt Filter Press	45-70
Chamber filtration	50-80
Vacuum Filter	35-40
Solid bowl centrifuge	15-35
basket centrifuge	15-35
gravity thickening	15-20
evaporation	up to 100

Table 7.6 indicates that settling ponds, filter presses and evaporation are the most effective dewatering methods. Task 5 went on to identify lime as a favourable option to the afore mentioned methods of dewatering in terms of cost (HK$79-114 per m^3 depending on throughput). Lime stabilisation would therefore be employed to remove free water from the dredged material and where necessary to reduce water content of the material to below 70%.

Lime Stabilisation

Lime treatment of contaminated sediments provides a method whereby the contaminants within the sediment can be stabilised through either physical or chemical treatment. Of the available treatment techniques, stabilisation is considered to be one of the cheapest methods but the effectiveness is dependent upon the composition of the waste for example the form of toxins present, and the limitations of the fixation process.

In terms of chemically stabilising the material, theoretically contaminants such as metallic ions are more readily adsorbed onto the surface of clay particles and are less readily lost to solution where they can have harmful effects on living organisms. Also, metals may be precipitated at the higher pHs produced through the addition of lime, again removing metals from solution. Physical stabilisation involves the production of a more solid matrix such as that formed through the addition of cement as some states of toxic species are less mobile in a solid matrix.

Pozzalons are materials used in conjunction with lime to improve stabilisation and are capable of reacting in the presence of water at ordinary temperatures to produce cementitious compounds. Examples of pozzalons include volcanic ash and pulverised fly ash. Such techniques can enhance the physical structure of the waste making it easier to transport and safely dispose of but its ability to chemically stabilise the material is far less certain. Mixtures of pozzalons and lime are successful for stabilising many inorganic chemicals but not all and only certain organic compounds may be stabilised. Research indicates that no single process such as use of cement, pozzolanic additives or "secret" chemicals and polymers is effective in providing chemical stabilisation for all contaminants as a group. For example, zinc, copper and lead have been found to be most effectively contained using a commercially available pozzolanic additive whereas polymer additives are more effective at containing PAHs. Every waste, therefore, should be assessed independently to design an appropriate stabilisation mix. Due to variation between channel sediments, optimum mixes are likely to vary from channel to channel. Laboratory tests are often not found to be representative of effects in the field. Also the final disposal option or use of the material can affect chemical stability, for example interaction with leachate produced in landfills can convert chemicals into more toxic forms.

The preferred process involves the addition of quicklime and cement to the sediment which results in dewatering due to the hydration of the quicklime and also, due to the exothermic reaction, heat is generated. The release of heat can have side effects such as the volatilisation of organics or the initiation of endothermic reactions which may change the nature of the material. Also the quicklime may react with compounds within the sediment and release gases such as ammonia. These side effects are desirable since they remove contaminants but such releases are health and safety factors which operators should account for.

The addition of lime will reduce the volume of water in the sediment and overall the process can result in a +/- 5% change in the original volume of material. Given the small volumes of material likely to be disposed of to landfill under the EVS criteria (6,000m^3), lime stabilisation will not add significantly to annual volumes of waste for landfilling.

A mobile solidification plant has been developed by Land and Water Services in the UK. Mobile plant incorporate specialist equipment capable of working in awkward locations and capable of working with sediments and waste of varying properties. Task 5 and 7 are investigating practical plant for use in Hong Kong.

<u>Key advantages of the process are:</u>

- Reduction in water content making the material suitable for landfill disposal, easier to handle, transport and dispose of and suitable for truck movements on the tipping face at the landfill;
- Helps to reduce mobility of toxic species, particularly metals and eliminates leachate from the sediment;
- Potential to open up opportunities for beneficial uses of waste - e.g. use on footpaths along channels, road side embankments and where not highly contaminated, use as a lime agent on agricultural land;
- The plant involved could be installed within one of the landfills as it is mobile and can be relocated as areas are used for disposal.

<u>Key disadvantages of the process are:</u>

- The final sediment may have a high pH which should still be treated as a contaminated waste at landfill sites;

- Many reactions are reversible and therefore there are limited disposal options, leaving landfill as the most viable option at present;
- The lime stabilisation process will require flexible, specialist mobile plant;
- Health and safety issues for operators of plant due to secondary reactions caused by adding quicklime to sludges;

The advantages of this method outweigh the disadvantages and this is the preferred option for dewatering. Necessary plant has been investigated by the Task 7 team and it is proposed that it will be small scale and installed near to the landfill. Figure 7.7 shows a schematic layout for the lime stabilisation plant provided by the Task 7 team.

7.3.4 Shoreline Disposal Facility

The draft Task 5 report proposed that a shoreline facility could be developed to accept contaminated dredged material from the river channels. Such a facility would require more sediment than that dredged from the study channels alone and should be looked upon as a strategic disposal option that results in a beneficial use such as a habitat for birds.

The shoreline disposal facility is uneconomical for the volumes of sediment which have been identified for removal from the channels. Disposal to East Sha Chau or to a landfill is therefore the preferred option for contaminated material on a cost basis.

If the facility would not be used for material from the channels alone then it is not possible to determine the environmental impacts of such a facility. The facility should be designed to contain contaminants and biological monitoring should be undertaken to ensure that containment was successful and that no adverse marine impacts were occurring. It would also be recommended that the area was developed so that it could become a habitat for birds and therefore be of ecological benefit in the long term.

In a similar way to the public dumps, it is not anticipated that the leachate from the material would have adverse impacts on marine water quality. However, an adequate lining system would have to be developed depending on the type of material it was to accept. Highly contaminated material should still be sent to landfill where any leachate produced by the waste is treated prior to discharge.

7.3.5 Other Options

The other options recommended for consideration in the Task 5 Draft Final Report are for the disposal of uncontaminated material. Generally this is considered to be acceptable from an environmental view point as there is no risk of sub lethal or lethal effects on marine organisms. The options include:

- Unconfined Disposal in Licensed disposal areas;
- Confined disposal by controlled bottom dumping into sea-bed depressions or redundant sand borrow pits;

Open disposal to gazetted marine disposal sites has the potential to cause sediment plumes which can increase turbidity and reduce light penetration into the water. This can have secondary impacts such as a reduction in dissolved oxygen and increased nutrients due to release from the sediment. Provided sediment loss during disposal at the sites is minimised and standard mitigation measures are used then the environmental impacts of disposal at gazetted open water disposal sites is not considered to be significant.

Beneficial uses of the sediment are generally only recommended for uncontaminated material and therefore are not expected to have adverse environmental impacts. Beneficial uses will be varied and will depend on what can be identified by the contractor at the time in the vicinity of the channel.

7.4 Summary of Preferred Disposal Options

Table 7.7 below summarises the preferred disposal options on environmental grounds. Generally; Class A sediments are recommended for local beneficial use; and Class C for disposal at East Sha Chau or to strategic landfill. In the long-term beneficial use is recommended for all clean sediments and a combination of strategic landfill, East Sha Chau (depending on EVS classification), public dump and future shoreline enclosure have been recommended. However, on cost grounds a shoreline enclosure is unlikely to be viable given the small quantities of sediment involved.

7.5 Environmental Monitoring and Audit

7.5.1 Sediment Monitoring

Sediment monitoring will be required to determine sediment classification in the future and the necessary monitoring will be dictated by the legislative requirements.

All channels will be subject to an EM&A programme. Since biological testing, particularly at Tier IV level can take a considerable amount of time and some dredging work has to be undertaken at short notice, it is considered necessary to devise an on-going monitoring programme whereby each river or tributary has a classification for which a suitable disposal option has been determined.

Appendix A9 outlines the methodology used for biological testing in the channels. It is recommended that this is used to determine whether the channel sediment is likely to have sub lethal or lethal effects on selected benchmark organisms. The proposed monitoring and testing programme are subject to review under the audit programme and may be revised at a later date once the new classification system has been implemented by EPD.

Sediment monitoring is discussed in greater detail in Section 8 - Environmental Monitoring and Audit, and the parameters recommended for analyses are included as Appendix A11.

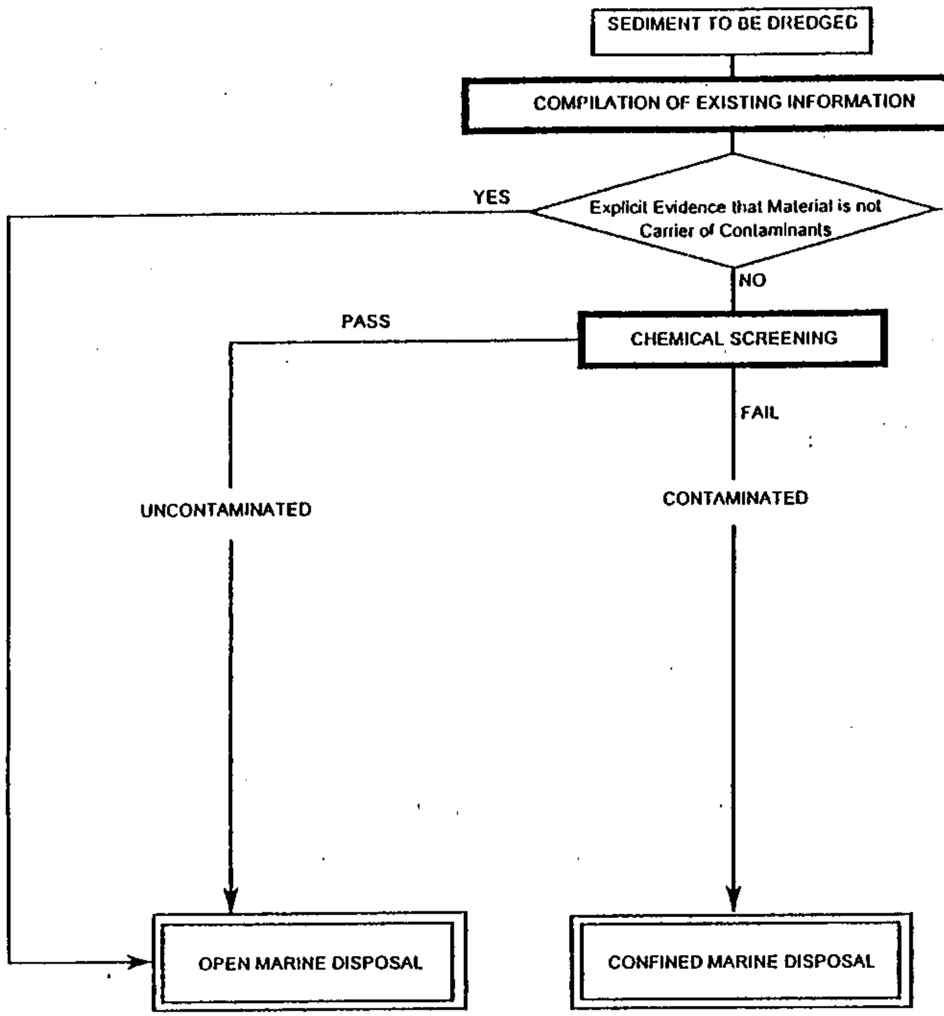
TABLE 7.7 SUMMARY OF PREFERRED DISPOSAL OPTIONS - SHORT AND LONG TERM

Channel	Estimated Annual Dredged Volume (m^3)	Access	Contamination Status (TC-1-1-92/*FMC New Classification*)	Preferred Disposal Option	
				Short-Term	Long -Term
River Silver:	650	Land	Class A/*Class 1*	Local Beneficial use - agricultural land/ habitat creation	N. Lantau Port Public Dump[1]/Beneficial use
Staunton Creek: Lower Reaches Upper Reaches	330	Land	C/*Class 2*	East Sha Chau / SENT Landfill	East Sha Chau/Strategic landfill
Kai Tak	2,000	Land	Class C/*Class 2*	SENT Landfill	Strategic Landfill
Shing Mun (main): Lower Reaches	20,000	Marine	C/*Class 2*	East Sha Chau	Strategic landfill/East Sha Chau
Upper Reaches		Land	B/*Class 1*	Pak Shek Kok[1]/Open Sea Disposal	Local Beneficial use
Fo Tan: Lower Reaches Upper Reaches	320	Land	C/*Class 2/3*	East Sha Chau SENT/NENT Landfill	Strategic landfill /East Sha Chau
Siu Lek Yuen	7,000	Marine	B/C/*Class 1/2/3*	Pak Shek Kok[1] / East Sha Chau /open sea disposal	Beneficial use / open sea disposal/East Sha Chau/Strategic Landfill
Tai Shui Hang	460	Land	A/*Class 1*	Pak Shek Kok[1] / Local Beneficial Use	Local Beneficial Use
Tai Po River	1,350	Marine	C/*Class 2*	Pak Shek Kok[1] / East Sha Chau	Strategic Landfill / East Sha Chau
Lam Tsuen River	1,350	Land / Marine	C/*Class 2*	Pak Shek Kok[1]/ East Sha Chau	As above (if clean -Beneficial Use)
River Indus	5,000	Land	C/*Class 2/3*	Landfill NENT/ East Sha Chau	Strategic Landfill/ East Sha Chau/ Beneficial Use
BEAS future	1,000	Land	A/*Class 1*	Local Beneficial use	Local Beneficial Use
Sutlej (future)	400	Land	A/*Class 1*	Local Beneficial use	Local Beneficial Use
Indus main (future)	4,500	Land	B/C /*Class 1/2*	Landfill NENT - East Sha Chau /	Strategic Landfill / East Sha

Channel	Estimated Annual Dredged Volume (m^3)	Access	Contamination Status (TC-1-1-92/*FMC New Classification*)	Preferred Disposal Option	
				Short-Term	Long -Term
				open sea disposal	Chau/Open Sea Disposal
San Tin (present)	3,000-6,000	Land	A/B/*Class 1* C/*Class 2*	Local beneficial use/ open sea disposal NENT/WENT/ESC	Local beneficial Use/Open Sea disposal Strategic Landfill / East Sha Chau
San Tin East (future)	210	Land	A/*Class 1*	Local beneficial use	Local beneficial use
San Tin West (future)	210	Land	C/*Class 2*	Landfill NENT / WENT/ East Sha Chau	Strategic Landfill / East Sha Chau
Yuen Long (future)	2,200	Land	C	East Sha Chau / WENT	Strategic landfill /East Sha Chau
Kam Tin	2,900	Land	C/Class 2	East Sha Chau / WENT	Strategic landfill /East Sha Chau
Ngau Tam Mei	600	Land	C/Class 2	East Sha Chau / WENT	Strategic landfill /East Sha Chau
Wo Sang Wai	1,760	Land	C/Class 2	East Sha Chau / WENT	Strategic landfill /East Sha Chau
Tin Shui Wai:	3,100	Land	A/C/Class 1/2	Local Beneficial Use / ESC / WENT	Local Beneficial use/strategic landfill /East Sha Chau
Tuen Mun:	10,000	Marine / Land	C/*Class 2/3*	East Sha Chau / WENT	Strategic Landfill/East Sha Chau
So Kwun Wat	1,150	Land	A/B *Class 1*	Tuen Mun Area 38 Public Dump[1]/ Local Beneficial Use/Open sea disposal	Open sea disposal/ Local Beneficial Use
Tai Lam Chung	140	Land	A/B/*Class 1*	Tuen Mun Area 38 Public Dump[1]/ Local Beneficial Use/Open Sea disposal	Open Sea disposal/ Local Beneficial Use
Sham Tseng	Negligible	Land	C/*Class 2*	WENT Landfill / ESC	East Sha Chau/Landfill

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.

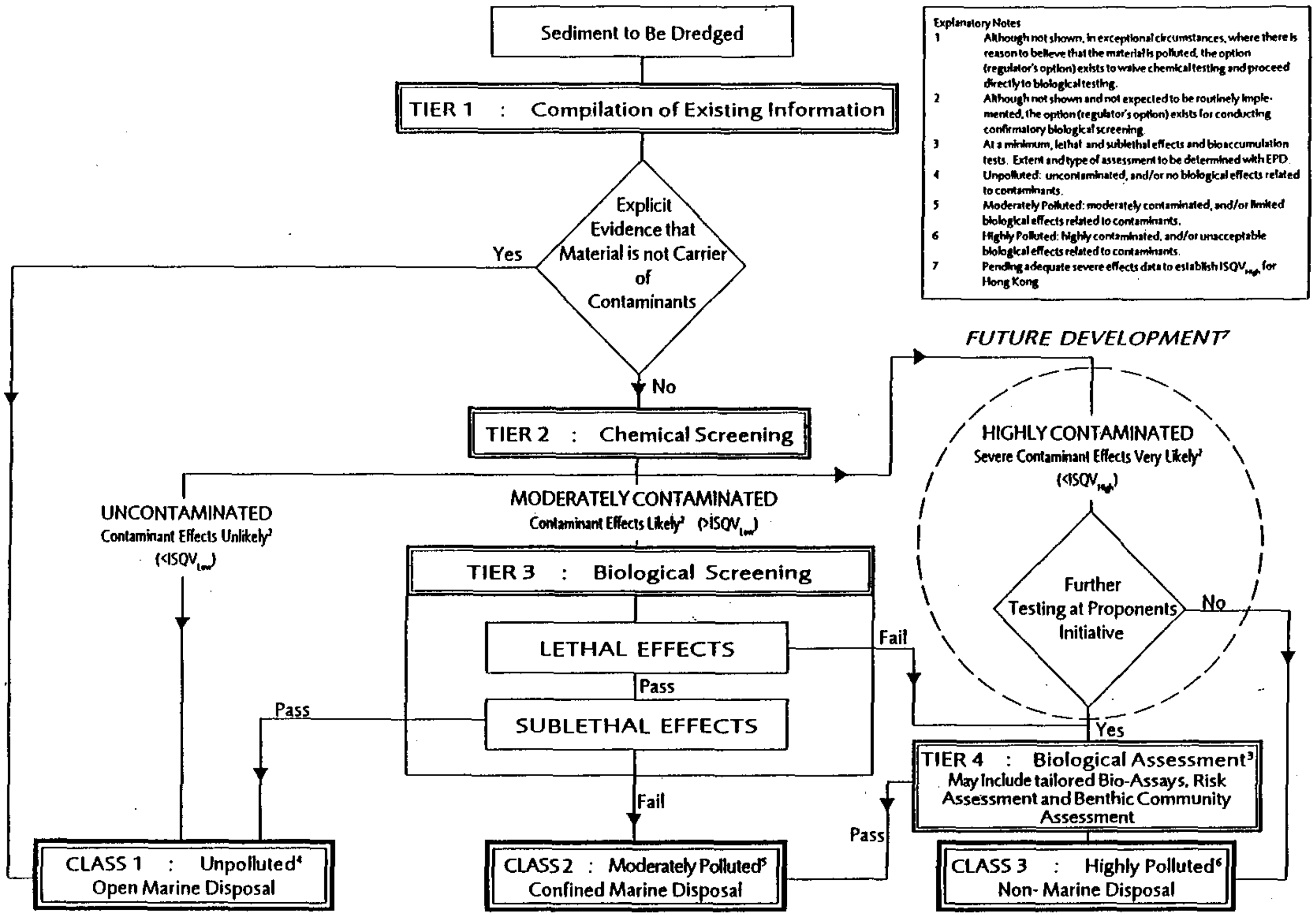
Note: Future Shoreline Enclosure - this study has not recommended enclosures as a long term option due to the small quantities arising. However, in the event that such a facility is commissioned to dispose of alternative waste streams (under other Government studies) it would become an appropriate long term disposal site.



Hyder Consulting

Figure 7.1 Existing System for Management of Dredged Material in Hong Kong

Source: EVS 1996



Hyder Consulting

Figure 7.2 Four Tier Sediment Testing System

Source: Modified From EVS 1996

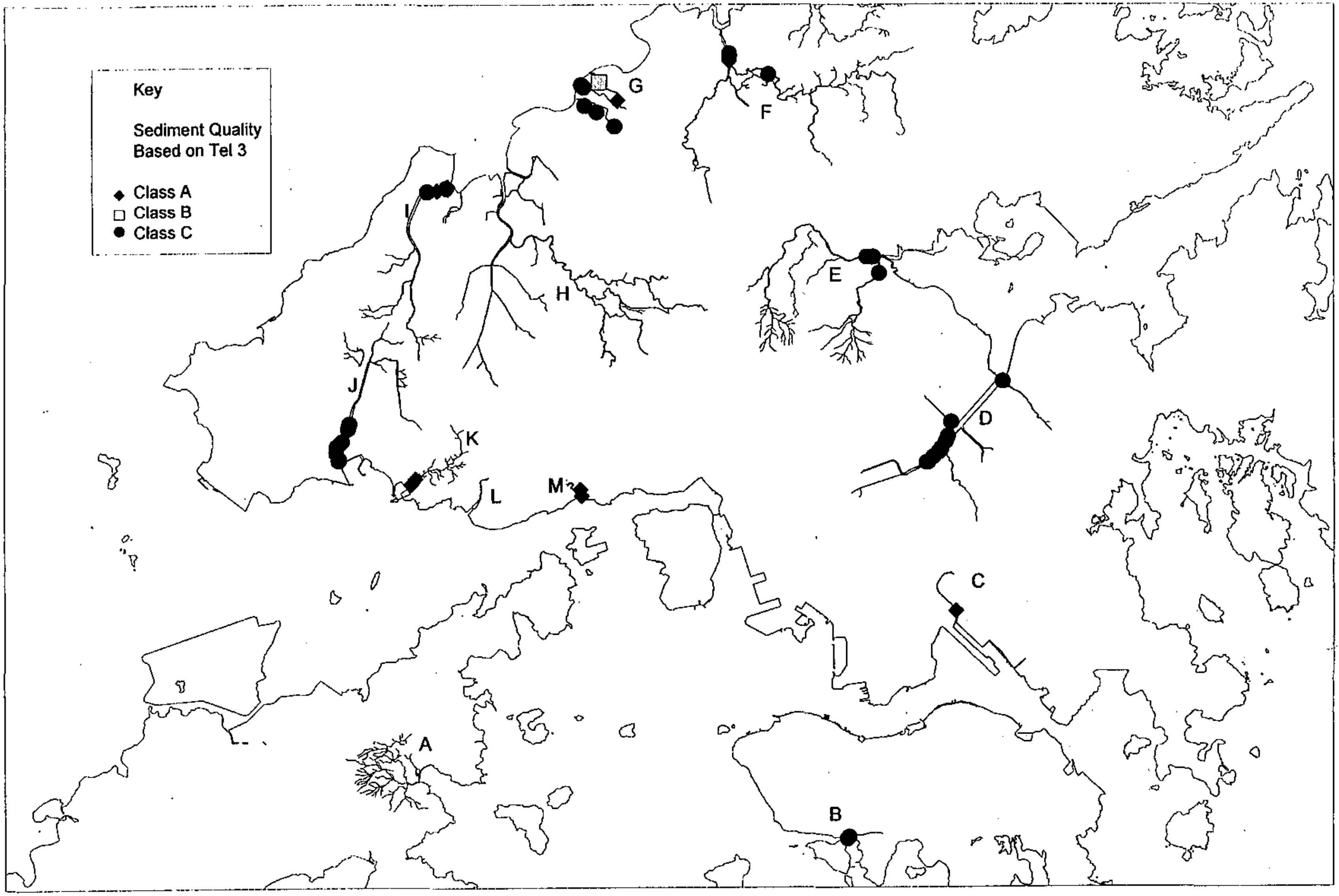
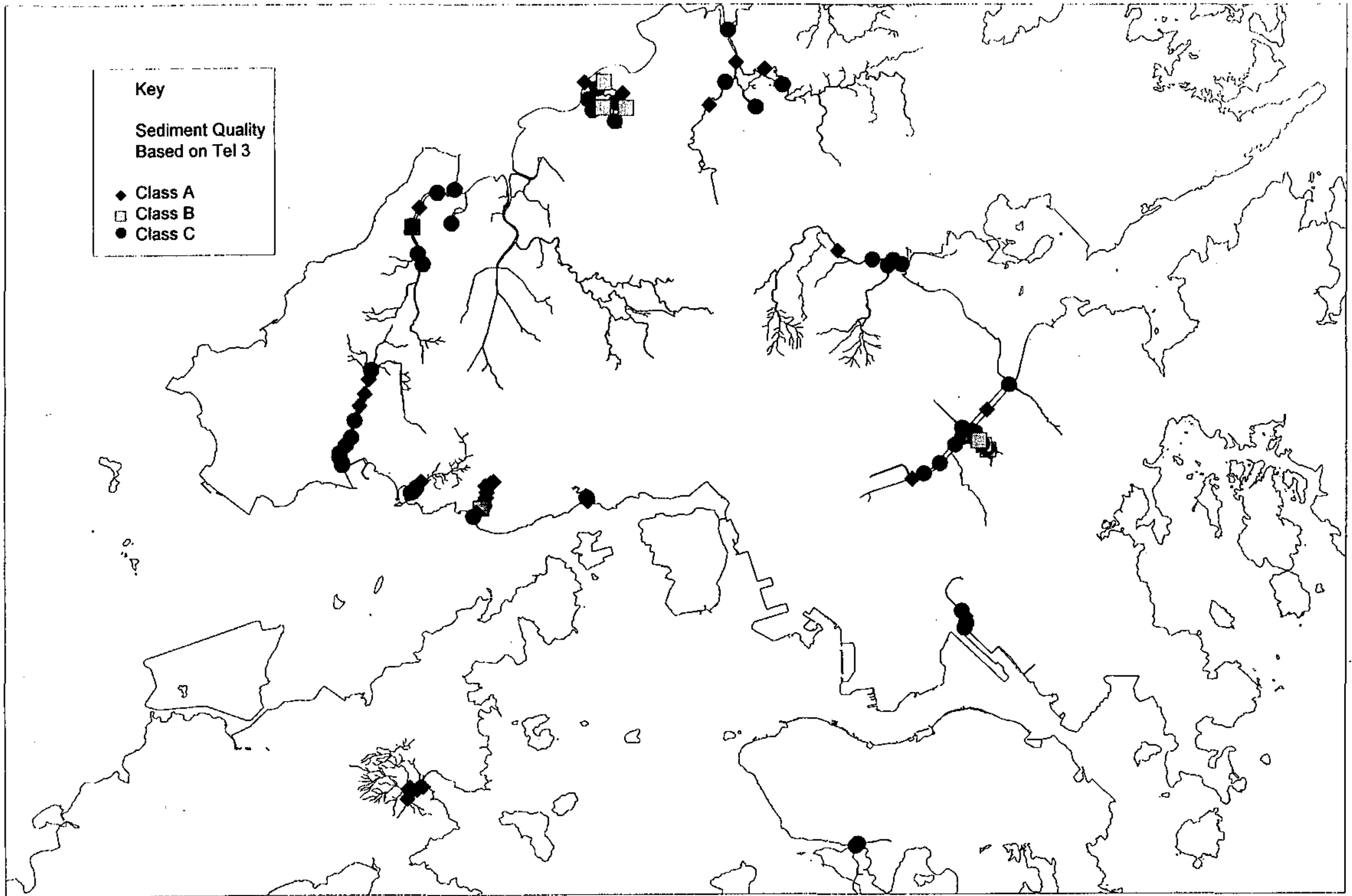
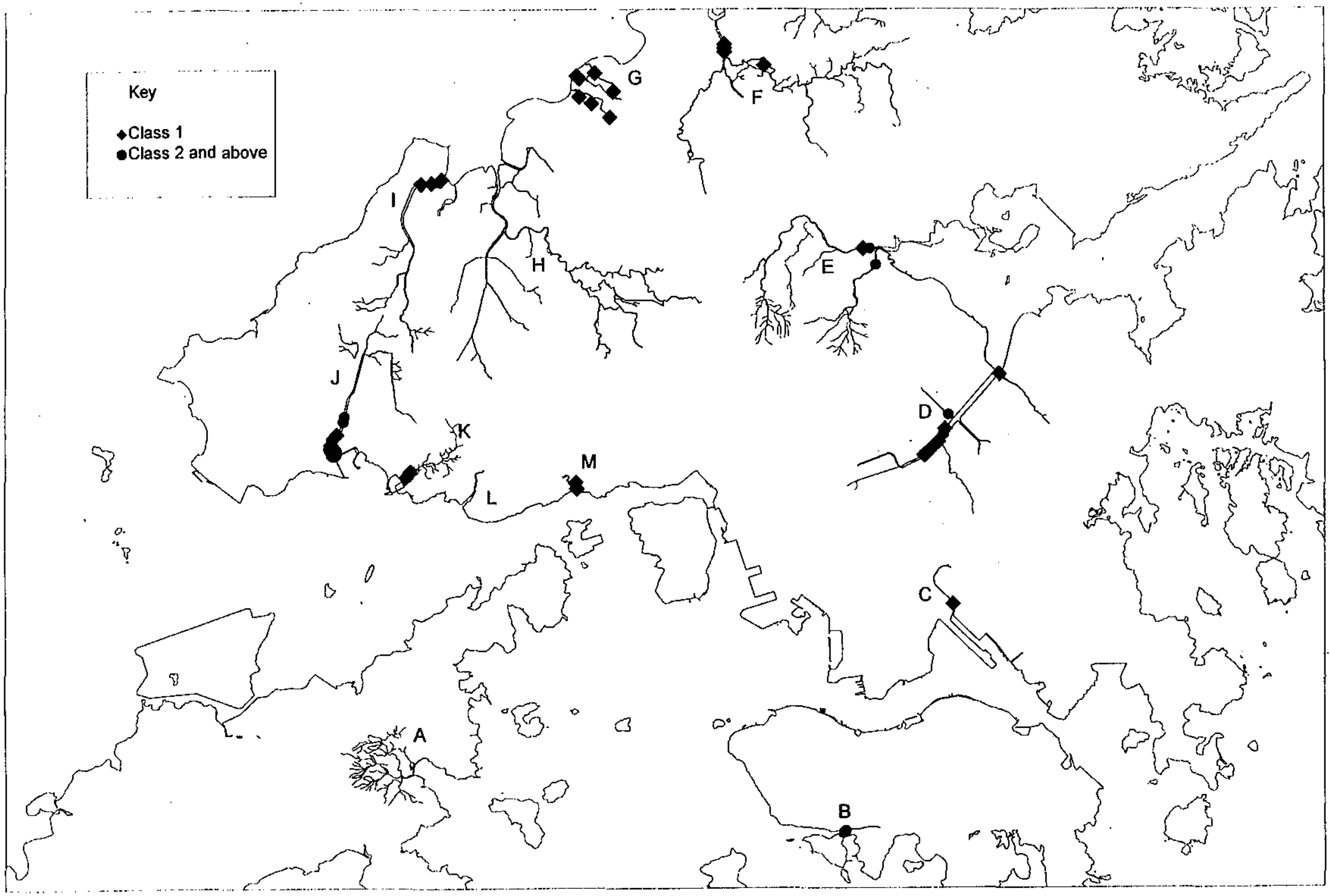


Figure 7.3 Sediment Quality based on Core Samples (Dry Season Survey)



Hyder Consulting

Figure 7.4 Sediment Quality based on Grab Samples (Wet Season Survey)



Hyder Consulting

Figure 7.5 New Classification of Sediment Core Samples (Dry Season Survey)

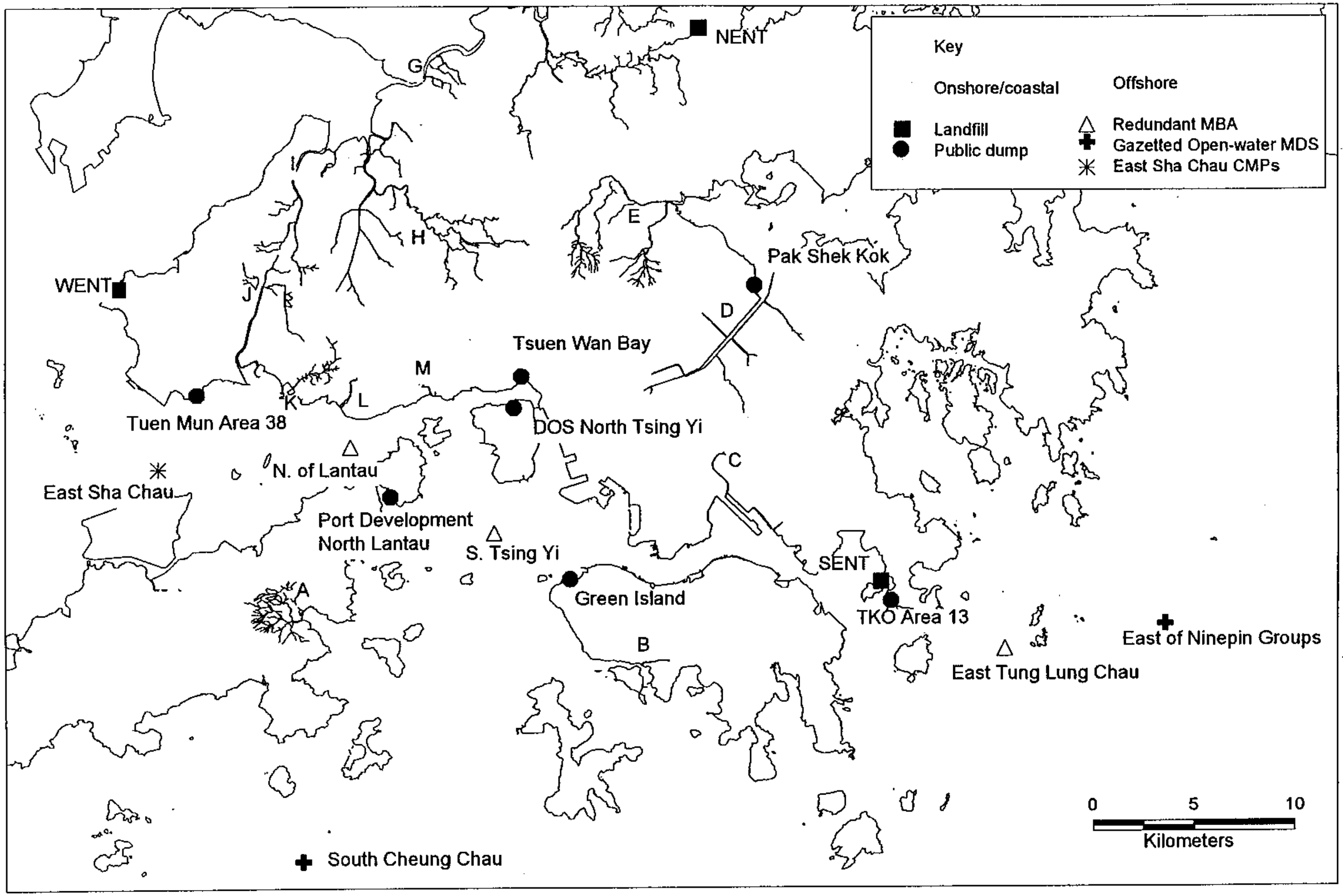


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Figure 7.6 Locations of Potential Disposal Sites for Dredged Sediment

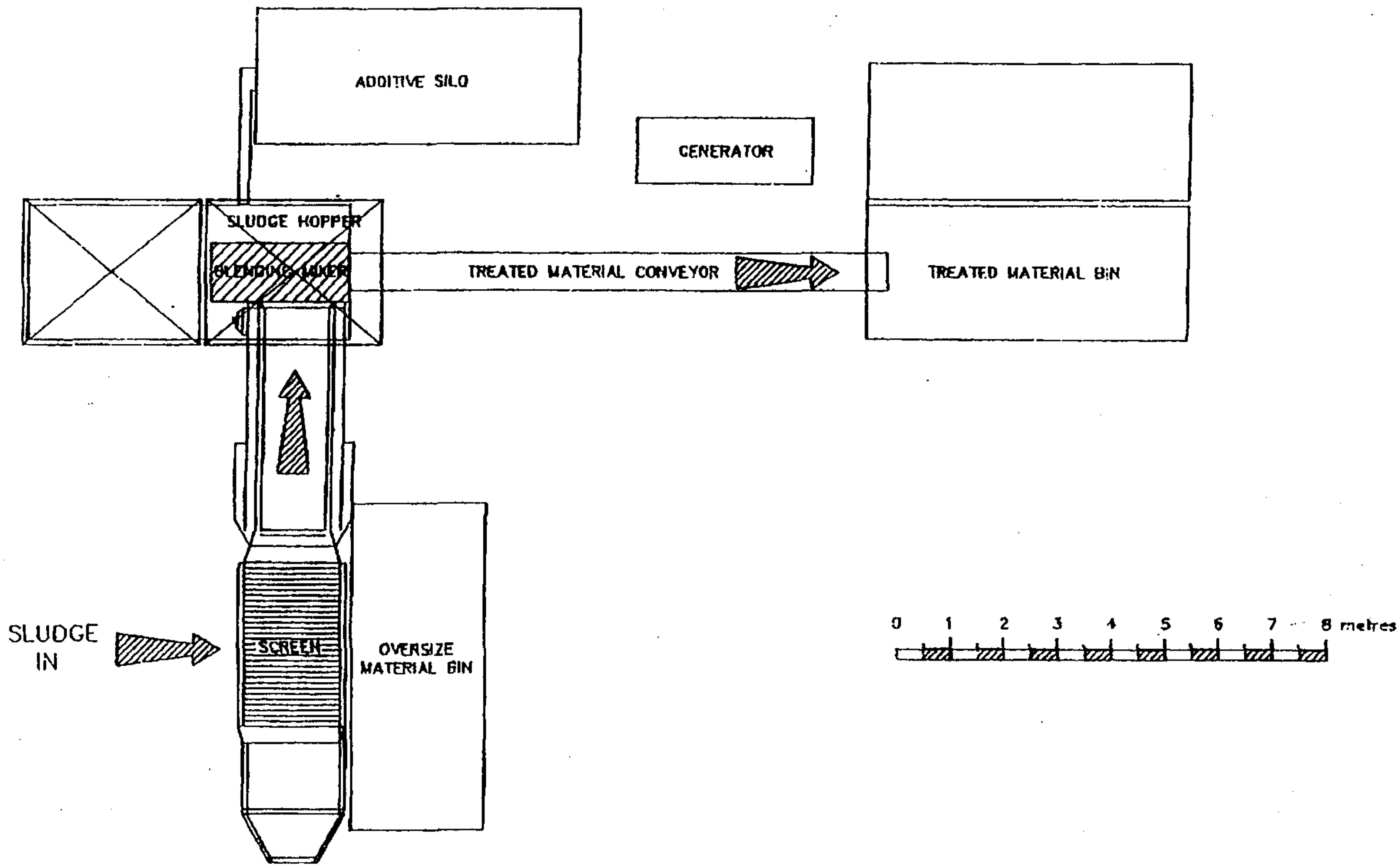

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Figure 7.7 Possible Schematic layout for line stabilisation plant

SECTION 8

ENVIRONMENTAL MONITORING AND AUDIT

8. ENVIRONMENTAL MONITORING AND AUDIT

8.1 Introduction

In order for the dredging strategy to be effectively applied the environmental monitoring and audit requirements must take the form of an integrated management approach. The necessity for this arises due to the diverse nature and duration of dredging works to be implemented and the possible need for emergency dredging to be conducted e.g. due to a blocked culvert as a result of increased channel bed level.

The proposed maintenance dredging works are strategic in nature and over time environmental conditions in the channels are likely to change. Environmental Monitoring and Audit (EM&A) provides the framework in which such changes can be monitored and mitigation measures amended as appropriate. It is important therefore to define a long term monitoring / management strategy as well as a monitoring programme to be operational whilst dredging is being conducted. Both of these programmes require agreed parameters to be set as constraints on either commencing a dredging programme or on continuing work. The dredging strategy relies on the ability to commence dredging with limited lead time and is based on a comprehensive long term monitoring programme to link into agreed sediment disposal routes for various classifications of sediment, as recommended by Task 5. It is necessary therefore that sediment be monitored on a continual basis and that this be linked to current water quality monitoring which may need to be supplemented to encompass the rivers or channels not currently under the EPD routine water quality monitoring.

An effective environmental monitoring programme for the Maintenance dredging work is essential to:

- Ensure that any environmental impacts resulting from maintenance dredging and sediment disposal are minimised or kept to acceptable levels;
- Establish procedures to ensure that mitigation measures have been implemented and are effective, and that the appropriate corrective action is undertaken if and when required;
- Provide a means to ensure compliance with environmental objectives, proper recording of anomalies, and documentation of corrective actions.

The full monitoring and audit programme is detailed in the EM&A manual which is a working document enforced contractually, a summary of the EM&A requirements is provided below.

8.2 Monitoring and Audit Schedules

8.2.1 Environmental Monitoring

<u>General</u>

(A) Long-Term Management / Monitoring Strategy

The long term management strategy proposed for these works would generally form the equivalent of baseline studies thereby allowing minimum lead time to commencement of dredging works. The exception to this scenario would be in the case where large volumes of mud are to be dredged and in this case, it would be important to have further classification of sediment quality prior to commencing a dredging exercise. This would therefore not apply to emergency dredging procedures.

Monitoring would provide background information on the sediment and water quality conditions so that prior to the commencement of a dredging exercise monitoring requirements would not be the limiting constraint on the ability to commence work.

Sediment monitoring will be dictated by the legislative requirements which apply to disposal arrangements. In the event that the EVS recommendations are endorsed the testing will be detailed and a significant cost.

(B) Compliance Monitoring

Compliance monitoring which should be carried out during dredging to achieve the following general objectives:

i) to assess the performance of construction/operation activities in environmental terms;
ii) to obtain early warning of potential problem areas, permit timely remedial action and identify any environmental impacts;
iii) to comply with appropriate standards and environmental objectives; and
iv) to respond to public complaints and provide reassurance to local communities.

Two quantitative levels would be set to monitor compliance with environmental objectives and to provide early warning of potential problem areas. This system of compliance monitoring will permit implementation of mitigation before the regulatory standards are reached. Action and limit levels will be based on relevant standards and guidelines and will be agreed with the EPD. The two levels are described below:

i) ***Action Level*** indicates that deterioration of environmental quality is significant and that urgent corrective action is required, increased frequency of monitoring may also be required;
ii) ***Limit Level*** is the maximum permissible level which will achieve compliance with the appropriate regulatory standards, or other standards such as construction noise criteria outside restricted hours, and is therefore the upper boundary/limit which is acceptable in terms of environmental quality. Consequently, exceedance of this level is undesirable. Daily monitoring, notifying EPD and a review of plant, equipment and work procedures are some actions that should be taken in the event of limit level exceedance. Compliance monitoring schedules are therefore devised such that remedial action is taken to prevent this level being attained. The Limit Level should not therefore, be considered as the desired level.

8.2.2 Environmental Auditing

General

The purpose of environmental auditing is to review the effectiveness of the overall environmental protection programme in terms of monitoring, mitigation and corrective action. The audit process should not be divorced from general management activities, and should promote a pro-active approach to environmental protection and Project management. The audit should be undertaken by an independent consultant and not the contractor to avoid conflicts of interest. However, the Contractor should be encouraged to provide inputs/comments/information to assist the Consultant in carrying out his duties. For minor maintenance works the Contractor may supervise works to ensure that contract conditions are met unless he chooses to delegate responsibility to an independent consultant.

The audit should seek to check:

- Records of monitoring procedures;
- Records of monitoring results;
- Records of exceedance of any regulatory requirements;
- Records of liaison with Contractors;
- Details of control and mitigation action taken in response to unacceptable impacts;
- Works progress and programme; and
- Effectiveness of overall environmental protection programme.

The auditing process should be undertaken on three levels:

- Routine site inspection (including an SI, deficiency and action reporting system);
- Compliance with legal and contractual requirements including review of works methods statements and pollution control measures; and
- Environmental complaints review, procedures and response.

8.3 Water Quality Monitoring and Audit

8.3.1 Introduction

The water quality monitoring proposed is based on a control station approach. Water quality monitoring and audit has been categorised in to three levels based on the scale of works, the size of channel and the sensitivity of the environment. For category A no monitoring is required. Categories B and C are defined as follows:

TABLE 8.1 WATER QUALITY MONITORING CATEGORISATION

Category	Stations	Baseline	Impact
B	One impact station upstream and one downstream of the works, to be used based on tidal flow. One Control Station. (location dependant on side channels, discharges etc. to be agreed with EPD)	Monitoring for at least two consecutive days in the week prior to dredging commencing. At mid-flood and mid-ebb and at mid-depth.	Monitoring three days per week with measurement at the designated monitoring stations. Increased frequency in the event of exceedances.
Parameters		In-situ measurements for Dissolved oxygen, turbidity, salinity, pH, temperature.	In-situ measurements for Dissolved oxygen, turbidity, salinity, pH, temperature.
C	Two impact stations downstream and one upstream of the works, to be used based on tidal flow. One Control Station (locations dependant on side channels, discharges etc. to be agreed with EPD)	Monitoring for 3 days per week for four weeks prior to commencement of the works. At mid-flood and mid-ebb and at mid-depth.	Monitoring three days per week with measurement at the designated monitoring stations. Increased frequency in the event of exceedances.
Parameters		In-situ measurements as defined above plus, sampling for: Ammoniacal Nitrogen Suspended Solids BOD_5 Sulphide Heavy metals (to be defined based on sediment results)	In-situ measurements as defined above plus, sampling for: Ammoniacal Nitrogen Suspended Solids BOD_5 Sulphide Heavy metals (to be defined based on sediment results)

NB: Monitoring of heavy metals initially once per week, then based on results.

Control station should be approximately 500m away and carefully located to reflect typical water quality conditions.

<u>Definition of Categories</u>

Category A: dredging events of <7000m^3 on the small channels and <10,000m^3 on the large channels do not require monitoring based on 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, (500m being the zone of influence of dredging on water quality as defined by the modelling results).

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. This amount is likely to apply only to the large channels.

Table 8.2 below provides the current categorisation table based on locations defined for the first maintenance works only. Future locations will be defined by the sediment bed monitoring programme and may change the monitoring category.

TABLE 8.2 WATER QUALITY MONITORING - CHANNEL CATEGORISATION

Channel	Dredging Event/Frequency	Approximate duration of works [1] (weeks)	Category of water quality monitoring required[2]	Comments
Recurrent Dredging				
Small Channels:				
River Silver	1,300 every 2 years	1.5	A	Unlikely to exceed 7,000m^3
Staunton Creek	5,000 every 15 years	5.0	A	Unlikely to exceed 7,000m^3
Kai Tak nullah	2,000 per year	2.0	A	Clearance in dry conditions, therefore no water monitoring required
Fo Tan	320 per year	0.5	A	Unlikely to exceed 7,000m^3
Siu Lek Yuen	7,000 per year	7.0	A/B	7,000m^3 or above requires category B monitoring
Tai Shui Hang	460 per year	0.5	A	Unlikely to exceed 7,000m^3
Beas future	6,000 every 6 years	6.0	A/B	With +20% margin of error, could be category B
Sutlej future	4,000 every 10 years	4.0	A	
San Tin (present)	4,500 per year	4.5	A	
Ngau Tam Mei	3,000 every 5 years	3.0	A	
Wo Sang Wai	17,600 every 10 years	18.0	B/C	Potentially within 500m of an SSSI or Ramsar site requiring category C
So Kwun Wat	4,650 every 4 years	4.5	A	
Tai Lam Chung	1,400 every 10 years	1.5	A	
Sham Tseng	no dredging defined		A	
Large Channels:				
Tai Po	4,050 every 3 years	4.0	B	Category B monitoring required for all dredging events due to existing low DO levels and fish population. Subject to consideration of dry

Channel	Dredging Event/Frequency	Approximate duration of works [1] (weeks)	Category of water quality monitoring required[2]	Comments
				season data.
Lam Tsuen	3,600 every 2 years	4.0	B	Category B monitoring required for all dredging events due to existing low DO levels and fish population. Subject to consideration of dry season data.
Shing Mun River (main)	20,000 per year	20.0	B	Equal to or above 30,000m^3 = category C
River Indus (present)	5,000 per year	5.0	A	
Indus future	8,100 every 3 years	8.5	A	
San Tin East (future)	2,100 every 10 years	2.0	A/B	Potentially within 500m of an SSSI or Ramsar site
San Tin West (future)	2,100 every 10 years	2.0	A/B	Potentially within 500m of an SSSI or Ramsar site
Yuen Long (future)	22,000 every 10 years	23.0	B	Above 30,000m^3 = category C
Kam Tin	14,500 every 5 years	15.0	B	
Tin Shui Wai	2,400 per year	2.5	A/B	Potentially within 500m of an SSSI or Ramsar site
Tuen Mun	10,000 per year	10.5	A/B	
Restoration Dredging[3]				
Shing Mun	147,980	6-7months[3]	C	Should also consider EPD on-going study recommendations when planning restoration works.
Tuen Mun	7,470	1-3 months	B	

Table Notes:

*1 **assumptions used in calculating the duration of the dredging works:***

i) Rate of dredging 20m^3 per hour removed for recurrent dredging as provided by Task 5.

ii) Only one dredger operational for an eight hour day, six day week, excluding Sundays.

*2 **assumptions used in defining category of water quality monitoring:***

i) Typically dredging events of <7000m^3 on the small channels and <10,000m^3 on the large channels do not require monitoring based on the small volumes and the short duration of the works.

ii) No water quality monitoring is required for dredging 7,000m^3 or less on the small channels = **category A.**

No water quality monitoring is required for dredging 10,000m^3 or less on the large channels = **category A.**

Unless within 500m of a water quality sensitive receiver or an SSSI/Ramsar site then **category B** would apply, (500m being the zone of influence of dredging on water quality as defined by the modelling results).

iii) Between 7,000 - 20,000m^3 **category B** monitoring is required for the small channels with contaminated sediments.

Between 10,000 - 30,000m^3 **category B** is required for the large channels with contaminated sediments.

If located within 500m of a designated Site of Special Scientific Interest SSSI, then Category C would apply.

iv) Above 20,000m^3 **category C** monitoring is required for contaminated sediments in the small channels, and above 30,000m^3 for the large channels, as a consequence of both the quantity and the duration of the works.

v). The above categorisation table is based on the locations defined and the predicted dredging requirements. The actual categorisation may change on determining the actual volumes, location and contamination status.

[3] ***assumptions made for restoration dredging:***

i) assume that the dredging rate will be higher due to larger grabs/ more than one dredger operating, duration is based on CED estimates.

As a minimum, the Designated Monitoring Stations shall include at least one control station and two impact monitoring stations one upstream and one downstream of the dredging site, with selection based on tidal flow. Selection of the station locations is a critical task and requires expert input to ensure proper interpretation of the results.

8.3.2 Water Quality Monitoring

Baseline / Long-Term Monitoring:

Baseline monitoring will ensure that the constraining limits proposed for dissolved oxygen are not exceeded and that work may commence. By using the results from the long term monitoring programme, the Action and Limit levels shall be formulated and submitted to DEP through the Contractor for approval prior to the commencement of the works.

Constraint Levels:

The constraining factor for commencement and continuation of work will be that minimum DO levels should be > 2 mg/l at mid-depth. Consideration will also be given to the long term monitoring data and in particular the dry season averages for dissolved oxygen. The objective is to define critical rather than typical conditions.

Action and Limit Levels:

The Action and Limit levels shall be formulated based on baseline (long-term) monitoring. The approach should be agreed with the Director of Environmental Protection. Suggested Action and Limit levels are presented in Table 8.3 below, based on extracts from the Civil Engineering Department (CED) dredging contract specification.

Action/event plan:

An Action / Event Contingency Plan is recommended as in Table 8.4 below. The Action/ Event Plan shall be followed in case of exceedance of Action and Limit levels.

Impact Monitoring:

The interval between two series of sampling/ measurement shall normally be less than 36 hours except where there are exceedances of Action and/ or Limit levels in which case the monitoring frequency will be increased.

Should the monitoring results of the water quality parameters at any Designated Monitoring Stations indicate that the Action and Limit levels are exceeded, immediate actions shall be taken in accordance with the Action/ Event Plan.

Sample analysis:

The Contractor should submit for approval the proposed analytical methods for the determination of heavy metals (Cd, Cr, Cu, Hg, Pb, Ni and Zn) if required. Reference can be made to "Methods for the Determination of Dissolved and Particulate Trace Metals (Ni, Cu, Zn, Cd and Pb) in Estuarine Waters" by Water Research Centre and "Standard Methods for Examination of Water and Wastewater" by APHA.

TABLE 8.3 ACTION AND LIMIT LEVELS FOR WATER QUALITY

Parameters	Action	Limit
DO in mg/l (Surface, Middle & Bottom)	Surface & Middle 1%-ile of baseline data for surface and middle layer, or midway between 5%-ile of baseline data and Limit levels Bottom 1%-ile of baseline data for bottom layer, or midway between 5%-ile of baseline data and Limit levels	Surface & Middle 4 mg/l except 5 mg/l for FCZ Bottom 2 mg/l
Turbidity (Tby) in NTU (depth-averaged)	95%-ile of baseline data and 120% of upstream control station's Tby at the same tide of the same day	99%-ile of baseline and 130% of upstream control station's Tby at the same tide of the same day

Notes:

- *"depth-averaged" is calculated by taking the arithmetic means of reading of all three depths.*
- *For DO, non-compliance of the water quality limits occurs when monitoring result if lower than the limits.*
- *For Tby, non-compliance of the water quality limits occurs when monitoring result if higher than the limits.*
- *All the figures given in the table are used for reference only and the EPD may amend the figures whenever it is considered as necessary.*

TABLE 8.4 EVENT AND ACTION PLAN FOR WATER QUALITY

Event	ET Leader	Contractor	Engineer (DSD)
Action level being exceeded by one sampling day	Repeat in-situ measurement to confirm findings; Identify source(s) of impact; Inform contractor and EPD; Check monitoring data, all plant, equipment and Contractor working methods; Discuss mitigation measures with Engineer and Contractor; Repeat measurement on next day of exceedance.	Inform the Engineer and confirm notification of the non-compliance in writing; Rectify unacceptable practice; Check all plant and equipment; consider changes of working methods; Propose mitigation measures to ER and discuss with ET and ER; Implement the agreed mitigation measures.	Discuss with ET and Contractor on the proposed mitigation measures; Make agreement on the mitigation measures to be implemented; Assess the effectiveness of the implemented mitigation measures.
Action level being exceeded by more than two consecutive sampling days	Repeat in-situ measurement to confirm findings; Identify source(s) of impact; Inform contractor and EPD; Check monitoring data, all plant, equipment and Contractor's working methods; Discuss mitigation measures with Engineer and Contractor; Ensure mitigation measures are implemented; Prepare to increase the monitoring frequency to daily; Repeat measurement on next day of exceedance.	Inform the Engineer and confirm notification of the non-compliance in writing; Rectify unacceptable practice; Check all plant and equipment; consider changes of working methods; Propose mitigation measures to ER within 3 working days and discuss with ET and ER; Implement the agreed mitigation measures.	Discuss with ET and Contractor on the proposed mitigation measures; Make agreement on the mitigation measures to be implemented; Assess the effectiveness of the implemented mitigation measures.
Limit level being exceeded by one sampling day	Repeat in-situ measurement to confirm findings; Identify source(s) of impact; Inform Contractor/Engineer and EPD; Check monitoring data, all plant, equipment and Contractor's working methods; Discuss mitigation measures with Engineer, Contractor & EPD; Ensure mitigation measures are implemented; Increase the monitoring frequency to daily until no exceedance of Limit level.	Inform the Engineer and confirm notification of the non-compliance in writing; Rectify unacceptable practice; Check all plant and equipment; consider changes of working methods; Propose mitigation measures to ER within 3 working days and discuss with ET and ER; Implement the agreed mitigation measures.	Discuss with ET and Contractor on the proposed mitigation measures; Request Contractor to critically review the working methods; Make agreement on the mitigation measures to be implemented; Assess the effectiveness of the implemented mitigation measures.
Limit level being exceeded by more than two consecutive sampling days	repeat in-situ measurement to confirm findings; Identify source(s) impact; Inform contractor and EPD; Check monitoring data, all plant, equipment and Contractor's working methods; Discuss mitigation measures with Engineer and Contractor; Ensure mitigation measures are implemented; Increase monitoring frequency to daily until no exceedance of Limit level for two consecutive days.	Inform the Engineer and confirm notification of the non-compliance in writing; Rectify unacceptable practice; Check all plant and equipment; consider changes of working methods; Propose mitigation measures to Engineer Implement the agreed mitigation measures; As directed by the Engineer, to slow down or to stop all or part of the works.	Discuss with Contractor/ET on the proposed mitigation measures and request Contractor to critically review the working methods; Agree the mitigation measures to be implemented; Assess effectiveness of the implemented mitigation measures; Consider and instruct, if necessary, the contractor to slow down or to stop all or part of the work until no exceedance of Limit level.

8.3.3 Water Quality General Standard Specifications

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 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.

8.4 Sediment Monitoring

The Task 5 Report highlighted the need to minimise the volume of sediment removed under the recurrent dredging programme. To facilitate this a monitoring strategy was recommended including:

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

ii) sampling and testing of sediments to establish particles size and particle size distributions; and

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

The frequency and location of sediment quality testing will be largely directed by the bed level surveys to be recommended by Task 5. The sediment monitoring programme and contractual requirements will be detailed under the Dredging Manuals produced as a result of Task 5. The parameters monitored will depend on the legislative requirements in force, existing metal sampling is detailed in Technical Circular 1-1-92. In the event that the EVS proposals are endorsed the following categories of parameters will need to be monitored, as identified in the EVS draft report, (Classification of Dredged Material for Marine Disposal, EVS, October 1996):

- Metals;
- Other Inorganics;
- PAHs;

- Monocyclic aromatic hydrocarbons/Chlorinated hydrocarbons, including volatile organic compounds (VOCs), chlorinated benzenes, PCBs, Chlorinated dioxin/furans (PCDDs and PCDFs);
- Phenolic compounds;
- Pesticides
- Organometallic and miscellaneous organic compounds, including TBT and phthalates esters;
- Nutrients and general parameters.

The full list of parameters is attached as Appendix A11 and is sourced from the EVS draft report. The monitoring data should be stored on an environmental database and then can be used to provide up to date information on sediment quality and quantity. Such a database incorporating Territory wide data is likely to be a product of the Sustainable Development Study soon to be commissioned by the EPD.

When/if the EVS guidelines are implemented it will be necessary to undertake ecotoxicological testing to determine suitability of sediment for marine disposal. Such a testing scheme would depend on recommended methods and should be undertaken well in advance of each dredging event so that the contractor can arrange for suitable disposal. The costs associated with the analyses are initially expected to be high. However, it is likely that testing can be significantly reduced in the future for many of the channels as knowledge of the catchments and channels develops.

8.5 Noise Monitoring and Audit

8.5.1 Introduction

As a general rule noise monitoring is not considered necessary for small scale maintenance dredging operations. However, if the contractor wishes to work in restricted hours a baseline survey will be necessary as well as the Construction Noise Permit (CNP), application. In the more typical cases of maintenance dredging Task 6 has recommended clauses to be incorporated into a general specification, the enforcement of which will maintain noise at acceptable levels.

In the event that complaints are made relating to noise generated by the dredging works, the Contractor/Engineer shall employ suitably qualified personnel to undertake performance monitoring. This shall continue until such time that the source of complaint has been identified and mitigated to the satisfaction of the EPD or indeed until the complaint is found to be unsubstantiated.

In addition, noise monitoring is required for extreme events defined as: dredging works taking place within 50m of a sensitive receiver for a continuous period of two weeks. This will not be a typical case due to the movement of the dredger along the channel.

8.5.2 Noise Monitoring

Baseline

a) The baseline monitoring should be carried out prior to the commissioning of the construction work for a period of at least 2 weeks, with measurement to be taken on a daily basis.

b) There should not be any construction activities in the vicinity of the stations during the baseline monitoring.

c) Reference could be made to a set of baseline monitoring data which should have been available in the EIA study at one or more of the most representative location(s), for the concerned project.

d) In case no monitoring data or reliable results are available, the EPD using its knowledge of the ambient noise condition in the project area have the right to assign a new set of data to be used as the baseline reference condition.

(i) Impact monitoring

For impact monitoring, the measurement frequency at least once per week should be strictly observed at all monitoring stations.

(ii) Compliance monitoring

In case of non-compliance with the recommended noise level, more frequent noise monitoring as specified in the Event and Action Plan should be carried out. This additional monitoring should be continued until the recorded noise levels are rectified.

8.5.3 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) suitably 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 indeed 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.

TABLE 8.5 NOISE EVENT CONTINGENCY PLAN

	Action	Limit
0700-1900 hrs on normal weekdays	When one documented complaint is received	75* dB(A) 60dB(A) in Buffer Zone 1
0700-2300 hrs on holidays; and 1900-2300 hrs on all other days	When one documented complaint is received	60/65/70** dB(A)
2300-0700 hrs of next day	When one documented complaint is received	45/50/55** dB(A)

* *reduce to 70 dB(A) for schools and 65 dB(A) during school examination periods.*

** *to be selected based on Area Sensitivity Rating.*

Noise Action and Limit levels whn monitoring is required are indicated in Table 8.5 above, the Limit value changes according to the timing of the works and the area sensitivity rating.

8.6 Air Quality Monitoring and Audit

8.6.1 Introduction

As mentioned previously no physical monitoring of odour and dust is recommended for maintenance dredging works. However, a series of contractual clauses are recommended to encourage and enforce "good practice" and prevent unacceptable air quality impacts. As with noise, if complaints are received relating to air quality, the Contractor will be required to undertake actions, as detailed in the EM&A manual. For the Shing Mun restoration dredging, relevant findings of the EPD Shing Mun River Improvement Study, if available, should be also be taken into account when planning the works.

8.6.2 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. The Contractor shall use water sparingly to avoid generating significant effluent / waste water.

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 indeed until the complaint is found to be unsubstantiated.

8.7 Ecological Preventative Measures

8.7.1 Introduction

Ecological preventative measures to minimise impacts will be very site specific and have generally been incorporated into the water and noise monitoring clauses to ensure good dredging practice and implementation of recommended mitigation measures to limit damage to ecological resources. Other contractual clauses are recommended below.

8.7.2 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 remediation 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.

8.8 Waste Management

The Contractor is responsible for waste control within the works area, removal of waste material produced from site and to implement any mitigation measures to minimise waste and to redress problems arising from waste management.

The waste material will include any sewage, wastewater or effluent containing sand, cement, silt or any other suspended or dissolved material to flow from the site onto adjoining land, storm sewer, sanitary sewer or any waste matter or refuse to be deposited anywhere within the site or onto any adjoining land.

The majority of waste from these dredging works will be dredged sediment and procedures for disposal will be clearly defined according to location and level of contamination. These have been discussed under the disposal strategy for each channel. It is recommended that records of removal, storage and disposal of sediment be submitted by the Contractor.

The Contractor shall comply with all current legislation and regulations including the Waste Disposal Ordinance, the Dumping at Sea Ordinance, the Public Health and Municipal Services Ordinance and the Water Pollution Control Ordinance, and carry out appropriate Waste Management work. The Contractor is responsible for obtaining the relevant licence/permit such as effluent discharge licence, the chemical waste registration or other permits as necessary.

SECTION 9

CONCLUSIONS AND RECOMMENDATIONS

9. CONCLUSIONS AND RECOMMENDATIONS

9.1 Introduction

The Sedimentation Study has defined a practical and environmentally sensitive approach to maintenance dredging. Importantly, the EIA was undertaken concurrently with the development of the dredging strategy in an iterative design process. The strategy therefore recognises potential environmental concerns and sensitive receivers and has applied mitigation through design. Emphasis has been placed on minimising dredging works as far as considered practical.

The annual quantities of sediment predicted to be dredged are approximately 60,000 m^3 and consequently the potential environmental impacts are also relatively minor with the exception of the Shing Mun restoration dredging. The amount of dredging will be controlled by a routine bed level monitoring programme. Dredging will only be initiated when the bed levels exceed defined flood trigger levels and where there is a feasible depth of sediment to facilitate dredging, (0.5m). This is likely to be on relatively small stretches of the channels, for example, on river bends and confluences, and the dredging period will typically be four to six weeks.

However, much of the sediment is contaminated and therefore requires careful removal, handling and disposal to avoid contamination of the environment. Dredging manuals will be prepared defining an approach based on best practise, the enforcement of which will be detailed in contractual clauses.

The EIA has evaluated the potential impacts of the proposed dredging strategy including access, transport, dredging methods and disposal options for each channel and assessed the significance of identified impacts. Dredging events have been defined in terms of recurrent and restoration dredging, providing both volumes of material and frequency of removal. In addition, the most appropriate dredging plant, equipment and working methods have been defined. Together this information has formed the basis for the environmental impact assessment.

To support the assessment process field surveys have been undertaken to gather baseline noise, air quality, ecological, water quality and sediment quality data. International dredging practice has been reviewed under Task 5 and sediment criteria under Task 6 with the aim of identifying best practice applicable to local conditions. The potential environmental impacts have been assessed and mitigation recommended.

The overall dredging requirement is determined in Task 4 to be equivalent to the coarse sediment input from natural catchment erosion and construction sites plus a volume required to maintain free flows in culverts and pipes discharging into the channels. Once the coarse sediment has entered the channel it will mix with the finer marine sediment increasing the volumes of material to be removed and complicating the disposal due to both contamination and physical handling requirements. Improved controls on construction site drainage, the use of properly designed and maintained sediment traps should enable much of this material to be collected before it enters the tidal reaches of the channel. This should reduce future dredging requirements.

Numerical modelling techniques have been used to provide a quantitative measure of the likely effects of the projected works. Due to the nature of the channels and the availability of information water quality modelling was restricted to the three main channels; Shing Mun, Tai Po/Lam Tsuen and Tuen Mun which together represent approximately 60% of the total anticipated dredging. A worst case scenario has been assumed when modelling the Shing Mun River Restoration dredging and is based on two dredgers operating simultaneously with an overall dredging rate of approximately $40m^3/hr$.

The environmental mitigation has been presented in the form of standard specifications applicable to all channels subject to maintenance dredging. These clauses will be included in the dredging manuals and are therefore enforceable contractually. Furthermore it has been recommended that the Engineer/Contractor works within the constraints of the assessment criteria, i.e. no greater than a $40m^3$ /hr production rate for dredging assuming two dredgers working simultaneously. With time however, monitoring results may indicate that this production rate may be increased marginally without causing an environmental impact. Environmental monitoring and audit has therefore been recommended as it will play a key role in both ensuring that environmental controls are implemented and in determining future criteria.

Potential Impacts and Mitigation

The main potential impact relates to a short term impact on water quality due to increased suspended solid levels and potential releases of metals, ammonia and reductions in dissolved oxygen. The water quality 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 DO depletion, appropriate mitigation and a monitoring programme have been defined with a focus on this issue. The mitigation is aimed at fostering 'good practice' and will be enforceable contractually as detailed in section 8.3.

Noise impacts have been assessed and in the majority of cases can be mitigated readily. However, for So Kwun Wat and Tai Lam Chung the works are expected at times to be very close to residential areas and therefore noise barriers would be needed to keep noise levels within the 75dB(A) day time guideline. Despite this the EIA recommends that barriers are not used, since their installation and very presence will have a greater impact on local residents than a short period of noise disturbance. No monitoring and audit is recommended for either noise or dust, with the exception of noise monitoring for dredging events for a two week period or more within 50m of a noise sensitive receiver. However, this will not be the typical case and will only be required in rare cases where sediment has accumulated in a confined area adjacent to, for example, a school building.

Residual air quality impacts are limited to short term odour impacts on recreational activities on or beside the Shing Mun River during 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 and thus minimise these impacts.

The key potential ecological impacts relate to habitat loss and disturbance to bird populations. For dredging works in sensitive ecological areas particular mitigation has been recommended to minimise bird disturbance during breeding and nesting periods. Standard specifications address the issue of potential habitat loss and are aimed at protecting all forms of bankside vegetation whether they alone have a specific ecological value or not.

Environmental Monitoring and Audit

The study has recommended that existing arrangements for routine monitoring of both sediment and water quality be extended to provide valuable baseline data for the maintenance dredging programme. This recommendation is supported by Task 6 as an improvement to the environmental baseline data for the main tidal channels within the Territory, facilitating environmental management of dredging projects.

The main monitoring recommended by Task 6 is for water quality. Three categories have been defined as follows:

- Category A where no monitoring is required;
- Category B which has a limited programme based on in-situ measurement only; and
- Category C with a comprehensive programme involving both sampling and in-situ measurement.

The objective of the categorisation system is to provide appropriate monitoring for a range of dredging scenarios in channels that vary in size and environmental sensitivity.

Sediment Disposal

Practical and environmentally acceptable disposal routes have been defined for both the current legislation and in the event that new guidelines be adopted based on proposals drafted by EVS Consultants. Under the existing system East Sha Chau continues to be the dominant route for disposing of contaminated material, Class C. The EIA recommends that the Pak Shek Kok public dump site be considered for Class B material from the Shing Mun and Tai Po Lam Tsuen channels subject to further study and open sea disposal remains an alternative for class B material. In the future if marine disposal is ruled out for highly contaminated material, strategic landfill is the recommended disposal option for the proposed Class 3 material. To facilitate this, a requirement for lime stabilisation has been identified in order to comply with the landfill acceptance criteria for <70% water content and particularly the absence of free draining water.

9.2 Summary of Channel Specific Conclusions and Recommendations

The channel specific project conclusions and recommendations are summarised as follows:

A: RIVER SILVER

The sediments to be removed from the channel are clean and are therefore recommended to be put to beneficial use rather than disposed of to the marine environment. Such uses will be local and determined by the contractor and may include small reclamation projects or habitat creation. The key recommendations are to minimise vegetation losses and to dredge outside of the bathing season which runs from May to October, overlapping slightly with the dry season when works will be undertaken.

B: STAUNTON CREEK

Identified impacts in the channel were largely concerned with control of odour when dredging the contaminated sediments. In the upstream areas the sediments will be removed manually and this should be carried out in dry conditions and material should be kept covered and taken off site as soon as possible. Concrete areas should not be sprayed down at the end of the works as this only disperses contaminants and sediment, generates odour and eventually allows a proportion of the sediment to re-accumulate. Focus in the future should be on control of expedient connections and illegal discharges so that the pollution problem is solved at source.

C: KAI TAK NULLAH

In line with previous years, sediment which needs to be removed is predominantly construction derived and will be removed manually by DSD in areas upstream of Kai Tak International Airport. Provided that this practice continues (as supported by Task 4 and 5 recommendations), the works do not impose an unacceptable environmental impact. However, in the future, focus should be placed on monitoring and controlling these construction materials at source to prevent their deposition in the channel in order to minimise flood risk and disposal problems.

D: SHING MUN RIVER

The proposed works in the Shing Mun River represent the most significant dredging requirements identified by the Study.

There exists a requirement to maintain the side culverts and nullahs to restore flow areas to trigger levels and clear them of sediment and debris; such works will be a one off dredging event (restoration dredging) consisting of the removal of 148,000m^3 of sediment. This dredging requirement is likely to impact upon recreational activities both in and around the channel through release of hydrogen sulphide which could generate odour. In addition, water quality impacts may arise through possible releases of ammoniacal nitrogen and suspended solids. Standard specifications to improve dredging practice should help to minimise impacts but comprehensive water quality monitoring and careful timing of the works are also recommended. Material will be contaminated and disposal is recommended to East Sha Chau due to the quantities involved.

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 the Shing Mun River.

In the event that recurrent dredging in the main channel is required, the EIA recommends that class B sediment is disposed of to Pak Shek Kok Public Dump, subject to further study of water quality impacts. If this proves to be unacceptable to Government, then open water disposal is the preferred option. For class C material, East Sha Chau is the preferred disposal option. In the future, material may be unsuitable for marine disposal and material will be sent to landfill following lime stabilisation. Dredging events will be timed to occur outside of the dragon boat season (April-June) and will avoid rowing activities so as to minimise disruption and odour impacts. Complaints procedures will ensure local concerns are addressed as and when they arise.

TAI SHUI HANG NULLAH

This is a tributary of the Shing Mun River which predominantly contains uncontaminated sediments and as a result, provided standard specifications are followed, impacts will be limited. Clean material (Class A) should be used for local beneficial use and Class B material disposed of to either Pak Shek Kok subject to further study or alternatively to open water disposal. Contaminated material will be disposed of to East Sha Chau. Liaison with schools to avoid examination periods will ensure that daytime noise guidelines are not exceeded.

SIU LEK YUEN

Sediment accumulation is predicted in two locations, one upstream and one close to the confluence with the main Shing Mun Channel. In future it is recommended that works should focus on identifying and controlling the source of sediment input in the upstream areas for which only a small proportion is predicted to be derived from natural erosion.

FO TAN

Catchment derived sediments mix with contaminated effluents and generally deposit in the downstream areas near the confluence with the Shing Mun River. It is likely that some of the sediment will be heavily contaminated and disposal to landfill is recommended for these small volumes. Again, it is necessary to avoid dredging during school examination periods to prevent noise exceedance.

The EIA has identified a high level of contamination which is inconsistent with the identified pollutant sources (EPD local control office), Task 6 therefore recommends further work to investigate potential pollutant sources. These might include for example, open food stall areas and paint factories etc. with illegal connections or discharges.

E: **TAI PO / LAM TSUEN**

The channel is a recovering system with low dissolved oxygen levels and a relatively large fish population. Therefore a cautious approach is recommended with detailed Category C water quality monitoring described in section 8.3, until such time that the channel recovers from historical and present pollutant loading, (as demonstrated by improved dissolved oxygen levels). Dredging works will be undertaken following liaison with the head teacher of the school in the vicinity of the works to ensure dredging is undertaken outside of examination periods thus minimising noise impacts.

F: **RIVER INDUS**

Indus Present

The River Indus is located on low ground in the NW New Territories and dredging offers little benefit in terms of reducing flood risk during extreme events. There is potential for damage to bankside vegetation which is mitigated through the incorporation of standard specifications into contractual clauses.

Indus Future

Potential currently exists for the deposition of contaminated sediment entering the Indus from the Shenzhen River, and this is expected to continue for the foreseeable future. The design of the future channel should therefore give due consideration to this scenario to prevent accumulation of contaminated sediments and should also consider methods to minimise upstream sediment accumulation.

G: **SAN TIN PRESENT**

There is potential for short stretches of dredging on this channel when sediment accumulates above the flood trigger levels. The key concern is ecological impacts given the proximity of the channels to Mai Po Nature Reserve. Only a small portion of the channel lies within Buffer Zone 1 and dredging will be restricted to between 0800-1700 hrs to minimise disturbance to roosting birds. The environmental mitigation also focuses on minimising habitat loss and water quality deterioration. Security grills located at the border fence and confluence with the Shenzhen River represent a significant hydraulic obstruction, particularly if entangled in water hyacinth. Regular maintenance is recommended to avoid blockages at these locations.

SAN TIN FUTURE

Regular bed level monitoring and maintenance of sediment traps will be necessary as part of an on-going management programme. The proposed dredging will be outside of Buffer Zone 1 and therefore ecological disturbance will be less in the future.

H: **YUEN LONG**

This channel and its tributaries have recently been the subject of a large scale training programme for flood control. Regular bed level monitoring and maintenance of sediment traps will be necessary as part of an on-going management programme. The dredging of key concern will be that proposed for Wo Sang Wai due to its proximity to the Ramsar Site. Mitigation is recommended to minimise potential noise and water quality impacts on local ecological resources. This will be in the form of water quality monitoring described in section 8.3 and noise controls for Deep Bay described in section 8.5 which will restrict periods of disturbance.

I: TIN SHUI WAI

Tin Shui Wai Eastern and Western Channel is the third of the study channels for which dredging impacts on the ecology of the Ramsar site at Deep Bay are a key concern. The Contractor will be required to plan works with due regard to flora and fauna, minimising habitat disturbance or loss. Currently, most of the dredging required is relatively remote from Deep Bay and ecological impacts are considered unlikely. In the future, the level of water quality monitoring necessary will depend on the dredging location and hence proximity to the Mai Po Ramsar site. If works are within 500m of the Ramsar site, then comprehensive water quality monitoring will be required and for works at the moth of the channel, within the Deep Bay Special Measures Zone, noise disturbance will be controlled to avoid dusk and dawn when birds will be roosting. It is recommended that land access to the dredge locations is used as opposed to marine access which would cause greater disturbance to wetland birds.

J: TUEN MUN

There is a requirement for both restoration and recurrent dredging at Tuen Mun. The necessary dredging will be via marine access and therefore the most acceptable disposal option would be by barge to East Sha Chau or the WENT landfill. A key concern identified was the potential for impacts on the improving water quality. Good dredging practice such as use of sealed grabs has been recommended to minimise impacts on water quality. Works should avoid school examination periods to prevent exceedance of guideline noise levels.

K: SO KWUN WAT

Task 6 recommends the removal of large obstructions observed in the channel north of the Castle Peak Road bridge. These materials include construction debris, bicycles etc. If dredging is found to be necessary there is potential for damage to bankside vegetation which is mitigated through the implementation of standard specifications.

Noise impact has been identified as the key concern in this channel due to the proximity of the noise sensitive receivers. Practical mitigation measures have been explored and exceedances cannot be brought down to within recommended guideline levels. Noise calculations have indicated that a noise barrier would be required for a very short duration whilst the dredger passes the noise sensitive buildings. However, it is predicted that the barrier would have a greater impact in terms of visual, nuisance, noise from installation and removal etc. and its use is therefore not recommended. Institutions affected will be consulted prior to works to explain the reason for the works, likely short term impacts and outline the benefits in terms of improved water quality and reduced flood risk to affected villagers.

L: TAI LAM CHUNG

In the event that dredging is required the key environmental issues will be the potential for noise impact and for damage to bankside vegetation. However, the works would be of very short duration and impacts have been addressed through adoption of the standard specifications for water quality, noise and air impacts etc. As with So Kwun Wat, the relative impact of noise barrier erection and intrusion is considered greater than the short duration of daytime noise impact and liaison with relevant institutions prior to commencement of works is recommended.

M: SHAM TSENG NULLAH

No dredging works are recommended for Sham Tseng. However, the channel is subject to significant pollutant loading which contributes to sedimentation as well as odour and water quality deterioration. In conjunction with the sediment monitoring programme Task 6 recommends monitoring of the pollutants at source and enforcement to minimise future contamination of sediments.

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REFERENCES:

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APPENDICES

APPENDIX A1

WATER QUALITY BASELINE MONITORING RESULTS

Appendix A1 Baseline Water Quality Monitoring Results
Tide Cycle Monitoring

Location	DATE	Time	Weather	Depth	Current	Tide	Temp.(oC)	Salinity	Cond.	DO	% D.O.	SS	BOD 5	NH 4	TON	Total Cu	Dissolved Cu	Ni	Zn	Pb	Cd	Cr	Hg	WQI
				(cm)	(m/s)			(ppt)	(ms)	(mg/l)		(mg/l)	(mg/l)	(mgN/l)	(mgN/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(ug/l)	
RIVER SILVER																								
A7	4/15/96	05:05	Fine	1	0.04	Flood	19.6	29.4	41.25	5.62	60.9	19	1.5	0.1	0.03	-	0.05	-	-	-	-	-	-	4.4
A7		08:01	Fine	1.2	0.046	Flood	19.5	31.6	48.32	6.38	70	13	1.5	0.1	0.03	-	0.05	-	-	-	-	-	-	
A7		11:04	Fine	0.09	0.067	Ebb	19.9	26.6	40.4	6.68	73.7	18	1.5	0.1	0.03	-	0.05	-	-	-	-	-	-	
A7		14:03	Fine	0.55	0.095	Flood	21.8	19.3	33.78	6.88	78.9	15	1.5	0.1	0.08	-	0.05	-	-	-	-	-	-	
A7		17:05	Fine	1.55	0.051	Flood	19.8	31.6	43.17	6.91	79.1	23	1.5	0.1	0.04	-	0.05	-	-	-	-	-	-	
																-		-	-	-	-	-	-	
A10		05:25	Fine	1.8	0.109	Flood	19.4	32.2	44	7	75.6	23	1.5	0.1	0.03	-	0.05	-	-	-	-	-	-	4.2
A10		08:32	Fine	2.15	0.047	Ebb	19.4	32.4	49.42	6.56	71	17	1.5	0.1	0.02	-	0.05	-	-	-	-	-	-	
A10		11:31	Fine	1.75	0.084	Ebb	19.7	32.3	49.27	6.4	69.8	12	1.5	0.1	0.04	-	0.05	-	-	-	-	-	-	
A10		14:33	Fine	1.2	0.107	Flood	20.9	32.2	48.76	6.51	72.3	18	1.5	0.1	0.04	-	0.05	-	-	-	-	-	-	
A10		17:34	Fine	2.3	0.045	Flood	19.6	32.7	44.57	6.95	79.6	26	1.5	0.1	0.03	-	0.05	-	-	-	-	-	-	
SHING MUN & TRIBUTARIES																								
D1	4/17/96	07:31	Overcast	1.2	0	Flood	20.3	29.6	45.56	1.09	11.7	9	5	1.7	0.005	0.05	0.05	0.05	0.025	0.25	0.025	0.025	0.5	10.4
D1		10:32	Overcast	1.8	0.019	Ebb	20.4	32.5	47.68	1.21	12.9	9	6	1.6	0.21	0.05	0.05	0.05	0.025	0.25	0.025	0.025	0.5	
D1		13:31	Overcast	0.5	0	Ebb	21.6	20.3	22.39	0.5	5.2	17	5	1.3	0.21	0.05	0.05	0.05	0.025	0.25	0.025	0.025	0.5	
D1		16:31	Overcast	1.05	0.036	Flood	20.8	29.9	46.02	0.6	6.5	9	7.5	1.9	0.63	0.05	0.05	0.05	0.07	0.25	0.025	0.025	0.5	
D1		19:31	Overcast	1.3	0.038	Flood	20.6	30.4	45.58	1.06	11.4	7	7.5	1.5	0.37	0.05	0.05	0.05	0.025	0.25	0.025	0.025	0.5	
D2		08:06	Overcast	2.85	0	Flood	19.9	31.1	47.61	2.77	30.1	12	7	0.5	0.15	0.05	0.05	0.05	0.025	0.25	0.025	0.025	0.5	10.4
D2		11:05	Overcast	3.05	0.022	Ebb	20.3	33.2	47.95	1.27	13.5	15	9.5	0.6	0.16	0.05	0.05	0.05	0.025	0.25	0.025	0.025	0.5	
D2		14:06	Overcast	1.55	0	Ebb	20.2	30.7	46.99	0.61	6.5	15	8	0.8	0.23	0.05	0.05	0.05	0.025	0.25	0.025	0.025	0.5	
D2		17:04	Overcast	2.5	0.027	Flood	20.2	30.7	47.19	1.55	17.3	15	8	1.3	0.34	0.05	0.05	0.05	0.33	0.25	0.025	0.025	0.5	
D2		20:04	Overcast	2.9	0.031	Flood	19.9	30.9	46.26	1.87	20.3	13	5.5	1.7	0.75	0.05	0.05	0.05	0.025	0.25	0.025	0.025	0.5	
D3		08:38	Overcast	3.1	0.021	Flood	19.3	31.9	48.81	4.12	44.6	9	8	0.5	0.19	0.05	0.05	0.05	0.025	0.25	0.025	0.025	0.5	9.4
D3		11:40	Overcast	2.8	0.028	Ebb	20.1	32.3	48.77	4.14	44.8	6	8.5	0.5	0.18	0.05	0.05	0.05	0.025	0.25	0.025	0.025	0.5	
D3		14:39	Overcast	1.95	0	Ebb	20.2	31.1	47.73	2.46	27.6	10	10.5	0.8	0.35	0.05	0.05	0.05	0.025	0.25	0.025	0.025	0.5	
D3		17:36	Overcast	2.8	0	Flood	20.5	31.2	47.78	4.07	45.8	9	10	0.3	0.22	0.05	0.05	0.05	0.025	0.25	0.025	0.025	0.5	
D3		20:35	Overcast	3.15	0.029	Flood	20.1	31.9	47.96	4.28	47.9	8	10	0.3	0.22	0.05	0.05	0.05	0.025	0.25	0.025	0.025	0.5	
D4		09:13	Overcast	4.1	0.036	Flood	19.1	32.2	48.51	6.23	72.4	10	9	0.05	0.11	0.05	0.05	0.05	0.05	0.25	0.025	0.025	0.5	6.6
D4		12:15	Overcast	3.4	0.067	Ebb	20.5	32.7	48.92	5.14	57.5	9	8.5	0.2	0.17	0.05	0.05	0.05	0.025	0.25	0.025	0.025	0.5	
D4		15:14	Overcast	2.5	0.032	Flood	20.5	32.1	49.5	5.02	56.3	10	8	0.2	0.18	0.05	0.05	0.05	0.025	0.25	0.025	0.025	0.5	
D4		18:10	Overcast	3.6	0.103	Flood	19.9	31.3	48.26	8.7	95.8	10	10.5	0.05	0.1	0.05	0.05	0.05	0.025	0.25	0.025	0.025	0.5	
D4		21:11	Overcast	4.2	0.064	Flood	19.6	31.9	48.39	7.23	84.2	9	11	0.05	0.06	0.05	0.05	0.05	0.025	0.25	0.025	0.025	1	
TAI PO / LAM TSUEN																								
E5	4/17/96	07:31	Overcast	2.05	0.043	Flood	21.3	31.6	48.83	3.74	43.4	9	3.5	0.5	0.24	0.05	0.05	0.05	0.025	0.25	0.025	0.025	0.5	6.2
E5		10:30	Overcast	2	0.025	Ebb	21.3	31.7	48.41	7.09	81.7	8	4.5	1.3	0.41	0.05	0.05	0.05	0.1	0.25	0.025	0.025	0.5	
E5		13:31	Overcast	1.2	0.152	Ebb	21.4	29.9	41.83	3.43	39.2	8	5.5	0.5	0.51	0.05	0.05	0.05	0.025	0.25	0.025	0.025	0.5	
E5		16:31	Overcast	1.95	0.031	Flood	22.1	30.6	46.46	8.41	97.5	16	5.5	0.2	0.15	0.05	0.05	0.05	0.025	0.25	0.025	0.025	0.5	
E5		19:31	Overcast	2.1	0	Flood	22	30.9	47.23	8.26	95.8	14	6	0.2	0.2	0.05	0.05	0.05	0.025	0.25	0.025	0.025	0.5	
E6		07:58	Overcast	1.9	0.035	Flood	21.4	31.3	48.33	3.65	42.5	8	3	0.6	0.33	0.05	0.05	0.05	0.025	0.25	0.025	0.025	0.5	6
E6		11:05	Overcast	1.9	0.024	Ebb	21.4	31.4	48.07	7.32	84.2	8	4	0.3	0.12	0.05	0.05	0.05	0.025	0.25	0.025	0.025	0.5	
E6		13:58	Overcast	1.1	0.167	Ebb	21.5	29.7	45.67	3.39	38.7	12	6.5	0.5	0.48	0.05	0.05	0.05	0.025	0.25	0.025	0.025	1	
E6		16:58	Overcast	1.85	0.03	Flood	22.2	30	46.17	8.39	97.2	19	6	0.2	0.17	0.05	0.05	0.05	0.025	0.25	0.025	0.025	1	
E6		20:02	Overcast	2	0	Flood	22	30.2	46.75	8.13	94.8	10	6	0.2	0.13	0.05	0.05	0.05	0.025	0.25	0.025	0.025	0.5	

Location	DATE	Time	Weather	Depth (cm)	Current (m/s)	Tide	Temp.(oC)	Salinity (ppt)	Cond. (ms)	DO (mg/l)	% D.O.	SS (mg/l)	BOD 5 (mg/l)	NH 4 (mgN/l)	TON (mgN/l)	Total Cu (mg/l)	Dissolved Cu (mg/l)	Ni (mg/l)	Zn (mg/l)	Pb (mg/l)	Cd (mg/l)	Cr (mg/l)	Hg (ug/l)	WQI
TAI PO / LAM TSUEN																								
E7		08:33	Overcast	2	0.028	Flood	21.5	29.1	45.05	1.72	19.5	4	8	0.5	0.88	0.05	0.05	0.05	0.025	0.25	0.025	0.025	0.5	10.2
E7		11:27	Overcast	1.7	0	Ebb	21.6	29.2	45.01	6.74	84	1	7	0.5	0.2	0.05	0.05	0.05	0.025	0.25	0.025	0.025	1	
E7		14:29	Overcast	1.25	0	Ebb	22	28.9	44.58	0.63	6.8	6.1	7	1.4	1.6	0.05	0.05	0.05	0.34	0.25	0.025	0.025	0.5	
E7		17:31	Overcast	1.9	0	Flood	22.2	27.1	42.14	0.13	1.4	6	9	1.6	1.3	0.05	0.05	0.05	0.06	0.25	0.025	0.025	0.5	
E7		20:36	Overcast	2.1	0	Flood	22.1	27.3	42.65	0.25	2.7	7	11	2	1.3	0.05	0.05	0.05	0.36	0.25	0.025	0.025	1	
E9		09:09	Overcast	0.05	0.292	Flood	23.7	0.2	474	5.05	60.4	7	9	7.5	5.5	0.05	0.05	0.05	0.025	0.25	0.025	0.025	0.5	11.8
E9		11:46	Overcast	0.05	0.323	Ebb	23.9	0.2	463	5.44	68	16	9.5	12	4.7	0.05	0.05	0.05	0.025	0.25	0.025	0.025	0.5	
E9		14.58	Overcast	0.06	0.309	Flood	23.9	0.2	459	5.36	67.3	6	10	6.9	4	0.05	0.05	0.05	0.025	0.25	0.025	0.025	0.5	
E9		18:08	Overcast	0.06	0.311	Flood	23.8	0.2	461	5.16	65.2	7	10.5	6.3	5.9	0.05	0.05	0.05	0.025	0.25	0.025	0.025	0.5	
E9		21:13	Overcast	0.06	0.319	Flood	21.1	0.2	467	5.09	64.3	6	12	7.5	5.8	0.05	0.05	0.05	0.025	0.25	0.025	0.025	0.5	
RIVER INDUS																								
F3	16/4/96	08:52	Sunny	0.60	0.000	Flood	22.00	0.60	586.00	0.88	9.9	56.0	19.000	11.000	3.200	0.050	0.050	0.050	0.690	0.250	0.025	0.025	1.000	15
F3		11:40	Sunny	0.95	0.013	Ebb	21.90	0.90	594.00	0.94	10.3	46.0	15.000	11.000	2.500	0.050	0.050	0.050	0.080	0.250	0.025	0.025	0.500	
F3		14:41	Sunny	0.65	0.012	Ebb	22.80	0.60	592.00	0.67	7.8	32.0	16.500	10.000	2.600	0.050	0.050	0.050	0.080	0.250	0.025	0.025	0.500	
F3		17:39	Sunny	0.30	0.028	Ebb	25.70	0.30	560.00	0.59	6.7	33.0	12.000	6.900	6.000	0.050	0.050	0.050	0.160	0.250	0.025	0.025	0.500	
F3		20:51	Sunny	0.65	0.021	Flood	25.20	0.40	579.00	0.45	5.4	36.0	13.000	6.900	5.300	0.050	0.050	0.050	0.200	0.250	0.025	0.025	0.500	
F1	16/4/96	07:01	Sunny	0.70	0.078	Flood	21.40	0.40	629.00	0.36	4.1	41.0	84.000	11.000	0.005	0.050	0.050	0.050	0.170	0.250	0.025	0.025	0.500	14.4
F1		10:03	Sunny	1.60	0.063	Flood	22.10	0.40	620.00	0.41	4.7	26.0	85.000	12.000	0.005	0.050	0.050	0.050	0.120	0.250	0.025	0.025	0.500	
F1		13:02	Sunny	1.10	0.069	Ebb	22.60	0.30	615.00	0.48	5.3	30.0	62.000	10.000	0.010	0.050	0.050	0.050	0.130	0.250	0.025	0.025	0.500	
F1		16:02	Sunny	0.50	0.073	Ebb	24.30	0.30	621.00	0.48	5.6	41.0	49.000	9.200	0.010	0.050	0.050	0.050	0.090	0.250	0.025	0.025	0.500	
F1		19:02	Sunny	1.20	0.069	Flood	23.90	0.50	615.00	0.51	5.9	70.0	48.000	11.000	0.005	0.050	0.050	0.050	0.070	0.250	0.025	0.025	0.500	
F5		07.37	Sunny	0.95	0.041	Flood	21.20	0.40	559.00	0.68	7.7	29.0	15.500	8.100	63.000	0.050	0.050	0.050	0.150	0.250	0.025	0.025	0.500	14.2
F5		10:38	Sunny	1.90	0.046	Ebb	22.20	0.60	716.00	0.72	8.4	26.0	15.000	5.800	9.700	0.050	0.050	0.050	0.120	0.250	0.025	0.025	0.500	
F5		13:35	Sunny	1.05	0.057	Ebb	22.60	0.40	617.00	0.48	5.6	25.0	15.000	5.800	64.000	0.050	0.050	0.050	0.760	0.250	0.025	0.025	1.000	
F5		16.32	Sunny	0.30	0.147	Flood	24.10	0.10	612.00	3.31	39.4	27.0	28.500	5.800	59.000	0.050	0.050	0.050	0.160	0.250	0.025	0.025	0.500	
F5		19:38	Sunny	1.50	0.047	Flood	23.90	0.20	637.00	0.76	8.7	35.0	29.500	3.500	54.000	0.050	0.050	0.050	0.190	0.250	0.025	0.025	1.000	
F6		08:16	Sunny	0.65	0.096	Ebb	21.60	0.70	595.00	2.23	25.7	31.0	7.500	5.700	0.000	0.050	0.050	0.050	0.210	0.250	0.025	0.025	0.500	12.8
F6		11:12	Sunny	0.65	0.098	Ebb	23.20	0.50	613.00	2.47	28.2	28.0	7.500	3.200	10.000	0.050	0.050	0.050	0.210	0.250	0.025	0.025	0.500	
F6		14:09	Sunny	0.60	0.132	Ebb	23.70	0.30	632.00	2.81	33.4	31.0	8.000	3.100	11.000	0.050	0.050	0.050	0.260	0.250	0.025	0.025	0.500	
F6		17:04	Sunny	0.65	0.101	Flood	24.00	0.20	632.00	2.35	28.9	38.0	11.000	3.600	14.000	0.050	0.050	0.050	0.270	0.250	0.025	0.025	1.000	
F6		20:15	Sunny	0.65	0.108	Flood	23.80	0.40	621.00	2.41	29.5	36.0	10.500	3.700	11.000	0.050	0.050	0.050	0.220	0.250	0.025	0.025	0.500	
TIN SHUI WAI																								
I1	16/4/96	07:00	Sunny	1.35	0.023	Flood	21.50	7.20	1.62	0.13	1.5	27.0	14.500	12.000	0.040	0.050	0.050	0.050	0.050	0.250	0.025	0.025	0.500	14.2
I1		10:03	Sunny	1.55	0.025	Flood	21.60	8.60	1.64	0.15	1.7	20.0	19.500	12.000	0.030	0.050	0.050	0.050	0.025	0.250	0.025	0.025	0.500	
I1		13:02	Sunny	0.90	0.036	Ebb	23.00	7.20	11.81	0.25	2.9	30.0	20.500	9.200	0.030	0.050	0.050	0.050	0.080	0.250	0.025	0.025	0.500	
I1		16:02	Sunny	0.30	0.032	Ebb	24.20	5.80	5.76	0.49	5.6	7.0	20.000	5.800	0.170	0.050	0.050	0.050	0.160	0.250	0.025	0.025	0.500	
I1		19:01	Sunny	1.20	0.037	Flood	23.60	6.90	5.13	0.35	3.6	10.0	6.000	5.800	0.360	0.050	0.050	0.050	0.200	0.250	0.025	0.025	0.500	
I6	16/4/96	07:25		1.75	0.031	Flood	21.3	8.10	1.95	0.33	3.3	110.0	6.500	8.100	0.005	0.010	0.050	0.050	0.025	0.250	0.025	0.025	0.500	14.8
I6		10:31		1.98	0.043	Ebb	21.4	8.20	2.02	0.35	3.5	49.0	7.000	8.600	0.005	0.050	0.050	0.050	0.025	0.250	0.025	0.025	0.500	
I6		13:32		1.30	0.045	Ebb	22.9	7.20	12.81	0.36	4.0	82.0	6.500	9.800	0.005	0.050	0.050	0.050	0.050	0.250	0.025	0.025	0.500	
I6		16:30		0.50	0.031	Flood	23.9	7.10	1.70	0.31	3.2	82.0	16.000	12.000	0.005	0.050	0.050	0.050	0.025	0.250	0.025	0.025	0.500	
I6		19:33		1.70	0.042	Flood	23.2	7.80	6.25	0.32	5.7	92.0	16.500	12.000	0.005	0.010	0.050	0.050	0.050	0.025	0.025	0.025	0.500	
I5	16/4/96	07:58	Sunny	1.65	0.042	Flood	20.70	11.80	2.37	0.21	2.5	22.0	13.500	11.000	0.040	0.050	0.050	0.050	0.050	0.250	0.025	0.025	0.500	13.8
I5		11:01	Sunny	1.90	0.035	Ebb	20.80	12.10	2.53	0.23	2.7	24.0	25.000	9.200	0.030	0.050	0.050	0.050	0.390	0.250	0.025	0.025	0.500	
I5		14:03	Sunny	1.20	1.230	Ebb	21.40	12.10	2.54	0.24	2.7	25.0	21.000	6.300	0.030	0.050	0.050	0.050	0.025	0.250	0.025	0.025	0.500	
I5		16:59	Sunny	0.70	0.048	Flood	23.70	11.50	2.03	0.21	2.5	79.0	19.000	14.000	0.030	0.050	0.050	0.050	0.025	0.250	0.025	0.025	0.500	
I5		20:06	Sunny	1.60	0.087	Flood	23.10	12.40	6.02	0.23	2.7	87.0	18.500	12.000	0.030	0.050	0.050	0.050	0.050	0.250	0.025	0.025	0.500	

Location	DATE	Time	Weather	Depth	Current	Tide	Temp.(oC)	Salinity	Cond.	DO	% D.O.	SS	BOD 5	NH 4	TON	Total Cu	Dissolved Cu	Ni	Zn	Pb	Cd	Cr	Hg	WQI
				(cm)	(m/s)			(ppt)	(ms)	(mg/l)		(mg/l)	(mg/l)	(mgN/l)	(mgN/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(ug/l)	
TUEN MUN																								
J1	18/4/96	09:20	Good	0.70	0.064	Flood	23.20	15.00	25.91	4.53	53.8	7.0	3.500	0.200	1.700	0.050	0.050	0.050	0.025	0.250	0.025	0.025	0.500	9.4
J1		11:57	Good	0.75	0.045	Ebb	23.70	16.90	27.86	4.13	49.6	7.0	4.000	0.200	1.600	0.050	0.050	0.050	0.050	0.250	0.025	0.025	0.500	
J1		15:16	Good	0.50	0.036	Ebb	23.80	16.30	26.78	3.25	39.0	3.0	4.500	0.500	1.900	0.050	0.050	0.050	0.025	0.250	0.025	0.025	0.500	
J1		17:45	Good	0.02	0.025	Ebb	22.30	2.20	4.15	3.60	41.6	73.0	66.000	3.000	0.020	0.050	0.050	0.050	0.910	0.250	0.025	0.025	0.500	
J1		20:45	Good	0.02	0.025	Ebb	22.10	2.10	4.18	3.48	40.5	34.0	60.000	2.900	0.030	0.050	0.050	0.050	0.060	0.250	0.025	0.025	0.500	
J3A		08:35	Good	1.80	0.035	Flood	22.60	24.20	38.15	0.63	7.5	11.0	5.500	0.600	0.040	0.050	0.050	0.050	0.025	0.250	0.025	0.025	1.000	9
J3A		11:30	Good	1.80	0.036	Ebb	22.80	24.50	38.76	0.84	9.8	9.0	5.500	0.600	0.030	0.050	0.050	0.050	0.025	0.250	0.025	0.025	0.500	
J3A		14:39	Good	1.10	0.048	Ebb	23.40	24.90	39.10	0.93	10.6	11.0	6.000	0.700	0.010	0.050	0.050	0.050	0.025	0.250	0.025	0.025	0.500	
J3A		17:12	Good	0.25	0.072	Flood	25.50	24.30	38.20	3.81	46.7	41.0	9.000	0.400	0.120	0.050	0.050	0.050	0.025	0.250	0.025	0.025	0.500	
J3A		20:14	Good	0.90	0.071	Flood	24.60	24.50	39.32	3.42	40.4	21.0	8.000	0.600	0.830	0.050	0.050	0.050	0.025	0.250	0.025	0.025	0.500	
J3B		8:10	Good	1.90	0.036	Flood	22.40	24.60	40.24	1.57	17.4	10.0	5.500	0.700	0.030	0.050	0.050	0.050	0.025	0.250	0.025	0.025	1.000	9.2
J3B		11:08	Good	2.00	0.038	Ebb	22.50	24.90	40.68	1.83	20.6	12.0	4.000	0.600	0.040	0.050	0.050	0.050	0.130	0.250	0.025	0.025	0.500	
J3B		14:16	Good	1.30	0.052	Ebb	23.20	24.90	42.18	1.36	14.9	12.0	4.000	0.700	0.020	0.050	0.050	0.050	0.025	0.250	0.025	0.025	0.500	
J3B		16:40	Good	0.35	0.076	Flood	25.30	25.40	40.38	3.96	48.1	21.0	7.500	0.800	0.300	0.050	0.050	0.050	0.025	0.250	0.025	0.025	0.500	
J3B		19:40	Good	1.00	0.078	Flood	24.40	25.80	40.61	3.51	41.3	19.0	7.000	0.600	1.000	0.050	0.050	0.050	0.025	0.250	0.025	0.025	0.500	
J4		07:46	Good	3.10	0.048	Flood	21.20	29.80	42.68	4.88	54.9	20.0	1.500	0.200	0.170	0.050	0.050	0.050	0.050	0.250	0.025	0.025	0.500	6.2
J4		10:42	Good	3.00	0.052	Ebb	21.40	29.80	45.83	5.37	61.4	16.0	1.500	0.200	0.190	0.050	0.050	0.050	0.890	0.250	0.025	0.025	0.500	
J4		13:45	Good	2.10	0.098	Ebb	21.60	29.80	45.23	5.12	59.6	36.0	1.500	0.200	0.190	0.050	0.050	0.050	0.150	0.250	0.025	0.025	0.500	
J4		16:15	Good	2.10	0.000	Ebb	23.70	26.00	41.80	3.17	38.1	20.0	4.500	0.300	0.080	0.050	0.050	0.050	0.025	0.250	0.025	0.025	0.500	
J4		19:15	Good	2.70	0.052	Flood	22.80	28.40	42.31	3.24	38.9	19.0	1.500	0.400	0.070	0.050	0.050	0.050	0.025	0.250	0.025	0.025	0.500	
SHAM TSENG																								
M1		06:45	Sunny	0.02	0.064	Flood	22.00	0.20	0.34	2.28	26.1	4.0	5.500	4.600	0.140	0.050	0.050	0.500	0.090	0.250	0.025	0.025	0.500	13
M1		09:46	Sunny	0.02	0.058	Ebb	22.70	0.10	0.28	2.19	25.5	8.0	9.500	8.600	0.120	0.050	0.050	0.050	0.080	0.250	0.025	0.025	0.500	
M1		12:45	Sunny	0.02	0.060	Ebb	22.80	0.10	0.28	2.21	25.7	7.0	10.000	8.600	0.110	0.050	0.050	0.050	0.025	0.250	0.025	0.025	0.500	
M1		15:45	Sunny	0.02	0.054	Ebb	24.00	0.10	0.24	2.43	29.1	9.0	7.000	6.900	0.150	0.050	0.050	0.050	0.025	0.250	0.025	0.025	0.500	
M1		18:45	Sunny	0.02	0.600	Flood	23.90	0.10	0.23	2.27	26.3	6.0	7.000	5.800	0.160	0.050	0.050	0.050	0.025	0.250	0.025	0.025	0.500	
M3	18/4/96	07:12	Sunny	0.80	0.035	Flood	20.50	29.30	45.47	5.15	58.2	24.0	7.000	0.100	0.320	0.050	0.050	0.500	0.080	0.250	0.025	0.025	0.500	9.8
M3		10:05	Sunny	1.10	0.000	Ebb	20.80	31.10	47.62	3.43	39.5	47.0	32.000	0.500	0.010	0.050	0.050	0.050	0.060	0.250	0.025	0.025	0.500	
M3		13:07	Sunny	0.90	0.032	Ebb	21.30	30.60	47.13	3.12	36.4	45.0	34.000	0.700	0.020	0.050	0.050	0.050	0.050	0.250	0.025	0.025	0.500	
M3		15:31	Sunny	0.03	0.840	Ebb	24.30	0.40	0.81	1.94	23.1	330.0	94.000	9.800	0.010	0.050	0.050	0.050	0.280	0.250	0.025	0.025	0.500	
M3		18:3	Sunny	0.30	0.052	Flood	22.20	29.20	45.00	4.95	58.1	21.0	1.500	0.100	0.200	0.050	0.050	0.050	0.025	0.250	0.025	0.025	0.500	

APPENDIX A2

WATER QUALITY - DELWAQ MODELLING RESULTS

APPENDIX A2. WATER QUALITY MODELLING

A2.1 Delwaq input parameters

It has been assumed that the concentration immediately outside the model area is influenced by the previous outflows and thus, on an incoming tide, part of the water returns. To account for this effect, DELWAQ uses the Thatcher-Harleman time lag. During the modelling assessment this time lag has been considered and assessed, resulting in a two hour time lag being deemed appropriate for the study areas under consideration.

The DELWAQ software contains numerous default parameters and coefficients required for the calculation of water quality processes. These default values are commonly used for similar river modelling projects and are appropriate for this study. Due to the limited data available for the calibration of the water quality models many of these default values have therefore been retained except where more suitable values could be ascertained:

- Temperature — 22 °C
- Wind velocity — 0
- Latitude — 22.5
- Mineralisation rate of BODC (RcBODC) — 0.2 d^{-1}
- Sediment oxygen demand (fSOD) — 2 $gm^{-2}d^{-1}$
- Sedimentation rate (vsedIM1) based on mean particle sizes found during grab sampling — 8 md^{-1}

Grab and core sample surveys were taken under pre and post wet season conditions. Maximum concentrations of contaminant found, from the supplied data sets, over the area of dredging have been assumed to provide a worst case scenario. From the concentration data, loads have been determined by multiplying the concentration by the sediment release rate. The loads have then been released for a ten hour period, to represent daylight hours, each day for an eight day period extending from a mid spring to a mid neap tide.

Table A2.1

River Stretch	Sediment Release Rate (Kg/s)
Shing Mun - up stream of Lion Bridge	0.097
Shing Mun - down stream of Lion Bridge	0.194
Fo Tan Nullah	Done in the dry
Siu Lek Yuen Nullah	0.175
Tai Shui Hang	0.175
Tuen Mun	0.194
Tai Po	0.194
Lam Tsuen	0.194

Metal Concentration used form core data survey results supplied

Concentrations are maximum values for the sample locations specified in brackets

River Stretch	Cd (mg/Kg)	Pb (mg/Kg)
Shing Mun - up stream of Lion Bridge	0.5 (core data D5/D)	115 (core data D5/D)
Shing Mun - down steam of Lion Bridge	0.8 (core data D6/D)	182 (core data D6/D)
Fo Tan Nullah	0.8 (core date D9/D)	142 (core data D9/D)
Siu Lek Tuen Nullah	0.8 (core date D4/D)	160 (core data D4/D)
Tai Shui Hang	0.8 (core date D9/D)	160 (core data D4/D)
Tuen Mun	1.2 (core date J1/D)	1650 (core data J1/D)
Tai Po	0.8 (core date E5/D)	200 (core data E1/D)
Lam Tsuen	0.8 (core date E5/D)	200 (core data E1/D)

Once released in the model, metals are transported in both the dissolved and particulate phase. The model code assumes that metals concentrations are in equilibrium which implies a fixed partitioning between dissolved and adsorbed metals. Metals introduced into the model instantaneously partition in the ration of K_d given by:

$$K_d = \frac{C_a}{C_d}$$

Where:

C_a = adsorbed concentration [Kg (metals)/Kg (suspended solid)]
C_d = dissolved concentration (Kg/m^3)
C_d = partition coefficient (m^3/Kg)

The fraction of dissolved and adsorbed concentrations are given by:

$$F_d = \frac{1}{1+(K_d*SS)} \qquad Fa = \frac{(Kd * SS)}{1+(K_d**SS)}$$

Where:

F_a = adxorved fraction
F_d = dissolved fraction
SS = concentration of suspended solids (g/m^3)

The assumption that the adsorption/dissolution process is completely reversible is also made as the partitioning between the dissolved and particulate phases is adjusted at each time step as tidal conditions change. The value of K_d is fixed in space and time but differs for each metal included in the simulation, with common literature values (Referenced below) used for each metal. In this case K_d for Cd =130m^3/kg of dry weight sediment and for Pb = 640 m^3/kg dry weight sediment.

A2.2 Shing Mun Channel

A2.2.1 Configuration

The main 6km branch of the Shing Mun was sub-divided into 32 segments, whilst the Fo Tan Nullah, Siu Lek Yen Nullah, and Tai Shui Hang branches were sub-divided into 7, 12, and 6 segments respectively, a total of 57 segments. The average size of the segments in the overall network are therefore approximately 180m.

The SOBEK model was run with an average spring to neap tide prediction for an eight day period (7th to 14th January 1996) for Tai Po Kau tidal station and upstream boundary river flows of:

- Shing Mun 0.060 m^3/s
- Fo Tan Nullah 0.005 m^3/s
- Siu Lek Yuen Nullah 0.075 m^3/s
- Tai Shui Hang 0.005 m^3/s

DELWAQ input files were then set up to include information on boundary values at upstream river locations and the downstream tidal boundary, based on the EPD river quality surveys undertaken in 1994 and 1995, see Table A2.1.

A2.2.2 Simulations and Results

Separate model application simulations were then undertaken for:

- BOD, DO, NH4, NO3 and suspended solids (IM1)
- Suspended solids, total cadmium (Cd), cadmium in sediment, total lead (Pb), and lead in sediment

The results provided the baseline existing scenario.

The baseline scenario model runs were repeated for the river bed levels set at the dredging trigger levels as per Task 4 and the model runs were repeated. This provides an indication of the impact of accretion. Figures A2.1a,b and c show the comparison between the baseline and the adjusted bed level scenarios. The figures show the predicted concentrations towards the end of the simulation period, after the model has stabilised.

The predictions indicate that the increase in bed level results in an improvement in water quality, most notably as an increase of 0.5mg/l in dissolved oxygen concentrations over much of the channel length. This effect is considered to result from the reduced storage volume in the channel improving the effective tidal flushing and reducing the residence time.

Model runs were then repeated with additional input loads to simulate the effect of the dredging. Input locations were at the upstream extent of the anticipated underwater dredging, determined on the basis of sufficient water depth for the operation not to be undertaken in dry conditions. Two input loads were simulated, assuming concurrent operation in two areas. The dredging input load locations used to the model were:

- Shing Mun — Chainage 1185 Segment 7
- Shing Mun — Chainage 1630 Segment 11
- Siu Lek Yuen Nullah — Chainage 375 Segment 47
- Tai Shui Hang — Chainage 500 Segment 50

Figures A2.2a,b and c show the comparison between the baseline and the with dredging scenarios. It can be seen that only the suspended solids, total cadmium (Cd) and total lead (Pb) concentrations are affected by dredging activities. At the dredging site, the increase in concentration of cadmium is less than 0.05µg/l, the effective resolution of standard analytical methods. The increase in concentration of lead approximately 10µg/l against a modelled background of approximately 26µg/l (defined by the downstream boundary concentration - see Table A2.1). This increase reflects the relatively much higher concentrations of lead in the sediments (significantly in excess of the existing Class C criterion).

The tributaries were also modelled and, although the much lower flow increases the unreliability of the predictions, the same basic effects were observed.

A2.3 Tai Po / Lam Tsuen Channel

A2.3.1 Configuration

The 3.2km branch of the Lam Tsuen river was sub-divided into 22 segments, whilst the Tai Po branch was sub-divided into 7 segments. Two additional segments were added for the two loops in the system. The average size of the segments in the overall network are therefore approximately 160m.

The SOBEK model was run with an average spring to neap tide prediction for an eight day period (7th to 14th January 1996) for Tai Po Kau tidal station and low river flows of:

- Tai Po — 0.040 m^3/s
- Lam Tsuen — 0.040 m^3/s

DELWAQ input files were then set up to include information on boundary values at upstream river locations and the downstream tidal boundary, based on the EPD river quality surveys undertaken in 1994 and 1995, see Table A2.2.

A2.3.2 Simulations and Results

Separate model application simulations were then undertaken for:

- BOD, DO, NH4, NO3 and suspended solids (IM1)
- Suspended solids, total cadmium (Cd), cadmium in sediment, total lead (Pb), and lead in sediment

The results provided the baseline existing scenario.

The baseline scenario model runs were repeated for the river bed levels set at the dredging trigger levels as per Task 4 and the model runs were repeated. This provides an indication of the impact of accretion. Figures A2.3a,b and c and A2.4a,b and c show the comparison between the baseline and the adjusted bed level scenarios for the Tai Po and Lam Tsuen channels respectively. The figures show the predicted concentrations towards the end of the simulation period, after the model has stabilised.

As for the Shing Mun, the predictions indicate a minor improvement in water quality in both the Tai Po and Lam Tsuen as a result of the increased bed levels. The effect is most noticeable for dissolved oxygen concentration which improve by 0.1 to 0.2mg/l in the lower reaches of both channels.

Model runs were then repeated with additional input loads to simulate the effect of the dredging. Input locations were at the upstream extent of the anticipated underwater dredging, determined on the basis of sufficient water depth for the operation not to be undertaken in dry conditions. Two input loads were simulated, assuming concurrent operation in two areas. The dredging input load locations used to the model were:

- Lam Tsuen — Chainage 1825 Segment 14
- Tai Po — Chainage 640 Segment 28

Figures A2.5a,b and c and A2.6a,b and c show the comparison between the baseline and the with dredging scenarios for the Tai Po and Lam Tsuen respectively. The effects observed are similar on each channel and comparable to those predicted for the Shing Mun. Suspended solids concentrations increase significantly in the immediate dredging area, reducing rapidly with distance. The increased suspended solids is reflected in an increase in total lead (Pb) concentration due to the high levels of contamination of the sediment.

A2.4 Tuen Mun channel

A2.4.1 Configuration

The 4.1km branch of the Tuen Mun has been sub-divided into 27 segments, averaging approximately 150m in length.

The SOBEK model was run with an average spring to neap tide prediction for an eight day period (7th to 14th January 1996) for the Quarry Bay tidal station and a low river flow of:

- Tuen Mun — 0.015 m^3/s

DELWAQ input files were then set up to include information on boundary values at upstream river locations and the downstream tidal boundary, based on the EPD river quality surveys undertaken in 1994 and 1995, see Table A2.3.

A2.4.2 Simulations and Results

Separate model application simulations were then undertaken for:

- BOD, DO, NH4, NO3 and suspended solids (IM1)
- Suspended solids, total cadmium (Cd), cadmium in sediment, total lead (Pb), and lead in sediment

The results provided the baseline existing scenario.

The baseline scenario model runs were repeated for the river bed levels set at the dredging trigger levels as per Task 4 and the model runs were repeated. This provides an indication of the impact of accretion. Figures A2.7a,b and c show the comparison between the baseline and the adjusted bed level scenarios. The figures show the predicted concentrations towards the end of the simulation period, after the model has stabilised.

As for the Shing Mun, the predictions indicate a minor improvement in water quality in the Tuen Mun as a result of the increased bed levels.

Model runs were then repeated with additional input loads to simulate the effect of the dredging. Input locations were at the upstream extent of the anticipated underwater dredging, determined on the basis of sufficient water depth for the operation not to be undertaken in dry conditions. Two input loads were simulated, assuming concurrent operation in two areas. The dredging input load locations used to the model were:

- Tuen Mun Chainage 2180 - Segment 15

Figures A2.8a,b and c show the comparison between the baseline and the with dredging scenarios. The effects observed comparable to those predicted for the other channels modelled. Suspended solids concentrations increase significantly in the immediate dredging area, reducing rapidly with distance. The increased suspended solids is reflected in an increase in total lead (Pb) concentration due to the high levels of contamination of the sediment.

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TABLE A2.1 INPUT DATA FOR SHING MUN WATER QUALITY MODEL

	BOD	DO	NH4	NO3	SS	SS IM1	Cd	Dis Cd	QCd IM1	CdS1	Pb	Dis Pb	QpBIM1	PbS1
Boundary Conditions	**mg/l**	**mg/l**	**mg/l**	**mg/l**	**mg/l**	**mg/l**	**mg/l**	**mg/l**	**mg/l**	**mg/l**	**mg/l**	**mg/l**	**mg/l**	**mg/l**
Initial Conditions	6.0	4.0	1.0	0.2	5	5	0.0006	0	0	0.0005	0.017	0	0	0.1
Upstream Boundary	18	6.4	4.4	1.80	420	420	0.0009	0	0	0.0008	0.080	0	0	0.182
Downstream Boundary	4.5	5.0	0.2	0.17	6.7	6.7	0.0007	0	0	0.0008	0.026	0	0	0.160
Fo Tan Nullah	320	0.2	10.0	0.72	140	780	0.0007	0	0	0.0011	0.026	0	0	0.182
Siu Lek Yuen Nullah 1	8.0	1.8	0.9	0.91	32	72	0.0020	0	0	0.0008	0.038	0	0	0.182
Siu Lek Yuen Nullah 2	8.0	1.8	0.9	0.91	32	72	0.0020	0	0	0.0008	0.038	0	0	0.182
Siu Lek Yuen Nullah for Tai Shui	8.0	1.8	0.9	0.91	32	72	0.0020	0	0	0.0008	0.038	0	0	0.182
Dredging Load	**g/s**	**g/s**	**g/s**	**g/s**	**g/s**	**g/s**	**g/s**	**g/s**	**g/s**	**g/s**	**g/s**	**g/s**	**g/s**	**g/s**
Shing Mun 1 ch.1185	0.0014*	0.0008	0.0114**	0.0	97	97	0.000049	0	0	0	0.011	0	0	0
Shing Mun 2 ch.1630	0.0025*	0.0003	0.0316**	0.0	194	194	0.000155	0	0	0	0.035	0	0	0
Siu Lek Yuen ch.375	0.0007	0.0008	0.0457**	0.0	175	175	0.00014	0	0	0	0.028	0	0	0
Tai Shui Hang ch.500	0.0007	0.0008	0.0457**	0.0	175	175	0.00014	0	0	0	0.028	0	0	0

Key: ** As no BOD data, used peak TOC from core/grab*

*** As no NH_4 data, used peak NH_3 from core/grab*

TABLE A2.2 INPUT DATA FOR TAI PO / LAM TSUEN WATER QUALITY MODEL

	BOD	DO	NH4	NO3	SS	SS IM1	Cd	Dis Cd	QCd IM1	CdS1	Pb	Dis Pb	QpBIM1	PbS1
Boundary Conditions	**mg/l**	**mg/l**	**mg/l**	**mg/l**	**mg/l**	**mg/l**	**mg/l**	**mg/l**	**mg/l**	**mg/l**	**mg/l**	**mg/l**	**mg/l**	**mg/l**
Initial Conditions	7	4.5	1.0	0.4	5	5	0.0025	0	0	0.0008	0.02	0	0	0.12
Upstream Boundary	22	4.8	3.8	3.6	1100	1100	0.0006	0	0	0.0008	0.086	0	0	0.2
Downstream Boundary	5.13	5.0	0.308	0.085	7.4	7.4	0.0034	0	0	0.0008	0.024	0	0	0.1
Lam Tsuen	31	0.5	6.7	8.6	190	190	0.0009	0	0	0.0008	0.017	0	0	0.2
Dredging Load	**g/s**	**g/s**	**g/s**	**g/s**	**g/s**	**g/s**	**g/s**	**g/s**	**g/s**	**g/s**	**g/s**	**g/s**	**g/s**	**g/s**
Tai Po ch. 640	0.0003*	0	0.0384**	0	194	194	0.00016	0	0	0	0.0388	0	0	0
Lam Tsuen ch. 1825	0.0003*	0	0.0384**	0	194	194	0.00016	0	0	0	0.0388	0	0	0

TABLE A2.3 INPUT DATA FOR TUEN MUN WATER QUALITY MODEL

	BOD	DO	NH4	NO3	SS	SS IM1	Cd	Dis Cd	QCd IM1	CdS1	Pb	Dis Pb	QpBIM1	PbS1
Boundary Conditions	**mg/l**	**mg/l**	**mg/l**	**mg/l**	**mg/l**	**mg/l**	**mg/l**	**mg/l**	**mg/l**	**mg/l**	**mg/l**	**mg/l**	**mg/l**	**mg/l**
Initial Conditions	6.0	4.0	1.0	.2	5	5	0.008	0	0	0.0012	0.2	0	0	0.7
Upstream Boundary	620	0.22	33.1	7.0	920	920	0.013	0	0	0.0012	0.22	0	0	1.65
Downstream Boundary	.4	5.0	0.01	0.17	0.5	0.5	0.013	0	0	0.012	0.024	0	0	0.075
Dredging Load	**g/s**	**g/s**	**g/s**	**g/s**	**g/s**	**g/s**	**g/s**	**g/s**	**g/s**	**g/s**	**g/s**	**g/s**	**g/s**	**g/s**
Tuen Mun ch. 3150	0.001*	0.0008	0.4113**	0.0	194	194	0.00023	0	0	0	0.32	0	0	0

Key: ** As no BOD data, used peak TOC from core/grab*

*** As no NH_4 data, used peak NH_3 from core/grab*

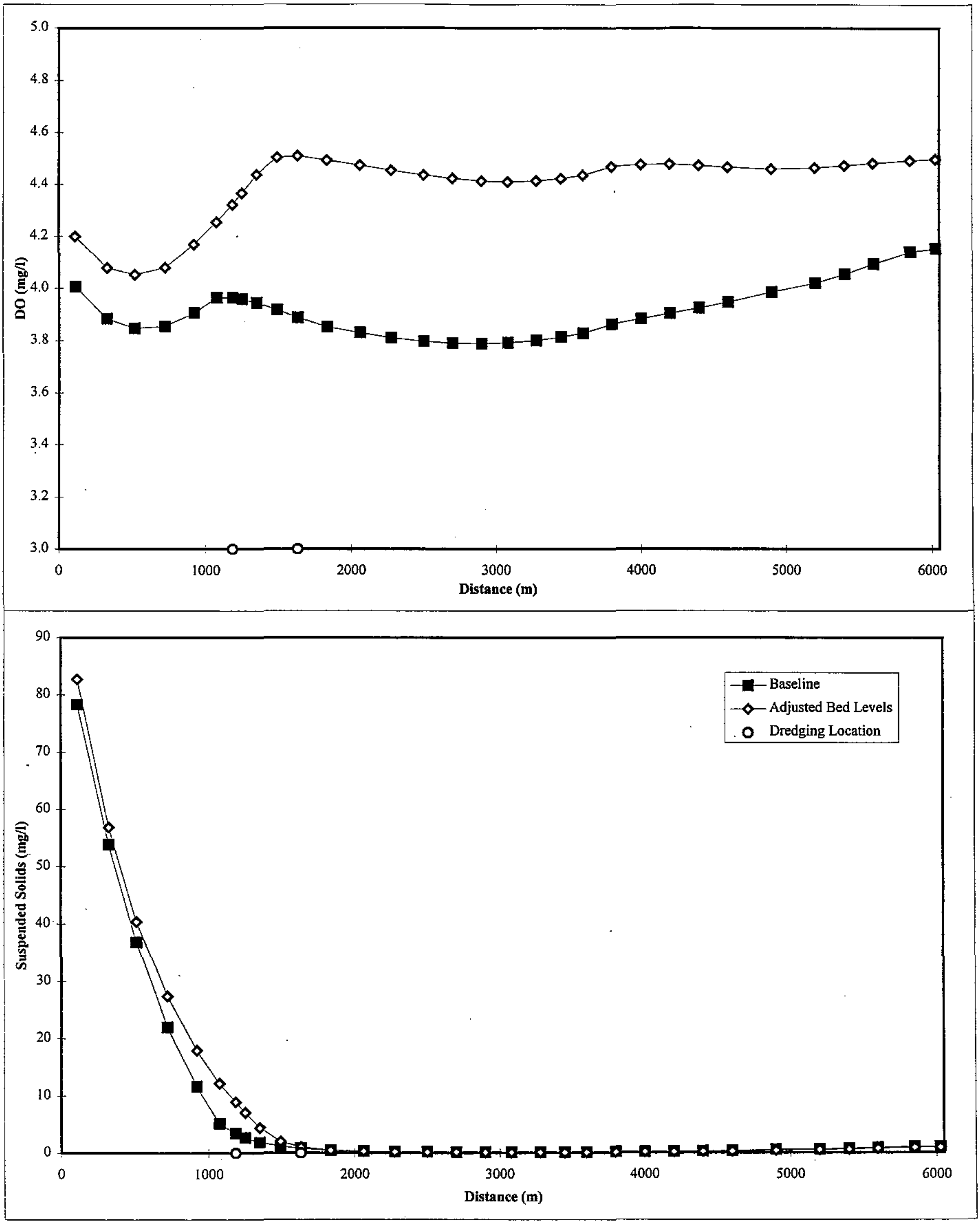

FIGURE A2.1a SHING MUN CHANNEL LONGITUDINAL WATER QUALITY
BASELINE AND ADJUSTED BED LEVEL SCENARIOS 13/1/96 07:00
DISSOLVED OXYGEN (DO) & SUSPENDED SOLIDS CONCENTRATIONS

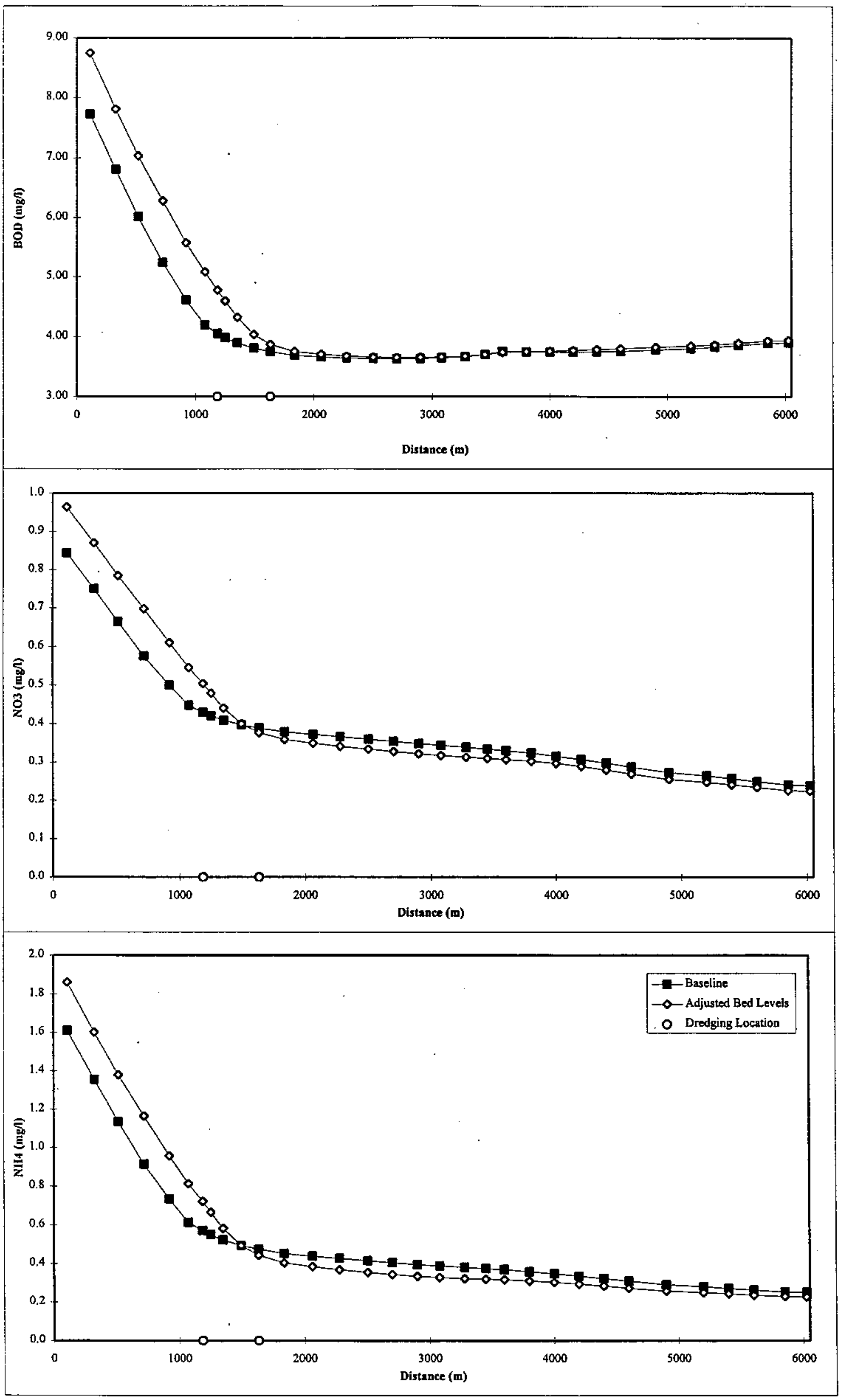

FIGURE A2.1b SHING MUN CHANNEL LONGITUDINAL WATER QUALITY
BASELINE AND ADJUSTED BED LEVEL SCENARIOS 13/1/96 0700
BIOCHEMICAL OXYGEN DEMAND (BOD), NITRATE (NO3) AND AMMONIACAL NITROGEN (NH4) CONCENTRATIONS

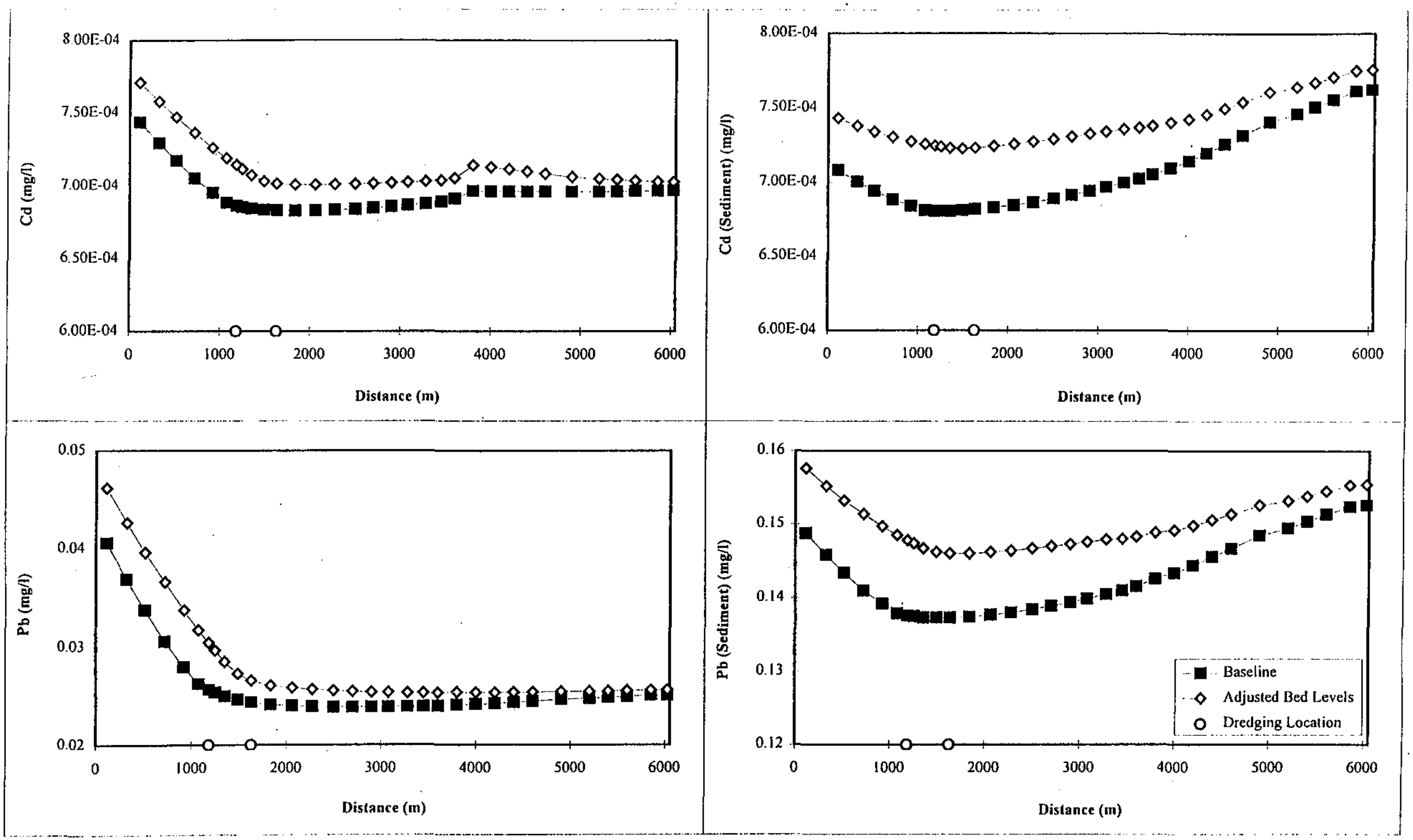

FIGURE A2.1c SHING MUN CHANNEL LONGITUDINAL WATER QUALITY
BASELINE AND ADJUSTED BED LEVEL SCENARIOS 13/1/96 07:00
CADMIUM (Cd) & LEAD (Pb) TOTAL (dissolved & particulate) AND SEDIMENT CONCENTRATIONS

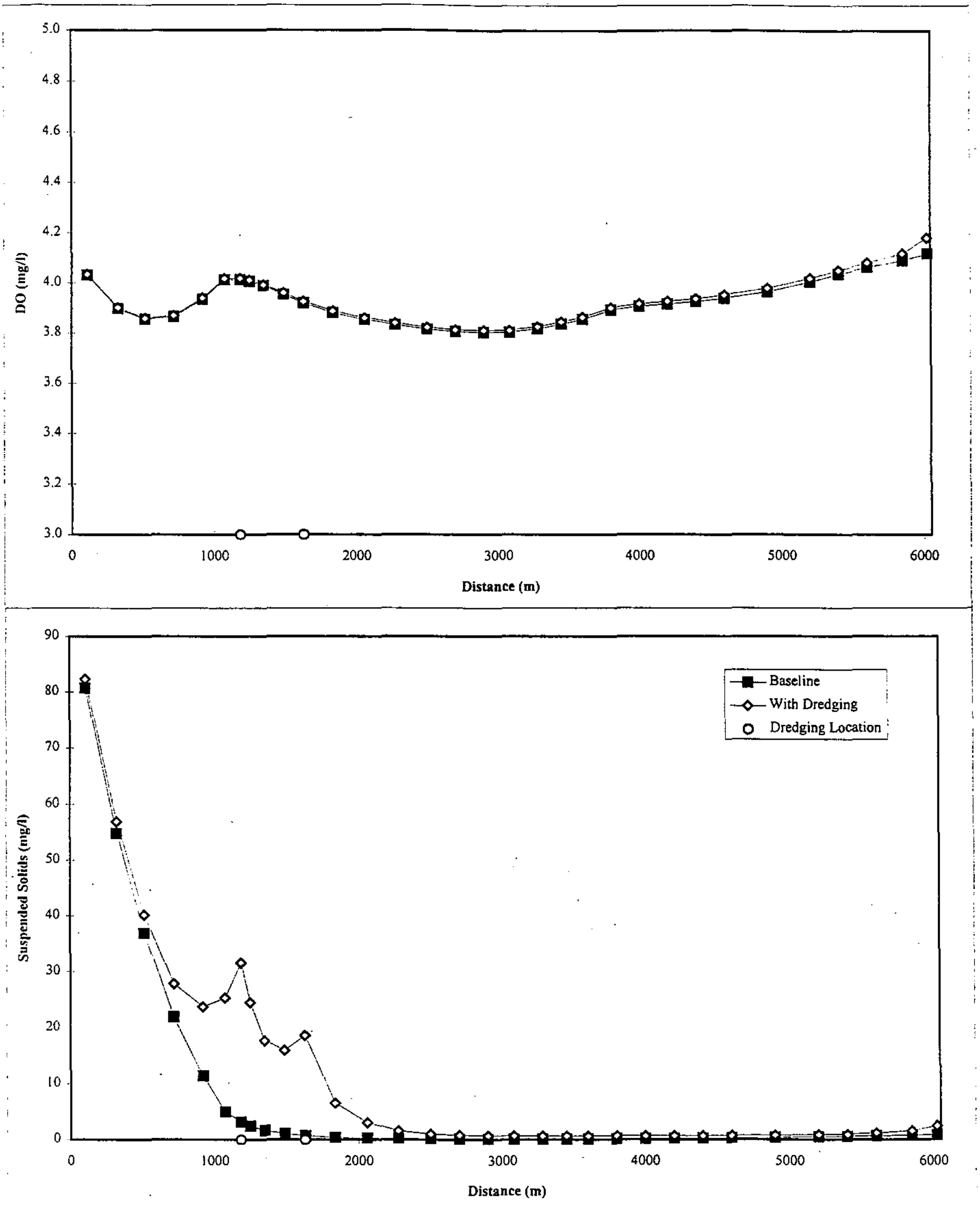

FIGURE A2.2a SHING MUN CHANNEL LONGITUDINAL WATER QUALITY
BASELINE AND WITH DREDGING SCENARIOS 13/1/96 09:00
DISSOLVED OXYGEN (DO) & SUSPENDED SOLIDS CONCENTRATIONS

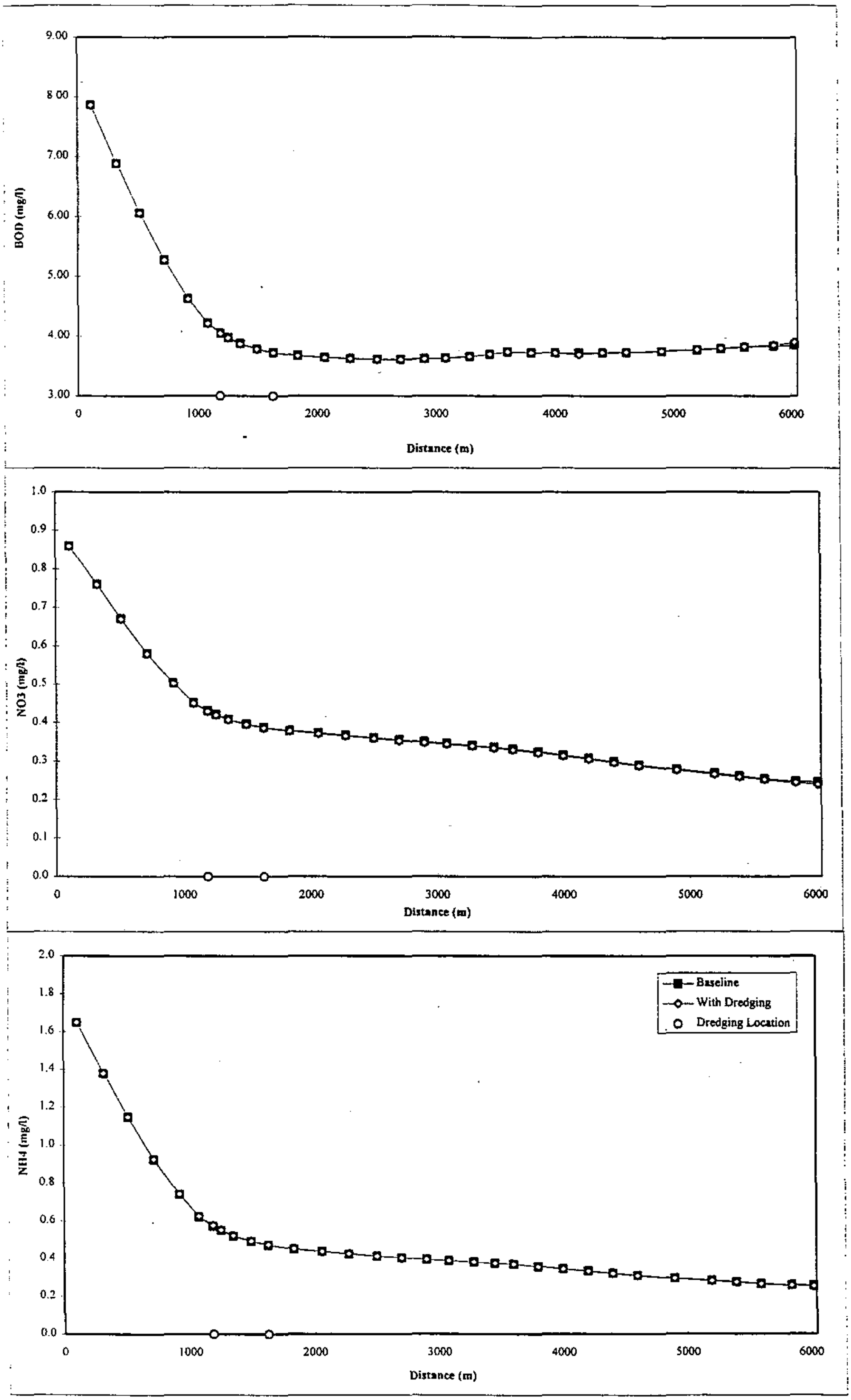

FIGURE A2.2b SHING MUN CHANNEL LONGITUDINAL WATER QUALITY
BASELINE AND WITH DREDGING SCENARIOS 13/1/96 0900
BIOCHEMICAL OXYGEN DEMAND (BOD), NITRATE (NO3) AND AMMONIACAL NITROGEN (NH4) CONCENTRATIONS

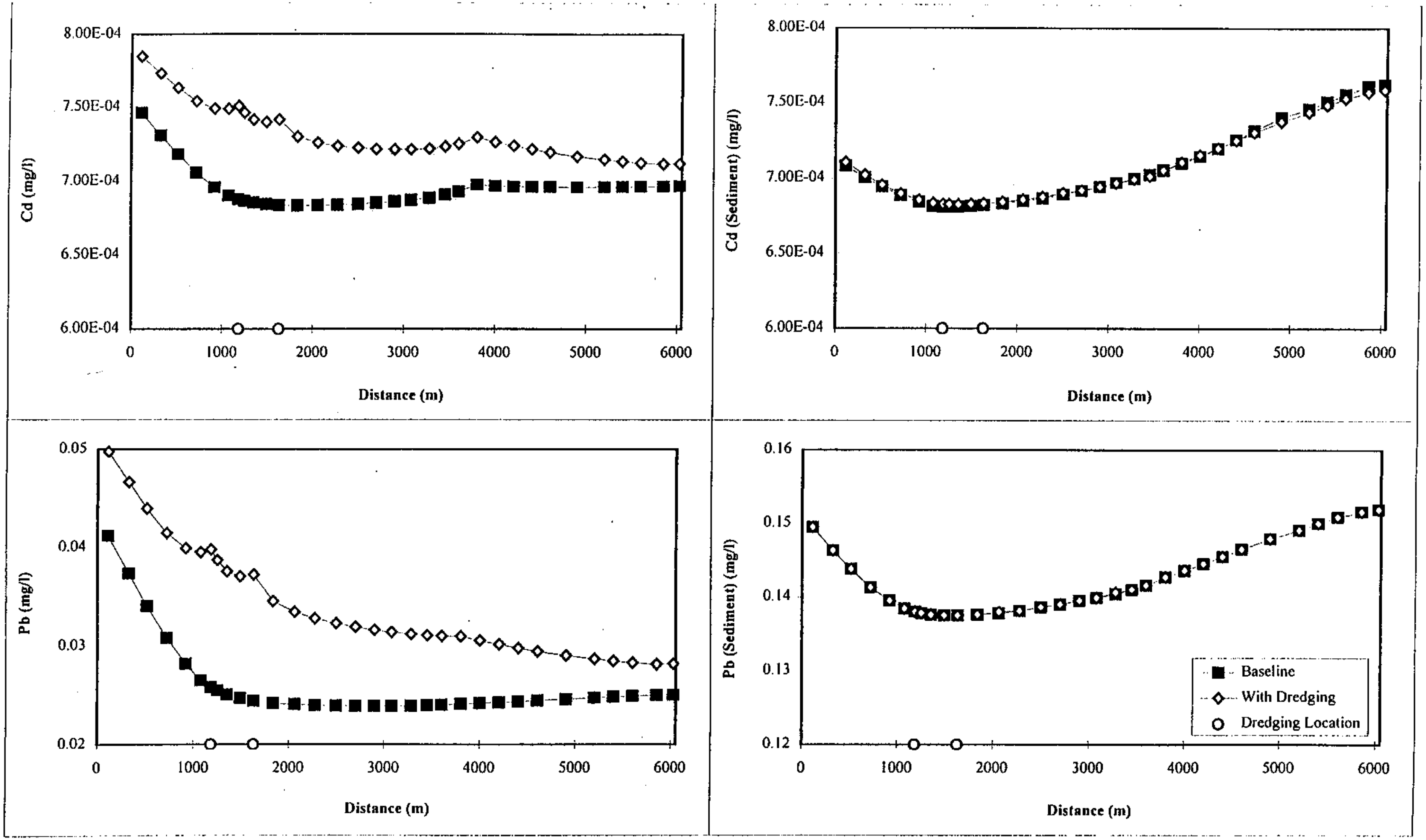

FIGURE A2.2c SHING MUN CHANNEL LONGITUDINAL WATER QUALITY
BASELINE AND WITH DREDGING SCENARIOS 13/1/96 09:00
CADMIUM (Cd) & LEAD (Pb) TOTAL (dissolved & particulate) AND SEDIMENT CONCENTRATIONS

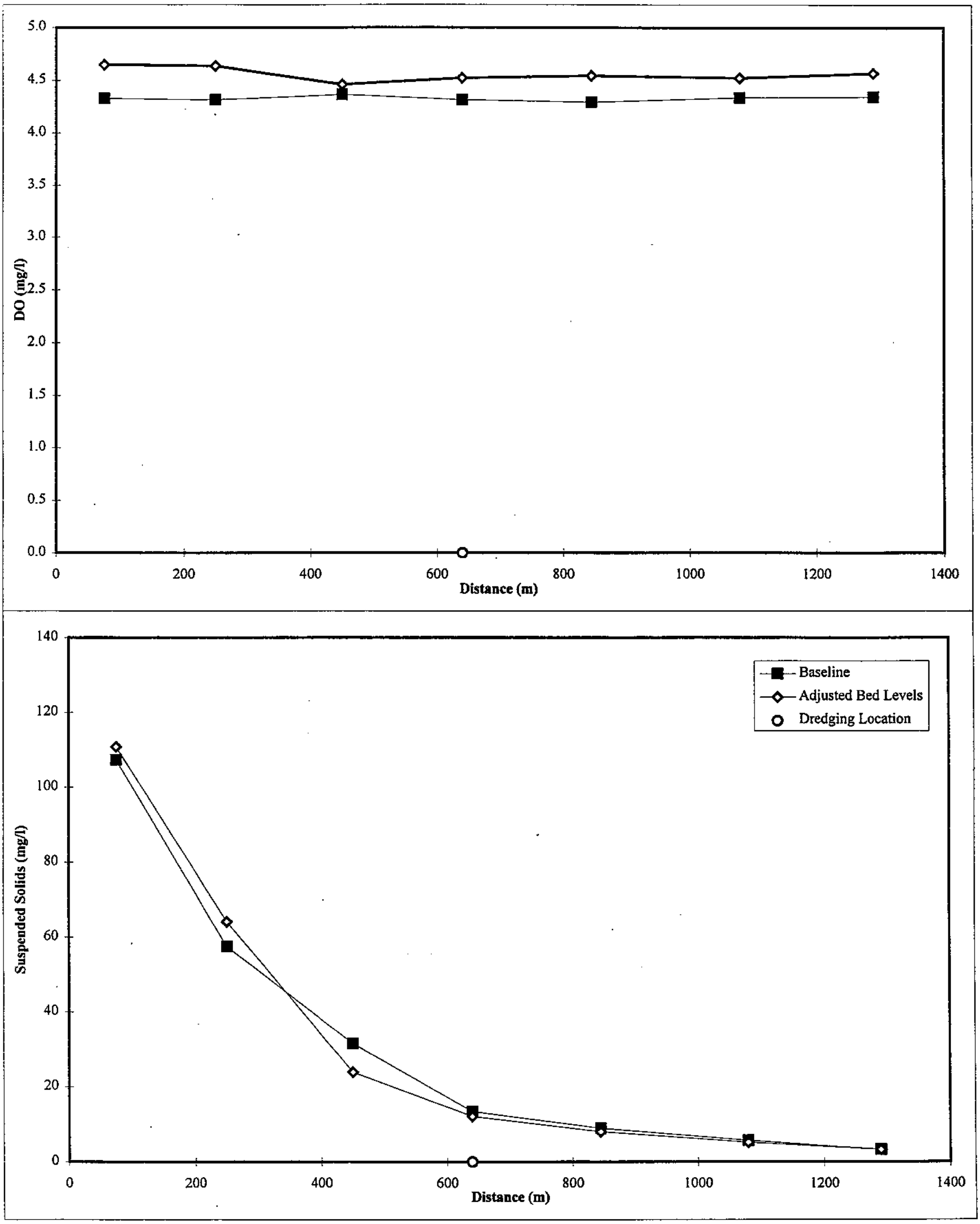

FIGURE A2.3a TAI PO CHANNEL LONGITUDINAL WATER QUALITY
BASELINE AND ADJUSTED BED LEVEL SCENARIOS 13/1/96 07:00
DISSOLVED OXYGEN (DO) & SUSPENDED SOLIDS CONCENTRATIONS

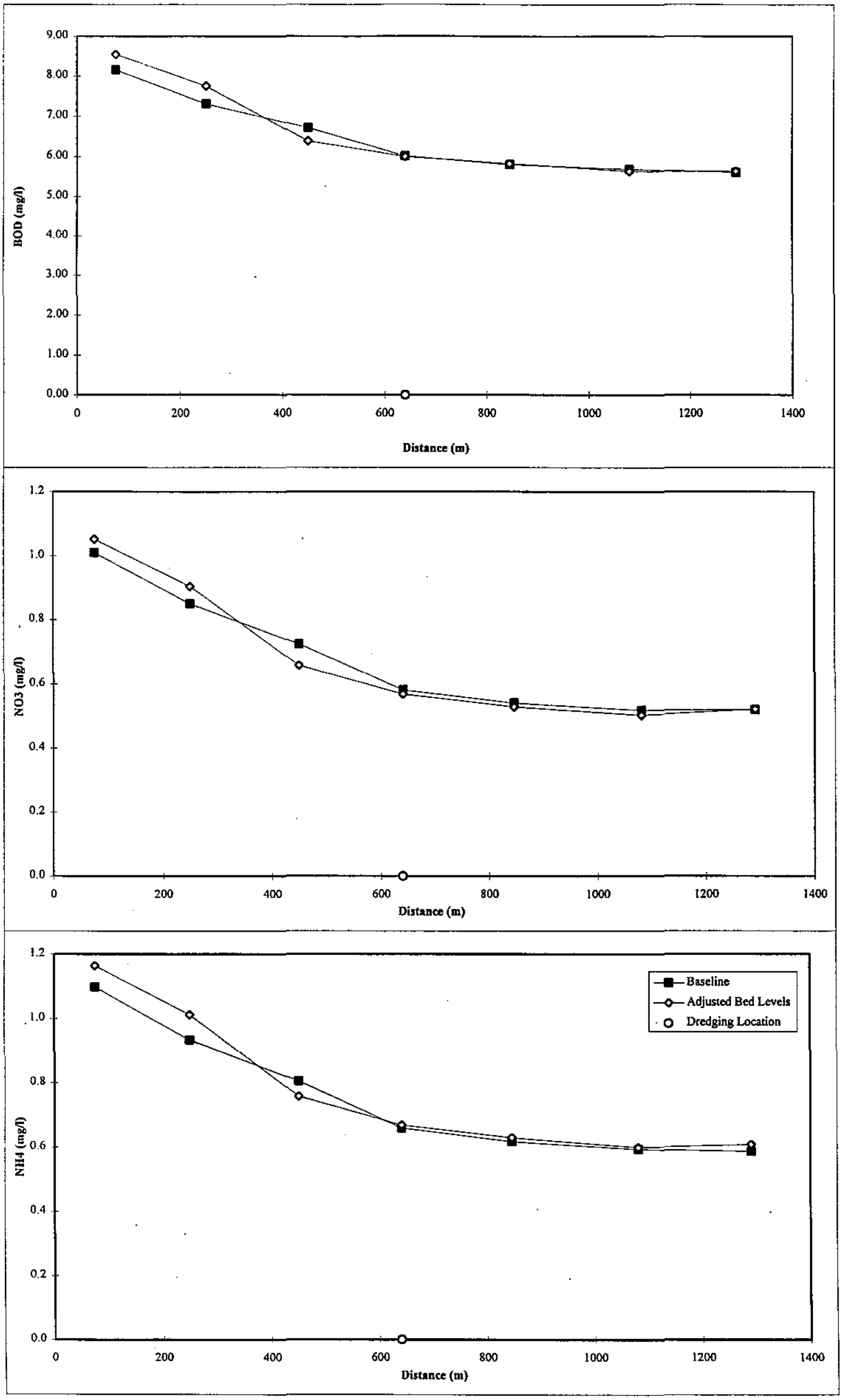

FIGURE A2.3b TAI PO CHANNEL LONGITUDINAL WATER QUALITY
BASELINE AND ADJUSTED BED LEVEL SCENARIOS 13/1/96 0700
BIOCHEMICAL OXYGEN DEMAND (BOD), NITRATE (NO3) AND AMMONIACAL NITROGEN (NH4) CONCENTRATIONS

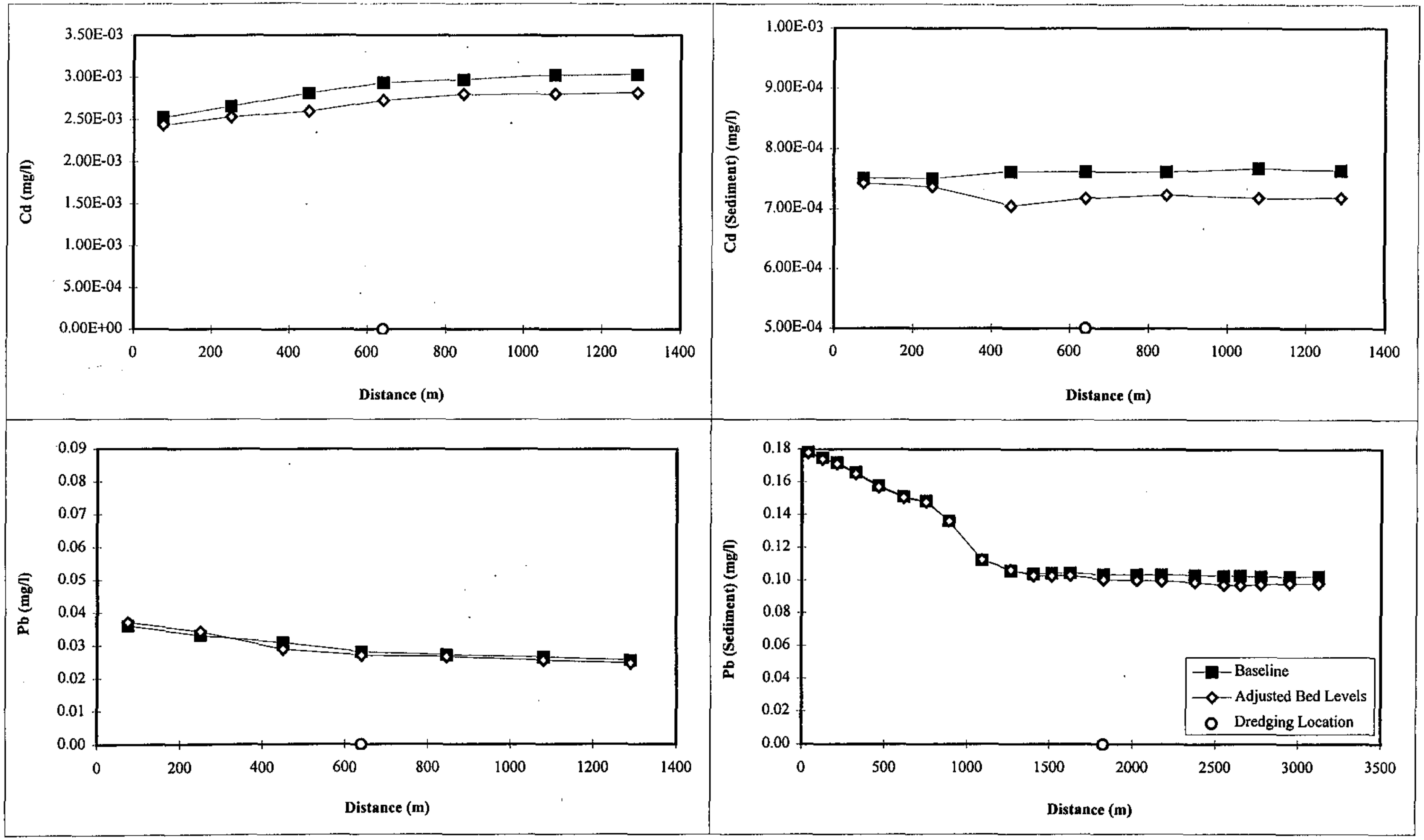

FIGURE A2.3c TAI PO CHANNEL LONGITUDINAL WATER QUALITY
BASELINE AND ADJUSTED BED LEVEL SCENARIOS 13/1/96 07:00
CADMIUM (Cd) & LEAD (Pb) TOTAL (dissolved & particulate) AND SEDIMENT CONCENTRATIONS

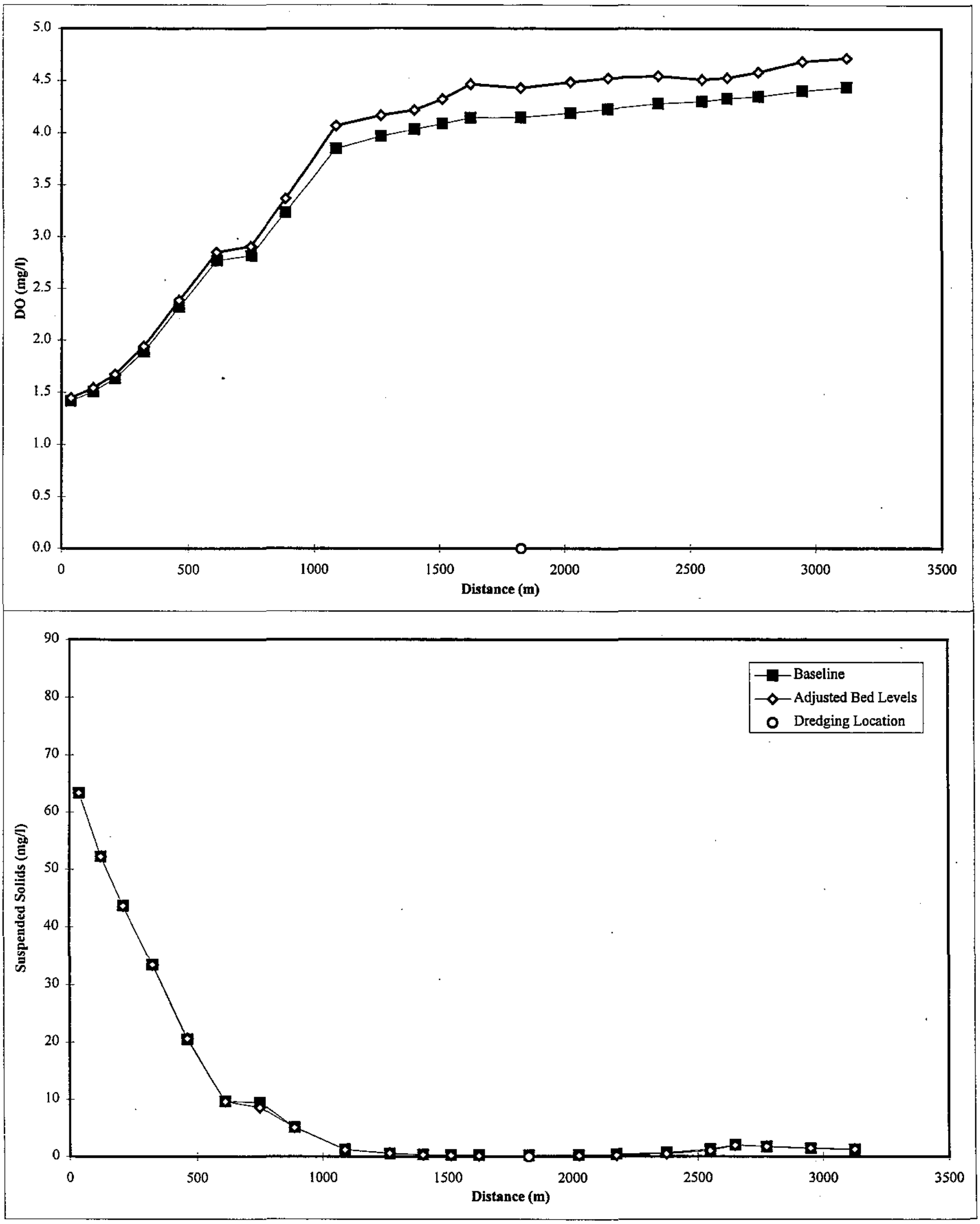

FIGURE A2.4a LAM TSUEN CHANNEL LONGITUDINAL WATER QUALITY
BASELINE AND ADJUSTED BED LEVEL SCENARIOS 13/1/96 07:00
DISSOLVED OXYGEN (DO) & SUSPENDED SOLIDS CONCENTRATIONS

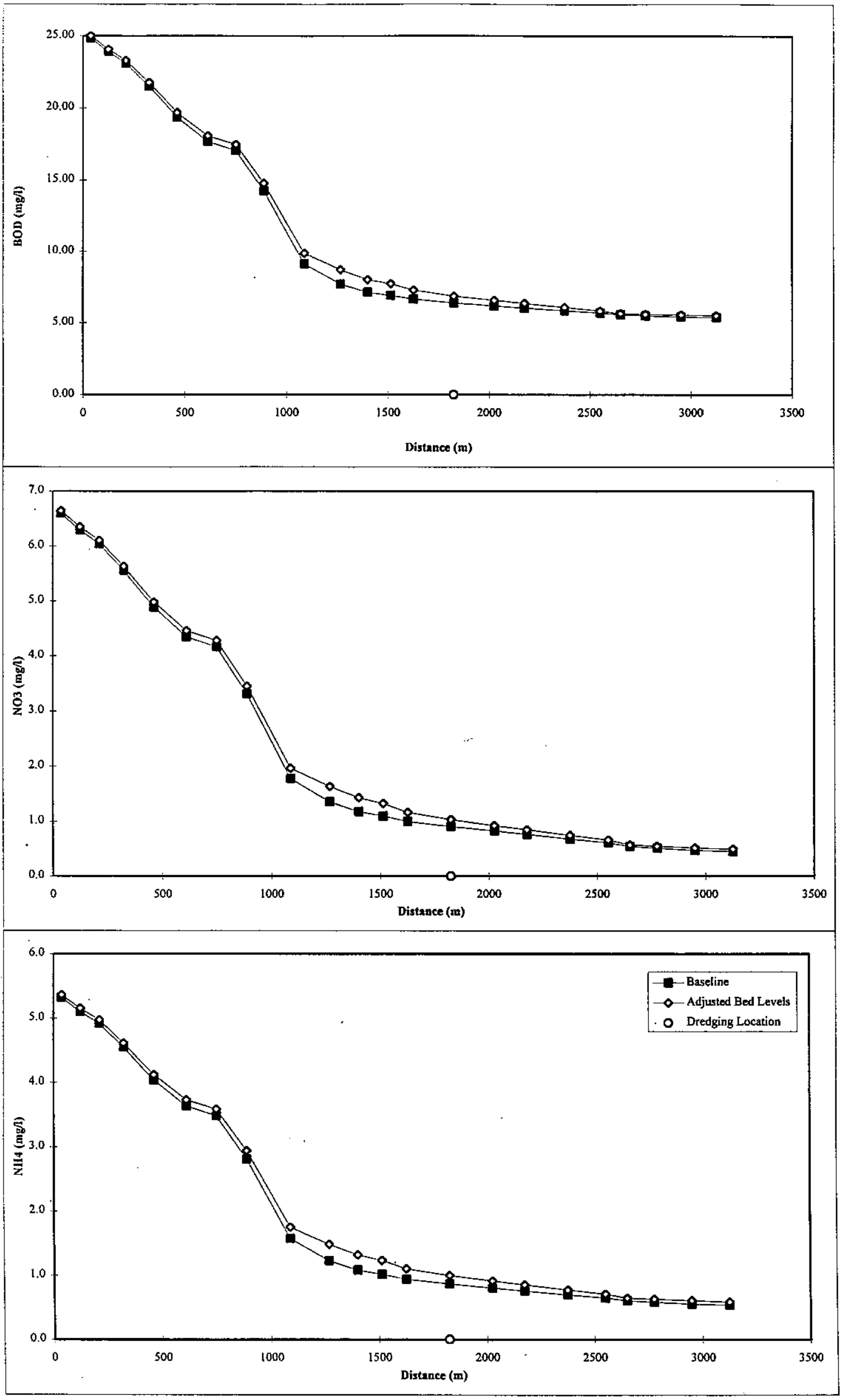

FIGURE A2.4b LAM TSUEN CHANNEL LONGITUDINAL WATER QUALITY
BASELINE AND ADJUSTED BED LEVEL SCENARIOS 13/1/96 0700
BIOCHEMICAL OXYGEN DEMAND (BOD), NITRATE (NO3) AND AMMONIACAL NITROGEN (NH4) CONCENTRATIONS

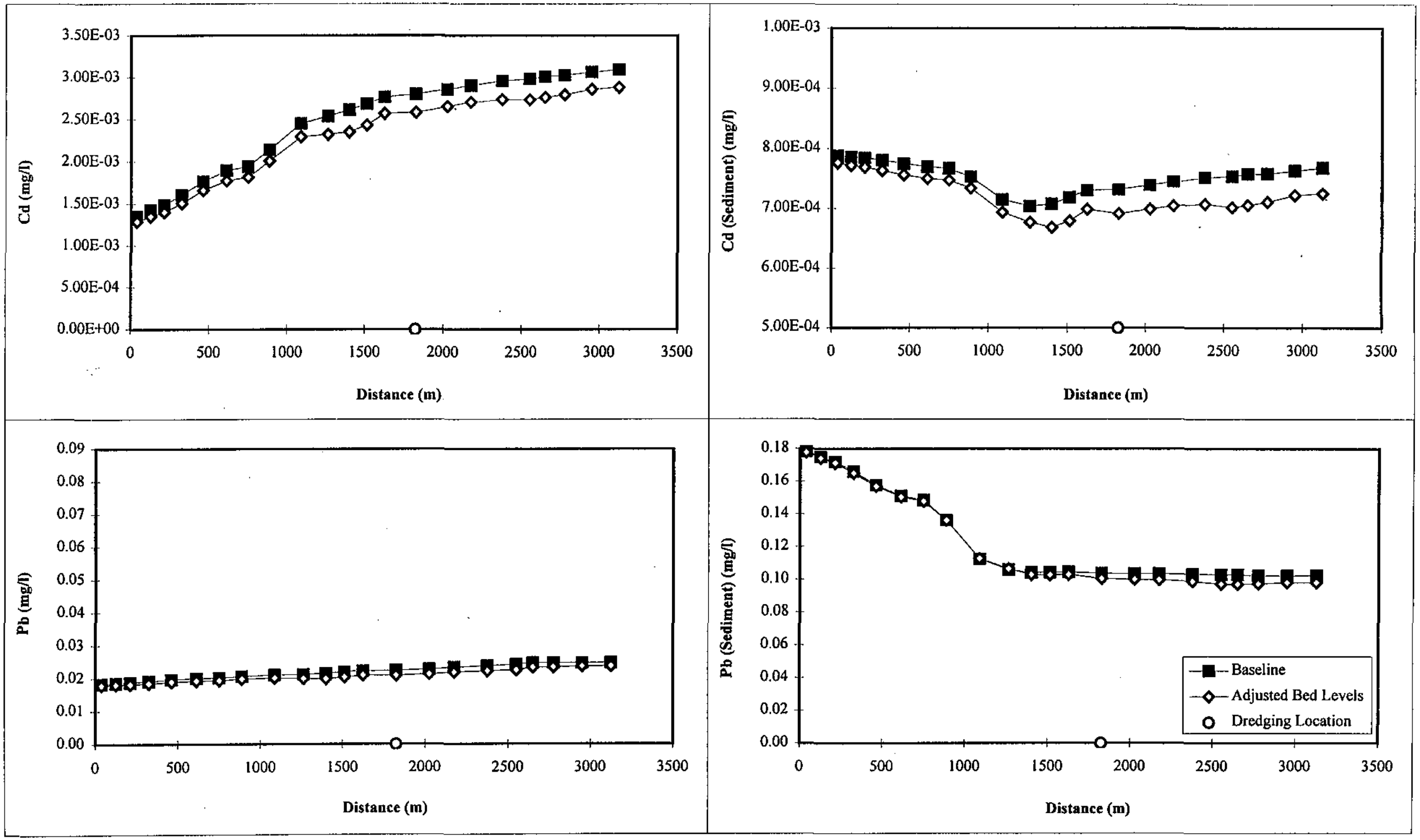

FIGURE A2.4c LAM TSUEN CHANNEL LONGITUDINAL WATER QUALITY
BASELINE AND ADJUSTED BED LEVEL SCENARIOS 13/1/96 07:00
CADMIUM (Cd) & LEAD (Pb) TOTAL (dissolved & particulate) AND SEDIMENT CONCENTRATIONS

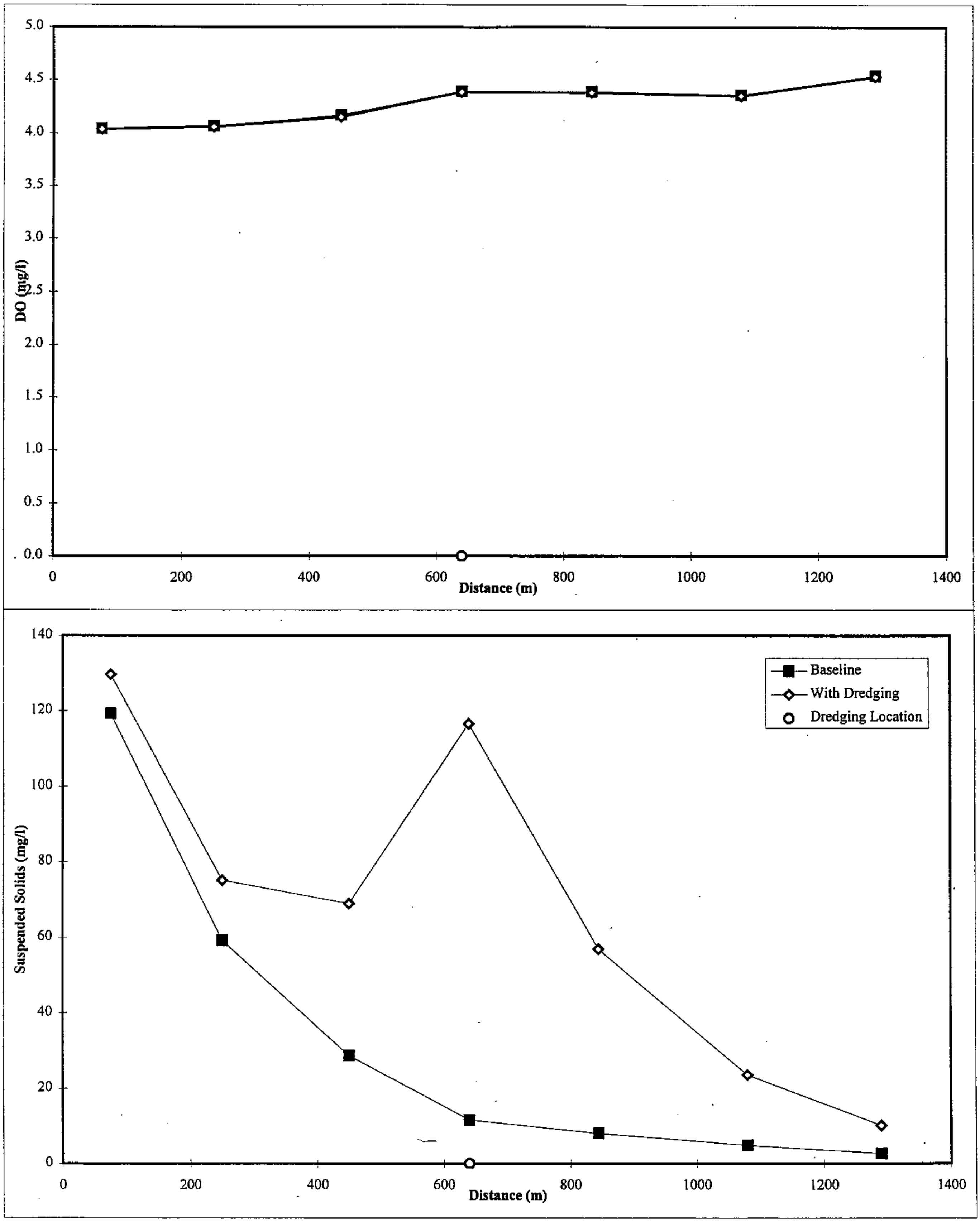

FIGURE A2.5a TAI PO CHANNEL LONGITUDINAL WATER QUALITY
BASELINE AND WITH DREDGING SCENARIOS 13/1/96 09:00
DISSOLVED OXYGEN (DO) & SUSPENDED SOLIDS CONCENTRATIONS

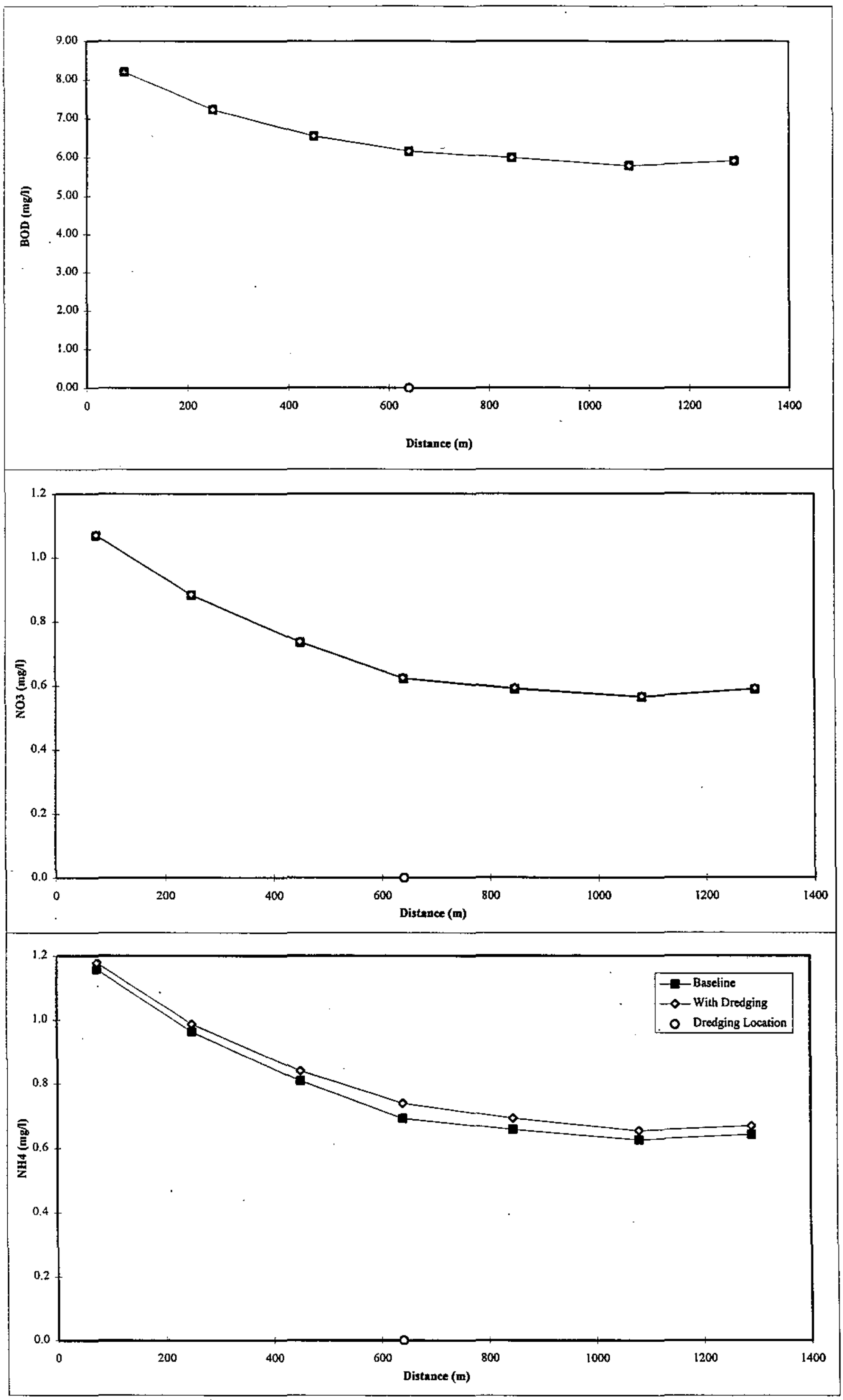

FIGURE A2.5b TAI PO CHANNEL LONGITUDINAL WATER QUALITY
BASELINE AND WITH DREDGING SCENARIOS 13/1/96 09:00
BIOCHEMICAL OXYGEN DEMAND (BOD), NITRATE (NO3) AND AMMONIACAL NITROGEN (NH4) CONCENTRATIONS

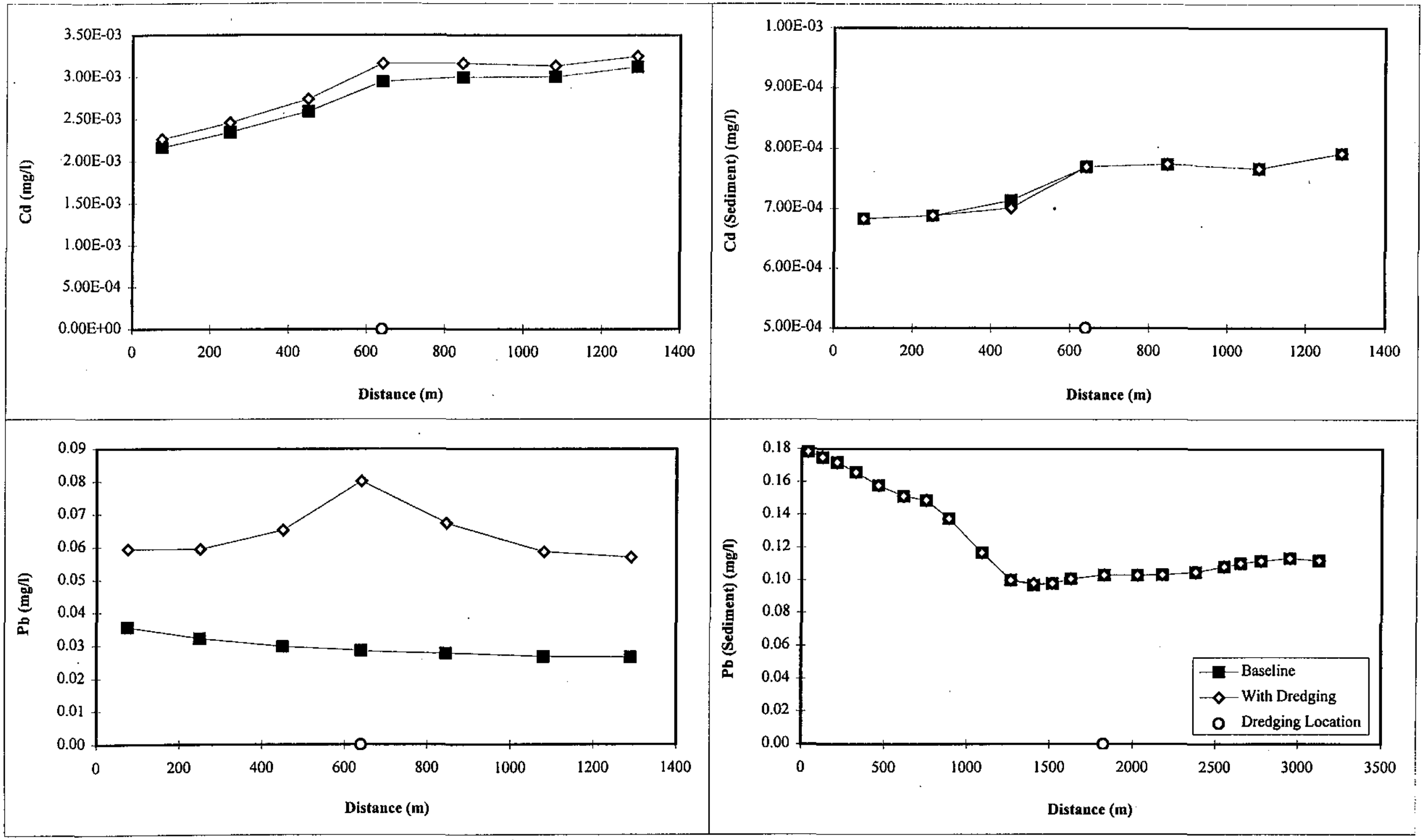

FIGURE A2.5c TAI PO CHANNEL LONGITUDINAL WATER QUALITY
BASELINE AND WITH DREDGING SCENARIOS 13/1/96 09:00
CADMIUM (Cd) & LEAD (Pb) TOTAL (dissolved & particulate) AND SEDIMENT CONCENTRATIONS

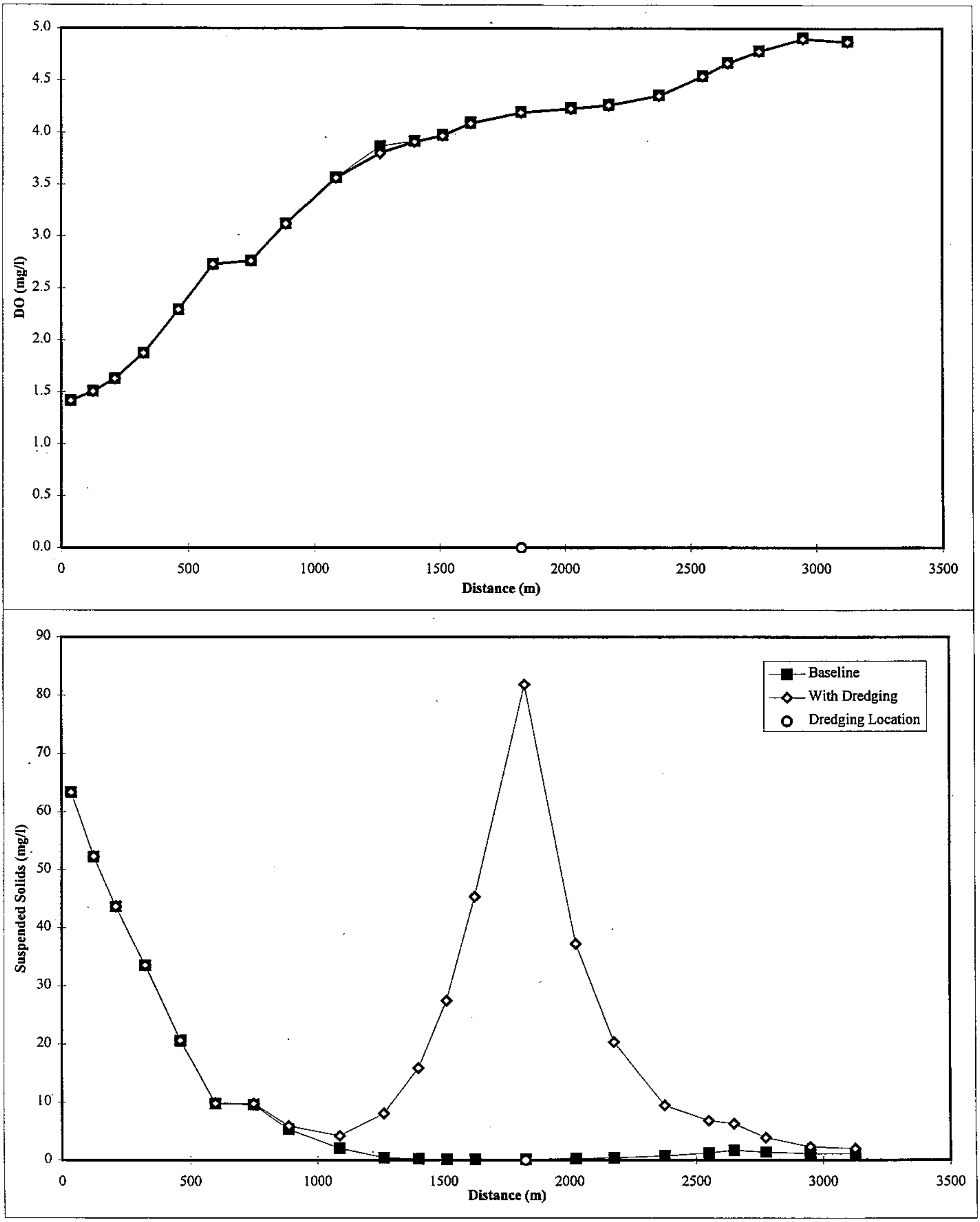

FIGURE A2.6a LAM TSUEN CHANNEL LONGITUDINAL WATER QUALITY
BASELINE AND WITH DREDGING SCENARIOS 13/1/96 09:00
DISSOLVED OXYGEN (DO) & SUSPENDED SOLIDS CONCENTRATIONS

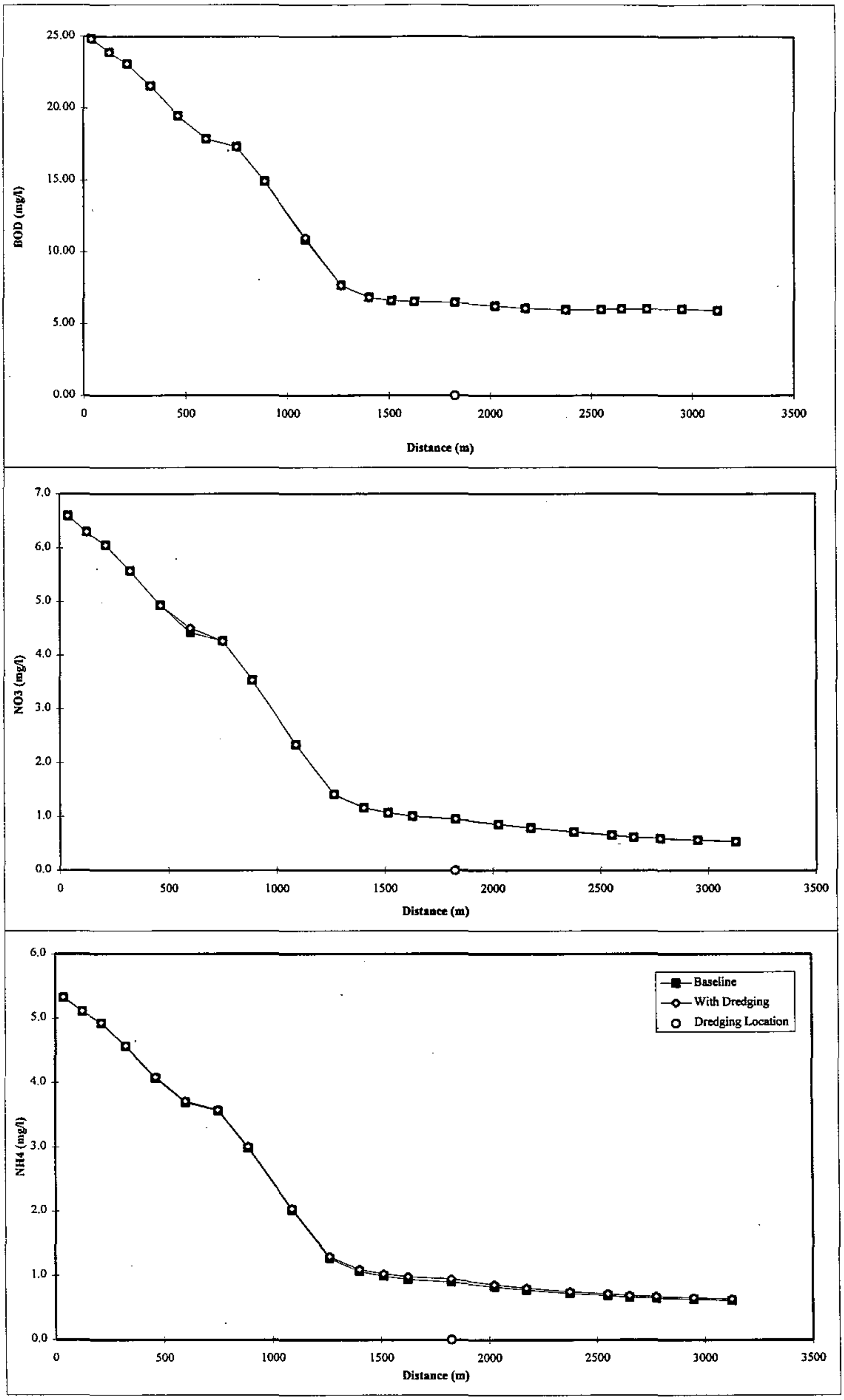

FIGURE A2.6b LAM TSUEN CHANNEL LONGITUDINAL WATER QUALITY
BASELINE AND WITH DREDGING SCENARIOS 13/1/96 09:00
BIOCHEMICAL OXYGEN DEMAND (BOD), NITRATE (NO3) AND AMMONIACAL NITROGEN (NH4) CONCENTRATIONS

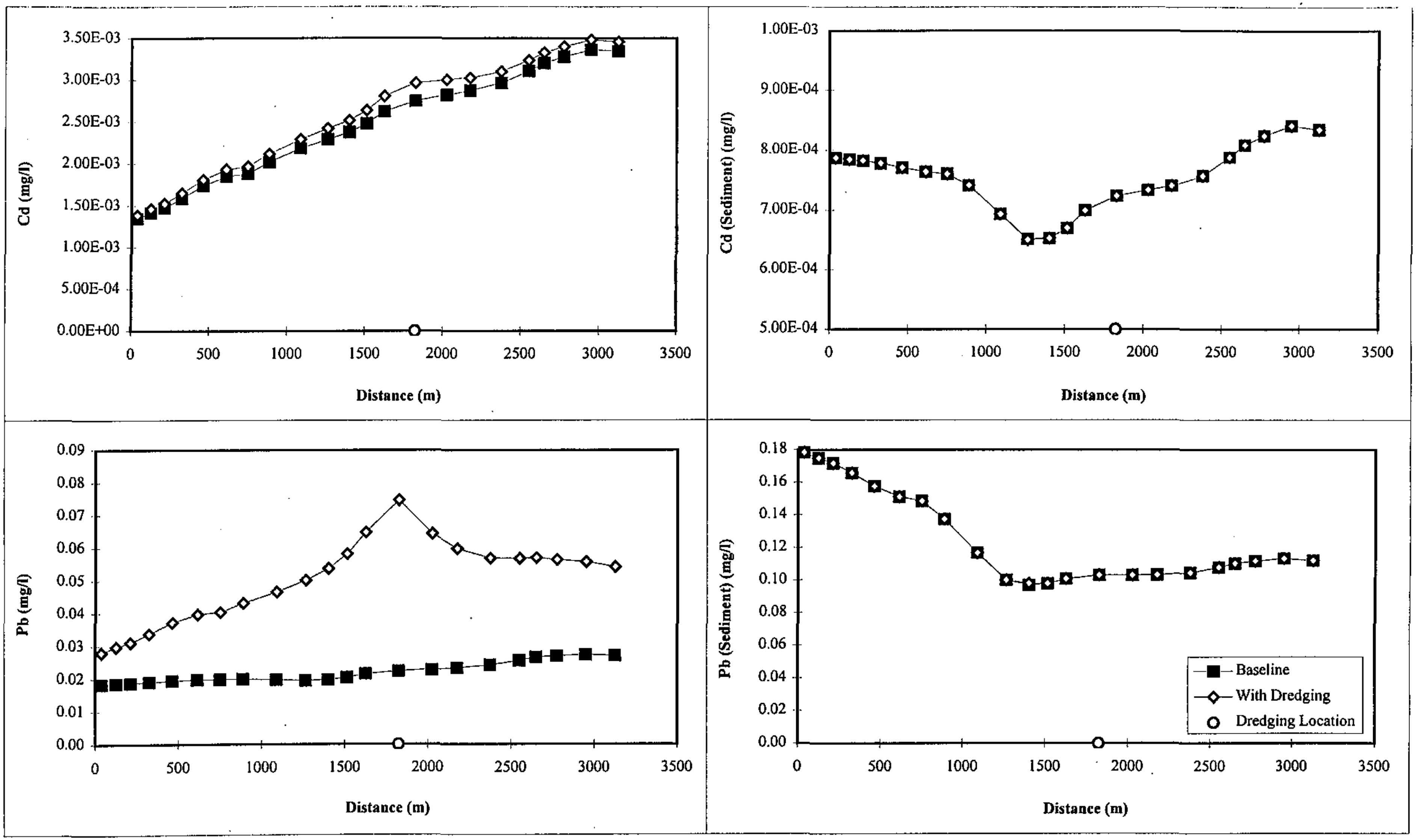

FIGURE A2.6c LAM TSUEN CHANNEL LONGITUDINAL WATER QUALITY
BASELINE AND WITH DREDGING SCENARIOS 13/1/96 09:00
CADMIUM (Cd) & LEAD (Pb) TOTAL (dissolved & particulate) AND SEDIMENT CONCENTRATIONS

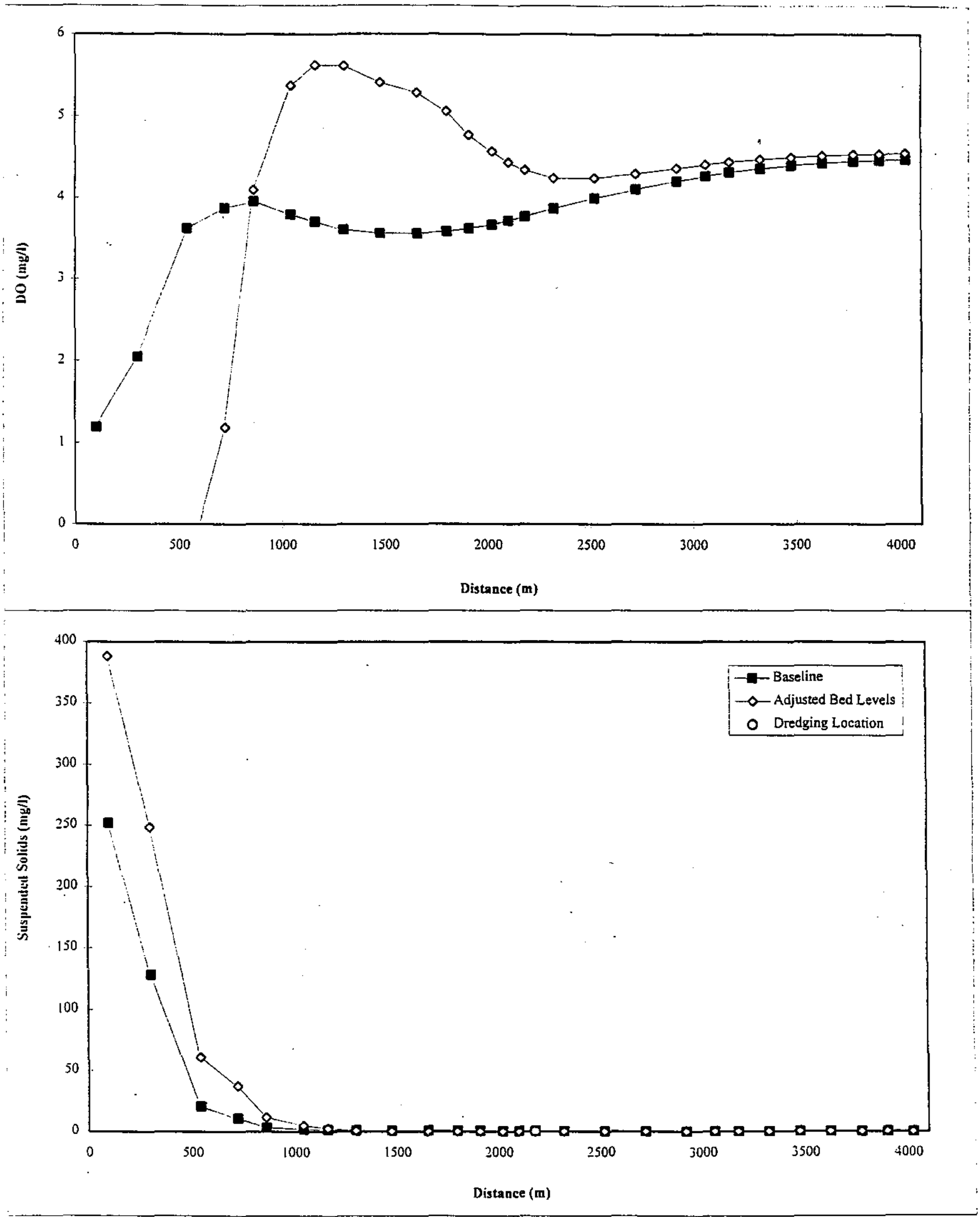

FIGURE A2.7a TUEN MUN CHANNEL LONGITUDINAL WATER QUALITY
BASELINE AND ADJUSTED BED LEVEL SCENARIOS 13/1/96 07:00
DISSOLVED OXYGEN (DO) & SUSPENDED SOLIDS CONCENTRATIONS

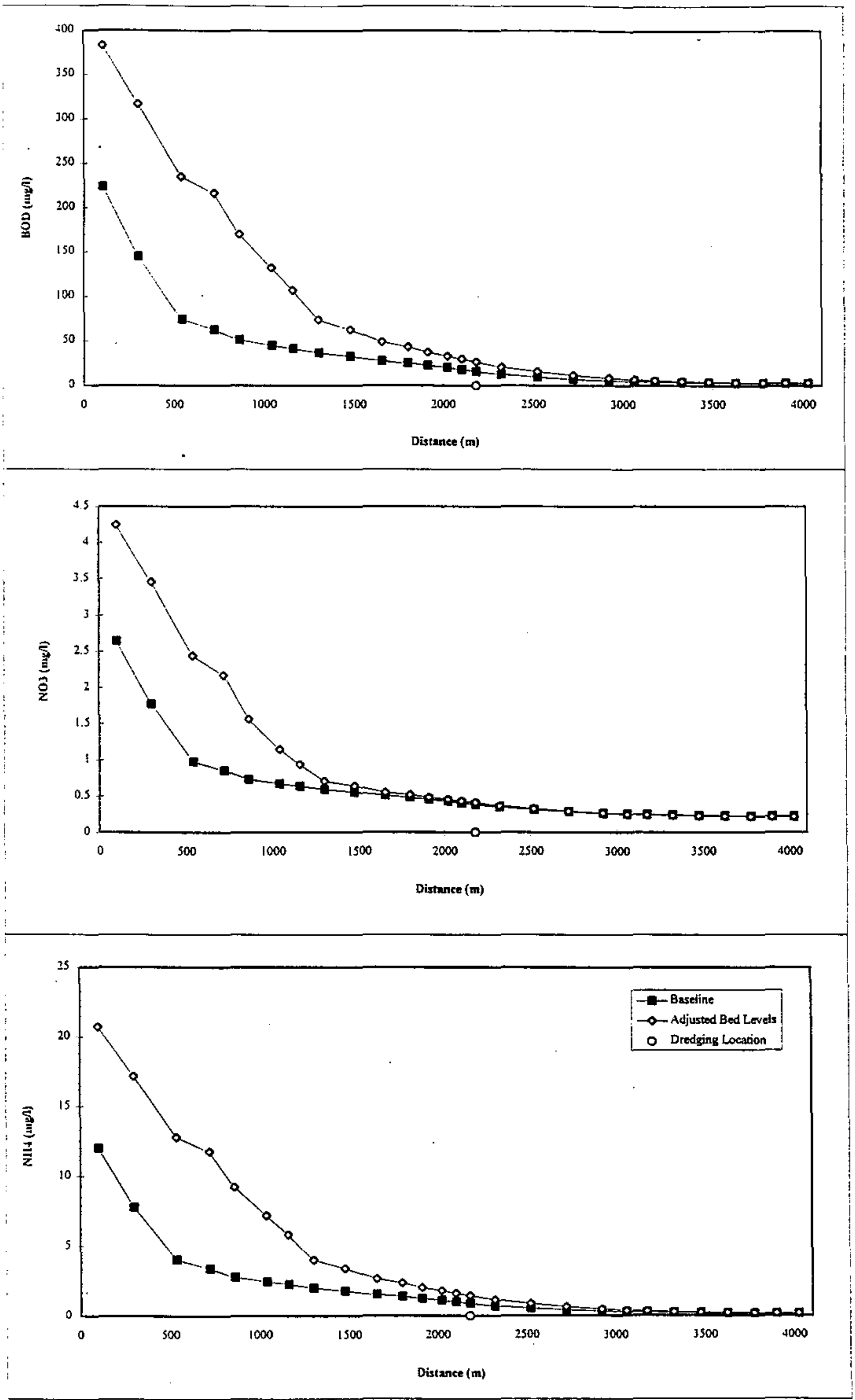

FIGURE A2.7b TUEN MUN CHANNEL LONGITUDINAL WATER QUALITY
BASELINE AND ADJUSTED BED LEVEL SCENARIONS 13/1/96 07:00
BIOCHEMICAL OXYGEN DEMAND (BOD), NITRATE (NO3) AND AMMONIACAL NITROGEN (NH4) CONCENTRATIONS

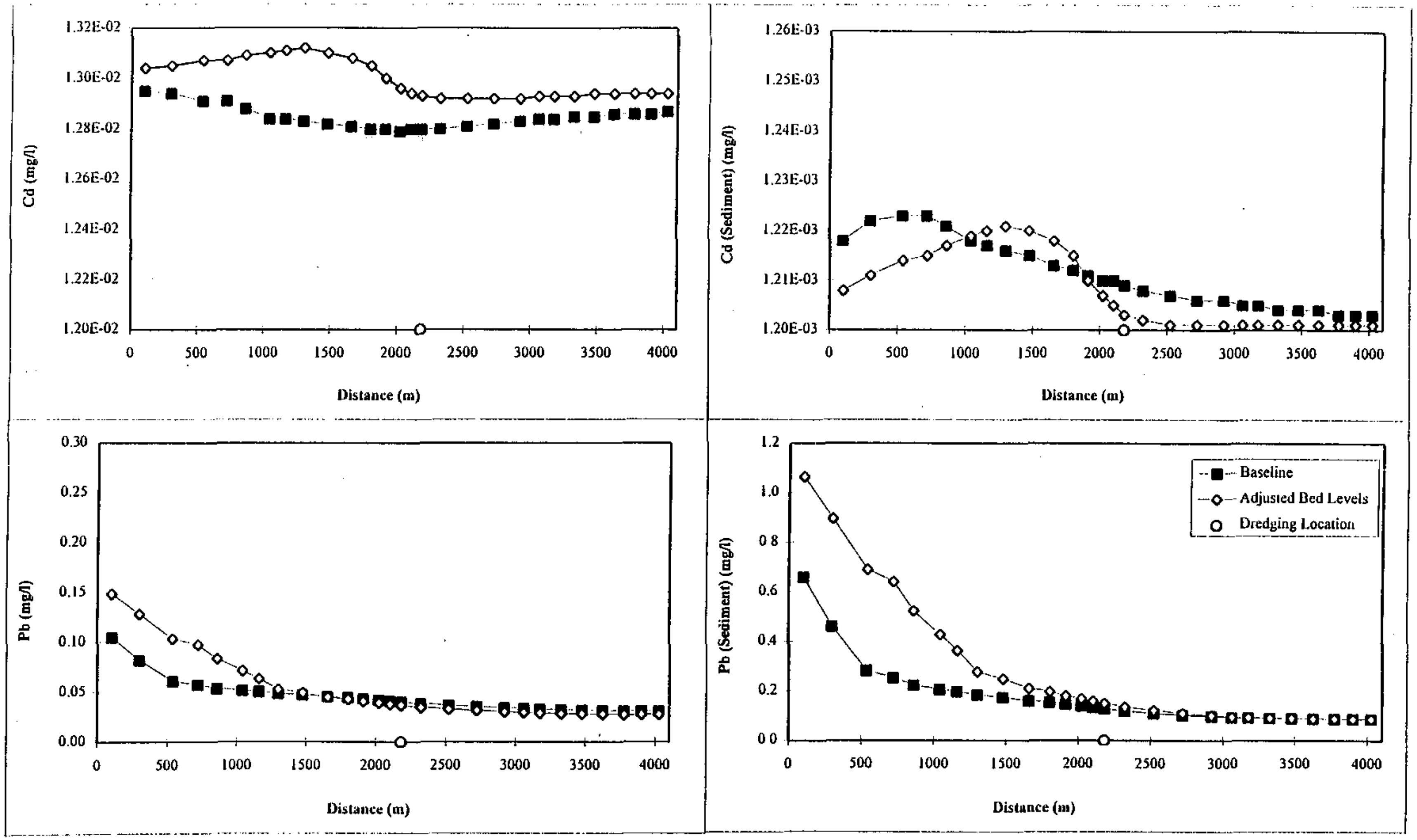

FIGURE A2.7c TUEN MUN CHANNEL LONGITUDINAL WATER QUALITY
BASELINE AND ADJUSTED BED LEVEL SCENARIOS 13/1/96 07:00
CADMIUM (Cd) & LEAD (Pb) TOTAL (dissolved & particulate) AND SEDIMENT CONCENTRATIONS

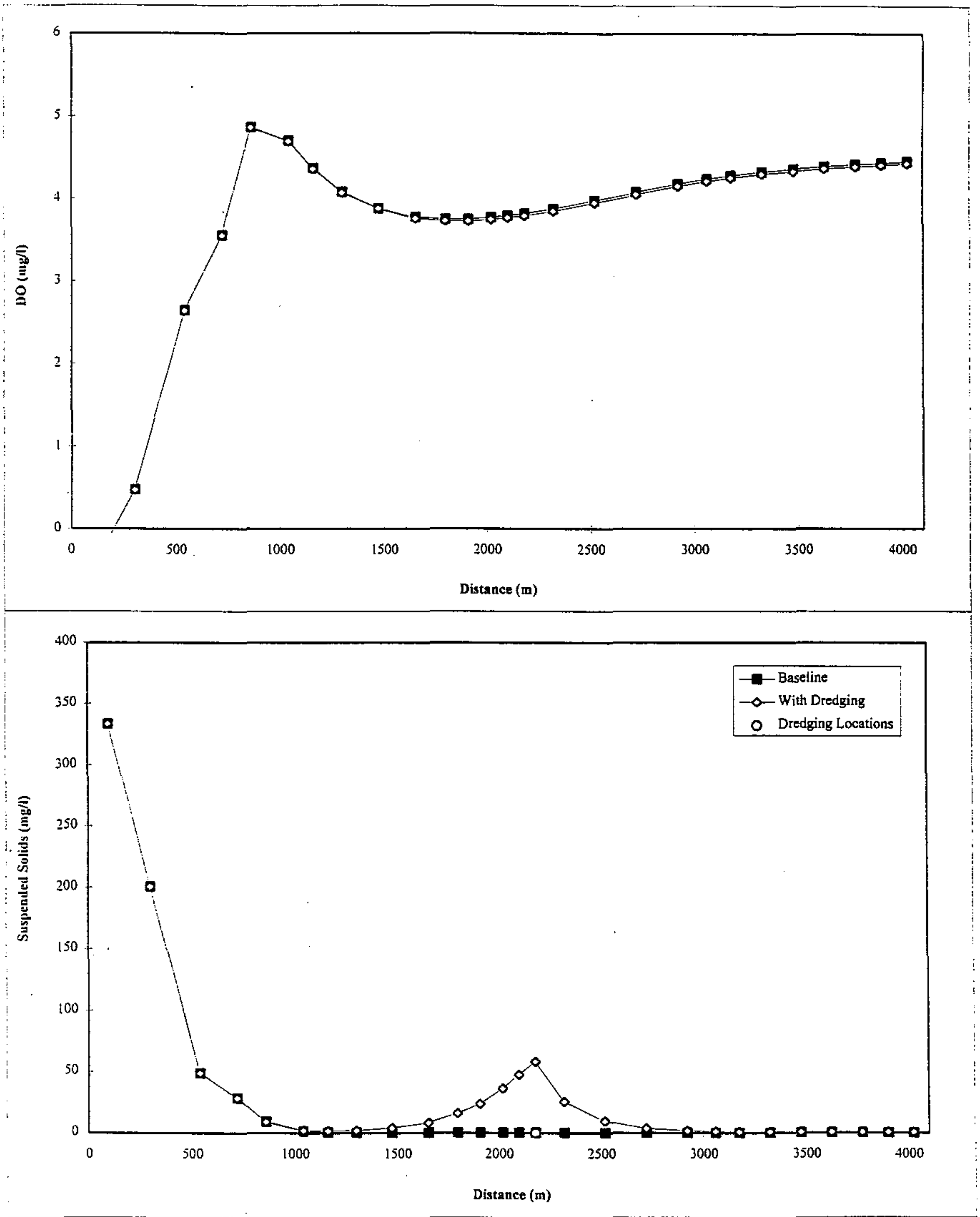

FIGURE A2.8a TUEN MUN CHANNEL LONGITUDINAL WATER QUALITY
BASELINE AND WITH DREDGING SCENARIOS 13/1/96 09:00
DISSOLVED OXYGEN (DO) & SUSPENDED SOLIDS CONCENTRATIONS

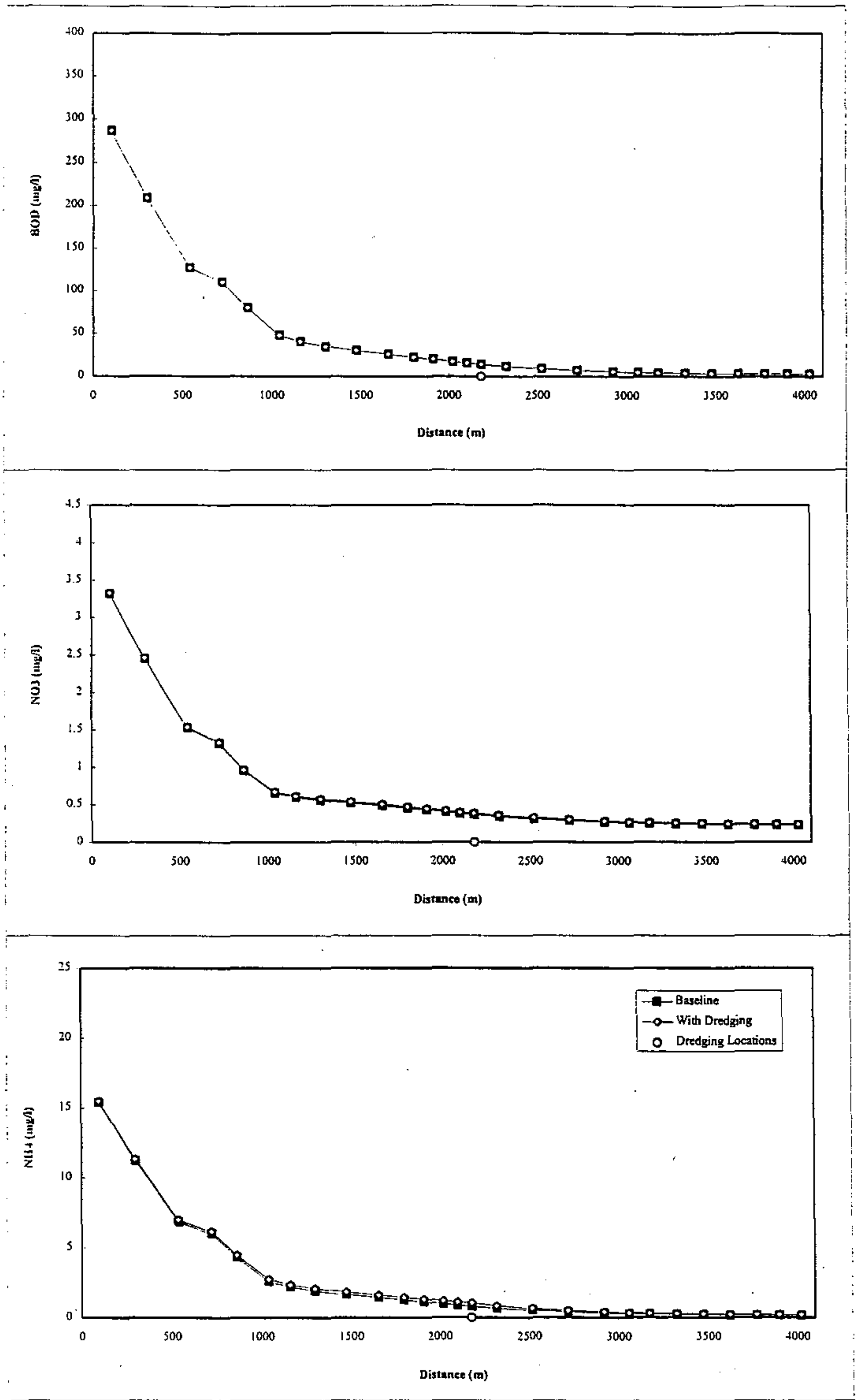

FIGURE A2.8b TUEN MUN CHANNEL LONGITUDINAL WATER QUALITY
BASELINE AND ADJUSTED BED LEVEL SCENARIONS 13/1/96 09:00
BIOCHEMICAL OXYGEN DEMAND (BOD), NITRATE (NO3) AND AMMONIACAL NITROGEN (NH4) CONCENTRATIONS

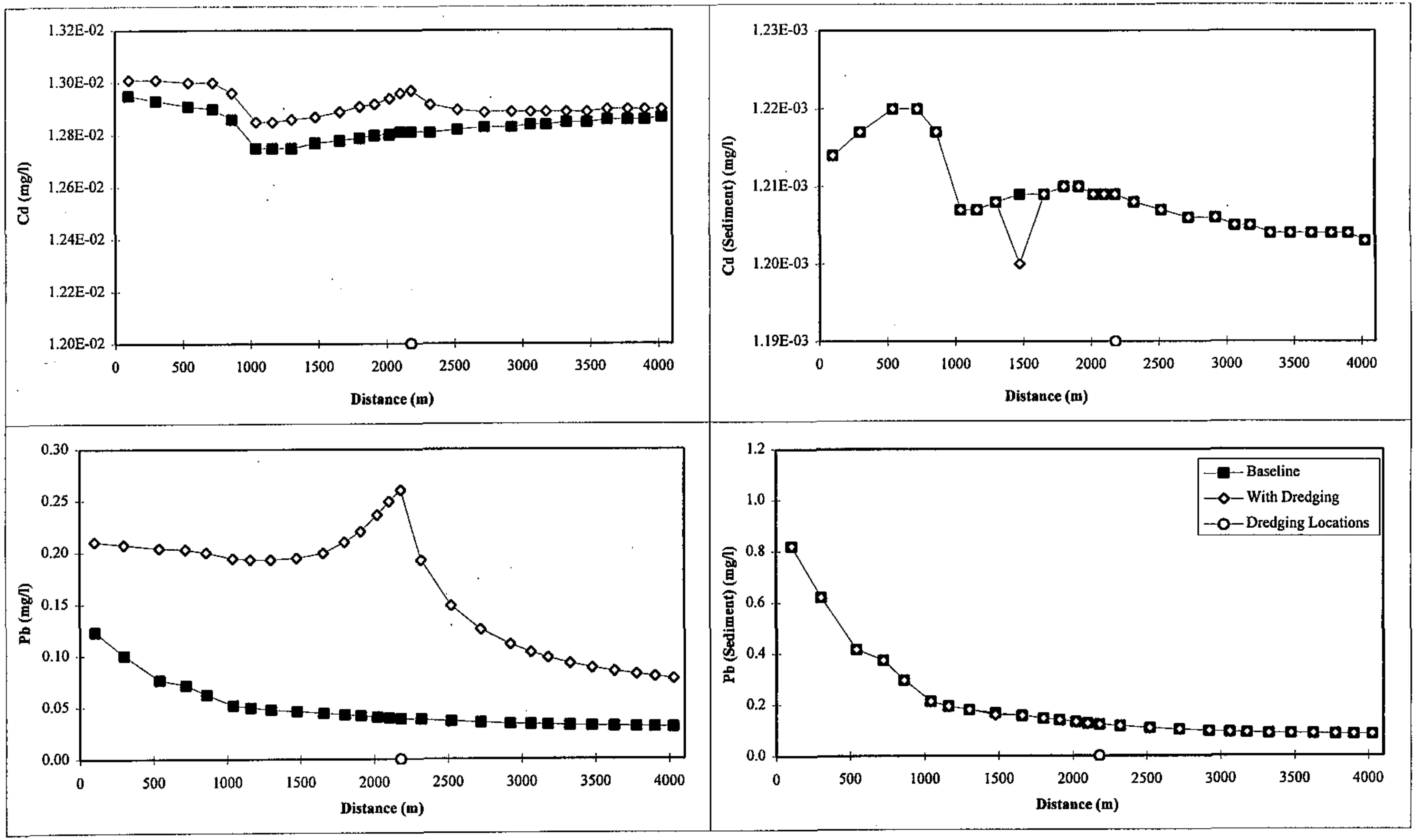

FIGURE A2.8c TUEN MUN CHANNEL LONGITUDINAL WATER QUALITY
BASELINE AND WITH DREDGING SCENARIOS 13/1/96 09:00
CADMIUM (Cd) & LEAD (Pb) TOTAL (dissolved & particulate) AND SEDIMENT CONCENTRATIONS

APPENDIX A3

WATER QUALITY MONITORING METHODOLOGY

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MateriaLab

Water Quality Survey April 15th to 18th 1996.

Introduction.

On behalf of Acer Consultants MateriaLab Ltd were asked to obtain water samples from Water Courses through out Hong Kong as the third and final part of The Sedimentation Study. Certain revisions had to be made to the BOQ with regard to laboratory testing and also insitu measurements, due to the delay in this part of the survey an increment on testing rates had to be applied.

Water samples were taken over a thirteen hour period and totalled five samples per location, this was to obtain the correct tide status and conditions for the samples to be taken.

The original schedule that was proposed by Acer Consultants after discussions had to be amended slightly due to the early start time given to River Silver, the survey was then conducted over four days as oppose to a three day period.

	CHANNELS SURVEYED.	Nos. OF LOCATIONS.
1.	Tin Shui Wai.	3
2.	Tuen Mun.	4
3.	River Silver.	2
4.	River Indus.	4
5.	Tai Po.	4
6.	Shing Mun.	4
7.	Sham Tseng.	2

SAMPLE SCHEDULE.

	Location.	Date.	Time period.
1.	River Silver.	15/04/96	5:00am to 6:00pm
2.	Tin Shui Wai & Indus	16/04/96	7:00am to 8:00pm
3.	Tai Po & Shing Mun	17/04/96	7:30am to 8:30pm
4.	Tuen Mun & Sham Tseng	18/04/96	6:45am to 7:45pm

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MateriaLab

Method Statement For Sample Collection Of Surface Water.

Samples were obtained from locations previously chosen by Acer Consultants, the sampling period took a total of four days in which seven channels were sampled.

Procedure.
Water Samples were taken from mid - depth only for determination. The determinants followed were that contained in the revised BQ correspondence dated 12th April 1996.
An automatic water sampler is lowered into the flow and a sample obtained from the desired depth. At this stage the a fraction of the sample is transferred to a vessel where insitu measurements are taken, the remainder is bottled and preserved at 4°C. All samples were returned to the laboratory within eight hours for test procedures to be undertaken.

Equipment.
1. Kahlsico auto water sampler.
2. YSI 30 Salinity meter.
3. YSI 58 Dissolved Oxygen Meter.
4. Montec 3013 spot velocity meter.
5. TOA, P series CM - 11P Conductivity meter.

APPENDIX A4

NOISE AND AIR QUALITY BASELINE SURVEY METHODOLOGY

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MateriaLab

I. Introduction

MateriaLab Ltd. was requested by the Client to provide services for the baseline monitoring on the total suspended particulates (TSP) content in the ambient air and baseline noise monitong for the captioned project. Eight drainage channels/rivers were designated for the monitoring survey. The exact location and monitoring details of each monitoring location were proposed by MateriaLab and agreed by the Client and all other parties concerned. The monitoring locations are as follows.

1. Shing Mun River

   1.1 KCBC Hay Nien Primary School
   Air - On the upper podium just above the Ist floor corridor, closest to Tai Shui Hang Nullah
   Noise - On the roof of the staff housing quarter, facing Tai Shui Hang Nullah

   1.2 Jockey Club Ti - I College
   Air - At the outer side of roundabout, closest to the south bank of Fo Tan Nullah
   Noise - At the far end of the swimming pool, facing the Fo Tan Nullah

2. Tai Po/Lam Tsuen River Channel

   2.1 Wong Shiu Chi Secondary School
   Air - At the roof top of a water tank above the assembly hall of the school
   Noise - At the facade just next to a water tank above the assembly hall, facing the Lam Tsuen channel river

3. San Tin Main Drainage Channel

   3.1 Yan Shau Wai
   Air - At an open concrete yard in front of No. 24 Yan Shau Wai
   Noise - At an open leisure area in front of No. 68 Yan Shau Wai, facing the San Tin Main Drainage Channel

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4. Tin Shui Wai Drainage Channel

   4.1 MFBM Chan Lui Chung Tak Memorial College
   Air - On the roof of Wet Wood Store of the school, closest to the nullah
   Noise - At the roof of the assembly hall of the school, facing the nullah

5. So Kwun Wat Drainage Channel

   5.1 So Kwun Wat
   Air - At the backyard of DD379 Lot 612D, 18 Miles, So Kwun Wat, closest to the river channel
   Noise - At an open lane in front of quarter TM/SKW/B/196 Kar Wo Lei, facing the river channel

6. Tuen Mun River Channel

   6.1 Islamic Secondary School
   Air - On the rooftop of the assembly hall of the school
   Noise - At the roof top of the assembly hall of the school, facing the river channel

7. River Silver

   7.1 Ling Tsui Tau Village
   Air - On the bank of the river, closest to Ling Tsui Tau Village, Mui Wo
   Noise - The SLM is mounted on a 1.2 m high tripod, placed in front of No.1 Ling Tsui Tau Village, Mui Wo, facing the main river

This report presents the baseline air and noise monitoring survey undertaken at San Tin Main Drainage Channels. The details of the monitoring location are as illustrated in the location map in Appendix A.

MateriaLab Ltd. was responsible for the provision of manpower, equipment and other supplies for the satisfactory execution of the above mentioned activity.

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II. Testing Requirements and Work Undertaken

A. Air Monitoring

1. One 24-hour TSP level as measured by the conventional High Volume Sampler is required to be monitored for 7 consecutive days at the designated locations.

2. Meteorological monitoring such as wind speed and wind direction is to be undertaken during the course of air monitoring using a handheld anemometer to be recorded before and after changing of filter paper.

3. The baseline air monitoring work was undertaken from 15/11/1996 to 22/11/1996 for the determination of one 24-hour TSP level for seven consecutive days

4. Calibration of high volume sampler prior to monitoring was undertaken on 15/11/1996 and the result is found in Appendix B.

B. Noise Monitoring

1. Four 30-min Noise Level measurement of L_{eq} , L_{10} and L_{90} per day at different times is to be carried out for 7 consecutive days using a sound level meter.

2. The baseline noise monitoring at this location was udertaken from 15/11/1996 to 21/11/1996 on 7 consecutive days.

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III. Method Statements

1. 24-hour TSP Measurement

The total suspended particulates (TSP) monitoring is to be carried out in accordance with USEPA Standard Method 40 CFR Part 50 Appendix B.

A piece of conditioned and preweighed filter paper is installed inside a high volume sampler. Air is drawn through the filter at a controlled flowrate for a certain sampling period. After sampling, the filter is removed and transported back to the laboratory for reconditioning and reweighing. The weight of retained particlates is determined.

The concentration of total suspended particulate matter in the ambient air is computed as the mass of collected particulate divided by the volume of air sampled, corrected to standard conditions, and is expressed in micrograms per standard cubic meter (µg/std m^3).

2. Noise Level Measurement

The baseline noise monitoring is to be carried out in accordance with the "Technical Memorandum for the Assessment lof Noise From Construction Work other than Percussive Piling issued Pursuant to the Noise Control Orinance".

The Noise Level in terms of Leq, L10 and L90 is determined by a direct reading of an integrating sound level meter of Model B&K 2236 complying with International Electrotechnical Commission Publications 651:1979 (Type I) and 804:1985 (Type I).

The measurement is to be made at a position of 1.2 metre above the ground and/or 1 metre from the external facade of buildings at each of the assessment point identified as Noise Sensitive Receiver.

Immediately prior to and following each set of readings, the accuracy of sound level meter is checked using an acoustic calibrator of Model B&K 4230, generating a known sound pressure level at a known frequency. Measurement may be accepted as valid only if the calibration levels from before and after the noise measurement agree to within 1.0 dB

Noise measurements should not be made in the presence of fog, rain, wind with a steady speed exceeding 5 m/s or wind with gust exceeding 10 m/s.

APPENDIX A5

NOISE CALCULATION SPREADSHEET

Ref.	River	Works Area	NSR	Description	ASR	Daytime guideline, dB(A	Evening ANL, dB(A)	Night-time ANL, dB(A)	PME	I.D. Code	SWL. dB(A)	Dist (m	Dist. Att dB(A)	PNL (F.Corr.) by each PME.	F. PNL (F. Corr), dB(A)
A	River Silver	Conference	A1	Dwelling to the north of Ngan Shu St.	A	75	63	48	grab	CNP 063	112	55	43	72	77
									bulldozer	CNP 030	115	55	43	75	
A	River Silver	Conference	A2	Dwelling to the west Old Watch Tower	A	75	63	48	grab	CNP 063	112	55	43	72	77
									bulldozer	CNP 030	115	55	43	75	
A	River Silver	Conference	A3	Ngan Wan Estate	A	75	63	48	grab	CNP 063	112	170	53	62	67
									bulldozer	CNP 030	115	170	53	65	
A	River Silver	Conference	A4	Dwellings adjacent to Ngan Kwong Wan Rd.	A	75	63	48	grab	CNP 063	112	177	53	62	67
									bulldozer	CNP 030	115	177	53	65	
B	Staunton Creek Nulla	Mouth	B1	Regional Seminary	C	75	70	55	grab/excavator	CNP 063 & 081	112	116	49	66	68
									tug boat	CNP 221	110	116	49	64	
									derrick barge	CNP 061	104	192	54	53	
B	Staunton Creek Nulla	Mouth	B2	Rehabilation Centre	C	75	70	55	grab/excavator	CNP 063 & 081	112	306	58	57	60
									tug boat	CNP 221	110	306	58	55	
									derrick barge	CNP 061	104	429	61	46	
D	Shing Mun River Restoration Dredging	Above Lion Bridge	D1	Shatin Temp. Housing Area	B	75	65	50	grab/excavator	CNP 063 & 081	112	47	41	74	76
									tug boat	CNP 221	110	47	41	72	
D	Shing Mun River Restoration Dredging	Above Lion Bridge	D2	Shatin Public Sec. Sol.	B	70	65	50	grab/excavator	CNP 063 & 081	112	134	51	64	67
									tug boat	CNP 221	110	134	51	62	
D	Shing Mun River Restoration Dredging	Below Lion Bridge	D3	Yue Shing Court	B	75	65	50	grab/excavator	CNP 063 & 081	112	117	49	66	68
									tug boat	CNP 221	110	117	49	64	
D	Shing Mun River Restoration Dredging	Below Lion Bridge	D4	Buddhist Kok Kwong Sec.	B	70	65	50	grab/excavator	CNP 063 & 081	112	117	49	66	68
									tug boat	CNP 221	110	117	49	64	
D	Shing Mun River Restoration Dredging	Below Lion Bridge	D5	Shatin Town Hall	B	75	65	50	grab/excavator	CNP 063 & 081	112	170	53	62	65
									tug boat	CNP 221	110	170	53	60	
D	Shing Mun River Restoration Dredging	Below Lion Bridge	D6	Shatin Centre	B	75	65	50	grab/excavator	CNP 063 & 081	112	200	54	61	63
									tug boat	CNP 221	110	200	54	59	
D	Shing Mun River Restoration Dredging	Below Lion Bridge	D7	Belair Garden	B	75	65	50	grab/excavator	CNP 063 & 081	112	124	50	65	67
									tug boat	CNP 221	110	124	50	63	
D	Shing Mun River Restoration Dredging	Below Lion Bridge	D8	Hip Wo House Wo Che Est.	B	75	65	50	grab/excavator	CNP 063 & 081	112	166	52	63	65
									tug boat	CNP 221	110	166	52	61	
D	Shing Mun River Restoration Dredging	Below Lion Bridge	D9	Shatin Technical Institute	B	70	65	50	grab/excavator	CNP 063 & 081	112	176	53	62	64
									tug boat	CNP 221	110	176	53	60	
D	Shing Mun River Restoration Dredging	Below Lion Bridge	D10	Block 15, City One Shatin	B	75	65	50	grab/excavator	CNP 063 & 081	112	141	51	64	66
									tug boat	CNP 221	110	141	51	62	
D	Shing Mun River Recurrent Dredging	Tai Shui Hang	D11	Chevalier Garden	B	75	65	50	grab/excavator	CNP 063 & 081	112	45	41	74	76
									tug boat	CNP 221	110	45	41	72	
D	Shing Mun River Recurrent Dredging	Tai Shui Hang	D12	Ma On Shan Tsung Tsin Sec. Sol.	B	70	65	50	grab/excavator	CNP 063 & 081	112	80	46	69	71
									tug boat	CNP 221	110	80	46	67	
D	Shing Mun River Recurrent Dredging	Siu Lek Yuen	D13	Block 3, City One	B	75	65	50	grab/excavator	CNP 063 & 081	112	108	49	66	68
									tug boat	CNP 221	110	108	49	64	
D	Shing Mun River Recurrent Dredging	Siu Lek Yuen	D14	Dwellings in Siu Lek Yuen	B	75	65	50	grab/excavator	CNP 063 & 081	112	158	52	63	65
									tug boat	CNP 221	110	158	52	61	
D	Shing Mun River Recurrent Dredging	Fo Tan Nullah (Upper)	D15	Dwelling adjacent to Fotan nullah	B	75	65	50	grab/excavator	CNP 063 & 081	112	67	45	70	73
									tug boat	CNP 221	110	67	45	68	
D	Shing Mun River Recurrent Dredging	Fo Tan Nullah (Upper)	D16	Sui Wo Court	B	75	65	50	grab/excavator	CNP 063 & 081	112	224	55	60	62
									tug boat	CNP 221	110	224	55	58	
D	Shing Mun River Recurrent Dredging	Fo Tan Nullah (Upper)	D17	T.I. College	B	70	65	50	grab/excavator	CNP 063 & 081	112	115	49	66	68
									tug boat	CNP 221	110	115	49	64	
D	Shing Mun River	Fo Tan Nullah (Upper)	D18	Jockey Club Qaurters	B	75	65	50	grab/excavator	CNP 063 & 081	112	236	55	60	62

Ref.	River	Works Area	NSR	Description	ASR	Daytime guideline, dB(A	Evening ANL, dB(A)	Night-time ANL, dB(A)	PME	LD. Code	SWL. dB(A)	Dist (m	Dist, Att dB(A)	PNL (F.Corr.) by each PME.	F. PNL (F. Corr), dB(A)
	Recurrent Dredging								tug boat	CNP 221	110	236	55	58	
E	Tai Po/Lam Tsuen	Tai Po River	E1	Fung Leung Kit Sec. Sch.	B	70	65	50	grab/excavator	CNP 063 & 081	112	30	38	77	77
E	Tai Po/ Lam Tsuen	Lam Tsuen River	E2	Kwong Fuk Est.	B	75	65	50	grab/excavator	CNP 063 & 081	112	150	52	63	64
	Recurrent Dredging								derrick barge	CNP 061	104	150	52	55	
F	River Indus			Nil											
	Existing														
F	River Indus	Near Fu Tei Au Road	F1	Squarters adjacent to	A	75	60	45	dredger,grab	CNP 063	112	66	44	71	74
	Future Scenario			Fu Tei Au Road					excavator	CNP 081	112	66	44	71	
F	River Indus	Near Sheung Shui	F2	Sheung Shui Temporary	A	75	60	45	dredger,grab	CNP 063	112	55	43	72	75
	Future Scenario	Temporary Housing		Housing					excavator	CNP 081	112	55	43	72	
G	San Tin Main Drainag		G1	Yau Shau Wai	A	75	60	45	excavator	CNP 081	112	39	40	75	75
G	San Tin Main Drainag		G2	Tsing Lung Tsuen	A	75	60	45	excavator	CNP 081	112	158	52	63	63
G	San Tin Main Drainag		G3	Villages adjacent Castle Pea	A	75	60	45	excavator	CNP 081	112	158	52	63	63
G	San Tin Main Drainag		G2	Tsing Lung Tsuen	A	75	60	45	excavator	CNP 081	112	175	53	62	62
G	San Tin Main Drainag		G3	Villages adjacent Castle Pea	A	75	60	45	excavator	CNP 081	112	145	51	64	64
G	San Tin Main Drainag		G4	Ha Wan Tsuen	A	75	60	45	excavator	CNP 081	112	220	55	60	60
H	Yuen Long / Kam Tin	Near Fairview Park	H1	Fairview Park	A	75	60	45	grab/excavator	CNP 063 & 081	112	126	50	65	65
H	Yuen Long / Kam Tin	Near Fairview Park	H2	Chuk Yuen Tsuen	A	75	60	45	grab/excavator	CNP 063 & 081	112	121	50	65	65
H	Yuen Long / Kam Tin	To the North of		Nil											
	Ngau Tam Mei	Nam San Wai													
H	Yuen Long / Kam Tin	Adjacent to	H3	Tung Tau Wai Sun Tsuen	A	75	60	45	grab/excavator	CNP 063 & 081	112	50	42	73	73
	Ngau Tam Mei	Tung Tau Wai							dump truck	CNP 067	0	50	42	-39	
H	Yuen Long / Kam Tin	Adjacent to	H4	San Pui Chung Hau Tsuen	A	75	60	45	grab/excavator	CNP 063 & 081	112	38	40	75	75
	Ngau Tam Mei	Tung Tau Wai							dump truck	CNP 067	0	38	40	-37	
H		To the south-west of		Nil											
		Sai Po													
I	Tin Shui Wai	Near Tin Shui Estate	I1	Shui Lung Hse, Tin Shui Est	B	75	65	50	excavator	CNP 081	112	98	48	67	67
									dump truck	CNP 067	0	55	43	-40	
I	Tin Shui Wai	Near Tin Shui Estate	I2	Chan Lui Chung Tak Sec.	B	70	65	50	excavator	CNP 081	112	150	52	63	63
									dump truck	CNP 067	0	125	50	-47	
J	Tuen Mun River	Downstream	J1	San Fat Tsuen	B	75	65	50	grab/excavator	CNP 063 & 081	112	82	46	69	71
									tug boat	CNP 221	110	82	46	67	
J	Tuen Mun River	Near Mouth	J2	Sun Teun Mun Centre	B	75	65	50	grab/excavator	CNP 063 & 081	112	123	50	65	67
									tug boat	CNP 221	110	145	51	62	
K	So Kwun Wat River		K1	Ka Wo Lei	A	75	60	45	excavator	CNP 081	112	14	31	84	84
K	So Kwun Wat River		K2	Hong Kong Gold Coast	A	75	60	45	excavator	CNP 081	112	50	42	73	73
K	So Kwun Wat River		K3	So Kwun Tan	A	75	60	45	excavator	CNP 081	112	9	27	88	88
L	Tai Lam Chung River		L1	Tai Lam Chung Tsuen	A	75	60	45	grab/excavator	CNP 063 & 081	112	20	34	81	83
									tug boat	CNP 221	110	20	34	79	
L	Tai Lam Chung River		L2	Luen On San Tsuen	A	75	60	45	grab/excavator	CNP 063 & 081	112	143	51	64	66
									tug boat	CNP 221	110	143	51	62	
M	Sham Tseng River		M1	Sham Tseng Village	B	75	65	50	grab/excavator	CNP 063 & 081	112	65	44	71	73
									tug boat	CNP 221	110	65	44	69	
M	Sham Tseng River		M2	New residential blocks at th	B	75	65	50	grab/excavator	CNP 063 & 081	112	65	44	71	73
				western mouth of the channel					tug boat	CNP 221	110	65	44	69	

APPENDIX A6

NOISE BASELINE SURVEY RESULTS

Summary of Noise Monitoring Survey

Location : River Silver
Ling Tsui Tau Village

Date	Test no.	Time	Leq 30 min dB(A)	L_{10} dB(A)	L_{90} dB(A)
29/11/96	1	16:00-16:30	61.5	64.0	58.0
	2	16:30-17:00	62.2	64.5	58.0
	3	17:00-17:30	60.9	63.5	57.5
	4	17:30-18:00	60.6	63.5	57.0
30/11/96	1	15:00-15:30	61.8	64.0	54.0
	2	15:30-16:00	62.3	64.0	54.5
	3	16:00-16:30	62.6	64.5	54.5
	4	16:30-17:00	61.7	64.0	53.5
1/12/96	1	14:00-14:30	62.9	65.0	55.5
	2	14:30-15:00	63.7	65.5	56.0
	3	15:00-15:30	64.4	65.5	56.5
	4	15:30-16:00	64.0	65.5	56.5
2/12/96	1	13:00-13:30	58.9	62.5	53.5
	2	13:30-14:00	58.6	62.0	53.5
	3	14:00-14:30	61.3	64.0	55.0
	4	14:30-15:00	62.1	64.5	55.5
3/12/96	1	12:00-12:30	62.5	64.5	55.0
	2	12:30-13:00	63.1	64.5	55.5
	3	13:00-13:30	61.9	64.0	54.5
	4	13:30-14:00	61.3	63.5	54.5
4/12/96	1	11:00-11:30	58.7	62.5	54.0
	2	11:30-12:00	58.2	62.5	54.0
	3	12:00-12:30	59.5	63.0	54.5
	4	12:30-13:00	60.1	63.0	54.5
5/12/96	1	09:00-09:30	62.5	65.0	56.0
	2	09:30-10:00	63.1	65.5	56.0
	3	10:00-10:30	63.7	65.5	56.5
	4	10:30-11:00	64.3	66.0	57.0

Summary of Noise Monitoring Survey

Location : So Kwun Wat
Kar Wo Lei

Date	Test no.	Time	Leq 30 min dB(A)	L_{10} dB(A)	L_{90} dB(A)
22/11/96	1	11:10-11:40	52.6	54.0	47.5
	2	11:40-12:10	51.4	52.5	47.0
	3	12:10-12:40	51.1	52.0	46.5
	4	12:40-13:10	51.1	53.0	45.5
23/11/96	1	17:00-17:30	61.5	62.5	51.5
	2	17:30-18:00	58.1	59.5	50.5
	3	18:00-18:30	54.7	56.0	51.5
	4	18:30-19:00	55.7	56.5	52.0
24/11/96	1	07:00-07:30	50.2	52.0	43.5
	2	07:30-08:00	50.9	52.5	44.5
	3	08:00-08:30	49.9	52.0	45.0
	4	08:30-09:00	52.1	54.0	45.5
25/11/96	1	15:00-15:30	56.5	58.5	51.5
	2	15:30-16:00	56.0	58.0	51.0
	3	16:00-16:30	56.3	58.0	51.5
	4	16:30-17:00	56.8	58.5	51.0
26/11/96	1	15:30-16:00	56.6	59.5	51.0
	2	16:00-16:30	60.0	61.0	51.0
	3	16:30-17:00	56.1	58.5	51.0
	4	17:00-17:30	55.1	57.5	51.0
27/11/96	1	09:00-09:30	54.2	56.5	50.0
	2	09:30-10:00	53.5	55.5	49.5
	3	10:00-10:30	52.7	55.0	48.5
	4	10:30-11:00	53.1	55.0	49.0
28/11/96	1	13:00-13:30	51.9	54.5	46.5
	2	13:30-14:00	51.7	54.0	46.5
	3	14:00-14:30	53.8	55.5	48.5
	4	14:30-15:00	53.1	56.0	47.5

Summary of Noise Monitoring Survey

Location : Tin Shui Wai Drainage Channel
MFBM Chan Lui Chung Tak Memorial College

Date	Test no.	Time	Leq 30 min dB(A)	L_{10} dB(A)	L_{90} dB(A)
22/11/96	1	14:30-15:00	68.2	74.0	63.5
	2	15:00-15:30	67.3	69.5	63.0
	3	15:30-16:00	64.5	66.5	61.0
	4	16:00-16:30	64.6	66.5	61.5
23/11/96	1	11:00-11:30	61.9	65.5	58.5
	2	11:30-12:00	60.2	63.5	53.5
	3	12:00-12:30	59.9	63.5	51.5
	4	12:30-13:00	61.5	64.5	53.5
24/11/96	1	09:30-10:00	59.6	63.0	50.5
	2	10:00-10:30	60.2	63.0	54.0
	3	10:30-11:00	60.2	63.5	52.5
	4	11:00-11:30	60.7	64.0	52.0
25/11/96	1	11:00-11:30	59.6	62.5	52.0
	2	11:30-12:00	58.9	62.0	51.5
	3	12:00-12:30	58.6	62.0	51.5
	4	12:30-13:00	59.0	62.0	51.0
26/11/96	1	13:00-13:30	65.0	67.0	60.0
	2	13:30-14:00	64.1	66.5	59.5
	3	14:00-14:30	64.2	66.5	58.5
	4	14:30-15:00	68.2	71.5	60.5
27/11/96	1	07:00-07:30	57.5	60.5	50.0
	2	07:30-08:00	60.0	63.5	54.0
	3	08:00-08:30	62.2	65.5	55.0
	4	08:30-09:00	63.7	66.0	58.5
28/11/96	1	17:00-17:30	66.0	69.0	60.5
	2	17:30-18:00	65.7	68.5	60.0
	3	18:00-18:30	65.5	68.5	58.0
	4	18:30-19:00	65.1	68.5	55.5

Summary of Noise Monitoring Survey

Location : Tai Po / Lam Tsuen River Channel
Wong Shiu Chi Secondary School

Date	Test no.	Time	Leq 30 min dB(A)	L_{10} dB(A)	L_{90} dB(A)
15/11/96	1	11:20-11:50	70.3	73.0	65.0
	2	11:50-12:20	70.6	73.5	64.5
	3	12:20-12:50	71.1	74.0	65.5
	4	12:50-13:20	70.8	73.5	65.5
16/11/96	1	14:30-15:00	70.8	74.0	64.0
	2	15:00-15:30	70.6	73.5	64.5
	3	15:30-16:00	70.9	74.0	65.0
	4	16:00-16:30	70.6	73.5	64.5
17/11/96	1	09:30-10:00	71.4	74.0	64.5
	2	10:00-10:30	70.8	74.0	64.5
	3	10:30-11:00	70.7	73.5	64.5
	4	11:00-11:30	69.6	72.5	63.5
18/11/96	1	07:00-07:30	71.1	74.0	65.0
	2	07:30-08:00	72.8	75.5	67.0
	3	08:00-08:30	72.7	75.5	67.0
	4	08:30-09:00	72.1	75.0	66.5
19/11/96	1	13:00-13:30	70.4	73.5	64.0
	2	13:30-14:00	70.5	73.5	65.0
	3	14:00-14:30	70.3	73.5	64.0
	4	14:30-15:00	70.3	73.0	64.5
20/11/96	1	17:00-17:30	70.9	74.0	65.5
	2	17:30-18:00	72.0	75.0	66.0
	3	18:00-18:30	71.1	74.5	66.5
	4	18:30-19:00	70.9	74.0	65.5
21/11/96	1	11:00-11:30	69.5	72.5	64.0
	2	11:30-12:00	71.3	73.0	64.0
	3	12:00-12:30	71.4	73.5	64.5
	4	12:30-13:00	71.0	73.5	65.0

<u>**Summary of Noise Monitoring Survey**</u>

Location : San Tin Main Drainage Channels
Yan Shau Wai

Date	Test no.	Time	Leq 30 min dB(A)	L_{10} dB(A)	L_{90} dB(A)
15/11/96	1	14:30-15:00	55.8	55.5	48.0
	2	15:00-15:30	56.2	57.0	47.0
	3	15:30-16:00	49.8	51.0	45.5
	4	16:00-16:30	48.8	49.5	46.0
16/11/96	1	11:00-11:30	53.3	53.5	49.5
	2	11:30-12:00	50.8	52.0	48.5
	3	12:00-12:30	51.8	51.5	48.0
	4	12:30-13:00	50.2	51.5	47.5
17/11/96	1	07:00-07:30	47.5	49.0	45.0
	2	07:30-08:00	50.4	51.0	46.5
	3	08:00-08:30	50.4	51.5	47.0
	4	08:30-09:00	51.0	52.5	48.0
18/11/96	1	09:30-10:00	59.9	60.0	52.5
	2	10:00-10:30	57.0	57.0	52.0
	3	10:30-11:00	55.8	58.0	51.5
	4	11:00-11:30	54.4	56.5	51.0
19/11/96	1	17:00-17:30	51.9	46.0	42.0
	2	17:30-18:00	50.6	48.5	44.5
	3	18:00-18:30	46.5	47.5	43.5
	4	18:30-19:00	56.4	48.5	45.0
20/11/96	1	13:00-13:30	49.9	51.5	47.0
	2	13:30-14:00	49.8	50.5	46.5
	3	14:00-14:30	51.7	51.0	47.5
	4	14:30-15:00	50.8	50.0	46.5
21/11/96	1	14:30-15:00	45.4	47.5	42.0
	2	15:00-15:30	47.5	49.0	42.5
	3	15:30-16:00	47.7	48.0	41.5
	4	16:00-16:30	49.5	49.0	43.0

Summary of Noise Monitoring Survey

Location : Shing Mun River
KCBC Hay Nien Primary School

Date	Test no.	Time	Leq 30 min dB(A)	L_{10} dB(A)	L_{90} dB(A)
8/11/96	1	14:30-15:00	60.8	62.0	55.5
	2	15:00-15:30	62.3	66.0	55.5
	3	15:30-16:00	61.0	62.5	55.5
	4	16:00-16:30	59.9	62.0	56.5
9/11/96	1	07:00-07:30	64.2	66.5	59.0
	2	07:30-08:00	60.1	62.5	56.0
	3	08:00-08:30	60.3	62.5	56.0
	4	08:30-09:00	60.2	62.5	56.5
10/11/96	1	09:30-10:00	60.0	62.0	56.5
	2	10:00-10:30	59.8	61.5	56.0
	3	10:30-11:00	59.1	61.0	56.0
	4	11:00-11:30	58.7	61.0	55.5
11/11/96	1	11:00-11:30	60.1	62.0	56.5
	2	11:30-12:00	60.1	62.5	56.5
	3	12:00-12:30	61.7	64.0	57.5
	4	12:30-13:00	63.3	65.0	59.0
12/11/96	1	11:00-11:30	61.6	64.5	56.5
	2	11:30-12:00	59.8	65.0	60.0
	3	12:00-12:30	60.3	61.5	55.5
	4	12:30-13:00	59.2	61.0	55.0
13/11/96	1	17:00-17:30	62.1	65.0	57.0
	2	17:30-18:00	60.6	62.0	54.5
	3	18:00-18:30	59.5	61.5	55.5
	4	18:30-19:00	58.8	61.0	54.5
14/11/96	1	13:00-13:30	63.8	66.5	59.0
	2	13:30-14:00	61.1	63.0	56.5
	3	14:00-14:30	62.0	62.5	55.5
	4	14:30-15:00	60.5	61.0	56.0

Summary of Noise Monitoring Survey

Location : Shing Mun River
Jockey Club Ti-I College

Date	Test no.	Time	Leq 30 min dB(A)	L_{10} dB(A)	L_{90} dB(A)
8/11/96	1	11:00-11:30	63.7	65.5	60.0
	2	11:30-12:00	67.5	69.0	60.0
	3	12:00-12:30	65.7	66.5	60.0
	4	12:30-13:00	64.4	66.5	60.5
9/11/96	1	09:30-10:00	63.8	65.5	60.5
	2	10:00-10:30	63.2	64.5	60.0
	3	10:30-11:00	65.9	67.0	60.5
	4	11:00-11:30	64.2	66.5	60.5
10/11/96	1	07:00-07:30	59.8	62.0	55.5
	2	07:30-08:00	61.0	63.0	56.5
	3	08:00-08:30	61.4	63.5	57.5
	4	08:30-09:00	62.0	64.5	58.0
11/11/96	1	14:30-15:00	62.1	63.5	59.0
	2	15:00-15:30	62.7	64.0	59.5
	3	15:30-16:00	62.9	64.5	59.0
	4	16:00-16:30	63.1	64.0	59.0
12/11/96	1	14:30-15:00	61.9	63.5	59.0
	2	15:00-15:30	62.2	63.5	59.0
	3	15:30-16:00	62.6	63.5	59.0
	4	16:00-16:30	62.6	64.5	59.5
13/11/96	1	13:00-13:30	63.6	65.0	60.5
	2	13:30-14:00	63.9	65.5	60.5
	3	14:00-14:30	62.8	64.5	60.0
	4	14:30-15:00	62.8	65.0	60.0
14/11/96	1	17:00-17:30	62.5	64.5	59.5
	2	17:30-18:00	61.8	63.5	58.5
	3	18:00-18:30	62.0	64.0	58.5
	4	18:30-19:00	61.9	63.5	58.5

APPENDIX A7

AIR QUALITY (DUST) SURVEY RESULTS

<u>**Summary of 24-hrs. TSP Monitoring**</u>

Location : River Silver
Ling Tsui Tau Village

Date	Weather	Time		Wind		TSP Level
				Speed (m/s)	Direction	(μg/std.m^3)
29/11/96	Fine	From	14:10	1-2	NE	133
		To	14:03	1-2	NE	
30/11/96	Fine	From	14:04	1-2	NE	121
		To	13:17	2-3	N	
1/12/96	Fine	From	13:20	2-3	N	103
		To	12:31	<1	Nil	
2/12/96	Cloudy	From	12:30	<1	Nil	95
		To	11:41	1-2	NE	
3/12/96	Cloudy	From	11:40	1-2	NE	53
		To	10:41	<1	Nil	
4/12/96	Cloudy	From	10:55	<1	Nil	146
		To	09:33	1-2	NE	
5/12/96	Cloudy	From	11:10	1-2	NE	160
		To	11:15	1-2	NE	

Summary of 24-hrs. TSP Monitoring

Location : Tin Shui Wai Drainage Channel
MFBM Chan Lui Chung Tak Memorial College

Date	Weather	Time		Wind		TSP Level
				Speed (m/s)	Direction	(µg/std.m^3)
22/11/96	Fine	From	14:50	<1	Nil	182
		To	13:50	<1	Nil	
23/11/96	Fine	From	14:55	<1	Nil	236
		To	13:55	<1	Nil	
24/11/96	Fine	From	13:55	<1	Nil	146
		To	12:57	<1	Nil	
25/11/96	Fine	From	12:58	1-2	NE	137
		To	11:58	<1	Nil	
26/11/96	Fine	From	12:00	<1	Nil	255
		To	11:00	3-4	NE	
27/11/96	Fine	From	11:00	3-4	NE	155
		To	10:41	2-3	NE	
28/11/96	Fine	From	10:45	2-3	NE	119
		To	11:02	1-2	NE	

Summary of 24-hrs. TSP Monitoring

Location : So Kwun Wat
Kar Wo Lei

Date	Weather	Time		Wind		TSP Level
				Speed (m/s)	Direction	(µg/std.m^3)
22/11/96	Fine	From	12:20	<1	Nil	189
		To	23:00	<1	Nil	
23/11/96	Fine	From	11:25	<1	Nil	205
		To	10:25	<1	Nil	
24/11/96	Fine	From	10:30	<1	Nil	155
		To	09:41	<1	Nil	
25/11/96	Fine	From	09:40	<1	Nil	116
		To	09:41	<1	Nil	
26/11/96	Fine	From	10:10	<1	Nil	220
		To	09:36	<1	Nil	
27/11/96	Fine	From	09:40	<1	Nil	162
		To	09:39	<1	Nil	
28/11/96	Fine	From	09:55	<1	Nil	120
		To	09:45			
29/11/96	Fine	From	09:50	<1	Nil	517
		To	09:45	<1	Nil	

Summary of 24-hrs. TSP Monitoring

Location : San Tin Main Drainage Channels
Yan Shau Wai

Date	Weather	Time		Wind		TSP Level
				Speed (m/s)	Direction	(μg/std.m^3)
15/11/96	Cloudy	From	15:05	<1	Nil	195
		To	14:05	3-4	N	
16/11/96	Coludy	From	14:05	<1	Nil	240
		To	13:05	<1	Nil	
17/11/96	Cloudy to fine	From	13:10	<1	Nil	260
		To	12:11	1-3	NE	
18/11/96	Fine and windy	From	12:15	1-3	NE	160
		To	11:44	<1	Nil	
19/11/96	Cloudy to fine	From	11:45	<1	Nil	250
		To	10:45	<1	Nil	
20/11/96	Cloudy to fine	From	10:50	0-2	NE	264
		To	10:30	<1	Nil	
21/11/96	Fine	From	10:30	<1	Nil	186
		To	10:24	<1	Nil	

Summary of 24-hrs. TSP Monitoring

Location : Tai Po / Lam Tseun River Channel
Wong Shiu Chi Secondary School

Date	Weather	Time		Wind		TSP Level
				Speed (m/s)	Direction	(μg/std.m^3)
15/11/96	Cloudy	From	13:10	<1	S	77
		To	13:07	<1	Nil	
16/11/96	Cloudy	From	13:25	<1	Nil	111
		To	12:26	<1	Nil	
17/11/96	Cloudy to fine	From	12:30	<1	Nil	116
		To	11:43	1-2	SW	
18/11/96	Fine and windy	From	11:45	1-2	SW	99
		To	11:04	<1	Nil	
19/11/96	Cloudy to fine	From	11:10	<1	Nil	123
		To	10:20	<1	Nil	
20/11/96	Cloudy to fine	From	10:20	<1	Nil	116
		To	09:53	<1	Nil	
21/11/96	Fine	From	10:00	<1	Nil	113
		To	09:50	<1	Nil	

Summary of 24-hrs. TSP Monitoring

Location : Shing Mun River
KCBC Hay Nien Primary School

Date	Weather	Time		Wind		TSP Level
				Speed (m/s)	Direction	(μg/std.m³)
8/11/96	Fine	From	09:00	<1	Nil	89
		To	08:34	<1	Nil	
9/11/96	Fine	From	08:40	<1	Nil	105
		To	08:40	1-2	NE	
10/11/96	Fine	From	09:25	1-2	NE	115
		To	09:25	<1	Nil	
11/11/96	Fine	From	11:00	<1	Nil	70
		To	10:00	<1	Nil	
12/11/96	Cloudy with some fine drops	From	10:05	<1	Nil	83
		To	10:05	<1	Nil	
13/11/96	Cloudy	From	10:15	<1	Nil	71
		To	10:15	1-2	N	
14/11/96	Fine	From	10:40	1-2	N	73
		To	10:40	<1	Nil	

Summary of 24-hrs. TSP Monitoring

Location : Shing Mun River
Jockey Club Ti-I College

Date	Weather	Time		Wind		TSP Level
				Speed (m/s)	Direction	(μg/std.m^3)
8/11/96	Fine	From	09:00	<1	Nil	98
		To	09:04	0-2	N-NE	
9/11/96	Fine	From	09:20	0-2	N-NE	103
		To	08:30	2-3	N-NE	
10/11/96	Fine	From	08:40	2-3	N-NE	94
		To	08:57	1-2	N-NW	
11/11/96	Fine	From	10:35	1-2	N-NW	74
		To	09:35	<1	Nil	
12/11/96	Cloudy with some fine drops	From	09:40	<1	Nil	86
		To	09:48	1-2	N	
13/11/96	Cloudy	From	09:50	1-2	N	87
		To	10:11	1-2	N-NE	
14/11/96	Fine	From	10:10	1-2	N-NE	92
		To	10:16	<1	Nil	

APPENDIX A8

DREDGED SEDIMENT MANAGEMENT CRITERIA

Reg'd in R/I 23 NOV

Ref.: EP 100/C10/16

Environmental Protection Department
28/F., Southorn Centre
130 Hennessy Road
Wanchai, Hong Kong.

9 November 1992

ENVIRONMENTAL PROTECTION DEPARTMENT

TECHNICAL CIRCULAR NO. (TC) NO 1-1-92

Classification of Dredged Sediments for Marine Disposal

In fulfilment of my responsibility as the designated officer under paragraph 2(1) in Schedule I of the Dumping at Sea Act 1974 (Overseas Territories) Order 1975, I wish to notify you that dredged sediments will be classified as indicated below for the purpose of issuing licences under the Act. This circular should be read in conjunction with the Works Branch Technical Circular No. 22/92 - Marine Disposal of Dredged Mud which outlines the procedures to be followed in all works, whether public or private, which involve the marine disposal of dredged sediments.

2. Sediments will be classified according to their level of contamination by toxic metals. The classes are 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 resuspension.

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

....../3.

3. The classification criteria for contamination levels are laid down in Table A. It should be noted 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 class.

Table A - Classification of Sediments by Metal Content (mg/kg dry weight)

	Cd	Cr	Cu	Hg	Ni	Pb	Zn
Class A	0.0-0.9	0-49	0-54	0.0-0.7	0-34	0-64	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: Tests results should be rounded off to two significant figures before comparing with the table, e.g. Cd to the nearest 0.1mg/kg, Cr to the nearest 1 mg/kg, and Zn to the nearest 10 mg/kg, etc.

(Stuart B. Reed)
Director of Environmental Protection

APPENDIX A9

EVS ENVIRONMENT CONSULTANTS -
BIOLOGICAL TESTING PROCEDURES

APPENDIX A9. EVS BIOLOGICAL TESTING (TAKEN FROM EVS QA REPORT)

A9.1 Introduction

Toxicity tests were conducted on all samples using: the estuarine amphipod, *Eohaustorius estuarius;* the juvenile polychaete, *Neanthes arenaceodentata;* and larvae of the blue mussel, *Mytilus edulis.*

Each sample was shipped in two 1-L plastic containers. The four containers from each of the stations were composited and homogenized prior to testing. Sediments were stored under nitrogen (if there was an air space) at 4°C, according to PSDDA (1989).

The amphipod tests were initiated with field-collected immature adult amphipods and the exposure duration was 10 days. The test endpoints were survival and behaviour (sediment avoidance and ability to rebury in clean sediment). The polychaete tests were initiated with juvenile polychaetes obtained from laboratory cultures and the exposure duration was 20 days. The test endpoints were survival and growth (change in dry weight). The mussel larvae tests were initiated with larvae that were 2-h post-fertilization. The exposure duration was 48 h and the test endpoints were survival and development (% abnormal shell formation).

A9.2 Methods

Ten-day toxicity tests using the estuarine amphipod, *Eohaustorius estuarius,* were conducted according to EVS SOP 1077-1 (EVS Environment Consultants, 1995a), which is based on methods described in ASTM (1994a) and PSEP (1995). Amphipods were collected subtidally from Beaver Creek, Oregon, using a shovel. Amphipods were sieved from the sediments, counted and then transferred to small sandwich containers containing approximately a 1 cm layer of collection site sediment. Each container held approximately 100 amphipods. Sediment from the collection site was also retained for use as a clean control sediment for the toxicity tests. This material was sieved (500-µm screen), placed in a clean container and stored at 4°C in the dark prior to testing.

The amphipods were acclimated to laboratory conditions for seven days prior to testing. During this time, amphipods received aeration but were not fed. The amphipods were kept in large plastic basins each holding about 12 sandwich containers. Each basin was filled with seawater (28 ± 2 ppt salinity) and maintained at 15 ± 1°C under continuous light. Seawater in the holding containers was replaced every two days. The seawater was obtained from Burrard Inlet, Vancouver, BC, at a depth of 12 m. This water was passed through a sand filter, a 0.5-µm filter and an ultraviolet light sterilizer, aerated vigorously and used within 2 d of collection. Water quality was measured before the water change and dead amphipods were removed.

Tests were conducted in 1-L glass jars. Five replicates were prepared for each sample, including the control sediment. A sixth jar was prepared specifically for water quality measurements. Two additional replicates were prepared for measuring interstitial ammonia on Day 0. Sediments were distributed to the test containers the day before test initiation (Day-1). Each test sediment was homogenized by thorough manual mixing. Large pieces of organic material (e.g., grasses, algae) and any live animals were removed at this time. A 175-mL volume (representing a 2-cm layer) of test sediment was added to each jar. Approximately 800 mL of seawater (28 ± 2 ppt salinity) was added to each jar. All except one test container from each sample were stirred with a glass rod for one minute to increase the interstitial salinity since some of the samples had low interstitial salinity. The jars were covered with clean plastic lids, fitted with aeration lines, and left to settle overnight. The following day (Day 0), the sediment in the unstirred replicate and one of the stirred containers was filtered and the interstitial water collected to measure ammonia. The remaining jars were seeded with 20 amphipods each. The amphipods were not fed during the tests.

Tests were conducted in a constant environment chamber at 15 ± 1oC under continuous light. Text jars were gently aerated. Water quality parameters (temperature, pH, dissolved oxygen, salinity) were measured daily in the water quality jar. Test containers were checked daily for emergent amphipods, indicating sediment avoidance or mortality. Amphipods which had left the sediment and become trapped by surface tension at the air / water interface were re-submerged with a glass rod. Composite subsamples of overlying seawater were collected from each jar on Day 0 and Day 10 for ammonia and sulfide analyses.

At the end of the 10-d exposure, the sediments were sieved through a 500-µm screen, and the number of live, dead and missing amphipods were counted in each replicate. Amphipods were presumed dead if there was no response to physical stimulation or examination revealed no evidence of pleopod movement. Missing amphipods were presumed to have died and decomposed prior to the termination of the text (Swartz et al., 1985). Surviving amphipods were transferred to plastic weighboats containing control sediment and seawater. The number of animals able to rebury within 1 h was recorded. For the test to be considered valid, mean survival in the control sediment had to be ≥90% (ASTM, 1994a; PSEP, 1995).

Mean responses (± SD) for survival were calculated for each sediment. Amphipod mean avoidance was determined from daily counts of amphipods that had emerged from the sediments. After 10 d, the total number of amphipods emerged was divided by 50 (5 replicates x 10 d), to give mean avoidance (per jar per day). Percent reburial was calculated by dividing the total number of amphipods that did rebury within 1 h by the total number of surviving amphipods.

Survival data were analyzed using the TOXCALC computer program (Tidepool Scientific Software, 1994). Two-sample *t*-tests were conducted to determine significant ($p \leq 0.05$) differences relative to the control sediment.

To assess the relative sensitivity of the test organisms, a concurrent 96-h reference toxicant test was conducted with cadmium (prepared from cadmium chloride, $CdCl_2.2\frac{1}{2}H_2O$) with 1 L of test solution containing 10 amphipods per concentration. A series of seven concentrations (0.56, 1.0, 1.8, 3.2, 5.6, 10.0, 18.0 mg/L Cd), were prepared in 1-L glass jars from a 1,000 mg/L cadmium stock solution. Water quality measurements and mortalities were recorded daily. The 96-h LC50 value (expressed as mg/L Cd) was calculated using the TOXCALC program. This test was used to assess the relative health and sensitivity of the amphipods by comparing the results to a range (mean ± 2SD) obtained by this laboratory in previous testing.

APPENDIX A10

TOXIC CHARACTERISTIC LEACHATE PROCEDURE (TCLP)
AND ELUTRIATE TEST RESULTS

METHOD 1311

TOXICITY CHARACTERISTIC LEACHING PROCEDURE

1. SCOPE AND APPLICATION

The TCLP is designed to determine the mobility of both organic and inorganic analytes present in liquid.

If a total analysis of the waste demonstrates that individual analytes are not present in the waste, or that they are present but at such low concentrations that the appropriate regulatory levels could not possibly be exceeded, the TCLP need not be run.

If an analysis of any one of the liquid fractions of the TCLP extract indicates that a regulated compound is present at such high concentrations that, even after accounting for dilution from the other fractions of the extract, the concentration would be above the regulatory level for that compound, then the waste is hazardous and it is not necessary to analyze the remaining fractions of the extract.

If an analysis of extract obtained using a bottle extractor shows that the concentration of any regulated volatile analyte exceeds the regulatory level for that compound, then the waste is hazardous and extraction using the ZHE is not necessary. However, extract from a bottle extractor cannot be used to demonstrate that the concentration of volatile compounds is below the regulatory level.

2. SUMMARY OF METHOD

For liquid wastes (i.e., those containing less than 0.5% dry solid material), the waste, after filtration through a 0.6 to 0.8 μm glass fiber filter, is defined as the TCLP extract.

For wastes containing greater than or equal to 0.5% solids, the liquid, if any, is separated from the solid phase and stored for later analysis; the particle size of the solid phase is reduced, if necessary. The solid phase is extracted with an amount of extraction fluid equal to 20 times the weight of the solid phase. The extraction fluid employed is a function of the alkalinity of the solid phase of the waste. A special extractor vessel is used when testing for volatile analytes (see Table 1 for a list of volatile compounds). Following extraction, the liquid extract is separated form the solid phase by filtration through a 0.6 to 0.8 μm glass fiber filter.

If compatible (i.e., multiple phases will not form on combination), the initial liquid phase of the waste is added to the liquid extract, and these are analyzed together. If incompatible, the liquids are analyzed separately and the results are mathematically combined to yield a volume-weighted average concentration.

ID	Station	Cd	Cr	Cu	Pb	Zn	Dried Solid	Arsenic	PCB	Ammonia	Benz[K]fluoranthene	Benzo[A]Pyrene	Bewnzo[GHI]Pyrene
		(mgkg)	(mgkg)	(mgkg)	(mgkg)	(mgkg)	(%)	(mgkg)	(ugkg)	(mgkg)	(mgkg)	(mgkg)	(mgkg)
	Shing Mun River												
D	D2/D	0.50	25.00	85.00	97.00	269.00	38.50	9.00	1.00	116.00	0.051	0.036	0.053
D	D4/D	1.30	18.00	71.00	109.00	394.00	23.00	9.00	1.00	158.00	0.175	0.100	0.150
D	D6/D	1.30	19.00	62.00	112.00	329.00	27.70	8.00	1.00	229.00	0.260	0.170	0.160
D	D9/D	0.50	28.00	172.00	106.00	264.00	73.80	2.00	1.00	10.00	0.038	0.010	0.026
	Tai Po/Lam Tsuen River												
E	E1/D	1.40	13.00	47.00	236.00	252.00	53.90	16.00	1.00	68.00	0.026	0.010	0.021
E	E4/D	0.50	4.00	15.00	42.00	116.00	76.70	5.00	38.20	6.00	0.023	0.010	0.010
E	E5/D	0.50	3.00	11.00	41.00	86.00	79.70	9.00	1.00	4.00	0.021	0.010	0.010
	Tuen Mun River												
J	J1/D	0.50	25.00	12.00	21.00	118.00	47.20	5.00	1.00	17.10	0.031	0.010	0.025
J	J2/D	1.40	88.00	77.00	86.00	368.00	24.20	7.00	1.00	234.00	0.280	0.332	0.306
J	J3/D	1.20	45.00	53.00	74.00	221.00	58.60	4.00	1.00	177.00	0.088	0.078	0.067
J	J4/D	1.40	119.00	81.00	91.00	381.00	21.00	11.00	1.00	612.00	0.099	0.093	0.147

Table 1 Additional Sediment Survey - Sediment quality data

Hyder Consulting Limited Southern Laboratories, UK

ID	Station	Indeno[123, CD] Pyrene	Naphthalene	Acenaphthylene	Acenaphthene	Flueorene	Phenanthrene	Anthracene	Pyrene
		(mgkg)	(mgkg)	(mgkg)	(mgkg)	(mgkg)	(mgkg)	(mgkg)	(mgkg)
	Shing Mun River								
D	D2/D	0.040	0.000	0.010	0.010	0.036	0.171	0.037	0.113
D	D4/D	0.100	0.500	0.750	0.010	0.060	0.248	0.105	0.355
D	D6/D	0.115	0.035	0.100	0.010	0.040	0.280	0.100	0.445
D	D9/D	0.021	0.029	0.010	0.010	0.010	0.063	0.010	0.083
	Tai Po/Lam Tsuen River								
E	E1/D	0.010	0.024	0.010	0.010	0.010	0.067	0.010	0.048
E	E4/D	0.010	0.010	0.010	0.010	0.010	0.045	0.010	0.010
E	E5/D	0.010	0.010	0.010	0.010	0.038	0.010	0.010	0.010
	Tuen Mun River								
J	J1/D	0.023	0.010	0.010	0.010	0.010	0.065	0.010	0.039
J	J2/D	0.222	0.052	0.104	0.058	0.184	0.894	0.196	1.280
J	J3/D	0.050	0.055	0.032	0.010	0.052	0.220	0.048	0.333
J	J4/D	0.080	0.087	0.010	0.060	0.202	0.985	0.067	0.611

Table 1 Continued

ID	STATION	Benz[A]anthracene	Chrysene	Dibenz(AH) Anthracene	Fluoranthene	Benz[B]fluoranthene
		(mgkg)	(mgkg)	(mgkg)	(mgkg)	(mgkg)
	Shing Mun River					
D	D2/D	0.038	0.062	0.010	0.099	0.033
D	D4/D	0.123	0.195	0.010	0.275	0.110
D	D6/D	0.200	0.235	0.030	0.430	0.125
D	D9/D	0.010	0.041	0.010	0.068	0.020
	Tai Po/Lam Tsuen River					
E	E1/D	0.010	0.027	0.010	0.037	0.010
E	E4/D	0.010	0.010	0.010	0.010	0.010
E	E5/D	0.010	0.010	0.010	0.010	0.010
	Tuen Mun River					
J	J1/D	0.010	0.024	0.025	0.041	0.010
J	J2/D	0.386	0.578	0.058	1.590	0.200
J	J3/D	0.096	0.181	0.010	0.162	0.053
J	J4/D	0.150	0.315	0.025	0.257	0.099

Table 1 Continued

Station	Moisture Content	Arsenic	Cd	Cr	Cu	Ni	Pb	Zn
		(mgkg)	(mgkg)	(mgkg)	(mgkg)	(mgkg)	(mgkg)	(mgkg)
Shing Mun River								
D2/D	73.00	9.00	0.48	29.70	107.00	27.00	103.00	275.00
D4/D	72.20	7.00	0.86	22.10	85.00	21.50	116.00	459.00
D6/D	73.60	7.00	0.68	21.50	75.30	20.50	112.00	393.00
D9/D	28.50	2.00	0.28	69.40	223.00	45.30	64.10	302.00
Tai Po/ Lam Tsuen River								
E1/D	39.40	9.00	0.51	13.30	34.70	5.80	157.00	179.00
E4/D	24.10	3.00	0.16	4.90	7.90	2.90	27.40	92.00
E5/D	20.90	13.00	0.15	3.90	14.10	2.10	32.90	78.00
Tuen Mun River								
J1/D	67.30	6.00	0.34	37.50	34.80	20.40	43.10	218.00
J2/D	25.20	2.00	0.28	40.90	37.90	9.30	63.60	208.00
J3/D	40.10	3.00	0.33	52.00	51.30	14.50	67.10	220.00
J4/D	71.20	8.00	0.97	152.00	120.00	15.40	83.20	408.00

Table 2 Additional Sediment Survey - Sediment quality data

Australian Laboratories Services - Hong Kong

ID	STATION	DATE	TIME	pH value	Arsenic (ugl)	Cd (ugl)	Cr (ugl)	Cu (ugl)	Ni (ugl)	Pb (ugl)	Zn (ugl)	Ammonia (mgl)	Kjeldhal Nitrogen (mgl)	Total Phosphorus (mgl)
	Shing Mun & Tributaries													
D	D2/D	09/08/1996	9:40am	7.40	50.00	0.20	11.00	10.00	16.00	2.00	30.00	10.00	10.30	0.070
D	D4/D	09/08/1996	9:58am	7.70	50.00	0.20	4.00	8.00	5.00	0.50	40.00	7.70	8.30	0.005
D	D6/D	09/08/1996	9:46am	7.80	50.00	0.40	3.00	9.00	5.00	0.50	40.00	11.80	11.90	0.005
D	D9/D	09/08/1996		7.50	50.00	0.20	2.00	7.00	20.00	0.50	30.00	5.20	5.50	0.090
	Tai Po / Lam Tsuen													
E	E1/D	09/08/1996	11:14am	7.50	40.00	0.20	3.00	7.00	6.00	0.50	40.00	8.30	8.90	0.100
E	E4/D	09/08/1996	10:59am	7.60	40.00	0.10	2.00	6.00	9.00	2.00	20.00	0.05	0.05	0.040
E	E5/D	09/08/1996	11:04am	7.70	50.00	0.10	1.00	9.00	6.00	9.00	40.00	0.02	0.40	0.005
	Tuen Mun													
J	J1/D	13/08/1996	10:30am	9.50	30.00	0.10	0.50	5.00	8.00	0.50	30.00	0.50	0.50	0.040
J	J2/D	13/08/1996	10:25am	7.80	30.00	0.10	0.50	5.00	9.00	0.50	30.00	20.60	20.90	0.080
J	J3/D	13/08/1996	10:10am	7.90	30.00	0.20	0.50	4.00	9.00	0.50	20.00	38.50	40.20	0.080
J	J4/D	13/08/1996	10:05am	8.00	20.00	0.10	0.50	5.00	9.00	0.50	30.00	37.30	38.10	0.005

Table 3 Elutriate: River Water

Australian Laboratories Services - Hong Kong

ID	STATION	DATE	TIME	pH value	Arsenic (ugl)	Cd ugl)	Cr (ugl)	Cu (ugl)	Ni (ugl)	Pb (ugl)	Zn (ugl)	Ammonia (mgl)	Total Kjeldahl Nitrogen (mgl)	Total Phosphorus (mgl)
	Shing Mun and tributaries													
D	D2/D	9/8/96	9:40am	7.40	5.00	0.20	2.00	0.50	2.00	0.50	5.00	9.30	9.40	0.005
D	D4/D	9/8/96	9:58am	7.80	10.00	0.40	4.00	1.00	4.00	0.50	5.00	6.50	7.00	0.090
D	D6/D	9/8/96	9:46am	8.00	5.00	0.40	2.00	0.50	0.50	0.50	5.00	9.00	9.50	0.020
D	D9/D	9/8/96		7.70	5.00	0.10	2.00	0.50	2.00	0.50	5.00	1.50	2.40	0.005
	Tai Po / Lam Tsuen													
E	E1/D	9/8/96	11:14am	8.00	5.00	0.20	2.00	0.50	0.50	0.50	5.00	6.90	7.80	0.005
E	E4/D	9/8/96	10:59am	7.50	5.00	0.10	1.00	0.50	0.50	0.50	5.00	0.50	1.10	0.005
E	E5/D	9/8/96	11:04am	8.00	5.00	0.10	1.00	0.50	0.50	0.50	5.00	0.80	1.10	0.020
	Tuen Mun													
J	J1/D	13/8/96	10:30am	11.20	5.00	0.10	2.00	1.00	2.00	0.50	5.00	0.60	1.10	0.005
J	J2/D	13/8/96	10:25am	8.10	5.00	0.20	2.00	0.50	0.50	0.50	20.00	17.70	17.90	0.080
J	J3/D	13/8/96	10:10am	8.20	5.00	0.20	2.00	0.50	1.00	2.00	10.00	34.00	34.70	0.005
J	J4/D	13/8/96	10:05am	8.20	10.00	0.10	2.00	0.50	3.00	16.00	20.00	36.30	36.80	0.140

Table 4 Elutriate Distilled Water

Australian Laboratories Services - Hong Kong

ID	Station	Date	Time	pH value	Arsenic (ugl)	Cd(ugl)	Cr(ugl)	Cu (ugl	Ni(ugl)	Pb(ugl)	Zn(ugl)	Ammonia	Total Kjeldah Nitrogen (mgl	Total Phosphorous (mgl)
	Shing Mun													
D	D2/D	9/8/96	9:40am	5.70	20.00	0.10	0.50	2.00	110.00	2.00	30.00	10.30	10.900	0.005
D	D4/D	9/8/96	9:58am	5.40	10.00	0.10	0.50	3.00	88.00	3.00	20.00	7.30	8.100	0.080
D	D6/D	9/8/96	9:46am	5.50	10.00	0.10	0.50	2.00	84.00	1.00	40.00	12.10	12.600	0.005
D	D9/D	9/8/96		5.60	5.00	0.10	0.50	1.00	230.00	19.00	260.00	3.60	3.700	0.005
	Tai Po /													
E	E1/D	9/8/96	11:14am	6.50	5.00	0.10	0.50	2.00	34.00	0.50	10.00	8.30	10.700	0.005
E	E4/D	9/8/96	10:59am	5.20	5.00	0.10	0.50	1.00	29.00	2.00	110.00	0.80	1.200	0.005
E	E5/D	9/8/96	11:04am	5.40	5.00	0.10	0.50	2.00	33.00	0.50	70.00	0.80	1.200	0.040
	Tuen Mun													
J	J1/D	13/8/96	10:30am	5.80	10.00	0.10	0.50	3.00	34.00	1.00	10.00	0.90	1.000	0.005
J	J2/D	13/8/96	10:25am	6.30	5.00	0.10	0.50	2.00	42.00	0.50	20.00	9.50	19.300	0.005
J	J3/D	13/8/96	10:10am	6.10	5.00	0.10	0.50	2.00	60.00	0.50	20.00	37.60	38.700	0.005
J	J4/D	13/8/96	10:05am	5.90	5.00	0.10	0.50	2.00	78.00	0.50	50.00	39.50	42.200	0.005

Table 5 Elutriate:TLCP Solution

Australian Laboratories Services - Hong Kong

APPENDIX A11

SEDIMENT PARAMETERS RECOMMENDED FOR ANALYTICAL TESTING

Table 1-1. Summary of contaminants of concern and prioritization criteria.

		Fate and Effects Characteristics				
Parameters	International Priority	Persistence	Toxicity	Accumulation	Presence in Hong Kong[1]	Category
Metals & Inorganics						
Aluminium		++	-	-	EPD; EVS	
Antimony	NPRI;TRI	+	+	NI		
Arsenic	LC;NPRI;TRI	++	++	++	EPD; EVS	1
Barium	TRI	-	-	NI	EPD; EVS	
Beryllium	LC;TRI	++	+	+	EVS	1
Boron		+	NI	+	EPD	
Cadmium	LC;NPRI;TRI	++	++	++	CSMS; EPD; EVS	1
Chromium	LC;NPRI;TRI	++	+	+	CSMS; EPD; EVS	1
Cobalt	NPRI;TRI	++	NI	-	EVS	
Copper	LC;NPRI;TRI	++	+	-	CSMS; EPD; EVS	1
Iron		++	-	NI	EPD; EVS	
Lead	LC;NPRI;TRI	++	+	+	CSMS; EPD; EVS	1
Manganese	NPRI;TRI	+	NI	NI	EPD; EVS	
Mercury	LC;NPRI;TRI	++	+	++	CSMS; EPD; EVS	1
Molybdenum		+	-	+	EVS	
Nickel	LC;NPRI;TRI	+	+	+	CSMS; EPD; EVS	1
Selenium	NPRI;TRI	+	+	+	EVS	1
Silver	NPRI;TRI	++	+	+	EVS	1
Thallium	TRI	+	NI	+		
Tin		++	-	-	EVS	
Vanadium	LC	NI	NI	+	EPD; EVS	1
Zinc	LC;NPRI;TRI	++	+	+	CSMS; EPD; EVS	1
Cyanide	LC;NPRI;TRI	+	+	NI	EPD	1
Fluoride	LC	+	NI	-	EVS	1
Polycyclic Aromatic Hydrocarbons						
Total PAHs	NPRI;TRI	++	+	++	EPD; EVS	1
Volatile Organic Compounds and Monocyclic Aromatic Hydrocarbons	LC[2]					
Benzene	NPRI;TRI	-	-	-		
Carbon tetrachloride	NPRI;TRI	-	NI	-		
Chloroethanes	NPRI;TRI	-	-	-		
Chloroform	NPRI;TRI	-	NI	-		
Dichloroethylene	TRI	-	-	-		
Dichloromethane	NPRI;TRI	-	NI	-	EVS	
Dichloropropane	NPRI;TRI	+	NI	NI		2
Dichloropropylene	TRI	+	+	NI		2
Ethylbenzene	NPRI;TRI	+	NI	+		2
Styrene	TRI	-	NI	-		
Toluene	NPRI;TRI	-(+)	NI	-	EVS	
Tri/Tetra-chloroethylene	NPRI;TRI	-(+)	NI	-		
Trichlorofluoromethane	TRI	-(+)	NI	NI		
Vinyl chloride	NPRI;TRI	-	NI	NI		
Xylenes	NPRI;TRI	-	+	-		

Table 1-1 continued....

		Fate and Effects Characteristics				
Parameters	International Priority	Persistence	Toxicity	Accumulation	Presence in Hong Kong[1]	Category
Chlorinated Benzenes	LC[2]					
Monochlorobenzene	NPRI;TRI	+	NI	++		2
Dichlorobenzene	NPRI;TRI	++	NI	++		2
Tri/Tetra/Penta-chlorobenzenes	NPRI;TRI	++	+	+	EVS	1
Hexachlorobenzene		++	NI	++	EVS	1
Polychlorinated Biphenyls						
Total PCBs	TRI	++	+	++	EPD; EVS	1
Dioxins and Furans						
Dioxins and furans		++	+	++	EVS	1
Dibenzofuran		+	NI	+		2
Phenolic Compounds						
Chlorinated phenolics (including PCP)	TRI	+	+	-(+)		2
Non-chlorinated phenolics	NPRI;TRI	+	NI	-(+)	EVS	1
Organometillics and Phthalates						
Methlymercury		+	+	++		
Tributlytin		++	+	++	CES; EVS	1
Phthalate esters	NPRI;TRI	+	NI	-(+)	EVS	1
Pesticides	LC					
Acrolein	TRI	NI	+	NI		2
Chlordane	TRI	+	NI	+		2
Diazinon		NI	+	NI		2
Dieldrin		+	NI	+		2
Endosulfan		+	+	+		2
Endrin		+	NI	+		2
Lindane	TRI	+	NI	+		2
Mirex		+	NI	+		2
Paraquat		+	+	NI		2
Total DDT		+	+	++	EVS	1
Toxaphene	TRI	+	NI	+		2
2,4-D	TRI	+	+	NI	EVS	1

LC = London Convention, Annex I and II substances (IMO, 1991)

NPRI = National Pollutant Release Inventory substances (Canada) (NPRI, 1996)

TRI = Toxic Release Inventory substances (USA) (TRI, 1996)

[1] Data sources include:

"EPD" - EPD and CED, pers. comm. 1996

"CSMS" - Mott MacDonald, 1991

"Axis" - EPD and Axis, 1995

"CES" - CES, 1995

"EVS" - EVS, 1996b

[2] London Convention includes a broad category of "organohalogens"

NI = No information

- = Unlikely to cause adverse effects

+ = Likely to cause adverse effects

++ = Very likely to cause adverse effects

-(+) = Unlikely to cause adverse effects, but possible under certain conditions (see text)