Hong Kong Government
Territory Development Department
Urban Area Development Office

Central and Wan Chai Reclamation Development

Focussed Study for the Proposed Extension to the Hong Kong Convention and Exhibition Centre

Stage 2 Final Report
Volume 2 Environment

Maunsell Consultants Asia Ltd
in association with
Balfours International (Asia)
MVA Asia Ltd · Urbis Travers Morgan Ltd
CES Consultants in Environmental Sciences (Asia) Ltd

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HWR Hydraulics and Water Research (Asia) Ltd.

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1. Introduction

1. Introduction

1.1 Background

The reclamation and road layout given in the Central and Wanchai Reclamation Feasibility (CWRFS, 1989) allowed for a possible extension of the Hong Kong Convention and Exhibition Centre (HKCEC), then already being discussed by the Hong Kong Trade Development Council (TDC). CWRFS was endorsed by LDPC in 1989 but no firm programme for the reclamation in the Exhibition Cell was established.

Subsequently, TDC has made submissions to Government for the construction of an extension facility to the centre on reclaimed land in front of the existing HKCEC.

Government commissioned consultants to look at the infrastructure requirements for a HKCEC Extension in 1991, and for an Island Scheme in 1992 with a view to establishing an optimum reclamation and infrastructure package to support the HKCEC extension.

A preliminary environmental appraisal was also carried out by the Environmental Protection Department (EPD) in September 1992 to identify any major in-principle environmental issues and the likely actions that need to be taken to address potential environmental concerns. It was concluded that the proposed full scale reclamation with a transport link to the Island Eastern Corridor (IEC) could have significant environmental impact because of the temporary embayment created by the staging of the reclamation construction. It was recommended that an environmental impact assessment study should be carried out. However, in respect of the Island Scheme, shown on Figure 1.1, EPD's initial assessment above concluded that some deterioration in local water was expected to occur but the change in conditions will not be as great as in the case of the full scale reclamation. The extent of water quality impact would, however, need to be confirmed by an environmental impact assessment study.

Transport Department had also expressed reservations, in their case on the capacity of the proposed road network shown in the 1991 and 1992 studies referred to above.

To properly address the areas of concern, a multi-disciplinary focused study was commissioned to examine the Island Scheme for the HKCEC extension proposal in more detail in order to examine its feasibility and, if found feasible, to subsequently determine the required reclamation and infrastructure package for the HKCEC Extension development.

1.2 Planning Constraints

1.2.1 General

The HKCEC Extension should be consistent with the urban design framework set up for the Central and Wanchai Reclamation Development.

The Central and Wanchai Reclamation Development consists of approximately 108ha of new reclamation and 60ha of water basin and existing land to be redeveloped. The reclamation has three distinct development cells separated by parks, as shown on Figure 1.2. These are Central, north of the existing Central area, Tamar, north of Admiralty and Exhibition, north of the existing Hong Kong Convention and Exhibition Centre.

The capacity of the proposed and existing infrastructure was the main factor in determining the level of development for the reclamation.

1.2.2 Outline Development Plan

The land uses for the new reclamation were generally established in the Central and Wanchai Reclamation Feasibility Study (CWRFS) Final Report (1989). In 1990 Government commissioned the Urban Design Parameters Investigation to establish the development parameters for all sites within the reclamation to ensure a fully integrated urban design framework.

The land uses for the Exhibition cell are shown on Figure 1.3. The study has been advised that there is now no intention to provide for hotel or commercial development. The proposed Exhibition Park will be located to the west of the Extension and a waterfront pedestrian promenade will be constructed to the north of Extension. Artist's impressions of the proposed park and waterfront promenade are shown on Figures 1.4 and 1.5 respectively. A ferry pier and commercial development, C45/43 will eventually be built to the east of the Extension.

The proposed ground levels for the new reclamation range from +4.0mPD to +6.0mPD as shown on Figure 1.6.

Planning Department's Draft Brief for the Extension is included in Appendix I of Volume 1 of the Stage 2 Report.

1.2.3 Transport Network

The planning principles of the transport network are described in Section 1.2.3 of Volume 1 of the Stage 2 Report.

1.2.4 Services

(i) Storm Drainage

The storm water culverts will simply be extended to the new seawall in the final scheme. Some up-grading of the drainage network in the existing areas will be required. Culverts will not discharge into the typhoon shelter or other water basins, ensuring good water quality in these areas. Culvert extensions and upgrading of existing storm drains are not necessary for implementation of the Island Scheme, but provision for future culvert extensions should be made.

(ii) Sewerage

Three new deep trunk sewers are proposed under the Central, Western and Wan Chai West Sewerage Master Plan. Two of these trunk sewers along Connaught Road Central and Harcourt Road/Gloucester Road will collect sewage from the new reclamation development and the existing areas, and convey it to the Central and Wan Chai East Sewage Screening Plants. The design of the reclamation sewerage system will be compatible with the Sewerage Master Plan proposals, which are currently scheduled to be completed in 1998. Therefore, SMP provisions for sewage disposal from the HKCEC Extension will be implemented in time for the completion of the Extension.

(iii) Sea Water Pumping Stations

There are a large number of sea water pumping stations along the existing water front, which supply cooling and flushing water for the air conditioning systems of buildings in the existing areas. New pumping stations and connections will be constructed on the new water front. The sea water supply and discharge systems will be fully operational before the existing systems are abandoned. The pumping stations will be constructed underground to facilitate an uninterrupted waterfront pedestrian promenade running the complete length of the reclamation.

Reprovisioning of the existing pumping stations is not required for the Island Scheme. Provision must be made on the new waterfront for future construction of the relocated pumping stations when the final scheme is implemented. The existing cooling water pumping stations are shown on Figure 1.9.

1.3 Study Objectives

The objectives of the study were, for the first stage, consisting of an initial assessment to establish the viability of the Island Scheme for the HKCEC extension. The Stage 1 Report was issued on 24th July 1993 and was considered by Working and Steering Groups. It was concluded that the Island Scheme was feasible in principle in terms of traffic and environmental matters, and the Steering Group accepted the report as the basis for proceeding to the second stage of the study.

The second stage of the study was required to determine in more detail the extent of reclamation and the amount of infrastructure and associated costs that are absolutely essential for the HKCEC extension.

The purpose of the traffic impact assessment study was to assess the requirements for transport infrastructure and traffic management schemes to cope with traffic and pedestrian demands arising from the proposed HKCEC Extension within the traffic study area.

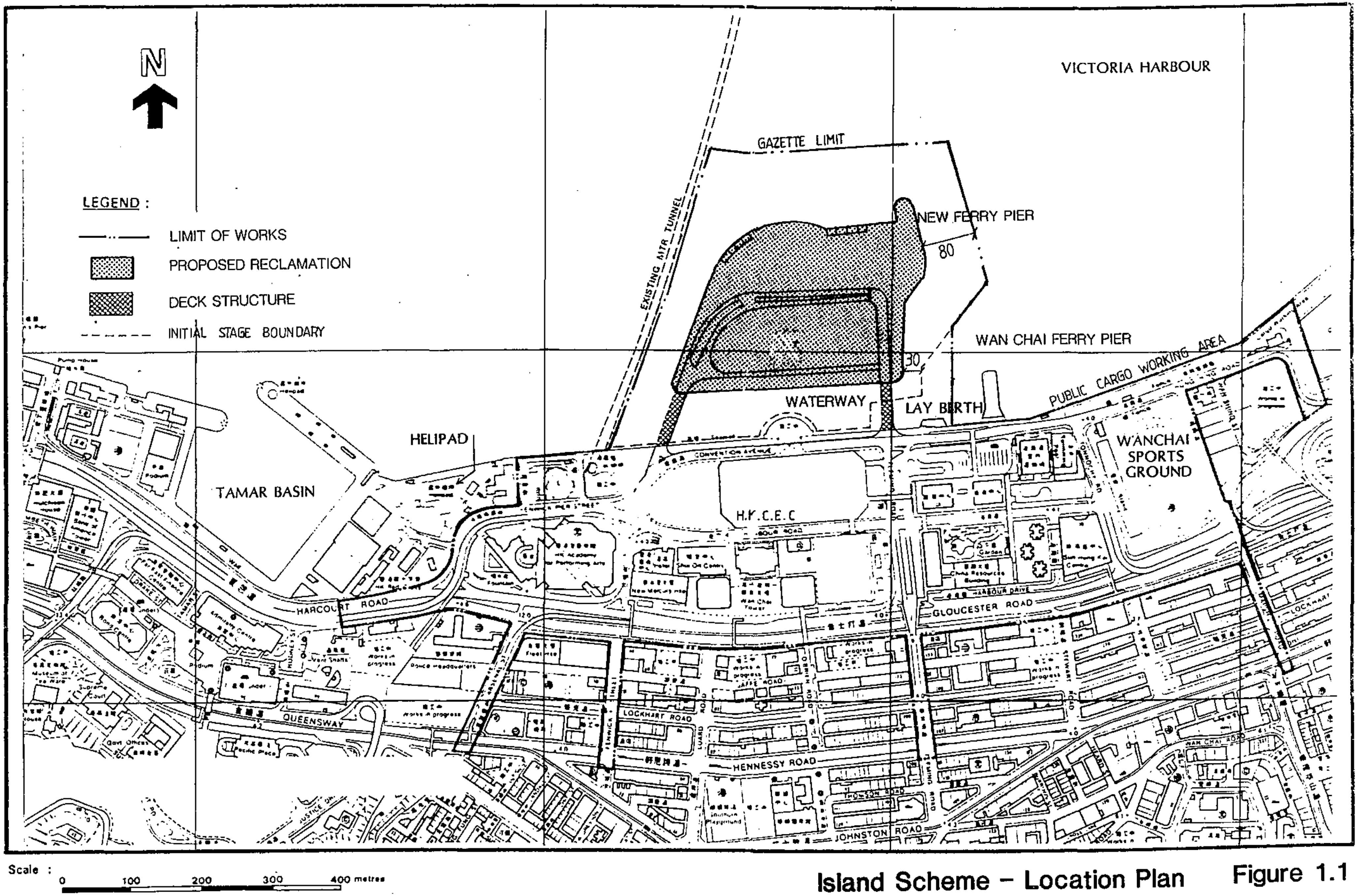
The purpose of the environmental impact assessment (EIA) study was to confirm the environmental acceptability of the Scheme and to work out the full environmental requirements and required mitigation measures.

1.4 Circulation of Study Reports

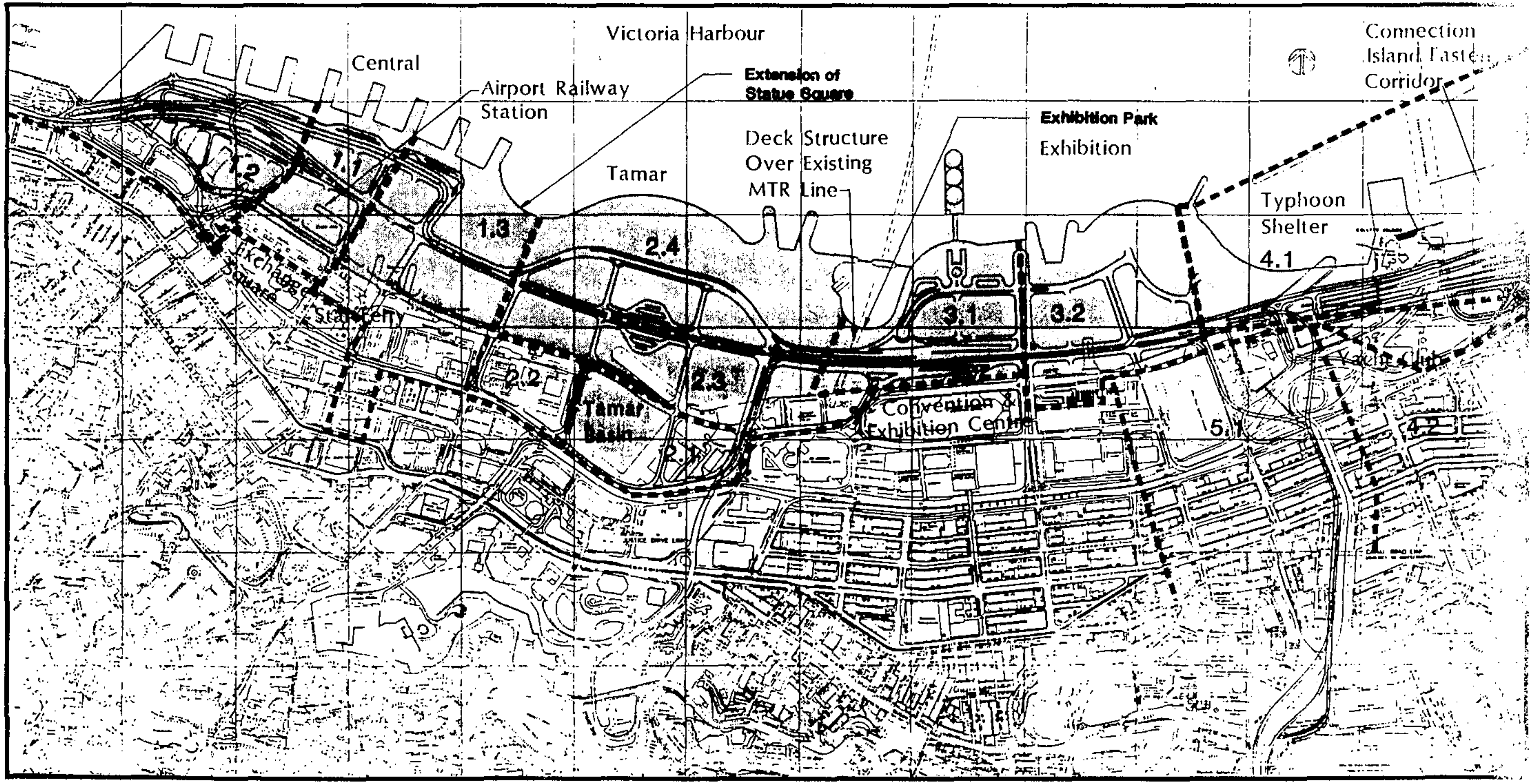
The Stage 2 draft Final Reports (Volume 1 and 2) were circulated on 5th and 4th October respectively comments were received and responses made. The Traffic Working Group Meeting No. 3, held on 26th October 1993, and the Steering Group No. 2, held on 28th October 1993, generally endorsed the conclusions of the draft Final Reports.

The draft Environmental Monitoring and Audit Manual was issued on 5th November 1993 and, after receipt of comments, the final manual will be issued separately.

The comments and responses on the Stage 2 draft Final Reports are included in Volume 3.



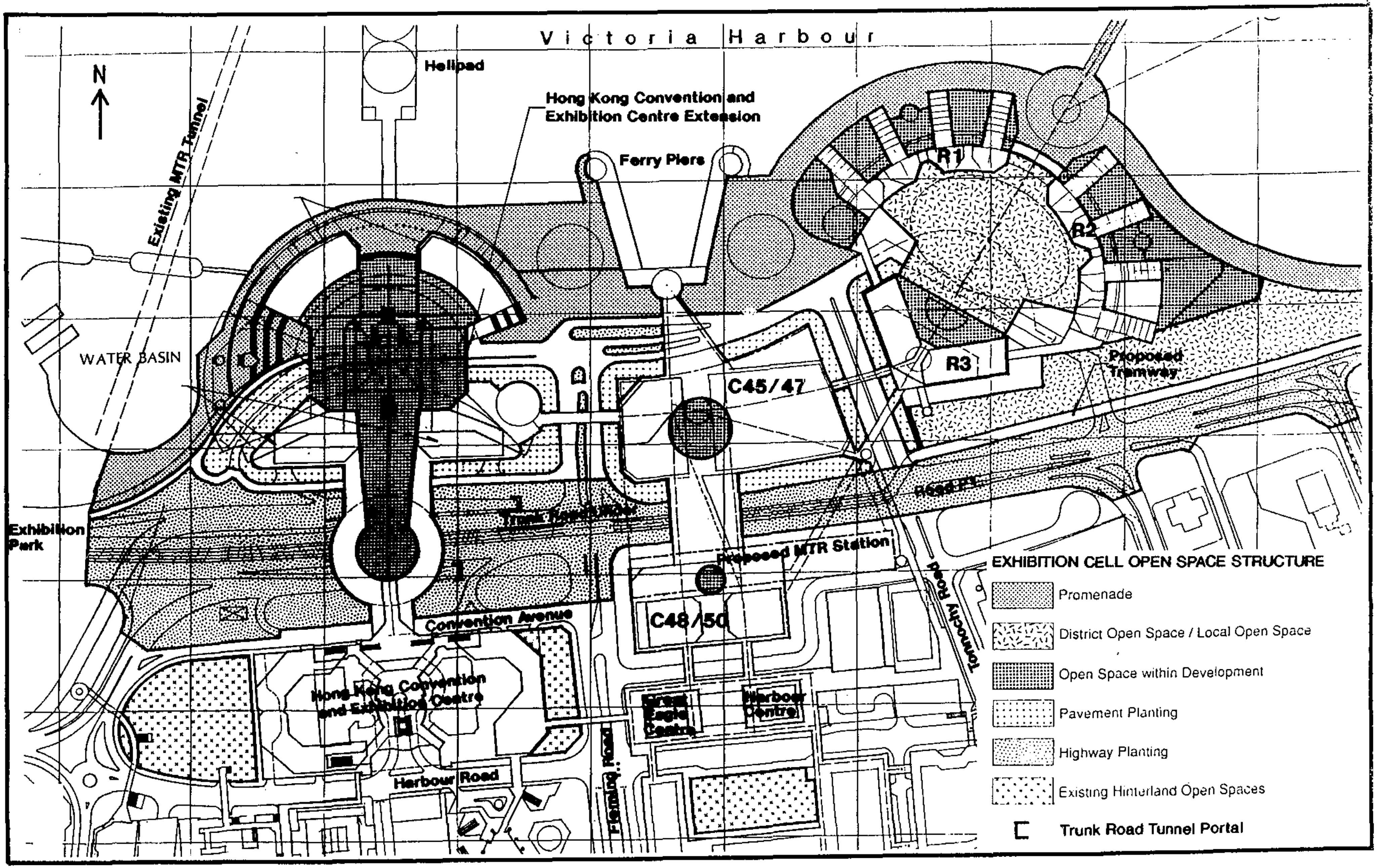
Island Scheme – Location Plan Figure 1.1



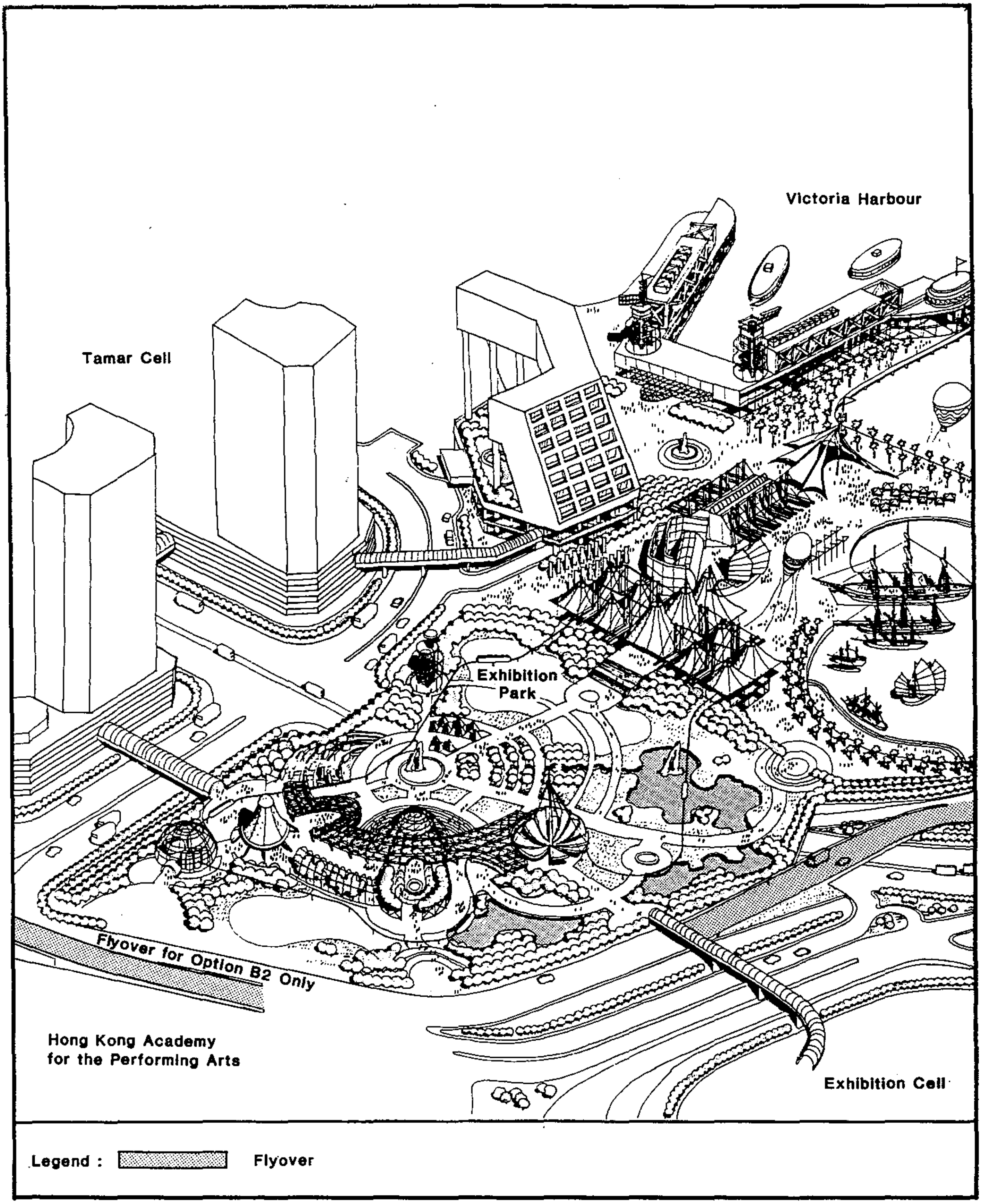
Legend : New Reclamation
Package Boundaries

Central and Wan Chai Reclamation

Figure 1.2

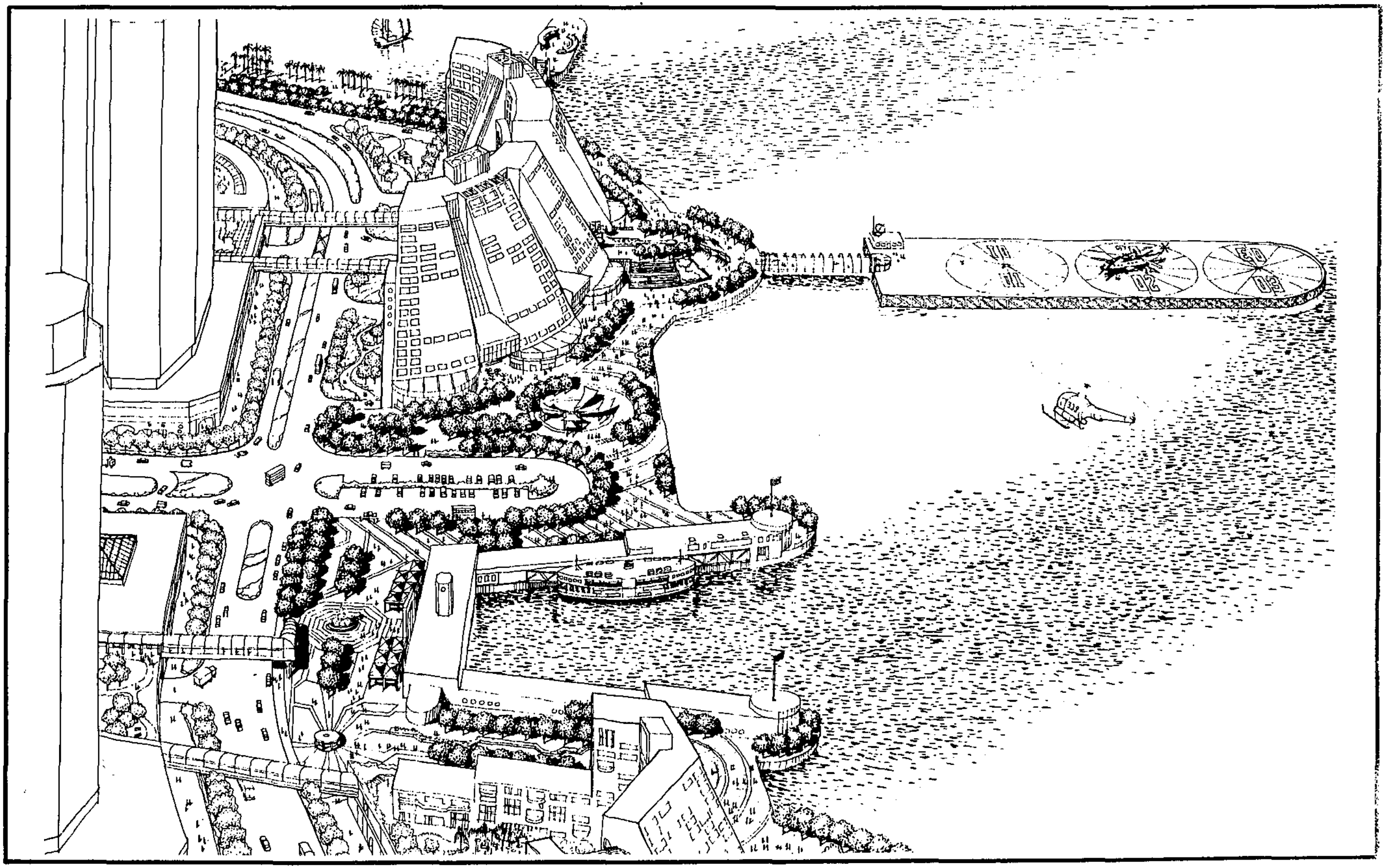


Proposed Outline Development Plan **Figure 1.3**



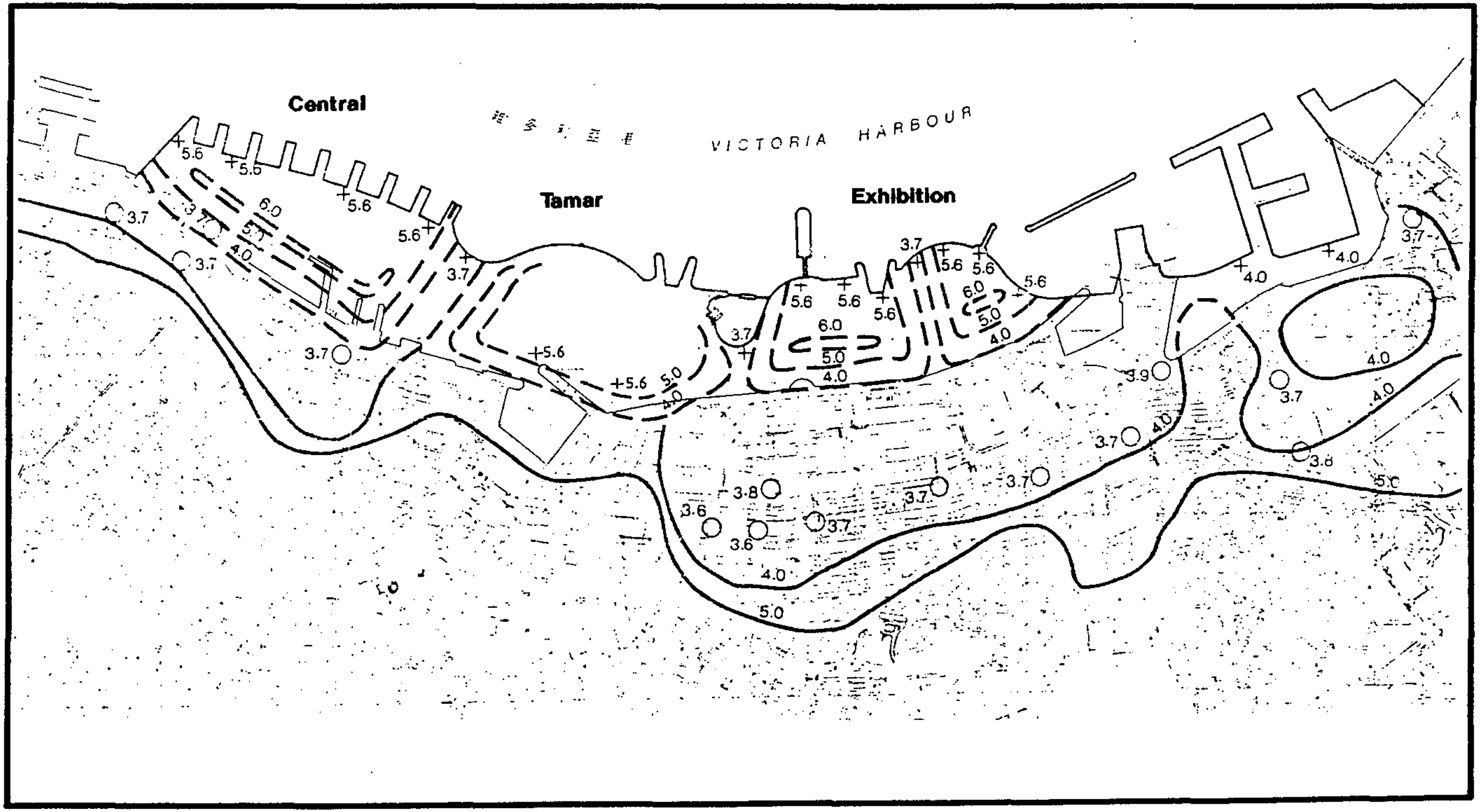
Artist's Impression of Exhibition Park

Figure 1.4



Artist's Impression of Exhibition Waterfront

Figure 1.5



0 200 400 600m

Build Up Levels in New Reclamation

Figure 1.6

Legend

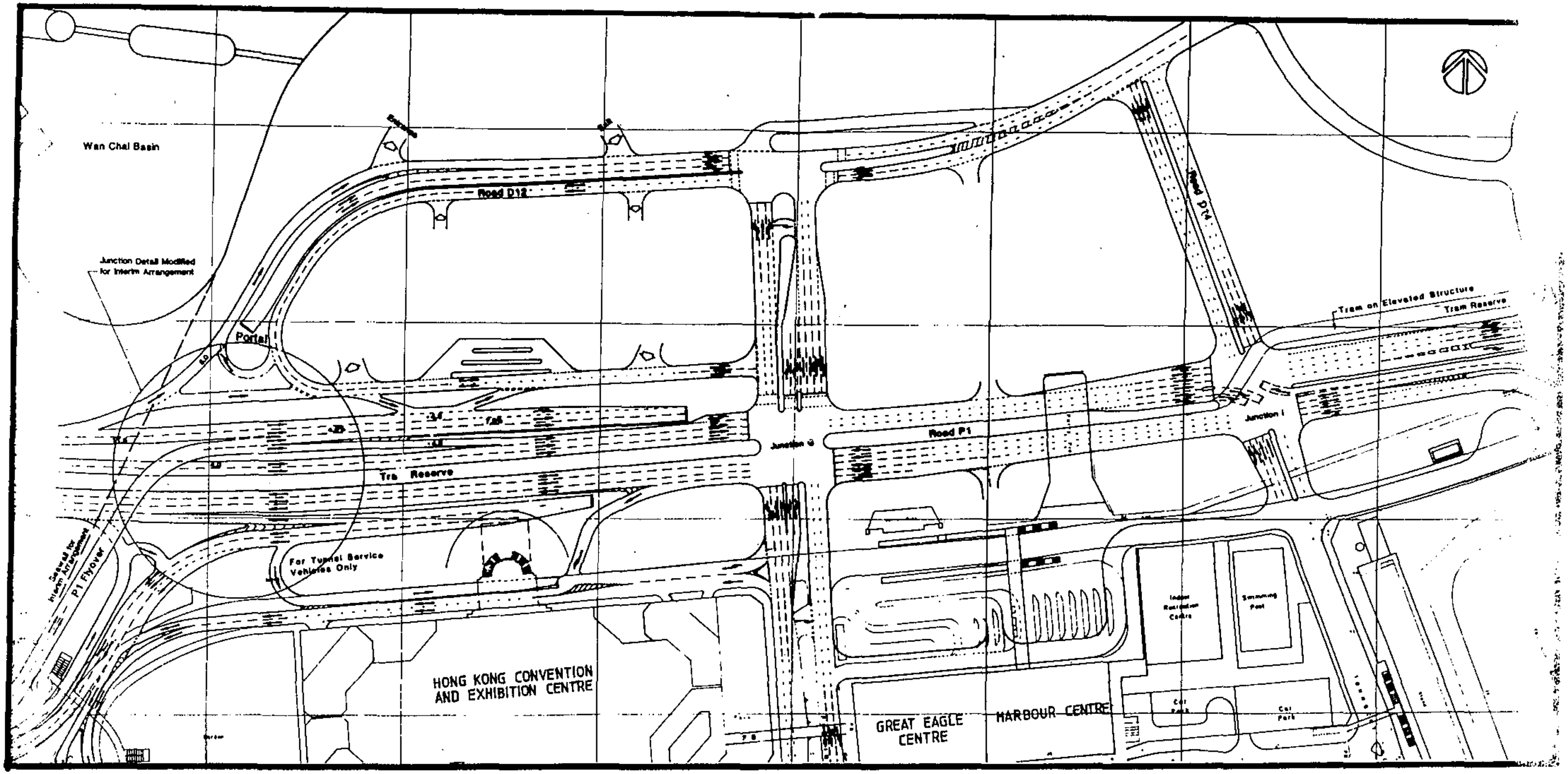
4.0 Contour Line with Level (mP.D.)

3.7○ Existing Spot Levels indicating ground to be below 4.0mP.D.

+5.6 Proposed Spot Levels (mP.D.)

Area to be Reclaimed or Redeveloped

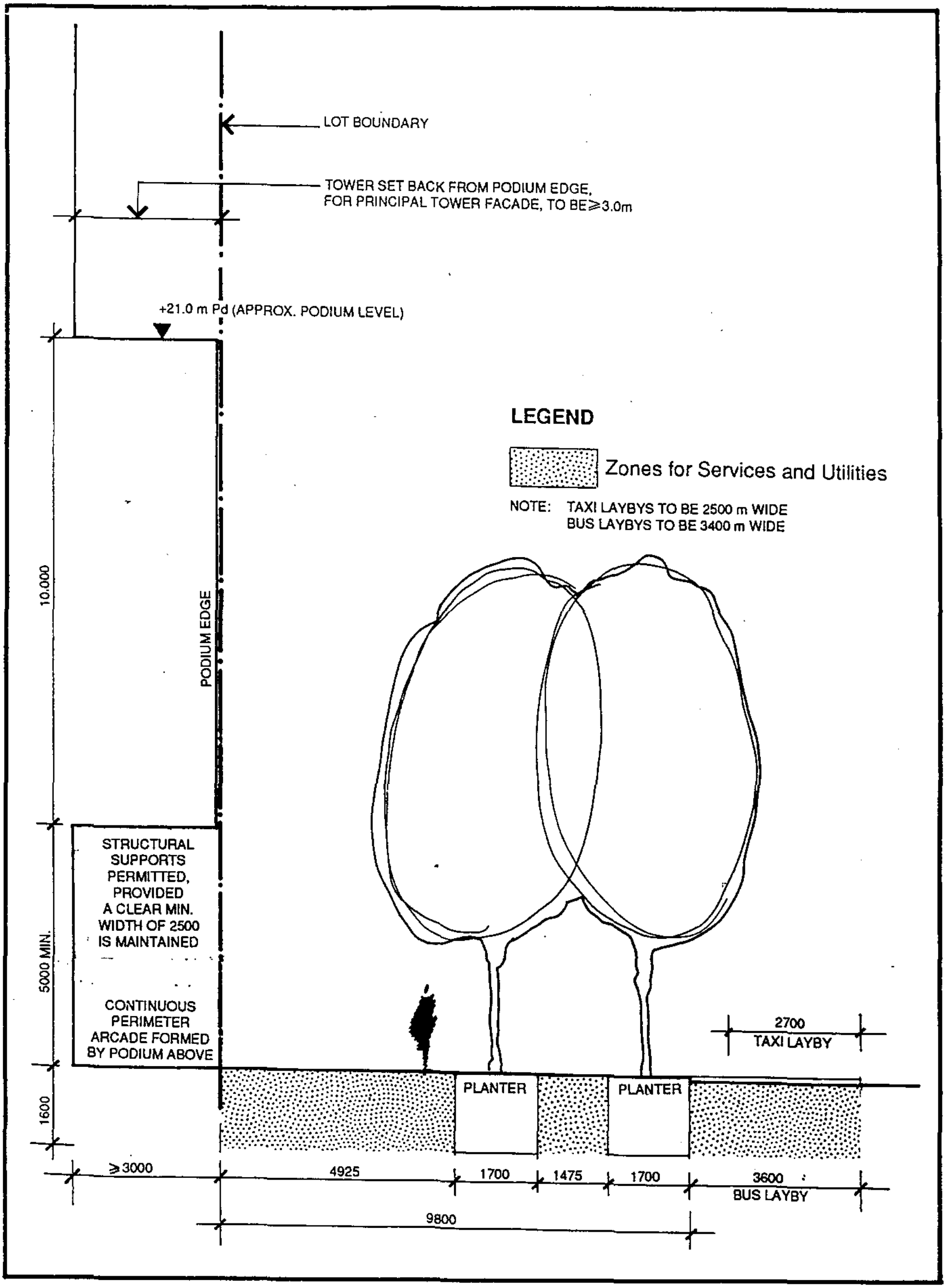
4.0 Proposed Contour Line on Reclamation with level (mP.D.)



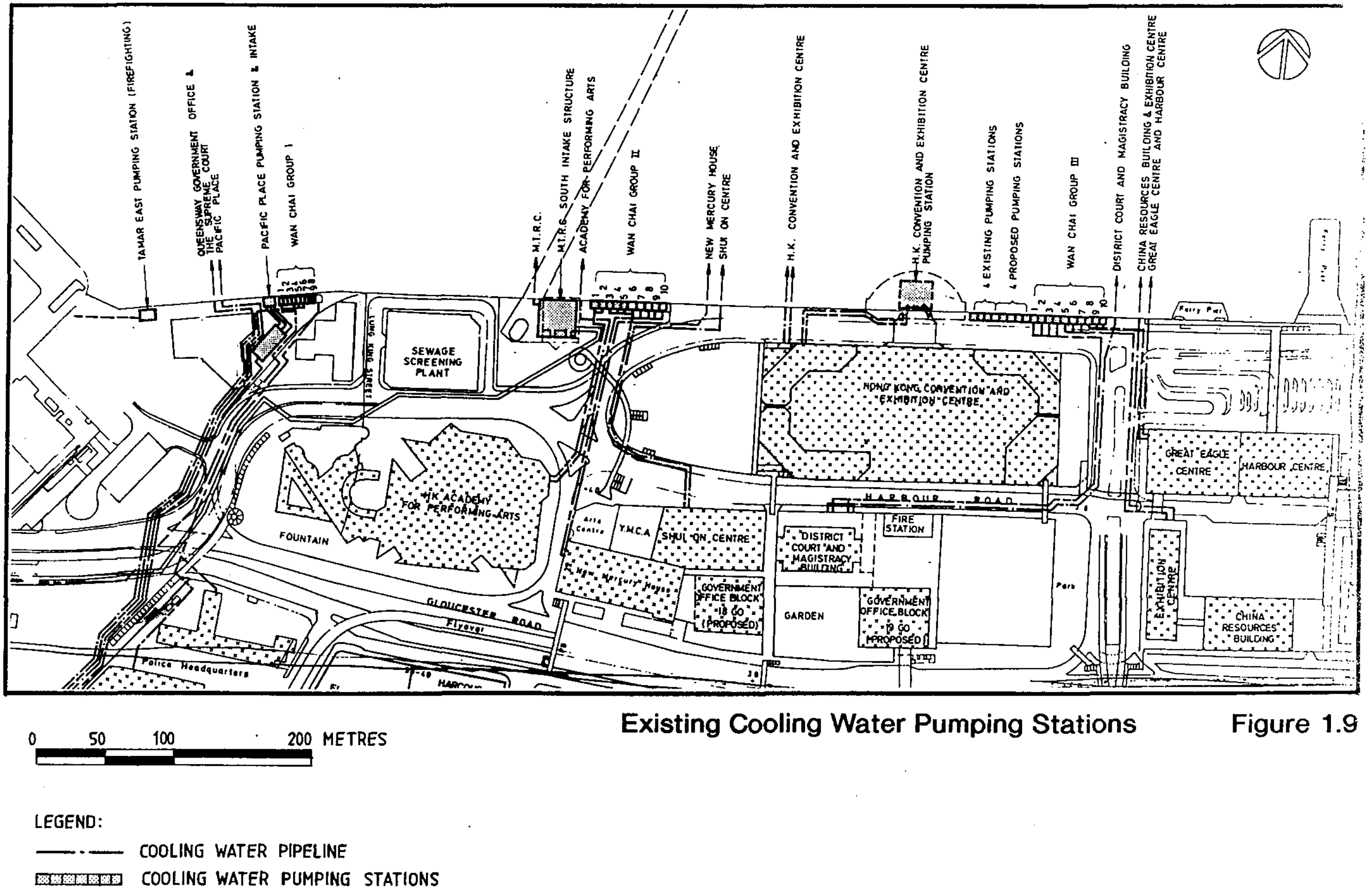
0 25 50 100 METRES

LEGEND:
TRAFFIC PATH

Recommended Road Layout **Figure [illegible]**



Footpath Widths **Figure 1.8**



Existing Cooling Water Pumping Stations **Figure 1.9**

2. Principle Features of the Project

2 Principal Features of the Project

2.1 Description

The proposed extension consists of a 6.5 ha of reclamation and 2.5 ha of waterway and extends from Fenwick Street to Fleming Road. A 75 metre-wide waterway separates the new island reclamation from the existing seawall. Access to the island will be by two piled deck structures which will provide both road and service links. The layout is shown in Figure 2.1. The present cooling water and stormwater culverts will not be affected by the reclamation although relocation of these will be required during future reclamation works. The Wanchai ferry pier will not require relocation at this stage but reprovision will be required for the stub pier, which presently berths the Hong Kong and Yaumati Ferry Company (HYF) nightclub and restaurant vessels.

The western link to the island will serve Fenwick Street and Convention Avenue and the eastern link will connect with Fleming Road. These are temporary structures which will be removed when the remainder of this area is reclaimed. It is proposed that the HKCEC will join with the extension over the waterway at a height of approximately +28.5 mPD. As there will be no supports, there will be no interference with the roads and MTRC tunnels which will eventually run the length of the waterway. The proposed positioning of these future structures is shown in Figure 2.2 of Volume 1 of the report.

The fill material used to form the reclamation has yet to be decided. There are three options which are to be considered,

i) Land-based contractor sourced material. This would probably consist of demolition material.

ii) Operation of the site as a public dump.

iii) Marine-based fill material.

The first two operations will probably generate similar environmental effects close to the site and will probably both involve use of construction waste for reclamation fill, although the contractor would be able to utilise any material that meets the requirements of fill material. Since the road access to the site will not be available until a late stage of the reclamation works, all fill material, whatever the source, will need to be barge hauled to the site. Therefore, in environmental terms, all options, including the use of marine sand, will be similar.

In view of the tight programme scheduling for the extension to the Exhibition Centre it is likely that the marine-based fill source will be utilised. Marine sand is more accessable and can be quickly and easily placed.

2.2 Phasing

Phasing of construction is described in Section 5 of Volume 1 of the Report, Figure 5.2.

A permanent berthing facility will be provided for the HYF vessels. In addition, the cooling water shells for future use will be constructed in the seawalls with a view to minimising future disruption of the waterfront promenade. Relocation of the actual intakes will not be necessary until future stages of reclamation commence.

2.3 Construction Activities

It has recently become desirable to limit the quantities of marine mud removed prior to reclamation, especially in areas such as Victoria Harbour which are known to be highly contaminated. In previous phases of the Central and Wanchai Reclamation conventional vertical seawall have been proposed, these requiring dredging of all soft muds in the area. For this study it is understood that alternative methods of seawall construction and design are under consideration to minimising the extent of dredging. The design has not been finalised, so the precise quantities of dredged material are not available. However, dredging will certainly be required next to the MTR tunnel.

The reclamation will require approximately 1100 m of new seawall. The fill requirements are as follows;

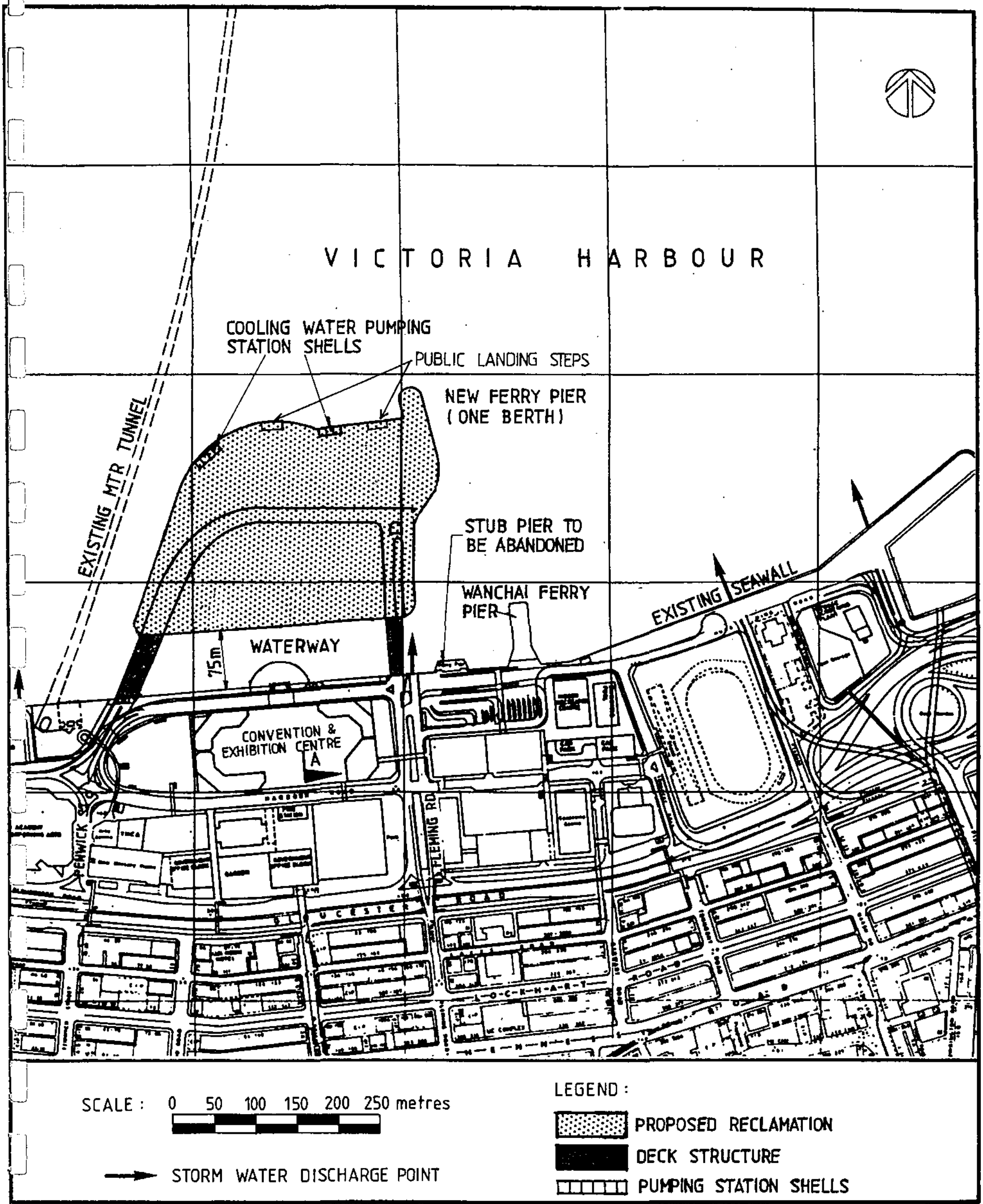
Soft Fill	1.5 Million m^3
Rock Fill	0.5 Million m^3

Two piled deck structures are proposed to provide road and service links to the island reclamation. The western deck structure will carry a road linking the new reclamation to Fenwick Street and Convention Avenue, while the eastern structure will provide a link to Fleming Road. These structures will be removed when proposed additional future reclamation is carried out.

It has been proposed in the Stage 1 Report that the island reclamation could be used as a steel fabrication area if required.

2.4 Development and Landuse

The reclamation will eventually form part of the 'Exhibition Cell' phase of the Central and Wanchai Reclamation which will consist of the exhibition centre extension, offices and open space. At this stage the island will consist of HKCEC extension only. The landuses for the area are shown in Figure 1.3 of Volume 1 of the Report.



Island Scheme – Layout **Figure 2.1**

3. Sewerage and Drainage Aspects

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3.1 SEWERAGE

3.1.1 Existing Sewerage

The Central, Western and Wan Chai Sewerage Master Plan (CW3-SMP) Study carried out for the Environmental Protection Department (EPD) has recommended extensive improvement measures to the existing foul sewer system within an area which overlaps with the reclamation proposals. Included in the CW3-SMP proposals is a new deep trunk sewer along Harcourt Road and Gloucester Road which will divert foul water from the Wan Chai West catchment to the Wan Chai East Sewage Screening Plant, which will be expanded. The Wan Chai West Plant will be phased out and the sewage from both catchments eventually conveyed to the deep trunk sewers forming the future Strategic Sewage Disposal Scheme (SSDS) for ultimate discharge to the oceanic outfall, more than 15 km south of Hong Kong.

The Wan Chai section (Stage II) of the CW3-SMP proposals are currently programmed to be designed in detail commencing in 1994, with completion of the trunk sewer and reticulation improvements by 1998. The current target date for the commissioning of the Hong Kong North Island section (Stage III) of the SSDS is 2003.

The existing sewer reticulation within the Wan Chai area will not be directly affected by the proposed Island Scheme. The Wan Chai West and East Sewage Screening Plants are within 0.5 km to the west and east of the reclamation respectively, and their effluents are discharged into Victoria Harbour via submarine outfalls which extend about 600 m from the sea wall. Again, these will not be directly affected by the reclamation.

3.1.2 Reclamation Sewerage

The Hong Kong Convention and Exhibition Centre (HKCEC) Extension Study Stage 1 Concept Brief prepared for the Hong Kong Trade Development Council in 1990 gives guidance relating to anticipated sewage flows. The Report states that foul water drains should be sized to remove all potable water supplied, and that the water mains should be sized for a demand of 3 $l.s^{-1}$ per 1,000 m^2 of exhibition space. Assuming that this is peak demand and using the revised gross floor areas (GFA) presented in the Preliminary Urban Design Brief for the Extension (August 1993), the predicted peak sewage flow generated from the development is approximately 80 $l.s^{-1}$.

Assuming a peak factor of 3 and a 16 hour sewage flow day, the predicted daily sewage flow is of the order of 1500 $m^3.d^{-1}$. For an average BOD and suspended solids (SS) concentration of say 300 $mg.l^{-1}$ (moderate strength sewage as extensive catering facilities are proposed), then the daily pollution load from the development will be about 450 $kg.d^{-1}$ for both BOD and SS. Allowance for additional sewage from the final phase of the reclamation would not be required as the area is self-contained and all building development will be incorporated within the initial reclamation phase.

A major consideration regarding disposal of sewage from the reclamation is the method of conveying the foul water across the water channel between the development and the existing sea wall. Two options are available as described below, but in both cases the pipeline would have to follow either one of the road deck structures linking the reclamation to the mainland.

Option A - Gravity Flow

This comprises a conventional gravity pipe reticulation carrying foul water from various connection points from the HKCEC complex to a terminal manhole located at the end of one of the road decks on the reclamation side (see Figure 3.1). The main sewer (probably a 350 mm diameter at a minimum gradient of 1 in 300) would then cross over the waterway and below the road deck, draining by gravity to a header manhole on the mainland side. Intermediate manholes along the bridge would be difficult to incorporate and therefore the sewer run would have to be approximately 85 m in length. The maximum distance between manholes for pipes upto 400 mm in diameter is 90 m, as recommended by the CW3-SMP Technical Paper TP1 (revised).

It is understood that the depth of the road deck should be minimised to ensure that the soffit level will be kept above the general high tide level of + 2.5 mPD. Although the level of the sewers will be dependent on the final build-up levels on the reclamation, as yet unkown, it is envisaged that the invert level of the main sewer across the channel will be below + 2.5 m PD, and would therefore have to be located outside the bridge section, and suspended beneath it. A conventional concrete pipe would require frequent supports at every pipe joint (1 m spacings approximately) and therefore HDPE pipe or ductile iron externally coated with polyethylene for corrosion resistance would be a better option since these products are lighter and are available in much longer sections.

Head clearance below the road bridges for navigation purposes will not be required. However, the sewer will require protection from possible damage by floating debris and by the small vessel which will permanently operate within the waterway for maintenance dredging. A concrete fender arrangement, also supported from the deck structure could be provided for protection of the pipe.

Option B - Pumped Flow

An alternative to gravity discharge would be to pump the foul water across the bridge. The advantage of this would be that the pumping main could be incorporated within the deck structure and be completely protected, whereas in option A measures are required to protect the sewer which will be exposed and periodically submerged within the waterway. A small wet well sewage pumping station containing two submersible pumps (one duty, one standby rated at about 80 $l.s^{-1}$ each; head < 10 m) would have to be located where vehicular access could be provided for periodic maintenance.

The additional cost of providing a pumping station may be partially or wholly offset by the savings in not having to provide pipe protection, but a pumping option would incur ongoing maintenance and operational costs. Because of this, the Drainage Services Department (DSD) may not want to adopt such a system, and therefore the maintenance and operational responsibilities would have to be undertaken by the HKCEC management. As such, the pumping station could be incorporated within the basement servicing and car park level of the Extension building. Pumped flows would discharge into the header manhole on the mainland side, as for option A.

From the header manhole at the junction of Convention Avenue with either of the reclamation feeder roads, the sewage from the development would discharge into a gravity foul sewer system within the Wan Chai area. An existing 450 mm diameter sewer along Convention Avenue adjacent to the current HKCEC complex would not have sufficient capacity to accept the additional flow from the Extension. However, based on preliminary information, the sewer was identified by the CW3-SMP as one part of a reticulation draining to the Wan Chai West Sewage Screening Plant which requires complete upgrading and replacement. If this recommendation is confirmed during the SMP detailed design stage, about to commence in 1994, then the replacement sewer system should be designed to accept the reclamation flow, this being the simplest and most economical disposal option. If it is found that the existing reticulation does not require upgrading, then a new sewer would be required along Convention Avenue and Fenwick Pier Street to the Wan Chai West Screening Plant.

The sewage flow from the Screening Plant will be diverted to the new Harcourt Road trunk sewer, and therefore the design of the connecting pipe should also be sized to incorporate the

Extension flow. It is envisaged that the trunk sewer design will take into account the potential flows from the relevant sections of the Central and Wan Chai Reclamation Development. Since construction of the SMP proposals should be completed by 1998, the sewage infrastructure should already be available to accept flows from the reclamation by the time the Extension is implemented. The connection from the Island scheme would be via the west road bridge crossing the waterway.

3.2 Stormwater Drainage

3.2.1 Existing Stormwater System

The Central and Wan Chai Reclamation Feasibility Study (CWRFS) identified nineteen stormwater systems within the study area, eleven of which are within a range of approximately 1 km to the west and east of the HKCEC inside the water quality modelling zone for this study. These stormwater systems discharge into Victoria Harbour at various points along the seawall between City Hall and Causeway Bay, serving catchments of varying nature and size. Figure 3.2 shows the outfall locations and catchment areas of the eleven stormwater systems labelled J1 to S. Details of the outfalls are given in Working Paper WP1 of this sudy.

The stormwater is collected by a system of pipes and culverts which operate by gravity, with the flows generally draining from south to north. No treatment of stormwater is provided before ultimately being discharged into the harbour.

Of the eleven drainage catchments, the proposed reclamation will only have an impact on catchment M (although indirectly only), which will discharge into the proposed waterway between the reclamation and the existing sea wall. Catchment M covers an area of 108 ha from Mount Cameron, down Wan Chai Road and Fleming Road, and outfalls adjacent to the western side of the current HKCEC, a level difference of nearly 50 metres.

The upper part of the catchment collects run-off into natural streams and open nullahs from the steep rural areas, which are sparsely populated. The lower part of the catchment varies from steep to low gradient and comprises a combination of residential and commercial areas from Bowen Road to the sea wall. Queen's Road East, Hennessy Road, and Gloucester Road are the principal roads in the catchment.

The catchment M drainage system comprises nearly 10 km of open channels, pipes, and box culverts of varying size, with a twin cell 2740 mm wide x 2590 mm deep box culvert at the outfall. The outfall has an invert level of about - 0.6 m PD and therefore lies entirely within the tidal range of the harbour water, with partial submergence at a mean sea level of + 1.33 m PD. As such, the discharge characteristics of the culvert are subject to influence from the water level in the harbour, particularly at high tide (+ 2.5 m PD maximum).

The Surface Water Drainage Systems Investigation carried out for the Central and Wan Chai Reclamation (CWR) Development demonstrated that the majority of the catchment M drainage system has insufficient capacity. This is based on the criteria given in Volume 4 (Sewerage and Drainage) of the Civil Engineering Manual which requires main stormwater drains through developed areas to be designed for a 1 in 200 year return period storm and high tide level of + 2.5 m PD. Extensive flooding was predicted within the catchment, although the main spine of the system along Fleming Road was found to have adequate capacity in places.

3.2.2 Reclamation Drainage System

The performance of the drainage system with the reclamation was also analysed in the drainage investigation mentioned in section 3.2.1, and the results indicated that there would be a minor increase in predicted flooding as a result of the reclamation. As the flooding would increase, albeit by a small amount, some remedial works would be necessary, which would require significant upgrading of the Fleming Road box culvert as well as improvements to other parts of the existing drainage network. The cost of these remedial works to prevent deterioration from existing conditions was estimated to be HK$ 17 million at 1992 prices.

The proposed reclamation for the HKCEC Extension will be separated from the mainland by a 75 m wide waterway, and therefore outfall M would continue to discharge directly into the Harbour at its current location. Remedial works would therefore not be necessary for this phase of the development, and may be deferred until the full reclamation of the Exhibition Cell is implemented.

The drainage culvert would eventually have to be extended through the full reclamation to the new sea wall to maintain discharge to the Harbour. The extension alignment should follow the route of Road D13 northwards to avoid the proposed commercial lots to the east, and the HKCEC Extension to the west (Figure 3.3). For the Island Scheme, three options for Culvert M are considered as follows :

Option 1 - Partial culvert provision

To avoid reconstruction of Road D13 and minimise future disruption to traffic, provisions could be made in this phase of the reclamation for the future extension of Culvert M. This would require the construction of a triple cell box culvert of 2700 mm x 2700 mm approximate cell dimensions, as suggested by the CWRFS, although it would not be necessary for the implementation of the Island Scheme itself. The culvert size allows for additional stormwater run-off from the Exhibition Cell section of the reclamation development. The approximate invert level at the proposed sea wall would be - 0.91 m PD.

The stormwater drainage system for the proposed scheme will be a conventional gravity pipe system located within the carriageways, and would discharge into the culvert M extension. Since the culvert would be designed to eventually receive run-off from the whole of catchment M, the relatively minor flows contributed from the reclamation only (about 7% of the total catchment M area) during the interim period would not be sufficient to minimise siltation of the new culvert. Temporary closure of two of the three cells of the culvert with only one cell operational in the Island phase may be a solution, with particular attention being given to measures to facilitate desilting.

Option 2 - No culvert provision

Since the partial culvert extension would be mostly redundant until the final reclamation phase is implemented, it may be decided not to make such provisions in the Island Scheme. The reclamation drainage would therefore require an independent outfall at the new sea wall. Preliminary calculations indicate that this would probably be a 1650 mm diameter culvert at a minimum gradient of 1 in 250 and an invert level of about + 1 m PD at the point of discharge.

Option 3 - Full culvert provision

The full culvert extension from the existing to the new sea wall could be constructed in this phase of the reclamation. The culvert could be constructed on piles across the waterway beneath the road deck structure, which would divert the polluted stormwater discharges away from the channel and into the open part of the Harbour. This would also avoid the requirement for future diversion works to the existing culvert and consequent traffic disruption during the construction of the full reclamation.

However, there are significant disadvantages to this option. The piles supporting the road deck structure would have to be spaced further apart as the culvert construction would require a minimum clearance of approximately 9 m between piles. This compares to a spacing of 7.5 m, not allowing for pile diameter, as suggested by the Initial Assessment

Report for the scheme. The wider spacing necessary would require a deeper deck structure which would in turn require the vertical alignment of the new and existing connecting roads to be raised to prevent the deck beams from interfering with the culvert. To avoid these problems, the culvert could be diverted to one side of the bridge, but this would cause additional disruption to Fleming Road and Convention Avenue traffic during construction, and may also be visually unacceptable.

The full culvert extension would also be a significant obstruction to the flushing of the waterway, which is essential to prevent deterioration of the water quality around the proposed reclamation. Furthermore, full extension of outfall M through the reclamation would increase potential flooding as suggested by the drainage investigation for the CWR Scheme, and therefore remedial measures would have to be implemented. Because of these disadvantages, full culvert extension is not recommended for this phase of the reclamation.

The principal flood relief paths through the Exhibition Cell of the CWR as proposed by the CWRFS are located to the west and east of the Island Scheme. Therefore, the formation levels of this section of the reclamation may be higher than the minimum + 3.7 m PD required for the flood relief corridors.

Allowance should be made in the drainage design for additional run-off when the waterway is reclaimed. Drainage of the promenade would probably be independent of the main stormwater system. The peak discharge from the Island catchment during a 1 in 200 year storm would be of the order of 5 $m^3.s^{-1}$, and about 6.5 $m^3.s^{-1}$ including the waterway area after full reclamation.

3.2.3 Stormwater Pollution

The investigations carried out for the CWRFS suggest that 'partially combined' systems have evolved over many years due to the practice of cross-connecting foul and surface water drains for a variety of reasons. Whilst these connections are the main source of pollution as confirmed by the SMP studies for Central, Western and Wan Chai (CW3), and for Wan Chai East and North Point (WENP), other sources have been identified.

The nature of the inputs to the storm system in the urban sections of the catchments vary from area to area but are likely to include large amounts of foul sewage derived from accidental or intentional cross connections, direct discharge of polluted effluent to the storm system and the disposal of polluted water to gulleys from street markets, vendors and restaurants. The pollution discharged into Victoria Harbour at the seawall from the stormwater outfalls within the vicinity of the proposed scheme are described in Working Paper WP1 of this Study and the loadings are reproduced in Table 3.1. The discharges from the Wan Chai West and East Sewage Screening Plants are also included.

Table 3.1 Pollution Loads Measured in Stormwater Discharges

Outfall Ref.	Flow ($m^3.d^{-1}$)	BOD_5 Load ($kg.d^{-1}$)	SS Load ($kg.d^{-1}$)	*E. coli* Load ($count.s^{-1}$)
J1	7,430	2,500	980	310×10^8
J2	31,800	79	2330	4×10^8
K[1]	N/A	N/A	N/A	N/A
L	10,845	2,326	3,011	391×10^8
M	9,405	2,364	1,617	132×10^8
N	Insignificant			
O	2,524	408	240	N/A
P	98	13	6	N/A
Q	5015	1020	336	N/A
R	1,811	109	158	N/A
S	Insignificant			
WW[2]	35,000	12,500[3]	N/A	N/A
WE[2]	61,000	14,000[3]	N/A	N/A

Notes
1. [1] Catchment not surveyed
2. [2] WW = Wan Chai West SSP, WE = Wan Chai East SSP; [3] WP1 loads revised
3. N/A - data not available
4. Data for J1 to M are from the CW3-SMP surveys in 1990, and those for N to S are from the 1992 surveys for the WENP-SMP study currently being carried out. SS loads for N to S were calculated in this Study by multiplying the average sample concentrations by the daily flows provided.
5. Sampling points were located some distance upstream of the seawall discharge points and therefore, the loads may be underestimates since there could be additional inputs from possible unknown expedient connections within the sections of culverts not monitored.

Catchment M discharges directly into the proposed channel between the existing sea wall and the reclamation. No overflows or cross connections within the storm system are indicated on DSD record drawings but the survey for CW3-SMP suggests that there is significant foul contamination as indicated in Table 3.1. Of the more than 30 catchments identified in the CW3-SMP, catchment M was ranked fourth highest in terms of pollution loads based on BOD, and will therefore have a significant impact on water quality around the Island reclamation.

Catchments J1, L, O and Q also discharge high pollution loads but their impact on the scheme will be much less or negligible compared to catchment M because they are located much further away or are less contaminated. Potential improvement measures to reduce the pollution loadings are discussed in section 3.4.

3.3 Cooling Water Systems

3.3.1 Existing Pumping Stations

There are numerous groups of seawater pumping stations along the existing sea wall in the vicinity of the Extension Proposal, which serve buildings or complexes near the waterfront utilising sea water for air conditioning cooling and for toilet flushing (Figure 3.4). The pumping stations extract water from Victoria Harbour at one location in the seawall, and discharge the used water at another point typically 40 to 60 metres away. As a consequence, large sections of the seawall in the Wan Chai District are occupied by numerous cooling water intakes and outfalls which would have to be reprovisioned as various phases of the Exhibition Cell of the CWR Development are implemented.

Currently, about 7 $m^3.s^{-1}$ of seawater during peak summer demand is supplied to existing air-conditioning and toilet flushing systems by pumping stations located between Wan Chai West Sewage Screening Plant and the Wan Chai Ferry Pier. Working Paper WP2 of this Study details the cooling water discharge flows from individual buildings in the Wan Chai District.

In the Island phase of the reclamation, the pumping stations will continue to operate in their current locations, since the proposed waterway between the reclamation and the waterfront will provide uninterrupted intake and discharge of seawater from and to the Harbour. Therefore, reprovisioning of the existing stations will not be required. The proposed link road bridge north of Fleming Road is located immediately adjacent to the Wan Chai Group III pumping stations, and therefore this proximity should be taken into account in the detailed design of the bridge.

Some pumping station owners have reported existing problems with siltation and blockages by floating refuse, and have also expressed concern at the level of silt likely to enter the stations during reclamation works. The CWRFS indicated that silt was unlikely to be a major problem because of the technique which will be used to convey and place the material. However, silt levels in the water during reclamation will be higher than the existing conditions. If warranted, measures such as silt curtains could be used to minimise migration of silt into the stations.

3.3.2 Reprovisioning of Pumping Stations

The existing pumping stations between the Wan Chai West Sewage Screening Plant and the Wan Chai Ferry Pier as listed in Table 3.2, would require reprovisioning in the final phase of the reclamation on this section of the Exhibition Cell (referred to as Package 3.1 in the CWRFS). Pumping station shells could be constructed along the new waterfront under the Island phase of the reclamation to avoid disruption to the waterfront promenade when the full development is implemented. The pumping station shells should be constructed underground to ensure that the waterfront pedestrian promenade, which will run the complete length of the CWR Development, is uninterrupted.

Table 3.2 Existing Pumping Stations Requiring Reprovisioning

Building Name	Pumping Station	Ref.
Central Station Admiralty Station	)) South Intake Structure)	1
HK Acad.Perform.Arts	Wanchai I, Nos. 1,2	2
Shui On Centre	Wanchai II, Nos. 3,4,5,6	3
Telecom House (former New Mercury House)	Wanchai II, Nos. 7,8,9,10	4
Hong Kong Convention & Exhibition Centre (inc. Grand Hyatt & New World Harbour View Hotels)	HKCEC Pumping Station	5
Revenue & Immigration Towers (Government 18/19)	Wanchai III, Nos. 1,2,3,4	6
Dist Court & Magistrate (Wan Chai Tower)	Wanchai III, Nos. 1,2,3,4	7
China Resources & Exhibition Centre	Wanchai III, Nos. 5,6,7	8
Great Eagle & Harbour Centre	Wanchai III, Nos. 8,9,10	9

Two pumping stations will be provided along the new waterfront (Figure 3.5), each comprising a sufficient number of shells to reprovide for the existing stations listed in Table 3.2. It envisaged that the western pumping station would occupy about 40 m of new seawall, probably housing existing station numbers 1 to 5, and includes provisions for the new HKCEC Extension. The eastern pumping station would probably occupy about 60 m of new sea wall, assuming that 20 m would be reserved for future development sites C45, C48, C50 and the proposed Exhibition MTRC Station, and would reprovide for existing stations 6 to 9. These pumping station lengths are based on the assumption of a 5 m wide shell per 500 $l.s^{-1}$ of required pumping capacity. Electricity sub-stations supplying the pumping stations should be provided at suitable locations where they will not be obtrusive.

The intake and discharge pipework to the pumping station shells could also be installed during the island reclamation phase, again to minimise disruption and abortive work when the final phase is constructed. The pipework would be laid underneath the wide footway/verge areas which act as service and utility zones, a principle established in the CWRFS.

3.4 Potential Improvement Measures

3.4.1 Sewerage

The recommendations of the CW3-SMP would significantly improve existing deficiencies in the foul sewer system over a large area of north Hong Kong Island, including the Wan Chai District. By improving the hydraulic capacities of existing sewers, there would be less potential for contamination of the stormwater drainage system from overflows and cross-connections. This could potentially remove a significant proportion of the pollution loading currently being discharged into the Harbour via stormwater drains.

The simplest and most economical method of disposing of sewage generated from the proposed HKCEC Extension would be to connect the reclamation system to the existing reticulation in the Convention Avenue/Fenwick Pier Street area. This network was identified as requiring upgrading and replacement by the SMP and therefore it is proposed that the detailed design of the SMP measures should take into account the additional reclamation catchment.

The SMP proposals are currently programmed to be implemented by 1998, which coincides with the target completion date for the Island Scheme.

3.4.2 Stormwater Drainage System

Catchment M will not be affected by the initial Island phase of the reclamation, but provisions could be made during this stage to construct the extension for Culvert M through the reclamation. This would minimise abortive work and disruption during the final reclamation phase. However, the culvert extension would be mostly redundant for potentially quite a long period and would still require maintainance if one cell is used for reclamation drainage. If the culvert extension is not provided in the initial phase, there would not be any problems in providing an independent drainage system for the Island reclamation.

Contaminated stormwater from outfall M will probably have the greatest impact on water quality within the vicinity of the proposed reclamation, and therefore remedial measures required to mitigate this impact should be implemented as a part of the Island Scheme. The CW3-SMP identified the occurrence of expedient connections within the stormwater network as being the major source of contamination. However, it was not possible to identify the connections between the foul sewers and stormwater system due to the scope, timescale of the Study, and also the presence of silt, grease and surcharging of the foul sewer system. Therefore, it would be necessary to carry out an extensive expedient connection survey to determine the source and precise location of all connections of foul flows to the stormwater system before remedial measures are proposed in detail. This work should ideally be carried out before the SMP detailed design stage commences in 1994 so that the findings could be incorporated within the SMP improvement measures.

The potential remedial measures would be based on a principle of interception and diversion of foul flows. The proposals would follow the recommendations of the CW3-SMP and would in concept comprise the following work :

- expedient connection survey to identify 'cross' connections;
- disconnection of major expedient connections to return the sewer and stormwater drainage networks to separate systems wherever possible;
- diversion of disconnected sewers to the existing and new reticulation sewers proposed in the SMP;
- the SMP identified significant stormwater contamination in catchment M from oil/grease and food wastes suggesting that the pollution may in part be arising from discharges from markets and restaurants. It was suggested that the intensive street markets could be the source of the heavy contamination detected at one of the sampling points. If warranted, those storm drains polluted by food and street market stalls should be considered for

disconnection from the stormwater system and connection into the sewerage system. However, as a consequence, there could be significant increases in flow in the sewers during periods of rainfall and therefore the drains to be diverted would have to be selected with this consideration in mind. Another possible option would be for EPD to carry out an education/awareness programme to encourage stall holders/shop owners to take care regarding disposal of their wastes. This was recommended in the Expedient Connection Survey Report for catchments C and D in the Central District.

Since details of remedial measures cannot be proposed at this stage, the resulting improvement to pollution reduction cannot be predicted. However, it has been accepted by EPD to assume mitigation scenarios based on a 25% reduction in pollutants for the purposes of water quality modelling. This is discussed in detail in Chapter 4.

3.4.3 Cooling Water Pumping Stations

Since the existing seawater pumping stations will not be physically affected by the Island Scheme, improvement measures are not considered necessary. However, shells for future reprovisioning of the stations will be incorporated into the scheme as discussed in section 3.3.2. During reclamation work, special measures may be required to prevent worsening of siltation problems already experienced by some pumping stations. This problem is addressed in the following Chapter.

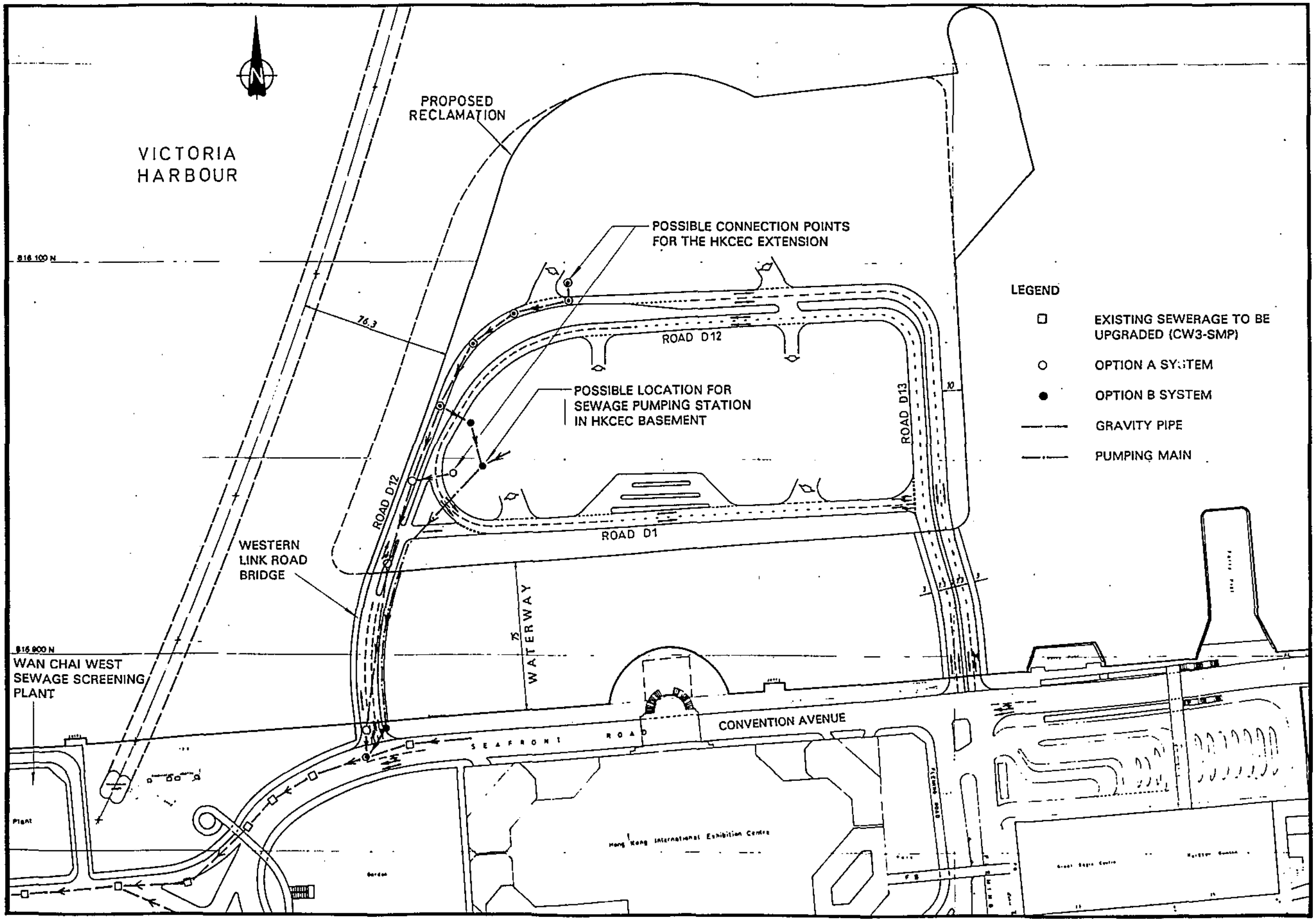

FIGURE 3.1 SEWERAGE OPTIONS

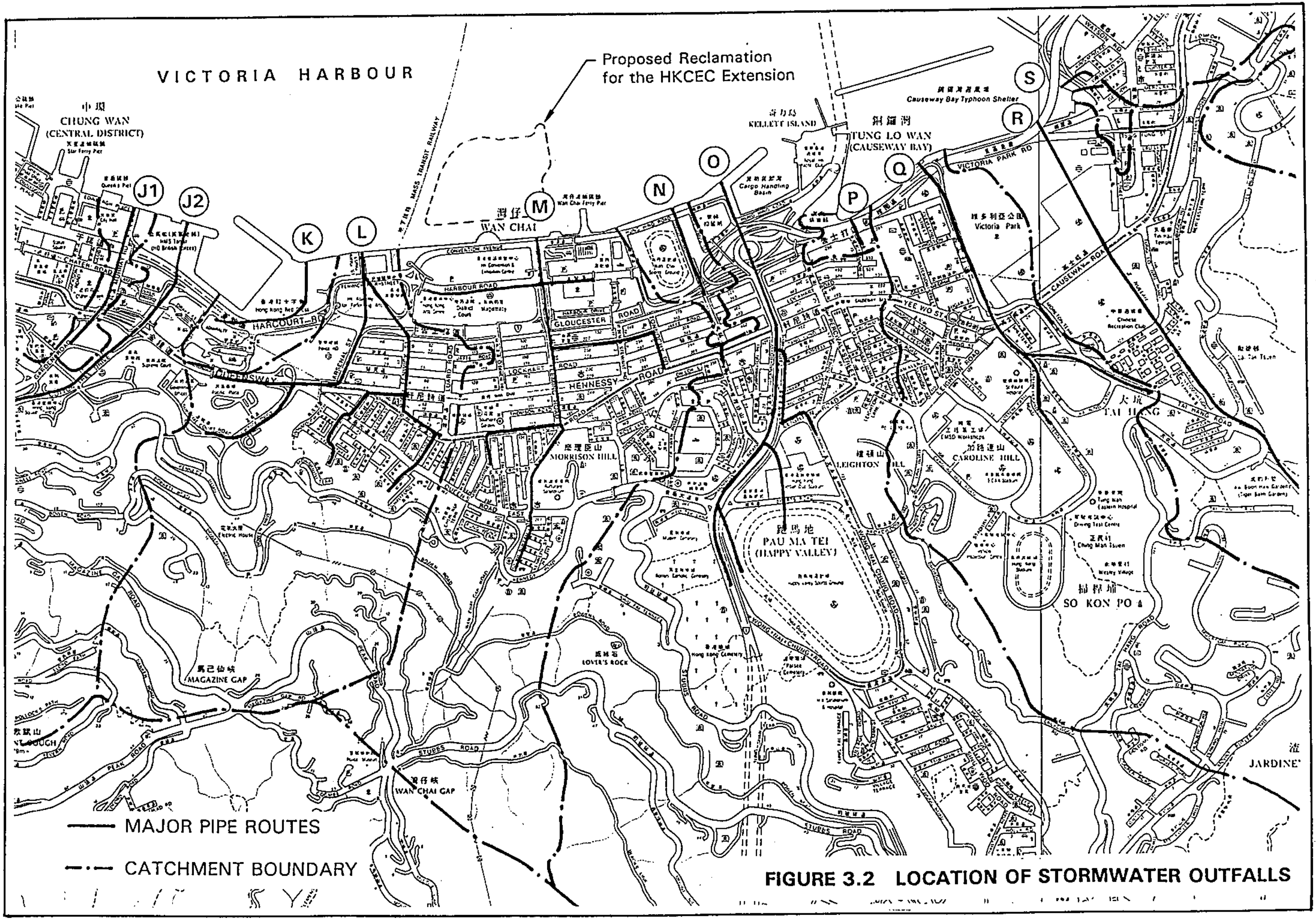

FIGURE 3.2 LOCATION OF STORMWATER OUTFALLS

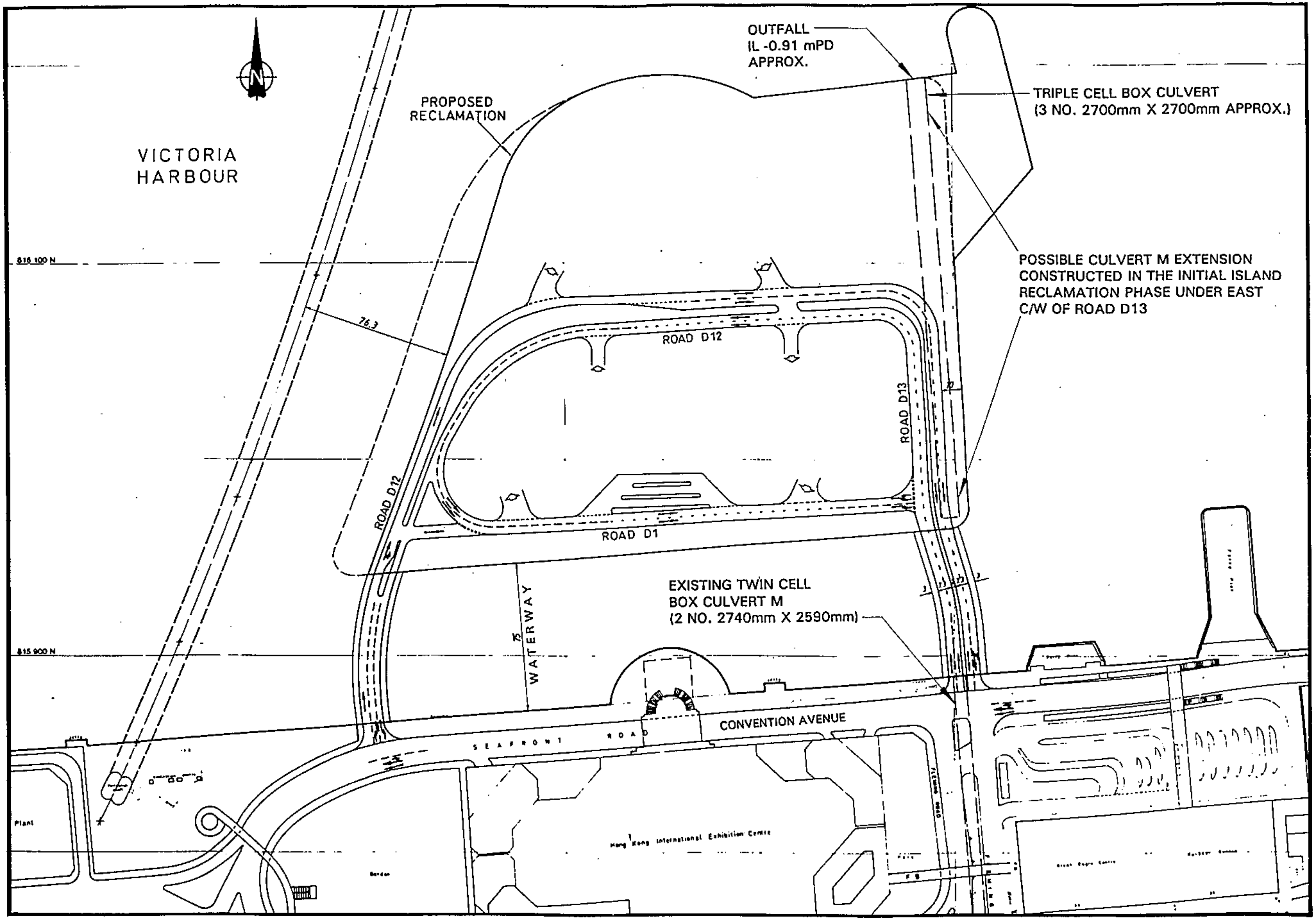

FIGURE 3.3 EXTENSION OF CULVERT M THROUGH THE RECLAMATION

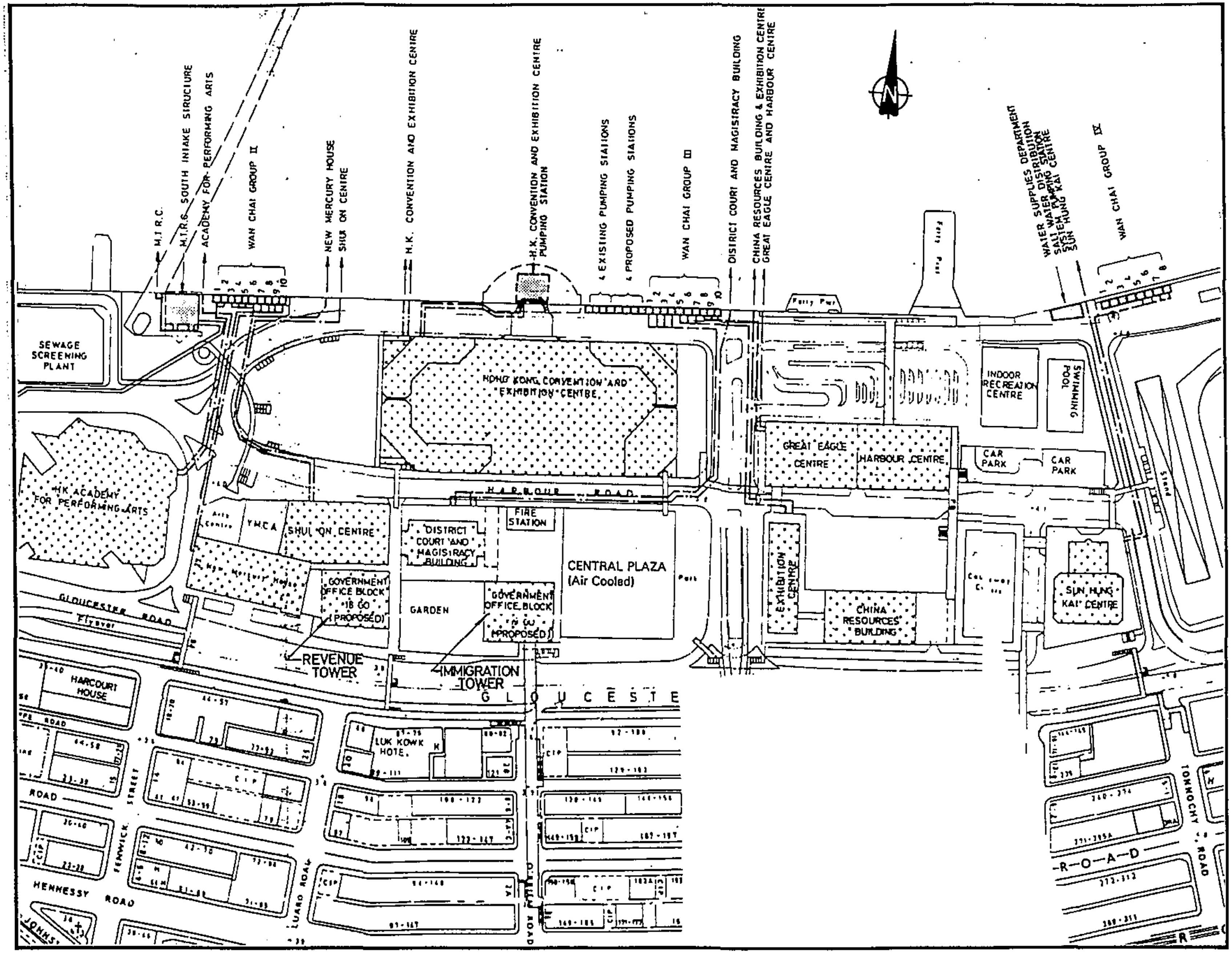

FIGURE 3.4 LOCATION OF COOLING WATER PUMPING STATIONS

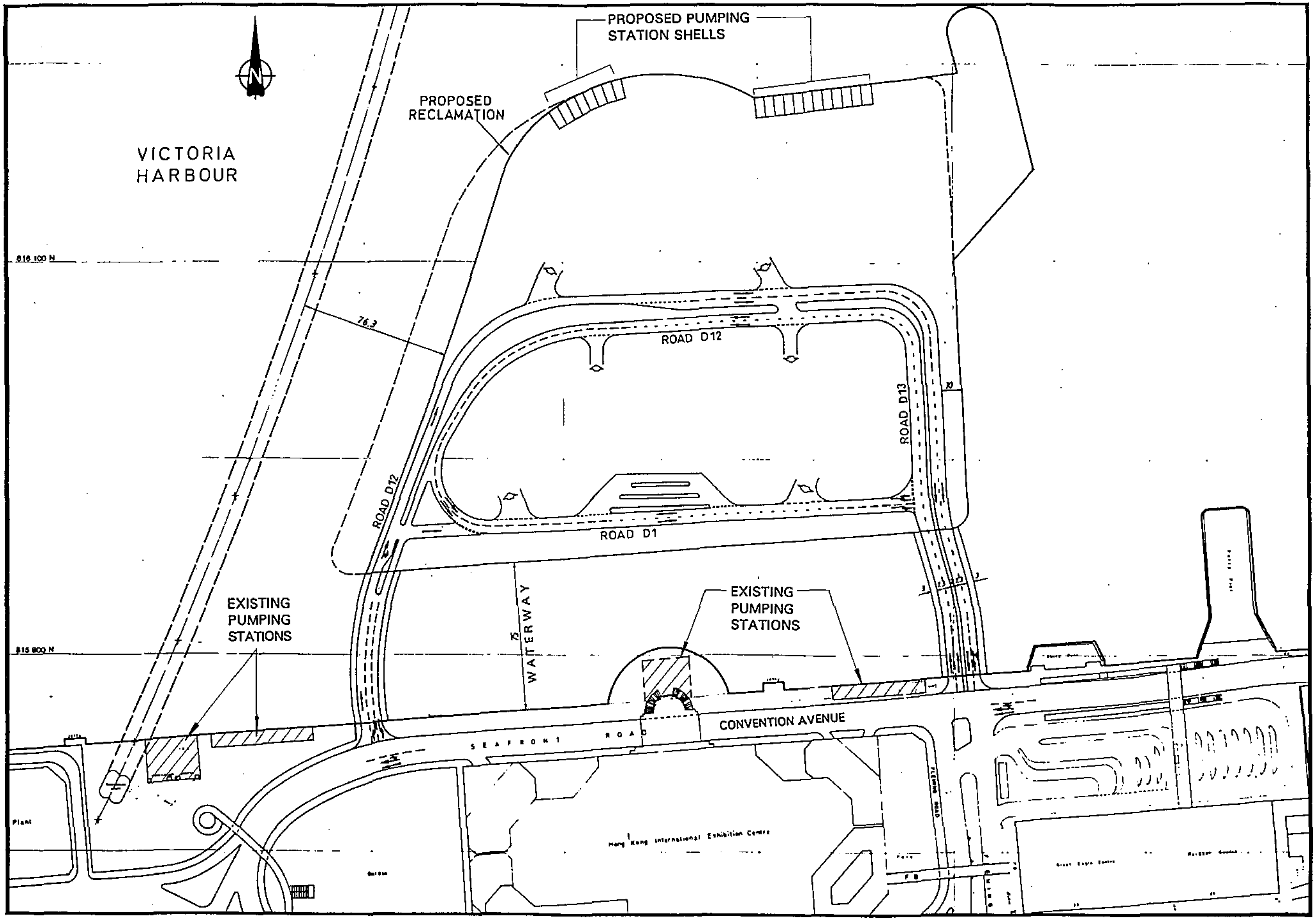

FIGURE 3.5 REPROVISIONING OF COOLING WATER PUMPING STATIONS

4. Water Quality Impacts

4 Water Quality Impacts

4.1 Introduction

Following the issue of the Stage 1 Report a meeting was subsequently held between EPD, SDU and the Consultants to discuss specific issues to be addressed *inter alia* in the Stage 2 Report. The conclusions relevant to water quality were:

a) Pollution loads from screening plants were to be taken as the May 1993 regression trendline figures of 12.5 tonnes BOD for Wanchai West and 14.0 tonnes for Wanchai East.

b) The Stage 2 Report would indicate the scale of effect of the Island Scheme on *E.coli* and other contaminant concentrations with respect to mitigation measures.

c) Measures were to be considered for mitigating the potential for the area to become a collection spot for floating debris.

d) A sediment plume model would be run for wet season spring and neap tides.

e) A desk top assessment of increased BOD arising from suspended sediments during dredging would be undertaken.

4.2 Existing Environment

The existing environment was described in the Stage 1 Report but is reproduced here for ease of reference. Water quality in the area is generally acknowledged to have deteriorated steadily since full records began in 1972 and suffers from relatively low dissolved oxygen saturation (50 - 80%), high inorganic nitrogen and phosphorus concentrations (annual means above 0.3 $mg.l^{-1}$ and 0.09 $mg.l^{-1}$ respectively) and high bacterial counts (10^2 to 10^4). Although the declining trend has now been slowed, a major improvement in water quality in the wider area is not expected until major sewage works are undertaken as part of the Strategic Sewage Disposal Scheme (SSDS).

A brief monitoring survey was carried out between 14 - 18 May 1993 to provide calibration data for modelling and the survey findings are summarised below in Table 4.2.1

Table 4.2.1 Results of a survey conducted in May 1993 to obtain calibration data for modelling runs.

PARAMETER	RESULTS
Current Speed	Low (<20 $cm.s^{-1}$)
Direction	East on ebb and west on flood tides, change did not exactly coincide with high/low water.
Temperature	24°C to 25.5°C
Salinity	Normally 30 to 32.5 ppt, but on occasion much lower values were recorded. The lowest value was 17.6 ppt. The low values were normally recorded on ebb tides.
Suspended Solids	Surface : 0 to 3 $mg.l^{-1}$. Bottom : 5 to 15 $mg.l^{-1}$. Occasional transient higher values.
Dissolved Oxygen (DO)	4 to 7 $mg.l^{-1}$, sometimes exceeding 100% saturation.
Biochemical Oxygen Demand (BOD)	<2 to 4 $mg.l^{-1}$
Nitrite-nitrogen	<0.01 to 0.02 $mgN.l^{-1}$
Total oxidised nitrogen	≤0.1 $mg.l^{-1}$
Ammoniacal nitrogen	0.2 to 0.3 $mgN.l^{-1}$
Total Kjeldahl nitrogen	0.4 to 0.7 $mgN.l^{-1}$
Orthophosphate	0.02 to 0.04 $mgP.l^{-1}$
Chlorophyll-a	1.8 to 6.3 $\mu g.l^{-1}$

Victoria Harbour has not yet been gazetted as a Water Control Zone (WCZ) and therefore there are no statutory water quality objectives published at this time. However, assuming that the minimum standards for pH, dissolved oxygen, ammoniacal nitrogen and nutrients will be similar to gazetted WCZ's, then the present water quality in Victoria Harbour would exceed all these water quality objectives on some occasions during each year, with the possible exception of dissolved oxygen.

Sediments in the study area also have high concentrations of contaminants as summarised in Table 4.2.2 below.

Table 4.2.2 Sediment Contamination Data

DETERMINAND	CONCENTRATION
Total Organic Carbon (TOC)	>2.5% dry weight
Total nitrogen (TN)	>2000 $mg.kg^{-1}$ dry weight
Total phosphorus (TP)	>800 $mg.kg^{-1}$ dry weight
Polychlorinated Biphenyls (PCB)	>150 $\mu g.kg^{-1}$ dry weight
Polycyclic Aromatic Hydrocarbons (PAH)	>50 $\mu g.kg^{-1}$ dry weight
Metals (see Section 5)	Heavily polluted

The depth to which sediments are contaminated in the study area has been the subject of a separate site investigation and the results of this study are presented in Section 5 of this Report. In summary, the top 0.3 m of sediment was considered to be contaminated.

4.3 Sediment Losses During Dredging Activities

4.3.1 Introduction

In order to examine the fate of sediment lost to suspension during removal of the soft marine deposits before the placement of fill for the reclamation begins, the results from the WAHMO model of tidal flows produced by CED were used as the input to the WAHMO sediment plume model. This model simulates the transport in suspension and, if hydraulic conditions permit, deposition and re-erosion of sediment lost using a random walk particle tracking technique. Each particle has a mass of sediment associated with it where this mass depends on the rate of loss of sediment. The main advantage of this model over the more conventional transport models is that the solution does not depend on a model grid size and relatively narrow sediment plumes can be simulated.

The maximum total dredging for the island reclamation will amount to approximately 500,000m^3 of mud and the dredging would be carried out over a period of 10 months. In the simulations, this worst case was adopted and it was assumed that the dredging would be carried out continuously over this period at a rate of approximately 1,700 m^3/day. Two other dredging options are under consideration and these involve volumes of 220,000 and 50,000 m^3 according to whether all or part of the sea wall foundations are dredged. As the model is linear, pro-rata reductions can be made for these options.

In previous studies of dredging losses, it has been assumed that, for a grab dredger, sediment losses to suspension would be approximately 3% of the dredged volume. This estimate was based on the best available data from studies of dredging losses in Europe. At present, no specific field data is available in Hong Kong although a data collection exercise is planned for September 1993. However, in the absence of this data, it was again assumed that dredging losses would be 3% of the dredged volume.

Field measurements of the vertical density distribution of the marine mud in Hong Kong have been carried out in Victoria Harbour and the Western Harbour. It has been found that a dry density of approximately 500 kg/m^3 can be taken as being representative of the consolidated soft marine mud. Based on this dry density, the estimated dredging rate of 1,700 m^3/day and a loss rate of 3% gives a loss of mud to suspension of 0.3 $kg.s^{-1}$. This loss rate was used in the sediment plume simulations. In order to examine the worst case conditions, it was assumed that the sediment losses all occurred in the surface layer of the two-layer flow model. In this way, any immediate re-settlement of the sediment to the sea bed would be minimised and the sediment losses would have the greatest opportunity to be dispersed from the dredging site.

It was intended to examine the sediment losses on tides which had large and small tidal excursions in order to examine the total area which could be impacted by the sediment plume and the likely range of suspended sediment concentrations which might be generated. On the larger amplitude tides, it is to be expected that suspended concentrations would be lower than on the smaller amplitude tides but that the sediment plume would cover a larger area. Following an examination of particle tracks generated by CED as part of the Stage I studies, it was decided that the wet season spring and neap tides generated the largest range of flow conditions and these tides were used as the basis for the sediment plume simulations.

It was assumed that the island reclamation would be constructed following completion of the baseline reclamations and so the tidal flow fields from the baseline simulations carried out under the Stage I studies were used. The dredger was assumed to be working in the centre of the area to be reclaimed (Figure 4.3.1) and the sediment plume moael was run to simulate a period of 3 days. This length of simulation was required in order to allow the background concentrations of spoil losses to build up and for an equilibrium situation to become established.

4.3.2 Wet Season Spring Tide Simulations

The sediment plumes and predicted suspended sediment concentrations for the wet season spring tide are shown in Figures 4.3.2 to 4.3.9 From the Figures, it can be seen that in both the surface and bed layers, suspended sediment concentrations are low with peak values generally in the range 0.001 $kg.m^{-3}$ (1ppm) to 0.005 $kg.m^{-3}$ (5ppm) throughout the tide. There is little evidence of a coherent sediment plume except in the lower layer around peak ebb tide (Fig 4.3.9). It is to be expected that water speeds will be largest on the ebb spring tide and it is thought that the higher concentrations at this time of the tide are generated by re-erosion of spoil which had settled out at an earlier time. In Figure 4.3.9, it can be seen that some of the highest suspended sediment concentrations are predicted just off North Point rather than close to the dredging site and it is thought that this is further evidence of re-erosion of losses from the sea bed.

Figures 4.3.10 to 4.3.13 show the distribution of spoil losses on the sea bed at 4 times during the tide, high and low water and peak flood and ebb currents on the third day from the start of the simulation. The pattern of deposition is not quite as expected; the higher deposition rates are found in the vicinity of the dredger as might be expected but there is a second area of relatively high deposition just off North Point. This may be the result of the higher suspended concentrations generated in the vicinity of the dredger at high water being transported to the area off North Point on the ebb tide when, in this area, water speeds reduce towards low water and deposition to the sea bed takes place.

Overall, the bed deposits do not appear to change significantly during the tidal cycle. However, on close inspection it can be seen that, in the area between Causeway Bay and North Point, there has been some erosion of the bed deposits between high water (Fig 4.3.12) and peak ebb currents (Fig 4.3.13). It is expected that this re-erosion is the cause of the higher suspended sediment concentrations observed at the time of peak ebb currents off North Point (Fig 4.3.9). There does not seem to be the same evidence of re-erosion of bed deposits in the area impacted to the west of the dredging site where peak tidal currents are expected to be lower in the nearshore areas than off North Point.

As a result of the pattern of deposition and re-erosion, it is expected that spoil losses will accumulate more to the west of the dredging site towards and past Central. To the east of the dredging site, it is thought that the pattern of deposition and subsequent re-erosion on wet season spring tides would result in a net transport and dispersion of the spoil losses westwards and eventually out of the area modelled.

4.3.4 Wet Season Neap Tide

The sediment plumes and predicted suspended sediment concentrations for the wet season neap tide are shown in Figures 4.3.14 to 4.3.21. From the Figures, it can be seen that the coherent mud plume with concentrations in excess of 0.001 $kg.m^{-3}$ is relatively small. Compared to the sediment plumes simulated on the wet season spring tide, it can be seen that there is evidence that, on the neap tide, the plume is smaller in extent and sightly more coherent probably because the higher tidal currents on the spring tide disperse the sediment losses over a larger area at a lower concentration.

The most instructive evaluation of the sediment plume is perhaps obtained from examination of the footprint of sediment which settles to the sea bed (Figs 4.3.22 to 4.3.25). From Figure 4.3.22, it can be seen that, on the neap tide, the sediment losses extend westwards just past the Central Reclamation and almost as far as on the spring tide (Figure 4.3.10). The eastward extent of the sediment deposits, however, is much less than on the spring tide. The footprint of sediment deposits on the neap tide is predicted to be marginally wider than on the spring tide and the higher rates of deposition on the neap tide cover a marginally larger area. The differences are not large and reflect the differences in tidal currents on the spring and neap tides.

As on the spring tide, the highest rate of deposition (of the order of 0.5 $kg.m^{-2}$ in 3 days) is in the vicinity of the dredging site and over most of the area, re-deposition rates of between 0.01 $kg.m^{-2}$ and 0.05 $kg.m^{-2}$ in three days was predicted. On the neap tide, the sediment deposits are distributed as might be expected around the dredging site and, unlike the predictions for the spring tide, there is no secondary area of higher deposition rates detached from the main deposition zone.

4.3.5 Discussion

The sediment plume model has been used to simulate the transport, deposition and re-erosion of spoil losses during dredging for the island reclamation. The dredger was assumed to be located in the centre of the area to be dredged and the resulting sediment plumes have been presented in the form of contour plots of suspended sediment concentrations and rates of deposition to the sea bed.

It was assumed that dredging would proceed at a uniform rate over the whole 10 month period allocated for dredging. If, in fact, dredging rates are higher for a shorter period, the rate of loss of sediment to the receiving waters would be correspondingly higher and it should be expected that the predicted suspended sediment concentrations would also be higher. The increase in suspended sediment concentrations could be assumed, to first order, to increase linearly with the dredging rate although, because of the process of deposition and only partial re-erosion, this first order assumption would not be completely accurate. Nevertheless, it was predicted that, over most of the area impacted by the spoil losses, concentrations in suspension would be of the order of between 0.001 $kg.m^{-3}$ and 0.005 $kg.m^{-3}$ over most of the area affected outside the immediate vicinity of the dredger. The one exception was on the wet season spring tide when a pattern of deposition and re-erosion generated local high concentrations just off North Point reaching 0.01 $kg.m.^{-3}$ in the lower layer of the water column. Allowing for the uncertainty in the rate of loss of spoil for the type of dredger to be employed and for the uncertainty in the rate of dredging, it would be prudent to assume that suspended sediment concentrations over the area which would be impacted would be of the order of 0.005 $kg.m^{-3}$ or less with local higher concentrations in the vicinity of the dredger and off North Point reaching the order of 0.01 $kg.m^{-3}$.

The simulations were carried out with the dredger placed in the centre of the area to be dredged. It can be assumed that as the dredger proceeds inshore, local water speeds will reduce and the sediment plumes would have a shorter extent and would impact along the seawalls. The main plume passes, for example, Causeway Bay Typhoon shelter on the ebb tide when flows will be out of the shelter and so any direct influx of sediment in suspension to the shelter would be small. On the subsequent rising tide, any sediment which did not settle out at low water slack, could enter the typhoon shelter but it is expected that the concentration would be low. Again, it could be assumed that, along the seawall where there are cooling water abstraction points, during part of the dredging operations, increases in the natural suspended sediment concentrations of the order of 0.005 $kg.m^{-3}$ or less could be expected outside the immediate vicinity of the dredger. It is not thought that this increase in background concentration would impact on the operation of the cooling water systems or their efficiency. When the dredger is working closer inshore, for any very local cooling water abstraction points, it would be wise to monitor the suspended sediment concentrations to make sure that local areas of higher concentration close to the dredger do not impact on the cooling water systems.

When the dredger is working further offshore than the position used in the simulations, it is to be expected that tidal water speeds will be slightly higher than at the position simulated. The net effect of this should be to have lower concentrations distributed over a slightly larger area than indicated in the figures for the assumed dredger location.

The net effect of the dredger moving over the area to be dredged will be to move the simulated suspended sediment plumes either further offshore of further inshore. It will also generate a wider footprint for the spoil deposits on the seabed. It should be noted that, in the areas of higher tidal currents offshore of the position simulated, the higher water speeds may reduce the amount of spoil settling on the seabed and the footprint of spoil deposits could be expected to be, if anything, of a lower rate of deposition over a slightly larger extent than indicated by the simulations carried out in this study.

In Victoria Harbour, in the areas impacted by the sediment plumes, the natural background concentrations of suspended sediment have been measured in previous field exercises carried out to calibrate the WAHMO models in both the wet and dry seasons. The observations showed that the natural concentrations were fairly constant at around 0.01 kg/m^3 when averaged over the upper and lower water column. The predicted increases in suspended concentrations, over most of the area affected, therefore, could be expected to be of the order of 50% or less of the natural background concentrations.

In summary, the model predicted that the worst case scenario would result in sediment plumes of relatively low concentration and would cover an area of approximately 7 km in length along the northern shore of Hong kong Island. Suspended sediment concentrations in the surface layer of the water column would be less than 0.001 $kg.m^{-3}$ over most of the area affected whereas bottom waters would have up to 0.005 $kg.m^{-3}$. North Point could have the highest concentrations of suspended sediment of over 0.1 $kg.m^{-3}$ in bottom waters but less than 0.005 $kg.m^{-3}$ in upper layers. Based on these figures, pro-rata reduction for the 220,000 m^3 dredged volume would result in maximum concentrations at North Point of 0.044 and 0.002 $kg.m^3$ for bottom and surface waters. Predicted increases in suspended sediments for the 50,000 m^3 scenario would not be physically measurable in the environment.

Although the predicted increases in suspended sediment were low and, for example, unlikely to impact on the operation of cooling water systems which abstract water from the harbour, changes in turbidity could be visible over the area affected. It is thought however, that with most of the sediment losses going into suspension in the lower layer of the water column, any visible plume would be small and confined to the local dredging area. Once the works have begun, the monitoring programme should identify any visible impacts.

4.3.6 Sediment Plume BOD Demand

For the purpose of establishing oxygen demand arising from suspended sediment generated by dredging activities, three scenarios have been considered :

a) Removal of all sediments within the whole footprint of the island extension, yielding a volume of 500,000 m^3.

b) Removal of sediments underlying the base of the entire new sea wall around the island extension, yielding a volume of 220,000 m^3.

c) Removal of sediments from only the west sea wall base, yielding a volume of 50,000 m^3.

Sediment analyses of vibrocore samples have shown the sediments to be predominantly sand and gravel at four stations (71% to 82% mean combined value for depth of core) and 46% and 58% for the remaining two stations. The highest silt-clay content therefore was 54% (Station VC3) as compared with greater than 90% for marine sediments in many other areas of Hong Kong waters. Previous studies have reported a loss of mud to the water column during dredging of 3% for marine sediments that were essentially 100% mud (also used as the loss factor in sediment plume modelling exercises). For the purposes of calculations of oxygen demand arising from suspended sediments, as the maximum recorded silt content was 54%, the loss of material to the water column during dredging has been halved to 1.5%.

EPD data for sediment analyses in Victoria Harbour during the last three years have produced the following characteristics:

Specific Gravity	=	2.4
Dry Weight Ratio	=	0.45
COD ($mg.kg^{-1}$)	=	14,200

Assuming a COD to BOD ratio of 2:1 yields a BOD of 7,100 $mg.kg^{-1}$

Further assumptions are necessary in order to estimate the nett effect of this BOD load on dissolved oxygen levels in the water column. For the purposes of this estimate, it has been assumed that the volume of water in which the sediments will disperse is equal to the area defined for the sediment plume from the modelling runs presented in Section 4.3 multiplied by the mean depth, taken here as 14 m. This yields a volume of 2×10^7 m^3. It has been further assumed that (conservatively) there will be no loss from the study area and that replacement of oxygen is dependent upon natural reaeration only.

A simple mass balance approach is given by:

$$r_R = [\ K_r\ (C_s - C)\ V] \div 1000$$

where

r_R	=	reaeration rate ($kg.d^{-1}$)
K_r	=	rate constant
C_s	=	dissolved oxygen concentration at saturation (assumed to be 7.4 $mg.l^{-1}$)
C	=	steady state dissolved oxygen concentration ($mg.l^{-1}$)
V	=	volume of the system in m^3

A value for K_r for a water temperature of 25°C has been taken as 0.30 on the basis of values adopted previously for Hong Kong waters (e.g. WAHMO and SHRUG studies). If it is assumed that the present reaeration rate satisfies the existing BOD loading, resulting in the existing mean dissolved oxygen concentration in the study area, then substitution of the steady state (measured) oxygen concentration in the above equation yields a figure for reaeration rate. EPD data for Victoria Harbour typically give a range of 50% - 60% saturation for bottom waters and 60% - 80% saturation for surface waters. For the purposes of the present calculations the depth-averaged dissolved oxygen concentration has been taken as 60% saturation i.e. 4.44 $mg.1^{-1}$.

Substituting the above values in the equation yields a reaeration rate of 1.776×10^4 kg O_2.day^{-1}. This represents the quantity of oxygen which must diffuse through the surface layer of the sediment plume area each day to maintain a steady state mean dissolved oxygen concentration of 4.44 mg.l^{-1}.

Assuming that the additional BOD derived from suspended sediments has to be accommodated by the existing reaeration rate, then the projected resulting dissolved oxygen concentration can be estimated by incorporating the additional BOD demand per day into the equation as follows:

$$C = C_s - [(1000 \times \{r_R + BOD\}) \div (K_r \times V)]$$

Performing these calculations for the three scenarios gives the results presented in Table 4.3.1

Table 4.3.1 Calculations of increased oxygen demand resulting from three dredging scenarios.

DETERMINAND	SCENARIO A (500,000 m^3)	SCENARIO B (220,000 m^3)	SCENARIO C (50,000 m^3)
Total Sediment Mass	540,000 tonnes	237,600 tonnes	54,000 tonnes
Mass Dispersed	8,100 tonnes	3,564 tonnes	810 tonnes
Total Oxygen Demand	57.5 tonnes	25.3 tonnes	5.8 tonnes
Duration of Dredging	294 days	130 days	30 days
Oxygen Demand/day	196 kg	195 kg	193 kg
Projected DO	4.337 mg.l^{-1}	4.337 mg.l^{-1}	4.337 mg.l^{-1}
Decrease in DO	0.003 mg.l^{-1}	0.003 mg.l^{-1}	0.003 mg.l^{-1}

It can be seen from Table 4.3.1 that the governing factor on oxygen demand is the daily mass of sediment lost to the water column. not the total volume excavated. Each of the scenarios has been based on the same daily dredging rate with the resulting variable being the duration of the dredging. The nett impact of this increased BOD load will depend upon the volume of water through which it is dispersed. The greater the volume, the less the impact. The relatively small volumes of sediment in the above scenarios are more than adequately counterbalanced by the relatively large volume of water available for dispersion (daily ratio of approximately 400,000 : 1; water : sediment loss).

The projected impact on dissolved oxygen within the plume due to suspended sediments is therefore negligible and providing that the dredging rate is not increased over that proposed (1,700 m^3.d^{-1}), then BOD demand from suspended sediments due to dredging will not be a key issue.

4.4 Water Quality Modelling

4.4.1 Introduction

Water Quality modelling is a useful tool in evaluating the impact of proposed reclamation developments on marine water quality, particularly when comparisons are required of water quality before and after construction. For this study water quality modelling has been used to assess the effect of the Convention & Exhibition Centre Island with full loads on water quality, followed by additional runs to investigate how its detrimental impact may be reduced by applying mitigation measures which would reduce the pollution load applied through stormwater

The WAHMO water quality model was used to simulate the tidal variations in concentration of dissolved oxygen and related parameters. The water quality model was driven by the hydrodynamic model output produced by CED during Stage 1 of the study, based on a 25-metre resolution grid covering Victoria Harbour from about 2 km West of the proposed HKCEC island to some 4 km East.

All outfalls discharging into that part of Victoria Harbour within the model boundary were included in the model. The loads to be used were discussed and agreed prior to the modelling exercise. Two mitigation measure scenarios were run which assumed the transfer of some loads from stormwater outfalls to screening plant outfalls as discussed below.

The sections which follow outline the modelling which has been carried out, the validation of the model and the scenario conditions to which the model was applied. Results are presented in the form of Figures and Tables and brief observations are made upon them.

4.4.2 Background to Model

The two dimensional, two layer tidal water quality model used for the Hong Kong Convention and Exhibition Centre Extension water quality modelling exercise was developed by WRc plc and is one of the WAHMO (**WA**ter Quality and Hydrodynamic **MO**dels) suite of models. For this study it has been run to a grid size of 25m using flow results files generated by CED Port Works Division, from which information on the depth of the cells and on the two horizontal flow components at each of the cell faces are obtained.

Altogether the model calculates the distribution of 15 substances; there are also a number of derived quantities such as benthic oxygen demand. The basic equation that the model solves for each of the 15 substances is the two-dimensional conservation of mass equation which deals with effects of advection (flow), diffusion (mixing), interactions (transformation and decay) and loading. There is a separate equation for each layer and allowance is made for vertical flow and mixing between layers. The equations are solved using finite difference methods. The data input to the model consists of the effluent loadings, the chemical and algal rate coefficients, the incident light, the open boundary conditions and the water depths and flows from the hydrodynamic model.

The model has been calibrated against extensive field data which were collected specifically for that purpose. Validation of the model for this study has been achieved by making comparisons of the model predictions for the existing condition, wet season neap tide against field data collected at three sites during this study.

4.4.3 Existing Conditions - Model Validation

Field data were collected during the early part of Stage 1 of the HKCEC study (May 1993) at three locations to provide data which could be used for the validation of the hydrodynamic and water quality models. Two locations were located adjacent to the proposed island site, the third being towards the middle of Victoria Harbour. The field data were collected during wet season neap tidal conditions.

The hydrodynamic model simulation of existing conditions was used to drive the water quality model. Boundary concentration values were selected to give the best agreement with the observations of dissolved oxygen, salinity, temperature, BOD, ammonia, oxidised nitrogen, organic nitrogen, chlorophyll and suspended solids. Although data were not collected for *E.coli* during the survey, a few relevant observations were available for the Eastern boundary; those values were also used on the Western boundary.

The differences between the observed and predicted values are within the limits which may be expected given that the tidal conditions for which samples were collected will have been significantly different to those for which the model was originally calibrated. The comparisons demonstrate that the values predicted by the model are acceptable.

A summary of the comparison of the model predictions against the field data collected is given in Figures 4.4.2 a - j.

4.4.4 Results - Positions

Model results have been produced for relevant parameters against time at nine agreed positions in the vicinity of the proposed island and further afield. The coordinates of the positions, on the Hong Kong Metric Grid, are given in Table 4.4.1.

Table 4.4.1 - Results Plots Positions

REF	DESCRIPTION	EASTINGS	NORTHINGS
A	RHKYC entrance	836650	816300
B	Stage 1 Position 4	835570	815900
C	EGS data point 1	835898	815918
D	EGS data point 2	835572	815980
E	EPD monitoring point VM5	835520	816180
F	EGS data point 3	836061	816492
G	Stage 1 Position 5	835830	815920
H	Additional far field point	835000	816300

These locations are also shown in plan relative to the model boundary in Figure 4.4.1.

4.4.5 Description of Model Layout/Scenarios

The stages which have been modelled are as follows:

Existing — Conditions representing the present day situation. Validation carried out against these results.

Baseline — As for existing with planned or committed reclamations within the hydrodynamic model area added (with the exception of the HKCEC extension) to represent the likely layout at the time of the proposed development.

Scenario 1 — Layout as for baseline with island added. Full pollution loads used (see 4.4.5 below).

Scenario 2 — Layout as for baseline with island added. First stage of mitigation measures included (ie stormwater outfall loads adjusted and re-allocated - see below).

Scenario 3 — Layout as for baseline with island added. Second stage of mitigation measures included - see below.

Because of the large combination of parameters, results positions and model layouts large amounts of data were generated by the simulations. Time history plots are therefore presented selectively to illustrate significant findings. Average values of all parameters at all positions for all runs are presented in the Tables.

4.4.6 Pollution Loads

The pollution loads exerted by effluent through the outfalls from the Wanchai East and Wanchai West screening plant (WE and WW respectively) have been determined by a review of DSD effluent quality records for May 1993. It was agreed that the nominal load from each should remain constant for the baseline and scenario runs, subject to the adjustments described below.

Other existing and baseline loads were taken from the WAHMO pollution files, updated by SMP loads as appropriate.

Loads for the first scenario (with the island in place) were the same as those for existing and baseline conditions.

The second scenario investigated a situation which assumed that relevant stormwater outfall loads would be reduced by 25% to simulate a hypothetical diversion of expedient connections into the foul sewer system. The outfalls for which loads were adjusted were those which lie along the north coast of Hong Kong island in the vicinity of Wanchai East, Wanchai West and North Point screening plant with the difference in load being reallocated to the nearest of these in each case.

The third scenario was to assume either a greater or lesser degree of mitigation depending on whether the second scenario indicated water quality to be better or worse than for the baseline condition. In either case adjustment would be made to the outfall M load only which discharges into the channel between the land and the proposed island: for the former case, the original loads would be applied to all outfalls except outfall M, which would be reduced by 25%; and in the latter, an additional 25% reduction would be applied to outfall M over and above the reduction in scenario 2 (ie outfall M would be reduced by 50% in total).

The loads are summarised in Table 4.4.2 below.

Table 4.4.2 - Outfall and Loads Details

OUTFALL REFERENCE	EASTINGS	NORTHINGS	Initial Loads (t/d BOD)	First Mitigation (t/d BOD)	Second Mitigation	
					A (t/d)	B (t/d)
WW1	835500	816400	12.5	14.31	13.09	14.90
WE1	836400	816500	14.0	14.47	14.0	14.47
NP1	838400	817400	7.20	7.98	7.20	7.98
KS1	836500	817000	20.36	20.36	20.36	20.36
KE1	840000	817500	9.93	9.93	9.93	9.93
5A.10	838100	819800	3.92	3.92	3.92	3.92
5B.01	837900	818400	1.30	1.30	1.30	1.30
5B.02	838500	819000	8.29	8.29	8.29	8.29
5B.15+5B.16	837900	819200	3.37	3.37	3.37	3.37
5B.18	838100	819400	2.21	2.21	2.21	2.21
5B.22	838100	819800	1.16	1.16	1.16	1.16
5B.99	837925	818300	1.69	1.69	1.69	1.69
6.13	835800	817100	1.07	1.07	1.07	1.07
6.15	836800	817300	1.07	1.07	1.07	1.07
6.17	836900	817825	0.57	0.57	0.57	0.57
6.99	837600	817900	0.52	0.52	0.52	0.52
32.10 [R]	837525	816325	0.11	0.08	0.11	0.08
32.11	837500	816525	0.34	0.26	0.34	0.26
32.14	838300	817500	0.74	0.56	0.74	0.56
32.15	838900	817300	0.37	0.28	0.37	0.28
32.17+32.16	839400	817500	1.50	1.13	1.50	1.13
32.99	837900	816925	0.56	0.42	0.56	0.42
33.11 [O]	836550	816100	0.41	0.31	0.41	0.31
33.13 [P+Q]	837100	816125	1.03	0.77	1.03	0.77
34.12 [J2]	834950	816025	0.08	0.06	0.08	0.06
34.14 [K+L]	835450	815875	2.33	1.75	2.33	1.75
34.15 [M]	835975	815950	2.36	1.77	1.77	1.18
34.99 [J1]	834775	816025	2.50	1.88	2.50	1.88
35.28	833500	816725	1.30	1.30	1.30	1.30
35.3	833900	816750	1.30	1.30	1.30	1.30
35.31	834000	816700	1.30	1.30	1.30	1.30
Total			**105.39**	**105.39**	**105.39**	**105.39**

4.4.7 Results

Baseline Conditions

The baseline layout results, which excluded the HKCEC island and did not involve any increase in pollution loads, were very similar to the results for existing conditions for both the dry and wet season neap tides. This is consistent with what might be expected because there were no reclamations in the immediate vicinity of the island being added as part of the baseline file.

Tidal average values for all positions and parameters are presented in Tables 4.4.3 and 4.4.4 for dry and wet seasons respectively.

Scenario 1

The model was run for both wet and dry season neap tides with the island added. The results indicated little change in the levels of salinity, temperature, oxidised nitrogen, or chlorophyll. The positions at which changes for any parameter were most appreciable were C and G; this is in line with expectations because these points lie in the "channel" to the south and east of the island. Minor increases were observed in the concentrations of suspended solids and organic nitrogen; greater changes were apparent for DO, BOD, ammoniacal nitrogen and *E.coli*.

Further scenario runs, incorporating reduced loads to simulate mitigation measures, were to be carried out on the worst of the two neap tides only. A comparison of the results from the first scenario for both tides indicated that the wet neap tide experienced a bigger decrease in DO levels at position C than the dry neap tide. This was identified as the most significant measure and the wet neap tide was therefore selected for further model runs.

Tidal average values are presented for both wet and dry seasons in Tables 4.4.5 and 4.4.6. Time history plots for the first scenario against baseline conditions are presented for selected positions and parameters in Figures 4.4.3 and 4.4.4.

Scenario 2

The second scenario, incorporating redistributed loads between relevant stormwater and screening plant outfalls, showed that DO levels at positions C and G were still lower than those for baseline conditions and concentrations of BOD, ammoniacal nitrogen and *E.coli* were higher. Although some improvements in water quality could be observed at positions further from the island, these were slight by comparison and it has therefore been concluded that, taking an overall view, water quality was worse for this scenario than for the baseline condition. This result was the basis for the decision to adopt more severe mitigation levels for the third scenario run, as described in section 4.4.5.

Tidal average values are presented for the wet season in Table 4.4.7. Relevant time history plots are given in Figure 4.4.5.

Scenario 3

The third scenario demonstrated a significant improvement over the second, particularly at positions C and G where the worst effects of the island were apparent, as a result of the further 25% reduction of load from Outfall M.

The relative levels of DO, BOD, Ammoniacal nitrogen and *E.coli* between this scenario and the baseline condition for the wet neap tide are illustrated in Figures 4.4.6. The graphs show that, over the tidal cycle, slight improvements can be observed at all positions except for C and G. At C and G, water quality is marginally poorer than for the baseline situation although this effect would appear to be localised.

4.5 Sewage Disposal

Section 3 of this Report provides a detailed discussion on the sewerage and drainage of the proposed Hong Kong Convention and Exhibition Centre (HKCEC) Extension. The existing sewage outfalls serving the Wan Chai West and East Sewage Screening Plants, which are within 0.5 km to the west and east of the reclamation respectively, extend approximately 600 m offshore from the present sea wall. It has been proposed that the sewage from the Extension be incorporated into the Wan Chai West reticulation.

The daily pollution load from the Extension has been calculated in Section 3 as 450 $kg.d^{-1}$ for both BOD and suspended solids based on a daily total flow of 1500 m^3 and average BOD and suspended solids of 300 $mg.l^{-1}$. Present combined daily BOD input to Victoria Harbour from Wan Chai West and East is approximately 21,000 $kg.d^{-1}$. The increase in BOD load due to the Extension therefore represents approximately 2% of present load.

The pollution scenarios investigated by modelling in Section 4.4 of this Report indicated that for the mitigation measures investigated, the most favourable predicted an increase in *E.coli* over baseline of 8.6% for wet season, neap tide (area depth averages - Baseline: 11,314 counts.100 ml^{-1}; Scenario 3: 12,293 counts.100 ml^{-1}). This disproportionate increase in *E.coli* concentration relative to the increase in loading derives from the reduced volume of Victoria Harbour and associated reduced flushing, due to the combined reclamation proposals for the study area which were included in the model.

Changes in predicted concentrations of ammonia and organic nitrogen as modelled for Scenario 3, are negligible, and BOD shows a small increase of less than 1.5%.

4.6 Floating Debris

Modelling studies presented in the Stage 1 Report regarding float track simulations indicated that some of the floats moved inshore to the sea wall and remained there. This raised concerns that there was a possibility of floating debris collecting in the lee of the island extension. Consideration of this possibility involves two separate mechanisms.

Firstly, the float track model simulates the movement of the top metre or so of the water column i.e. the 'surface' hydrodynamic flow. This is driven by tidal elevation and the physical shape of the area. There is generally no wind component included in this simulation. If a wind factor is included, its affect on the water body is generally of the order of 1% to 3% of wind speed and must prevail for an extended period of time to have a significant effect on a float track. Within Victoria Harbour, it is unlikely that wind speed will have a modifying influence on surface hydrodynamics.

The second factor for consideration is the nature of floating debris. Materials such as polystyrene which float *on top* of the water rather than *in* it, will be affected more by wind than surface water flow. At times of no, or very light winds, this material will be transported by the water mass. More dense materials which float within the top few centimetres of the surface layer e.g. wood, will also tend to be influenced by wind. However, the mass of water acting on the wood will be greater than the influence of the wind and the wood will tend to follow the water flow but at a tangent to the main axis of flow depending on wind speed and duration.

Observations at the study site readily show the predominance of material presently trapped inshore to be polystyrene and plastics which have a high air profile. Also of significance on the observed distribution of the floating debris was the influence of cooling water intakes and outlets. Due to the relatively close proximity of inlets and outlets, cells of contra-flowing water are set up. Between these cells, zones of convergence occur which trap floating debris. These zones can be seen as long lines of closely-packed debris separated by corridors of water which are clear of debris. This mechanism in fact aids the collection of the debris.

are set up. Between these cells, zones of convergence occur which trap floating debris. These zones can be seen as long lines of closely-packed debris separated by corridors of water which are clear of debris. This mechanism in fact aids the collection of the debris.

In view of the above comments, it is unlikely that the presence of the island extension will significantly increase the accumulation of floating debris in the area. There will be a possibility of floating material becoming lodged on the windward and lee sides of the island extension but it is considered that this will not significantly increase the present problem in the general area. Changes in tidal flow and wind direction will tend to move debris away from the island extension into the main body of water.

4.7 Mitigation Proposals

Modelling has shown predicted sediment losses to the water column to be very small in relation to the volume of water into which it is dispersed with resulting impacts on water quality parameters being negligible. It would be very difficult to provide an effective physical barrier to sediment dispersion (such as a silt curtain) with this type of development close to shore without adversely affecting water flow along the sea wall. However, in view of the limited predicted impact of dredging losses, the most effective means of mitigation is by carefully controlling the rate at which dredging is undertaken. If this does not exceed the dredging rate used for calculating the impacts in this Report, and efficient close-fitting grabs are used, then these measures should provide adequate mitigation.

Water quality impacts are further mitigated by the adoption of the conditions used in modelling Scenario 3. i.e. by adjustment and re-allocation of stormwater outfalls to achieve a 25% reduction in load and reducing the flow from Outfall M by 50% (outfall M discharges into the channel between the land and the proposed island). Adoption of these measures should result in water quality marginally better than Baseline conditions (ie committed reclamations but excluding the island extension).

The mitigation of sewage impacts is essentially constrained by the lack of suitable sewage treatment works. The Strategic Sewage Disposal Scheme will ultimately route sewage away from Victoria Harbour in the long term. However, in the short term, the best option investigated to date would be to route the sewage from the Extension to Western Wan Chai and adopt the recommendations of modelling Scenario 3 mentioned above.

Floating debris will naturally collect along the waterfront, partially under the influence of circulation patterns set up by cooling water intakes and outlets, and partially under the influence of wind and tide. There are no mitigation measures which could sensibly be incorporated into the design of the island within existing constraints. Therefore, the best option will be to continue to physically collect floating debris from the area.

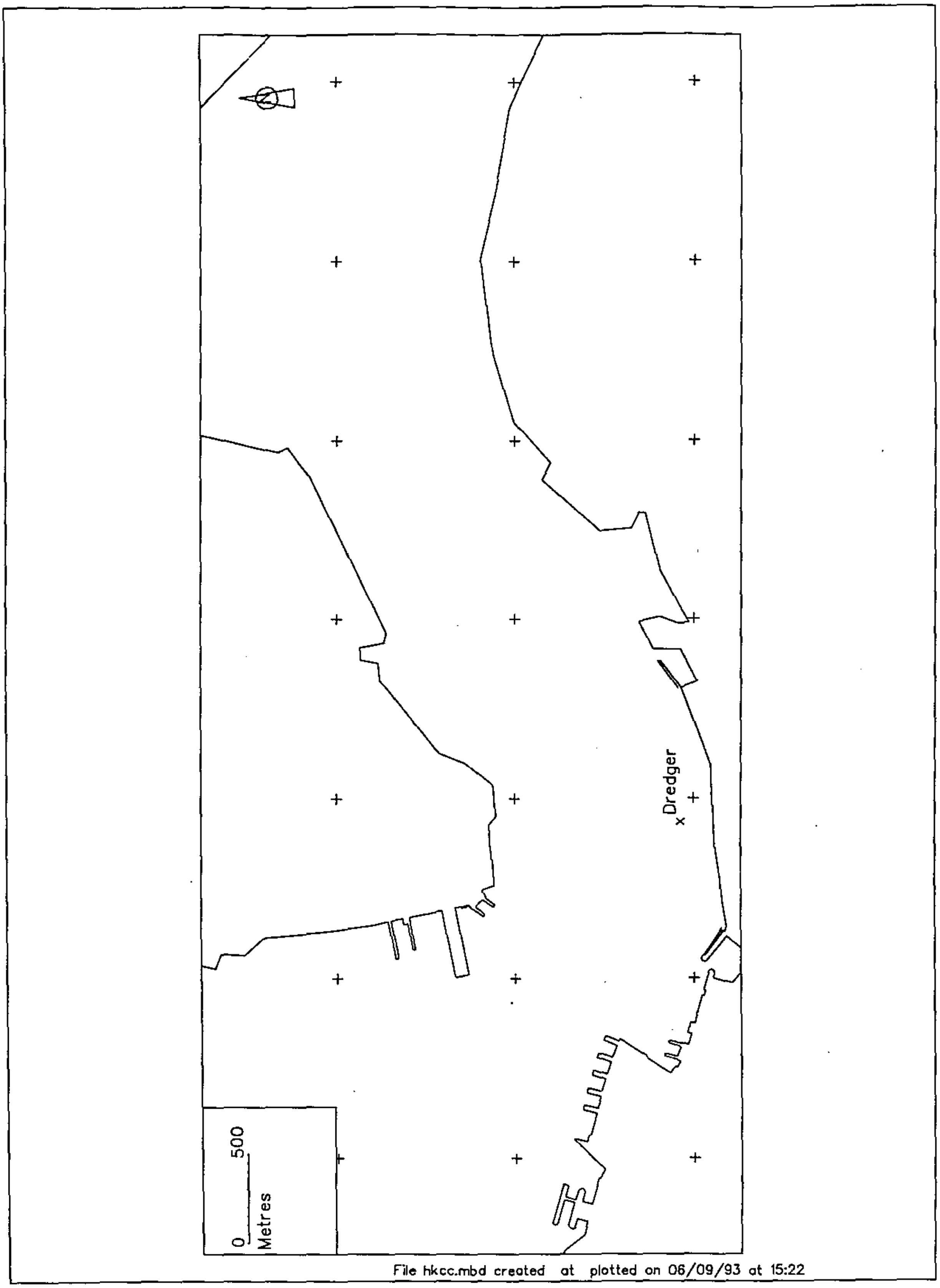

Figure 4.3.1 Hong Kong Convention and Exhibition Centre. Dredger location during construction.

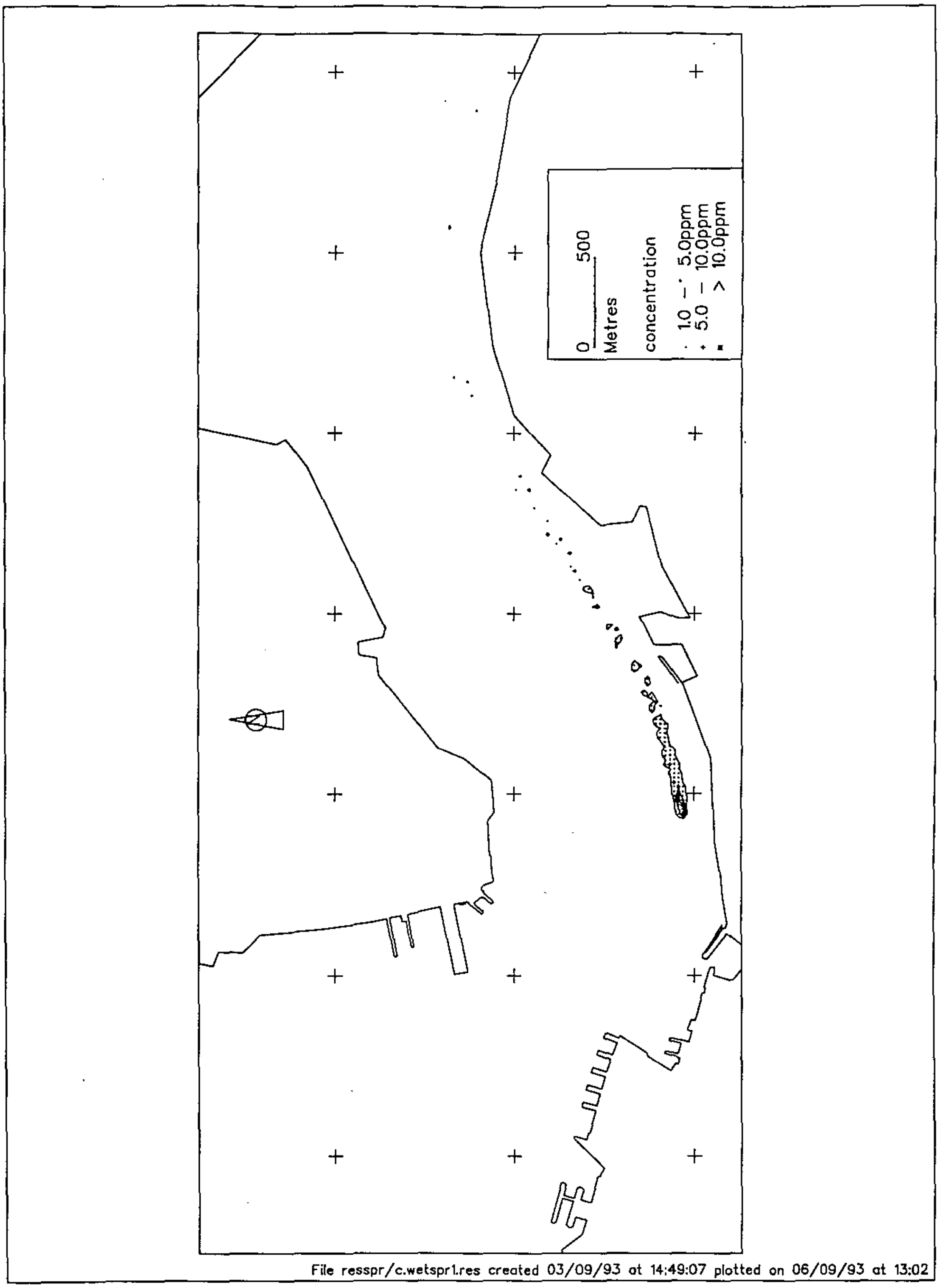

Figure 4.3.2 Suspended mud concentrations.
Wet season spring tide.
Low water. Upper layer.

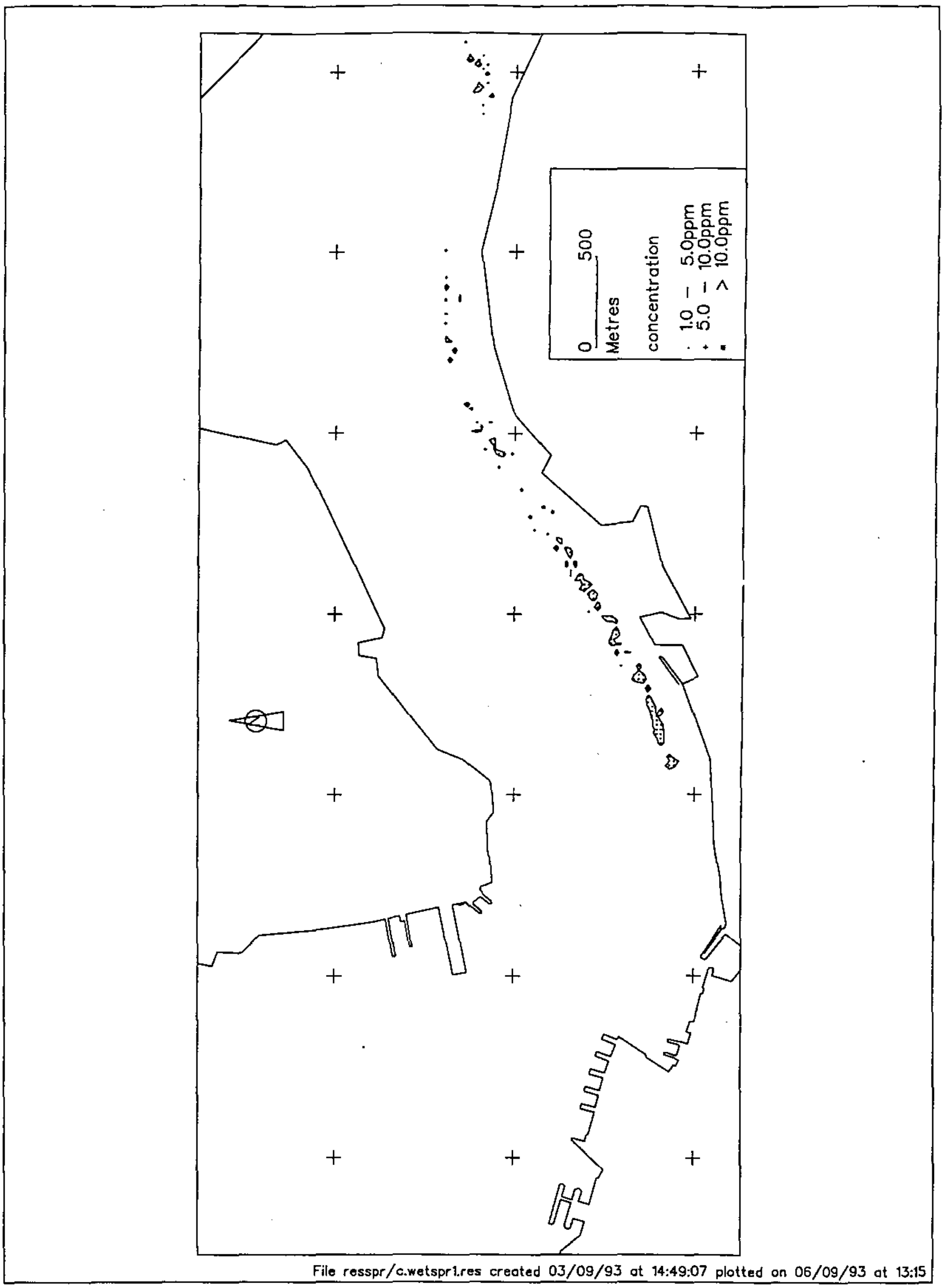

Figure 4.3.3 Suspended mud concentrations.
Wet season spring tide.
Low water. Lower layer.

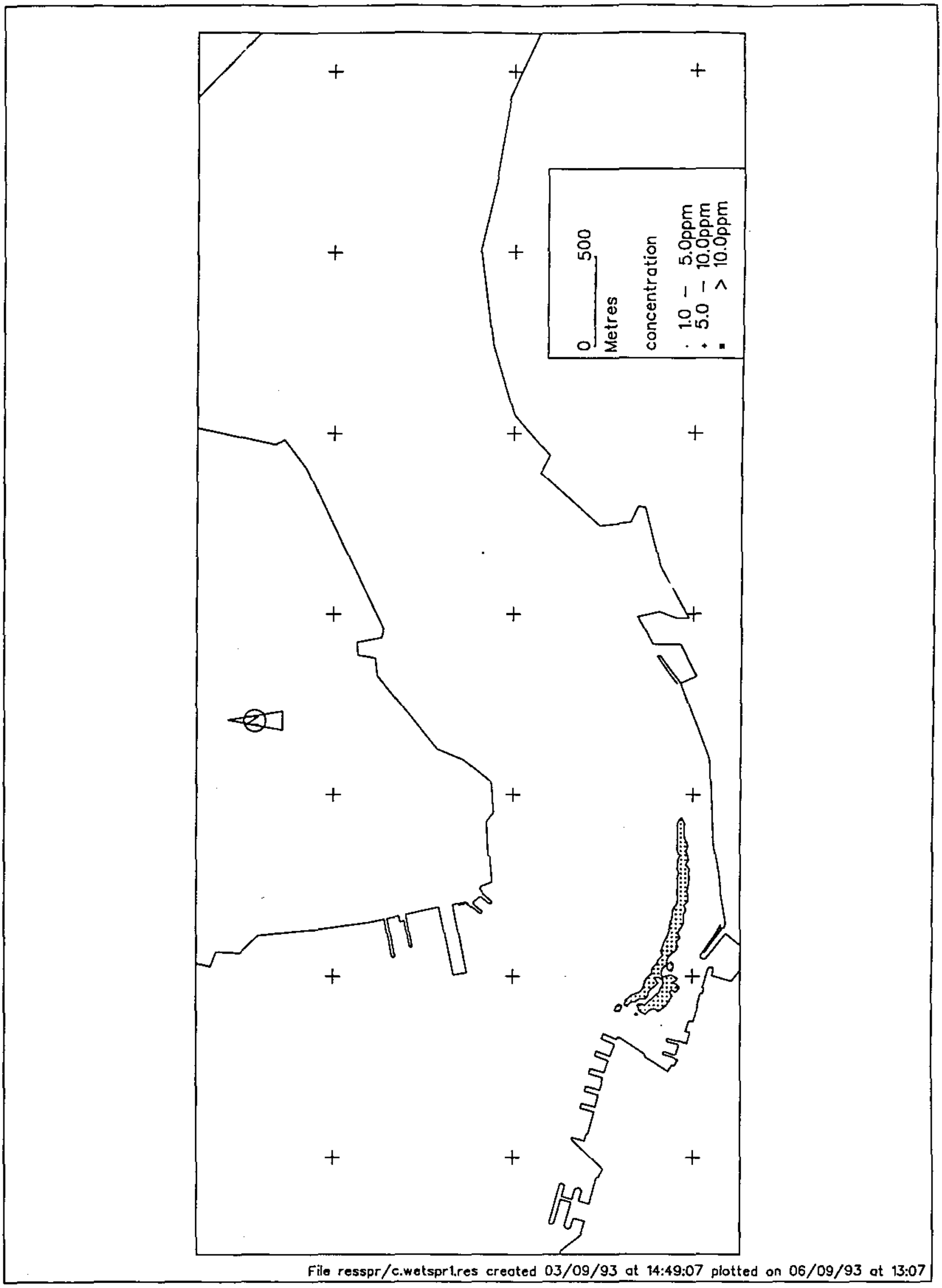

Figure 4.3.4 Suspended mud concentrations. Wet season spring tide. Peak flood. Upper layer.

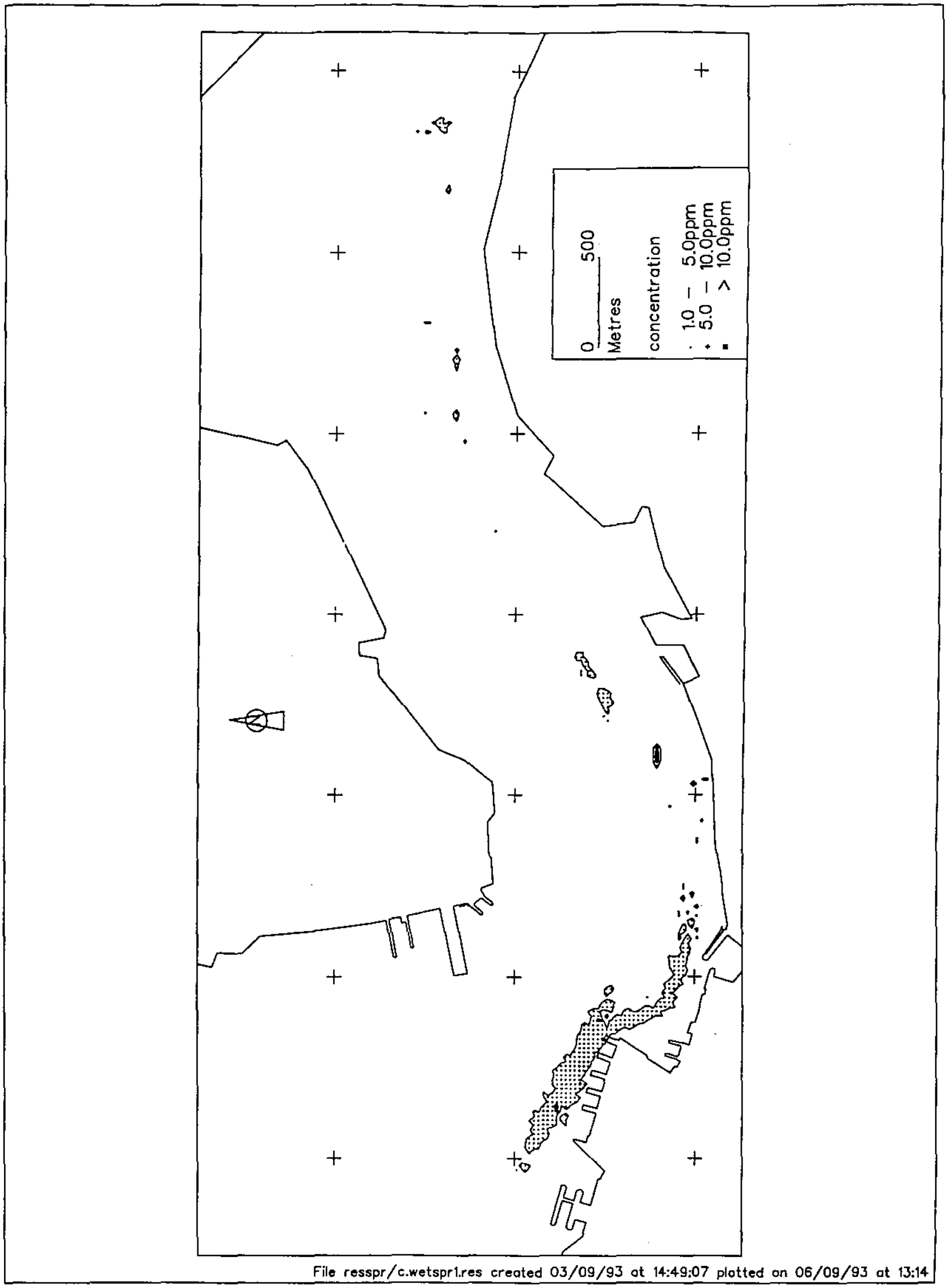

Figure 4.3.5 Suspended mud concentrations.
Wet season spring tide.
Peak flood. Lower layer.

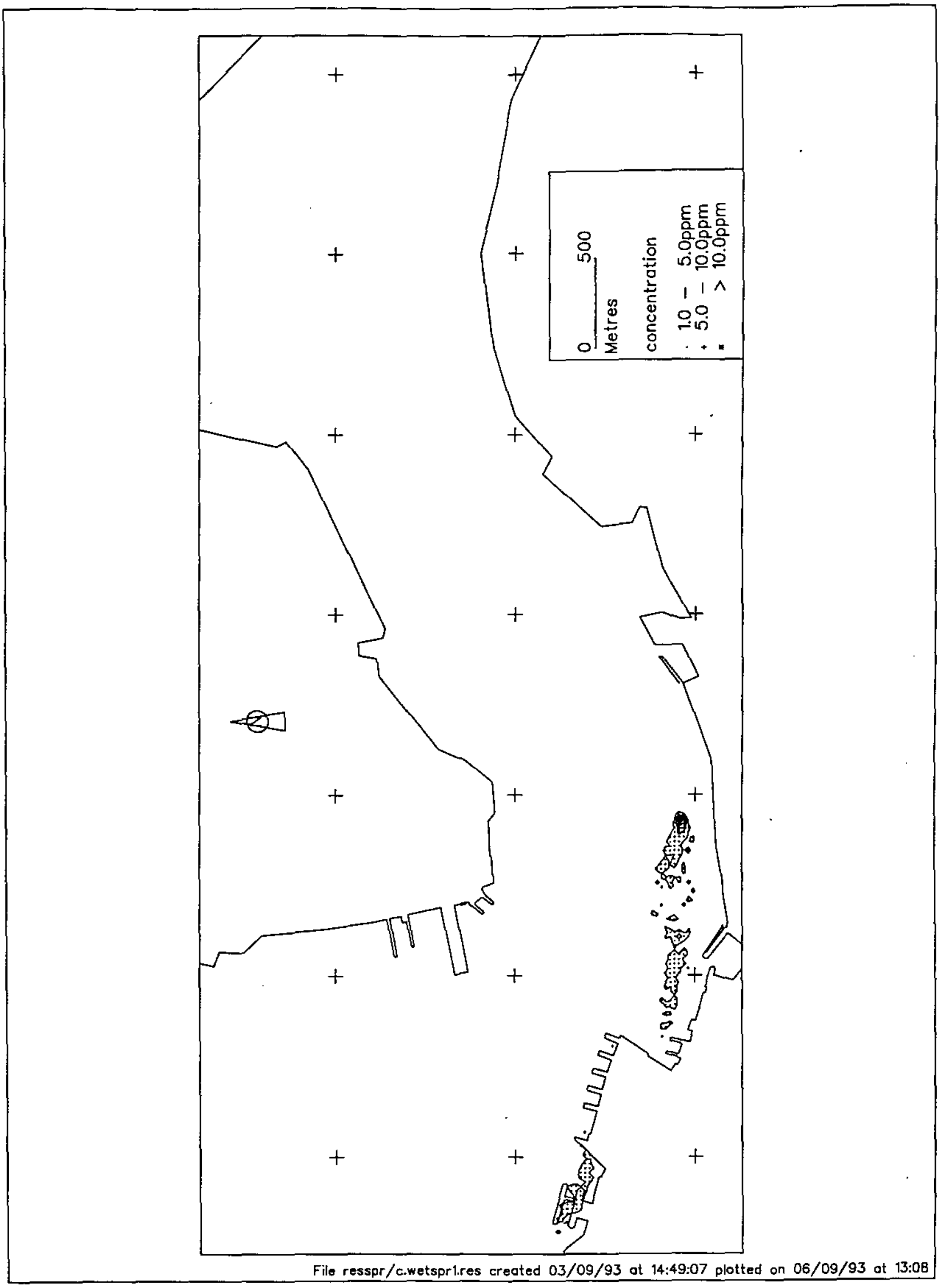

Figure 4.3.6 Suspended mud concentrations.
Wet season spring tide.
High water. Upper layer.

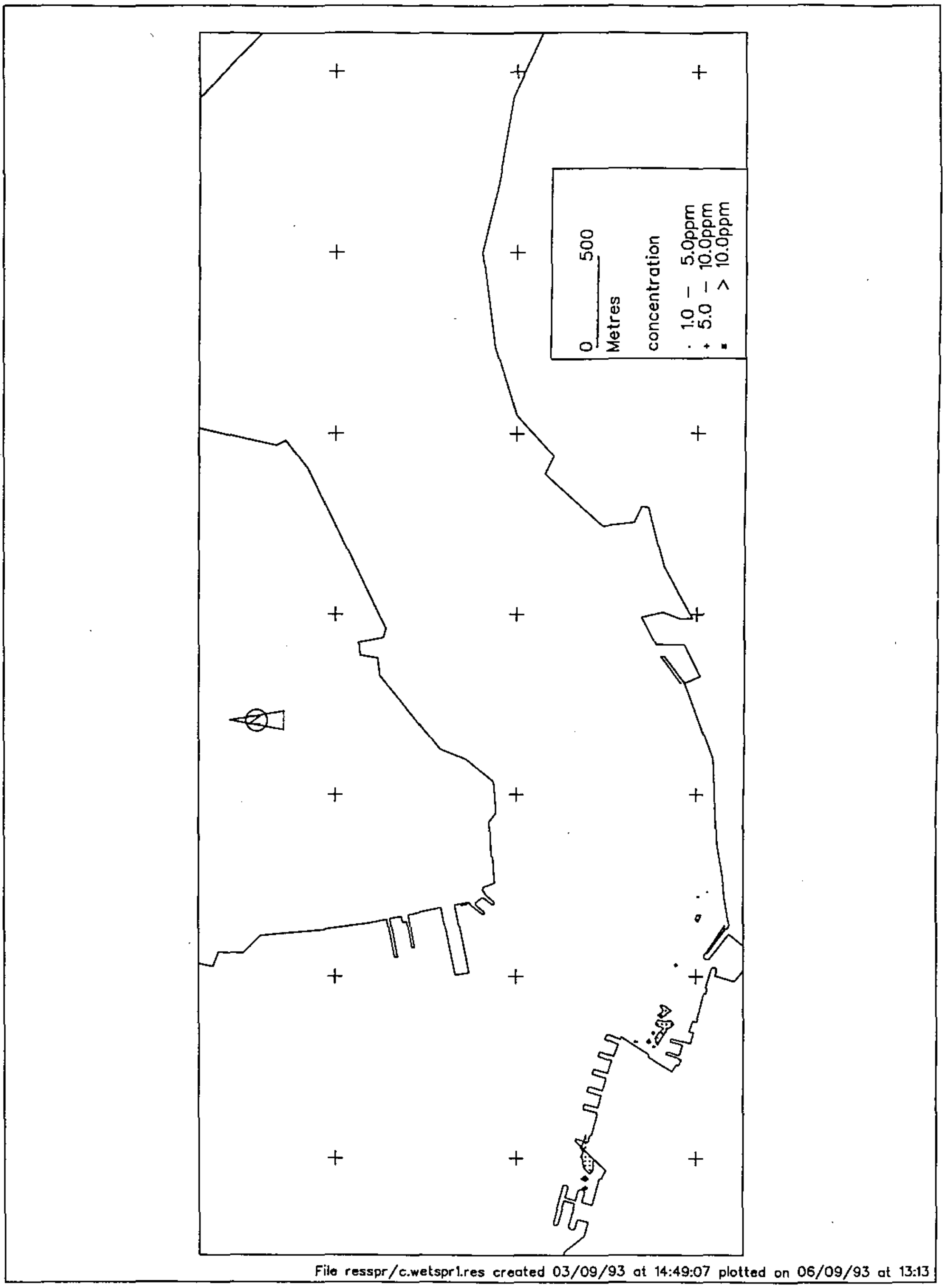

Figure 4.3.7 Suspended mud concentrations.
Wet season spring tide.
High water. Lower layer.

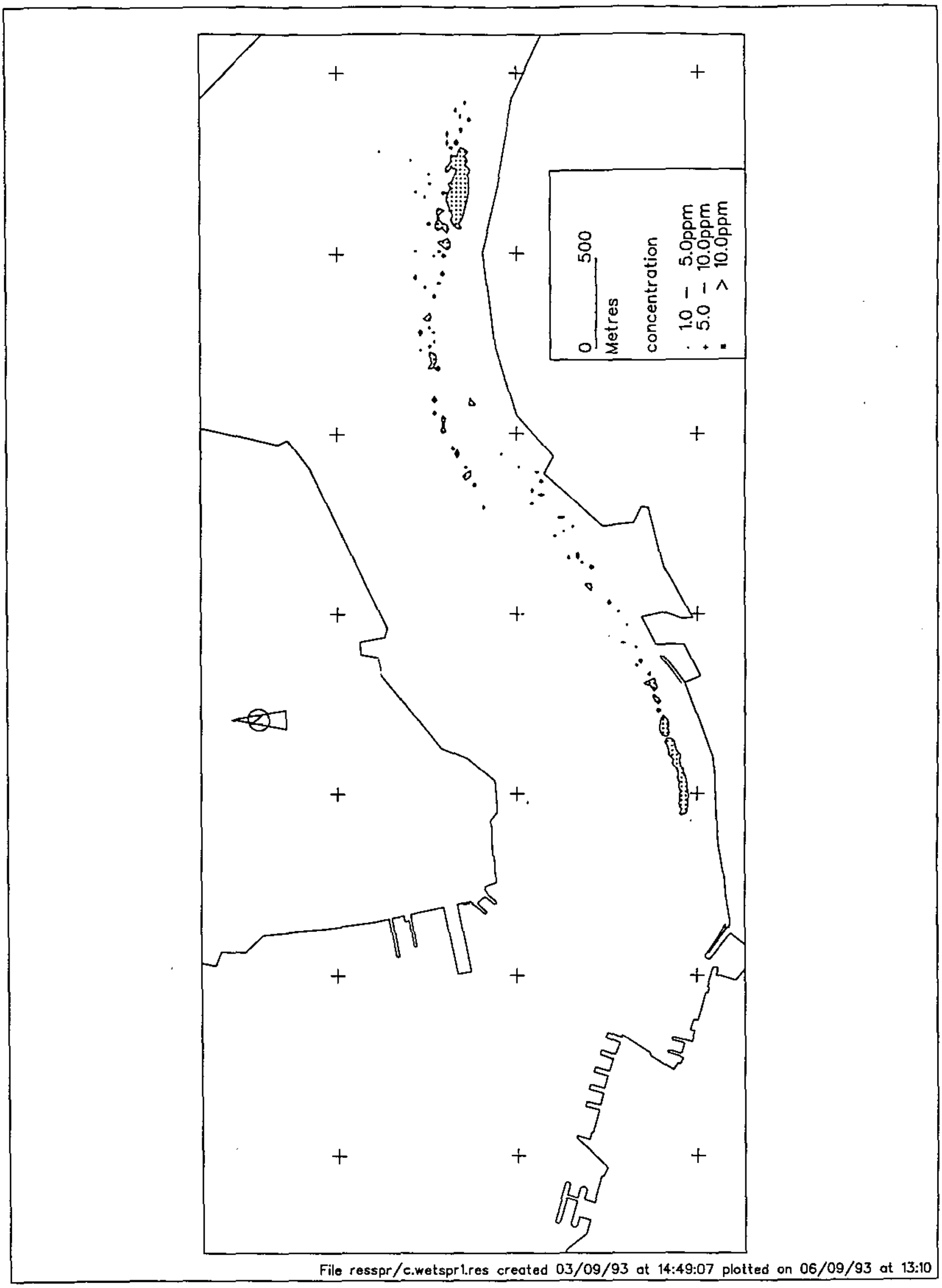

Figure 4.3.8 Suspended mud concentrations.
Wet season spring tide.
Peak ebb. Upper layer.

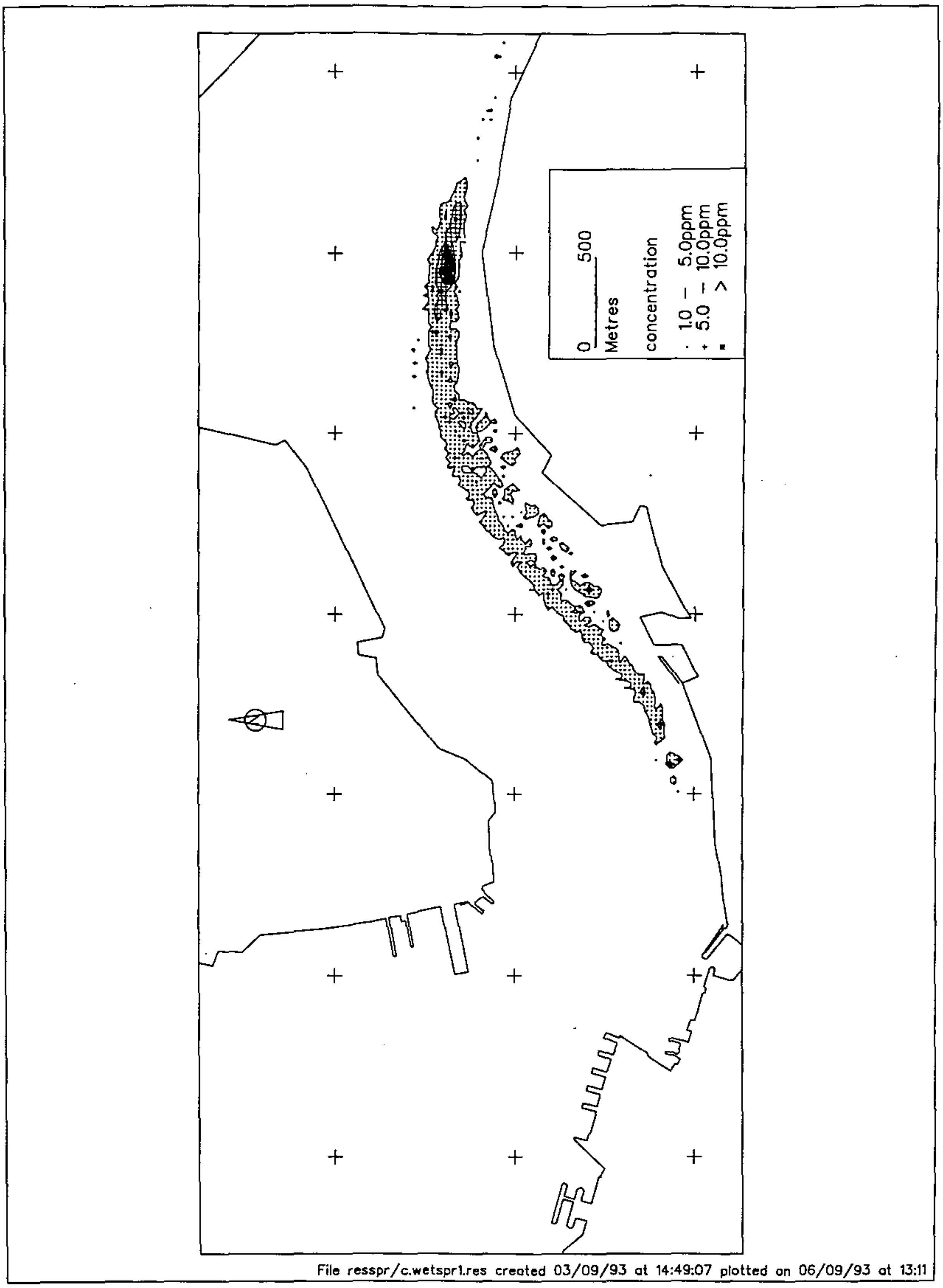

Figure 4.3.9 Suspended mud concentrations.
Wet season spring tide.
Peak ebb. Lower layer.

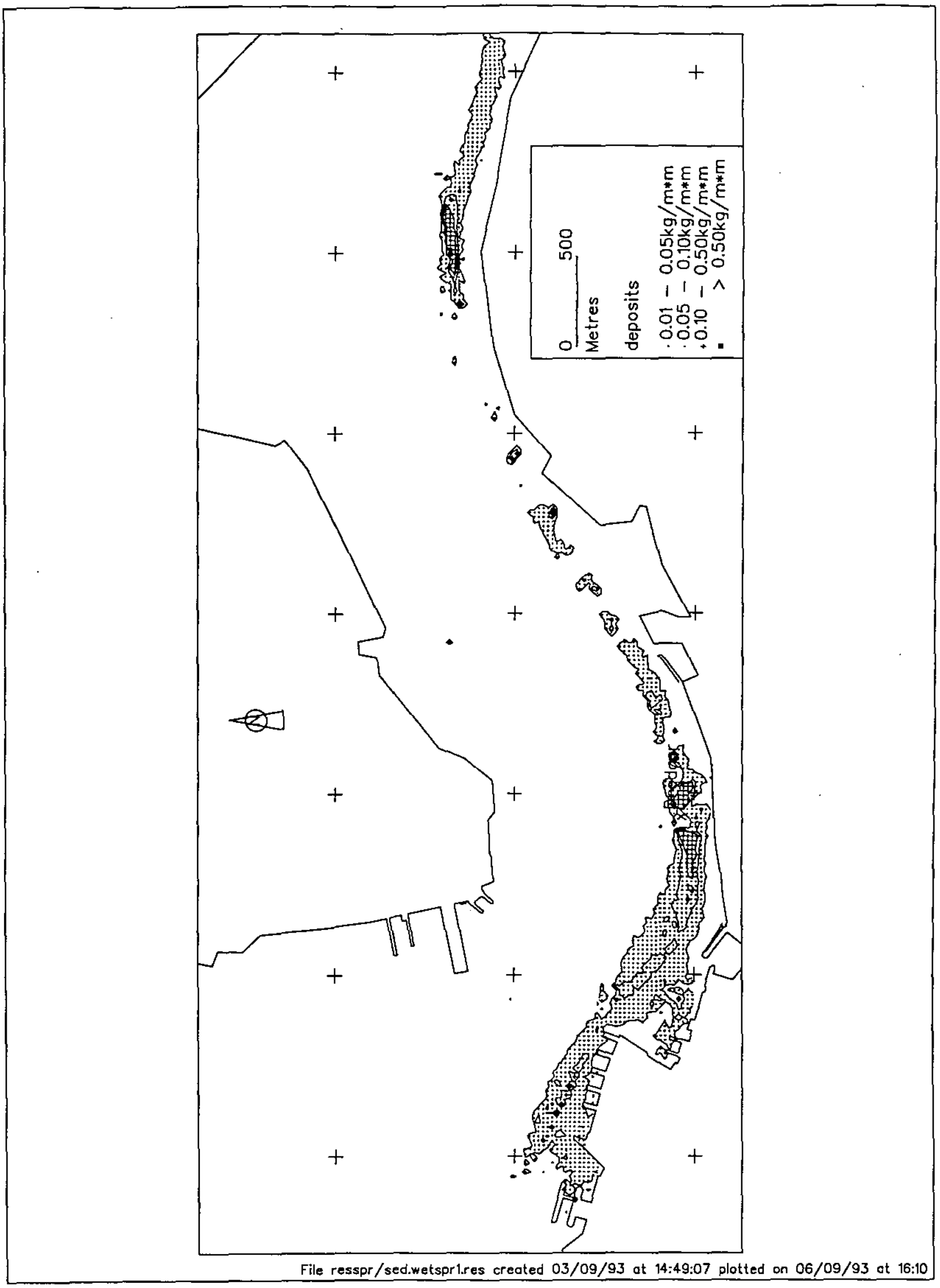

Figure 4.3.10 Mud deposits.
Wet season spring tide.
Low water

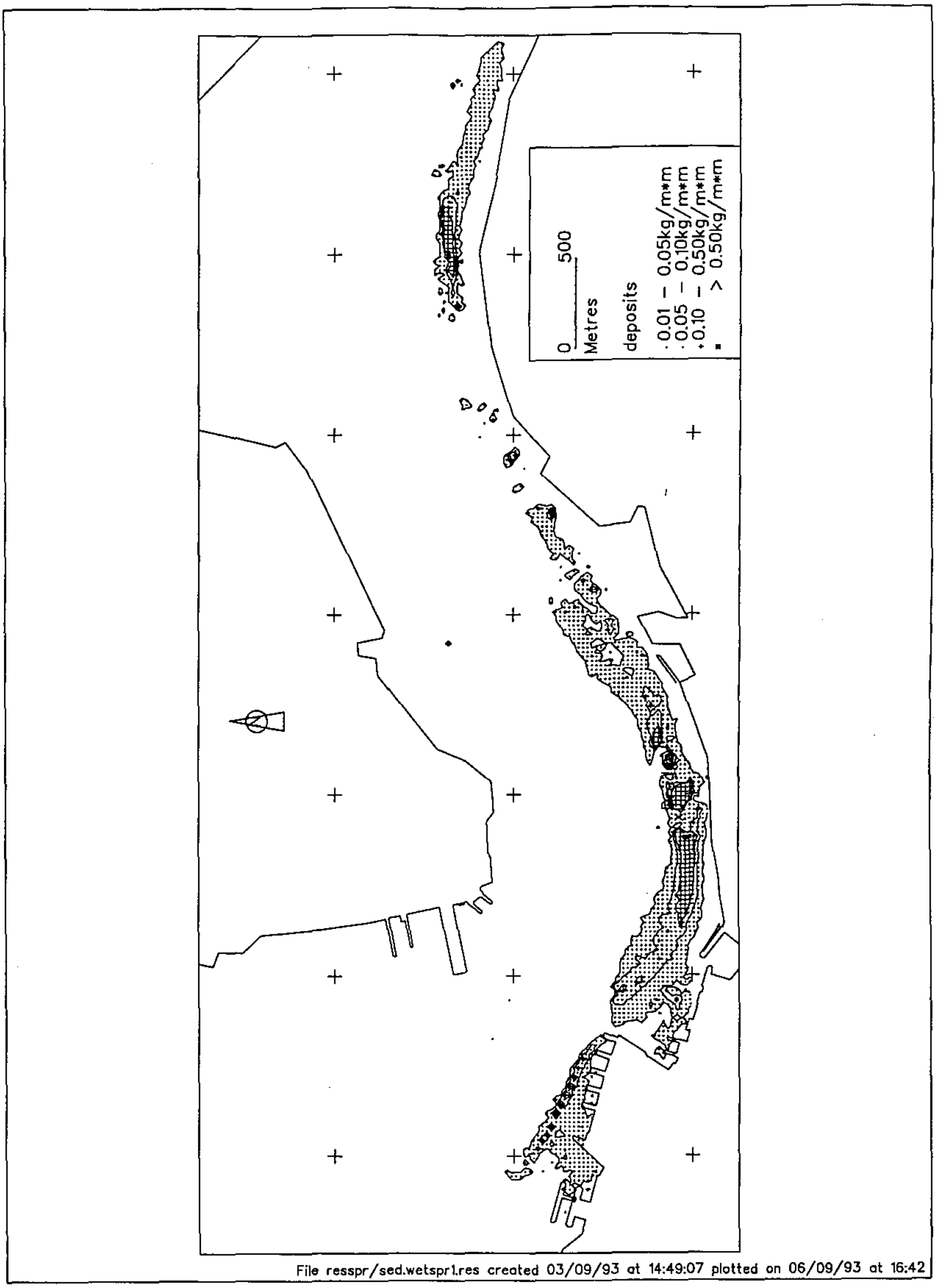

Figure 4.3.11 Mud deposits.
Wet season spring tide.
Peak flood.

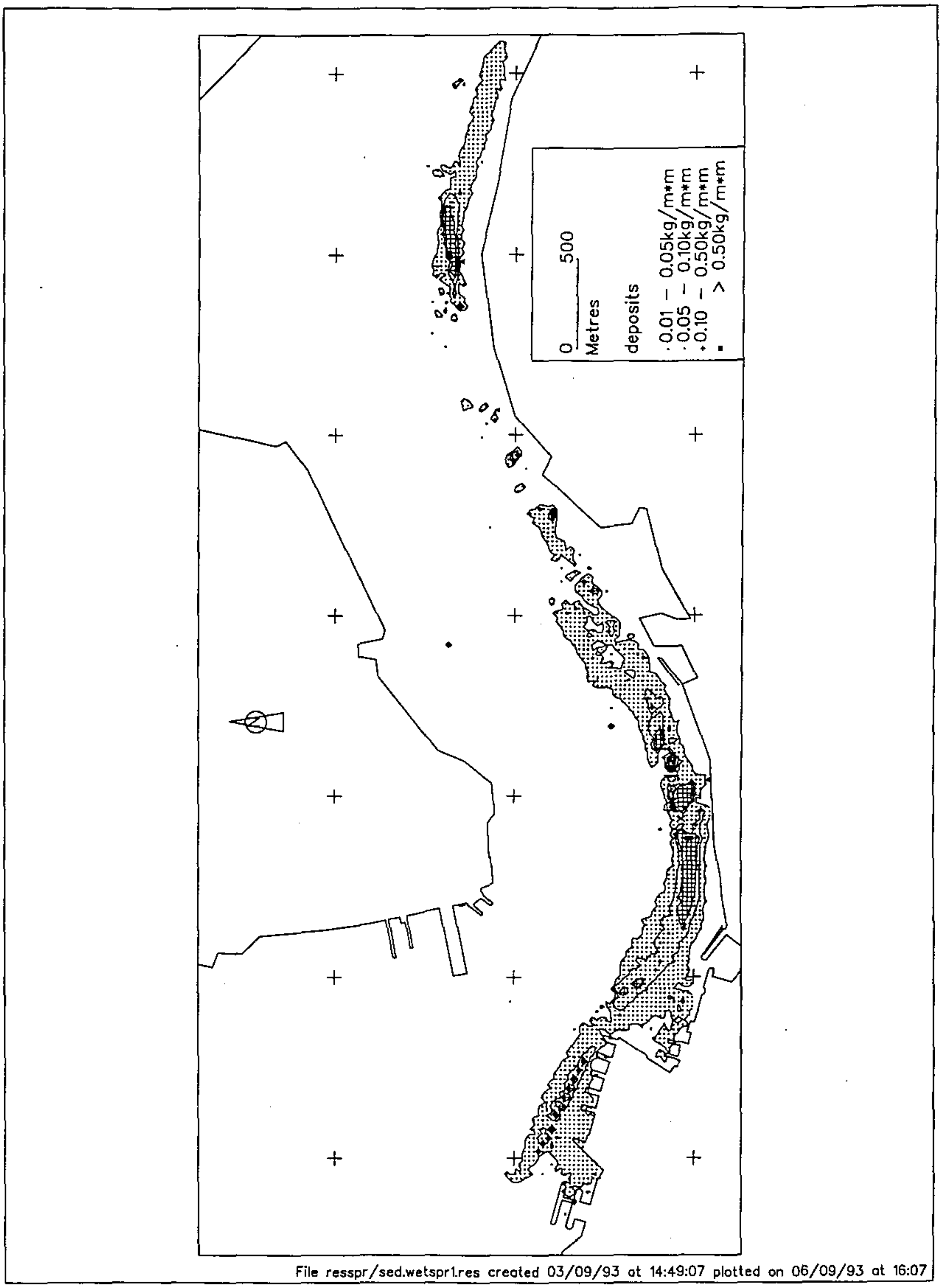

Figure 4.3.12 Mud deposits.
Wet season spring tide.
High water.

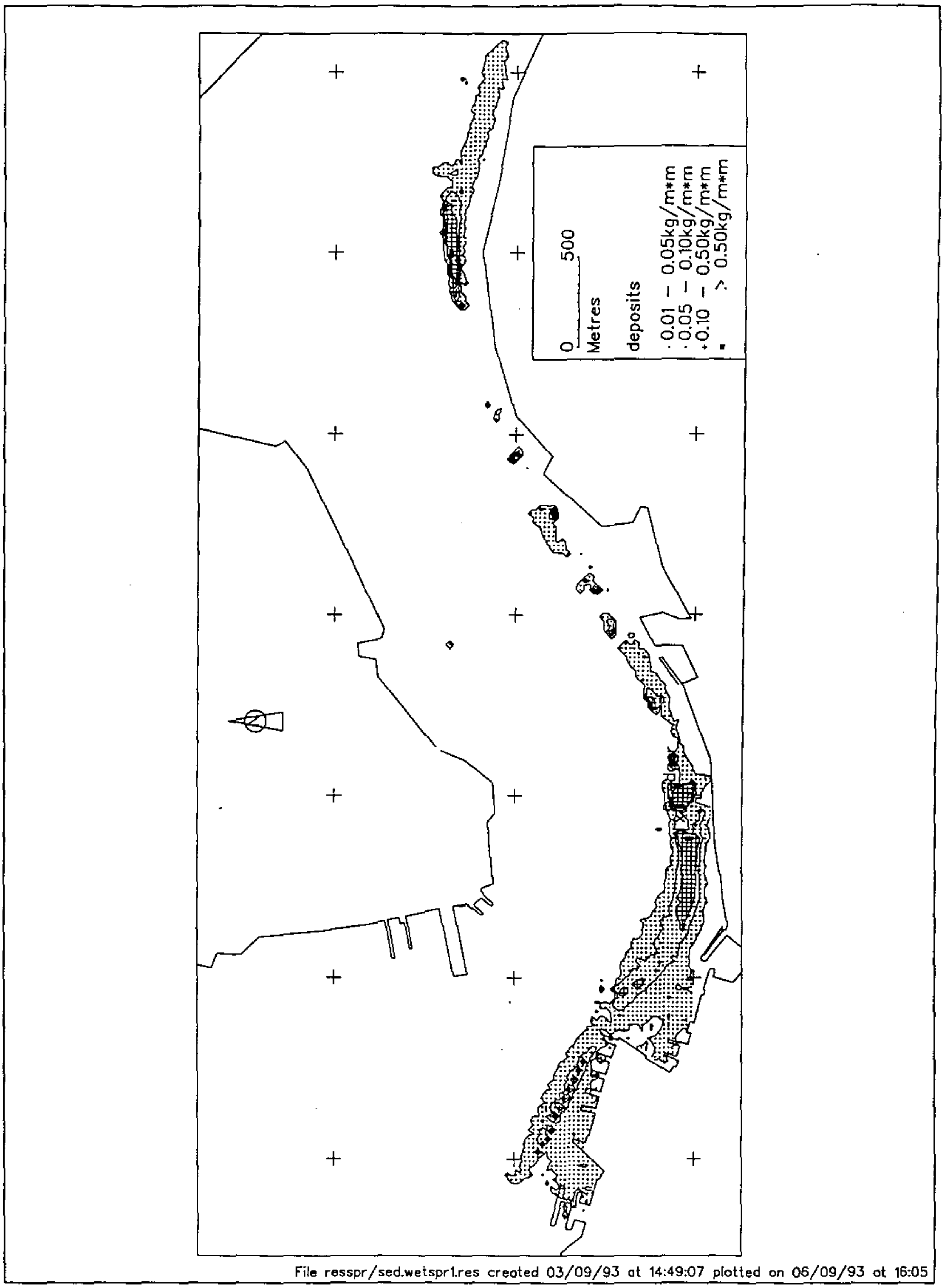

Figure 4.3.13 Mud deposits.
Wet season spring tide.
Peak ebb.

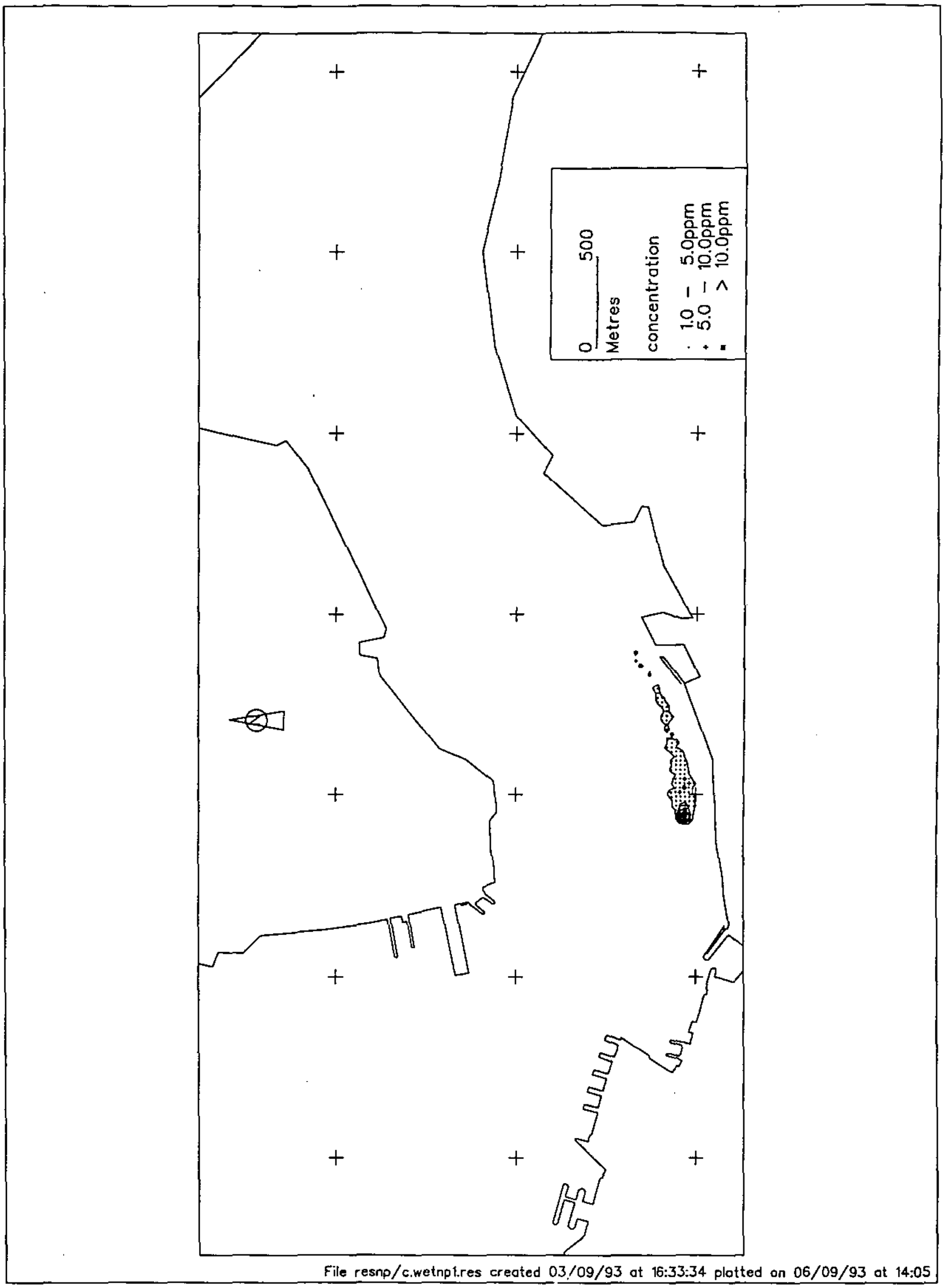

Figure 4.3.14 Suspended mud concentrations.
Wet season neap tide.
Low water. Upper layer.

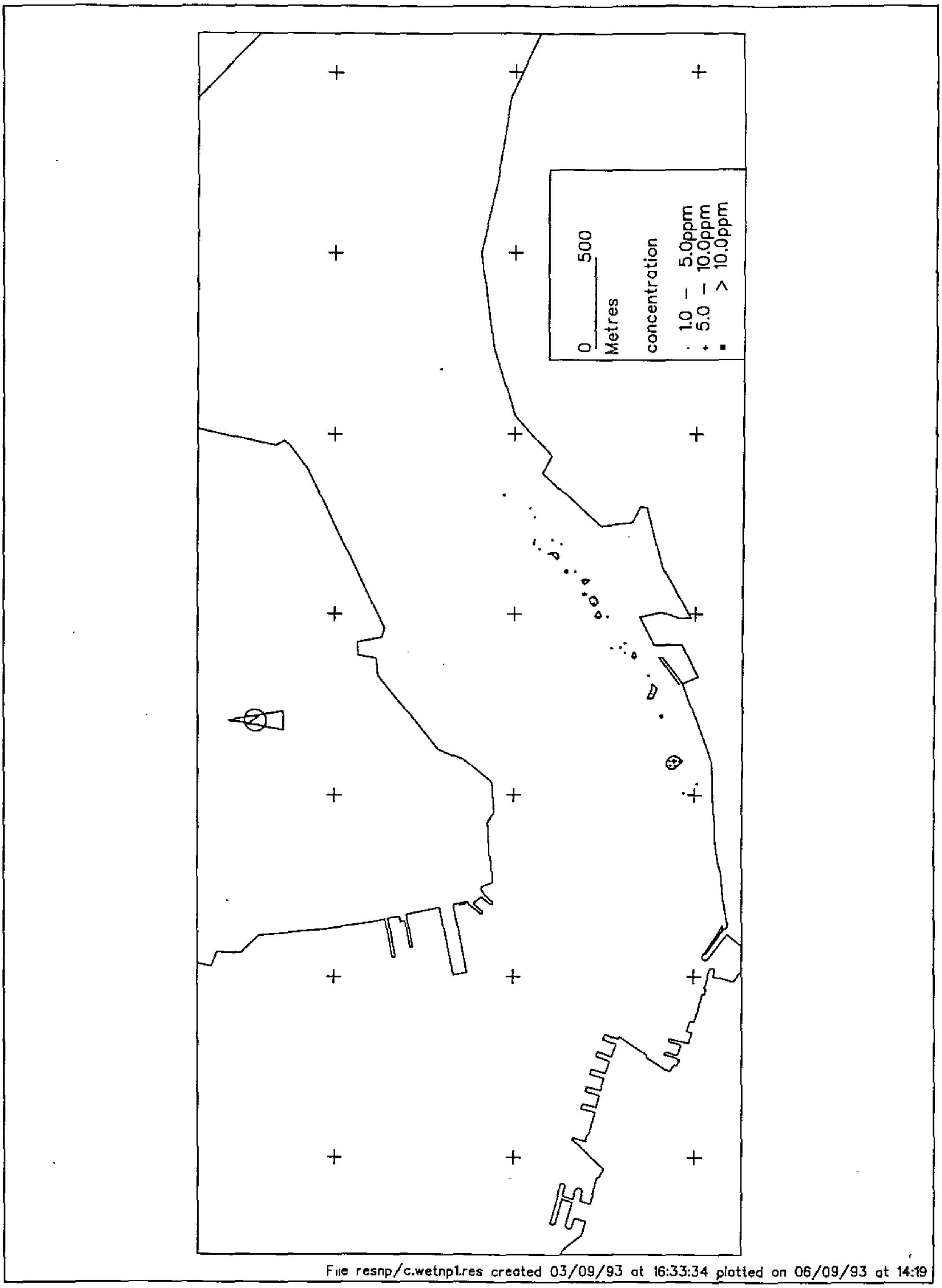

Figure 4.3.15 Suspended mud concentrations.
Wet season neap tide.
Low water. Lower layer.

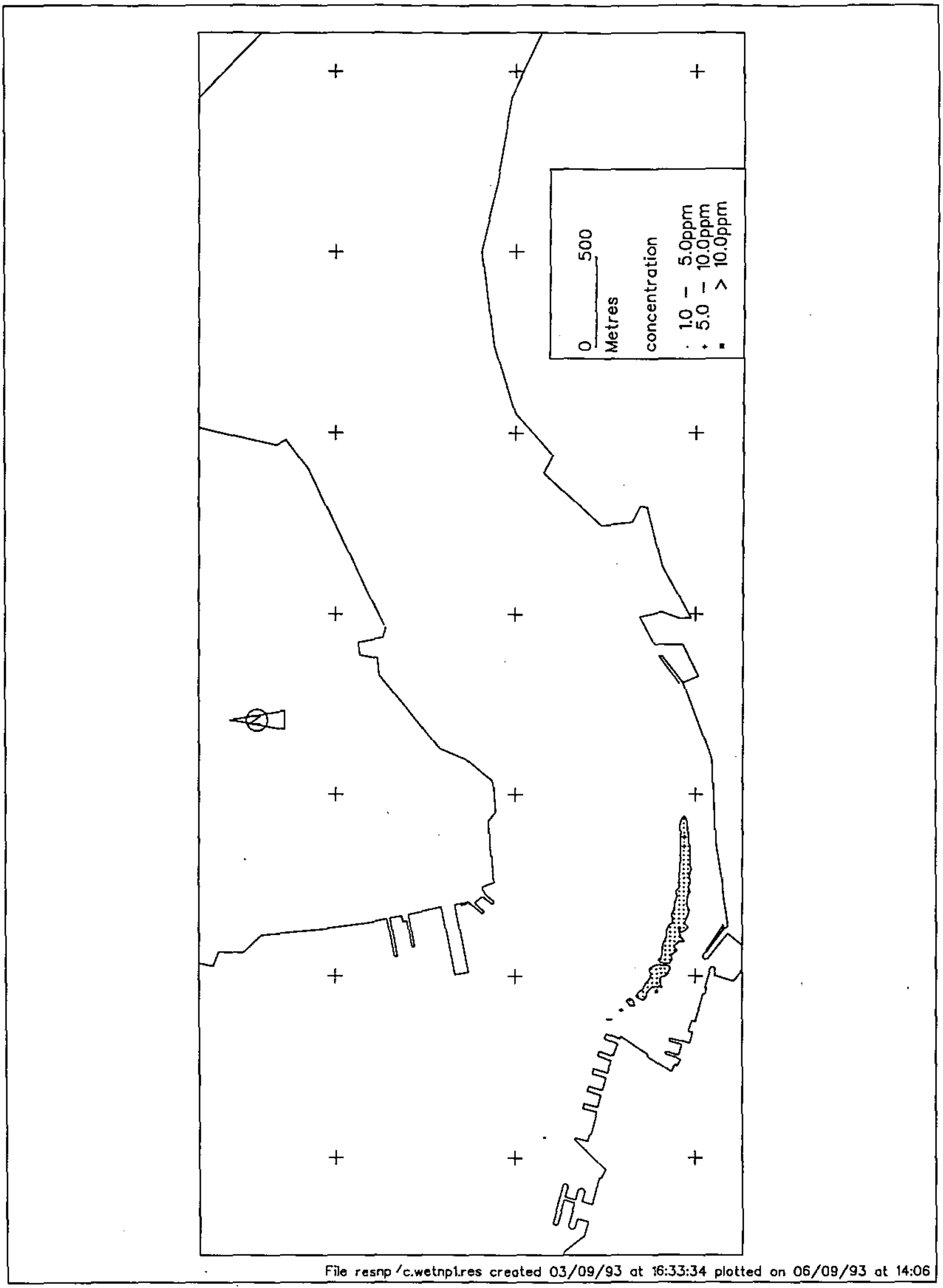

Figure 4.3.16 Suspended mud concentrations.
Wet season neap tide.
Peak flood. Upper layer.

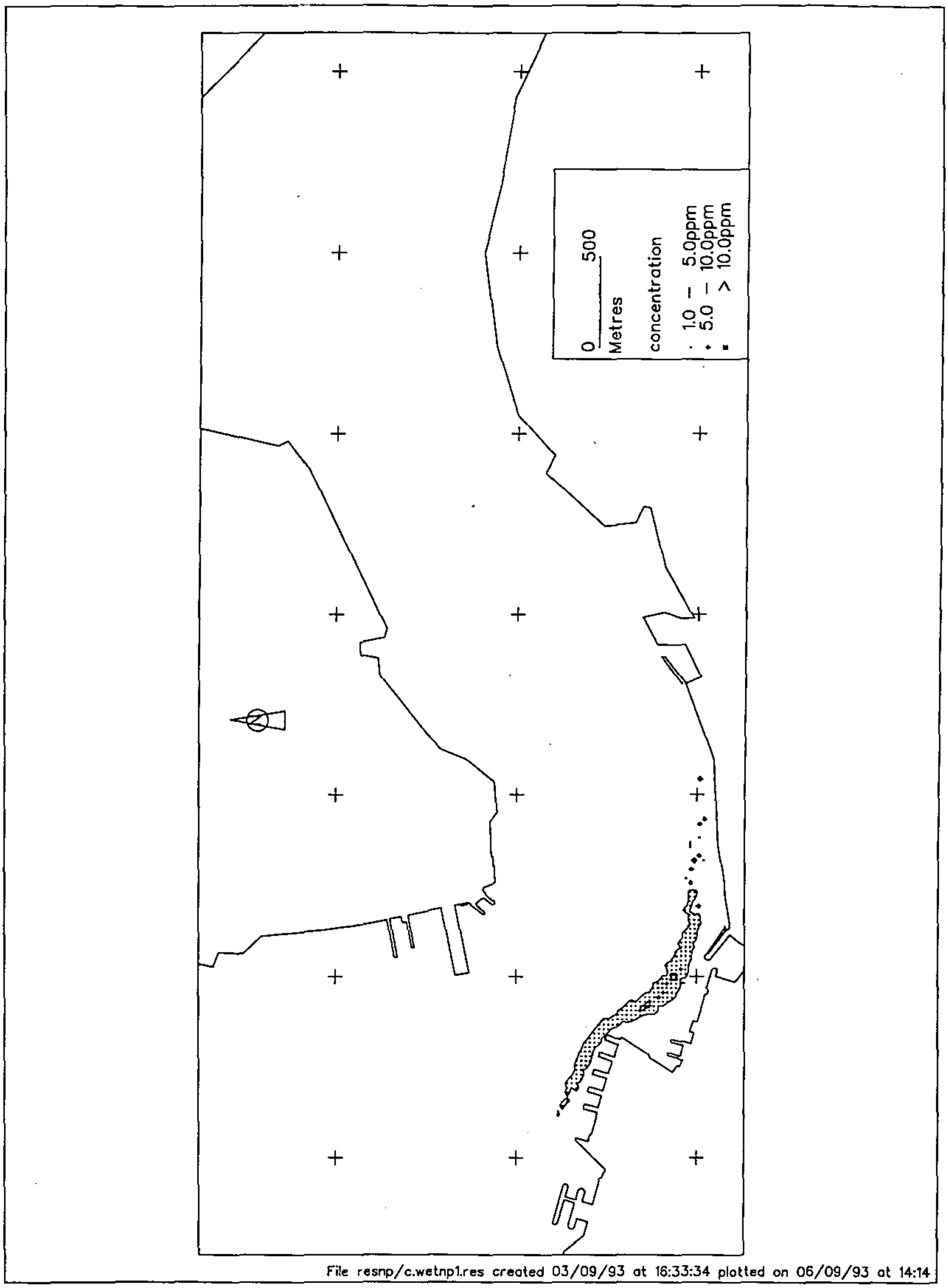

Figure 4.3.17 Suspended mud concentrations.
Wet season neap tide.
Peak flood. Lower layer.

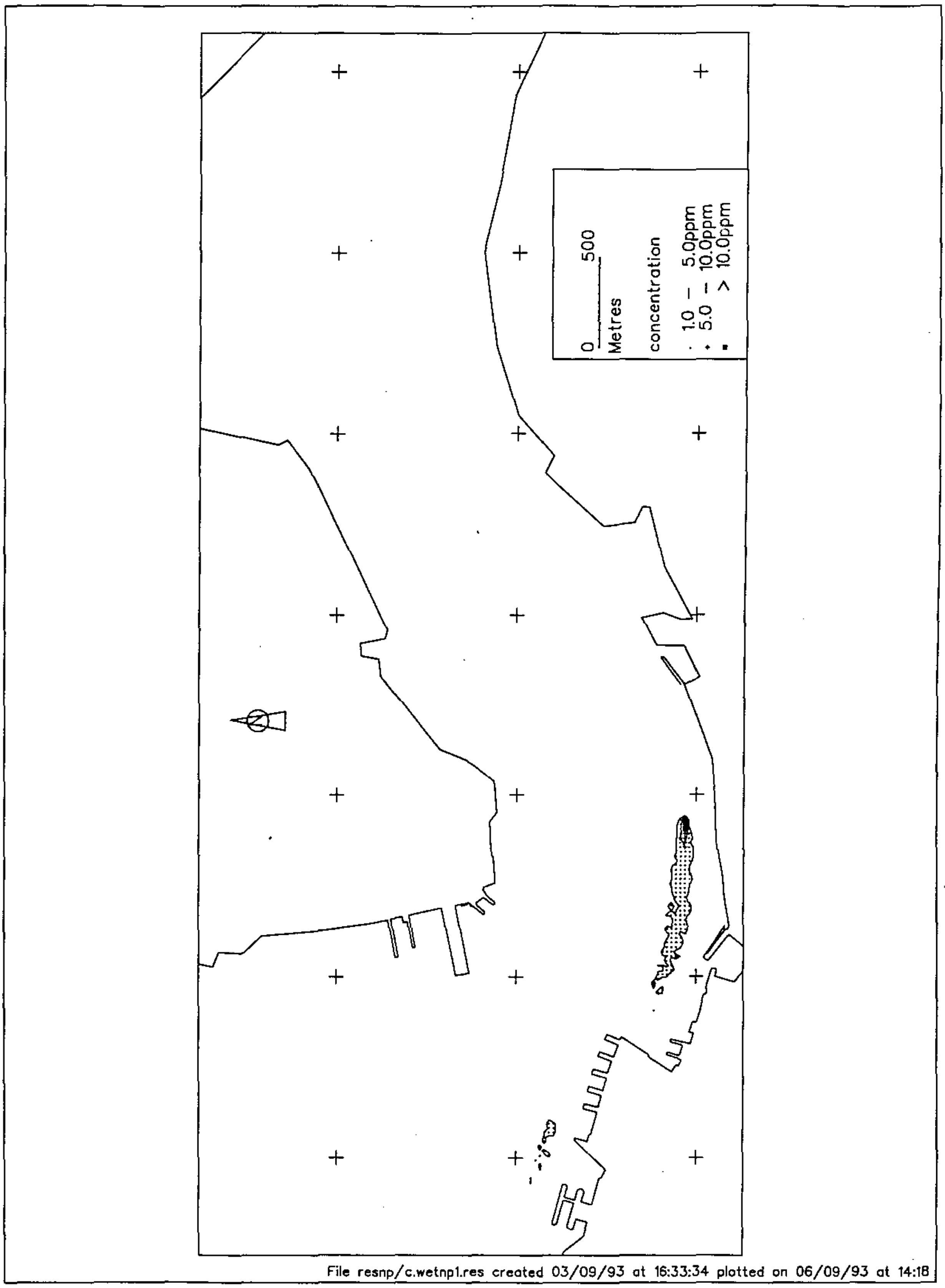

Figure 4.3.18 Suspended mud concentrations.
Wet season neap tide.
High water. Upper layer.

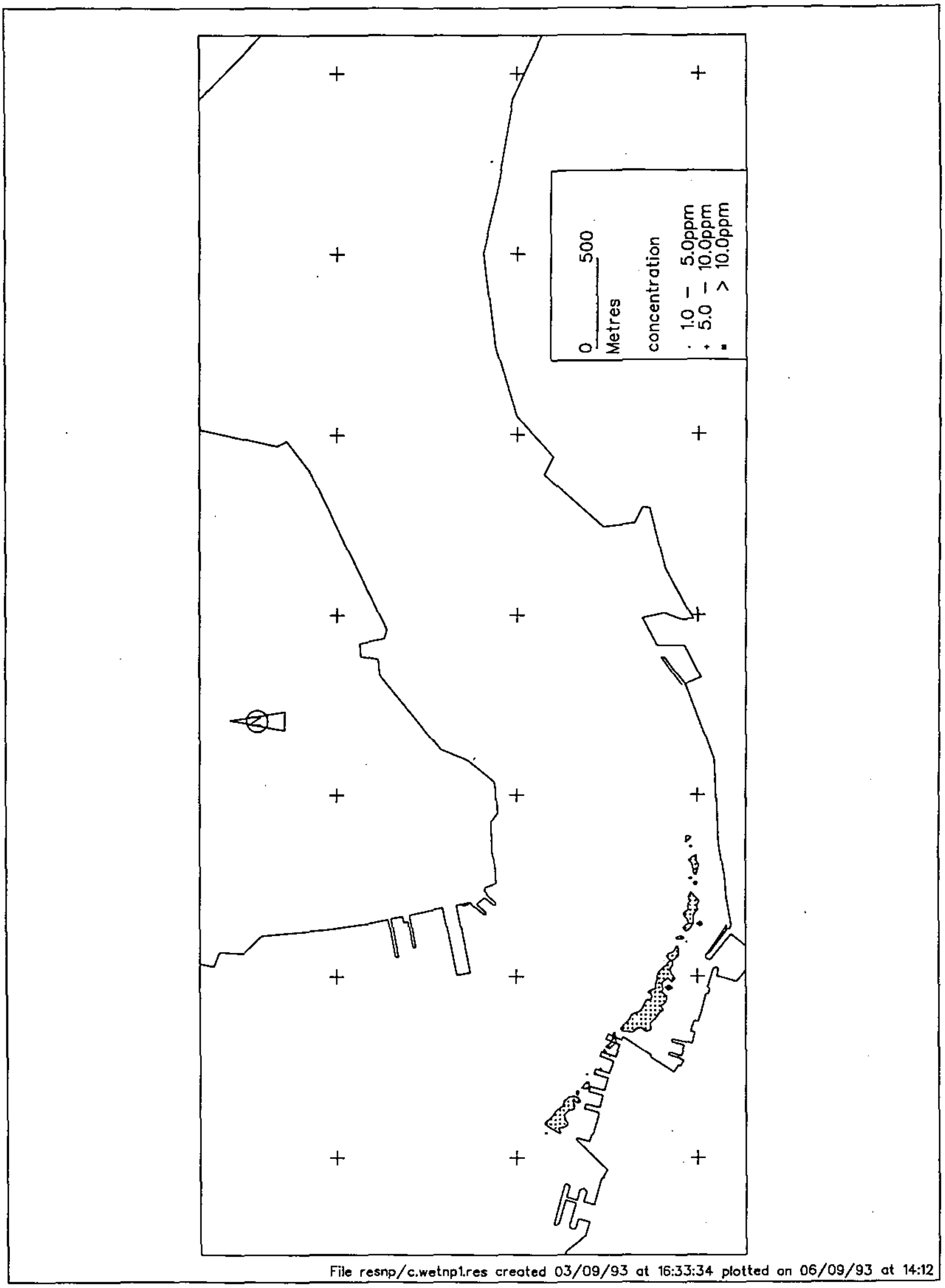

Figure 4.3.19 Suspended mud concentrations.
Wet season neap tide.
High water. Lower layer.

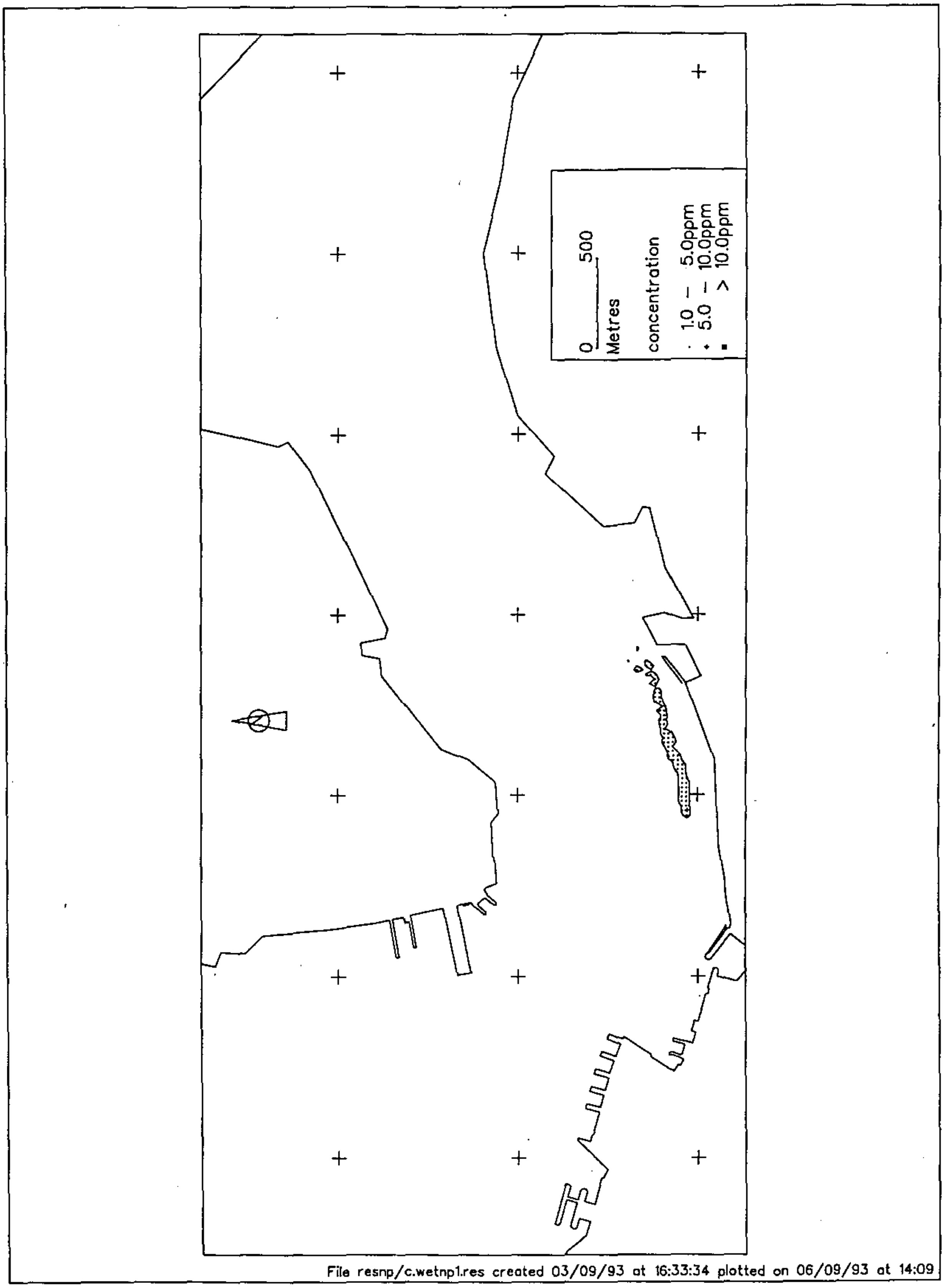

Figure 4.3.20 Suspended mud concentrations.
Wet season neap tide.
Peak ebb. Upper layer.

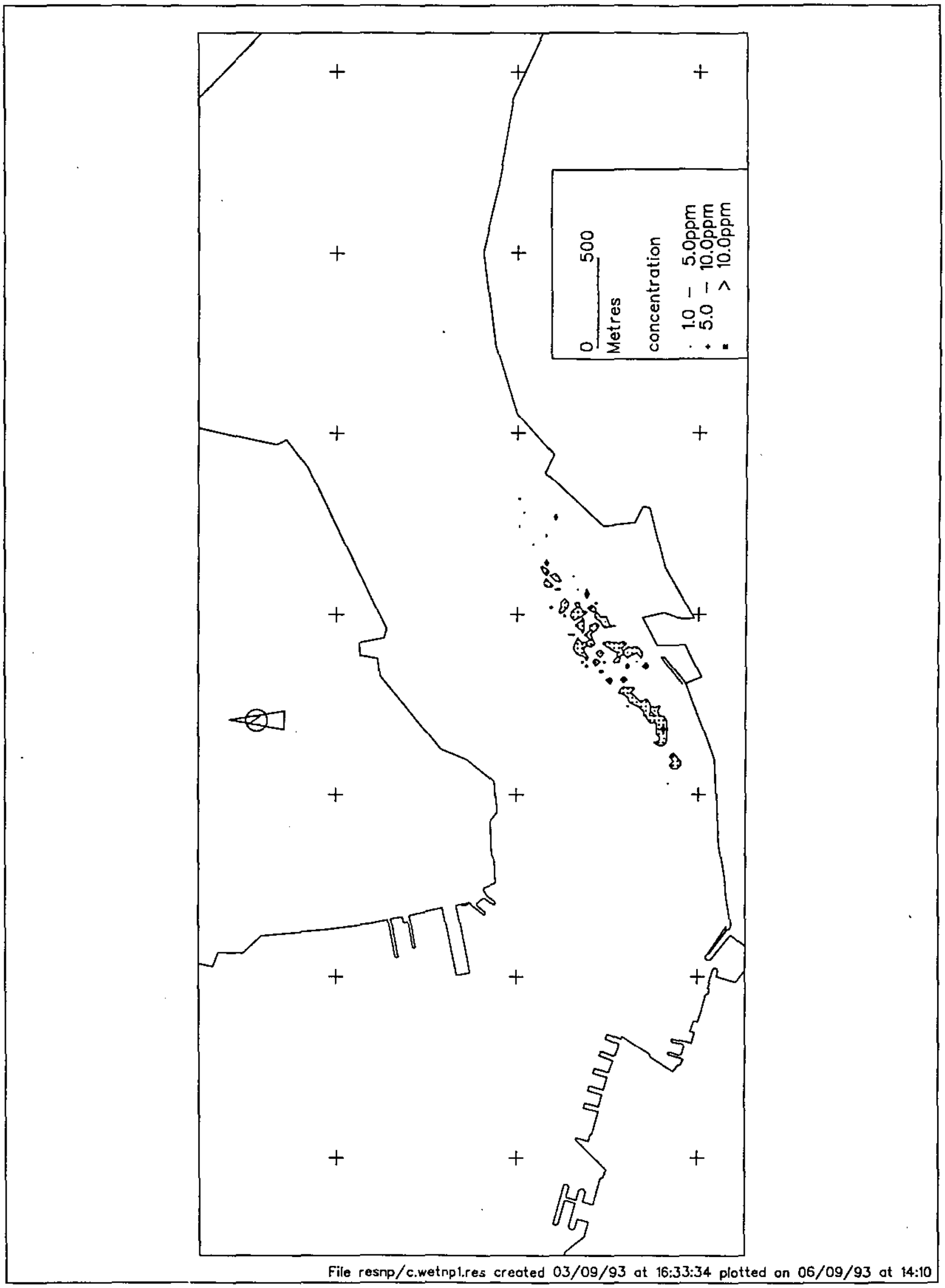

Figure 4.3.21 Suspended mud concentrations.
Wet season neap tide.
Peak ebb. Lower layer.

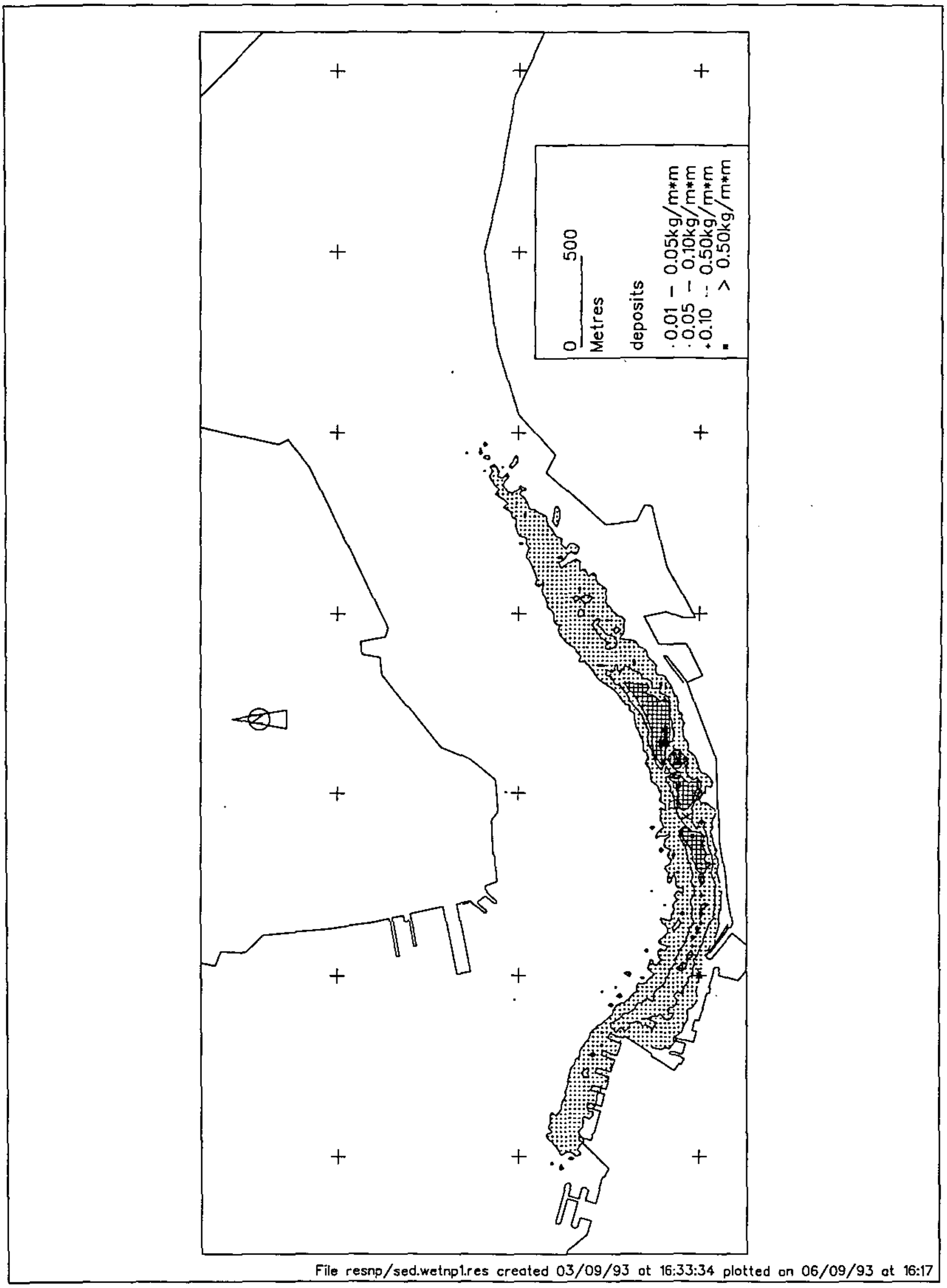

Figure 4.3.22 Mud deposits.
Wet season neap tide.
Low water.

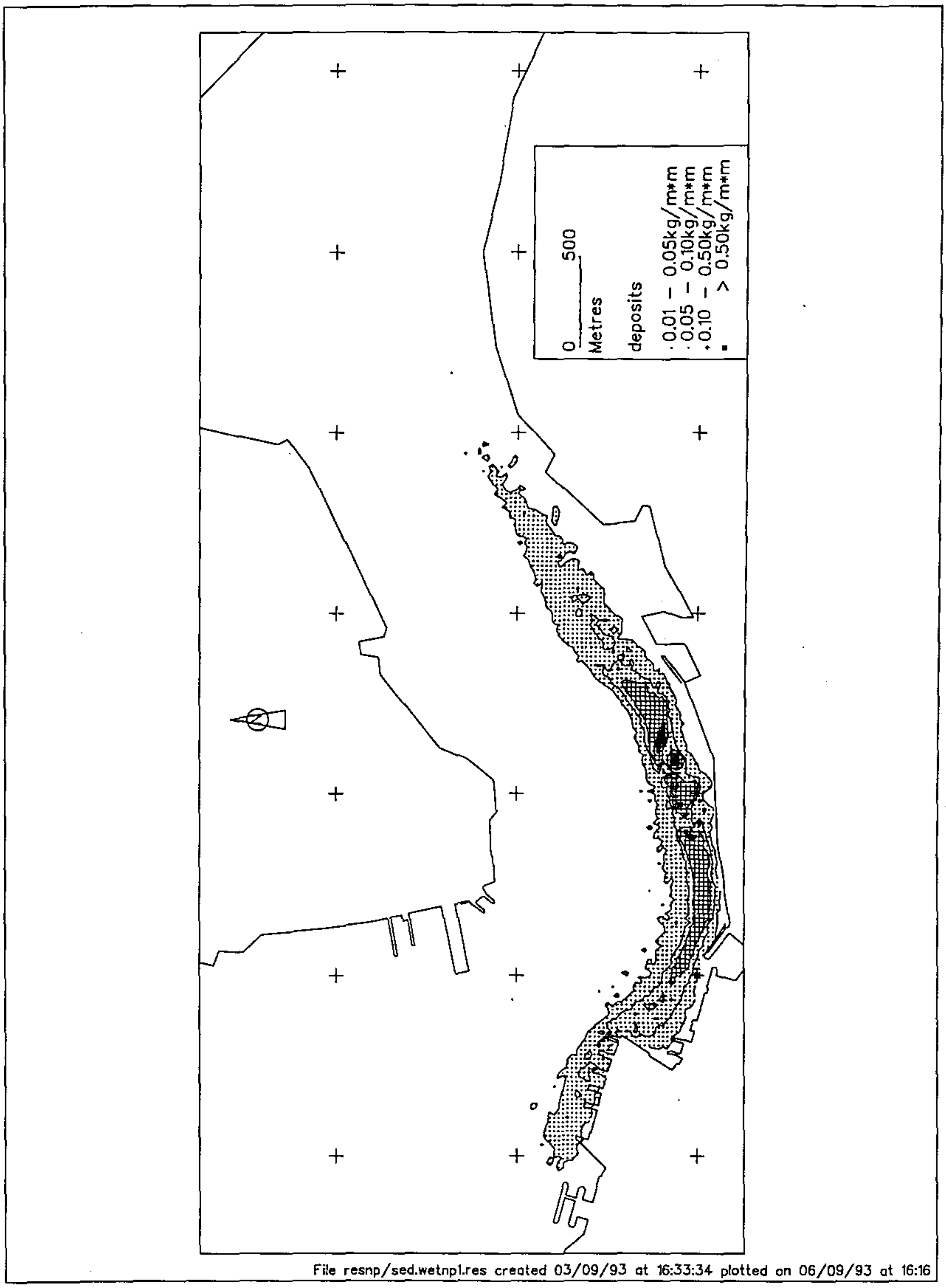

Figure 4.3.23 Mud deposits.
Wet season neap tide.
Peak flood.

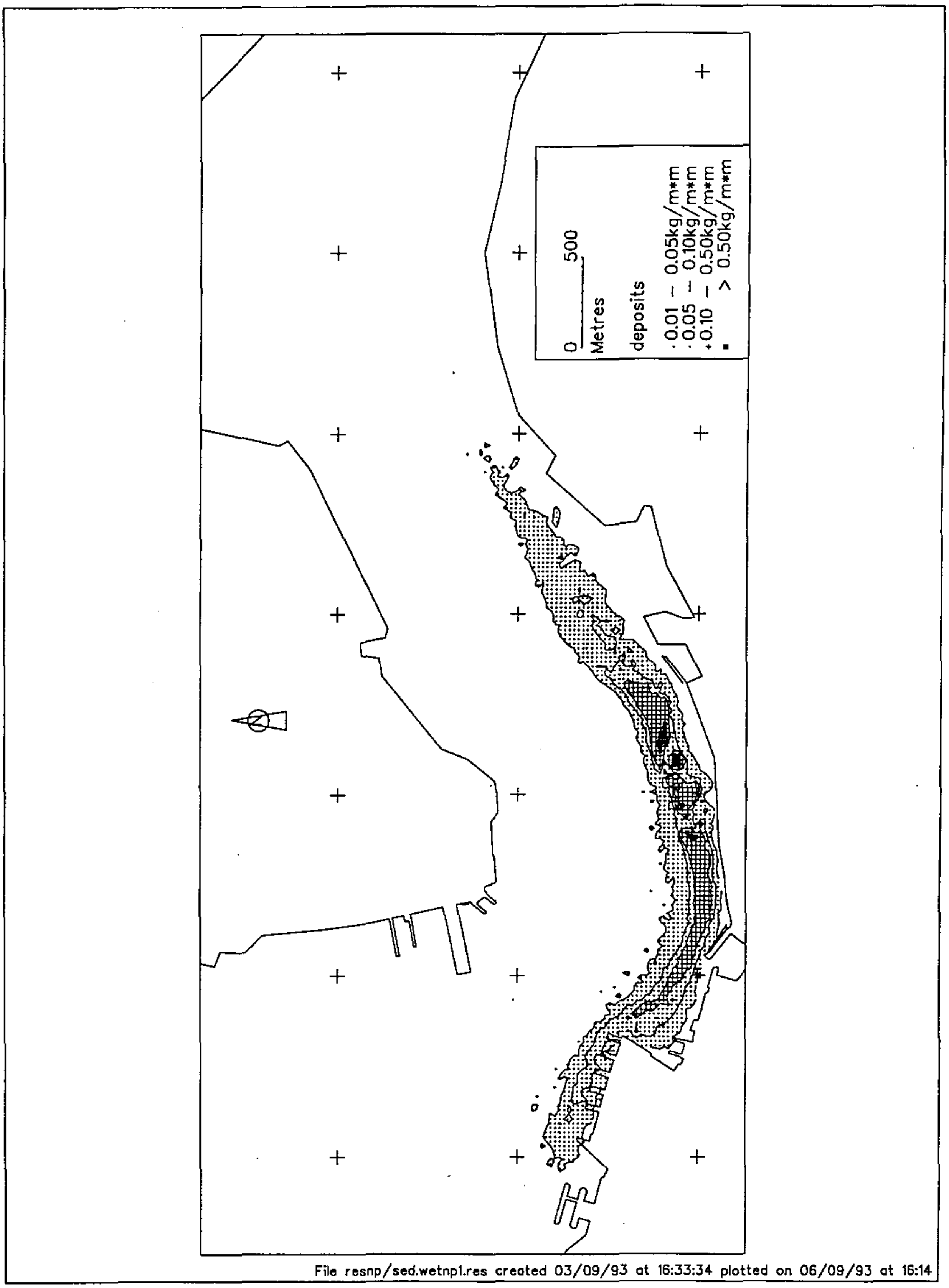

Figure 4.3.24 Mud deposits.
Wet season neap tide.
High water.

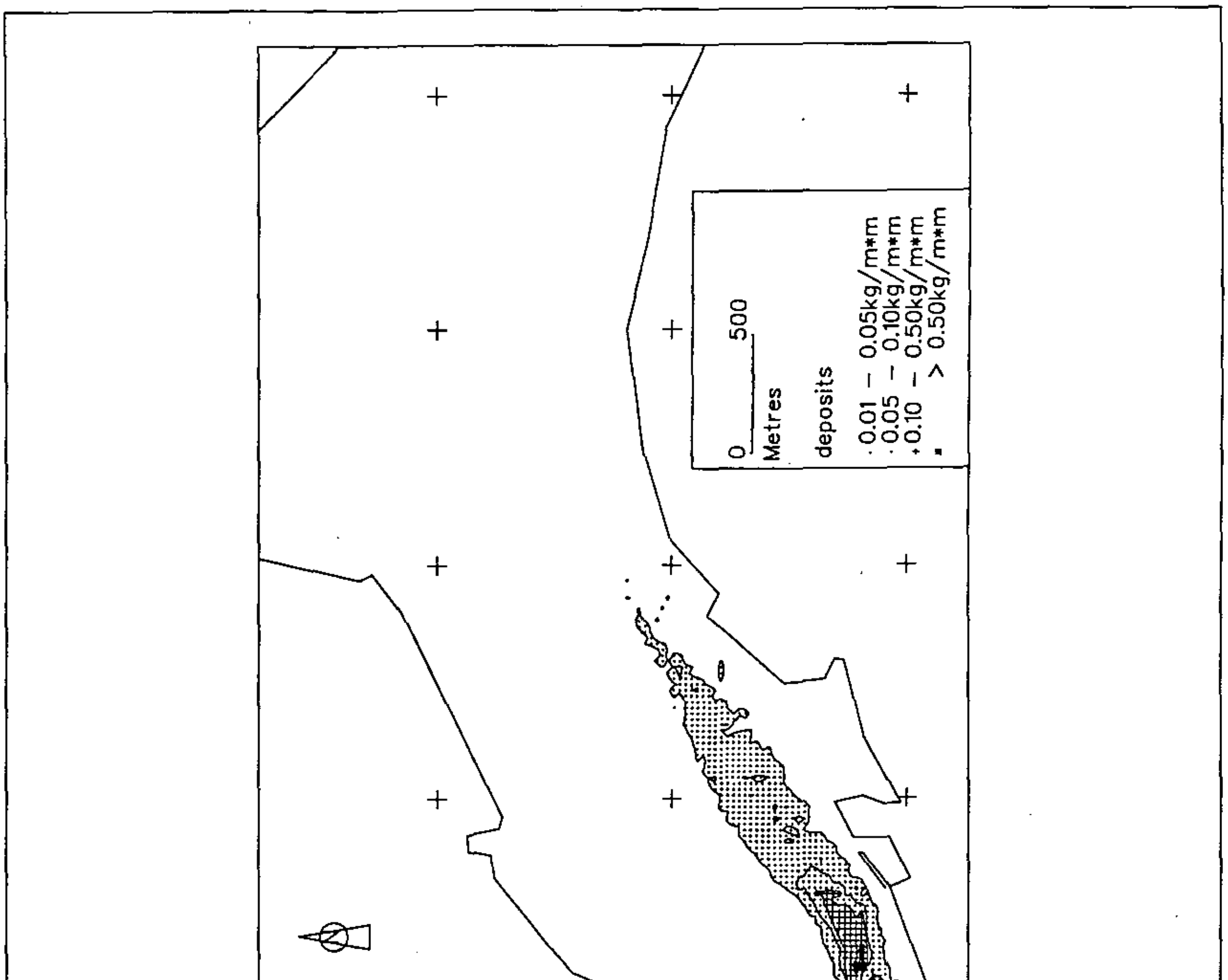

Figure 4.3.25 Mud deposits.
Wet season neap tide.
Peak ebb.

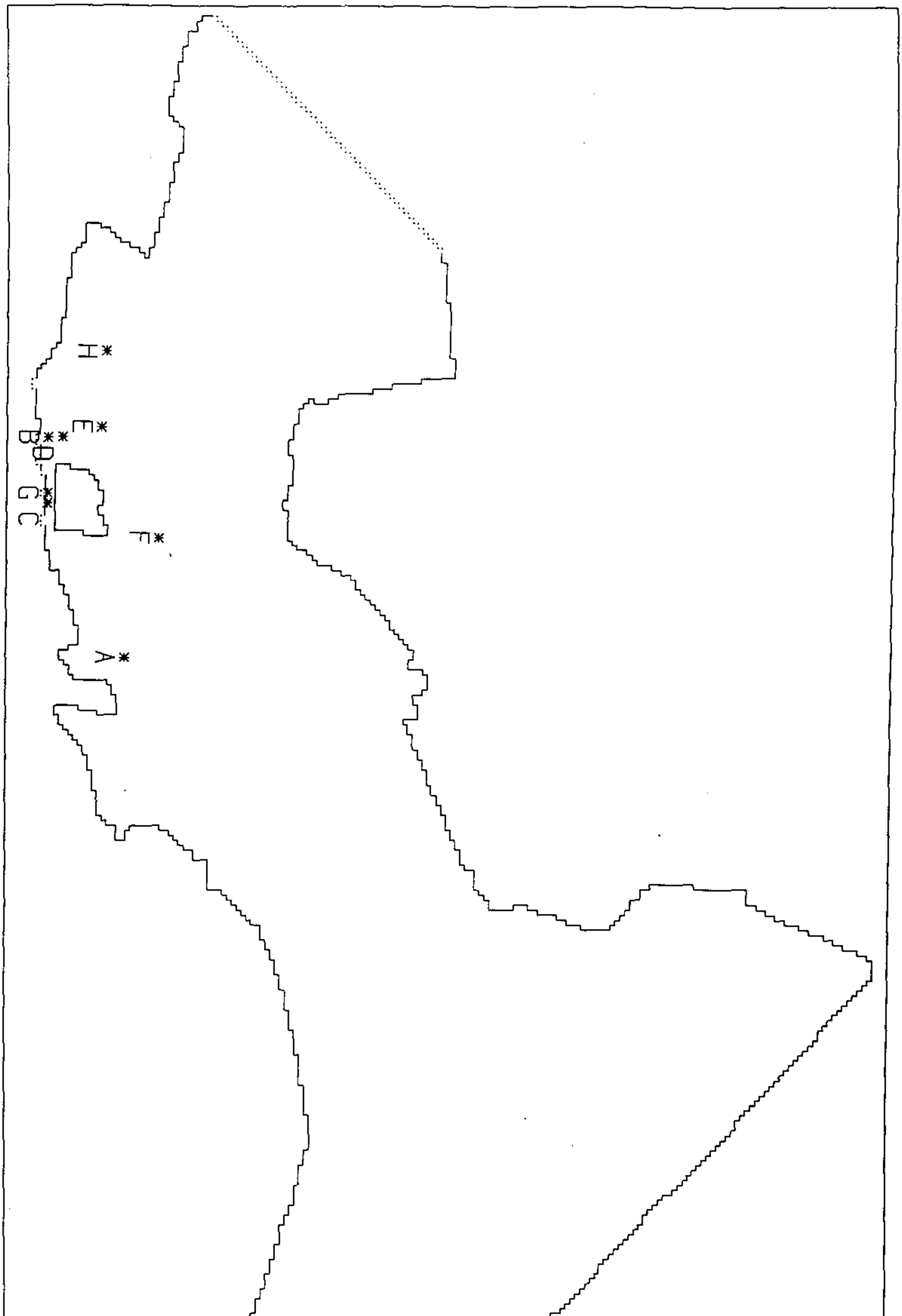

Figure 4.4.1 Time History Plot Positions

BASELINE: DRY SEASON, NEAP TIDE (25m grid)

2 layers
9 stations
Averaged over 73 steps

Station	Layer	Height	Temp	Salin	DO%	BOD	Amm	OxN	OrgN	Chl	SS	EColi
A	1	8.31	17.84	33.00	53.93	2.51	0.26	0.11	0.15	1.53	9.91	8983.
	2	3.31	17.88	33.00	53.50	2.44	0.26	0.11	0.15	1.51	9.81	7929.
B	1	8.32	17.84	33.00	53.76	2.61	0.27	0.12	0.16	1.53	10.04	12495.
	2	3.21	17.88	33.00	53.06	2.46	0.26	0.12	0.15	1.49	9.27	8257.
C	1	10.16	17.84	33.00	53.68	2.61	0.27	0.12	0.16	1.52	9.90	12749.
	2	0.00	17.84	33.00	53.68	2.61	0.27	0.12	0.16	1.52	9.90	12749.
D	1	8.32	17.84	33.00	53.79	2.58	0.27	0.11	0.15	1.52	10.03	11040.
	2	3.60	17.88	33.00	53.08	2.45	0.26	0.12	0.15	1.49	9.39	8009.
E	1	8.32	17.86	33.00	53.94	2.52	0.27	0.11	0.15	1.52	10.05	9412.
	2	3.86	17.90	33.00	53.26	2.41	0.26	0.11	0.14	1.49	9.70	7151.
F	1	8.31	17.89	33.00	54.10	2.47	0.26	0.11	0.14	1.52	10.10	9912.
	2	4.27	17.92	33.00	53.56	2.37	0.26	0.11	0.14	1.49	9.91	6541.
G	1	7.79	17.84	33.00	53.71	2.58	0.27	0.12	0.16	1.52	9.86	11180.
	2	0.00	17.84	33.00	53.71	2.58	0.27	0.12	0.16	1.52	9.86	11180.
H	1	8.32	17.86	33.00	53.95	2.50	0.26	0.11	0.15	1.52	10.04	8039.
	2	4.65	17.90	33.00	53.25	2.41	0.25	0.11	0.14	1.48	9.65	7088.

Table 4.4.3 Baseline, Dry Season Neap Tide (tidal averaged)

BASELINE: WET SEASON, NEAP TIDE (25m grid)

2 layers
9 stations
Averaged over 75 steps

Station	Layer	Height	Temp	Salin	DO%	BOD	Amm	OxN	OrgN	Chl	SS	EColi
A	1	8.16	24.47	31.99	68.53	2.29	0.25	0.14	0.36	2.37	8.28	9813.
	2	3.49	24.45	31.99	67.20	2.22	0.24	0.14	0.35	2.25	7.90	9187.
B	1	8.17	24.39	31.99	70.17	2.17	0.24	0.14	0.37	2.45	8.30	13577.
	2	3.39	24.38	31.99	68.53	2.05	0.23	0.14	0.36	2.35	7.57	10900.
C	1	8.15	24.42	31.99	69.50	2.26	0.24	0.14	0.37	2.43	8.31	14907.
	2	2.04	24.39	31.99	68.43	2.11	0.23	0.14	0.36	2.35	7.86	11255.
D	1	8.17	24.39	31.99	70.23	2.14	0.23	0.14	0.37	2.45	8.28	12276.
	2	3.77	24.38	31.99	68.48	2.05	0.23	0.14	0.36	2.34	7.61	10563.
E	1	8.19	24.37	31.99	70.69	2.08	0.23	0.14	0.36	2.44	8.30	11869.
	2	4.01	24.38	31.99	68.45	2.05	0.23	0.14	0.36	2.32	7.89	10120.
F	1	8.20	24.40	31.99	69.71	2.17	0.24	0.14	0.36	2.36	8.41	11763.
	2	4.41	24.41	31.99	67.93	2.12	0.23	0.14	0.35	2.26	8.16	9818.
G	1	7.82	24.41	31.99	69.59	2.21	0.24	0.14	0.37	2.43	8.19	13263.
	2	0.00	24.41	31.99	69.59	2.21	0.24	0.14	0.37	2.43	8.19	13263.
H	1	8.21	24.34	32.00	71.41	1.95	0.23	0.14	0.36	2.46	8.20	8920.
	2	4.79	24.35	31.99	69.11	1.95	0.22	0.14	0.36	2.34	7.74	9526.

Table 4.4.4 Baseline, Wet Season Neap Tide (tidal averaged)

SCENARIO 1 - FULL LOADS: DRY SEASON, NEAP TIDE (25m grid)

2 layers
9 stations
Averaged over 73 steps

Station	Layer	Height	Temp	Salin	DO%	BOD	Amm	OxN	OrgN	Chl	SS	EColi
A	1	8.31	17.83	33.00	53.88	2.57	0.27	0.11	0.15	1.54	9.85	10301.
	2	3.31	17.88	33.00	53.33	2.45	0.26	0.11	0.15	1.50	9.52	8231.
B	1	8.31	17.82	33.00	53.60	2.74	0.28	0.12	0.17	1.53	10.03	14878.
	2	3.21	17.87	33.00	52.75	2.52	0.26	0.12	0.15	1.49	8.96	9720.
C	1	10.16	17.81	33.00	53.36	2.89	0.29	0.12	0.18	1.53	9.90	21210.
	2	0.00	17.81	33.00	53.36	2.89	0.29	0.12	0.18	1.53	9.90	21210.
D	1	8.31	17.82	33.00	53.63	2.70	0.27	0.12	0.16	1.53	10.02	13248.
	2	3.60	17.88	33.00	52.76	2.50	0.26	0.12	0.15	1.49	9.00	9280.
E	1	8.31	17.84	33.00	53.82	2.60	0.27	0.11	0.16	1.52	10.04	10709.
	2	3.86	17.89	33.00	52.97	2.44	0.26	0.11	0.15	1.48	9.33	7856.
F	1	8.31	17.88	33.00	54.03	2.52	0.27	0.11	0.15	1.52	10.08	11197.
	2	4.27	17.92	33.00	53.47	2.39	0.26	0.11	0.14	1.49	9.84	7208.
G	1	7.78	17.81	33.00	53.41	2.84	0.28	0.12	0.17	1.53	9.86	18279.
	2	0.00	17.81	33.00	53.41	2.84	0.28	0.12	0.17	1.53	9.86	18279.
H	1	8.32	17.85	33.00	53.89	2.56	0.27	0.11	0.15	1.52	10.03	8869.
	2	4.65	17.91	33.00	53.05	2.42	0.26	0.11	0.14	1.48	9.34	7372.

Table 4.4.5 Scenario 1, Dry Season Neap Tide (tidal averaged)

SCENARIO 1 - FULL LOADS: WET SEASON, NEAP TIDE (25m grid)

2 layers
9 stations
Averaged over 75 steps

Station	Layer	Height	Temp	Salin	DO%	BOD	Amm	OxN	OrgN	Chl	SS	EColi
A	1	8.16	24.47	31.99	68.61	2.32	0.25	0.14	0.37	2.38	8.22	10671.
	2	3.49	24.45	31.99	67.09	2.23	0.24	0.14	0.35	2.24	7.76	9515.
B	1	8.17	24.38	32.00	70.36	2.24	0.24	0.14	0.38	2.48	8.31	15631.
	2	3.39	24.37	31.99	68.66	2.07	0.23	0.14	0.36	2.36	7.49	11937.
C	1	8.15	24.43	31.99	69.30	2.57	0.26	0.14	0.39	2.47	8.40	26101.
	2	2.04	24.41	31.99	68.93	2.49	0.26	0.15	0.39	2.45	8.34	24833.
D	1	8.17	24.38	32.00	70.42	2.20	0.24	0.14	0.37	2.48	8.29	14137.
	2	3.77	24.37	31.99	68.58	2.05	0.23	0.14	0.36	2.35	7.51	11390.
E	1	8.19	24.36	32.00	70.79	2.12	0.24	0.14	0.37	2.46	8.30	12999.
	2	4.01	24.38	31.99	68.49	2.05	0.23	0.14	0.36	2.32	7.76	10535.
F	1	8.20	24.40	31.99	69.92	2.17	0.24	0.14	0.36	2.38	8.37	12618.
	2	4.41	24.41	31.99	68.10	2.13	0.23	0.14	0.35	2.26	8.13	10428.
G	1	7.82	24.42	31.99	69.46	2.48	0.26	0.14	0.39	2.48	8.27	22684.
	2	0.00	24.42	31.99	69.46	2.48	0.26	0.14	0.39	2.48	8.27	22684.
H	1	8.21	24.33	32.00	71.55	1.97	0.23	0.14	0.36	2.48	8.21	9531.
	2	4.79	24.34	31.99	69.06	1.95	0.22	0.14	0.35	2.33	7.62	9615.

Table 4.4.6 Scenario 1, Wet Season Neap Tide (tidal averaged)

SCENARIO 2 - 1st MITIGATION: WET SEASON, NEAP TIDE (25m grid)

2 layers
9 stations
Averaged over 75 steps

Station	Layer	Height	Temp	Salin	DO%	BOD	Amm	OxN	OrgN	Chl	SS	EColi
A	1	8.16	24.47	31.99	68.64	2.31	0.25	0.14	0.36	2.38	8.22	10563.
	2	3.49	24.45	31.99	67.11	2.23	0.24	0.14	0.35	2.24	7.76	9532.
B	1	8.17	24.38	32.00	70.42	2.18	0.24	0.14	0.37	2.48	8.26	13669.
	2	3.39	24.37	31.99	68.70	2.05	0.23	0.14	0.36	2.36	7.47	11155.
C	1	8.15	24.42	31.99	69.39	2.44	0.25	0.14	0.39	2.47	8.28	21310.
	2	2.04	24.41	31.99	69.06	2.37	0.25	0.14	0.38	2.45	8.22	20323.
D	1	8.17	24.38	32.00	70.47	2.15	0.23	0.14	0.37	2.48	8.25	12687.
	2	3.77	24.37	31.99	68.62	2.04	0.22	0.14	0.36	2.35	7.49	10778.
E	1	8.19	24.36	32.00	70.83	2.11	0.23	0.14	0.37	2.46	8.29	13020.
	2	4.01	24.37	31.99	68.51	2.04	0.23	0.14	0.36	2.32	7.76	10308.
F	1	8.20	24.40	31.99	69.94	2.18	0.24	0.14	0.36	2.38	8.37	13020.
	2	4.41	24.41	31.99	68.11	2.13	0.23	0.14	0.35	2.26	8.13	10540.
G	1	7.82	24.42	31.99	69.55	2.38	0.25	0.14	0.38	2.48	8.17	18755.
	2	0.00	24.42	31.99	69.55	2.38	0.25	0.14	0.38	2.48	8.17	18755.
H	1	8.21	24.33	32.00	71.59	1.96	0.23	0.14	0.36	2.48	8.19	9161.
	2	4.79	24.34	31.99	69.09	1.94	0.22	0.14	0.35	2.33	7.61	9384.

Table 4.4.7 Scenario 2, Wet Season Neap Tide (tidal averaged)

SCENARIO 3 - 2nd MITIGATION (B): WET SEASON, NEAP TIDE (25m grid)

2 layers
9 stations
Averaged over 75 steps

Station	Layer	Height	Temp	Salin	DO%	BOD	Amm	OxN	OrgN	Chl	SS	EColi
A	1	8.16	24.47	31.99	68.65	2.30	0.25	0.14	0.36	2.38	8.21	10483.
	2	3.49	24.45	31.99	67.12	2.23	0.24	0.14	0.35	2.24	7.76	9482.
B	1	8.17	24.38	32.00	70.44	2.16	0.23	0.14	0.37	2.48	8.24	13247.
	2	3.39	24.37	31.99	68.72	2.04	0.22	0.14	0.36	2.36	7.46	10902.
C	1	8.15	24.42	31.99	69.46	2.33	0.25	0.14	0.38	2.48	8.17	16995.
	2	2.04	24.41	31.99	69.15	2.27	0.24	0.14	0.38	2.45	8.12	16295.
D	1	8.17	24.38	32.00	70.50	2.14	0.23	0.14	0.37	2.48	8.23	12359.
	2	3.77	24.37	31.99	68.64	2.03	0.22	0.14	0.36	2.35	7.48	10581.
E	1	8.19	24.36	32.00	70.84	2.11	0.23	0.14	0.37	2.46	8.28	13083.
	2	4.01	24.37	31.99	68.53	2.04	0.23	0.14	0.36	2.32	7.75	10263.
F	1	8.20	24.40	31.99	69.94	2.18	0.24	0.14	0.36	2.38	8.37	13097.
	2	4.41	24.41	31.99	68.12	2.13	0.23	0.14	0.35	2.26	8.13	10563.
G	1	7.82	24.42	31.99	69.61	2.29	0.24	0.14	0.38	2.48	8.08	15378.
	2	0.00	24.42	31.99	69.61	2.29	0.24	0.14	0.38	2.48	8.08	15378.
H	1	8.21	24.33	32.00	71.60	1.95	0.23	0.14	0.36	2.48	8.19	9201.
	2	4.79	24.34	31.99	69.10	1.94	0.22	0.14	0.35	2.33	7.61	9374.

Table 4.4.8 Scenario 3, Wet Sesaon Neap Tide (tidal averaged)

Wet season Neap tide, 14 - 18 May 1993

Dissolved Oxygen (% saturation) against time

2 Layer model (8 September 1993) —— Exist. 25m

Observed symbols: * Upper layer, △ Lower layer

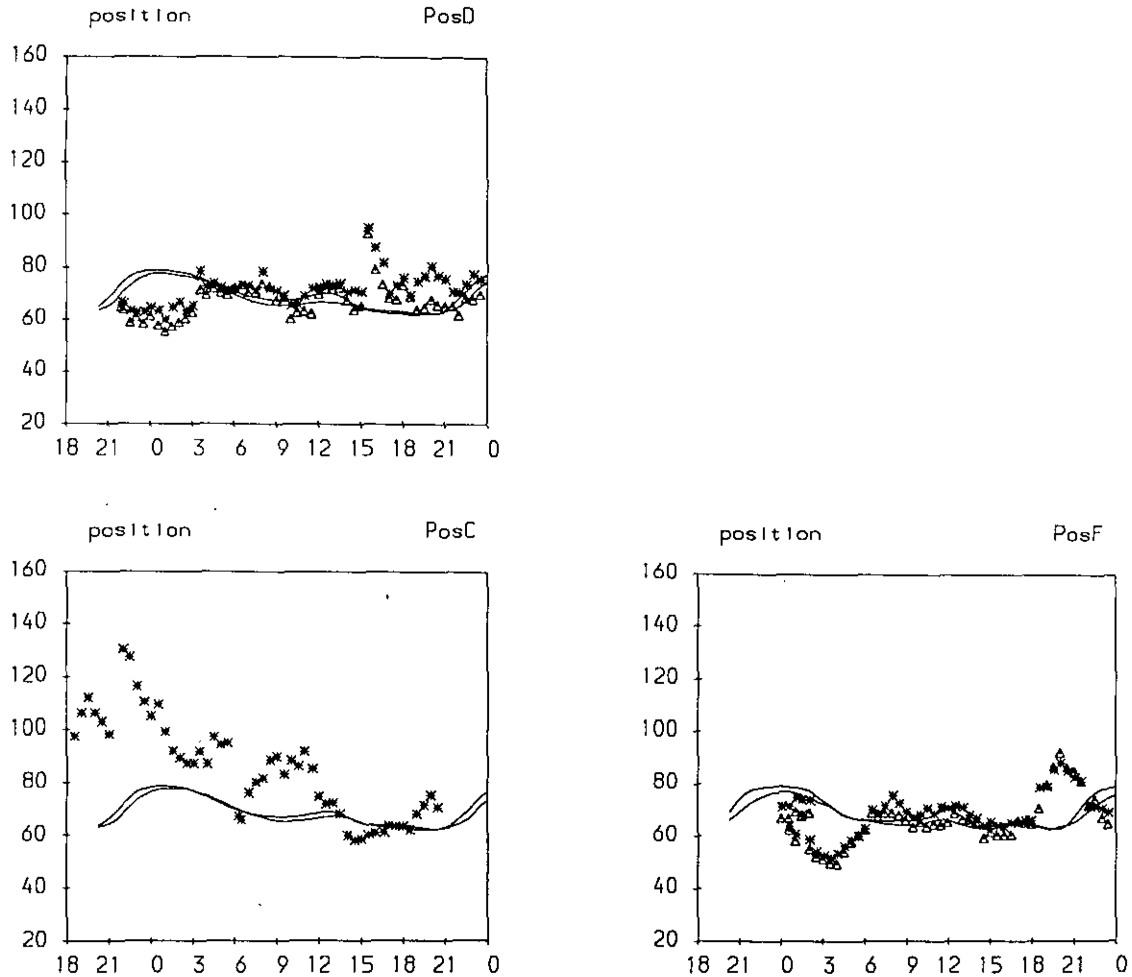

Figure 4.4.2a Wet Season Neap Tide - Existing (Validation): Dissolved Oxygen

Wet season Neap tide, 14 - 18 May 1993

Salinity (g/kg) against time

2 Layer model (8 September 1993) —— Exist. 25m

Observed symbols: * Upper layer, △ Lower layer

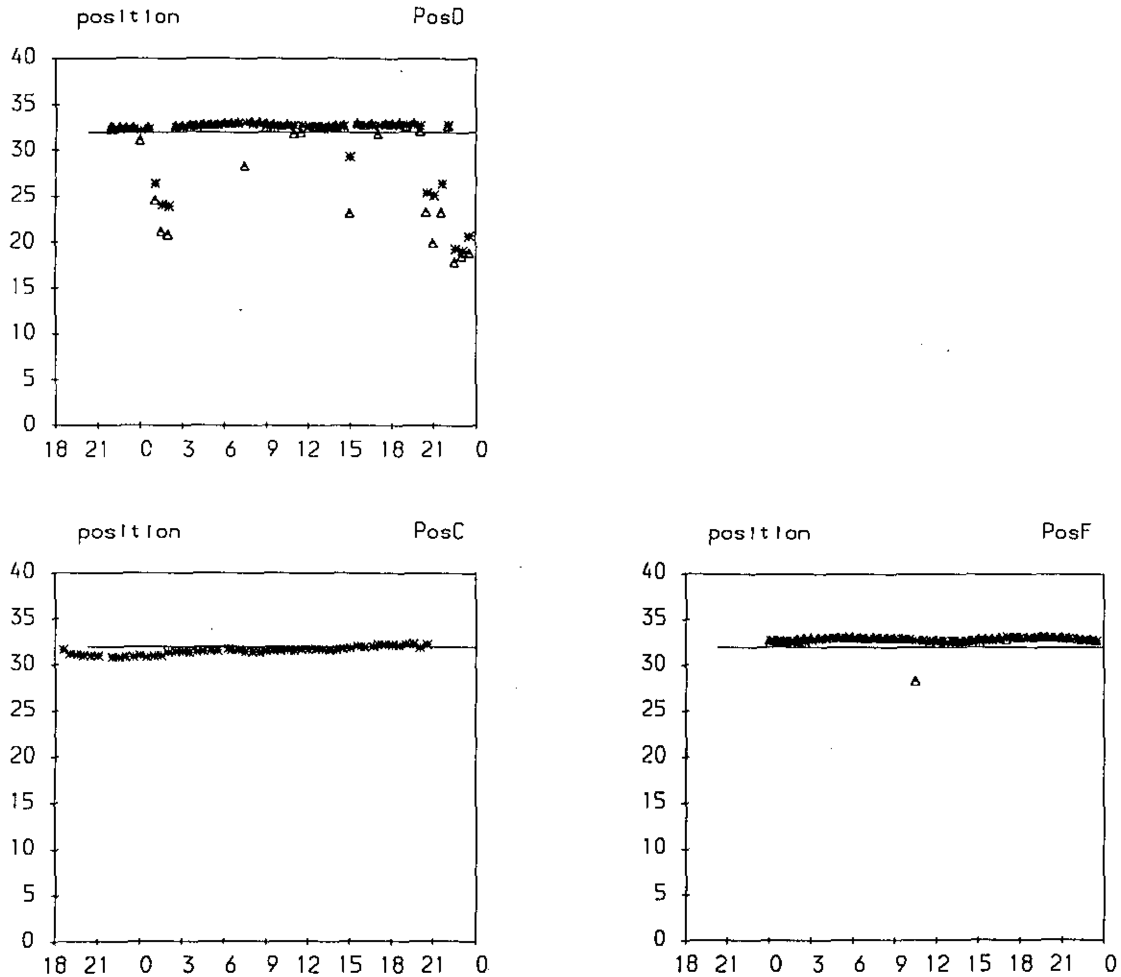

Figure 4.4.2b Wet Season Neap Tide - Existing (Validation): Salinity

Wet season Neap tide, 14 - 18 May 1993

Temperature (degrees C) against time

2 Layer model (8 September 1993) —— Exist. 25m

Observed symbols: * Upper layer, △ Lower layer

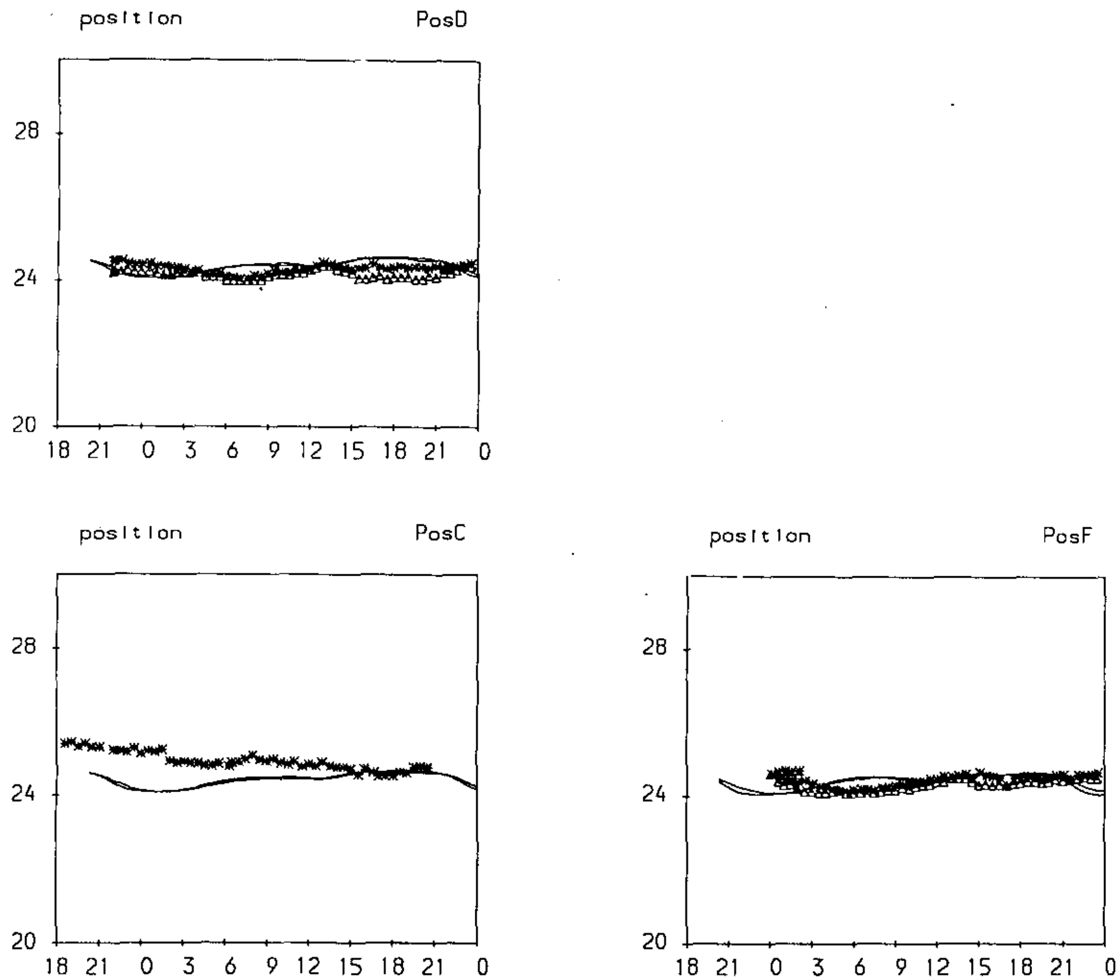

Figure 4.4.2c Wet Season Neap Tide - Existing (Validation): Temperature

Wet season Neap tide, 14 - 18 May 1993

BOD (mg/l) against time

2 Layer model (8 September 1993) —— Exist. 25m

Observed symbols: * Upper layer, △ Lower layer

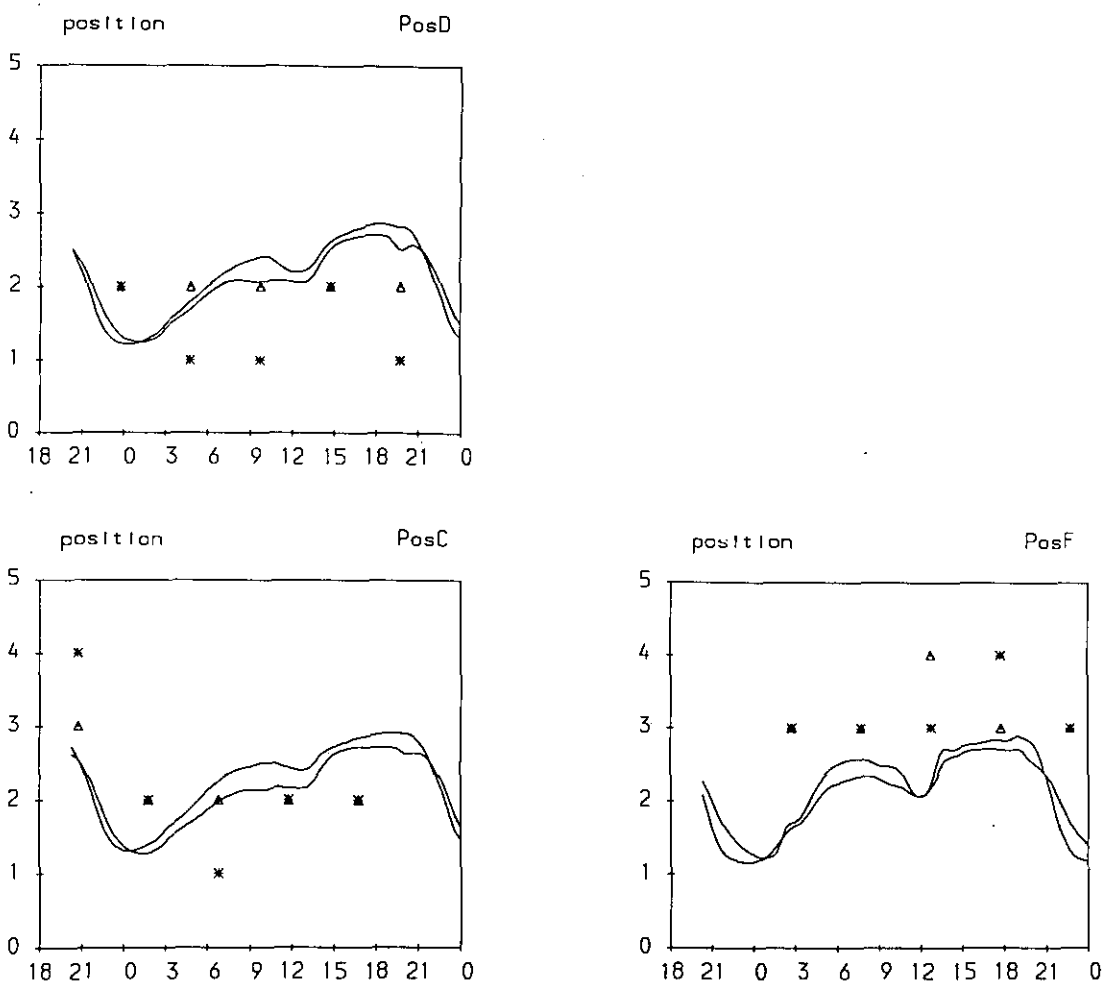

Figure 4.4.2d Wet Season Neap Tide - Existing (Validation): BOD

Wet season Neap tide, 14 - 18 May 1993

Ammoniacal Nitrogen (mg N/l) against time

2 Layer model (8 September 1993) —— Exist. 25m

Observed symbols: * Upper layer, Δ Lower layer

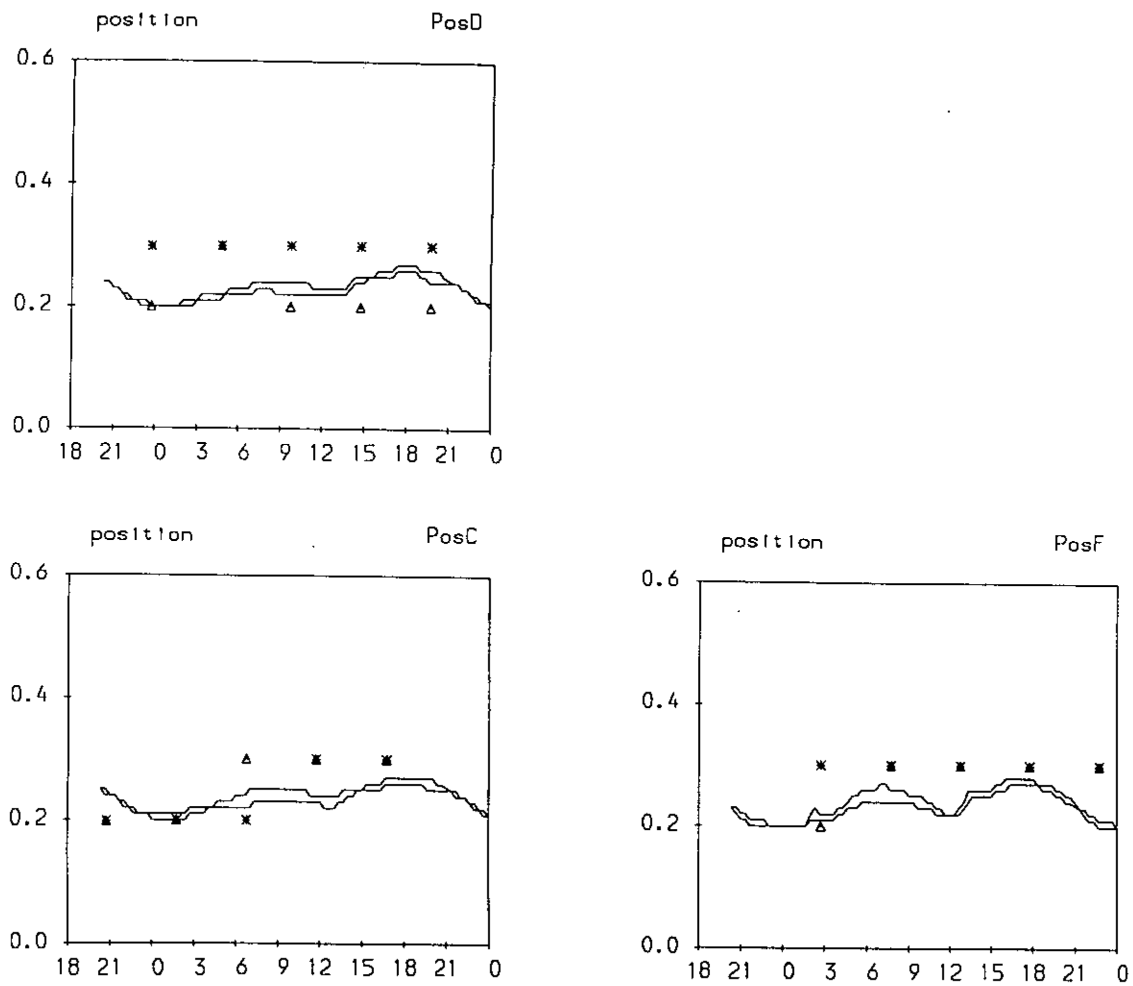

Figure 4.4.2e Wet Season Neap Tide - Existing (Validation): Ammoniacal Nitrogen

Wet season Neap tide, 14 - 18 May 1993

Oxidised Nitrogen (mg N/l) against time

2 Layer model (8 September 1993) —— Exist. 25m

Observed symbols: * Upper layer, △ Lower layer

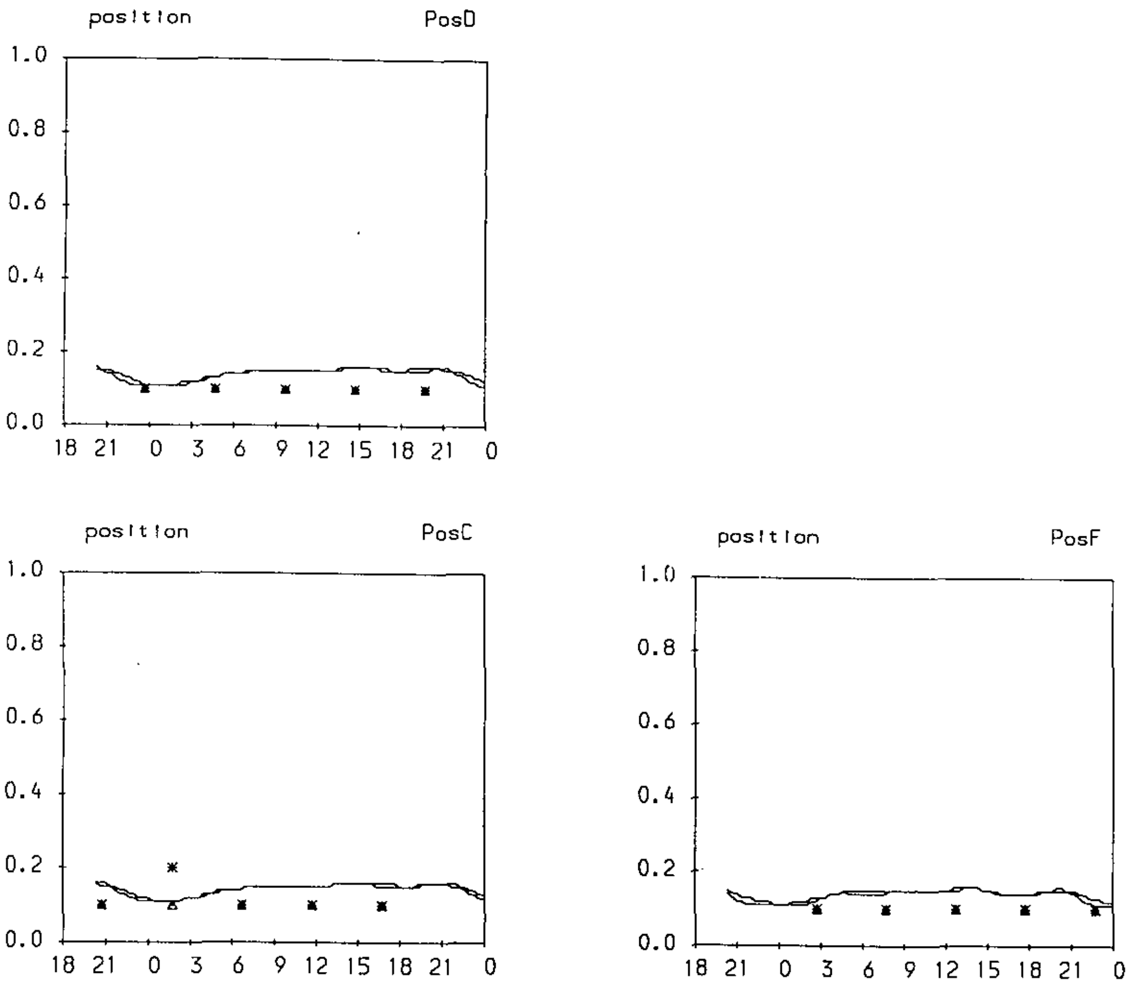

Figure 4.4.2f Wet Season Neap Tide - Existing (Validation): Oxidised Nitrogen

Wet season Neap tide, 14 - 18 May 1993

Organic Nitrogen (mg N/l) against time

2 Layer model (8 September 1993) —— Exist. 25m

Observed symbols: * Upper layer, △ Lower layer

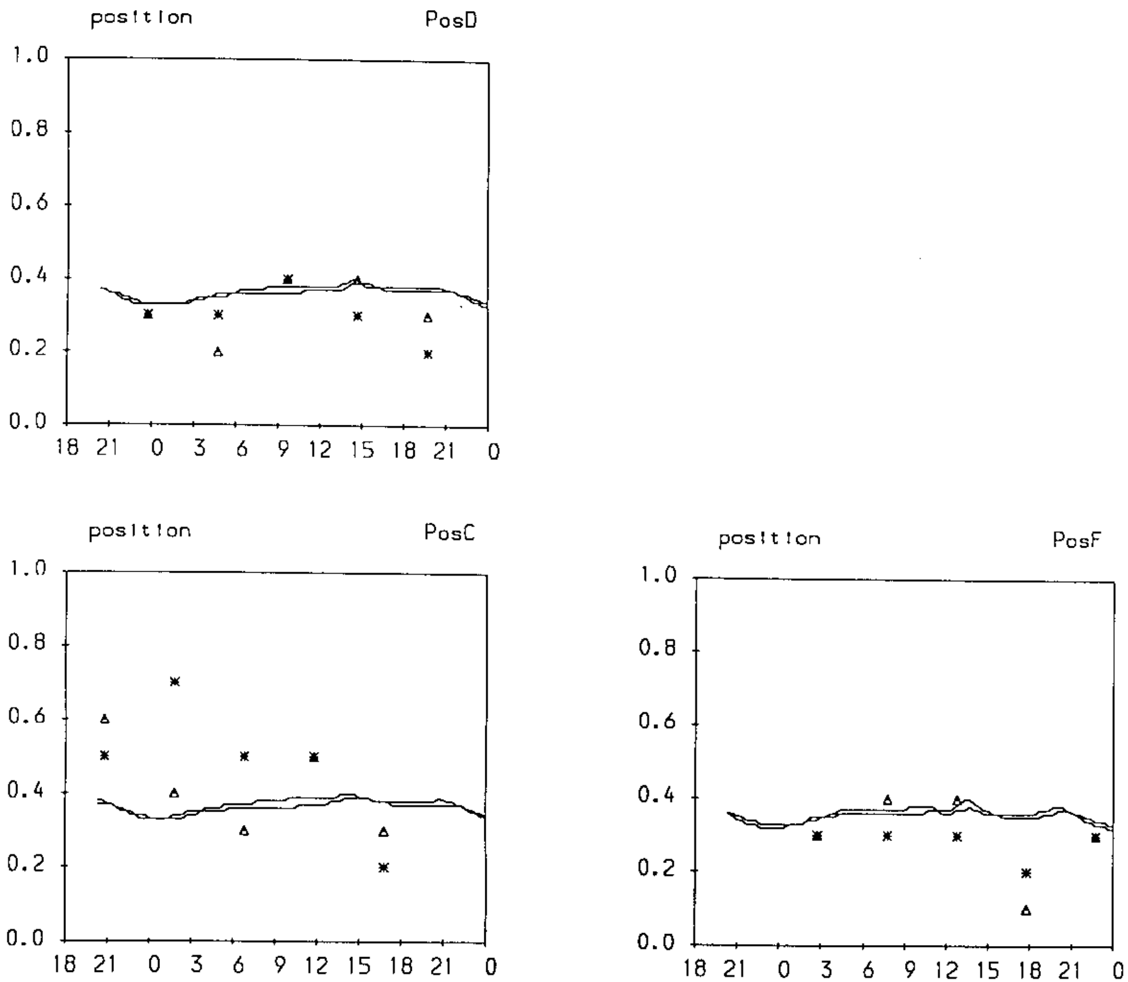

Figure 4.4.2g Wet Season Neap Tide - Existing (Validation): Organic Nitrogen

Wet season Neap tide, 14 - 18 May 1993

Chlorophyll (ug/l) against time

2 Layer model (8 September 1993) —— Exist. 25m

Observed symbols: * Upper layer, △ Lower layer

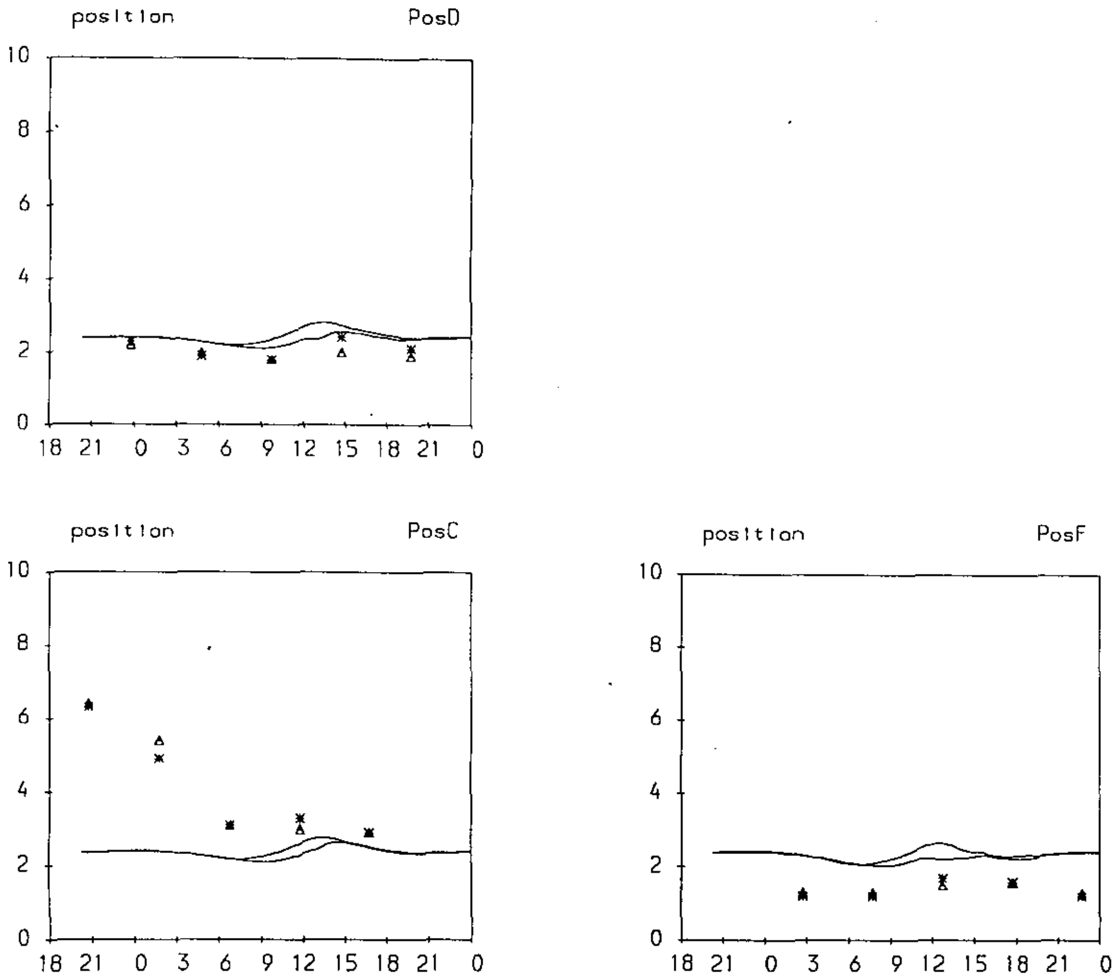

Figure 4.4.2h Wet Season Neap Tide - Existing (Validation): Chlorophyll

Wet season Neap tide, 14 - 18 May 1993

Suspended Solids (mg/l) against time

2 Layer model (8 September 1993) —— Exist. 25m

Observed symbols: * Upper layer, △ Lower layer

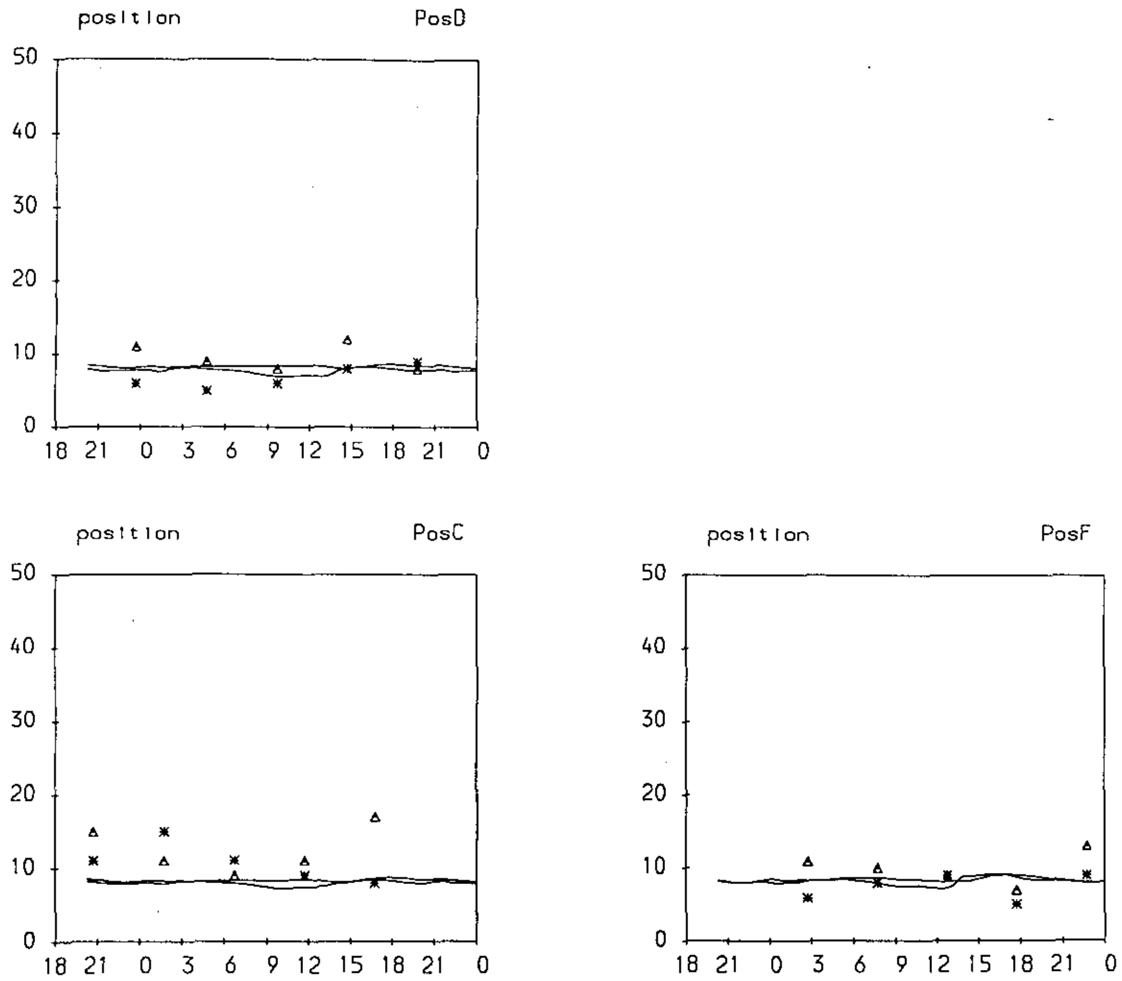

Figure 4.4.2i Wet Season Neap Tide - Existing (Validation): Suspended Solids

Wet season Neap tide, 14 - 18 May 1993

E.Coli (no/100ml) against time (log to base 10 on y-axis)

2 Layer model (8 September 1993) —— Exist. 25m

Observed symbols: * Upper layer, ▵ Lower layer

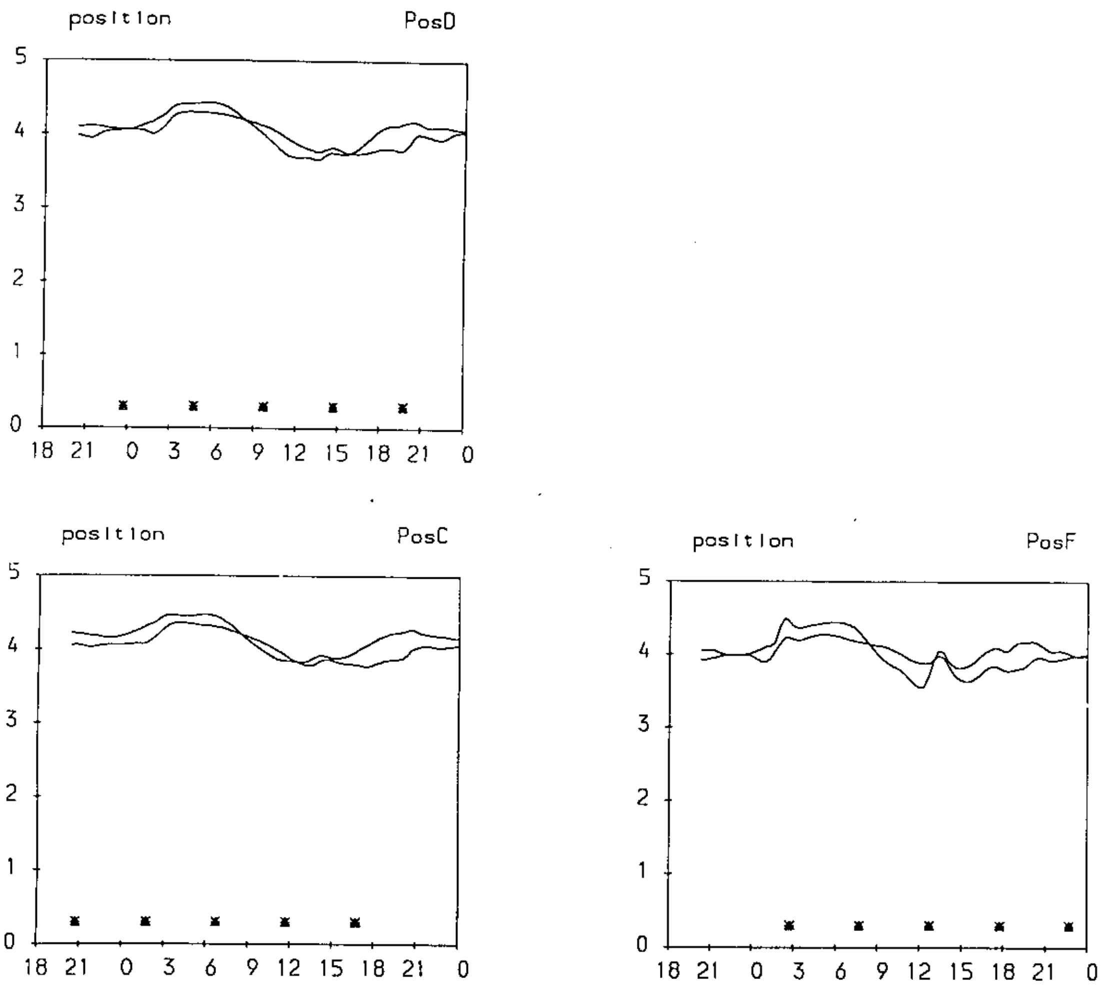

Figure 4.4.2j Wet Season Neap Tide - Existing (Validation): *E.coli*

Dry season Neap tide (25m grid)

Dissolved Oxygen (% saturation) against time

2 Layer model (11/9/93): —— Baseline ········ Scenario

Observed symbols: * Upper layer, ▵ Lower layer

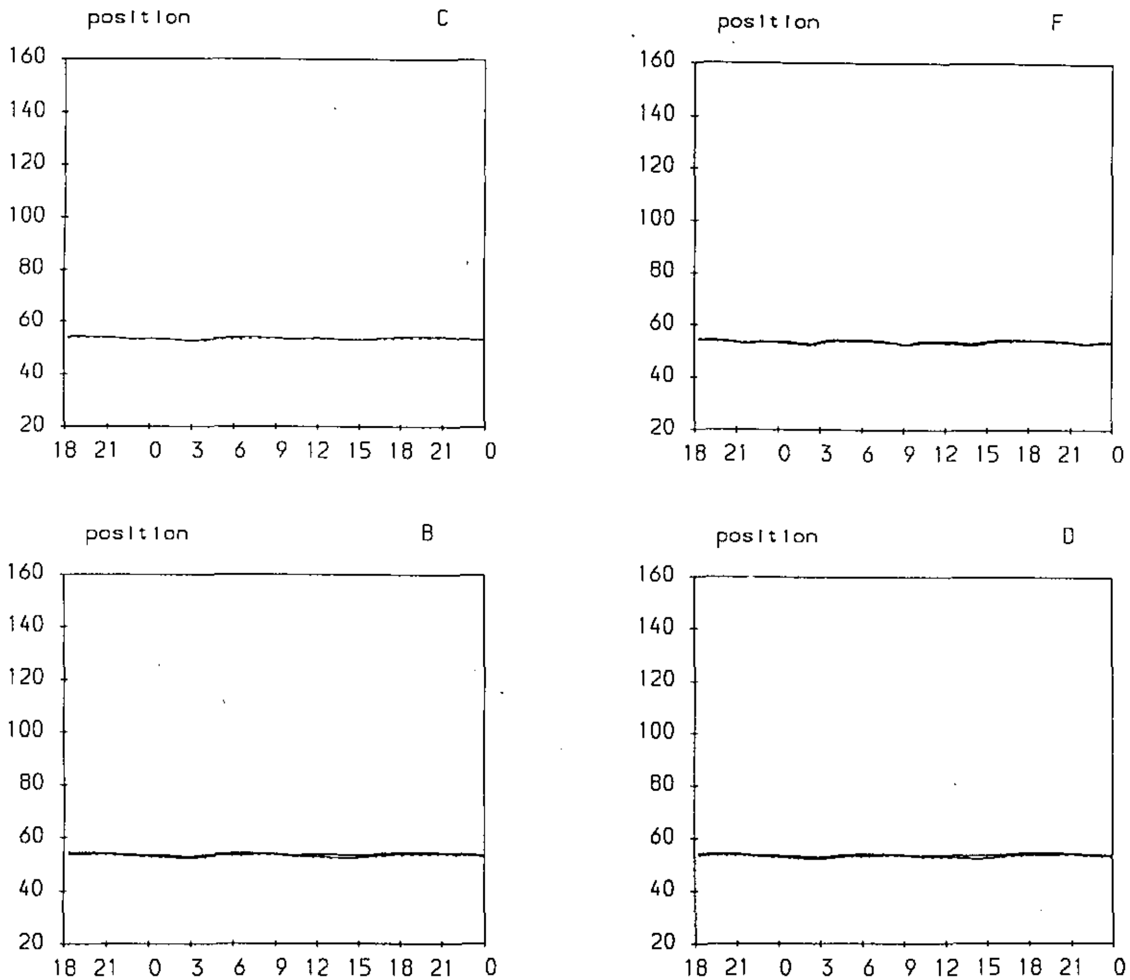

Figure 4.4.3a Dry Season Neap Tide - Baseline / Scenario 1: Dissolved Oxygen

Dry season Neap tide (25m grid)

BOD (mg/l) against time

2 Layer model (11/9/93): ——— Baseline ········ Scenario

Observed symbols: * Upper layer, △ Lower layer

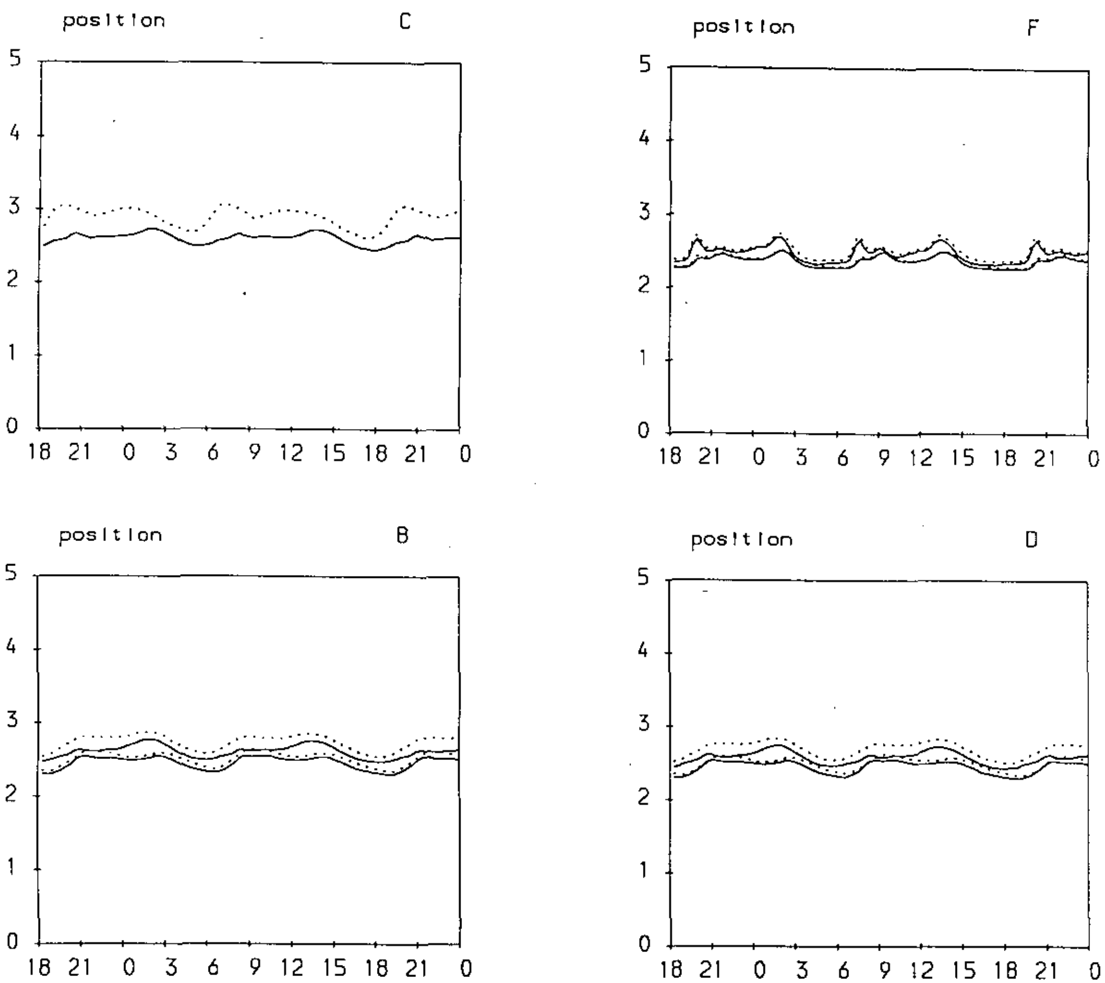

Figure 4.4.3b Dry Season Neap Tide - Baseline / Scenario 1: BOD

Dry season Neap tide (25m grid)

Ammoniacal Nitrogen (mg N/l) against time

2 Layer model (11/9/93) : —— Baseline ········ Scenario

Observed symbols: * Upper layer, ▵ Lower layer

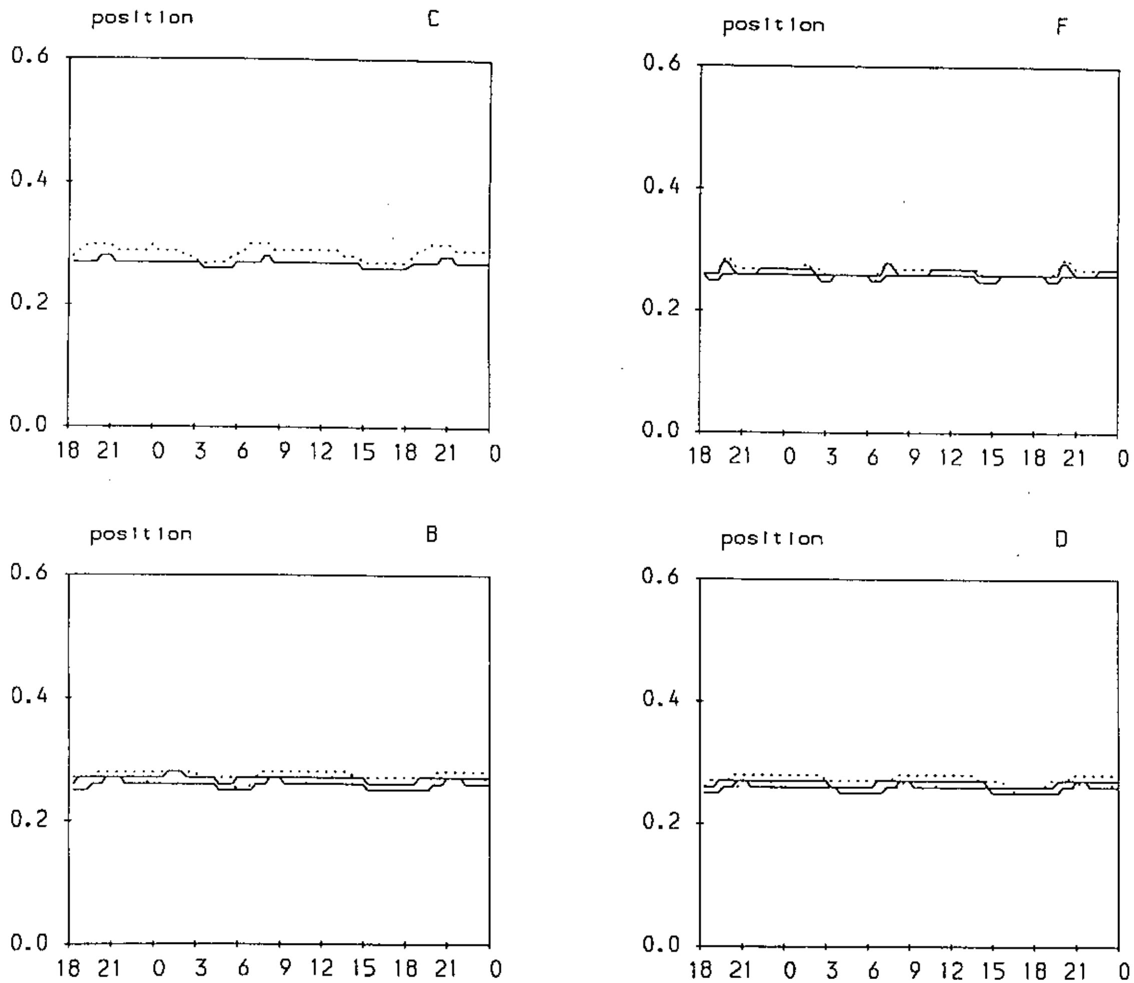

Figure 4.4.3c Dry Season Neap Tide - Baseline / Scenario 1: Ammoniacal Nitrogen

Dry season Neap tide (25m grid)

E.Coli (no/100ml) against time (log to base 10 on y-axis)

2 Layer model (11/9/93): —— Baseline ········ Scenario

Observed symbols: * Upper layer, ▵ Lower layer

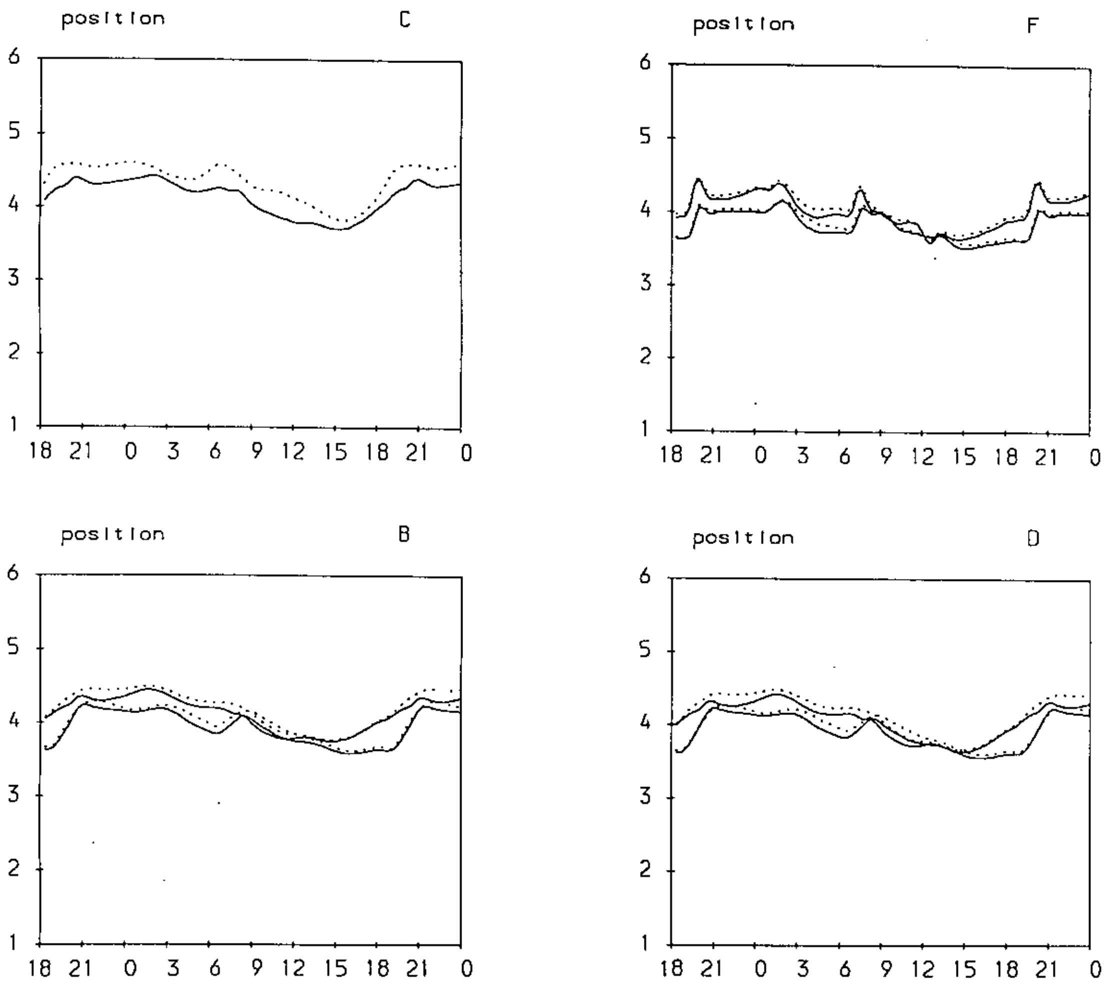

Figure 4.4.3d Dry Season Neap Tide - Baseline / Scenario 1: *E. coli*

Wet season Neap tide, 14 - 18 May 1993 (25m grid)

Dissolved Oxygen (% saturation) against time

2 Layer model (9/9/93): —— Baseline ········ Scenario

Observed symbols: * Upper layer, △ Lower layer

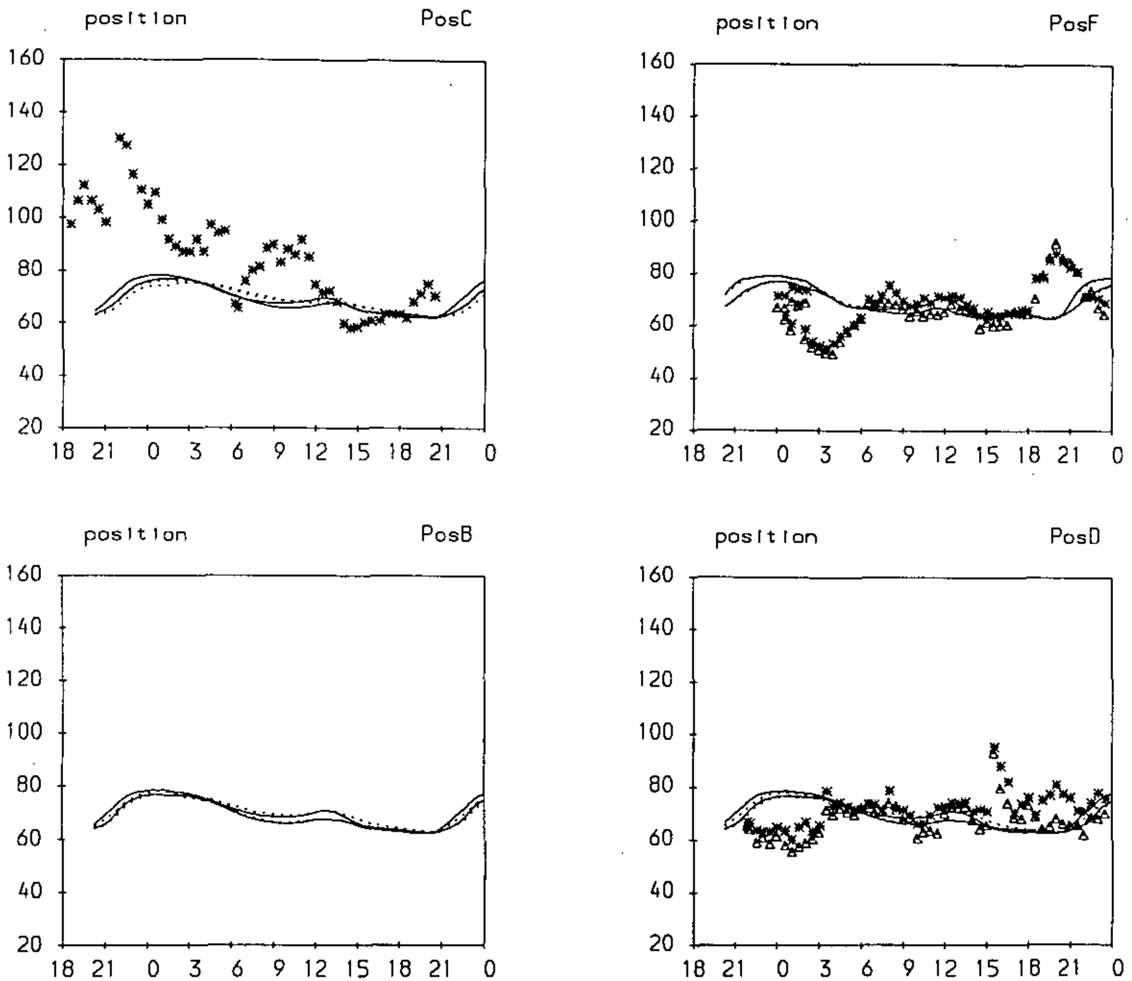

Figure 4.4.4a Wet Season Neap Tide - Baseline / Scenario: Dissolved Oxygen

Wet season Neap tide, 14 - 18 May 1993 (25m grid)

BOD (mg/l) against time

2 Layer model (9/9/93): ——— Baseline ········ Scenario

Observed symbols: * Upper layer, ▵ Lower layer

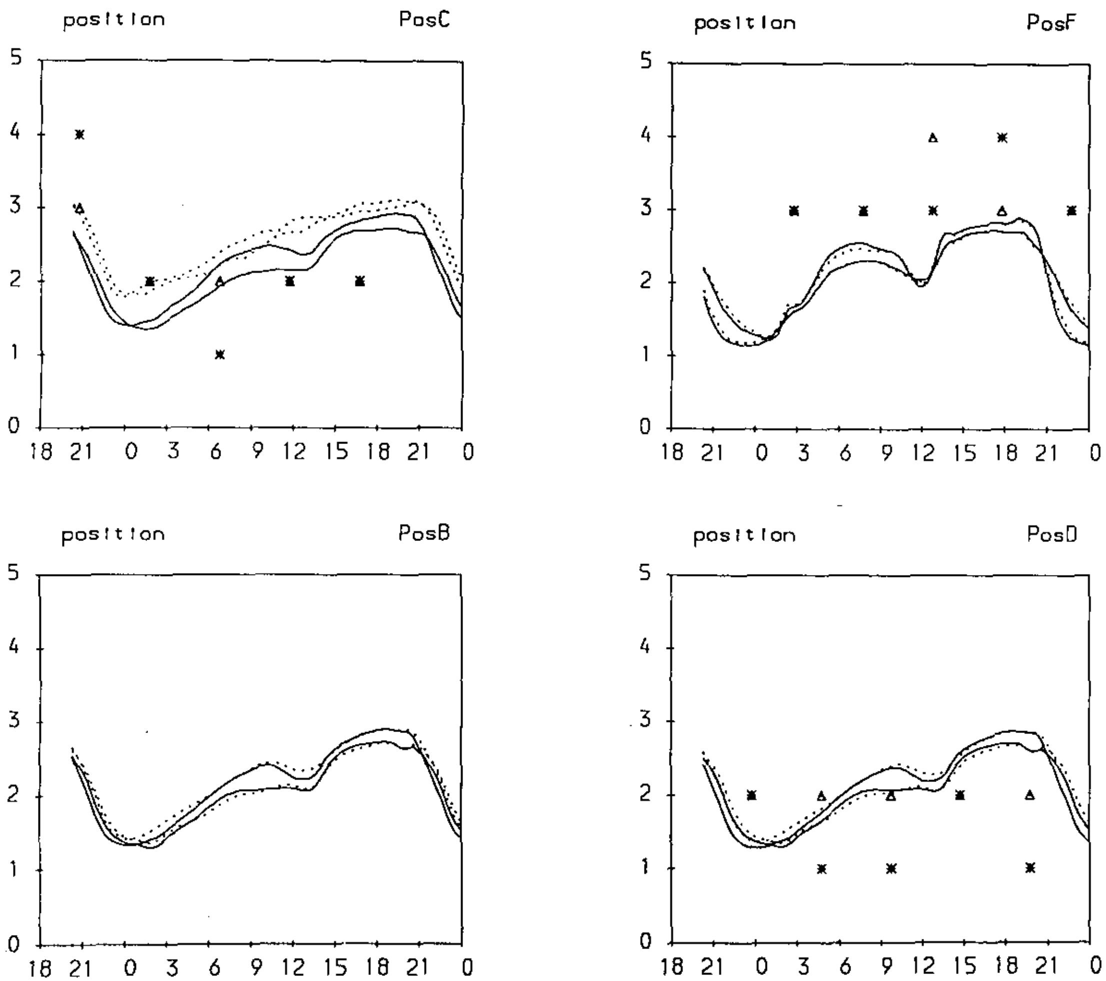

Figure 4.4.4b Wet Season Neap Tide - Baseline / Scenario: BOD

Wet season Neap tide, 14 - 18 May 1993 (25m grid)

Ammoniacal Nitrogen (mg N/l) against time

2 Layer model (9/9/93): —— Baseline ········ Scenario

Observed symbols: * Upper layer, Δ Lower layer

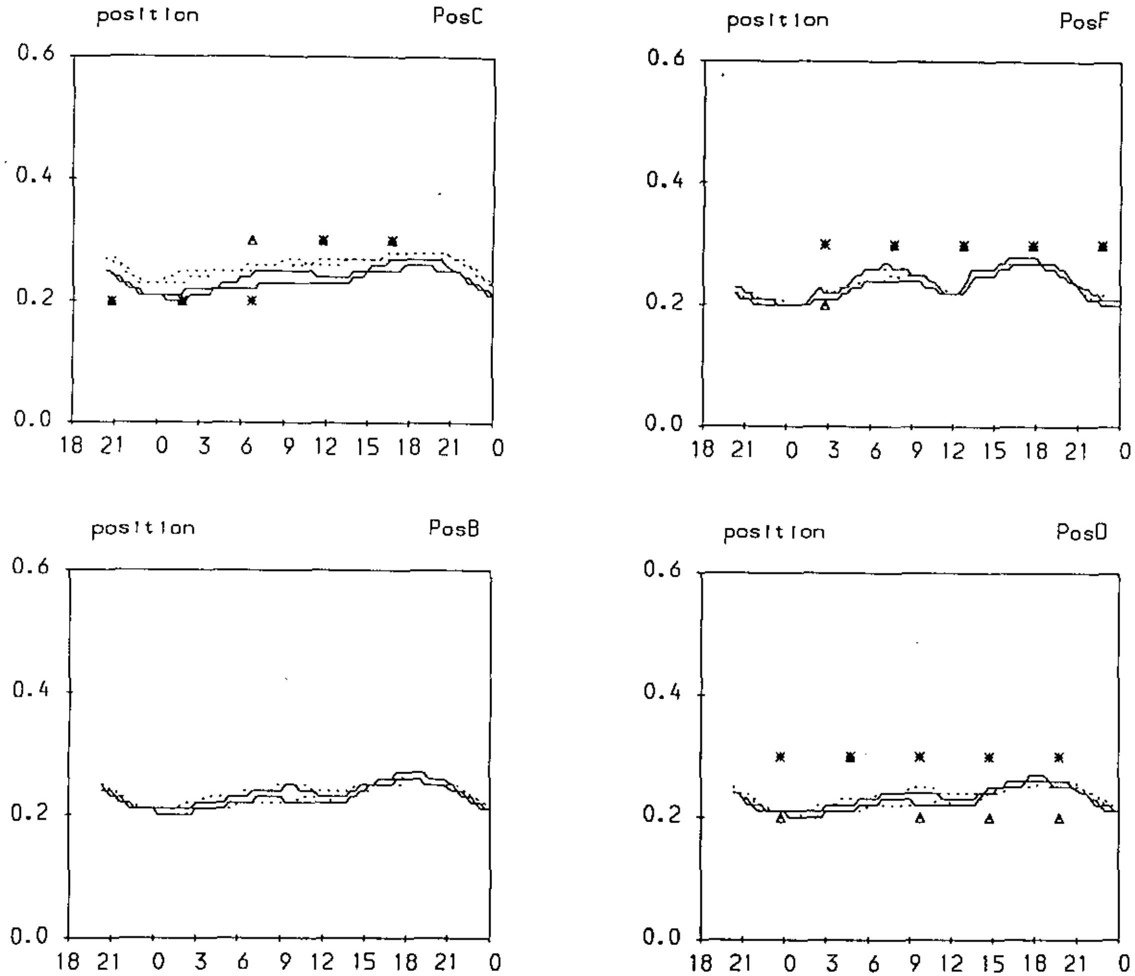

Figure 4.4.4c Wet Season Neap Tide - Baseline / Scenario: Ammoniacal Nitrogen

Wet season Neap tide, 14 - 18 May 1993 (25m grid)

E.Coli (no/100ml) against time (log to base 10 on y-axis)

2 Layer model (9/9/93): —— Baseline .... Scenario

Observed symbols: * Upper layer, ▵ Lower layer

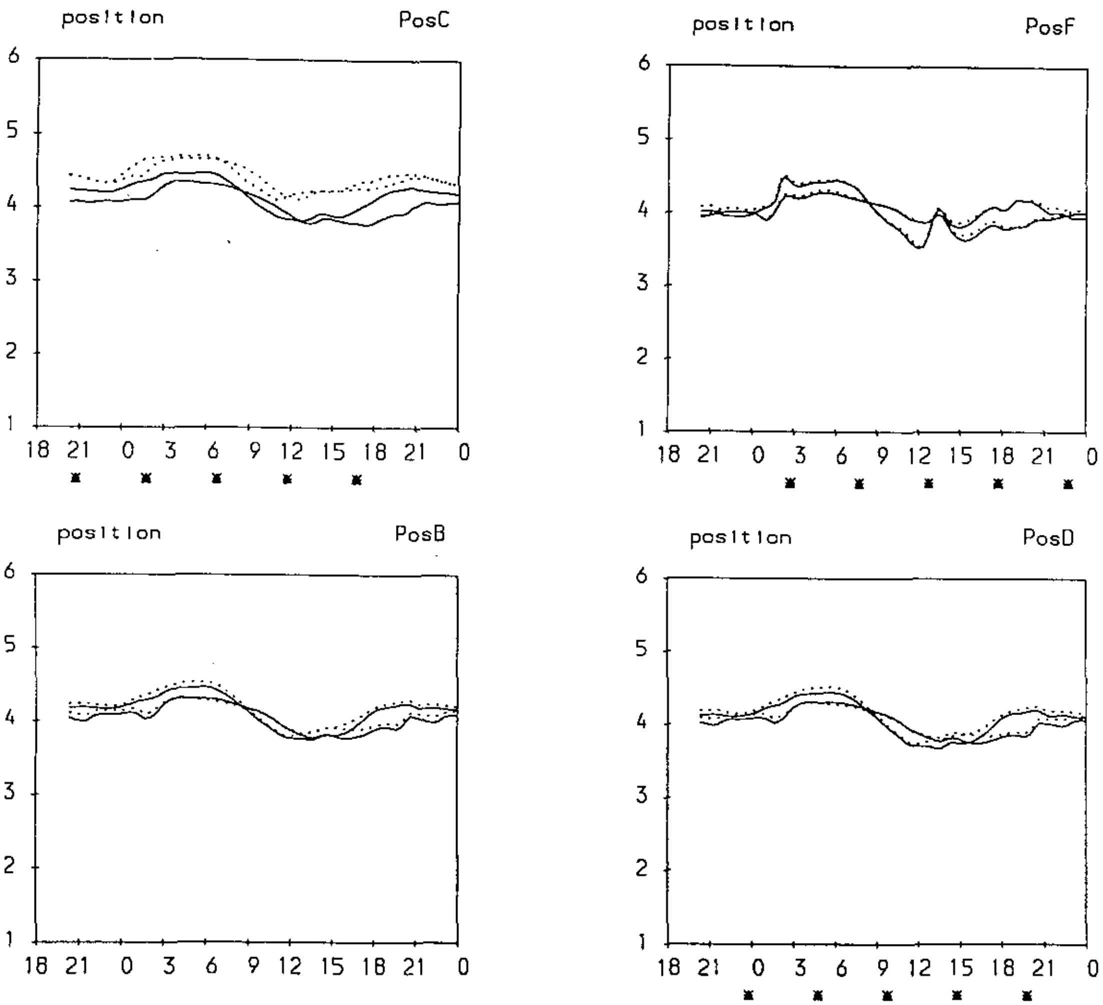

Figure 4.4.4d Wet Season Neap Tide - Baseline / Scenario: *E. coli*

Wet season Neap tide, 14 - 18 May 1993 (25m grid)

Dissolved Oxygen (% saturation) against time

2 Layer model (10/9/93): —— Baseline .... Sc Mitgn 1

Observed symbols: * Upper layer, ▵ Lower layer

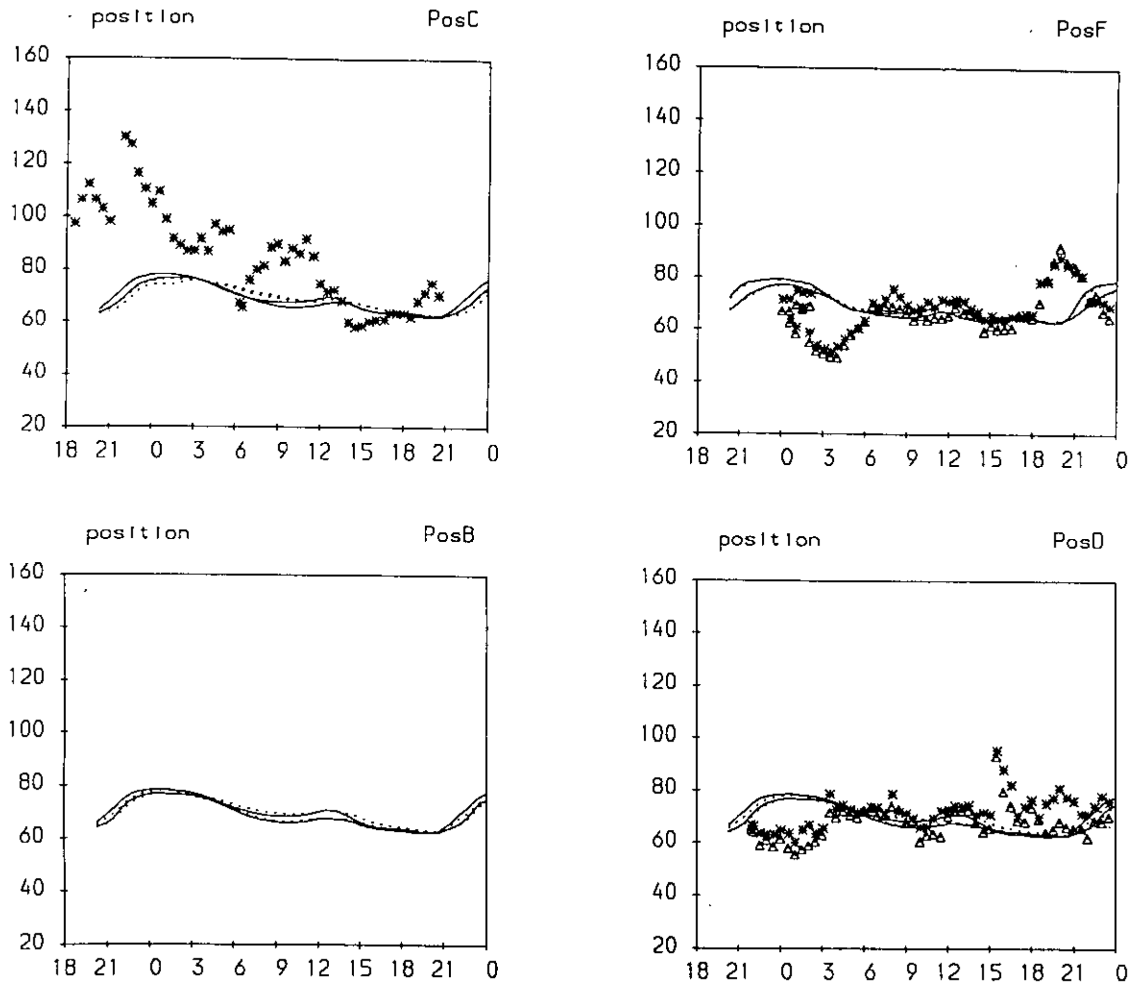

Figure 4.4.5a Wet Season Neap Tide - Baseline / Scenario 2 (1st Mitigation level): Dissolved Oxygen

Wet season Neap tide, 14 - 18 May 1993 (25m grid)

BOD (mg/l) against time

2 Layer model (10/9/93): —— Baseline ········ Sc Mitgn 1

Observed symbols: * Upper layer, Δ Lower layer

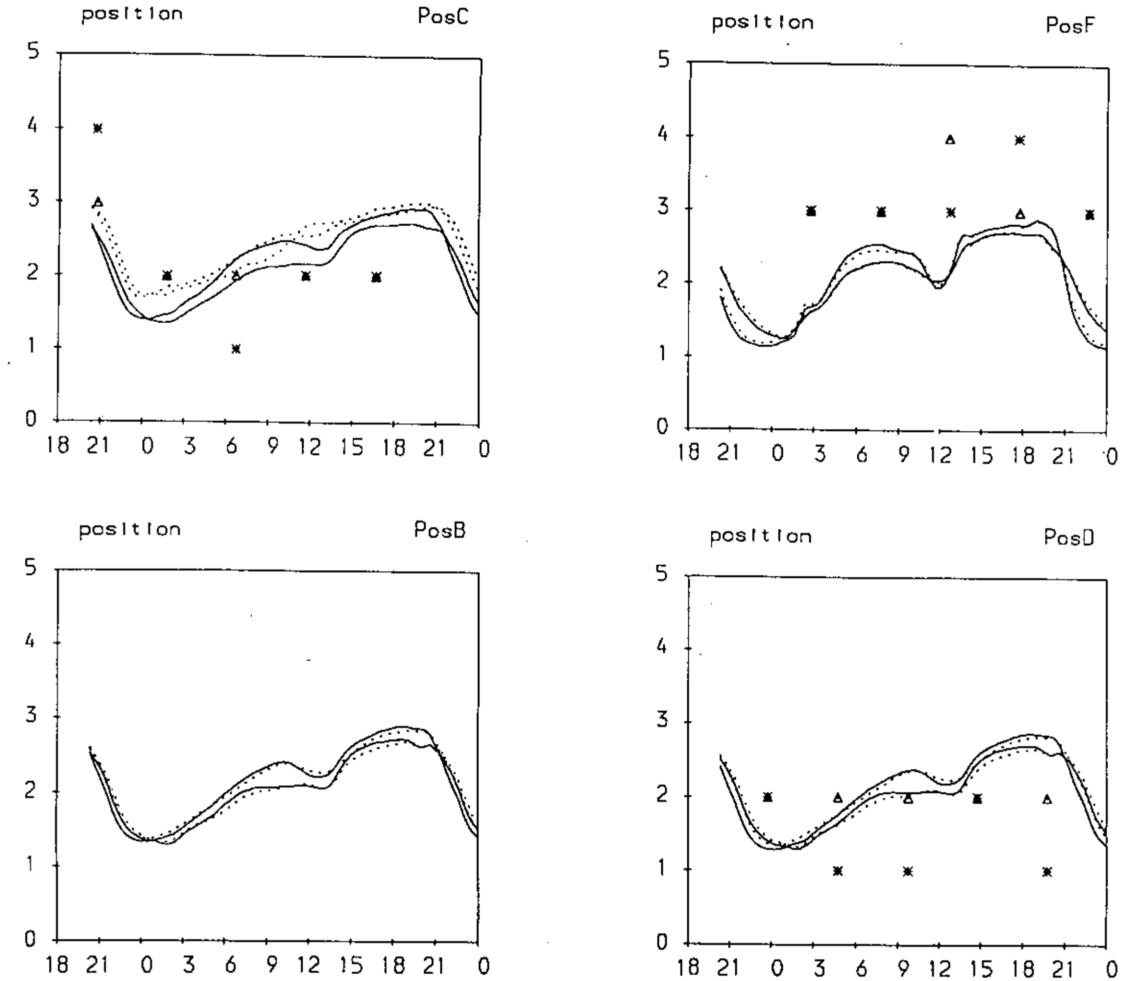

Figure 4.4.5b Wet Season Neap Tide - Baseline / Scenario 2 (1st Mitigation level): BOD

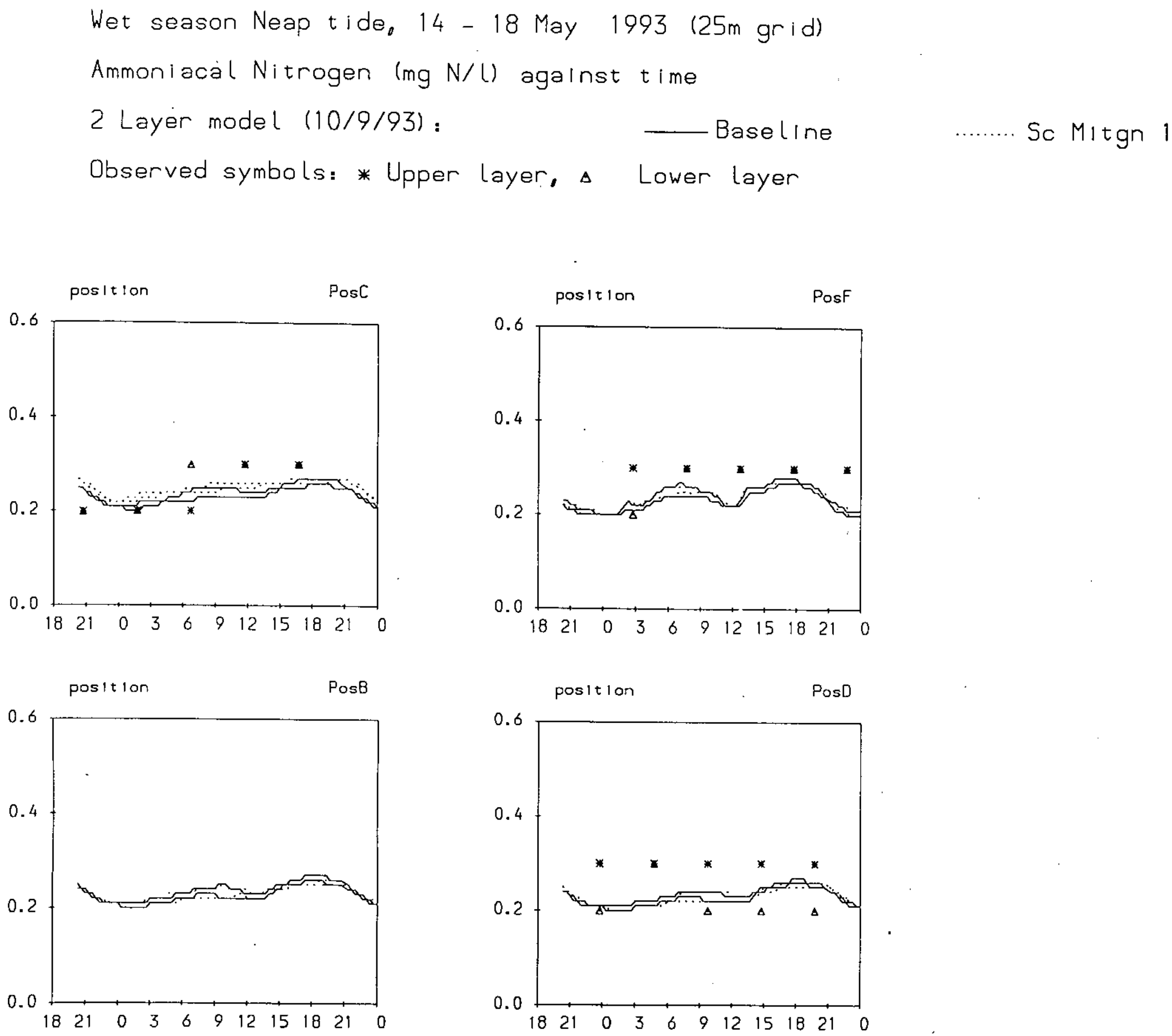

Figure 4.4.5c Wet Season Neap Tide - Baseline / Scenario 2 (1st Mitigation level): Ammoniacal Nitrogen

Wet season Neap tide, 14 - 18 May 1993 (25m grid)

E.Coli (no/100ml) against time (log to base 10 on y-axis)

2 Layer model (10/9/93): —— Baseline .... Sc Mitgn 1

Observed symbols: * Upper layer, ∆ Lower layer

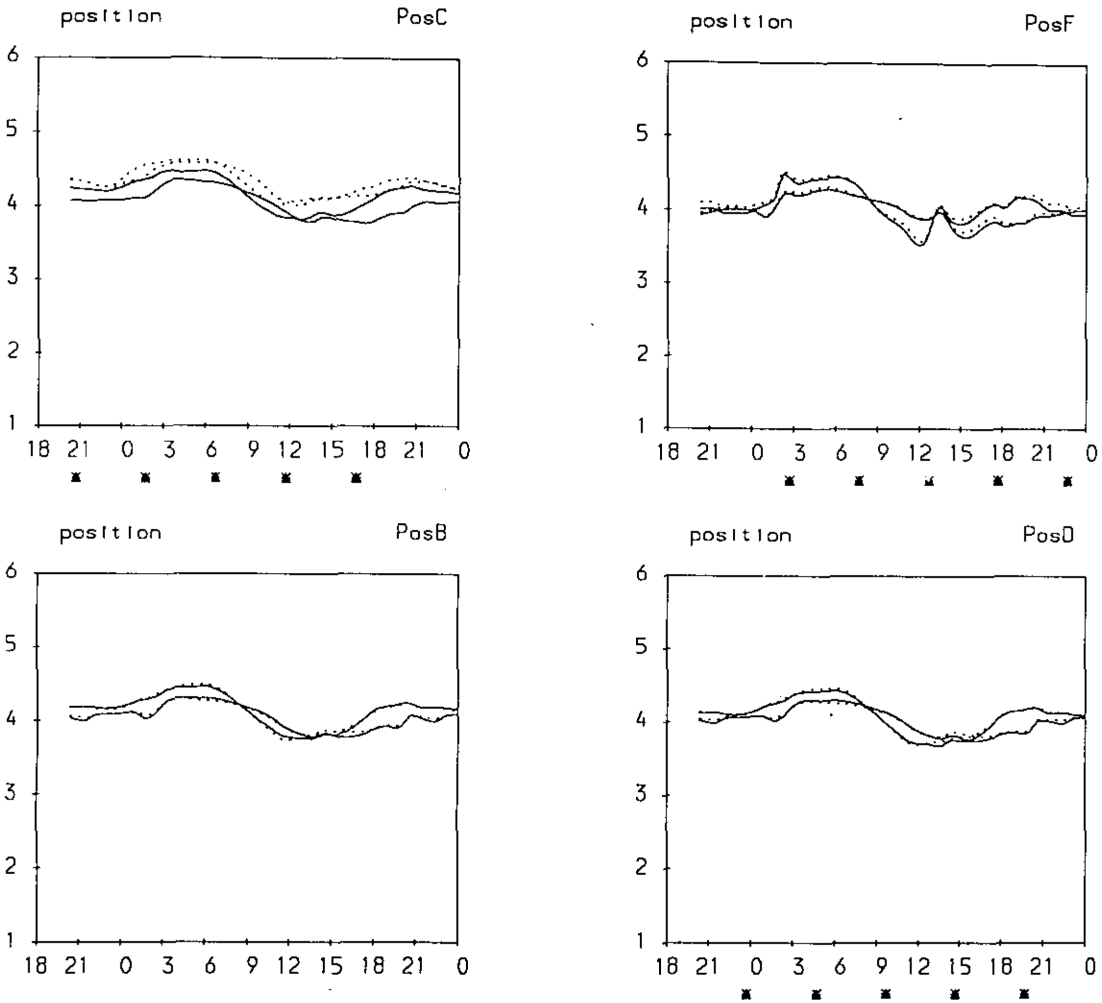

Figure 4.4.5d Wet Season Neap Tide - Baseline / Scenario 2 (1st Mitigation level):
E. coli

Wet season Neap tide, 14 - 18 May 1993 (25m grid)

Dissolved Oxygen (% saturation) against time

2 Layer model (9/9/93): —— Baseline ········ Sc Mitgn 2B

Observed symbols: * Upper layer, ∆ Lower layer

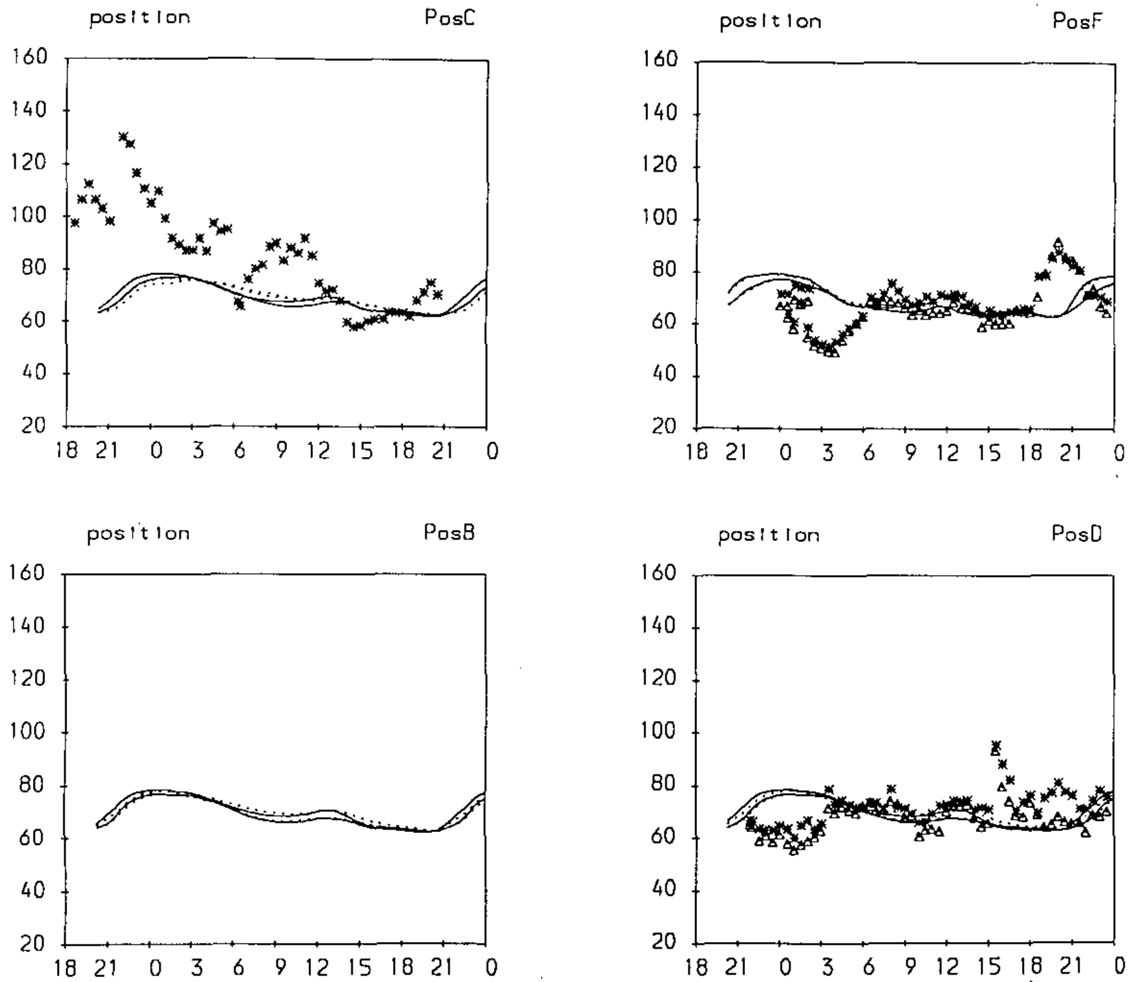

Figure 4.4.6a Wet Season Neap Tide - Baseline / Scenario 3 (2nd Mitigation level "B"): Dissolved Oxygen

Wet season Neap tide, 14 - 18 May 1993 (25m grid)

BOD (mg/l) against time

2 Layer model (9/9/93): ——— Baseline ········ Sc Mitgn 2B

Observed symbols: * Upper layer, △ Lower layer

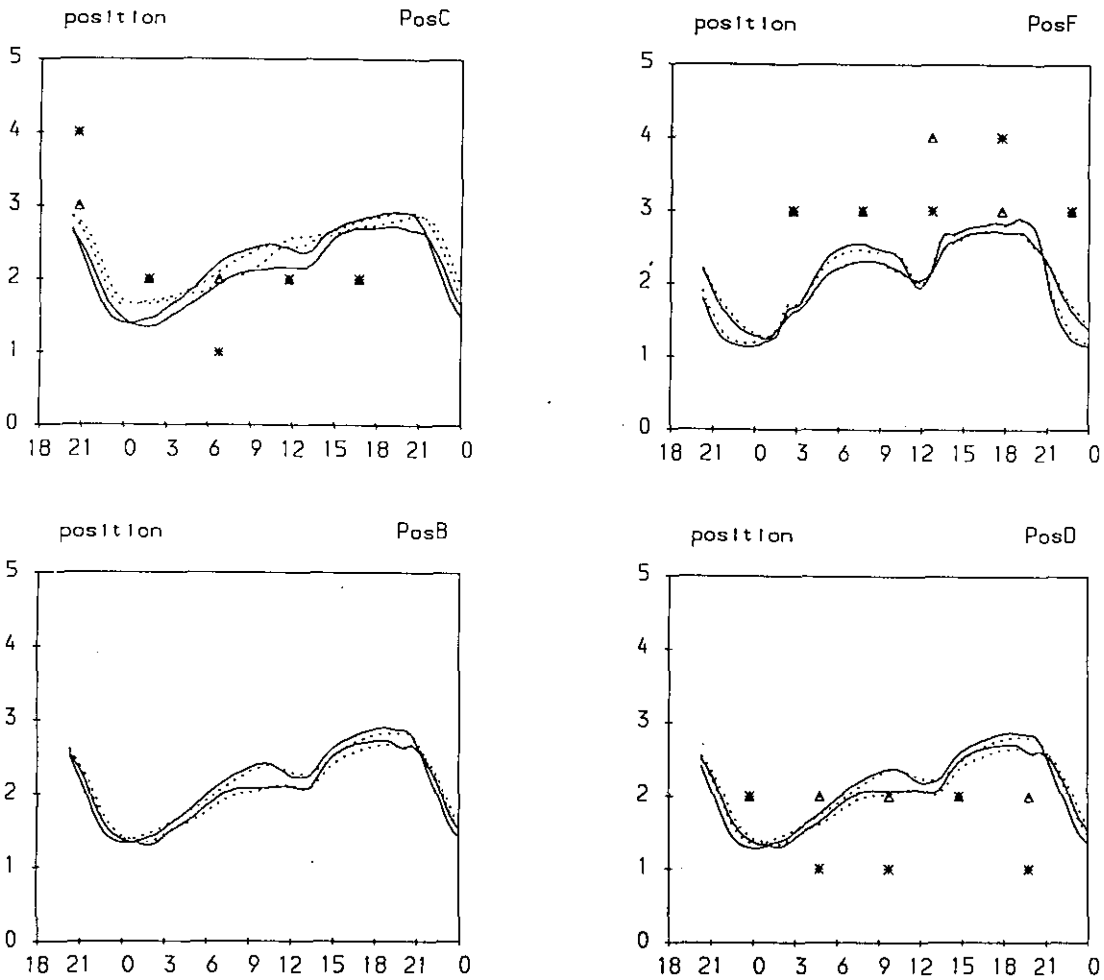

Figure 4.4.6b Wet Season Neap Tide - Baseline / Scenario 3 (2nd Mitigation level "B"): BOD

Wet season Neap tide, 14 - 18 May 1993 (25m grid)

Ammoniacal Nitrogen (mg N/l) against time

2 Layer model (9/9/93): —— Baseline ········ Sc Mitgn 2B

Observed symbols: * Upper layer, △ Lower layer

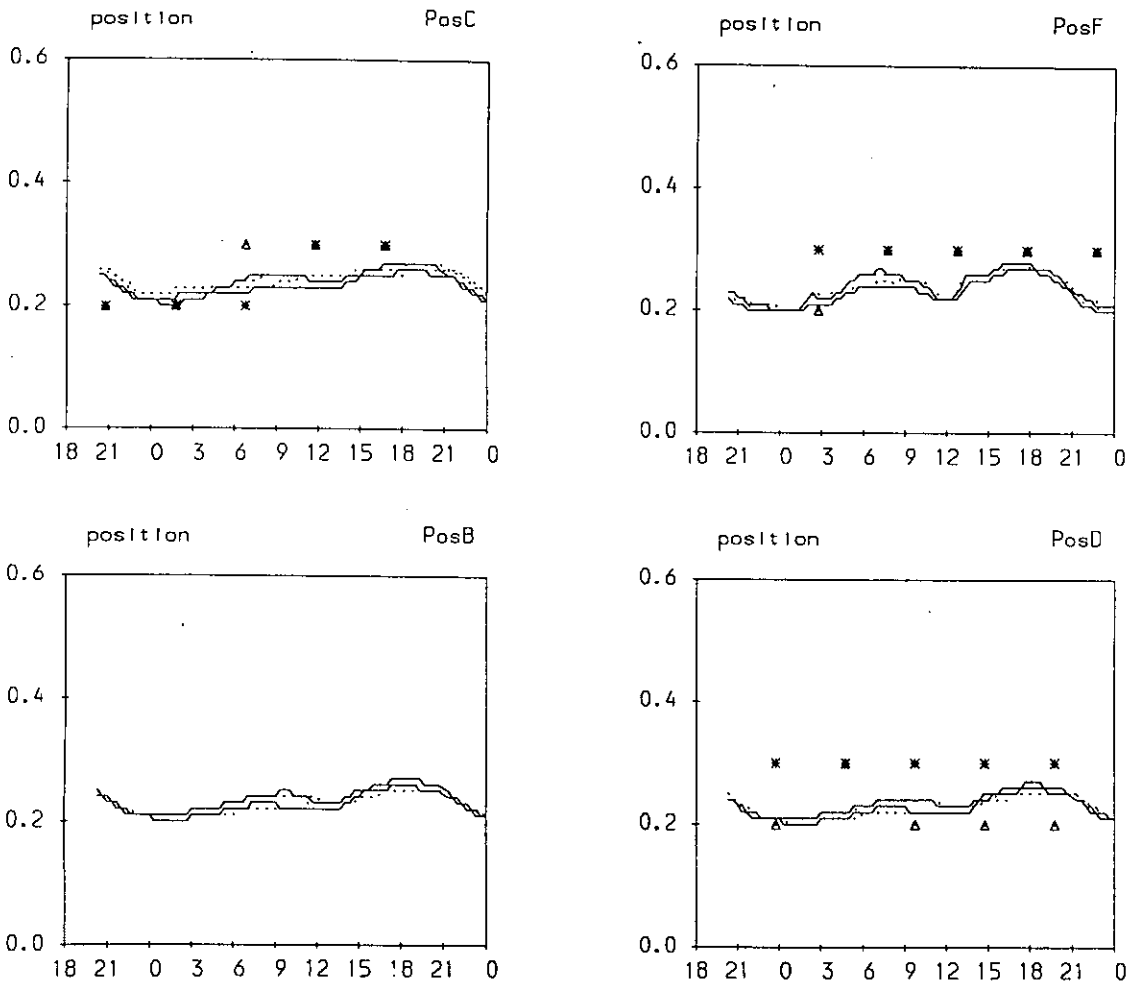

Figure 4.4.6c Wet Season Neap Tide - Baseline / Scenario 3 (2nd Mitigation level "B"): Ammoniacal Nitrogen

Wet season Neap tide, 14 - 18 May 1993 (25m grid)

E.Coli (no/100ml) against time (log to base 10 on y-axis)

2 Layer model (9/9/93): —— Baseline ········ Sc Mitgn 2B

Observed symbols: ⁎ Upper layer, ▵ Lower layer

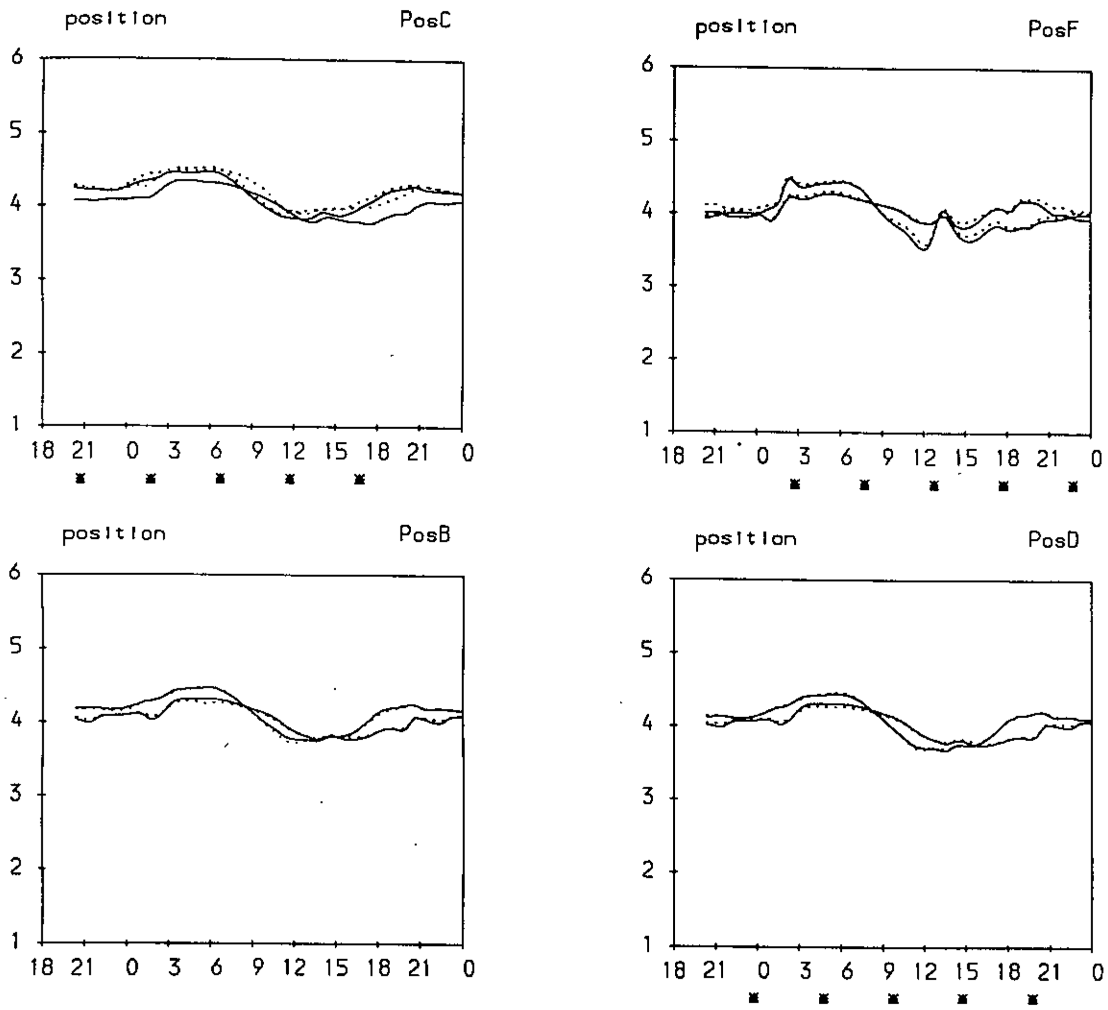

Figure 4.4.6d Wet Season Neap Tide - Baseline / Scenario 3 (2nd Mitigation level "B"): *E.coli*

5. Marine Mud Disposal

5 Marine Mud Disposal

5.1 Introduction

The construction of the extension to HKCEC necessitates dredging of marine sediment from the seabed for foundation piling and bedding purposes. Previous routine studies by the Environmental Protection Department (EPD) show that the marine sediments in Wanchai are contaminated with high levels of the priority heavy metals.[1] These EPD studies, however, have not investigated the vertical extent of contamination in the study area. It was considered necessary to carry out a marine ground investigation of the Study area so that the likely volumes of contaminated mud to be taken off site could be estimated and their disposal capacity allocated. A separate report has been produced on this issue. This Chapter summarises that report. Where full details of the investigation carried out and the conclusions are required, the unabridged report should be referred to.

5.2 Statutory Requirements and Guidelines

The procedures to be adopted in the dredging and disposal of marine sediments are detailed in Works Branch Technical Circular No. 22/92, Marine Disposal of Dredged Mud. The Circular outlines the steps that must be followed when applying for licensed disposal of dredged marine materials at sea. The criteria for the classification of sediments and their contamination status are contained in the EPD Technical Circular No. (TC) No 1-1-92, Classification of Dredged Sediments for Marine Disposal and are given in Table 5.1. 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.

The methods adopted and procedures undertaken for the purpose of assessing the contamination status of sediments in the study area, have been based on the above Guidelines/Technical Circulars.

Table 5.1 Classification of Sediments by Metal Content in Hong Kong ($mg.kg^{-1}$ dry wgt)

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

[1] 'Marine Water Quality in Hong Kong', Environmental Protection Department, Hong Kong, 1990

These three classes are categorised 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 minimises the loss of pollutants either into solution or by suspension.

* **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.

5.3 Methodology

5.3.1 Testing Locations

A total of six vibrocoring locations were chosen for assessing the marine sediment quality in the study area. They are shown on the Drawing "Site Investigation Plan" (Drawing No.96193/001), which is reproduced in Figure 5.1. Site investigation was carried out on 29 June to 3 July 1993. All sampling points were within 5 m of the coordinates of the proposed stations.

5.3.2 Sediment Sampling

Vibrocoring was required to take undisturbed samples in the seabed. The vibrocore samples were 75 mm in diameter and 6 m in length. Vibrocores were sectioned longitudinally on the barge and the samples of sediment were taken from the surface, 1 m, 2 m, 3 m, 4 m and 6 m down the length of the cores (Table 5.2):

Table 5.2 Cut Sections for Samples Representing Various Seabed Depths

Depth (m)	VC4 (m)	VC1-VC3, VC5-VC6 (m)
	Sections (m)	
surface	0-0.1	0-0.3
1	0.9-1	0.9-1.2
2	1.9-2	1.9-2.2
3	2.9-3	2.9-3.2
4	-	3.9-4.2
6	5.9-6	5.9-6.2

5.3.3 Sediment Analysis

Chemical Analysis

In Hong Kong, heavy metal testing is used for classification of sediment so that the volumes of contaminated sediment can be subsequently calculated. Therefore, chemical tests were carried out on each sediment sample.

Chemical analysis of samples was undertaken in accordance with the methods outlined in APHA 17th Ed. methods 3111 and 3112b, and were based on acid digestion followed by flame atomic absorption spectrophotometry (Flame-AAS) for the priority trace metals except mercury. In the case of Hg, the cold vapour generation method was adopted. The methods for chemical tests are shown in Table 5.3.

Table 5.3 Methods for Chemical Analysis

Parameter	Methodology	Reference	Detection Limit
Total Copper	Direct acid digestion followed by AAS	APHA 17th Ed. method 3111	0.1 $mg.kg^{-1}$
Total Cadmium	as above	as above	0.2 $mg.kg^{-1}$
Total Chromium	as above	as above	0.1 $mg.kg^{-1}$
Total Lead	as above	as above	0.1 $mg.kg^{-1}$
Total Nickel	as above	as above	0.1 $mg.kg^{-1}$
Total Zinc	as above	as above	2.0 $mg.kg^{-1}$
Total Mercury	Cold Vapour Generation	APHA 17th Ed. method 3112 b	0.01 $mg.kg^{-1}$

Testing Schedule

Testing of alternate samples at each station for physical properties was judged adequate. Laboratory testing schedule was as shown in Table 5.4.

Table 5.4 Testing Schedule of HKCEC Sediment

Depth (m)	VC1	VC2	VC3	VC4	VC5	VC6
0	P,C	P,C	P,C	P,C	P,C	P,C
1	C	C	C	C	C	-
2	P,C	P,C	P,C	P,C	P,C	-
3	C	C	C	C	C	-
4	P,C	P,C	P,C	P,C	P,C	-
6	-	C	-	-	-	-

P - Physical Tests - PSD, Bulk Density, Moisture Content
C - Chemical tests - 7 priority trace metals
'-': not tested because these are not marine deposits

Physical Analysis

In addition to chemical analysis physical testing was used for determination of the dispersion/resuspension potential as well as capacity requirement of the sediment. The methods used are given in Table 5.5.

Table 5.5 Methods for Physical Analysis

Parameter	Methodology	Reference
Particle Size Distribution (PSD)	wet sieving and sedimentation	BS 1377 (1975) Test 7A and 7B
Bulk Density	first principle	-
Moisture Content	drying and gravimetric	BS 1377 (1975) Test 1A

5.4 Results and Interpretation

5.4.1 Chemical Analysis Results

Classification of Contaminated Mud

The magnitude of the average levels of metals in the superficial sediment obtained in this study is considerably lower than (about three times) the EPD's data (1990) of the Wanchai region (see Table 5.7). Incidentally, this lower trend of data is also observed in the Western Harbour sediment in another Study carried out in the same period[2]. This might be explained by the possibility that the sample(s) taken by EPD were chosen at locations near sewage outfall or foul nullahs, resulting in higher values than the ones representative of the region. Another possibility is the better control of waste discharged to these regions of Victoria Harbour during last two years, although the first explanation is more likely.

The sediment quality classes for the seven metals at various depths and locations are listed in Table 5.6. Five metals (Pb, Zn, Hg, Cu and Cr) in the sediment are placed in Class C at some locations and depths. The concentration of Cd and Ni, however, are low (Class A) in all cases.

It is found that Class C sediment which requires special dredging and disposal is either limited to the surface layer or non-existent depending on the locations, with one exception, that is VC3 at which Class C sediment goes down to 1 m deep. The extent of contamination is therefore not widespread and localised in the surface.

Lateral and Vertical Distribution of Metals

Evidence has been clearly found for diminishing metal concentrations as a function of increasing seabed depth. Referring to Table 5.7, it can be seen that the major pollution load occurs in the top surface layer. The depth-averaged concentrations of the metals along the stations are shown in Table 5.8. It was observed that the levels of all metals increased at VC3 and VC1. For the case of VC3, higher contamination can be explained by its location close to piers with increasing sea traffic and vessel maintenance activities which could have been significant potential sources of trace metals. The concentrations of metals released by these activities in conjunction with the absence of any strong flows to aid dispersion of contaminants, is expected to lead to the conditions identified at this station. The cause for metal contamination in VC1 is less clear; perhaps it is a result of little dispersion due to its location (in the corner of MTR tunnel and shore intersection). The higher results at these locations, however, should not be regarded as representative of the whole study area. In fact, other than these two stations (VC1 and VC3), the concentrations of the metals in the sediment seem to be quite even for the study area.

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2 'Western Harbour Crossing - Mud Sampling and Testing', prepared by CES for submission to Government

Table 5.6 Contamination Classes of HKCEC Marine Sediment

Station	Depth (m)	Cu	Cd	Cr	Pb	Ni	Zn	Hg
VC1	0							
	1	B			C		C	C
	2							
	3							
	4							
VC2	0							
	1							
	2							
	3							
	4							
	6							
VC3	0	C		C	B		C	B
	1				C		C	C
	2							
	3							
	4							
VC4	0	C						
	1							
	2							
	3							
	6							
VC5	0	C						
	1							
	2							
	3							
	4							
VC6	0							

Blank = Class A

Shaded = Class C, contaminated mud

Table 5.7 **Vertical Distribution of metals in HKCEC Sediment using station-averaged concentration ($mg.kg^{-1}$ dry solid)#**

Depth	Cd	Cr	Cu	Pb	Zn	Ni	Hg
EPD surface*	not reported	75-100	>800	>125	>250	>35	1.2-1.5
Present Study							
0 m	< 0.28 (< 0.2-0.59)	36 (19-81)	115 (6.9-350)	38 (7.2-64)	112 (30-250)	15 (7.6-32)	0.39 (0.04-0.89)
1 m	< 0.23 (< 0.2-0.31)	24 (9.9-39)	26 (7.2-55)	76 (16-150)	185 (40-522)	8.4 (0.9-14)	1.0 (0.04-3.3)
2	< 0.2 (< 0.2)	23 (15-33)	7.8 (5.1-11)	24 (9.1-39)	40 (25-50)	10 (6.9-15)	0.26 (< 0.01-0.22)
3	< 0.2 (< 0.2)	18 (14-22)	5.9 (4.7-6.7)	18 (11-21)	39 (27-49)	9.8 (7.0-15)	< 0.01 (< 0.01)
4	< 0.2 (< 0.2)	12 (8.7-19)	4.4 (3.6-6.0)	16 (14-21)	28 (21-40)	7.6 (4.3-12)	< 0.02 (< 0.01-0.05)
6	< 0.2 (< 0.2)	9.9 (3.8-16)	3.7 (2.2-5.2)	13 (9-16)	25 (11-39)	6.1 (3.5-8.6)	< 0.01 (< 0.01)

* 1990 data
# range expressed in brackets

Table 5.8 **Lateral Distribution of metals in HKCEC Sediment using depth-averaged concentration ($mg.kg^{-1}$ dry solid)**

	Cd	Cr	Cu	Pb	Zn	Ni	Hg
VC1	0.22	23	23.7	55	143	12	0.72
VC2	< 0.2	13	11	29	43	7.6	< 0.12
VC3	< 0.29	36	83	40	128	15.3	< 0.5
VC4	< 0.21	25	5.2	31	58	11	< 0.094
VC5	< 0.22	20	7.3	18	45	8.3	< 0.098
VC6	< 0.2	19	6.9	13	30	8.5	0.04

5.4.2 Physical Analysis Results

The physical properties of the sediment provide information that could assist in determining the disposal method and capacity requirement. The variations of moisture content, percentage fine fraction (silt and clay) and dry density of the sediment with relative depth are shown in Tables

5.9-5.11. For the surface layer the average percentage fine fraction (< 63 μm) is 29%, somewhat greater than the value determined previously by the EPD routine studies in the Wanchai region (1990), that is, less than 20% of sediment in the fine fraction. This can be due to the large variability of the physical properties of the sediment, and this is consistent with previous findings.

VC3-VC6 follow the usual vertical profile of physical properties measured: decreasing moisture content and fine-grained material and increasing dry density with an increase in depth. VC1-VC2, however, show a different pattern with coarser material at the surface layer lying on top of finer material. There are two possibilities for this occurrence. This might reflect the high current speed near these locations eroding the lighter fine materials or simply the deposition of piling or bedding material which originated from the nearby MTR immersed tube.

Comparing Table 5.6 with Tables 5.9-5.11, high metal concentrations are found to be associated with mud that has high moisture content, high fine fraction and low density. This is consistent with the general experience that heavy metals tend to be concentrated in the fine grained clay-rich fractions. The contaminated mud is slurrified at some locations, notably VC3, and should therefore be monitored for its environmental impact during dredging and disposal because of its tendency towards dispersion and resuspension.

The physical values averaged over the Class C sediment are presented in Table 5.12. These values should be used for selection of the disposal method and calculation of capacity requirement.

Table 5.9 Moisture Content of Sediment (%)

Depth (m)	VC1	VC2	VC3	VC4	VC5	VC6
0	25	25	119	42	37	17
2	44	29	42	26	30	-
4	22	24	39	21	24	-

Table 5.10 Percentage Fine Fraction of Sediment (%)

Depth (m)	VC1	VC2	VC3	VC4	VC5	VC6
0	19	16	64	28	30	18
2	43	34	39	59	26	-
4	24	21	49	39	28	-

Table 5.11 Dry Density of Sediment (kg.l^{-1})

Depth (m)	VC1	VC2	VC3	VC4	VC5	VC6
0	1.39	1.44	0.58	0.98	1.26	1.72
2	1.18	1.56	1.26	1.49	1.39	-
4	1.62	1.56	1.82	1.66	1.59	-

Table 5.12 Average Physical Values for HKCEC Contaminated Sediment*

Parameter	Class C average
Moisture Content (%)	56 (25-119)
Percentage Fine Fraction (%)	38 (19-64)
Dry density (kg.l^{-1})	1.07 (0.58-1.39)

* The range of concentrations encountered is expressed in brackets

5.5 Extent of Sediment Contamination

5.5.1 Depths of Contaminated Sediment

After the results had been classified, the extent of contamination in terms of the depth of the seabed was considered so that the likely volumes of the contaminated mud to be taken off site could be estimated. Table 5.13 shows the depths of the seabed *at* which sediments are considered to be contaminated. In the actual dredging process, however, mixing of sediment is bound to occur. Because of the difficulty of ensuring complete segregation of sediment layers, the uncontaminated mud lying on top or sandwiched between the contaminated mud layers should be considered as contaminated as well. As a result, Table 5.14 shows the depths of the seabed *to* which sediments are considered to be contaminated.

Table 5.13 Depths *at* which sediment are considered to be contaminated

Station	Seabed Depth
VC1	1m
VC2	-
VC3	Surface to 1m
VC4	Surface
VC5	Surface
VC6	-

Table 5.14 Depths *to* which sediment are considered to be contaminated

Station	Seabed Depth
VC1	1 m
VC2	-
VC3	1 m
VC4	0.3 m
VC5	0.3 m
VC6	-

5.5.2 Volumes of Contaminated Sediment

It should be pointed out that the estimates of mud volumes are based on dredging design that is yet to be confirmed so the estimates discussed herein should not be interpreted as precise and finalised. CES calculated the volumes of dredged mud, contaminated and uncontaminated, on the basis of Table 5.15 which assumes the minimum depth to which contaminated mud to be dredged is 1 m due to practical dredging consideration.

Table 5.15 Depths to which contaminated sediments are to be dredged

Station	**Seabed Depth**
VC1	1 m
VC2	-
VC3	1 m
VC4	1 m
VC5	1 m
VC6	-

The depth of mud to be removed in the study area is estimated to be 5 m by MCAL. The total volume of dredged mud is simply the product of length of seawall (from the plan layout), the width of seawall (46 m) and the depth of mud. Currently there are two dredging scenarios proposed.

Scenario A Only western seawall is dredged.
Scenario B All seawalls are dredged.

The estimates are shown in Table 5.16.

Table 5.16 Estimated Volumes of Contaminated Mud*

Scenario	Total volume of dredged mud (m^3)	Volume of uncontaminated mud (m^3)	Vol of contaminated mud (m^3)
A	57,500	46,000	11,500
B	227,700	193,700	34,000

Assumes the minimum depth to which contaminated mud is dredged is 1 m due to practical dredging consideration. Also assumes that the top 1m of mud in areas of VC2 and VC6 are treated as uncontaminated mud in accordance with Table 5.15.

5.6 Conclusions

The magnitude of the levels of metals determined in this study are lower than those obtained previously by EPD in the same area. Five metals (Pb, Zn, Hg, Cu and Cr) show high concentrations in the sediment at some locations and depths. The concentrations of Cd and Ni are low in all cases tested.

Classification of the marine sediment in accordance with EPD's criteria indicates that, Class C sediment which requires special dredging and disposal is either limited to the surface layer or non-existent depending on the locations. VC3 is an exception with Class C sediment going down to 1 metre deep. Since sediments contaminated with metals are localised in the surface, the elevated metal loadings are probably derived from anthropogenic sources.

It was evident that metal concentrations diminished as a function of increasing depth. Higher contamination levels are found for VC1 and VC3 and this might be due to their enclosed locations hence the lack of dispersion of contaminants by water currents or due to their proximity to piers.

High metal concentrations are found to be associated with mud that has high moisture content, high fine fraction and low density. The contaminated sediment should be licensed to be disposed at a site designated specifically for that purpose, in a manner to be directed by the license.

It is therefore concluded that the volumes of contaminated mud generated in this project are estimated to be between 11,500 to 34,000 m^3, depending on the dredging scenario adopted. Exact volumes can only be determined after the detailed seawall design is undertaken.

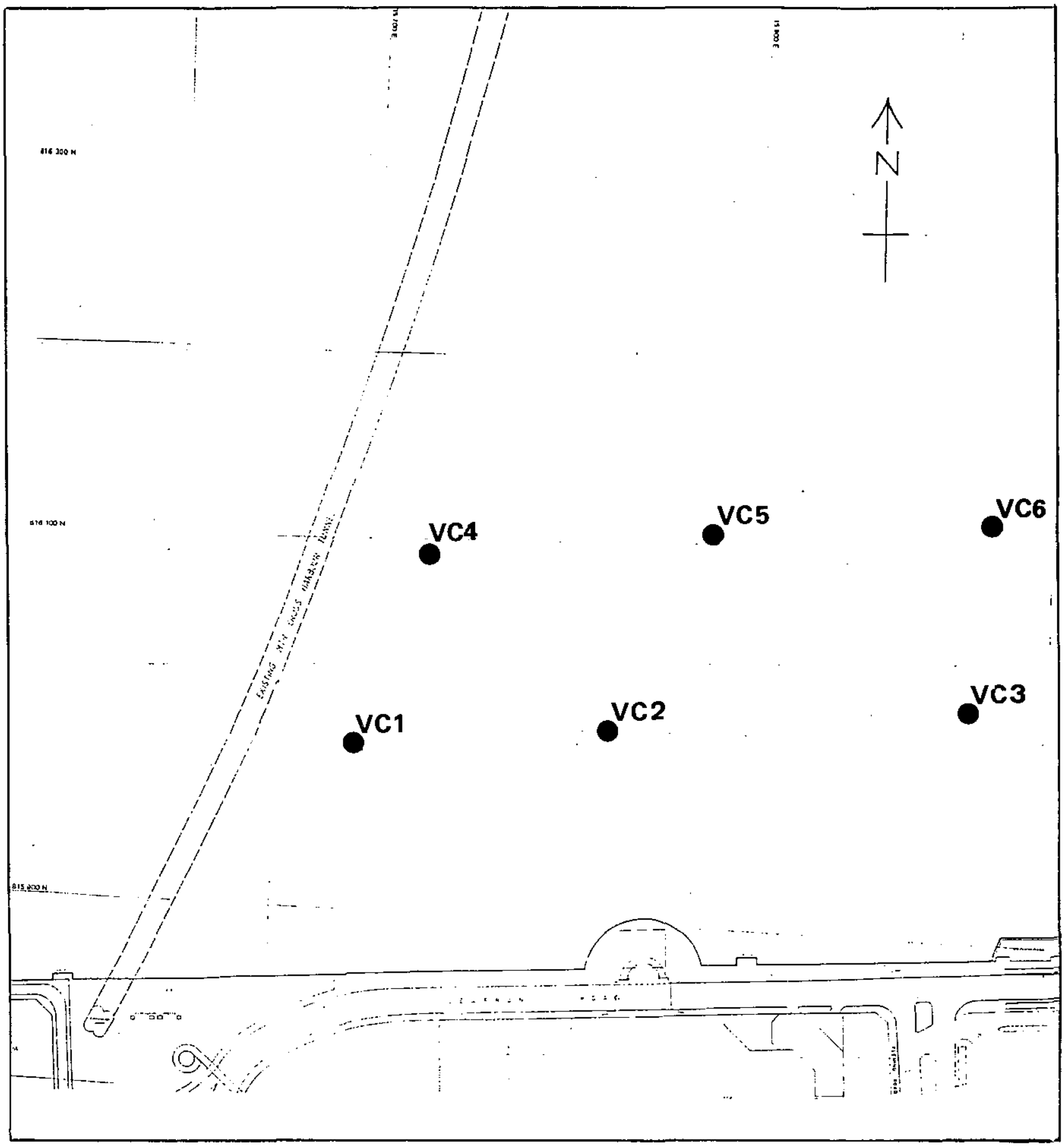


Figure 5.1 **Vibrocoring Locations for Mud Contamination Study**

6. Air Quality

6 Air Quality

6.1 Legislation and Guidelines Controls

The Air Pollution Control Ordinance (APCO) provides powers for controlling air pollutants from a variety of stationary and mobile sources, including fugitive dust emissions from construction sites. It encompasses a number of Air Quality Objectives (AQO) which stipulate concentrations for a range of pollutants. Those that are relevant to this study are listed in Table 6.1.

Table 6.1 Hong Kong Air Quality Objectives

Air Pollutant	Concentration in microgram per cubic metre			
	Averaging Time			
	1-Hour*	8-Hour	24-Hour**	Annual
CO	30000	10000		
NO_2	300		150	80
TSP	500+		260	80
RSP	346#		180	55

* Not to be exceeded more than once per year.

** Not to be exceeded more than three times per year.

\+ In addition to the above established legislative controls, it is generally accepted that an hourly average total suspended particulate (TSP) concentration of 500 μgm^{-3} should not be exceeded. Such a control limit is particularly relevant to construction work and has been imposed on a number of construction projects in Hong Kong in the form of contract clauses.

\# No specific 1-hour average criterion or guideline exists for respirable suspended particulate (RSP). However, a previous study adopted 346 μgm^{-3} as a criterion, based on the 500 μgm^{-3} guideline for TSP multiplied by the ratio of the RSP/TSP 24-hour AQOs.

6.2 Existing Environment

Estimation of background pollutant levels for the area in the future is not possible. However, an indication of the existing conditions is available from the monitoring programme undertaken by EPD. The closest Air Quality Monitoring Station is located in Central/Western district. Results for 1991 show that there were no exceedances of the annual average pollutant concentrations for NO_2 and TSP but exceedance of RSP. There were no exceedances of the 24-hour average AQOs.

6.3 Sensitive Receivers

The representative air quality sensitive receivers adopted for the purposes of assessment are the same for both construction and operational phases. Seventeen receivers were identified, these are the existing buildings located in the proximity of the site and to the north of Gloucester Road. These are shown in Figure 6.1 and listed in Table 6.2. The height used for the analysis was based on the ground floor level for buildings. As the reclamation is flat, this would represent a worst-case situation.

6.4 Construction Phase

6.4.1 Assessment Methodology

The major potential air quality impact during the construction phase will result from dust arising from the formation of the reclamation and other construction work. Vehicle and plant exhaust emissions from the site are not considered to constitute a significant source of air pollutants. For the formation of the reclamation, marine or land based fill material will be used. There will be three possible sources of fill material:

a) marine sand; or

b) contractor sourced material; or

c) public dump material.

The fill material will be transported to the reclamation and dumped by means of barges. Presuming all land based fill material will be wetted before transporting to the reclamation, the difference will be limited regarding the emission of fill material. Hence, for the purposes of air quality assessment, filling with all three sources of fill material will generate similar air quality impacts.

The major dust producing activities will be:

- site preparation;
- removal of existing seawalls;
- excavations, particularly those associated with construction of foundations;
- wind erosion of stockpiled materials and working areas;
- vehicle / plant movements on unpaved roads and over the site; and
- material transfer from trucks.

A number of assumptions were made in order to undertake the analysis. All fill material will be transported to the reclamation and dumped by barges. All land based fill material will be wetted before transporting to the reclamation.

Basic dust emissions were estimated using USEPA Compilation of Air Pollutant Emission Factors (AP-42). Emission factor for heavy construction operations with: (1) medium activity level, (2) moderate silt content (~30 percent), and (3) semiarid climate was adopted. The ISCST dispersion model was used for the modelling of dust emissions from the site. The modelling assumed that the whole area would be worked simultaneously. Worst-case meteorological conditions (Pasquill stability class D, mixing height 500 m, wind speed 2 ms^{-1}) were adopted for the calculation of 1-hour average TSP concentrations at the sensitive receivers.

No specific assessment was undertaken to calculate RSP concentrations. Previous studies indicate that the maximum RSP generation is approximately 50% of the TSP.

6.4.2 Impacts on Sensitive Receivers

Table 6.2 shows the worst-case 1-hour average TSP concentrations at the sensitive receivers without any dust suppression measures. As can be seen, there may be adverse impact at some of the sensitive receivers that have direct line of sight with the reclamation. With no mitigation, the predicted TSP concentrations may exceed the acceptable limit of 500 μgm^{-3}. Figure 6.2

shows the worst-case 1-hour average TSP concentration contours, with and without dust suppression measures, in the proximity of the reclamation.

Table 6.2 Worst-case 1-hour Average TSP Concentration at Sensitive Receivers

Receiver	Location	TSP Level (μgm^{-3})	
		Without Dust Suppression	With Dust Suppression
ASR 1	Hong Kong Convention & Exhibition Centre	640*	319
ASR 2	Grand Hyatt Hotel	679*	338
ASR 3	New World Harbour View Hotel	596*	296
ASR 4	Servicemen's Guides Association	410	204
ASR 5	Hong Kong Academy for Performing Arts	480	239
ASR 6	Hong Kong Arts Centre	439	219
ASR 7	YMCA Hotel	448	223
ASR 8	Shui On Centre	420	209
ASR 9	Wan Chai Tower	416	207
ASR 10	Kwong Wan Fire Station	411	205
ASR 11	Central Plaza	398	198
ASR 12	Great Eagle Centre	586*	292
ASR 13	Harbour Centre	501*	249
ASR 14	Hong Kong Exhibition Centre	416	207
ASR 15	China Resources Building	358	178
ASR 16	Causeway Centre	356	177
ASR 17	Sun Hung Kai Centre	326	162

* Exceedance of 500 μgm^{-3} guideline 1-hour average TSP level

Taking dust suppression measures into account, with reference to USEPA Compilation of Air Pollutant Emission Factors (AP-42), an effective watering program (that is, twice daily watering with complete coverage) is estimated to reduce dust emissions by up to 50 percent.

Table 6.2 shows the worst-case 1-hour average TSP concentrations at the sensitive receivers with adoption of an effective watering program. With the dust suppression measures taken into account, the TSP concentration at all receivers will be within the acceptable limit. Figure 6.3 shows the worst-case 1-hour average concentration contours, with adoption of dust suppression measures, in the proximity of the reclamation.

The modelling assumed construction activity over the whole site at the same time, which is conservative prediction. Emission rates for heavy construction operations over the whole construction phase were assumed which is also conservative. The probability of high dust generating activity coinciding with worst-case meteorological conditions is low. The dust levels predicted in Table 6.2 should occur only very rarely.

However, background dust levels in the Central/Western area are high according to EPD measurements. Every practical effort should be adopted to ensure minimal additional dust generation from the site.

RSP concentrations are also likely to be high in the area, particularly in view of the existing high levels monitored in the Central/Western area. The mitigation proposals for TSP will also lead to a corresponding reduction in the RSP generated.

6.4.3 Control and Mitigation Measures

In view of the potential high levels of dust arising from the formation of the reclamation and related construction activities, it will be necessary to adopt control and mitigation measures wherever practical.

The following measures should be adopted where applicable:

- use of regular watering to reduce dust emissions from exposed site surfaces and unpaved roads. Up to 50% reduction in dry dust emissions can be achieved by twice daily watering with complete coverage;
- use of frequent watering for particularly dusty static construction areas and areas on the southern side of the site;
- side enclosure and covering of any aggregate or dusty material storage piles to reduce emissions. Where this is not practicable owing to frequent usage, watering should be employed to aggregate fines;
- where possible, prevent placing dusty material storage piles on the southern side of the site;
- paving of frequently used site roads can reduce emissions by up to 85%. Alternatively geotextiles should be used to form flexible road surfaces;
- tarpaulin covering of all dusty vehicle loads transported to, from and between site locations;
- imposition of speed controls for vehicles on unpaved site roads. 8 km hr^{-1} is the recommended limit;
- establishment and use of vehicle wheel and body washing stations at the exit point of the site, combined with cleaning of public roads where necessary;
- if land based fill material is used, provision of a fixed spray bar system to wet fill material prior to load into barges before transporting to the reclamation; and
- instigation of a control program to monitor the construction process in order to enforce controls and modify methods of work if dusty conditions arise.

6.4.4 Dust Monitoring and Audit

TSP monitoring should be carried out by the Engineer or Contractor throughout the construction period. One high volume air sampler and associated equipment and shelter should be provided. Location of the monitoring station should be close to the site boundary, free from local obstructions or shelters and should be nearest to the Hong Kong Convention & Exhibition Centre. The exact location should be reviewed in relation to practical site constraints.

Baseline monitoring should be carried out by the Engineer prior to the commencement of the construction work to determine the ambient dust (TSP) levels at specified monitoring stations. The baseline monitoring should be carried out for a period of at least two weeks with measurements to be taken every 24-hours at each monitoring station.

Impact monitoring during the course of the reclamation and construction should be undertaken at a frequency not lower than one 24-hour measurement per six days at each monitoring station. Should the monitoring results indicate a deteriorating situation, closer monitoring may be undertaken by the Engineer until the monitoring results indicate an improving and acceptable level of air quality.

When it is determined that the recorded dust (TSP) level is significantly greater than the baseline levels, the Engineer may direct the Contractor to take mitigation measures concerning potential dust sources and working procedures.

The levels of RSP as monitored in the Central/Western district during 1991 showed exceedance of the annual average AQO. Therefore it is recommended that RSP is monitored in parallel with TSP.

6.5 Operational Phase

6.5.1 Assessment Methodology

Impacts following development may result from traffic pollutants arising from vehicles on the new road network. There are no proposals for industrial landuse.

The air quality assessment of operational phase impact was undertaken for the traffic flow composition of the two stages:

a) HKCEC Extension development only, design year 2001;

b) Full reclamation development, design year 2006.

The CALINE4 dispersion model was used for this study. Pollutants NO_2, CO and TSP were investigated. Vehicle emissions were calculated in accordance with the methodology given in USEPA Compilation of Air Pollutant Emission Factors (AP-42) with the following assumptions:

- By 2001 all light petrol vehicles will be fitted with catalytic converters. Estimated average mileage is 50000 miles. A basic NO_x emission level of 1.02 g veh^{-1} $mile^{-1}$ was used for vehicles fitted with catalytic converters.

- Light diesel vehicles will be on average 7 years old with an average mileage of 50000 miles. 1985+ data were used.

- Heavy diesel vehicles will be on average 10 years old with an average mileage of 200000 miles. 1987-92 and 1993-96 figures were used for 2001 and 2006 respectively.

- Only speed correction was applied. No other adjustments were made, e.g. extra load, humidity etc due to lack of available data.

- 20% NO_x to NO_2 conversion was assumed.

In the dispersion modelling, meteorological conditions of wind speed 1 ms^{-1}, Pasquill stability class D, mixing height of 500 m, horizontal wind direction standard deviation of 12 degrees and worst-case wind direction were considered to represent realistic worst-case 1-hour average conditions. PM peak hour traffic flow predictions (vehicles per hour) for the two development stages were used (Figures 6.4). Traffic composition of 38% light petrol, 51% light diesel and 11% heavy diesel was adopted, based on the traffic composition estimation of Gloucester Road, Harbour Road and Convention Avenue. Table 6.3 shows emission factors for this traffic composition with an assumed speed of 70 km hr^{-1} for Gloucester Road and 50 km hr^{-1} for other road network.

Table 6.3 Vehicle Emission Factors

Year	CO (g veh^{-1} $mile^{-1}$)		NO_x (g veh^{-1} $mile^{-1}$)		TSP (g veh^{-1} $mile^{-1}$)	
	50 km hr^{-1}	70 km hr^{-1}	50 km hr^{-1}	70 km hr^{-1}	50 km hr^{-1}	70 km hr^{-1}
2001	3.99 [2.48]	2.66 [1.65]	2.06 [1.28]	2.18 [1.35]	0.72 [0.45]	0.72 [0.45]
2006	3.47 [2.16]	2.23 [1.39]	1.97 [1.22]	2.08 [1.29]	0.72 [0.45]	0.72 [0.45]

[ ] Emission in g veh^{-1} km^{-1}

6.5.2 Impacts on Sensitive Receivers

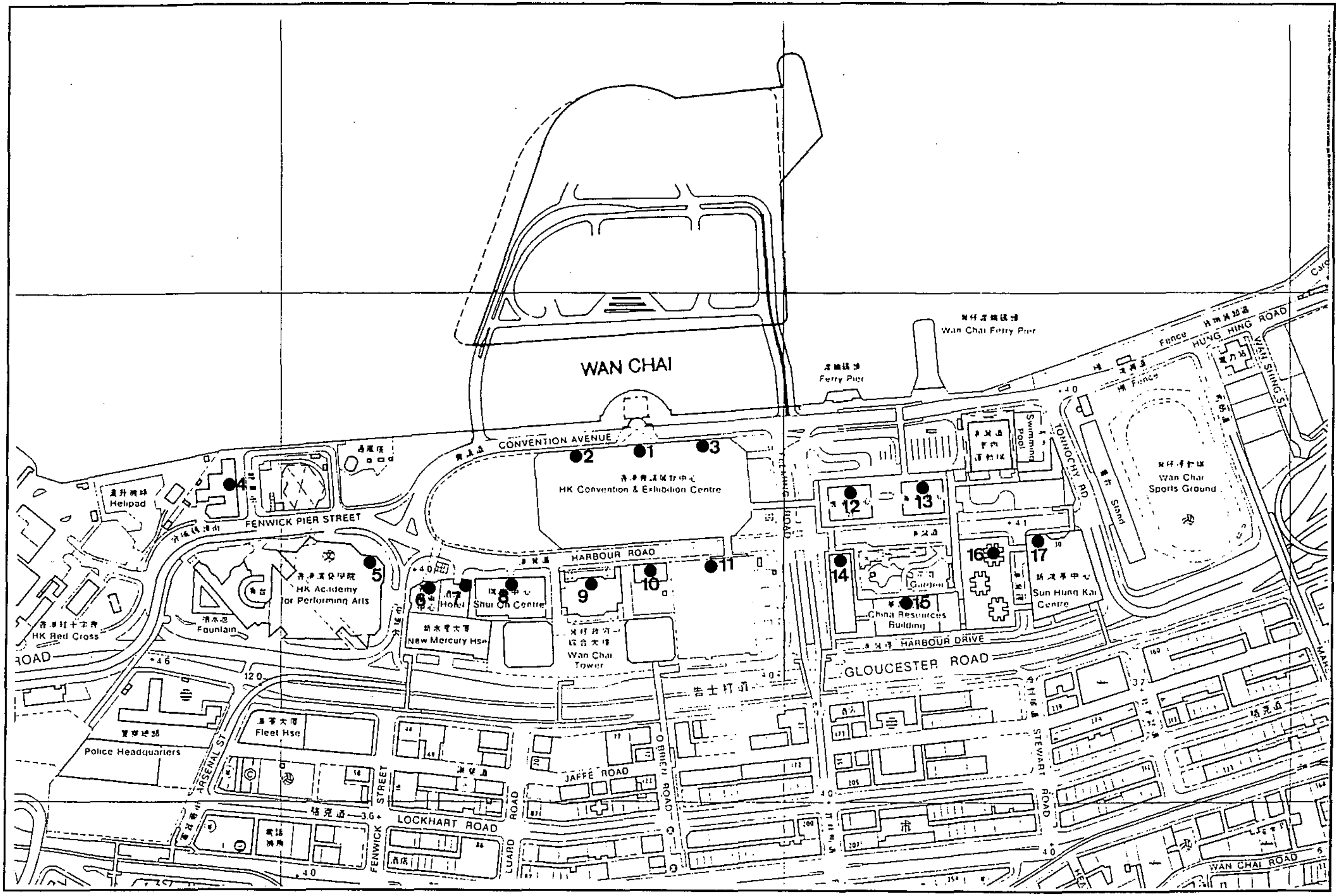
Worst-case 1-hour concentrations of CO, NO_2 and TSP (excluding ambient concentrations) at the sensitive receivers for the two stages are shown in Table 6.4. All predicted concentrations for CO , NO_2 and TSP are compliant with the statutory Air Quality Objectives.

Table 6.4 Worst-case 1-hour Pollutant Concentrations at Sensitive Receivers (μgm^{-3})

Receiver	2001			2006		
	CO	NO_2	TSP	CO	NO_2	TSP
1	683	95	123	373	66	86
2	636	88	114	359	61	80
3	665	93	120	449	80	106
4	572	93	117	490	87	115
5	608	94	119	611	94	127
6	487	74	92	384	66	85
7	570	80	103	437	68	92
8	564	78	102	417	68	88
9	546	80	99	421	74	96
10	664	92	119	519	80	108
11	780	109	141	618	95	128
12	710	114	145	686	105	142
13	542	92	116	507	81	107
14	858	143	181	715	121	159
15	673	134	166	533	117	151
16	508	87	107	442	76	98
17	611	89	110	507	78	105

6.5.3 Control and Mitigation Measures

The 1-hour average concentrations for CO NO_2 and TSP under worst-case conditions are in compliance with the Air Quality Objectives. Unacceptable air quality impact due to road traffic is not expected. It should be noted that, in situations such as this, mitigation for reduction of impacts from traffic air pollutants can only be achieved through control at source, ie. reduction in individual vehicle emissions, reduction in trips through provision of additional public transport facilities, or through traffic management schemes.



● **Air Quality Sensitive Receiver**

Figure 6.1 Locations of Air Quality Sensitive Receivers

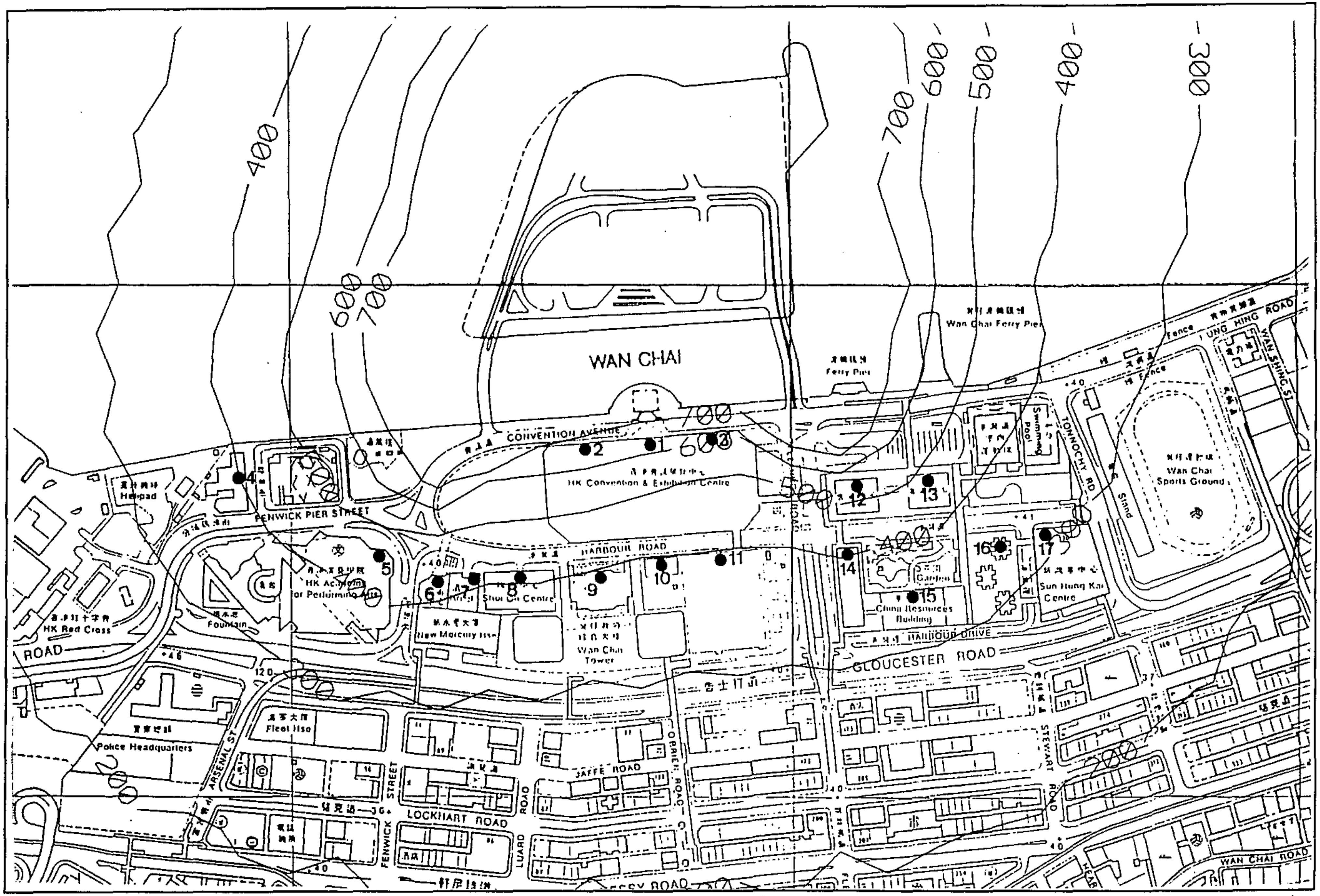


Figure 6.2 Worst-case 1-hour average TSP concentration contours, without dust suppression

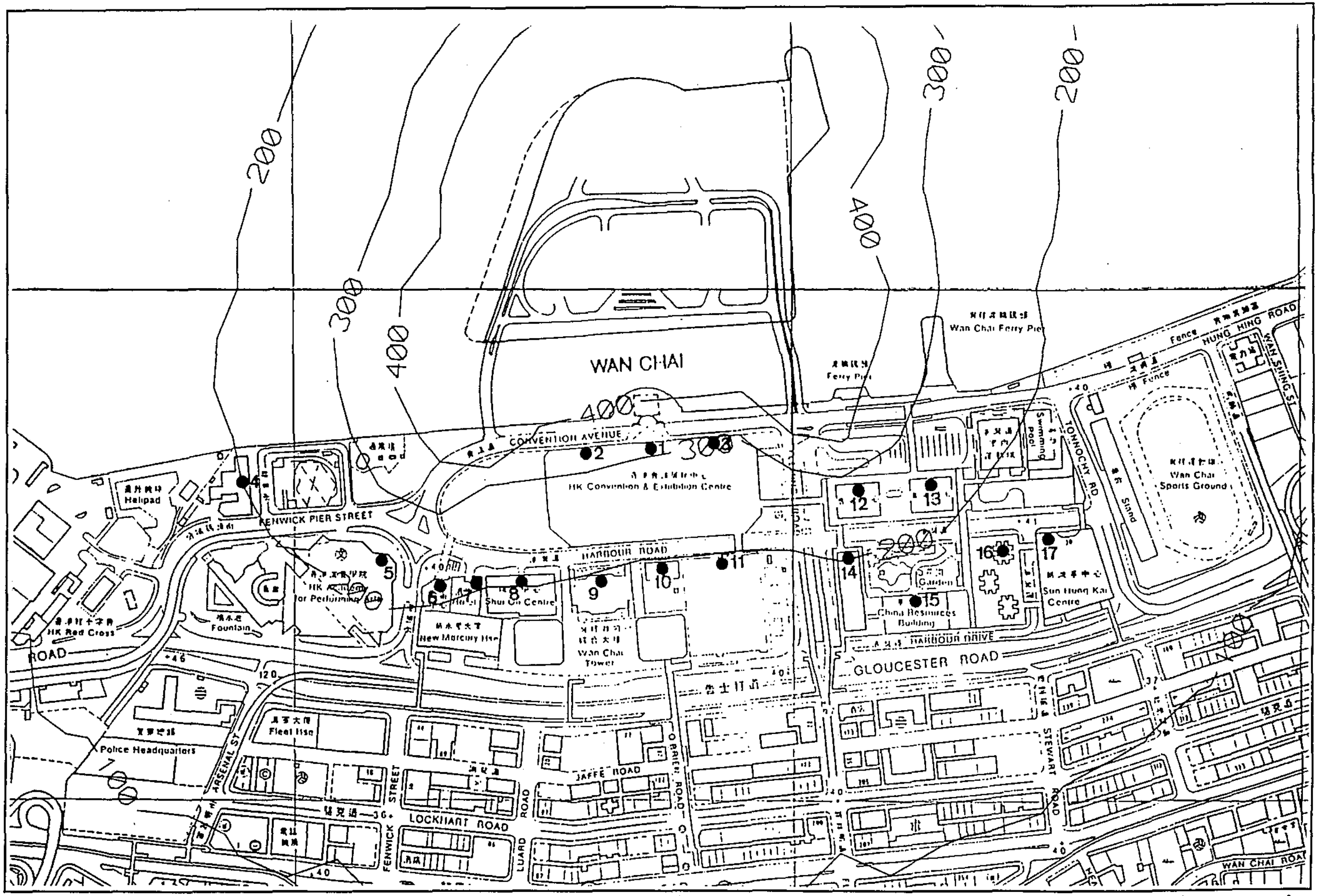


Figure 6.3 Worst-case 1-hour average TSP concentration contours, with dust suppression

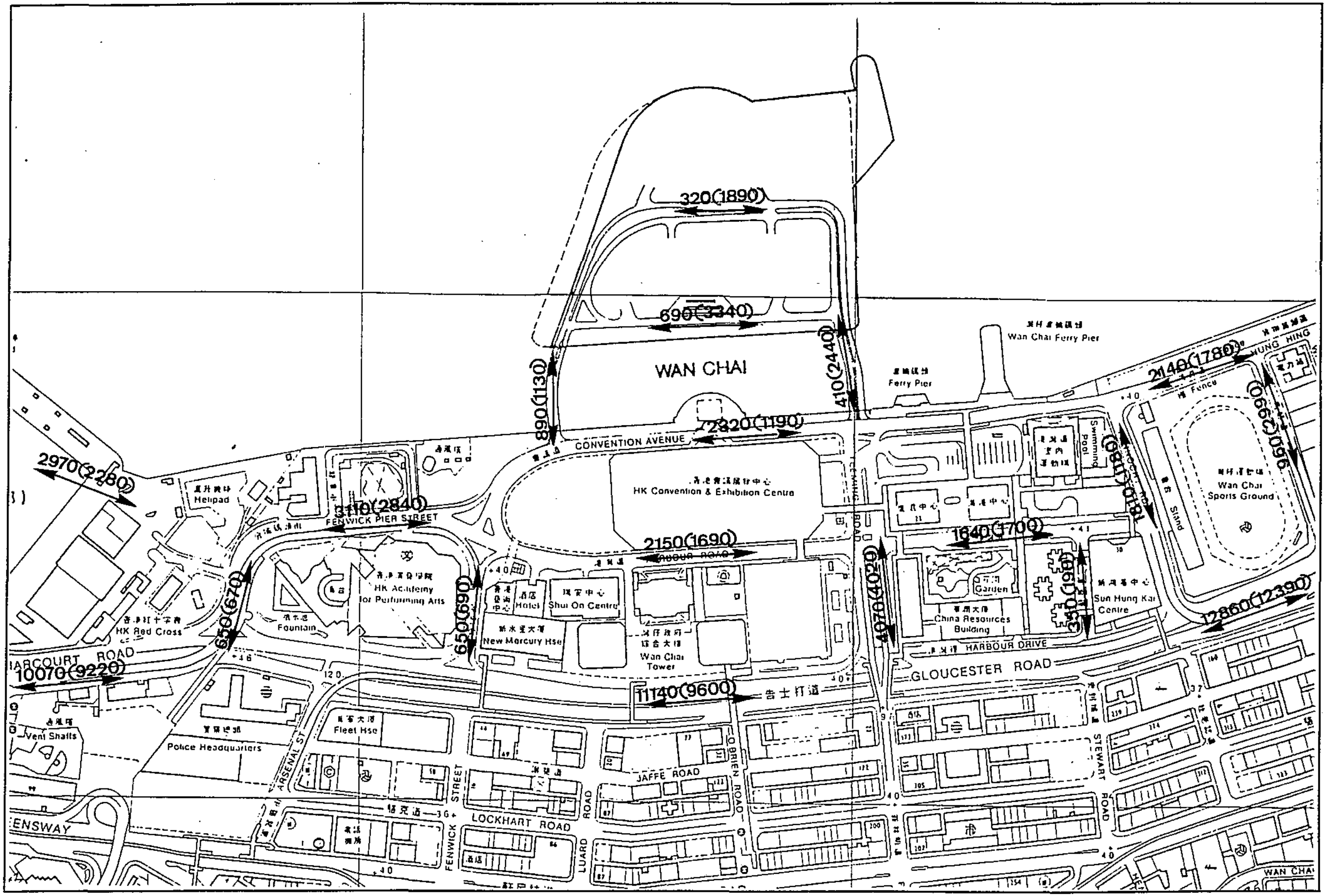


Figure 6.4 2001 (2006) pm peak hour traffic flow predictions in vehicle per hour

7. Noise

7 NOISE

7.1 Introduction

Receivers will be affected by the noise generated from construction activities and traffic. Impacts on the sensitive receivers were assessed for each of these sources, in accordance with statutory procedures and guidelines.

7.2 Legislation and Guideline Controls

The Noise Control Ordinance (NCO) provides the statutory framework for noise control and defines statutory limits that will apply to the construction of the Hong Kong Convention and Exhibition Centre Extension. In addition, EPD has stated that for better planning and in order not to contravene the NCO, consideration should be taken of the Hong Kong Planning Standards and Guidelines (HKPSG), although the environmental related guidelines included in this publication have no statutory basis. As well as setting out guidelines for planning practice with respect to noise, the HKPSG presents the only published limits on traffic noise in Hong Kong.

Noise from construction activities will be generated from powered mechanical equipment (PME) and percussive piling operation. Assessment of noise levels from PME at the Noise Sensitive Receivers (NSRs) was carried out in accordance with the procedures in the Technical Memorandum (TM) on Noise from Construction Work other than Percussive Piling. Assessment of noise levels from percussive piling operation was carried out according to the procedures in the TM on Noise from Percussive Piling.

Under this TM on Noise from Construction Work other than Percussive Piling, noise from PME is not restricted during the hours 0700 - 1900 (except Sundays and Public Holidays). However, a non-statutory guideline limit of 75 dB(A) is frequently adopted for day-time construction noise whenever practical. Consequently, EPD has suggested a day-time general construction noise limit of 75 dB(A) in $L_{eq\ (5\ min)}$. While this limit has no statutory significance with respect to Construction Noise Permits, it has been included in a number of contract specifications together with the requirement that appropriate noise mitigation measures should be considered once this limit is exceeded.

Between 1900 and 0700 and all day on Sundays and public holidays, construction activities are restricted unless a permit is obtained. A permit will be granted only if the Acceptable Noise Level (ANL) for the noise sensitive receiver can be met. Basic Noise Levels (BNLs) are assigned depending upon the Area Sensitivity Rating (ASR). As the NSRs in the vicinity of the development area are situated in an urban area, NSRs are likely to be assigned an ASR of either B or C. The BNLs for the respective ASRs are presented in Table 7.2.1.

Since 'Correction for the Duration of the Construction Noise Permit' and 'Correction for Multiple Site Situation' would not be applied in the assessment, BNLs as shown in Table 7.2.1 are directly equal to the ANLs for the corresponding noise sensitive receivers.

Table 7.2.1 Basic Noise Levels (BNLs)

Time Period	Basic Noise Level $L_{eq\ (5\ min)}$, dB(A)	
	ASR 'B'	ASR 'C'
All days during the evening (1900 to 2300), and general holidays (including Sundays) during the day-time and evening (0700 to 2300)	65	70
All days during the night-time (2300 to 0700)	50	55

Under a separate TM on Noise from Percussive Piling, piling is prohibited between 1900 and 0700 hours and on Sundays and Public Holidays, unless permission is granted by the Governor in Council. Between 0700 and 1900 hours, piling is allowed under permit, subject to noise level limits (termed Acceptable Noise Levels - ANLs). If the noise level is expected to exceed these limits, restricted hours of operation are included in the permit. Table 7.2.2 summaries the ANLs to be complied with.

Table 7.2.2 Acceptable Noise Levels (ANLs) for Percussive Piling

NSR Window Type or Means of Ventilation	ANL, dB(A)
NSR (or part of NSR) with no windows or other openings	100
NSR with central air conditioning system	90
NSR with windows or other openings but without central air conditioning system	85

* 10 dB(A) shall be deducted from the above when the NSRs are hospitals, schools or law courts.

There are currently no statutory controls to limit the impacts from road traffic noise, however, the HKPSG provide criteria which are shown in Table 7.2.3.

Table 7.2.3 HKPSG Limits for Traffic Noise

Receiver	Road Traffic $L_{A10\ (Peak\ Hour)}$, dB(A)
Dwelling	70
Hotel and Hostels	70
Offices	70
Technical Institute or School	65
Hospital	55

Note : These standards apply to receivers that rely on open windows for ventilation

7.3 Construction Phase

7.3.1 Sensitive Receivers

Fourteen NSRs which may be affected by the construction works for the Hong Kong Convention and Exhibition Centre Extension were identified. These are listed in Table 7.3.1 and shown in Figure 7.1. For the purposes of assessment, ASRs were also assigned to the respective NSRs in accordance with the TM on Noise from Construction Work other than Percussive Piling.

7.3.2 Existing Conditions

There is no construction work being undertaken in the vicinity of Hong Kong Convention and Exhibition Centre and therefore the sensitive receivers are not affected by existing construction noise. The receivers are subject to high noise levels from existing traffic in the area (see Section 7.4).

7.3.3 Assessment Methodology

The construction of Hong Kong Convention and Exhibition Centre is divided in 2 phases: (i) reclamation and building development - the reclamation works are scheduled from November 1994 until November 1996; and (ii) the building works executed from November 1995 until November of 1998. The assessment has taken account of both options for reclamation: (i) public dump or use contractor sourced material, and (ii) marine sand fill. However, plant schedules applying to both options are the same which means that the construction noise impacts from both options are also the same.

Plant schedules and sound power levels of the proposed equipment are given in Tables 7.3.2 and 7.3.3. The assessment for noise from PME followed the procedures given in the TM on Noise from Construction Work other than Percussive Piling. Attenuation for distances over 300 m is not provided in the TM.

For the purpose of assessment of noise arising from PME, the distance attenuation was calculated using the standard formula (7.1):

$$\textit{Distance Attenuation in } dB(A) = 20 \log D + 8 \quad (7.1)$$

where D is the distance in metres.

All PME, except the hydraulic breakers engaged in reclamation and building work, were assumed to be located at notional source positions (NSP), selected in accordance with the procedures in the TM. The hydraulic breakers (named as HB1 and HB2) for reclamation work were assumed to be located at fixed positions as shown in Figure 7.1.

For assessing noise emanating from percussive piling, the distance correction factors are presented in Table 7.3.4.

Table 7.3.1 Locations and ASRs of NSRs

Noise Sensitive Receiver	Location	ASR*
NSR1	Gloucester Road No. 169-170	C
NSR2	Sun Hung Kai Centre	B
NSR3	Causeway Centre	B
NSR4	Harbour Centre	B
NSR5	Great Eagle Centre	B
NSR6	New World Harbour View Hotel	B
NSR7	HK Convention and Exhibition Centre	B
NSR8	Grand Hyatt Hotel	B
NSR9	Central Plaza	B
NSR10	Wan Chai Magistracy	B
NSR11	Shui On Centre	B
NSR12	YMCA Hotel	B
NSR13	HK Arts Centre	B
NSR14	HK Academy for Performing Arts	B

* Assumed for assessment purposes only. The selection of an appropriate ASR is at the discretion of the Authority during the Noise Permit application procedure. These may be subject to change depending on future conditions.

Table 7.3.4 **Correction Factors to Obtain the Predicted Noise Level from the Total Sound Power Level of Percussive Piling at Given Distance 301 to 941**

Distance, m	Correction, dB(A)
301 - 317	63
318 - 350	64
351 - 387	65
388 - 427	66
428 - 471	67
472 - 520	68
521 - 574	69
575 - 634	70
635 - 700	71
701 - 772	72
773 - 852	73
853 - 941	74

7.3.4 Impact on Receivers

Powered Mechanical Equipment

Commercial premises are not considered as NSR's in accordance with the TM on Noise from Construction Work other than Percussive Piling. Only NSRs 1, 3, 6, 8, 10, 12, 13 and 14 are therefore to be considered in this section. The distance of each NSR to each corresponding NSP and the respective distance attenuation are given in Table 7.3.5.

Table 7.3.5 Distances from NSRs to Notional Source Positions and Respective Distance Attenuation

NSR	Reclamation and Building Work		Hydraulic Breaker 1		Hydraulic Breaker 2	
	Distance, m	Attenuation, dB(A)	Distance, m	Attenuation, dB(A)	Distance, m	Attenuation, dB(A)
NSR1	550	63	465	61	740	65
NSR3	280	57	220	55	505	62
NSR6	80	46	60	44	260	56
NSR8	85	47	255	56	60	44
NSR10	210	54	265	56	185	53
NSR12	240	56	380	60	150	52
NSR13	240	56	400	60	155	52
NSR14	225	55	450	61	160	52

The construction noise level at each NSR was calculated and presented in Table 7.3.6.

A commencement date for construction work is assumed as November 1994. From Table 7.3.6, the maximum noise level at the Gloucester Road No. 169 - 170 may be up to 71 dB(A) during December 1995 to August 1996. The maximum noise level at the Causeway Centre is estimated to be 77 dB(A) during January to August of 1996. However, this is likely to be an overestimate because the NSP is totally shielded by the Harbour Centre and Grant Eagle Centre. A 5 dB(A) reduction should be applied in accordance with the TM. Therefore, the resultant noise level is estimated to be 72 dB(A) which is acceptable during the worst months. The maximum noise level at the New World Harbour View Hotel is estimated to be 88 dB(A) during January to August 1996. The maximum noise level at the Grand Hyatt Hotel is also estimated to be 88 dB(A) in March 1996. The maximum noise level at the Wan Chai Magistracy is estimated to be 80 dB(A) during January to August 1996. However, these are likely to be an overestimate because part of the site is screened from direct view of the receivers. The maximum noise levels at YMCA Hotel and HK Arts Centre are estimated to be 79 dB(A) and 79 dB(A) from March to August 1996 respectively. Similarly, these are likely to be overestimates because part of the site is screened from direct view of the receivers. For the HK Academy for Performing Arts, the maximum noise level may reach 80 dB(A) in March, April and July 1996.

All NSRs except NSR 1 may be exposed to maximum noise levels which exceed the 75 dB(A) non-statutory day-time limit at some periods during the construction phase. However, all affected NSRs except Causeway Centre are fitted with high quality glazing and central air conditioning which will attenuate received noise levels inside the building. It is evident that mitigation would be necessary for evening and night time work.

Although potentially exposed to construction noise levels, the noise environment at NSR 2 in particular will be dominated by traffic noise from Gloucester Road as shown in Table 7.4.2.

The analysis presented in this section corresponds to a worst case scenario because it is assumed that plant would be working simultaneously at a single Notional Source Position for each stage of work (except hydraulic breakers). In reality, this would not be the case and it is therefore unlikely that such high levels will occur.

Percussive Piling

All NSRs listed in Table 7.3.1 will be considered in this section. Percussive piling operation will be undertaken at three different areas as shown in Figure 7.1. The distance of each NSR to each corresponding piling location and the respective distance attenuation are given in Table 7.3.7.

Table 7.3.7 Distances from NSRs to Locations of Percussive Piling Operations and Respective Distance Attenuation

NSR	Piling Location A		Piling Location B		Piling Location C	
	Distance, m	Attenuation, dB(A)	Distance, m	Attenuation, dB(A)	Distance, m	Attenuation, dB(A)
NSR1	465	67	740	72	690	71
NSR2	280	62	570	69	525	69
NSR3	220	60	505	68	500	68
NSR4	135	55	435	67	425	66
NSR5	85	60	360	65	420	66
NSR6	60	47	260	61	365	65
NSR7	155	56	160	57	410	66
NSR8	255	61	60	47	460	67
NSR9	170	57	265	62	500	68
NSR10	265	62	185	58	550	69
NSR11	330	64	145	56	580	70
NSR12	380	65	150	56	615	70
NSR13	400	66	155	56	630	70
NSR14	450	67	160	57	650	71

The noise level at each NSR emanating from percussive piling operation was calculated and is presented in Table 7.3.8.

The ANLs for NSRs 1 and 3 with respect to piling noise will be 85 dB(A) and 90 dB(A) for the other NSRs. Table 7.3.8 shows that all NSRs will be subjected to maximum noise levels emanating from percussive piling below the statutory requirements. Percussive piling can be executed for 12 hours a day without any mitigation. However, it should be noted that percussive piling is strictly prohibited between 1900 and 0700 and on general holidays.

7.3.5 Control and Mitigation

The current NCO and its subsidiary regulations such as Noise Control (Hand Held Pneumatic Breakers) Regulations and Noise Control (Air Compressors) Regulations should be strictly complied with. If construction works are carried out in the evening (1900 - 2300) and during the night time (2300 - 0700) or any time on general holidays (including Sundays), mitigation measures will be required to reduce the noise levels to acceptable limits in order to obtain construction noise permits. Possible measures include erection of substantial noise barriers to screen out the stationary plant which should be designed in accordance with BS5228:1984 or 'A Practical Guide for the Reduction of Noise from Construction Works' published by EPD.

All plant and equipment used on the construction works should be routinely maintained in good working condition and effectively 'sound-reduced' by means of silencers, mufflers or acoustic linings to avoid disturbance to any nearby noise sensitive receivers. Operational aspects should be considered, such as limiting the number of trucks at any place at the same time, where these conditions are practical and may be reasonably enforced. In the case of site operation as a public dump, such controls would be difficult to implement. However, a time restriction on the hours for operating the public dump should be required.

The above requirement should be incorporated in the contract documentation. The inclusion of a 75 dB(A) daytime construction noise limit, as measured at NSRs, in the contract documentation is not recommended. Such a limit is desirable, but may lead to conflict with other contractual requirements and may result in a significant lengthening of the reclamation period.

7.3.6 Monitoring and Audit Requirements

NSRs in the area are double glazed and are unlikely to be adversely affected by construction noise. However, there are some public amenity areas along the waterfront and to the east of the Grand Hyatt Hotel. In order to minimise impacts on these areas and provide a reference in case of public complaints, it is recommended that a programme of regular monitoring is undertaken involving two periods of 3 consecutive 5 minute L_{Aeq} measurements per week made at points recommended in the Monitoring and Audit Manual.

The instrumentation and procedures adopted for the measurements should comply with the requirements of the 'Technical Memorandum on Noise from Construction Work other than Percussive Piling'.

The results should be audited in accordance with the monitoring and audit manual.

7.4 Traffic Noise

7.4.1 Sensitive Receivers

Twenty-five existing sensitive facades in the study area were identified. These are shown in Figure 7.2 and described in Table 7.4.1.

Table 7.4.1 Location of Sensitive Facades

Sensitive Facade	Location
1	Gloucester No. 169-170
2	Sun Hung Kai Centre (South)
3	Sun Hung Kai Centre (North)
4	Causeway Centre (South)
5	Causeway Centre (North)
6	Harbour Centre
7	Great Eagle Centre
8	Harbour View Hotel (East)
9	Harbour View Hotel (North)
10	Harbour View Hotel (South)
11	HK Convention & Exhibition Centre (South)
12	HK Convention & Exhibition Centre (North)
13	Grand Hyatt Hotel (North)
14	Grand Hyatt Hotel (South)
15	Grand Hyatt Hotel (West)
16	Central Plaza (South)
17	Central Plaza (North)
18	Wan Chai Magistracy (South)
19	Wan Chai Magistracy (North)
20	Shui On Centre
21	YMCA Hotel
22	Arts Centre
23	HK Academy for Performing Arts (South)
24	HK Academy for Performing Arts (North)
25	Telephone House

The lowest levels of the sensitive facades, where sensitive uses are located, were adopted for the assessment of road traffic noise.

7.4.2 Existing Conditions

The existing environment is dominated by traffic noise from Gloucester Road and Harbour Road. An estimate of noise from these sources was made using traffic figures taken from the Annual Traffic Census 1990, Transport Department. Seven percent of the daily traffic flow was taken to represent peak hour flows. The percentage of heavy goods vehicles was calculated from the vehicle classification data for Core Station 1001. Calculations were carried out using the UK Department of Transport document 'Calculation of Road Traffic Noise', 1988 (CRTN). This methodology was adopted in the Final Report on 'Central Reclamation, Phase 1, Focused Environmental Impact Assessment Study'.

This assumes a distance of 10 m or less to the sensitive receivers. There are sensitive receivers on Gloucester Road and Harbour Road and therefore an additional correction for distance is not considered necessary.

The existing traffic noise levels at the facades of the buildings at lower floor levels on these roads are estimated as shown in Table 7.4.2. At higher floors, noise levels will reduce because of distance attenuation.

Table 7.4.2 Calculation of Existing Road Traffic Noise Levels (L_{10})

Statistic	Gloucester Road	Harbour Road
Daily vehicle flow 1990	155,650	12,330
7% (peak hour flow)	10,900	860
Basic Noise Level, dB(A)	82.6	71.5
% of HGVs	15.8	15.8
Correction for speed and % of HGVs, dB(A)	+0.5 @ 40 km/hr & +3.5 @ 80 km/hr	+0.5 @ 40 km/hr & +3.5 @ 80 km/hr
Facade effect, dB(A)	+2.5	+2.5
Corrected Noise Level, dB(A)	**83.1 to 86.1**	**72 to 75**

Note: Traffic noise is described in terms of L_{10} in accordance with the standard CRTN calculation methodology.

An empirical relationship between L_{10} and L_{eq}, i.e. $L_{10} = L_{eq} + 3$ dB(A), is given in the publication 'Road Traffic Noise' (Alexandre, A. *et al*, 1975). This equation holds for vehicle flows of more than or equal to about 100 vehicles per hour and thus it can be applied in these circumstances. Therefore, the L_{eq} of the traffic noise levels generated from the road traffic from these roads can be estimated approximately as follows:

Gloucester Road : 80.1 to 83.1 dB(A)
Harbour Road : 69 to 72 dB(A)

7.4.3 Assessment Methodology

The traffic noise levels at the facades of receivers were predicted using the UK Department of Transport 'Calculation of Road Traffic Noise' 1988 (CRTN). Sensitive facades were selected in accordance with the definition laid down in HKPSG. Assumptions for the assessment were:

(a) design year of 2001 for roads constructed as part of the HK Convention and Exhibition Centre Extension contract, and design year of 2006 for full completion of project;

(b) predicted peak hour flow (vehicles per hour) for the roads for design years 2001 and 2006 are shown in Figure 6.4 with 11% heavy goods vehicles (HGVs). It is noted that the traffic flows for the design years are predicted based on the master development.

(c) the CRTN methodology states that vehicles over 1,525 kg unladen weight should be considered as HGVs, which includes the Public Light Bus (PLB) category of vehicles;

(d) traffic speed was taken as 70 km/hr on Gloucester Road and 50 km/hr on other roads;

(e) the road surface was assumed to be impervious bitumen/concrete.

7.4.4 Impacts on Receivers

The impacts on sensitive facades 1 to 26 are shown in Table 7.4.3. Noise impacts on higher levels would be reduced due to distance attenuation.

Table 7.4.3 Noise Impacts on the Sensitive Facades

Sensitive Facade	Existing Noise Level, dB(A) (L_{10})	Design year of 2001, dB(A) (L_{10})	Design year of 2006, dB(A) (L_{10})
1	85.1	85.0	84.7
2	82.5	81.9	81.3
3	72.3	71.5	73.1
4	82.1	81.5	80.9
5	70.5	72.2	72.5
6	60.6	63.4	66.4
7	65.3	67.3	67.6
8	65.6	67.5	69.8
9	72.7	69.4	73.2
10	64.6	66.5	66.4
11	73.4	76.4	75.7
12	75.6	78.5	75.7
13	59.6	60.1	62.6
14	61.5	64.0	63.8
15	61.6	64.6	66.3
16	80.1	79.5	78.8
17	75.0	78.0	77.3
18	71.7	71.9	71.3
19	72.5	74.7	74.1
20	73.9	76.8	76.3
21	68.5	70.7	71.3
22	73.4	73.8	73.8
23	79.1	78.3	77.9
24	71.5	75.8	75.5
25	76.1	75.6	75.0

It may be observed that noise levels at most sensitive facades may potentially exceed the HKPSG limits. The predicted noise levels of all sensitive facades, which are in exceedance of HKPSG limit, are higher than for the existing traffic noise environment by not more than 4.3 dB(A) and 4 dB(A) for the year of 2001 and 2006 respectively. However, according to the accompanying Volume 1 to this Report "Engineering and Traffic" [Section 4.4.2 a, page 4/15], the introduction of traffic generated by the HKCEC Extension will only marginally alter the traffic levels (and hence the noise levels) on road links within the primary study area. In fact, traffic in the vicinity of Gloucester Road and Tonnochy Road for the year 2001 is predicted to be lower with the Extension than without the Extension (5184 pcu/h versus 5311 pcu/h respectively).

The maximum exceedance appears at the northern facade of The HK Academy for Performing Arts for both design years. It is because the predicted peak hour traffic flows for design years of 2001 and 2006 are higher than the existing peak hourly traffic flows on Fenwick Pier Street. In general, future noise levels at the sensitive facades facing Gloucester Road will be lower than the existing noise levels due to the decrease of traffic flow on Gloucester Road. It is predicted that the traffic noise impacts on the NSRs due to development of HKCEC will be immaterial.

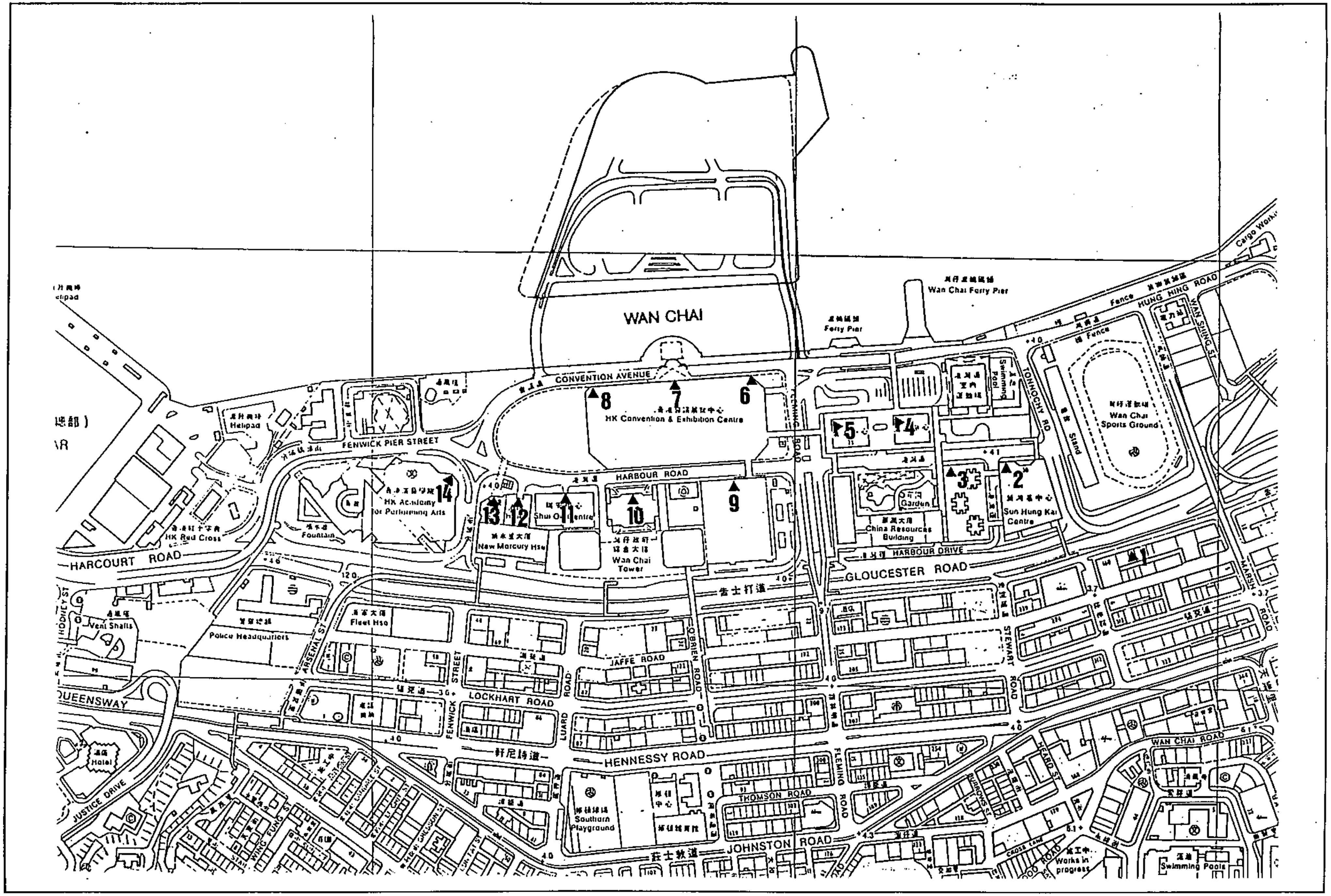
7.4.5 Control and Mitigation

All sensitive buildings are provided with central air-conditioning (except the Causeway Centre) and high quality glazing. This effectively means that the facades are non-sensitive to traffic noise, and hence that the requirements of the HKPSG can be met.

As the development has only negligible effect on traffic noise at the Causeway Centre, it is not considered in appropriate to recommend project-specific mitigation measures.

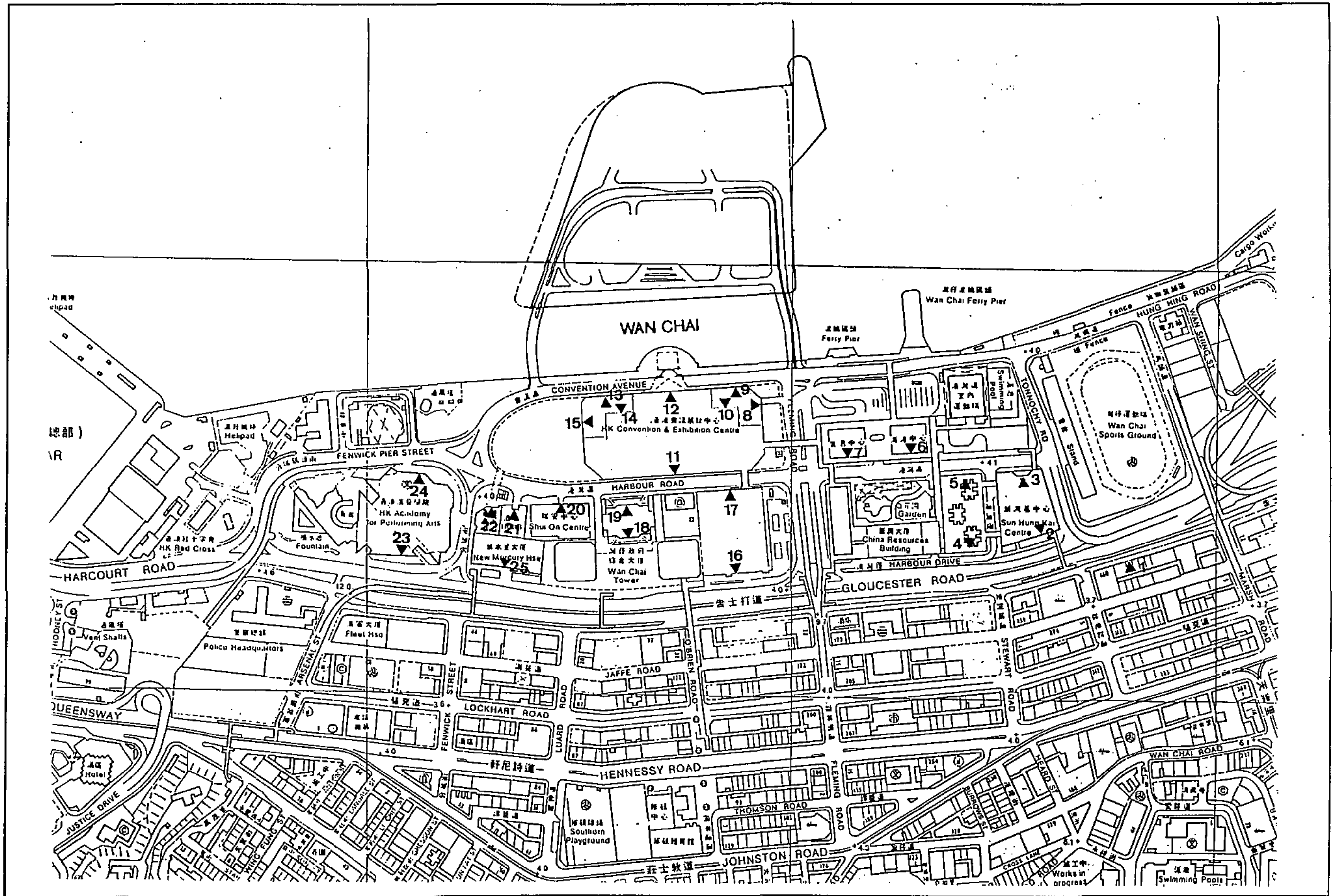
7.4.6 Monitoring and Audit Requirement

As traffic noise impact is a long term issue, monitoring and audit are not applicable.



▲ Noise Sensitive Receiver

Figure 7.1 Locations of Noise Sensitive Receivers



▲ Noise Sensitive Facade

Figure 7.2 Locations of Noise Sensitive Facades

Table 7.3.2 Plant Schedule 1 - Reclamation Contract

Equipment	Number of Items of Equipment in Operation (Total Sound Power Level, dB(A))																																					
	1994		1995												1996												1997											
	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12
Material Handling																																						
Mobile Crane	1 (112)	1 (112)	2 (115)	2 (115)	2 (115)	2 (115)	2 (115)	2 (115)	2 (115)	2 (115)	2 (115)	2 (115)	2 (115)	2 (115)	2 (115)	2 (115)	2 (115)	2 (115)	2 (115)	2 (115)	2 (115)	2 (115)	2 (115)	2 (115)	2 (115)													
Track Crane									1 (112)	1 (112)	1 (112)	1 (112)	1 (112)	1 (112)	1 (112)	1 (112)	1 (112)	1 (112)	1 (112)	1 (112)	1 (112)	1 (112)	1 (112)	1 (112)														
Concreting																																						
Ready-mix Trunk		2 (112)	2 (112)	2 (112)	2 (112)	4 (115)	4 (115)	4 (115)	4 (115)	4 (115)	4 (115)	4 (115)	4 (115)	4 (115)	4 (115)	4 (115)	4 (115)	4 (115)	4 (115)	4 (115)	4 (115)	4 (115)	4 (115)	4 (115)	4 (115)													
Concrete Pump			1 (109)	1 (109)	1 (109)	2 (112)	2 (112)	2 (112)	2 (112)	2 (112)	2 (112)	2 (112)	2 (112)	2 (112)	2 (112)	2 (112)	2 (112)	2 (112)	2 (112)	2 (112)	2 (112)	2 (112)	2 (112)	2 (112)														
Excavation and Filling																																						
Dump Truck								4 (123)	4 (123)	4 (123)	4 (123)	4 (123)	4 (123)	3 (122)	3 (122)	3 (122)	3 (122)	3 (122)	3 (122)	3 (122)	3 (122)	3 (122)	3 (122)	3 (122)														
Dozer		1 (115)	2 (118)	2 (118)	2 (118)	2 (118)	2 (118)	2 (118)	2 (118)	2 (118)	2 (118)	2 (118)	2 (118)	2 (118)	2 (118)	2 (118)	2 (118)	2 (118)	2 (118)	2 (118)	2 (118)	2 (118)	2 (118)	2 (118)														
Backhoe	2 (115)	2 (115)	2 (115)	2 (115)	2 (115)	2 (115)	2 (115)	2 (115)	2 (115)	2 (115)	2 (115)	2 (115)	2 (115)	2 (115)	2 (115)	2 (115)	2 (115)	2 (115)	2 (115)	2 (115)	2 (115)	2 (115)	2 (115)	2 (115)	2 (115)													
Lorry	2 (115)	2 (115)	3 (117)	3 (117)	3 (117)	3 (117)	3 (117)	3 (117)	3 (117)	3 (117)	3 (117)	3 (117)	3 (117)	3 (117)	3 (117)	3 (117)	3 (117)	3 (117)	3 (117)	3 (117)	3 (117)	3 (117)	3 (117)	3 (117)	3 (117)													
Marine																																						
Tug Boat	1 (110)	1 (110)	1 (110)	1 (110)	1 (110)	1 (110)	1 (110)	1 (110)	1 (110)	1 (110)	1 (110)	1 (110)	1 (110)	1 (110)	1 (110)	1 (110)	1 (110)																					
Barge	2 (107)	2 (107)	4 (110)	4 (110)	4 (110)	4 (110)	4 (110)	4 (110)	4 (110)	4 (110)	4 (110)	4 (110)	4 (110)	4 (110)	2 (107)	2 (107)	2 (107)																					
Grab Dregder	2 (115)	2 (115)	2 (115)	2 (115)	2 (115)	2 (115)	1 (112)	1 (112)	1 (112)	1 (112)	1 (112)	1 (112)	1 (112)	1 (112)	1 (112)	1 (112)	1 (112)																					
Lighter	1 (104)	1 (104)	2 (107)	2 (107)	2 (107)	2 (107)	2 (107)	2 (107)	2 (107)	2 (107)	2 (107)	2 (107)	2 (107)	1 (104)	1 (104)	1 (104)	1 (104)																					
Piling																																						
Bored Piling Rig												1 (115)	1 (115)	1 (115)																								
Tubular Steel Piling Rig			2 (135)	2 (135)	3 (137)	3 (137)	3 (137)	3 (137)																														
Auxiliary																																						
Compressor	1 (104)	1 (104)	2 (107)	2 (107)	2 (107)	2 (107)	2 (107)	2 (107)	2 (107)	2 (107)	2 (107)	2 (107)	2 (107)	2 (107)	2 (107)	2 (107)	2 (107)	2 (107)	2 (107)	2 (107)	2 (107)	2 (107)	2 (107)	2 (107)	2 (107)													
Generators	1 (108)	1 (108)	2 (111)	2 (111)	2 (111)	2 (111)	2 (111)	2 (111)	2 (111)	2 (111)	2 (111)	2 (111)	2 (111)	2 (111)	2 (111)	2 (111)	2 (111)	2 (111)	2 (111)	2 (111)	2 (111)	2 (111)	2 (111)	2 (111)	2 (111)													
Hydraulic Impact Breaker	2 (125)	2 (125)	2 (125)	2 (125)	2 (125)	2 (125)																																

Table 7.3.3 Plant Schedule 2 - Building Contract

Number of Items of Equipment in Operation (Total Sound Power Level, dB(A))

Equipment	1995 11	1995 12
Material Handling		
Mobile Crane	1 (112)	1 (112)
Track Crane		
Concreting		
Ready-mix Trunk		3 (114)
Concrete Pump		2 (112)
Excavation and Filling		
Dump Truck		
Dozer		1 (115)
Backhoe	2 (115)	2 (115)
Lorry	2 (115)	2 (115)
Marine		
Tug Boat	1 (110)	1 (110)
Barge	3 (109)	4 (110)
Grab Dregder	2 (115)	2 (115)
Lighter	1 (104)	1 (104)
Piling		
Bored Piling Rig	2 (118)	2 (118)
Diaphragm Wall Rig	2 (108)	4 (111)
Auxiliary		
Compressor	2 (107)	2 (107)
Generators	2 (111)	2 (111)
Hydraulic Impact Breaker	2 (125)	2 (125)

Equipment	1996 1	2	3	4	5	6	7	8	9	10	11	12
Material Handling												
Mobile Crane	2 (115)	2 (115)	2 (115)	2 (115)	2 (115)	2 (115)	2 (115)	2 (115)	2 (115)	2 (115)	2 (115)	2 (115)
Track Crane							1 (112)	1 (112)	1 (112)	1 (112)	1 (112)	1 (112)
Concreting												
Ready-mix Trunk	4 (115)	4 (115)	4 (115)	4 (115)	4 (115)	4 (115)	4 (115)	4 (115)	4 (115)	4 (115)	4 (115)	4 (115)
Concrete Pump	3 (114)	3 (114)	3 (114)	3 (114)	3 (114)	3 (114)	3 (114)	3 (114)	3 (114)	3 (114)	3 (114)	3 (114)
Excavation and Filling												
Dump Truck			4 (123)	4 (123)	4 (123)	4 (123)	4 (123)	4 (123)	4 (123)	4 (123)	4 (123)	4 (123)
Dozer	2 (118)	2 (118)	2 (118)	2 (118)	2 (118)	2 (118)	2 (118)	2 (118)	2 (118)	2 (118)	2 (118)	2 (118)
Backhoe	2 (115)	2 (115)	2 (115)	2 (115)	2 (115)	2 (115)	2 (115)	2 (115)	2 (115)	2 (115)	2 (115)	2 (115)
Lorry	3 (117)	3 (117)	3 (117)	3 (117)	3 (117)	3 (117)	3 (117)	3 (117)	3 (117)	3 (117)	3 (117)	3 (117)
Marine												
Tug Boat	1 (110)	1 (110)	1 (110)	1 (110)	1 (110)	1 (110)	1 (110)	1 (110)	1 (110)	1 (110)	1 (110)	1 (110)
Barge	4 (110)	4 (110)	4 (110)	4 (110)	4 (110)	4 (110)	4 (110)	4 (110)	4 (110)	4 (110)	4 (110)	4 (110)
Grab Dregder	2 (115)	2 (115)	2 (115)	2 (115)	1 (112)	1 (112)	1 (112)	1 (112)	1 (112)	1 (112)	1 (112)	1 (112)
Lighter	2 (107)	2 (107)	2 (107)	2 (107)	2 (107)	2 (107)	2 (107)	2 (107)	2 (107)	2 (107)	2 (107)	1 (104)
Piling												
Bored Piling Rig	4 (121)	4 (121)	4 (121)	4 (121)	4 (121)	4 (121)	4 (121)	3 (120)	3 (120)	3 (120)		
Diaphragm Wall Rig	4 (111)	4 (111)	4 (111)	4 (111)	4 (111)	4 (111)	4 (111)	3 (110)	3 (110)	3 (110)		
Auxiliary												
Compressor	3 (109)	3 (109)	3 (109)	3 (109)	3 (109)	3 (109)	3 (109)	3 (109)	3 (109)	3 (109)	3 (109)	3 (109)
Generators	3 (113)	3 (113)	3 (113)	3 (113)	3 (113)	3 (113)	3 (113)	3 (113)	3 (113)	3 (113)	3 (113)	3 (113)
Hydraulic Impact Breaker	2 (125)	2 (125)	2 (125)	2 (125)	2 (125)	2 (125)	2 (125)	2 (125)				

Equipment	1997 1	2	3	4	5	6	7	8	9	10	11	12
Material Handling												
Mobile Crane	2 (115)	2 (115)	2 (115)	2 (115)	2 (115)	2 (115)	2 (115)	2 (115)	2 (115)	2 (115)	2 (115)	
Track Crane	1 (112)	1 (112)	1 (112)	1 (112)	1 (112)	1 (112)	1 (112)	1 (112)	1 (112)	1 (112)		
Concreting												
Ready-mix Trunk	4 (115)	4 (115)	4 (115)	4 (115)	4 (115)	4 (115)	4 (115)	4 (115)	4 (115)	4 (115)	4 (115)	
Concrete Pump	3 (114)	3 (114)	3 (114)	3 (114)	3 (114)	3 (114)	3 (114)	3 (114)	3 (114)	3 (114)	3 (114)	
Excavation and Filling												
Dump Truck												
Dozer												
Backhoe	2 (115)	2 (115)	2 (115)	2 (115)	2 (115)	2 (115)	2 (115)	2 (115)	2 (115)	2 (115)	2 (115)	2 (115)
Lorry	3 (117)	3 (117)	3 (117)	3 (117)	3 (117)	3 (117)	3 (117)	3 (117)	3 (117)	3 (117)	3 (117)	3 (117)
Auxiliary												
Compressor	3 (109)	3 (109)	3 (109)	3 (109)	3 (109)	3 (109)	3 (109)	3 (109)	3 (109)	3 (109)	3 (109)	3 (109)
Generators	3 (113)	3 (113)	3 (113)	3 (113)	3 (113)	3 (113)	3 (113)	3 (113)	3 (113)	3 (113)	3 (113)	3 (113)

Equipment	1998 1	2	3	4	5	6	7	8	9	10	11	12
Material Handling												
Mobile Crane	1 (112)	1 (112)	1 (112)	1 (112)	1 (112)	1 (112)	1 (112)	1 (112)	1 (112)	1 (112)	1 (112)	
Excavation and Filling												
Backhoe	2 (115)	2 (115)	2 (115)	2 (115)	2 (115)	2 (115)	2 (115)	2 (115)	2 (115)	2 (115)	2 (115)	
Lorry	3 (117)	3 (117)	3 (117)	3 (117)	3 (117)	3 (117)	3 (117)	3 (117)	3 (117)	3 (117)	3 (117)	
Auxiliary												
Compressor	3 (109)	3 (109)	3 (109)	3 (109)	3 (109)	3 (109)	3 (109)	3 (109)	3 (109)	3 (109)	3 (109)	
Generators	3 (113)	3 (113)	3 (113)	3 (113)	3 (113)	3 (113)	3 (113)	3 (113)	3 (113)	3 (113)	3 (113)	

Table 7.3.6 Noise Levels at NSRs from Construction Activities other than Percussive Piling

NSR	Activity	1994		1995												1996												1997												1998											
		11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12
NSR1	Reclamation	61	63	64	64	64	65	64	67	67	67	67	67	67	67	66	66	66	66	66	66	66	66	66	66	62																									
	Building													63	65	67	67	68	68	68	68	68	68	68	68	67	67	63	63	63	63	63	63	63	63	63	63	63	60	61	61	61	61	61	61	61	61	61	61	61	
	HB1	64	64	64	64	64	64							64	64	64	64	64	64	64	64	64	64																												
	HB2	60	60	60	60	60	60							60	60	60	60	60	60	60	60	60	60																												
	Total SWL, dB(A)	67	67	68	68	68	68	64	67	67	67	67	67	70	71	71	71	72	71	71	71	71	71	70	70	68	67	63	63	63	63	63	63	63	63	63	63	63	60	61	61	61	61	61	61	61	61	61	61	61	
NSR2	Reclamation	65	67	68	68	68	69	68	71	71	71	71	71	71	71	70	70	70	70	70	70	70	70	70	70	66																									
	Building													67	69	71	71	72	72	72	72	72	72	72	72	71	71	67	67	67	67	67	67	67	67	67	67	67	64	65	65	65	65	65	65	65	65	65	65	65	
	HB1	68	68	68	68	68	68							68	68	68	68	68	68	68	68	68	68																												
	HB2	62	62	62	62	62	62							62	62	62	62	62	62	62	62	62	62																												
	Total SWL, dB(A)	71	71	72	72	72	72	68	71	71	71	71	71	74	74	75	75	75	75	75	75	75	75	74	74	72	71	67	67	67	67	67	67	67	67	67	67	67	64	65	65	65	65	65	65	65	65	65	65	65	
NSR3	Reclamation	67	69	70	70	70	71	70	73	73	73	73	73	73	73	72	72	72	72	72	72	72	72	72	72	68																									
	Building													69	71	73	73	74	74	74	74	74	74	74	74	73	73	69	69	69	69	69	69	69	69	69	69	69	66	67	67	67	67	67	67	67	67	67	67	67	
	HB1	70	70	70	70	70	70							70	70	70	70	70	70	70	70	70	70																												
	HB2	63	63	63	63	63	63							63	63	63	63	63	63	63	63	63	63																												
	Total SWL, dB(A)	72	73	74	74	74	74	70	73	73	73	73	73	76	76	77	77	77	77	77	77	77	77	76	76	74	73	69	69	69	69	69	69	69	69	69	69	69	66	67	67	67	67	67	67	67	67	67	67	67	
NSR4	Reclamation	70	72	73	73	73	74	73	76	76	76	76	76	76	76	75	75	75	75	75	75	75	75	75	75	71																									
	Building													72	74	76	76	77	77	77	77	77	77	77	77	76	76	72	72	72	72	72	72	72	72	72	72	72	69	70	70	70	70	70	70	70	70	70	70	70	
	HB1	74	74	74	74	74	74							74	74	74	74	74	74	74	74	74	74																												
	HB2	64	64	64	64	64	64							64	64	64	64	64	64	64	64	64	64																												
	Total SWL, dB(A)	76	76	77	77	77	77	73	76	76	76	76	76	79	79	80	80	81	80	80	80	80	80	79	79	77	76	72	72	72	72	72	72	72	72	72	72	72	69	70	70	70	70	70	70	70	70	70	70	70	
NSR5	Reclamation	72	74	75	75	75	76	75	78	78	78	78	78	78	78	77	77	77	77	77	77	77	77	77	77	73																									
	Building													74	76	78	78	79	79	79	79	79	79	79	79	78	78	74	74	74	74	74	74	74	74	74	74	74	71	72	72	72	72	72	72	72	72	72	72	72	
	HB1	78	78	78	78	78	78							78	78	78	78	78	78	78	78	78	78																												
	HB2	66	66	66	66	66	66							66	66	66	66	66	66	66	66	66	66																												
	Total SWL, dB(A)	79	80	80	80	80	80	75	78	78	78	78	78	82	82	83	83	83	83	83	83	83	83	81	81	79	78	74	74	74	74	74	74	74	74	74	74	74	71	72	72	72	72	72	72	72	72	72	72	72	
NSR6	Reclamation	78	80	81	81	81	82	81	84	84	84	84	84	84	84	83	83	83	83	83	83	83	83	83	83	79																									
	Building													80	82	84	84	85	85	85	85	85	85	85	85	84	84	80	80	80	80	80	80	80	80	80	80	80	77	78	78	78	78	78	78	78	78	78	78	78	
	HB1	81	81	81	81	81	81							81	81	81	81	81	81	81	81	81	81																												
	HB2	69	69	69	69	69	69							69	69	69	69	69	69	69	69	69	69																												
	Total SWL, dB(A)	83	84	84	84	84	85	81	84	84	84	84	84	87	87	88	88	88	88	88	88	88	88	87	87	85	84	80	80	80	80	80	80	80	80	80	80	80	77	78	78	78	78	78	78	78	78	78	78	78	
NSR7	Reclamation	78	80	81	81	81	82	81	84	84	84	84	84	84	84	83	83	83	83	83	83	83	83	83	83	79																									
	Building													80	82	84	84	85	85	85	85	85	85	85	85	84	84	80	80	80	80	80	80	80	80	80	80	80	77	78	78	78	78	78	78	78	78	78	78	78	
	HB1	73	73	73	73	73	73							73	73	73	73	73	73	73	73	73	73																												
	HB2	73	73	73	73	73	73							73	73	73	73	73	73	73	73	73	73																												
	Total SWL, dB(A)	80	81	82	82	82	83	81	84	84	84	84	84	86	86	87	87	88	88	88	88	88	87	87	87	85	84	80	80	80	80	80	80	80	80	80	80	80	77	78	78	78	78	78	78	78	78	78	78	78	
NSR8	Reclamation	77	79	80	80	80	81	80	83	83	83	83	83	83	83	82	82	82	82	82	82	82	82	82	82	78																									
	Building													79	81	83	83	84	84	84	84	84	84	84	84	83	83	79	79	79	79	79	79	79	79	79	79	79	76	77	77	77	77	77	77	77	77	77	77	77	
	HB1	69	69	69	69	69	69							69	69	69	69	69	69	69	69	69	69																												
	HB2	81	81	81	81	81	81							81	81	81	81	81	81	81	81	81	81																												
	Total SWL, dB(A)	83	83	84	84	84	84	80	83	83	83	83	83	86	86	87	87	88	87	87	87	87	87	86	86	84	83	79	79	79	79	79	79	79	79	79	79	79	76	77	77	77	77	77	77	77	77	77	77	77	
NSR9	Reclamation	70	72	73	73	73	74	73	76	76	76	76	76	76	76	75	75	75	75	75	75	75	75	75	75	71																									
	Building													72	74	76	76	77	77	77	77	77	77	77	77	76	76	72	72	72	72	72	72	72	72	72	72	72	69	70	70	70	70	70	70	70	70	70	70	70	
	HB1	72	72	72	72	72	72							72	72	72	72	72	72	72	72	72	72																												
	HB2	69	69	69	69	69	69							69	69	69	69	69	69	69	69	69	69																												
	Total SWL, dB(A)	75	76	77	77	77	77	73	76	76	76	76	76	79	79	80	80	80	80	80	80	80	80	79	79	77	76	72	72	72	72	72	72	72	72	72	72	72	69	70	70	70	70	70	70	70	70	70	70	70	
NSR10	Reclamation	70	72	73	73	73	74	73	76	76	76	76	76	76	76	75	75	75	75	75	75	75	75	75	75	71																									
	Building													72	74	76	76	77	77	77	77	77	77	77	77	76	76	72	72	72	72	72	72	72	72	72	72	72	69	70	70	70	70	70	70	70	70	70	70	70	
	HB1	69	69	69	69	69	69							69	69	69	69	69	69	69	69	69	69																												
	HB2	72	72	72	72	72	72							72	72	72	72	72	72	72	72	72	72																												
	Total SWL, dB(A)	75	76	77	77	77	77	73	76	76	76	76	76	79	79	80	80	80	80	80	80	80	80	79	79	77	76	72	72	72	72	72	72	72	72	72	72	72	69	70	70	70	70	70	70	70	70	70	70	70	
NSR11	Reclamation	69	71	72	72	72	73	72	75	75	75	75	75	75	75	74	74	74	74	74	74	74	74	74	74	70																									
	Building													71	73	75	75	76	76	76	76	76	76	76	76	75	75	71	71	71	71	71	71	71	71	71	71	71	68	69	69	69	69	69	69	69	69	69	69	69	
	HB1	67	67	67	67	67	67							67	67	67	67	67	67	67	67	67	67																												
	HB2	74	74	74	74	74	74							74	74	74	74	74	74	74	74	74	74																												
	Total SWL, dB(A)	76	76	77	77	77	77	72	75	75	75	75	75	79	79	79	79	80	80	80	80	80	80	78	78	76	75	71	71	71	71	71	71	71	71	71	71	71	68	69	69	69	69	69	69	69	69	69	69	69	
NSR12	Reclamation	68	70	71	71	71	72	71	74	74	74	74	74	74	74	73	73	73	73	73	73	73	73	73	73	69																									
	Building													70	72	74	74	75	75	75	75	75	75	75	75	74	74	70	70	70	70	70	70	70	70	70	70	70	67	68	68	68	68	68	68	68	68	68	68	68	
	HB1	65	65	65	65	65	65							65	65	65	65	65	65	65	65	65	65																												
	HB2	73	73	73	73	73	73							73	73	73	73	73	73	73	73	73	73																												
	Total SWL, dB(A)	75	75	76	76	76	76	71	74	74	74	74	74	78	78	78	78	79	79	79	79	79	79	77	77	75	74	70	70	70	70	70	70	70	70	70	70	70	67	68	68	68	68	68	68	68	68	68	68	68	
NSR13	Reclamation	68	70	71	71	71	72	71	74	74	74	74	74	74	74	73	73	73	73	73	73	73	73	73	73	69																									
	Building													70	72	74	74	75	75	75	75	75	75	75	75	74	74	70	70	70	70	70	70	70	70	70	70	70	67	68	68	68	68	68	68	68	68	68	68	68	
	HB1	65	65	65	65	65	65							65	65	65	65	65	65	65	65	65	65																												
	HB2	73	73	73	73	73	73							73	73	73	73	73	73	73	73	73	73																												
	Total SWL, dB(A)	75	75	76	76	76	76	71	74	74	74	74	74	78	78	78	78	79	79	79	79	79	79	77	77	75	74	70	70	70	70	70	70	70	70	70	70	70	67	68	68	68	68	68	68	68	68	68	68	68	
NSR14	Reclamation	69	71	72	72	72	73	72	75	75	75	75	75	75	75	74	74	74	74	74	74	74	74	74	74	70																									
	Building													71	73	75	75	76	76	76	76	76	76	76	76	75	75	71	71	71	71	71	71	71	71	71	71	71	68	69	69	69	69	69	69	69	69	69	69	69	
	HB1	64	64	64	64	64	64							64	64	64	64	64	64	64	64	64	64																												
	HB2	73	73	73	73	73	73							73	73	73	73	73	73	73	73	73	73																												
	Total SWL, dB(A)	75	75	76	76	76	76	72	75	75	75	75	75	78	79	79	79	80	80	79	79	80	79	78	78	76	75	71	71	71	71	71	71	71	71	71	71	71	68	69	69	69	69	69	69	69	69	69	69	69	

Table 7.3.8 Noise Levels at NSRs from Percussive Piling

NSR	Activity	1994		1995											
		11	12	1	2	3	4	5	6	7	8	9	10	11	12
NSR1	Other PME			68	68	68	68	68	68						
	Breaker 1			63	63	63	63	63	63						
	Breaker 2					64	64	64	64						
	Total SWL, dB(A)			69	69	70	70	70	70						
NSR2	Other PME			73	73	73	73	73	73						
	Breaker 1			66	66	66	66	66	66						
	Breaker 2					66	66	66	66						
	Total SWL, dB(A)			74	74	74	74	74	74						
NSR3	Other PME			75	75	75	75	75	75						
	Breaker 1			67	67	67	67	67	67						
	Breaker 2					67	67	67	67						
	Total SWL, dB(A)			76	76	76	76	76	76						
NSR4	Other PME			80	80	80	80	80	80						
	Breaker 1			68	68	68	68	68	68						
	Breaker 2					69	69	69	69						
	Total SWL, dB(A)			80	80	81	81	81	81						
NSR5	Other PME			85	85	85	85	85	85						
	Breaker 1			70	70	70	70	70	70						
	Breaker 2					69	69	69	69						
	Total SWL, dB(A)			85	85	85	85	85	85						
NSR6	Other PME			88	88	88	88	88	88						
	Breaker 1			74	74	74	74	74	74						
	Breaker 2					70	70	70	70						
	Total SWL, dB(A)			88	88	88	88	88	88						
NSR7	Other PME			79	79	79	79	79	79						
	Breaker 1			78	78	78	78	78	78						
	Breaker 2					69	69	69	69						
	Total SWL, dB(A)			82	82	82	82	82	82						
NSR8	Other PME			74	74	74	74	74	74						
	Breaker 1			88	88	88	88	88	88						
	Breaker 2					68	68	68	68						
	Total SWL, dB(A)			88	88	88	88	88	88						
NSR9	Other PME			78	78	78	78	78	78						
	Breaker 1			73	73	73	73	73	73						
	Breaker 2					67	67	67	67						
	Total SWL, dB(A)			79	79	79	79	79	79						
NSR10	Other PME			73	73	73	73	73	73						
	Breaker 1			77	77	77	77	77	77						
	Breaker 2					66	66	66	66						
	Total SWL, dB(A)			78	78	79	79	79	79						
NSR11	Other PME			71	71	71	71	71	71						
	Breaker 1			79	79	79	79	79	79						
	Breaker 2					65	65	65	65						
	Total SWL, dB(A)			80	80	80	80	80	80						
NSR12	Other PME			70	70	70	70	70	70						
	Breaker 1			79	79	79	79	79	79						
	Breaker 2					65	65	65	65						
	Total SWL, dB(A)			80	80	80	80	80	80						
NSR13	Other PME			69	69	69	69	69	69						
	Breaker 1			79	79	79	79	79	79						
	Breaker 2					65	65	65	65						
	Total SWL, dB(A)			79	79	80	80	80	80						
NSR14	Other PME			68	68	68	68	68	68						
	Breaker 1			78	78	78	78	78	78						
	Breaker 2					64	64	64	64						
	Total SWL, dB(A)			78	78	79	79	79	79						

8. Solid Waste Disposal

8 Solid Waste Disposal

8.1 Introduction

The main waste producing activities will be from the dredging of marine muds and from construction activities. In addition there will be quantities of demolition waste and the potential accumulation of floating refuse which will require collection and disposal. The issues relating to the dredging and disposal of marine muds are discussed in Section 5. The additional sources of waste and their disposal are dealt with here.

8.2 Current Legislation

Under the terms of the Waste Disposal Ordinance (Cap. 354), construction waste is classified as trade waste and as such the contractor is responsible for the disposal of any waste generated during construction activities.

If the site is operated as a public dump site then it is likely that most of the waste produced can be utilised as fill material. The current policy on the use of such material in public dumps is contained within the Works Branch Technical Circular No. 2/93, Public Dumps. This specifies the procedures for obtaining a license to dispose of waste at a public dump site. It is understood that a charge is to be made to dump construction material at sanitary landfill sites in order to encourage the use of public dumps for such material. The EPD together with CED have recently produced a leaflet titled 'New Disposal Arrangements for Construction Waste'. This specifies that construction waste with more than 20% inert material should be sorted and the inert material sent to a public dump site.

8.3 Waste Arisings

8.3.1 Demolition Waste

There will be a limited amount of demolition work for the reclamation. The amenity building next to the Exhibition Centre will probably be demolished and the north-facing canopy of the Centre may be removed in order to extend the building. Small amounts of paving will be removed to construct the piles.

8.3.2 Construction Waste

The fate of any additional material arising during construction works is again dependant on the fill option. Material will need to be taken off-site for disposal if it cannot be used in the reclamation.

8.4 Disposal Options

The fate of demolition and construction materials will depend on the fill material used in the reclamation. If the site is utilised as a public dump site then all or most of the material produced by demolition can be disposed of on site. If contractor-sourced material is chosen as the fill option then demolition waste may also be disposed of here as long as certain requirements such as size and nature of the material are met. This is dependant on restrictions placed on the contractor in terms of material that can be utilised on the site.

The use of the site as a public dump may be favoured, since construction waste from this and other sites can then be utilised for fill. However, the passage of materials to public dump sites cannot be easily controlled, the rate of reclamation is erratic and a large number of trucks may attempt to enter the site at one time causing traffic congestion. Previous studies have indicated that contractor-sourced fill is preferable to public dump as there is more control on site movements. The relative environmental merits of using marine sand instead of contractor sourced fill are arguable. The import of fill by land certainly creates more noise and nuisance impact than placement of sand by dredger. However, if the fill is construction waste, it would have to transported to landfill anyway. Landfills will be likely to be more distant and the route to them may go through urban areas. In addition, dredging of marine sand has been shown to cause considerable environmental impact in the sea.

8.5 Floating Refuse

Construction activities coupled with reduced water circulation in the area and temporary embayment may lead to the build up of floating refuse in certain areas. Mitigation will be required to prevent the build up of floating refuse both during the construction phase and once the scheme is completed.

One of the concerns regarding floating refuse is the potential impact on the cooling water intakes in the area. The partial blockage of some intakes in the area was identified in Working Paper WP2, Cooling Water Discharges. Discussion with property managers identified some intakes which are subject to blockage by litter.

The clearing of floating refuse can be made the responsibility of the contractor by inclusion of such measures in the contract documentation. In previous phases of the Central and Wanchai Reclamation the provision of a water witch, or similar craft has been specified in the contract conditions.

Once the development is complete the clearing of marine litter becomes the responsibility of the Marine Department.

9. Conclusions

9 CONCLUSIONS

9.1 Water Quality

Existing water quality in Victoria Harbour is poor. If compared to general water quality objectives applicable to gazetted Water Control Zones, all parameters would fail the required standards with the exception of dissolved oxygen. Sediments in the Harbour are highly contaminated with metals and also contain high concentrations of organics and nutrients. Therefore any additional inputs of contaminants into the water column will exacerbate the present situation. The key issues in this respect are increases in suspended sediments during dredging and the affect of those sediments on water quality, additonal inputs of sewage from the Extension, and the affect of reclamation programmes on the dispersion of contaminant's within Victoria Harbour.

Sediment plume modelling was based on dredging 500,000 m^3 of mud with a 3% loss to the water column. On this basis, most of the area would experience increases in suspended sediment loads of 0.001 to 0.005 $kg.m^{-3}$ for surface and bottom waters respectively, compared with an existing depth average of 0.01 $kg.m^{-3}$. The sediment plume was narrow and extended for 7 km just offshore of Central and Wan Chai. North Point was predicted as receiving the greatest sediment loads as this was the limit of tidal excursion and local conditions favour deposition. Wet season spring tide simulations represented the worst case for North Point with 0.01 $kg.m^{-3}$ and 0.005 $kg.m^{-3}$ for bottom and surface waters respectively.

Pro rata reductions in suspended sediment loads for lower volumes of dredged mud (220,000 and 50,000 m^3) for worst case conditions at North Point would result in concentrations of 0.044 and 0.01 $kg.m^{-3}$ for bottom waters and 0.002 and 0.0005 $kg.m^{-3}$ for surface waters. Throughout the general area, increases in suspended solids would not be physically measurable for these lower dredging volumes. In view of the wide dispersion of suspended sediments and the tendency for the highest concentrations to be found in the bottom waters, visual impacts of suspended sediments arising from dredging are not likely to be a key issue other than in the immediate vicinty of the dredger. It is also unlikely that local accumulations of sediment will occur.

Increased biochemical oxygen demand (BOD) arising from sediment resuspension under the proposed dredging rates will be negligible. The oxygen demand is dependent on dredging rate and the volume of water available for dispersion, not the total volume of mud to be removed. BOD resulting from dredging activities is therefore not considered to be a key issue.

Water quality modelling of several scenarios identified the option with least water quality impact to be Scenario 3 ie all stormwater loads reduced by 25% together with a 50% reduction on outfall M (which discharges into the channel between the shoreline and the island extension). Scenario 3 included committed reclamations for Central and Wan Chai, and the island extension. Water quality parameters were predicted to be marginally better than for the Baseline condition (committed reclamations without the island extension) except at Stations C and G which lie within the channel between the island extension and shoreline. At C and G, water quality was marginally poorer than for the Baseline although this effect would appear to be localised.

Additional sewage from the HKCEC Extension would represent 2% of the present load. Water quality model predictions indicated an increase in *E.coli* of 8.6% for wet season neap tide. This disproportionate increase in *E.coli* concentration arises from the reduced volume and assimilation capacity of Victoria Harbour resulting from the proposed reclamations. Scenario 3 represented the best mitigation measures in reducing the impact of *E.coli* and other water quality parameters but it should be noted that there will be an increase over present levels, albeit relatively small. Until there is an improvement in sewage treatment capability, no real improvement in water quality can be expected in the study area.

Floating debris will continue to be a problem in the study area, as at present. The construction of the island extension will provide opportunity for floating debris to collect on the east and west sides of the island. However, as the island nature of the extension will be a temporary measure pending further reclamations, there are probably no mitigation measures which could sensibly be incorporated into the design of the island within existing constraints. It is considered unlikely that the presence of the island extension will significantly increase the accumulation of debris in the general area and that the best option will be physical collection.

9.2 Marine Mud Disposal

Sediments in the study area have been classified as Class C and therefore require special dredging and disposal methods. Five metals (Pb, Zn, Hg, Cu and Cr) were present in particularly high concentrations. Concentrations of cadmium and nickel were low in all cases.

The Class C sediment was limited to the surface layer (<30 cm depth) or non-existent, depending on location, with the exception of Station VC3 where the depth of contaminated sediment was 1 m. Typically, metal concentrations diminished as a function of increasing depth. For the purposes of practical dredging, the contaminated muds have been defined as the top 1 m for contaminated locations. Depending on the dredging scenario adopted (part or all of the new sea wall), the volume of contaminated mud has been estimated to be between 11,500 and 34,000 m^3.

9.3 Air Quality

EPD records for 1991 show that present air quality exceeds the annual average Air Quality Objectives for RSP. The major potential additional impacts from the HKCEC Extension will arise from dust generated during reclamation and construction. Vehicle and plant exhaust emissions are not considered to be a key issue.

In the absence of mitigation measures, there may be adverse impacts at some of the sensitive receivers which have a direct line of sight with the reclamation ie HKCEC, Grand Hyatt Hotel, New World Harbour View Hotel, Great Eagle Centre and Harbour Centre. Calculations have shown that TSP concentrations may exceed acceptable limits by up to 35%. However, adoption of dust suppression measures, particularly an effective watering programme, calculations have shown that the TSP concentration at all receivers will be within the acceptable limit.

The evaluation of air quality assessment during the operational phase was considered for design horizons of 2001 and 2006. All predicted concentrations for CO, NO_2 and TSP were compliant with Air Quality Objectives.

9.4 Noise

Twelve out of the fourteen noise sensitive receivers (NSR's) assessed may be exposed to maximum noise levels which exceed the 75 dB(A) non-statutory day-time limit at some periods during the construction phase. However, all affected NSR's are fitted with high quality glazing and central air conditioning which will attenuate received noise levels inside the buildings and would not experience further adverse impact. Mitigation would be necessary for night-time work if the contractor is to obtain a construction noise permit. All NSR's will be subjected to maximum noise levels emanating from percussive piling below the statutory requirements.

Traffic noise levels at most sensitive facades may potentially exceed the HKPSG limits but by not more than 4.3 dB(A) and 4 dB(A) for the years 2001 and 2006 respectively. However, the effect on NSRs due to the HKCEC development will be immaterial.

9.5 Solid Waste Disposal

Disposal of marine muds has been discussed in 9.2 above. The main source of wastes for disposal will derive from demolition and construction activities. The fate of these wastes will depend upon the fill material used in the reclamation. If the site is categorised as a public dump site then all or most of the material produced by demolition and construction can be disposed of on site. Contractor-sourced fill as opposed to public dump fill may be preferable as this would permit more control on site movements. If marine sand is used as fill, all demolition material will require haulage off site.