Civil Engineering Department
Geotechnical Engineering Office

Agreement No. CE 52/94 West of Sulphur Channel Marine Borrow Area

Focused Environmental Impact Assessment

Final Report

December 1994

Scott Wilson Kirkpatrick
CONSULTING ENGINEERS

in association with

Aspinwall & Company
Hydraulics and Water Research Asia Ltd

Civil Engineering Department
Geotechnical Engineering Office

Agreement No. CE 52/94 West of Sulphur Channel Marine Borrow Area

Focused Environmental Impact Assessment

Final Report

December 1994

Scott Wilson Kirkpatrick
CONSULTING ENGINEERS

in association with

Aspinwall & Company
Hydraulics and Water Research Asia Ltd

LIST OF CONTENTS

LIST OF CONTENTS

LIST OF CONTENTS

Tables:

LIST OF CONTENTS

Figures:

LIST OF CONTENTS

LIST OF CONTENTS

SUMMARY, CONCLUSIONS & RECOMMENDATIONS

1. This Focused Environmental Impact Assessment (EIA) has been undertaken for the allocated use of the West of Sulphur Channel (WSC) Marine Borrow Area (MBA) for the dredging of reclamation material, and has been awarded by the Civil Engineering Department (CED) under Agreement No. CE 52/94.

2. The primary purpose of the Focused EIA is to assist in minimising pollution, environmental disturbance and nuisance from the proposed marine borrowing and all related activities in West of Sulphur Channel by providing information on the nature and extent of the potential environmental impacts, identifying the most appropriate dredging method and the recommendation of suitable mitigation measures.

3. Investigations in the WSC area have indicated that if the WSC area is added to the South Tsing Yi (STY) area to the north (Pits 1& 2), the utilisation of the overall sand resource can be optimised. The WSC MBA was authorised for dredging in November 1993. The Director of Environmental Protection indicated however, that a focused EIA, with emphasis on the possible impacts of the sediment plumes from the dredging, will be required prior to adding the WSC area to the STY area. The section of borrow area assessed for the purposes of this study is hereinafter referred to as WSC Pit 3.

4. The WSC Pit 3 is located in one of the busiest fairways in Hong Kong Harbour and lies in shipping routes for which a traffic scheme is in force. The Marine Department imposed the condition that two dredgers could work concurrently in either two of the pits in the area, but only one dredger will be permitted to dredge in the fairway at any one time. As such, it would be impractical to have two dredging contractors working concurrently in the area. For the purpose of this study, it is assumed that the sand extracted from this area will be used to supply sand for the Container Terminal 9 (CT9).

5. The material to be dredged in the borrow area consists of alluvial sand varying in thickness from 5 to 18m present to a depth of -52mPD, which is overlain by marine sand varying in thickness from nil to 8m down to a maximum depth of -42mPD. The marine sand is overlain by marine silt and clay varying in thickness from 2 to 7m, down to a maximum depth of -35mPD.

6. This assessment has been based on a worst case scenario of one trailer suction hopper dredger (TSHD) dredging marine sand in WSC Pit 3 and another TSHD dredging alluvial sand in STY Pit 2. It has also been assumed that dredging within the East of Lamma Channel Marine Borrow area, and that required for the Green Island Reclamation (Part) Public Dump (GIRPD) will be proceeding at the same time.

7. In addition to this Focused EIA, an Environmental Monitoring & Audit (EM&A) Manual has been prepared which specifies the objectives and responsibilities for monitoring and audit, together with protocols for undertaking these roles. Environmental performance requirements for the works are also provided, together with Action Plans for the implementation of mitigation measures to alleviate potentially adverse environmental impacts associated with the works. It is recommended that the EM&A Manual be used in conjunction with this Focused EIA report.

8. A scoping exercise of environmental impacts associated with the works identified major key issues relating to potential impacts in relation to marine water quality and marine ecology, and intermediate impacts with respect to fisheries, mariculture zones, utilities (e.g. submarine pipelines and cables) and visual quality. Minor potential impacts were identified in relation to noise and air quality. Subsequent to the scoping exercise, each of the key issues were assessed with respect to identified sensitive receivers.

Marine Water Quality and Sediments

9. The impacts of dredging in WSC Pit 3 have been investigated quantitatively by applying the WAHMO (Water Quality and Hydrodynamic) MUDFLOW model. The model, which is particularly well suited to simulating the fate of large amounts of sediment losses associated with the overflow dredging of marine and alluvial sand, was set up to predict the extent and concentrations of the sediment plume for four different tide types: spring and neap tides in the dry and wet seasons.

10. The model input data were based on the worst case dredging scenario advised by CED's dredging consultant, DEMAS. The worst case scenario comprised concurrent dredging of marine sand in WSC Pit 3 with dredging for alluvial sand in the nearby STY Pit 2. Because of uncertainties regarding the start of the dredging programme, it was assumed that dredging for GIRPD would also be underway during the most critical period and the dredging source for this project was therefore also included in the model.

11. Predicted impacts have been assessed against background levels, based primarily on the Environmental Protection Department's (EPD) routine monitoring data and against the acceptable limits for a range of specific sensitive receivers. An assessment of the cumulative impacts, taking into account the effects of dredging in the East Lamma Channel, has also been made. Based on the results, a system of monitoring to ensure that impacts are kept to acceptable limits during dredging has been proposed.

12. The fundamental impact that may be expected to result from dredging in WSC Pit 3 will be elevated levels of fine inert material suspended in the water column. These suspended solids will arise from the overflow dredging method using a TSHD and will be greatest when marine sand is being dredged, owing to the high fines content of this material compared to alluvial sand.

13. Existing water quality data, primarily that collected by EPD as part of their routine monitoring programme, indicate very low ambient levels of suspended solids in the waters likely to be affected by the sediment plume. Data on sediment quality, which is subject to confirmation by data collected specifically for this study, indicate that sediments are uncontaminated; overlying marine mud at WSC Pit 3 may therefore be disposed of accordingly.

14. Sediment transport modelling of the worst case scenario has been carried out for four tide types: spring and neap tides in both the wet and dry season. Comparison of the results for these indicate that the greatest impacts may be expected during the wet season spring tide. A further model run was carried out for a reduced impact scenario for this tide, assuming a lower loss rate by dredging a mixture of marine and alluvial sands during each dredging cycle. This approach could be adopted if mitigation is necessary following the exceedance of Trigger, Action and Target (TAT) limits.

15. Impacts have been assessed in relation to a range of sensitive receivers including flushing water intakes, cooling water intakes and mariculture zones. The only receiver predicted to be affected beyond acceptable limits is the WSD flushing water intake at Kennedy Town. It is recommended that the effects of the plume be mitigated to acceptable levels by installing a silt screen around the intake.

16. The Water Quality Objectives (WQOs) for suspended solids limits the increase above ambient levels in marine waters within the Southern Waters and Western Buffer WCZs to 30% of ambient. Because of the high losses associated with dredging of this nature, coupled with the extremely low ambient levels, it is inevitable that the WQOs will be exceeded by large parts of the plume. Although part of the plume generated by the worst case scenario may have some visual impacts, it will only apply for a few months and will not result in a long term detrimental trend. The exceedance of the WQOs is therefore not regarded as a serious problem in the circumstances.

17. A system of monitoring is recommended which comprises monitoring and control locations. While linking TAT limits to absolute values designed to protect sensitive receivers, the difference between monitoring and control stations will allow the trend of impacts to be monitored and will help to identify when suspended solids may be elevated from other causes. Baseline monitoring should begin prior to the works commencing to allow the true running background levels to be established. Further details on monitoring are given in the EM&A Manual.

Marine Ecology and Fisheries

18. A review of available information on local marine ecology and fisheries (including mariculture zones) has been undertaken in order to predict potential impacts associated with dredging WSC Pit 3.

Marine Ecology

19. Based on previous surveys of benthic marine organisms in the vicinity of WSC Pit 3 it is likely that the removal of seabed habitat will result in the loss of a relatively undisturbed macrobenthic community.

20. Marine silt and clay dredged from WSC Pit 3 will be disposed of in the marine dumping ground at South Cheung Chau. Whilst the dumping of this material in exhausted borrow pits can provide a suitable habitat for the recolonisation of the sea bed by marine organisms, it is likely that the positive impact of this will be limited, particularly if material is dumped over existing dumped material which has been partially recolonised. Eventual backfilling of WSC Pit 3 with uncontaminated marine silt and clay from other borrow areas in Hong Kong waters will initiate and enhance recolonisation by the macrobenthos, and it is recommended that such action be considered following the completion of works in WSC Pit 3.

21. Suspended sediments in the water column from the dredging operation will enhance sedimentation rates down current of the works. Benthic organisms are capable of sustaining an increase in sedimentation rate, where the actual capacity is dependent on the rate of deposition, species tolerance, stage of life-cycle (egg, larva, juvenile, adult) and other environmental stress factors (e.g. presence of toxins, water flow and temperature).

22. Hong Kong waters are known to contain a broad range of organisms with respect to sediment tolerance, but little is known about the absolute tolerance thresholds of most Hong Kong organisms (Ref 5.5). Sedimentation impacts may last for a relatively short or longer period of time depending on the extent, duration and rate of dredging, as well as environmental factors related to the hydrological regime. Sedimentation impacts may be lethal due to direct smothering of organisms, or be indirect through, for example, decreased light penetration. Non-lethal impacts may impair the functioning of the organism, for example via clogging of feeding and respiratory apparatus, and have the potential to alter community species composition as more tolerant species assume dominance. These impacts have been demonstrated on a range of organisms including crabs, polychaetes, oysters, lobsters and clams. Relatively high sediment concentrations, combined with multi-day exposures, are generally required to injure or kill these organisms. In most cases larvae were found to be more sensitive to high sediment concentrations than adult specimens.

23. It is worth noting that many benthic communities in Hong Kong are located on soft muds and sands which are frequently disturbed by storms which create high suspended sediment loads in the water column. Macrobenthic invertebrates are therefore not likely to be adversely affected by dredging activity with respect to sediment suspension and resettlement, and the main impact will relate to direct habitat loss in the WSC Pit 3 area.

24. Corals are also highly variable in their tolerance of sediment concentrations, where variations are species-specific and growth-form specific. In contrast to other benthic fauna, some of the most common hard coral species in Hong Kong are easily damaged and killed by sedimentation and are therefore considered to be the most sensitive marine organisms to sediment impacts associated with dredging activity. Coral damage can take place rapidly for sensitive species as a result of increased suspended solids levels which induce chronic effects and then sedimentation onto the coral surface which leads to death of the organism. Due to the slow growth rates of corals, full recovery takes many years and coral larvae are known to be inhibited from settling and developing due to the presence of fine sediment. Potential impacts on the local coral community, in the case of dredging WSC Pit 3, are therefore likely to be restricted to impacts from both increased suspended solids levels and increased sedimentation of the seabed, rather than a direct loss of habitat.

25. Further evaluation of sediment impacts on coral has been based on the sediment deposition predictions over the dredging period of six months for marine sands. Of the areas in the East Lamma Channel which are predicted to experience high rates of sediment deposition only the coral range on the northern coastline of Lamma Island (Pat Kok) and Luk Chau have dense populations of gorgonian corals between -10 and -16 mPD. Based on the growth form of these coral species and the fact that approximately 50% of the corals were found growing from vertical or sub-vertical substrate these corals would not be susceptible to sediment accumulation. As the total deposition is estimated to be less than 0.2 m in the areas concerned, it is also considered that the remainder of these organisms growing on the lower lying seabed would not be at risk of complete burial even if continuous deposition of sediment occur as predicted. The corals in this area are considered to have a medium conservation value (Ref 5.6). Although of high risk of mortality from deposition, the corals in the range adjacent to the west of Hong Kong Island are of low density and low conservation value. It is likely that much of the coral community in this area has already been damaged or destroyed as a result of the amount of shipping and other activities occurring within the East Lamma Channel. Soft coral colonies located in more open and faster flowing waters are more likely to survive due to the flexibility of soft corals and the cleansing action of the faster tidal currents. The actual degree of

impact is dependent on the resuspension and redistribution of sediments caused by storm events throughout the duration of works.

26. No toxicological impacts on the benthic fauna are envisaged, on the premise that surface sediment taken from WSC Pit 3 and analysed for heavy metals do not shown any signs significant contamination according to EPD criteria.

Marine Fisheries

27. Loss of seabed habitat from dredging operations associated with WSC Pit 3 will result in the avoidance of the area by adult fish species which are relatively mobile and able to quickly locate to a more congenial environment. The main direct impact of dredging activity will be the loss of feeding grounds for fish species dependent on the benthic fauna, but this can be expected to be limited in extent. The duration of this impact is dependent on the re colonisation of the borrow area following the cessation of dredging.

28. Commercial fishing activity in the vicinity of WSC Pit 3 will be affected for the duration of the works, due to restricted access because of the presence of dredging vessels and the aversion of fish species to the area affected by elevated suspended sediment concentrations.

29. Suspended sediments in the water column will have variable effects on the commercial fish and invertebrate population depending on a host of species-specific and environmental factors. Vulnerability of fisheries will be greater with respect to Fry collection areas due to the greater sensitivity of juveniles to high suspended sediment concentrations compared to adult fish.

30. Mariculture zones (MCZs) are potentially more vulnerable to sediment impacts than open water fisheries as fish populations are captive, and therefore more readily exposed to adverse effects associated with an increased suspended solid concentration. Maturation success of the fish types in the MCZs is dependent on water quality and the prevalence of disease. Fish are known to have a wide range of tolerance to sediment concentrations, where high concentrations may result in direct fish kills due to gill clogging, and lower concentrations may enhance susceptibility to disease. Fish may also be susceptible to the eutrophication of water as a result of sediment disturbance, either directly or indirectly via the proliferation of phytoplankton which can reduce dissolved oxygen levels and produce biochemical toxins.

31. Evaluation of sedimentation impacts on fisheries and MCZs has been based on the sediment plume modelling results, together with an estimate of predicted deposition rates. Comparing the extent and concentration of sediment plumes with the location of MCZs, it can be demonstrated that sediment concentration under the worst case scenario at the closest MCZ, Lo Tik Wan, will be in the range of 1 to 10 ppm above ambient (7 ppm) levels. The maximum concentration of 17 ppm in the vicinity of Lo Tik Wan is within the recommended guideline of 80 mg/l for the protection of MCZs. Total sediment deposition rates in the vicinity of Lo Tik Wan MCZ are estimated to be between 5 and 20 cm over the dredging period. Again, the actual accumulation rate is dependent on the resuspension and redistribution of sediments during storm events, and deposited sediments are unlikely to have adverse effects on the MCZ as fish cages are suspended above the sea bed.

Air Quality

32. The only perceived impact on air quality is the emissions from sea vessels associated with the marine borrowing. The nearest sensitive receptors in relation to potential air quality impacts from TSHD vessels are over 1 km distant from the boundary of WSC Pit 3.

33. The air pollutants emitted by the vessels may consist of:

- nitrogen dioxide;
- total suspended particulates;
- respirable suspended particulates; and
- sulphur dioxide

34. It is unlikely that even in the most adverse meteorological conditions that emissions from two dredgers in the marine borrowing area would have a measurable effect on any of the sensitive

receivers. As such, no mitigation measures are required and it is envisaged that no significant cumulative air quality impacts would be associated with the works.

Noise

35. The impact of the works on noise levels at Noise Sensitive Receivers (NSRs) is dependent on the prevailing background noise level and the proximity of the NSRs to the source of noise. The closest NSR is over 1 km distance from the boundary of WSC Pit 3.

36. Noise emission sources from dredging vessels may include diesel motors and metallic 'jolt and shock' noise. TSHDs are considered to one of the quieter types of dredger as the pumps and other equipment are located in the hull.

37. Based on a single dredger being located in WSC Pit 3 at any one time, the expected noise level at the NSR has been calculated as 37 dB (A). Additional TSHDs working in one of STY Pits 1 or 2, or at the East of Lamma Channel Marine Borrow Area or Green Island Reclamation (Part) Public Dump would not contribute significantly to this noise level. The night time construction acceptable noise limit of 45 db (A) will not therefore be breached and, as such, it is not envisaged that the works will result in any significant noise nuisance. No special mitigation measures are therefore required beyond good work practices which should include ensuring that all powered mechanical equipment is adequately maintained and that dredging vessels do not operate beyond the eastern boundary of WSC Pit 3, particularly at night.

Monitoring and Audit Requirements

38. Responsibilities for monitoring and audit are described together with a framework for baseline and operational monitoring, and a specification for environmental performance criteria and Action Plans. It is recommended that the EM&A Manual be used in conjunction with this Focused EIA Report for monitoring and audit requirements.

1. INTRODUCTION

1.1 This Focused Environmental Impact Assessment (EIA) has been undertaken for the allocated use of the West of Sulphur Channel Marine Borrow Area (WSC MBA) for the dredging of reclamation material, and has been awarded by the Civil Engineering Department (CED) under Agreement No. CE 52/94.

1.2 Details of the Study Brief are summarised in Sections 1.8 to 1.13 below. The primary purpose of this Focused EIA is to assist in minimising pollution, environmental disturbance and nuisance from the proposed marine borrowing and all related activities in WSC by providing information on the nature and extent of the potential environmental impacts, identifying the most appropriate dredging method and recommending mitigation measures, as appropriate. The assessment has been based on the description of works, as discussed in Chapter 3 of this report.

1.3 In addition to this Focused EIA, an Environmental Monitoring and Audit (EM&A) Manual has been prepared (Ref 1.1) which specifies the objectives and responsibilities for monitoring and audit, together with protocols for undertaking these roles. Environmental performance requirements for the works are also provided, together with Action Plans for the implementation of mitigation measures to alleviate potentially adverse environmental impacts associated with the works. It is recommended that the EM&A Manual be used in conjunction with this Focused EIA report.

Background

1.4 Investigations in the WSC area have indicated that if the WSC area is added to the South Tsing Yi (STY) area to the north (Pits 1& 2), the utilisation of the overall sand resource can be optimised. The WSC MBA was authorised for dredging in November 1993. The Director of Environmental Protection indicated however, that a Focused EIA, with emphasis on the possible impacts of the sediment plumes from the dredging, will be required prior to adding the WSC area to the STY area. The section of borrow area assessed for the purposes of this study is hereinafter referred to as WSC Pit 3.

1.5 The WSC Pit 3 is located in one of the busiest fairways in Hong Kong Harbour and lies in shipping routes for which a traffic scheme is in force. The Marine Department imposed the condition that two dredgers could work concurrently in either two of the pits in the area (shown in Figure 1.1), but only one dredger will be permitted to dredge in the fairway at any one time. As such, it would be impractical to have two dredging contractors working concurrently in the area. For the purpose of this study, it is assumed that the sand extracted from this area will be used to supply sand for the Container Terminal 9 (CT9).

1.6 Dredging for reclamation material from STY Pits 1 and 2 and WSC Pit 3 encompasses two authorised areas for marine sand gazetted under notification of the Foreshore and Seabed (Reclamations) Ordinance (Chapter 127). These areas include:

- West of Sulphur Channel Marine Borrow Area under Government Notice No. 36/1993, Gazette No. 3237 of 10 September 1993, as authorised 26 November 1993.
- West of Green Island Marine Borrow Area under Government Notice No. 629, Gazette No. 6/1990 of 8 February 1990, as authorised on 11 May 1990.

1.7 Based on the available site investigation data, a dredging assessment conducted by CED's dredging consultants (DEMAS) for WSC Pit 3 and STY Pit 2 has shown that the material to be dredged consists of:

- alluvial sand varying in thickness from 5 to 18 m to a maximum depth of -52mPD;
- marine sand varying in thickness from 0 to 8m to a maximum depth of -42mPD; and
- marine silt and clay varying in thickness from 2 to 7m, to a maximum depth of -35mPD.

Objectives of the Focused EIA

1.8 The objectives of the Focused EIA, as specified in the Study Brief, are as follows:

- to describe the proposed marine borrowing project and associated works together with the requirements for carrying out the proposed project;
- to identify and evaluate, where appropriate, emission sources and determine the significance of impacts on sensitive receivers and potentially affected uses;
- to identify and evaluate, where appropriate, any potential losses or damage to flora, fauna and natural habitats, based on a review of existing information;
- to propose the provision of practical and cost-effective mitigation measures so as to minimise pollution, environmental disturbance and nuisance during the proposed marine borrowing activities;
- to identify, predict and evaluate the residual (i.e. after practicable mitigation) environmental impacts and cumulative effects expected to arise during the proposed marine borrowing activities in relation to the sensitive receivers and potential affected uses; and
- to design and specify the environmental monitoring and audit requirements necessary to ensure the implementation and the effectiveness of the environmental protection and pollution control measures adopted.

Description of Focused EIA

1.9 In order to achieve the objectives given in Paragraph 1.8, the Study Brief requires that study tasks should include:

- identifying, collecting and analysing existing information relevant to the Focused EIA;
- reviewing existing environmental surveys, site investigations and baseline monitoring work to achieve the objectives and make recommendations on further studies if necessary;
- quantifying, by use of models or other predictive methods, the residual and cumulative environmental impacts arising from the construction and operation of the proposed marine borrowing project;
- proposing practical, effective and enforceable methods, measures and standards to effectively mitigate any significant environmental impacts in the short and long term; and
- outlining a programme by which the environmental impacts of the proposed marine borrowing project can be assessed, monitored and audited.

1.10 Baseline monitoring is not a requirement of the Study Brief. However, baseline information has been collected in the vicinity of WSC Pit 3 from previous studies and this information has been reviewed to provide an estimate of environmental baseline conditions at WSC Pit 3. Information which has been reviewed for the assessment includes:

- Binnie Consultants Ltd: Fill Management Study - Phase IV. Investigation and Development of Marine Borrow Areas. South Cheung Chau and Sulphur Channel Seabed Ecology Pilot Survey by Grab Sample. Draft Report. GEO, Civil Engineering Department, July 1994.
- Greiner - Maunsell: Focused EIA of Backfilling Operation at South Tsing Yi Marine Borrow Area. Provisional Airport Authority - Hong Kong, December 1993.
- HWR (Asia) Ltd: Disposal of Spoil at South Tsing Yi. An Assessment of the Stability and Losses of Dumped Spoil. GEO, Civil Engineering Department, July 1993.

- Binnie Consultants Ltd: Fill Management Study - Phase II. East Lamma Channel Borrow Area Scoped Environmental Assessment Final Report. GEO, Civil Engineering Department, January 1993.

- Binnie Consultants Ltd: Fill Management Study - Phase II. Environmental Review of Potential Borrow Area North Lamma Channel. GEO, Civil Engineering Department, April 1993.

- Binnie Consultants Ltd: Fill Management Study - Phase IV. Lamma Dredging Audit Baseline Survey Draft Final Baseline Report. GEO, Civil Engineering Department, August 1994.

- Scott Wilson Kirkpatrick: Green Island Reclamation (Part) Public Dump. Draft Final Report (EIA). Civil Engineering Department, September 1994.

1.11 Geotechnical Engineering Office of CED has undertaken a baseline survey to determine heavy metal concentrations of surface sediments within WSC Pit 3. The results of this survey are included in Appendix 1 to this report. Further information on baseline monitoring requirements, which should be undertaken prior to the commencement of the works, is provided in the EM&A Manual.

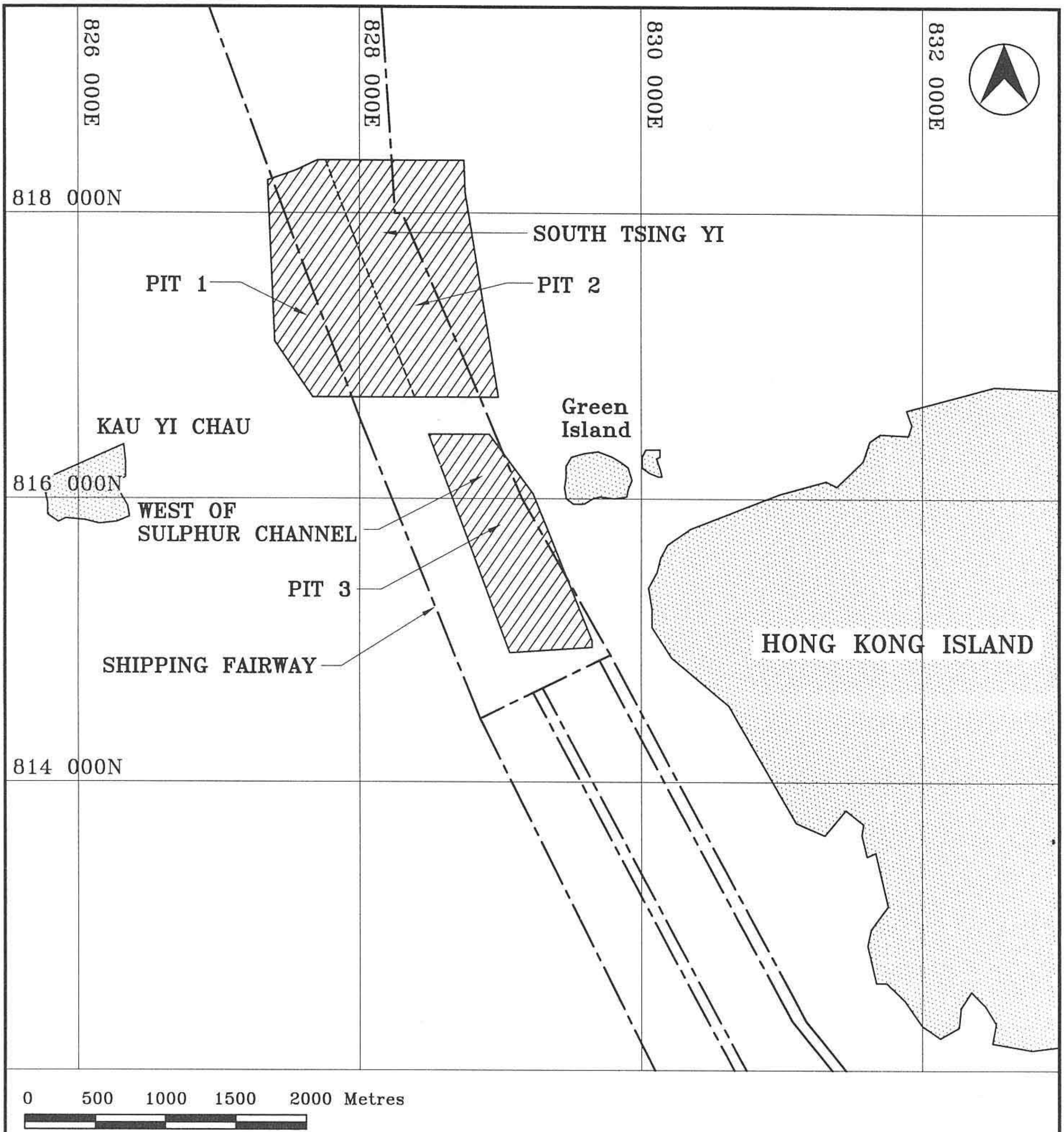
1.12 The identification of key environmental issues has been based on a review of the available information and the description of works in Chapter 2, and these key issues are presented in Chapter 3. Predictive modelling of environmental impacts associated with these works is restricted to marine water modelling (Chapter 4), as agreed with Government prior to the commencement of the Study.

1.13 The following chapters in this report include:

- Chapter 2: Description of Works
- Chapter 3: Identification of Key Issues
- Chapter 4: Marine Water and Sediment Quality
- Chapter 5: Marine Ecology and Fisheries
- Chapter 6: Air Quality
- Chapter 7: Noise
- Chapter 8: Environmental Monitoring and Audit Requirements

References

Ref 1.1 Civil Engineering Department. West of Sulphur Channel Marine Borrow Area. Draft Environmental Monitoring and Audit Manual, September 1994.



WEST OF SULPHUR CHANNEL MARINE BORROW AREA
FOCUSED ENVIRONMENTAL IMPACT ASSESSMENT
FINAL REPORT

Figure No. 1.1

Site Locations of STY Pits 1 & 2 and WSC Pit 3 Showing Shipping Fairway

2. DESCRIPTION OF WORKS

Introduction

2.1 It is proposed that WSC Pit 3 will be used to supply sand for the Container Terminal 9 (CT9) development at the south east tip of Tsing Yi Island. The boundaries of the borrow area are shown in Figure 1.1 and conform with the proposed extension of the Green Island Link. The pits in the original South Tsing Yi (STY) allocation for the CT9 development are STY Pit 1, the western pit, and STY Pit 2, the eastern pit. The locations of these pits are also shown in Figure 1.1. Information in this Chapter has been supplied by DEMAS, CED's dredging consultant for the WSC Pit 3 and STY Pit 2.

2.2 The study area is located in one of the busiest fairways in Hong Kong Harbour and lies in shipping routes for which a Traffic Separation Scheme is in force. The Marine Department has imposed the condition that two dredgers could work concurrently in either two of the three pits allocated for the CT9 project, but only one dredger will be permitted in the fairway at any one time.

Geology

2.3 The material to be dredged in the borrow area consists of alluvial sand varying in thickness from 5 to 18 m present to a depth of -52mPD, and is overlain by marine sand varying in thickness from nil to 8m up to a maximum depth of -42mPD. The marine sand is overlain by marine silt and clay (mud) varying in thickness from 2 to 7m, down to a maximum depth of -35mPD. The environmental impact of dredging of marine surface sand in STY Pits 1 and 2, north of the Study Area, do not require consideration as part of this assessment as dredging of this layer will have been completed when dredging work in WSC Pit 3 commences.

Sediment Characteristics

2.4 The average densities of the sediments in the area are presented in Table 2.1. The dry densities have been measured in a laboratory, while the saturated densities have been calculated using the dry density, assuming a water density of 1,025 kg/m^3 and a particle density of 2,650kg/m^3.

Table 2.1 Density of Sediments in West Sulphur Channel Marine Borrow Area. *(Figures supplied by DEMAS).*

Material type	Dry density kg/m^3	Saturated density kg/m^3
Overburden	960	1610
Marine Sand	1,600	2,010
Alluvial Sand	1,560	1,980

2.5 The typical particle size distribution of the marine sand in the area is presented in Figure 2.1. The typical particle size distribution of the alluvial sand in the area is presented in Figure 2.2.

Sediment Volumes

2.6 In order to be in a position to give a proper prediction of the method and speed of extraction of the material from the WSC Pit 3 it is necessary to consider the whole of the project for which the sand will be utilised.

2.7 The dredged material from the marine borrow area can only be placed in the CT9 reclamation site after unsuitable material has been removed from that part of the site. The majority of the uncontaminated mud from the CT9 site will be disposed of at South Cheung Chau marine dumping area. Part of the dredged uncontaminated mud will also be used to backfill the exhausted STY Pits 1 or Pit 2. In addition, the contaminated mud from the CT9 site will be disposed of in specially dredged pits in the East Sha Chau area.

2.8 For the CT9 reclamation and all its related works, a total of approximately 95 million cubic metres (Mcum) of material needs to be dredged, including the 39 Mcum of fill to be placed at the reclamation site. A summary of the approximate volumes of material to be dredged in the CT9 reclamation site and the marine borrow areas is given in Table 2.2. From the total volume, 9 Mcum of sand and 4.1 Mcum of silt and clay (mud) will be dredged from WSC Pit 3.

Table 2.2 Summary of Volumes of Material to be Dredged in the Reclamation Site and Marine Borrow Areas. *(Figures supplied by DEMAS).*

Dredging area	Volumes to be excavated (m)
Dredging of CT9 Reclamation Site (Mud)	21,100,000
Re-align Fairway Channel (Mud)	4,000,000
Dredging of Rambler Channel (Mud)	2,930,000
Dredging of STY Pit 1 and 2 (Mud)	9,300,000
Dredging of STY Pit 1 and 2 (Sand)	31,000,000
Dredging of WSC Pit 3 (Mud)	4,100,000
Dredging of WSC Pit 3 (Sand)	9,000,000
Total Volume	81,430,000

2.9 The volumes available in the STY Pit 1 and 2 and WSC Pit 3 area down to a depth of -50mPD are listed in Table 2.3. The volumes listed take into consideration the losses that occur during the dredging process, the configuration of the pits and the compaction of material at the reclamation site.

Dredging Details

2.10 The dredging programme assumed for the assessment is based the total volume that needs to be dredged within a period of 36 months. To comply with this condition, an average of 600,000 cum per week of all types of materials from several different locations needs to the dredged. However, it is assumed that only two larger dredgers (8,000 cum) are required to supply the sand to the CT9 site, and will operate within the borrow area at any one time (see Section 2.19).

2.11 It is anticipated that trailing suction hopper dredgers (TSHDs) of approximately 8,000 cum capacity will be used for the extraction of the marine mud and the sand. Most of the dredgers working in Hong Kong over the last three years are of this class.

Table 2.3 **Available Volumes in South Tsing Yi and West Sulphur Channel Pits for CT9 Allocation.** *(Figures supplied by DEMAS).*

Dredge to maximum -50mPD	**STY Pit 1 (Volume m^3)**	**STY Pit 2 (Volume m^3)**	**WSC Pit 3 (Volume m^3)**	**Total Pits 1, 2 and 3 (Volume m^3)**
Marine surface sand	640,000	2,290,000	0	2,930,000
Marine sand	5,370,000	8,610,000	3,760,000	17,740,000
Alluvial sand	6,820,000	11,110,000	5,280,000	23,210,000
All Sand	12,830,000	22,010,000	9,040,000	43,880,000
Marine silt and clay	7,070,000	4,630,000	4,100,000	15,800,000

2.12 It is anticipated that part of the uncontaminated mud dredged from the CT9 site and the Rambler Channel will be dumped in the exhausted STY Pits 1 and 2. For the purposes of this assessment it is assumed that part of the overburden dredged in WSC Pit 3 will be dumped in the marine dumping ground at South Cheung Chau.

2.13 Part of the reclamation works for CT9 will be executed with a smaller type of TSHD of $5,000m^3$ capacity or less. However, these dredgers would only extract marine surface sand at an early stage from STY Pits 1 and 2 to form the cap in the East Sha Chau disposal pits. It is assumed that this activity will be completed before any sand dredging at WSC Pit 3 commences. Grab dredgers will be used to dredge marine mud from the shallower parts of the CT9 reclamation site itself. In view of its great distance from the study area no cumulative environmental effect associated with the dredging at WSC Pit 3 is expected.

Extraction Rates

2.14 For the purpose of this assessment the likely extraction rates have been calculated for the material types encountered and the sailing distances required. The uncontaminated mud dredged from the three pits may be transported either to the South Cheung Chau (SCC) mud dumping site, to the East Sha Chau (ESC) disposal pits to form a cap, or to an exhausted pit within the allocation area.

2.15 It has been assumed that the marine surface sand dredged from STY Pits 1 and 2 will be partly used for the capping of the East Sha Chau Pits and partly for the reclamation of the CT9 site. The marine sand and the alluvial sand dredged in all three of the pits will be used only for the CT9 site. The weekly production rates for a TSHD of 5,000 cum and 8,000 cum are presented in Table 2.4.

Table 2.4 **Weekly Production Rates for Dredging.** *(Figures supplied by DEMAS).*

Dredger type	Material type	Dredging area	Discharging area	Weekly production (m^3/wk)
TSHD5000	Marine surface sand	STY Pit 1and2	ESC	78,000
TSHD8000	Marine silt and clay	STY/WSC	SCC	160,000
TSHD8000	Marine silt and clay	STY/WSC	ESC	70,000
TSHD8000	Marine surface sand	STY Pit 1and2	CT9	280,000
TSHD8000	Marine sand	STY/WSC	CT9	300,000
TSHD8000	Marine silt and clay	STY/WSC	STY 1and2	450,000
TSHD8000	Alluvial sand	STY/WSC	CT9	330,000
TSHD8000	Marine silt and clay	CT9	STY 1and2	320,000

Nb: The acronym TSHD5000 is short for a 5,000m^3 TSHD and TSHD8000 stands f or a 8,000 cum TSHD.

Overflow Losses

2.16 In order to give a forecast of the plume generated by the dredging process from WSC Pit 3 (see Chapter 6) the overflow losses of suspended solids during the dredging activity itself have been calculated. The calculation accounts for the cycle time whilst not loading, the particle size distribution of the layers to be dredged and the specifications of a typical TSHD of 8,000 m^3 as input to calculate the production, the overflow loss and the characteristics of the overflow. The model generates the volume of material loaded, the load remaining in the hopper, the loading time and the overflow losses. During the initial stage of the loading no dredge plume will be generated as the hopper has to be topped up before overflowing begins. With the input used for the model this results in approximately 17 minutes without overflow during each cycle.

2.17 The overflow has been simulated for dredging in marine and alluvial sand only, as dredging of marine mud will not generate dredging plumes as overflow is not permitted. Overflow losses are dependent on the flow entering the hopper, the hopper dimensions and the design of the overflow device. The model generates a particle size distribution and the concentration of suspended solids released into the water column through the overflow. Subsequently the percentage of fines (that is the percentage of particles with a size less than 63 μm) in the mixture is calculated. The release of fines per second through the overflow is the required input data for the sediment plume model. The overflow loss during the dredging cycle is presented in Table 2.5.

2.18 A TSHD typically works 24 hours per day seven days per week, apart from a scheduled stop of approximately 12 hours per week for maintenance and fueling, thus resulting in 156 operational hours per week.. During the operational hours non-scheduled delays may occur, due to navigational constraints, weather, and repairs due to failure of parts caused by additional wear and tear of equipment.

Table 2.5 Overflow Loss Over Time During a Single Dredge Cycle for Marine Sand and Alluvial Sand. *(Figures supplied by DEMAS).*

Material type	Marine sand	Alluvial sand
Sailing time	87 minutes	87 minutes
Dredging no overflow	17 minutes	17 minutes
Dredging with overflow	62 minutes	47 minutes
Total	166 minutes	151 minutes
Loss of fines per cycle	2,262 Mg	668 Mg
Av. rate of loss fines overflowing	610 kg/s	240 kg/s

Dredging Programme

2.19 In establishing the dredging programme it has been assumed that all targets for the timely completion of the CT9 reclamation need to be met. The progress of the associated works, e.g. construction of culverts to drain the hinterland and construction of quay walls, dictate the speed of filling because certain areas can only be made available for sand filling after other works have been completed. For the extraction of sand from WSC Pit 3, it has been assumed that two dredgers working two of the three pits (i.e STY Pits 1 and 2 and WSC Pit 3) will give sufficient capacity to meet the target dates.

2.20 It is assumed that after an initial period in which both TSHDs only work in the upper deposits, only one of the two dredgers will be converted to reach a greater depth. Even if the design of the dredger allows for dredging at greater depth and if it has worked already at such depths, it will still take some time to change the dredging installation from the shallow dredging configuration to the deep configuration. An extended dredge pipe, which is necessary to reach the greater depth, creates more resistance and is more vulnerable to damage than a shallow water pipe. For this reason the pipes will not be extended unless absolutely necessary. When the dredger has been converted to reach the greater depths it will only dredge in the deeper alluvial sand which underlies the other deposits. This assumption is supported by the experience gained from similar dredging undertaken for CT8 and Chek Lap Kok airport.

2.21 The commencement date of dredging for WSC Pit 3 is estimated from end April 1996 to early November 1996, assuming the CT9 reclamation commences in January 1995, although this is not definite due to uncertainties over the commencement date for the for the CT9 reclamation. For the purposes of cumulative assessment it has been assumed that dredging will be commensurate with dredging requirements for the East of Lamma Channel Marine Borrow Area (Ref 2.1) and the Green Island Reclamation (Part) Public Dump advanced works for the sea wall construction (Ref 2.2).

2.22 Based on the constraints identified in previous paragraphs, three potential worse case dredging scenarios have been defined. It has been assumed that Marine Department's rule of one dredger in the fairway at any one time will not prevent STY Pits 1 and 2 and WSC Pit 3 from being operated simultaneously. Because the demand for dredged sand will vary daily, the contractor will operate for shorter or longer periods according to one of the following scenarios.

Scenario 1

2.23 One TSHD works in the marine sand in WSC Pit 3 and the other TSHD works in the alluvial sand in STY Pit 2. Both dredgers either discharge their load by filling the CT9 reclamation site in a re-handling basin in front of a cutter suction dredger located in proximity to the reclamation site.

2.24 The production and overflow losses during the dredging are presented in Table 2.6. A typical sailing route for dredging in STY Pit 2 and WSC Pit 3 is presented in Figure 2.2.

Table 2.6 Production Per Week and Release of Fines During Overflowing: Scenario 1. *(Figures supplied by DEMAS).*

Dredging area	Material type	Production per week (m^3/wk)	Loss of fines per trip (Mg)	Loss of fines per day (Mg)	Duration of loss per cycle (min)	Av. rate of loss of fines (kg/s)
WSC Pit 3	Marine sand	300,000	2,262	19,600	47	610
STY Pit 2	Alluvial sand	330,000	668	6,400	47	240
Total loss of fines per day (Mg)				26,000		

Scenario 2

2.25 One TSHD works in the marine sand in WSC Pit 3 whilst the other one dredges overburden from STY Pit 1 and dumps the load in STY Pit 2. During the dredging no sediment is released from the dredger. However, there is considerable uncertainty at present regarding the percentage of the load which goes into suspension during dumping. Previous studies have assumed 3% and 5%. Until further investigation and measurement has been undertaken this uncertainty will remain. For the purpose of this study it is assumed that a maximum of 5% of the load will go into suspension. The production and overflow losses during such periods are presented in Table 2.7.

Table 2.7 Production Per Week and Release of Fines during Overflowing: Scenario 2. *(Figures supplied by DEMAS).*

Dredging area	Material type	Production per week (m^3/wk)	Loss of fines per trip (Mg)	Loss of fines per day (Mg)	Duration of loss per cycle (min)	Av. rate of loss of fines (kg/s)
WSC Pit 3	Marine sand	300,000	2,262	19,600	62	610
STY Pit 2	Dredged Marine silt and clay	450,000	0	0	0	0
STY Pit 2	Dumped Marine silt and clay	450,000	192	6,000	6	530
Total loss of fines per day (Mg)				25,600		

Scenario 3

2.26 One TSHD works in the marine sand in WSC Pit 3, discharges the load in the reclamation site, dredges uncontaminated mud in the CT9 site or in the Fairway Channel or Rambler Channel near CT9 and dumps the load in STY Pit 2. As for Scenario 2 no sediment is released from the dredger during the dredging, but it is assumed that 5% of this load will remain in suspension during the dumping of the load. Concurrently the other dredger would dredge alluvial sand and fill the CT9 site. The production and overflow losses during such periods are presented in Table 2.8.

2.27 Scenario 1 represents the worst case scenario for the dredging at the study area as the loss of fines per day is highest compared with the other scenarios. It is therefore recommended that the data for Scenario 1 be used for the sediment plume model (Chapter 4).

Table 2.8 Production Per Week and Release of Fines During Overflowing: Scenario 3. *(Figures supplied by DEMAS).*

Dredging area	Material type	Production per week (m^3/wk)	Loss of fines per trip (Mg)	Loss of fines per day (Mg)	Duration of loss per cycle (min)	Av. rate of loss of fines (kg/s)
Pit 3	Marine sand	230,000	2,262	14,400	62	610
Fairway Channel or Ramblers Channel or CT9	Dredged Marine silt and clay	150,000	0	0	0	0
Pit 2	Dumped Marine silt and clay	150,000	192	1,200	6	530
Pit 2	Alluvial sand	330,000	668	6,400	47	240
Total loss of fines per day (Mg)				22,000		

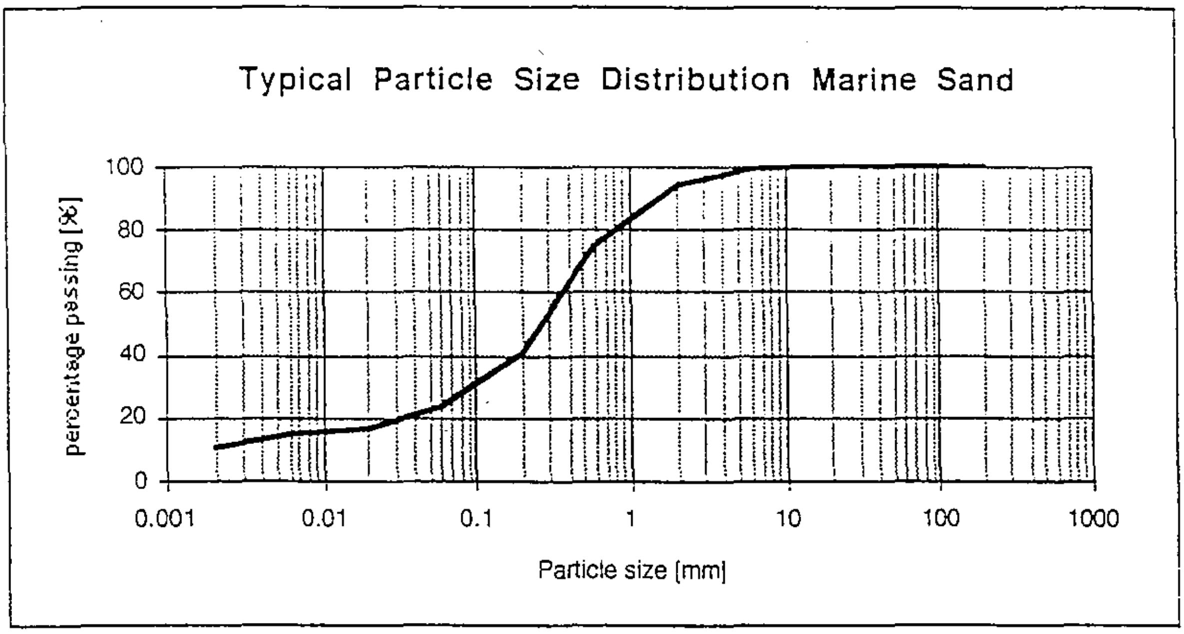
Worst Case Scenario

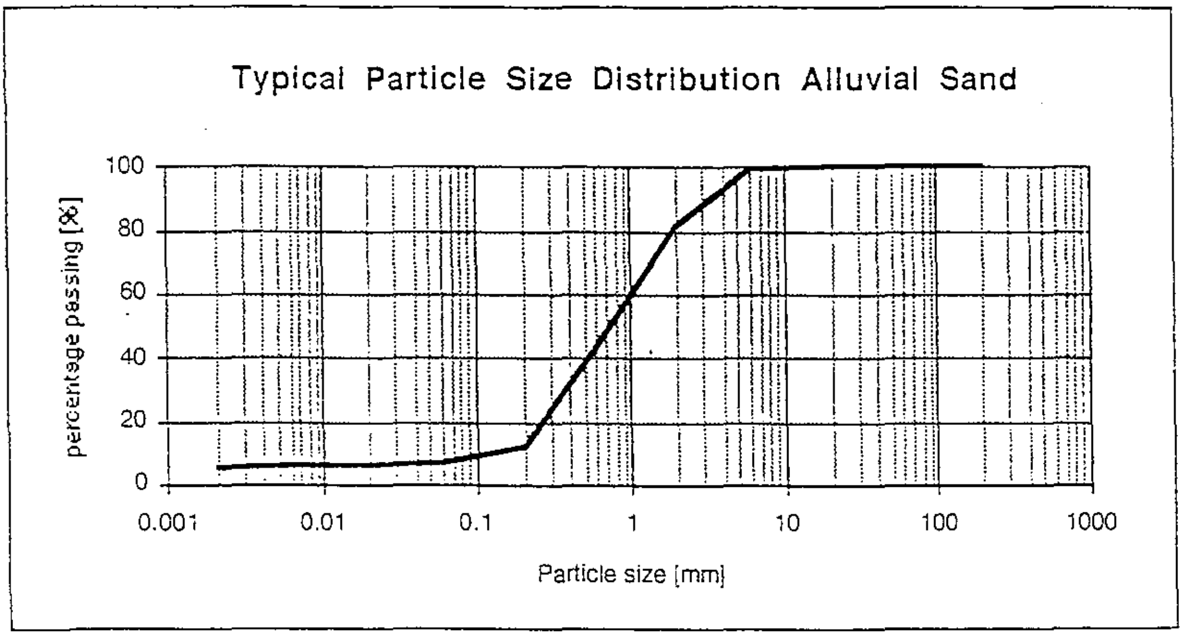
2.28 For the purposes of cumulative water quality assessment, it has been assumed that dredging in the WSC Pit 3 will be commensurate with the East of Lamma Channel Marine Borrow Area and the dredging works required for the Green Island Reclamation (Part) Public Dump advanced works seawall construction. This, together with Scenario 1 for the works associated with the WSC allocated area, represents the worst case scenario for assessing cumulative water quality impacts and has been used for modelling purposes.

References

Ref 2.1 Government Notice No. 2480, Dredging for Marine Sand in an Area in East Lamma Channel. Gazette No. 30 of July 1991.

Ref 2.2 Scott Wilson Kirkpatrick: Green Island Reclamation (Part) Public Dump. Draft Final Report (EIA). Civil Engineering Department, September 1994.



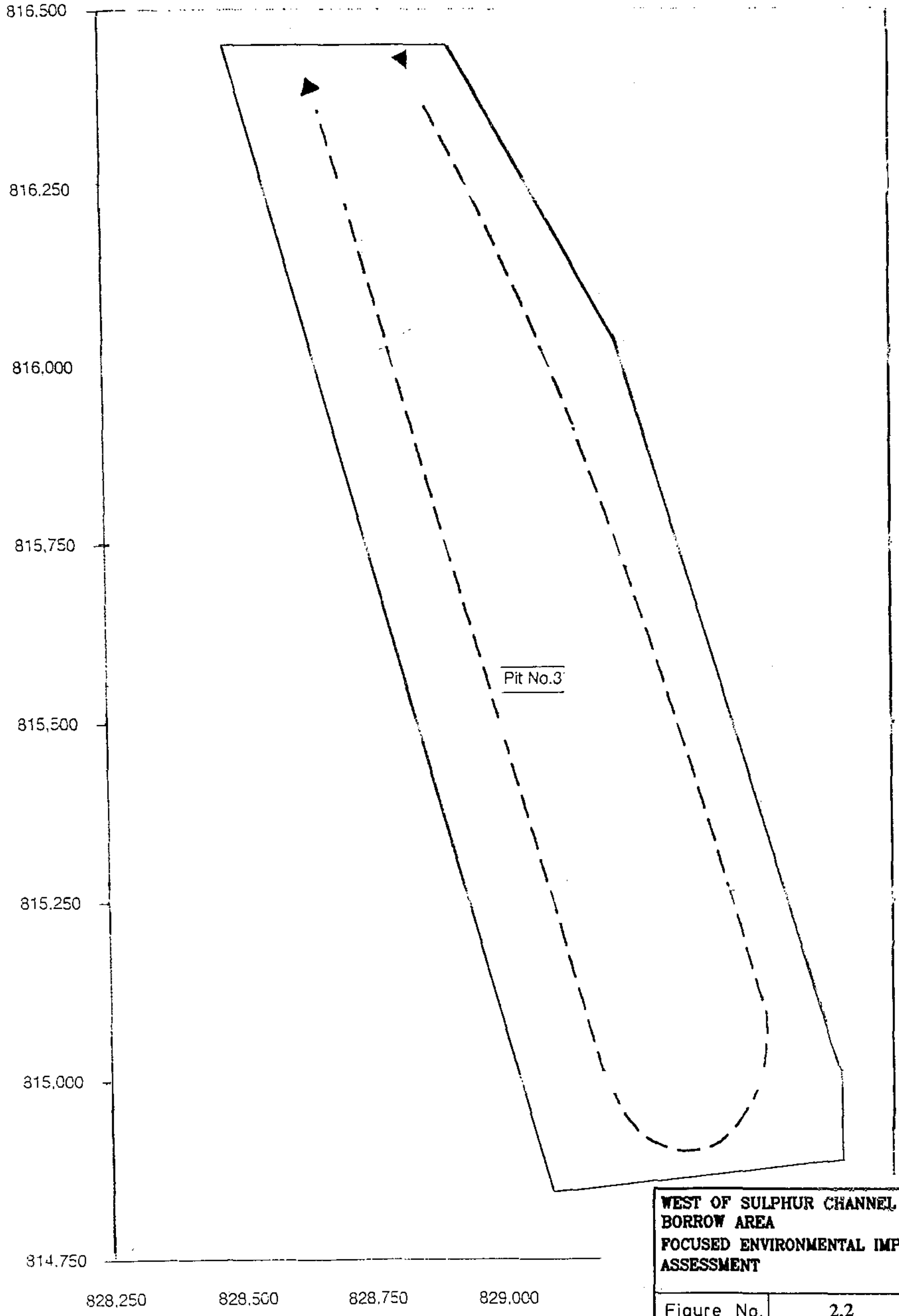


WEST OF SULPHUR CHANNEL MARINE BORROW AREA

FOCUSED ENVIRONMENTAL IMPACT ASSESSMENT

Figure No.	2.1 A & B

Particle Size Distributions of Marine and Alluvial Sands for WSC Pit 3



WEST OF SULPHUR CHANNEL MARINE BORROW AREA
FOCUSED ENVIRONMENTAL IMPACT ASSESSMENT

Figure No.	2.2

Typical Sailing Route of TSHD in WSC Pit 3

3. ENVIRONMENTAL SCOPING AND KEY ISSUES

Introduction

3.1 Environmental scoping is the process whereby the potential environmental impacts of a development are identified with respect to the human and natural environment. This process allows the identification and prioritisation of key environmental issues that require more detailed assessment.

3.2 A simple environmental scoping matrix for the identification of key issues arising from the works associated with WSC Pit 3 is shown in Figure 3.1, together with a preliminary assessment of their potential significance. The scoping process has been undertaken for each of the main stages involved in the dredging operation including:

- removal of marine silt and clay;
- removal of marine and alluvial sand;
- disposal of marine silt and clay; and
- marine traffic movements.

3.3 The classification of significance for each of the issues identified relates to potential rather than residual (net) impacts, where residual (net) impacts are dependent on applied mitigation measures to alleviate potential impacts. The designation of magnitude of impact (i.e. minor, intermediate or major) is based on an initial evaluation of impacts, review of available information (see Chapter 1), and the Consultant's experience. Further assessment in relation to the key issues is conducted in the following chapters with reference to potential mitigation measures, proximity of sensitive receivers and operational constraints of the works.

3.4 It is evident from Figure 3.1 that some environmental parameters have greater potential to be adversely affected by the works than others. Potentially major impacts associated with the works relate to the physical removal of sediment material from the sea bed and associated loss of ecological habitat, and suspension of that material into the water column and associated impacts on ecological communities, commercial fisheries in open waters and mariculture zones. Suspended sediments will impact upon the water column in the following principle ways:

- Increased suspended solids concentrations. This has the potential to affect fish physiology and reproduction. Increasing sedimentation rates on the sea bed also have the potential to affect sensitive benthic fauna and flora.
- Decreasing dissolved oxygen levels. This can occur via chemical and biological processes acting upon reduced chemical constituents and/or organic matter in the suspended sediments; and
- Release of contaminants (e.g. heavy metals, organics) associated with the solid and aqueous phase of the suspended sediments. The impact of contaminants is dependent on the levels initially present in the sediments, and they may be associated with acute or chronic effects on marine ecological communities.

3.5 The impacts on marine ecological communities, fisheries and mariculture zones are dominated by potential impacts on marine water quality as a result of the works. Impacts on marine biology can extend beyond the immediate dredging area, and areas of particular ecological sensitivity, such as coral beds and foreshore communities. Direct loss of sea bed from the dredging operation is also a major and unavoidable impact on marine ecological communities and fish feeding grounds. However, there is scope for some recompense of this impact by depositing overburden material in previously exhausted marine borrow areas (see Chapter 2) to initiate re-colonization by marine organisms. Mitigation of impacts on marine biology are closely associated with control measures to alleviate water quality impacts from dredging, and are discussed further in Chapters 4 and 5 of this report.

3.6 Lesser potential impacts of the works include those associated with noise levels, air quality and visual impacts. The vessel equipment (winches, diesel motors and metallic 'jolt and shock' noise) have the potential to create noise nuisance, particularly as the dredging operation will be virtually continuous over the 24 hour period (see Section 2.18). However, noise nuisance is dependent on the proximity of dredging vessels to sensitive receivers, which are normally terrestrially based and remote. This is also the case for sensitive receivers in relation to air quality, where emission sources are restricted to vessel exhaust emissions. Visual impacts are also dependent on the proximity of sensitive receivers, and on the concentration of suspended particulates in the water column. These environmental issues are assessed further in the Chapters 4, 6, and 7 of this report.

3.7 Other impacts associated with the works include the impacts on navigation safety, anchorage and utilities (e.g. pipelines and cables). Navigation safety and anchorage impacts have been formerly addressed by Civil Engineering Department in consultation with Marine Department, resulting in restrictions in the number and operation of dredging vessels in the WSC Pit 3 area (see Section 2.2). Civil Engineering Department have also verified that the works will not impact upon submarine utilities. These impacts are therefore not addressed further in this report.

Sensitive Receivers

3.8 Identified sensitive receivers for the purposes of water quality assessment are listed in Table 3.1, together with Hong Kong metric grid coordinates and distance to the centre of WSC Pit 3. Locations are also shown in Figure 4.3 (Chapter 4). Identified sensitive receivers considered for the purpose of potential noise and air quality impacts are given in Table 3.2. Locations are shown in Figure 3.2. Sensitive receivers for potential visual impacts are discussed in Chapter 4.

Table 3.1 Marine Water, Mariculture and Ecological Sensitive Receivers

Sensitive receiver	Coordinates		Distance from boundary of WSC Pit 3 (m)
1. WSD Kennedy Town Salt Water Pumping Station Intake	E 830 400	N 816 000	1,200
2. Housing Authority Flushing Water Intake, Wah Fu	E 832 000	N 812 100	3,800
3. Tsing Yi Power Station Cooling Water Intake	E 828 300	N 820 500	4,100
4. Lamma Island Power Station Intake	E 829 900	N 808 400	7,500
5. Queen Mary Hospital Cooling Water Intake	E 830 600	N 814 200	1,400
6. Ocean Park Seawater Intake	E 836 200	N 810 900	9,100
7. Lo Tik Wan Mariculture Zone	E 831 500	N 810 000	5,500
8. Sok Kwu Wan Mariculture Zone	E 831 500	N 807 700	8,200
9. Ma Wan Mariculture Zone	E 824 500	N 807 700	10,900

Table 3.2 Sensitive Receivers for Air Quality and Noise Impacts

Sensitive receiver	Coordinates		Distance from boundary of WSC Pit 3 (m)	Height above Principle Datum (m)
1. Police Buildings	E 830 144	N 815 142	1,050	40
2. Mount Davis Cottage Area	E 830 230	N 815 500	1,360	55
3. Residential Building	E 830 275	N 815 040	1,150	55

NB: The Green Island Refugee Camp is not considered to be a noise sensitive receiver, as it has no direct line of sight to WSC Pit 3, and it is shielded by the topography of Green Island.

Works Activity	Environmental Issues									
	Marine Water Quality			Noise Impact	Air Quality Impact	Marine Ecology	Fisheries	Mari-culture	Visual Impact	Other*
	Suspended Solid Concentr-ations	Dissolved Oxygen levels	Release of Contamin-ants							
Removal of marine silt & clay	***	***	**	*	*	** to ***	* to **	* to **	* to **	* to **
Removal of marine &alluvial sands	***	***	**	*	*	** to ***	* to **	* to **	* to **	* to **
Disposal of marine silt & clay	***	***	**	*	*	** to ***	* to **	* to **	* to **	* to **
Marine Traffic			* to **	* to **	*	*	* to **	*	*	*

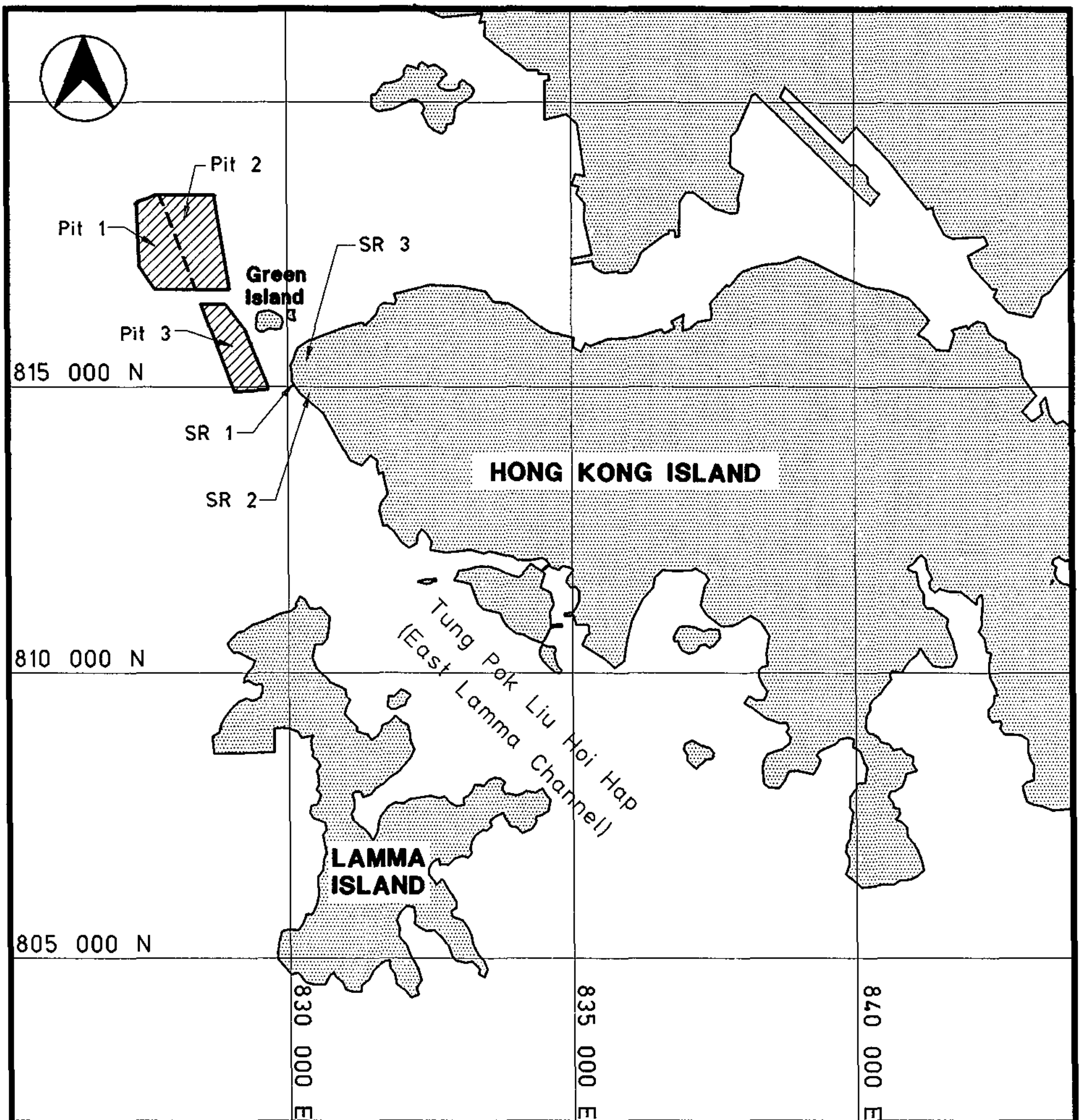
Nb: * also includes navigation safety, anchorages and utilities impacts (e.g. pipelines, cables)

* Minor Potential Impact ** Intermediate Potential Impact *** Major Potential Impact

WEST OF SULPHUR CHANNEL MARINE BORROW AREA
FOCUSED ENVIRONMENTAL IMPACT ASSESSMENT

Figure No. 3.1

Environmental Scoping of Potential Impacts Associated with Dredging Works



SR 1 - Police Building

SR 2 - Mount Davis Cottage Area

SR 3 - Residential Building

Scale = 1 : 100 000

WEST OF SULPHUR CHANNEL MARINE BORROW AREA FOCUSED ENVIRONMENTAL IMPACT ASSESSMENT FINAL REPORT	
Figure No.	3.2
Noise and Air Quality Sensitive Receivers	

4. MARINE WATER AND SEDIMENT QUALITY

Introduction

4.1 This chapter covers water quality aspects of the focused study which has been carried out on the WSC Pit 3 (see Figure 4.1), with close attention being paid to the concurrent and cumulative impacts of adjacent projects, including dredging and dumping operations underway in STY Pits 1 and 2, dredging for the Western Seawall of the Green Island Reclamation (Part) Public Dump (GIRPD) and dredging in the East Lamma Channel (ELC) Borrow Area. The impacts of the GIRPD works have already been assessed under a separate Environmental Impact Assessment (EIA) (Ref 4.1).

4.2 The activities involved within the proposed Works, as described in Chapter 2 of this report, have the potential to cause breaches of the Government's prescribed Water Quality Objectives (WQOs) and may affect specific users of the marine environment, known as "Sensitive Receivers". By their very nature the activities will result in temporary, localised changes in marine water quality.

4.3 Activities which could potentially result in changes in marine water quality over a wider area are identified as:

- Dredging of existing marine silt and clay (mud);
- Dredging of marine and alluvial sand from the borrow pits; and
- Dumping to backfill exhausted borrow areas.

4.4 With some types of dredger, the dredging of Marine mud has the potential to release sediment oxygen demand (COD and BOD) into the water column. However, for this project the material will be dredged using a trailing suction hopper dredger (TSHD) and, because no overflow is allowed when dredging marine mud, the losses of sediment are expected to be negligible. No significant increases in oxygen demand are expected, therefore.

4.5 No marine mud will be dumped in WSC Pit 3 during this project. Marine mud may be dumped in STY Pit 2 concurrent with dredging activities in Pit 3. Whilst such simultaneous activity has been taken into consideration in terms of the overall sediment losses which may be expected, oxygen demands associated with Pit 2 dumping have not been calculated because this pit is not within the EIA study area. The scenarios which have been considered, with details of anticipated losses of fines, are presented in Chapter 2 of this report.

4.6 The key water quality impact will therefore relate to the dredging of marine and alluvial sand. This will lead to significant increases in suspended solids concentrations in the water column, owing to the high proportion of fines material (particle size < 63 μm) lost overboard in the overflow discharge. Marine sand has a higher proportion of fine particles than alluvial sand and dredging of this material will therefore result in higher losses. The impacts of the worst case dredging scenario, based on information provided by DEMAS and assuming concurrent dredging for the Green Island western seawall, have been assessed using the WAHMO (**WA**ter quality and **H**ydrodynamic **MO**dels) MUDFLOW model. MUDFLOW was designed to simulate plumes generated by many sources covering a large area. It has been developed to include simulations of a moving dredger and was used in preference to the SEDPLUME model, which was designed to investigate narrow sediment plumes covering a small area, owing to its greater suitability for simulating the high loss rates associated with the overflow dredging of marine sand.

4.7 The impacts of the proposed Works have been investigated and compared with background conditions. The high fine material loss rates will inevitably result in high suspended solids concentrations in the vicinity of the dredging area and the large extent of the plume generated by the works may lead to significant increases above ambient levels, particularly in those zones where existing suspended solids levels are low. However, with the introduction of local mitigation measures where appropriate, sensitive receivers should not be adversely affected to unacceptable levels.

4.8 The impacts during dredging should be monitored on a regular basis and, in the event of exceedance of appropriate levels, actions to mitigate impacts should be enforced. A proposed system of monitoring, designed to give a practical means of controlling impacts and ensuring that they are not significantly worse than those predicted in this study, is detailed in the Environmental Monitoring and Audit Manual (Ref 4.2). The Manual also gives guidance on establishing appropriate Trigger, Action and Target (TAT) limits.

Background Information & Monitoring Data

4.9 Marine water quality data reported by the Environmental Protection Department (EPD) (Refs 4.3 - 4.7) together with data from the EPD marine water quality database and a recent intensive water quality monitoring programme (Ref. 4.8) carried out for the GIRPD have been used in this study.

4.10 The Green Island Link Preliminary Feasibility Study (GILPFS) (Ref. 4.10) included analysis of sediments in the project area; these, together with data from the EPD marine sediment quality database and data from two surveys also carried out for the Green Island project (Refs. 4.11 & 4.12), have been used to provide information on the sediment quality in and near the borrow area. Although the available data suggest that overburden sediments at the borrow area may be described as "uncontaminated", additional site-specific sediment data have been sought by GEO as part of this study. This additional data,included in Appendix 1, demonstrates that the surface sediment is not contaminated according to EPD criteria.

Environmental Standards and Guidelines

4.11 Marine water quality in Hong Kong is managed through the assignation of Beneficial Uses (BUs) to Water Control Zones (WCZs). The locations of the ten WCZs within Hong Kong waters are shown in Figure 4.2.

4.12 The Marine Borrow Area which is the subject of this focused study lies within the Western Buffer Zone. In assessing the impacts which may arise away from the immediate area of the Borrow Pits, the requirements of the Southern Waters WCZ and the (not yet gazetted) Victoria Harbour WCZ are also considered.

4.13 The BUs which have been identified as applicable for Hong Kong waters are (Ref. 4.14):

- BU-1 As a source of food for human consumption
- BU-2 As a resource for commercial fisheries and shell fisheries
- BU-3 As a habitat for marine life and a resource for human exploitation
- BU-4 For bathing
- BU-5 For secondary contact recreation - diving, sail-board and dinghy sailing
- BU-6 For domestic and industrial purposes
- BU-7 For navigation and shipping including the use of officially approved and endorsed sheltered harbours and typhoon shelters as temporary havens
- BU-8 For aesthetic enjoyment.

4.14 Not all BUs are applicable to all WCZs. The complete BU range has been applied to those WCZs which are already gazetted: Western Buffer and Southern Waters. At the present time no BUs are prescribed for Victoria Harbour WCZ but, for assessment purposes, similar BUs have been used in this study for that zone. This does not imply that these BUs will be assigned to Victoria Harbour when it is gazetted.

4.15 In order to maintain the water quality in any zone, water quality parameters appropriate to the assigned BUs are required to be controlled (Ref. 4.14). For different BUs different numerical absolutes, acceptable changes or qualitative standards are applied; these are defined as the WQOs.

4.16 For the Southern and the Western Buffer WCZs, WQOs have already been defined. The WQO for suspended solids is given in Table 4.1.

Table 4.1 : Suspended solids WQO for the Southern and Western Buffer WCZs

Water Quality Parameter	Objective	Part of Zone
Suspended Solids	waste discharge not to raise the natural ambient level by 30% nor cause the accumulation of suspended solids which may adversely affect the marine communities	marine waters

4.17 The WQOs are generally based on annual means or percentiles and are appropriate for comparisons of the long term changes in water quality. The range of some of the water quality parameters may be high even over a single tidal cycle, giving rise to values which are markedly different from the WQOs.

4.18 WQOs have been defined by the Water Supplies Department (WSD) for sea water at intake points of seawater flushing system pumping stations. The acceptable limit relating to suspended solids is defined as being 10 mg/l. No WQO has been set by the Housing Authority for their intake at Wah Fu.

4.19 Criteria for the classification of sediments, based on their degree of contamination, have been defined in a Technical Circular issued by EPD (Ref 4.15); these criteria are given in Table 4.2.

Table 4.2 : Concentrations of heavy metals and PCB in marine sediments and boundary values for EPD Class A, B and C sediments.

	Determinand (mg/kg)							
	Cd	Cr	Cu	Pb	Hg	Ni	Zn	PCB
Background	0.05	7	7	19	0.07	10	40	<0.005
Class A	<1	<50	<55	<65	<0.8	<35	<150	
Class B	1.0-1.4	50-79	55-64	65-74	0.8-0.9	35-39	150-190	
Class C	>=1.5	>=80	>=65	>=75	>=1.0	>=40	>=200	

4.20 The feeding behaviour of marine filter feeders such as mussels is not significantly affected by suspended solids concentrations as high as 100mg/l (Ref. 4.20); good to moderate freshwater fisheries are found in waters with concentrations in the range 25-80mg/l (Ref 4.21). In Hong Kong marine water mariculture is carried out in areas where concentrations are as high as 26mg/l (Ref. 4.16).

Sensitive Receivers

4.21 The Sensitive Receivers most likely to be affected by the impacts arising from the Works have been identified as sea water intakes (including WSD flushing water intakes, Housing Authority flushing water intakes and cooling water intakes), mariculture zones (MCZs) and fry collection areas. Other potential receivers include bathing beaches along the south coast of Hong Kong Island and recreation zones on Lamma Island although significant impacts are less likely owing to their distance from WSC Pit 3.

4.22 The only existing WSD flushing water pumping station intake within the area likely to be affected by the plume is at Kennedy Town. A new WSD flushing water pumping station is proposed at Telegraph Bay;

however, this will not become operational until late 1998 or early 1999 and is not therefore a concern in terms of impacts of the proposed dredging works. There is a flushing water pumping station at Wah Fu, operated by the Housing Authority. In addition to the flushing water intakes there are cooling water intakes for the power stations on Tsing Yi and Lamma Island, and for other developments around the Hong Kong coast (including Queen Mary Hospital). Further afield is the Ocean Park Seawater Intake.

4.23 Although there are no known sensitive biological receivers, important fish spawning grounds or fish culture zones within the immediate works area, there are some potentially vulnerable receivers within the possible extent of the sediment plume generated by the Works. The closest mariculture zones are located at Lo Tik Wan and Sok Kwu Wan on Lamma Island and, to the north, Ma Wan. There are Fry Collection Areas near Luk Chau Wan and Yung Shue Wan (Ref 4.13); it is predicted that the latter will not be reached by the plume and suspended solids concentration increases at Luk Chau Wan will be very similar to those at the Lo Tik Wan MCZ.

4.24 The locations of sensitive receivers are shown in Figure 4.3.

Water Quality Monitoring Data

4.25 As part of its role in monitoring and protecting the marine environment EPD carries out routine water quality surveys in the Territory's waters throughout the year. Suspended solids summaries for the years 1988 to 1992 in those water areas adjacent to the project area are given in Table 4.3 based on an aggregation of data from a number of sampling locations. Table 4.3a contains additional data for the EPD stations nearest to the Sok Kwu Wan and Yung Shue Wan MCZs over the same five year period.

4.26 EPD monitoring data for 1992 are presented for relevant individual stations in Table 4.4. The locations of these stations are indicated in Figure 4.4.

Table 4.3 Suspended Solids concentrations in areas adjacent to the Site, 1988 - 1992 Annual average and ranges in mg/l

Year	HK Island West	Victoria Harbour West	West Lamma Channel	East Lamma Island
1988	8.1 (0.8 - 28.0)	10.4 (1.8 - 57.0)	5.6 (1.8 - 16.7)	
1989	4.8 (0.0 - 18.0)	8.6 (2.0 - 30.0)	7.4 (1.0 - 29.8)	
1990	3.9 (1.2 - 12.7)	6.4 (0.9 - 28.3)		
1991	6.3 (1.2 - 18.7)	12.3 (1.0 - 50.3)	5.0 (1.8 - 10.5)	5.8 (2.0 - 13.3)
1992	7.0 (2.0 - 16.8)	8.75 (2.0 - 18.3)	6.1 (2.0 - 16.7)	4.7 (2.2 - 8.7)

Table 4.3a Suspended Solids concentrations at Stations SM3 and SM4 (near Lo Tik Wan and Sok Kwu Wan MCZs), 1988 - 1992
Annual average and ranges in mg/l

Year	SM3	SM4
1988	4.6 (2.3 - 10.3)	3.7 (2.5 - 4.5)
1989	3.1 (1.0 - 4.7)	3.4 (1.2 - 5.8)
1990	2.9 (0.5 - 4.3)	3.3 (0.7 - 6.2)
1991	6.2 (2.2 - 13.3)	5.4 (2.0 - 12.3)
1992	5.3 (3.3 - 8.7)	4.0 (2.2 - 7.5)

Table 4.4 Suspended Solids concentrations for relevant individual stations
EPD data for 1992: Annual average values and ranges in mg/l

Hong Kong Island West		Victoria Harbour West	
WM1	WM2	VM7	VM8
4.8 (2.0 - 7.8)	9.2 (3.5 - 16.8)	9.6 (2.0 - 18.3)	7.9 (2.3 - 16.3)

West Lamma Channel	Lantau Island East	East Lamma Island	
SM7	SM9	SM3	SM4
5.6 (3.7 - 7.3)	9.3 (2.8 - 18.7)	5.3 (3.3 - 8.7)	4.0 (2.2 - 7.5)

4.27 Apart from EPD data, other recent water quality data are available from the intensive monitoring survey which was carried out as part of the GIRPD EIA study. Collected prior to the commencement of works, these data represent the range of background levels experienced over a complete tidal cycle for spring and neap tides. Data were collected through both in situ monitoring and laboratory analysis of samples, for a range of parameters, at regular intervals over a spring and a neap tide. Background Suspended Solids values determined by the survey are presented in Table 4.5. The positions of the stations are shown in Figure 4.4.

Table 4.5 Background Suspended Solids concentrations in and adjacent to the project area. (Mean and range values as mg/l)

	GIRPD		
	GI_A	GI_B	GI_C
Upper Layer	12 (3 - 27)	15 (5 - 41)	14 (4 - 32)
Lower layer	19 (5 - 47)	23 (4 - 67)	20 (4 - 55)

Background Water Quality

4.28 Recent assessments of the background water quality relative to WQO levels have been made for the relevant water bodies as part of the GIRPD EIA (Ref 4.1) and the East Lamma Channel Borrow Area Scoped Environmental Assessment (Ref 4.17). The conclusion in both cases suggested that, with some short term exceptions and for most determinands, water within the Western Buffer and Southern Waters WCZs is relatively clean and complies with the limits of the WQOs. EPD data in these zones indicate very low suspended solids concentrations.

4.29 The two GIRPD intensive surveys revealed higher suspended solids concentrations with cycle-average values being as high as 15 mg/l in the upper layer and 23 mg/l in the lower layer. The mean of these results for both layers at all three stations is 17 mg/l.

4.30 The WQOs do not specify absolute limit values of suspended solids but concentrate rather on the percentage by which the natural ambient level may increase (Table 4.1). The average of the mean values for 1992 from relevant EPD monitoring stations, typical of levels at the same stations during recent years, is 7mg/l (Table 4.4), indicating an exceptionally low ambient level of suspended solids globally within the waters likely to be reached by the plume. The 30% increase over that value specified by the WQO would represent a level well below that which could have any discernible impact on marine communities.

4.31 An absolute value of 10mg/l is specified as the Target limit by WSD in respect of water taken for flushing purposes. Background suspended solids concentrations as monitored by EPD (Tables 4.3 and 4.4) suggest that the annual average concentrations in general lie beneath the WSD limit although on occasion they have exceeded it in Victoria Harbour West. The maximum values recorded by EPD in most areas have exceeded this limit at some time (Table 4.3).

Sediments

4.32 The marine muds to be dredged from the Marine Borrow Area are believed to be uncontaminated as defined by the EPD Technical Circular 1-1-92 (Ref 4.15). There are several sources of data which have been considered in drawing this conclusion:

- EPD sediment sampling data at positions SS4, WS2 and VS6;
- Dropcore samples taken for the GILPFS EIA, positions DC4, DC5, DC14 and DC15;
- GIRPD sampling taken in November 1993;
- GIRPD sampling taken in April 1994;
- Site-specific grab samples commissioned by CED GEO for this study.

4.33 Sediment characteristics from the relevant EPD sampling stations, stations used for the GILPFS survey and stations from both the November 1993 and April 1994 GIRPD surveys are summarised in Table 4.6. The sampling positions for all four sources of data are indicated in Figure 4.5.

Table 4.6 Existing bottom sediment data in the vicinity of the Works area

Determinand (mg/kg)	EPD Data				GILPFS Survey		GIRPD November 1993 Survey (Western seawall stations)					GIRPD April 1994 Survey (top layer)*		WSC August 1994 Survey
	VS6 1991	VS6 1992	SS4 1992-3	WS2 1992-3	DC4	DC14	4	5	6	7	8	5	7	Mean values **
Cd	9.2	<0.5	<0.5	<0.5	0.6	0.6	2.7	3.2	2.8	3.2	3.5	<0.5	<0.5	<0.2
Cr	73	49	40.5	40	16	15	32	42	41	36	40	30	28	32
Cu	255	151	56.2	47	6	9	23	41	32	33	37	12	17	27
Hg	1.2	0.21	0.08	0.08	0.03	0.04	0.40	0.25	0.22	0.31	0.27	0.06	0.25	0.12
Ni	29	27	24	25	10	10	25	30	27	28	31	11	16	15
Pb	83	59	50	38	20	19	79	102	90	108	108	<9	26	34
Zn	175	144	110	103	39	40	67	102	91	97	100	64	86	81

Class C	Class B	Class A

* - Average of triplicate sample results
** - Average of results from 26 grab samples; full data and locations provided in Appendix 1.

4.34 Samples taken by EPD at VS6 in 1991 and most of those taken during the 1993 GIRPD survey indicated a presence of Class "C" sediments, primarily as a result of high cadmium and lead levels. However, subsequent EPD samples and the second, more extensive GIRPD survey indicated that cadmium levels were low, although high copper levels have been recorded at VS6 and SS4 (Class "C" and Class "B" respectively) as indicated in Table 4.6.

4.35 The Marine Borrow Area currently under study lies to the west of the Green Island Public Dump area and, of the historical data available, is best represented by results from the GILPFS data. The GILPFS positions DC4 and DC14 lie close to if not within the boundary of the borrow area and results from these positions indicate very low levels of contamination. Disposal of dredged overburden material may therefore be made in accordance with the requirements of the Works Branch Technical Circular (WBTC) 22/92 for uncontaminated sediment (Ref 4.19).

4.36 Results of the recent grab sample survey commissioned by GEO to obtain site-specific sediment data are also summarised in Table 4.6. The results, full details of which are presented in Appendix 1 of this report, confirm that the sediments are uncontaminated.

Numerical Modelling

4.37 The main water quality concern associated with the proposed Works, elevated suspended solids levels, has been investigated quantitatively by applying the MUDFLOW model from the WAHMO suite. The model determines the excursion of the sediment plume generated by the dredging activities to enable increases in concentration which might be expected near Sensitive Receivers to be investigated.

4.38 The MUDFLOW model was driven by the 100m Green Island model results which were generated by CED Port Developments Division for the GIRPD study. This model was based on the CED Lantau Port and Western Harbour calibrated 100m model; its boundary is shown in Figure 4.1. The same baseline condition was used as for the GIRPD study which included (either directly or indirectly) the following planned or committed developments:

- Chek Lap Kok
- North Lantau Reclamation
- Lantau Fixed Crossing
- Container Terminal 8
- Container Terminal 9
- West Kowloon Reclamation (North and South)
- Central and Wan Chai Reclamation
- Kowloon Point Reclamation
- Kellett Bank Dredging
- South Tsing Yi Borrow Pit (depths after completion of Terminal 7 construction)
- Belcher Bay Reclamation (all three phases)

The results files from the Green Island 100m flow model do not include a representation of WSC Pit 3 in the bathymetry. However, the effects of the presence of Pit 3 on water velocities and sediment transport are judged to be small. The likely effect of the Pit would be that more material would be trapped in the lower, slow moving water below the level of the surrounding sea bed and would therefore settle out of suspension over the area of the Pit. The absence of Pit 3 in the model therefore means that the model predictions will tend to over-predict suspended solids concentrations.

4.39 Four model runs were carried out for four tide types (wet and dry season, spring and neap tides) to investigate the worst case dredging scenario. A further run was carried out for the wet season spring tide, following consultations with GEO and EPD, to consider the effects of a modified reduced impact scenario.

4.40 The worst case was advised by DEMAS to be the following activities occurring at the same time (Scenario 1 in Section 2.23):

- 1 dredger dredging in Marine Borrow Area Pit 3 for marine sand;
- 1 dredger dredging in Marine Borrow Area Pit 2 for alluvial sand.

No dumping would take place whilst the two dredgers were at work. The cycle of each dredger would be interrupted whilst sand in the hopper is shipped to the reclamation site and the vessel returns so that, in reality, both dredgers would only be dredging together for part of the time.

4.41 Because of the uncertainty of the programme start date, it was further assumed that this scenario would be effective concurrent with the dredging that will be required for the west sea wall of the GIRPD. The same dredging assumptions as made in that study were applied for the latest set of sediment transport model (MUDFLOW) runs.

4.42 The location of the source was simulated to represent a moving TSHD on a typical dredging route for Pits 2 and 3, dredging on an intermittent cycle. The GIRPD western sea wall dredging was represented by a single point in the midpoint of the line of the wall and was assumed to be continuous. The source terms for the first four runs are presented in Table 4.7.

Table 4.7 Sediment plume model input: dredging details for worst case scenario

	West of Sulphur Channel Borrow Area		GIRPD
Dredger details	Dredger 1 - Pit 3	Dredger 2 - Pit 2	Western seawall
Material	Marine Sand	Alluvial Sand	Marine clay
Sailing time (minutes)	87	87	Continuous
Dredge no overflow (minutes)	17	17	
Dredge with overflow (minutes)	62	47	
Total cycle time (minutes)	166	151	
Loss of fines per cycle (Mg)	2,262	668	
Average rate of loss of fines (kg/s)	610	240	8

4.43 The model was run for three consecutive cycles with all results being plotted from the third tide.

4.44 The second worst case (Section 2.25) assumes one dredger dredging for marine sand in Pit 3 whilst a second is dumping uncontaminated overburden material dredged from Pit 1 into Pit 2. The loss of fines for this scenario is less than that of two vessels dredging simultaneously so this combination has not been assessed further.

4.45 A third scenario was presented (Section 2.26) which assumed that one dredger would dredge uncontaminated mud from outside the area for disposal in Pit 2 in between its sand dredging cycles in Pit 3. Again, the overall losses associated with this scenario are lower so this case has not been investigated further.

4.46 The reduced impact scenario was based on Scenario 1 but assumes that a 50:50 mixture of marine:alluvial sand would be dredged during each cycle in Pit 3, instead of marine sand alone. This would have the effect of reducing the maximum losses of fines per second although the overall losses throughout the project would be similar.

Impacts of Dredging and Dumping Activities

Sediment Transport

Dry Season Spring Tide

4.47 During the dry season spring tide at peak ebb, the suspended sediments plume in the surface layer extends from the South coast of Tsing Yi in the North to Wong Chuk Kok on Lamma Island in the south and, at its widest, is approximately 5 km wide (Figure 4.6a). The influence of the high velocity ebb currents between Tsing Yi and Lantau can be seen clearly at the northern end of the plume and is further apparent from the "shadow" effect south of Kau Yi Chau. The concentrations in most of the plume are less than 10 mg/l but there is an area off the west coast of Hong Kong, some 9km long by 2km wide, where they are greater. At the core of the plume, extending south south east from the dredging source for about 3 km, concentrations exceed 50 mg/l. The plume impinges on the west coast of Hong Kong where maximum concentrations may be up to 20 mg/l and, to a less severe extent, on the south west coasts of Tsing Yi to the north and Ap Lei Chau to the south (< 10mg/l). The extent of the plume in the bed layer is similar, the main differences being that concentrations are in general slightly higher (Figure 4.6b).

4.48 During the peak flood stage of the tide, the surface layer plume occupies a much smaller area (Figure 4.6c). Concentrations in excess of 10 mg/l are confined to a smaller proportion of the overall plume area. Where the plume makes contact with the coast concentrations are less than 10 mg/l. The plume is larger in the bed layer but concentrations at the coast are similarly less than 10 mg/l (Figure 4.6d).

4.49 Average suspended solids concentrations are indicated in Figures 4.6e and 4.6f for the surface and bed layers respectively. As might be expected with the high loss rates associated with overflow dredging, concentrations in the immediate area of the Works remain constantly high. In the surface layer, average increases are less than 10 mg/l at all points where the plume makes contact with the coast. In the bed layer, which is less likely to affect sensitive receivers, average concentrations just reach 10 mg/l on Hong Kong Island's west coast.

Wet Season Spring Tide

4.50 Figure 4.7a shows the plume for the surface layer at peak ebb during the wet season spring tide. The plume is more extensive than for the dry season spring tide, particularly in that it reaches east into Victoria Harbour and south to both sides of Lamma Island. Contact is made with the coast on the west coast of Hong Kong Island (with concentrations up to 20 mg/l) and, with concentrations less than 10 mg/l, along the Western and Central waterfront, the south coast of Tsing Yi and Ap Lei Chau (including the northern leg of Aberdeen Harbour). The bed layer is slightly less extensive (Figure 4.7b) but a higher proportion of the total area (approximately half) contains concentrations of greater than 10 mg/l.

4.51 Similar to the dry season spring tide, the extent of the plume at peak flood (Figures 4.7c and 4.7d) is much less than at peak ebb in both layers. With some minor exceptions in the bed layer, concentrations at all points of contact with the coast are less than 10 mg/l.

4.52 Average plume concentrations for the surface and bed layers are shown in Figures 4.7e and 4.7f respectively.

Dry Season Neap Tide

4.53 The lower tidal velocities associated with the neap tide result in a lower extent of the plume. The 1mg/l contour does not reach Tsing Yi to the north in either layer during either the peak flood or peak ebb condition (Figures 4.8a-d) To the south, the plume is predicted to move down the East Lamma Channel to a similar extent to the dry season spring tide result; the plume moves slightly closer to the tip of the Ocean Park headland but it is not predicted to make contact with it and the Ocean Park seawater intake, a potential sensitive receiver on the east side of the headland, is approximately 1km away from the 1mg/l contour. The average concentrations in the surface and bed layers are shown in Figures 4.8e and 4.8f respectively.

4.54 Suspended solids concentrations where the plume makes contact with the west coast of Hong Kong Island are predicted to be similar to or lower than those predicted for either of the spring tides. Concentrations at a midpoint between the two main dredging sources are also lower and it can therefore be concluded that the dry season neap tide does not represent the worst case for water quality impact.

Wet Season Neap Tide

4.55 In contrast to the other three tides, the plume does not extend very far south of the dredging area during the wet season neap tide. At peak ebb (Figures 4.9a and 4.9b) the southern point of the 1mg/l contour of the plume is approximately 1km north of Lamma Island, its northern extreme extending to the north of Tsing Yi Island. Contact is made with the west coast of Tsing Yi Island but concentrations are very low (approximately 1mg/l) where this occurs. The extent of the plume is similar in both surface and bed layers.

4.56 At peak flood the plume moves further north still, the 1mg/l contour extending to the north and west of Ma Wan Island to meet the mainland coast between Tsing Ling Tau and Sham Tseng (Figures 4.9c and 4.9d). Similarly, concentrations are very low (in the order of 1mg/l) where the plume impinges with the coast. The plume does not reach the Ma Wan mariculture zone.

4.57 The central part of the plume (concentrations above 10mg/l) remains in a relatively compact area and does not make contact with the coast. Average concentrations for surface and bed layers are shown in Figures 4.9e and 4.9f.

Reduced Impact Scenario

4.58 A reduced impact scenario proposed by DEMAS which assumes that a mixture of marine sand and alluvial sand will be dredged in Pit 3 has been modelled for the worst case tide, the wet season spring tide. A mixture of 50% marine sand and 50% alluvial sand was assumed, giving an average overflow fines loss rate of 460 kg/s effective over a period of 53 minutes (compared with 610 kg/s and 62 minutes for the worst case scenario as detailed in Table 4.7). The average increases in concentration associated with this scenario are illustrated in Figures 4.10a and 4.10b for the surface and bed layers respectively.

4.59 Comparing these figures with Figures 4.7e and 4.7f for the worst case scenario, it can be seen that whilst the overall shape and extent of the plumes in both layers for both the standard and mitigated cases is similar, the area occupied by each concentration contour is slightly reduced for the mitigated situation. The difference is most significant in the >50ppm contour, reflecting the lower concentrations in the area of the pits resulting from the reduced initial loss rate.

Deposition

4.60 Deposition rates have been predicted both as mass of deposition over a single tide and as depth of deposition over a six month period. The mass deposited over a single tide has been predicted for each tide type and the results are presented in Figures 4.11 to 4.14. The predictions of depth of deposition over six months have been made for both dry and wet seasons, the results reflecting expected behaviour during both spring and neap tides; these figures are illustrative and represent the worst case, given that marine sand (which has the highest fines content) will only be dredged from Pit 3 for a period of approximately 3 months and losses at other times will be lower.

4.61 The deposition over a single dry season spring tide ranges between 0.01 - 0.50 kg/m^2 over the majority of the affected area, extending from Tsing Yi in the north to Lamma Island and the East Lamma Channel in the south. A relatively thin band (approximately 1km wide) runs from just north of STY Pits 1 & 2 down to Ap Lei Chau; a large proportion of this area experiences daily deposition of over 1kg/m^2. In those areas very close to the pits deposition can be over 2.0kg/m^2.

4.62 During the wet season spring tide the pattern of deposition is more fragmented. The affected area extends further south in the West Lamma Channel and light deposition (<0.5kg/m²/day) may be expected along parts of the north Hong Kong Island and Kowloon coastlines. The area affected by higher concentrations (>1.0kg/m²/day) is very similar to that for the dry spring tide, however. In the main part of the East Lamma Channel, where the channel is deep and flows relatively high on this tide, it can be observed that there is no significant deposition (<0.01kg/m²/day).

4.63 During the dry season neap tide the overall affected area is smaller than for the spring tides, although the pattern of deposition over 1kg/m²/day is similar. The tendency for the East Lamma Channel to be clear is again apparent.

4.64 Consistent with the suspended solids plumes for the wet season neap tide, the area affected is further north than for the other three tides, centring on South Tsing Yi and, in the lower deposition rate band (0.01 - 0.50 kg/m²/day), reaching up the west coast of Tsing Yi to the mainland at Ting Kau.

4.65 The illustrative depth of deposition which may be expected over 6 months during the dry season is predicted to be between 0.001m and 0.20m over much of the model area. The deepest deposition lies on the line running south south east from just north of the pits down to the southern end of the west coast of Hong Kong Island, near Wah Fu. In the areas closest to the pits depths are predicted to be in excess of 0.80m over the six month period.

4.66 The illustrative 6 month predictions for the wet season again show a more fragmented picture than the dry season results although the relative areas affected by the contour bands are similar in size. The influence of the wet season neap tide can be seen to have pushed the central area of high concentration slightly north. The deposition expected in the central part of the East Lamma Channel is again negligible (<0.001m) although the sides of the Channel, home to sensitive coral communities, may experience greater depths (but still likely to be less than during the dry season).

4.67 It should be noted that long term bed levels in the areas to be affected by deposition are, on the whole, stable and it is probable that some of this material will be re-eroded during subsequent storm events and dispersed over a wider area (Ref 4.18).

Impacts on Sensitive Receivers

4.68 Comparison of the results for the four tides suggests that the wet season spring tide presents the worst case. The high water velocities associated with this tide result in an extensive plume much of which contains concentration increases in excess of 10 mg/l.

4.69 The impacts are evaluated by comparing the predicted maximum increases in sediment concentrations, when added to background levels, with the concentrations which might result in water quality problems for sensitive receivers. The background levels are taken from routine EPD monitoring data for 1992 as presented in Table 4.4.

4.70 The contoured plots produced from the model runs described above indicate that several of the potential sensitive receivers identified will not be adversely affected by the sediment plume. These include the mariculture zones at Ma Wan and Sok Kwu Wan, the Ocean Park seawater intake and the bathing beaches on Hong Kong Island South. Similarly, although the plume does extend along the north coast of Hong Kong as far as Sheung Wan for short periods under some conditions, concentrations are very low and there is no likely significant impact on seawater intakes there.

4.71 Figures 4.17 - 4.20 present the predicted tidal variation in concentration increases, at positions of the sensitive receivers most at risk, for each of the four tide types: dry spring, wet spring, dry neap and wet neap tides respectively. The specific impacts associated with the wet season spring tide mitigated case are also presented (Figure 4.21). The key sensitive receivers in the areas which are affected by the plume include the mariculture zone at Lo Tik Wan, the Tsing Yi power station cooling water intake, the WSD flushing seawater intake at Kennedy Town, the Housing Authority flushing water intake at Wah Fu and the cooling water intake for Queen Mary Hospital at Pokfulam.

4.72 Table 4.8 summarises the maximum impacts that may be expected on these key sensitive receivers for all four tide types under the worst case scenario. The reduced impact "mitigated" case for the wet season spring tide is also included.

4.73 The results summarised in Table 4.8 indicate that, in general, predicted increases in sediment plume concentrations in the vicinity of most of the sensitive receivers will be significantly below maximum acceptable levels. The requirements for protecting pumping plant at Tsing Yi and other cooling water intakes are many times higher than maximum concentrations in any of the areas where the plume meets the coastline. Similarly, the guidelines for protecting mariculture zones are safely above the increases predicted at Lo Tik Wan, the only mariculture zone predicted to be affected at all by the plume.

4.74 Although it is located near the edge of the plume where increases are relatively low, the critical impact indicated in Table 4.8 is likely to be that at the WSD seawater intake at Kennedy Town. The WSD WQO of 10mg/l may occasionally be exceeded by background concentrations at Kennedy Town and the maximum values recorded at most stations are generally close to this limit. The maximum increases in the surface layer on both spring tides and the wet season neap tide are sufficiently high to result in regular exceedance of the WQO at this site.

4.75 The reduced impact scenario would result in the greatest reductions at those sensitive receivers along the west coast of Hong Kong Island, namely the Queen Mary Hospital cooling water intake and the Housing Authority flushing water intake at Wah Fu. There is little effect on sensitive receivers located to the north and south as a result of the reduced fines loss rate associated with this scenario.

4.76 The anticipated regular exceedance of the WSD WQO at the Kennedy Town intake indicates that mitigation measures will be required to reduce concentrations to an acceptable level.

Table 4.8 Summary of Impacts of Increased Suspended Solids on Sensitive Receivers

Sensitive Receiver	Maximum acceptable SS (mg/l)	Basis of maximum criterion	Background level (mg/l)	Maximum Increase in SS (mg/l)					Maximum Total SS (mg/l)				
				DS	WS	DN	WN	WS Mitigated	DS	WS	DN	WN	WS Mitigated
WSD Kennedy Town SW PS	10	WSD WQO	8 *(VM8)* (2 - 16)	5	9	1	6	8	**13** *7-21*	**17** *11-25*	**9** *3-17*	**14** *8-22*	**16** *10-24*
Tsing Yi Power Station Cooling Water Intake	140	Guidelines for pump wear	12 *(WM3)* (3 - 24)	3	5	-	5	5	**15** *6-27*	**17** *8-29*	**12** *3-24*	**17** *8-29*	**17** *8-29*
Queen Mary Hospital Cooling Water Intake	140	Guidelines for pump wear	5 *(WM1)* (2 - 8)	18	24	20	4	17	**23** *20-26*	**29** *26-32*	**25** *22-28*	**9** *6-12*	**22** *19-25*
Housing Authority Wah Fu SW PS	140	Guidelines for pump wear	5 *(WM1)* (2 - 8)	28	31	26	-	23	**33** *30-36*	**36** *33-39*	**31** *28-34*	**5** *2-8*	**28** *25-31*
Lo Tik Wan MCZ/ Luk Chau Wan fry collection zone	80	AFD Limit	5 *(SM3)* (3 - 9)	11	20	4	-	17	**16** *14-20*	**25** *23-29*	**9** *7-13*	**5** *3-9*	**22** *20-26*

Notes:

1. Background data are taken from EPD monitoring data for 1992 relating to monitoring stations as indicated.
2. Predicted suspended solids increases relate to the surface layer unless otherwise specified.
3. DS = Dry Season Spring Tide; WS = Wet Season Spring Tide; DN = Dry Neap; WN = Wet Neap; SW PS = Seawater Pumping Station.
4. Values in "maximum increase in SS" columns are maximum levels within each tidal cycle at the points specified as predicted by the model.
5. Values in **bold** in "maximum total SS" columns are based on average EPD background levels; values in *italics* are based on maximum levels from the range monitored by EPD.
6. Double lines surrounding values in "maximum total SS" columns indicate possible exceedance of maximum allowable concentrations; thick lines indicate likely exceedance of maximum allowable concentrations.

Table 4.9 Summary of Cumulative Impacts of Increased Suspended Solids on Sensitive Receivers (including effects of East Lamma Channel dredging)

Sensitive Receiver	Maximum acceptable SS (mg/l)	Basis of maximum criterion	Background level (mg/l)	Maximum Increase in SS (mg/l)					Maximum Total SS (mg/l)				
				DS	WS	DN	WN	WS Mitigated	DS	WS	DN	WN	WS Mitigated
WSD Kennedy Town SW PS	10	WSD WQO	8 *(VM8)* (2 - 16)	5	9	1	6	8	**13** *7-21*	**17** *11-25*	**9** *3-17*	**14** *8-22*	**16** *10-24*
Tsing Yi Power Station Cooling Water Intake	140	Guidelines for pump wear	12 *(WM3)* (3 - 24)	3	5	-	5	5	**15** *6-27*	**17** *8-29*	**12** *3-24*	**17** *8-29*	**17** *8-29*
Queen Mary Hospital Cooling Water Intake	140	Guidelines for pump wear	5 *(WM1)* (2 - 8)	18	34	20	4	27	**23** *20-26*	**39** *36-42*	**25** *22-28*	**9** *6-12*	**32** *29-35*
Housing Authority Wah Fu SW PS	140	Guidelines for pump wear	5 *(WM1)* (2 - 8)	28	41	36	-	33	**33** *30-36*	**46** *43-49*	**41** *38-44*	**5** *2-8*	**38** *35-41*
Lo Tik Wan MCZ/ Luk Chau Wan fry collection zone	80	AFD Limit	5 *(SM3)* (3 - 9)	11	30	14	-	27	**16** *14-20*	**35** *33-39*	**19** *17-23*	**5** *3-9*	**32** *30-36*

Notes:

1. Background data are taken from EPD monitoring data for 1992 relating to monitoring stations as indicated.
2. DS = Dry Season Spring Tide; WS = Wet Season Spring Tide; DN = Dry Neap; WN = Wet Neap; SW PS = Seawater Pumping Station.
3. Values in "maximum increase in SS" columns are maximum levels within each tidal cycle at the points specified as predicted by the model of WSC, increased by the maximum of the appropriate contour range for tida average conditions for the East Lamma Channel.
4. Values in **bold** in "maximum total SS" columns are based on average EPD background levels; values in *italics* are based on maximum levels from the range monitored by EPD.
5. Double lines surrounding values in "maximum total SS" columns indicate possible exceedance of maximum allowable concentrations; thick lines indicate likely exceedance of maximum allowable concentrations.

4.77 Because of the low background suspended solids concentrations in the relevant waters as indicated by the available data, the limit imposed by the WQO for suspended solids of a 30% increase over ambient levels results in a low target level which will be exceeded by many parts of the plume at certain stages of each tide. Taking the average of the annual mean values recorded by EPD for 1992 at stations in the area that will be affected by the plume gives an ambient background level of just 7mg/l which, when increased by 30%, gives a limit of less than 10mg/l. However, the actual impacts associated with this target limit would be negligible and large areas of the plume which do not comply with the WQO would still be at sufficiently low concentrations to be visually unapparent. In interpreting the predicted concentrations against the WQO, emphasis should be placed on ensuring that sensitive receivers and marine communities are protected.

4.78 Figures 4.22a and 4.22b illustrate, for the surface and bed layers respectively, the areas where, based on average concentrations in the surface layer for the wet season spring tide (worst case), the suspended solids concentrations are likely to rise more than 30% above the assumed background levels (representing an exceedance of the WQO). Also indicated is the area where total average concentrations (ie background + increase) may be expected to exceed 80mg/l, adopted as being a conservative limit above which adverse effects on some forms of marine life may be expected. A mid-range total concentration contour of 30mg/l is also shown. The figures clearly demonstrate that total average concentrations over 80mg/l are only likely to occur in very small areas in the immediate vicinity of the dredging works and that the area where concentrations would exceed 30mg/l is relatively small.

4.79 Although concentrations which would threaten marine communities or sensitive receivers are not expected to arise on a large scale, it is possible that visual impacts may arise in the parts of the plume with concentrations over, say, 30mg/l. Such visible impacts will be of a temporary nature but they may attract complaints from fisherman or the general public, particularly where the plume is visible at the coast or from passing ferries. It is not anticipated that concentrations will be sufficiently high to present a threat to vessel water intakes.

Cumulative Impacts

4.80 An assessment has been carried out of the possible additive effects of the dredging to be undertaken in the West of Sulphur Channel Borrow Area with those of other concurrent activities nearby. The sediment plume modelling undertaken as part of this study has already included the dredging sources at Pits 1/2 and at the GIRPD western seawall. The other major dredging area in the vicinity with which additive effects are likely to be experienced is the East Lamma Channel Borrow Area.

4.81 The effect of the interaction of the two plumes is a complex one. If, for example, the plume from the ELC dredging extended as far as the dredger working on the WSC pits, the losses from the WSC would be directly additive to the suspended concentrations in the receiving waters generated by the ELC dredging. More remote from either dredger, the interaction of the plumes will be complex depending on the tidal flows and mixing processes. The resulting combined plume concentration will vary from almost 100% ELC and 0% WSC to a weighted average of the two concentrations to 0% ELC and 100% WSC depending on location.

4.82 It is difficult to estimate the combined plume concentrations with much accuracy without simulating both dredging operations simultaneously in the same model. In carrying out the assessment of cumulative impacts, the concentrations have therefore simply been added together giving the upper limit on possible combined impacts. Table 4.9 indicates the "maximum" levels at the key sensitive receivers based on the maximum within-tide increases predicted by the model for WSC, increased with the maximum end of the relevant tide average contour band for ELC, where applicable. Based on the ELC study results, the average increase in suspended solids at any of the WSC sensitive receiver locations in Table 4.9 lies within the 1-10mg/l band. The additional impacts caused by ELC dredging over and above the maximum predictions for WSC have therefore been represented by adding 10mg/l at each sensitive receiver location where the plumes overlap.

4.83 Figures 4.23 - 4.25 show the predicted cumulative concentration increases in plan form, derived by adding together the *tide average* predicted concentrations for both WSC and ELC, in those areas where the average plumes from the two sources are expected to overlap. For the dry season spring tide the overlap is confined to a relatively short stretch of the East Lamma Channel and gives the combined concentration increases illustrated in Figure 4.23.

4.84 During the wet season spring tide, the overlap in the surface layer covers an almost identical area to that for the dry season spring tide with similar cumulative concentrations expected. In the bed layer the overlap extends to the 10-20mg/l contour of both plumes over limited areas off the west coast of Hong Kong Island giving a possible maximum increase of over 40 mg/l (although it is unlikely to be as high as this). However, the impact of such concentrations in the lower layer is less serious than it would have been in the upper layer; given the short duration and limited area over which such additive effects may be expected and considering the sensitive receivers nearest to the relevant areas, this is not perceived to cause any unacceptable impacts. The combined effects where the plumes overlap are shown in Figure 4.24.

4.85 During the dry season neap tide, the overlapping area extends from north of Green Island to south of the Ocean Park headland. The northern part of the overlapping areas includes the high concentrations of suspended solids concentrations that will occur in the vicinity of the WSC pits. The ELC plume is less than 10mg/l over the entire area of overlap, however, so the marginal effect of the overlap is of limited significance. The combined effects of the overlapping plumes are shown in Figure 4.25.

4.86 There is no overlap between the two plumes during the wet season neap tide.

4.87 The environmental review of potential borrow areas in the North Lamma Channel (Ref. 4.13) identified a potential borrow area between Pit 3 in the current study and the north of Lamma Island. However this area has not been gazetted and, in the absence of details relating to its probable environmental impacts and dredging programme, the cumulative effects of this area have not been taken into consideration.

Control & Mitigation Measures

4.88 In order to minimise adverse impacts on water quality resulting from the Works, methods of working should be carried out to:

- minimise disturbance to the sea bed during dredging and disposal activities;
- minimise leakage of dredged material during lifting or disposal activities;
- minimise loss of material during transport of fill or dredged material;
- prevent discharge of fill or dredged material except at approved locations; and
- prevent the breach, due to the Works, of the TAT limits specified in the Environmental Monitoring & Audit (EM&A) Manual by the timely implementation of suitable Action Plans.

4.89 Unacceptable impacts have been predicted at the WSD flushing seawater intake at Kennedy Town. In order to reduce these to acceptable levels it is recommended that a silt screen should be provided around the intake. A suitably designed screen may be expected to reduce suspended solids concentrations reaching the intake by a factor of approximately 2.5 so that, for example, the expected maximum concentration of 17 mg/l during the wet season spring tide (Table 4.8) would be reduced to 7mg/l. In the event that the tidal cycle maximum increase at Kennedy Town due to the plume should coincide with ambient levels of the order of the maximum recorded by EPD at Station VM8 during 1992, the resulting concentration of 25mg/l would be reduced to 10mg/l with the screen present.

4.90 It is recommended that the reduced impact scenario, comprising the dredging of a mixture of marine sand and alluvial sand during each cycle in Pit 3, is implemented only as a mitigation measure in the event of exceedance of the Action level specified in the EM&A Manual. The marine sand overlays the alluvial sand and would therefore be dredged first, allowing the reduced impact scenario to be adopted at any time whilst reserves of marine sand remain.

4.91 Appropriate monitoring will be necessary to confirm quantitative predictions of environmental impacts and to ensure that increases in suspended solids are contained within limits which will prevent significant detrimental effects on sensitive receivers. Because parts of the plume will inevitably consist of high suspended solids levels which would exceed the long term WQO limits, a system of TAT limits which relates to protection of the marine communities will be required.

4.92 Compliance monitoring should comprise a system of monitoring stations and control stations. Whilst the TAT levels will relate ultimately to absolute values it is important that the increase in concentrations within the plume over the running background concentrations are monitored to check that impacts of the Works do not worsen as the project progresses. The control stations will also highlight any increase linked to causes other than the WSC dredging works, preventing the unjustified imposition of mitigation actions on the Contractor. The recommended monitoring and control stations are shown in Figure 4.26.

4.93 A further three stations indicated in Figure 4.26 are recommended in accordance with the requirements of AFD concerning the monitoring of impacts at Sok Kwu Wan and Yung Shue Wan fish culture zones. One station is located adjacent to the boundary of each zone (F1 and F2), with another single station approximately midway between the borrow area and the zones (CF1). Monitoring at these stations should take place on a daily basis and will be interpreted according to a different set of TAT limits and action plans, as detailed in the EM&A Manual.

4.94 Three stations are located adjacent to water intakes at the Tsing Yi power station, the Queen Mary Hospital and the Wah Fu Estate (SR1 to SR3 respectively in Figure 4.26). These stations are recommended for the purpose of ensuring that the respective sensitive receivers are protected from unacceptable impacts and will only be used in the event of the exceedance of Action limits at monitoring station M1 (for SR1) or M3 (for SR2 and SR3).

4.95 To ensure that the running background level is applied appropriately, it is recommended that monitoring should begin a period of six weeks prior to the commencement of dredging. This will be important to establish adequately the actual background concentrations which exist at the start of the project so that impacts may be assessed against a fair baseline.

4.96 Monitoring and audit requirements which address the key potential environmental impacts identified in the course of this EIA are presented in detail in the EM&A Manual which is submitted in conjunction with this report (Ref 4.2). The Manual identifies the responsibilities of various parties, the monitoring programme and procedures to be adopted, and presents Action Plans linked to performance requirements.

Conclusions and Recommendations

4.97 The fundamental impact on marine water quality that may be expected to result from the West of Sulphur Channel dredging in Pit 3 will be elevated levels of fine inert material suspended in the water column. These suspended solids will arise from the overflow dredging method using a TSHD and will be greatest when marine sand is being dredged, owing to the high fines content of this material compared to alluvial sand.

4.98 The worst case scenario will comprise a combination of dredging for marine sand from WSC Pit 3 (the study area for this focused EIA) and for alluvial sand in STY Pit 2. Because of uncertainties with the timescale of the project, it is further assumed that this worst case will coincide with dredging work for the west sea wall for the GIRPD.

4.99 Existing water quality data, primarily that collected by EPD as part of the Department's routine monitoring, indicate very low ambient levels of suspended solids in the waters likely to be affected by the sediment plume. Data on sediment quality, subject to confirmation by data collected specifically for this study, indicate that sediments are uncontaminated; overlying marine mud at WSC Pit 3 may therefore be disposed of accordingly.

4.100 Sediment transport modelling of the worst case scenario has been carried out for four tide types: spring and neap tides in both the wet and dry season. Comparison of the results for these indicate that the greatest impacts may be expected during the wet season spring tide. A further model run was carried out for a reduced impact scenario for this tide, assuming a lower loss rate by dredging a mixture of marine and alluvial sands during each dredging cycle. This approach could be adopted if mitigation is necessary following the exceedance of TAT levels.

4.101 Impacts have been assessed in relation to a range of sensitive receivers including flushing water intakes, cooling water intakes and mariculture zones. The only receiver predicted to be affected beyond acceptable limits is the WSD flushing water intake at Kennedy Town. It is recommended that the effects of the plume be mitigated to acceptable levels by installing a silt screen around the intake.

4.102 The WQO for suspended solids limits the increase above ambient levels in marine waters within the Southern Waters and Western Buffer WCZs to 30% of ambient. Because of the high losses associated with dredging of this nature coupled with the extremely low ambient levels, it is inevitable that the WQO will be exceeded by large parts of the plume. However, the major part of the plume which exceeds the WQO is likely to be invisible and the level above which fish life may begin to be affected, conservatively assumed to be 80mg/l, is only exceeded in very small parts of the pits themselves. Although part of the plume generated by the worst case scenario may have some visual impact, the exceedance of the WQO is not generally regarded as a serious problem in the circumstances.

4.103 A system of monitoring is recommended which comprises monitoring and control stations. While linking TAT limits to absolute values designed to protect sensitive receivers, the difference between monitoring and control stations will allow the trend of impacts to be monitored and will help to identify when suspended solids may be elevated from other causes. Monitoring should begin prior to the works to allow the true running background levels to be established.

References

4.1 Green Island Reclamation (Part) - Public Dump. Environmental & Traffic Assessment. Revised Draft Final Report (EIA) Volume I (Main Report). Chapter 7 - Water Quality and Dredged Sediments. May 1994. Scott Wilson Kirkpatrick.

4.2 Draft Environmental Monitoring & Audit Manual: West of Sulphur Channel Borrow Area. Version 1. August 1994.

4.3 Marine Water Quality in Hong Kong. Results from the EPD marine water quality monitoring programme for 1988. Marine Section, Water Policy Group. EPD Hong Kong Government, 1989.

4.4 Marine Water Quality in Hong Kong. Results from the EPD marine water quality monitoring programme for 1989. Marine Section, Water Policy Group. EPD Hong Kong Government, 1990.

4.5 Marine Water Quality in Hong Kong. Results from the EPD marine water quality monitoring programme for 1990. Marine Section, Water Policy Group. EPD Hong Kong Government, 1991.

4.6 Marine Water Quality in Hong Kong. Results from the EPD marine water quality monitoring programme for 1991. Marine Section, Water Policy Group. EPD Hong Kong Government, 1993.

4.7 Marine Water Quality in Hong Kong. Results from the EPD Marine Water Quality Monitoring Programme for 1992. Monitoring Section, Water Services Group. Environmental Protection Department Hong Kong Government, 1994.

4.8 Green Island Reclamation Model Validation Field Measurement. Green Island Reclamation (Part) Public Dump, Draft Final Report EIA, December 1993.

4.9 Western Harbour Crossing Study Volume 5, Environmental Assessment. Western harbour Crossing Consultants. Highways Department Hong Kong Government.

4.10 Green Island Link Preliminary Feasibility Study Volume 4. PAPM Consultants.

4.11 Analytical Results of Sediment Sampling Exercise. Green Island Reclamation (Part) Public Dump, Draft Final Report EIA, December 1993.

4.12 Green Island Sediment Analysis - April 1994 Survey. Interim Report. Severn Trent Laboratories, April 1994.

4.13 Fill Management Study - Phase II. Investigation and Development of Marine Borrow Areas. Environmental Review of Potential Borrow Area, North Lamma Channel. April 1993. Binnie Consultants Limited.

4.14 Sewage Strategy Study, Working Paper 2, Water Quality Objectives. Watson Hawksley. EPD Hong Kong Government.

4.15 Hong Kong Government, EPD. 1992. Technical Circular No (TC) No 1-1-92, Classification of Dredged Sediments for Marine Disposal.

4.16 Assessment of the Environmental Impact of Marine Fish Culture in Hong Kong. Ove Arup & Partners, Final Report. EPD Hong Kong Government. 1991.

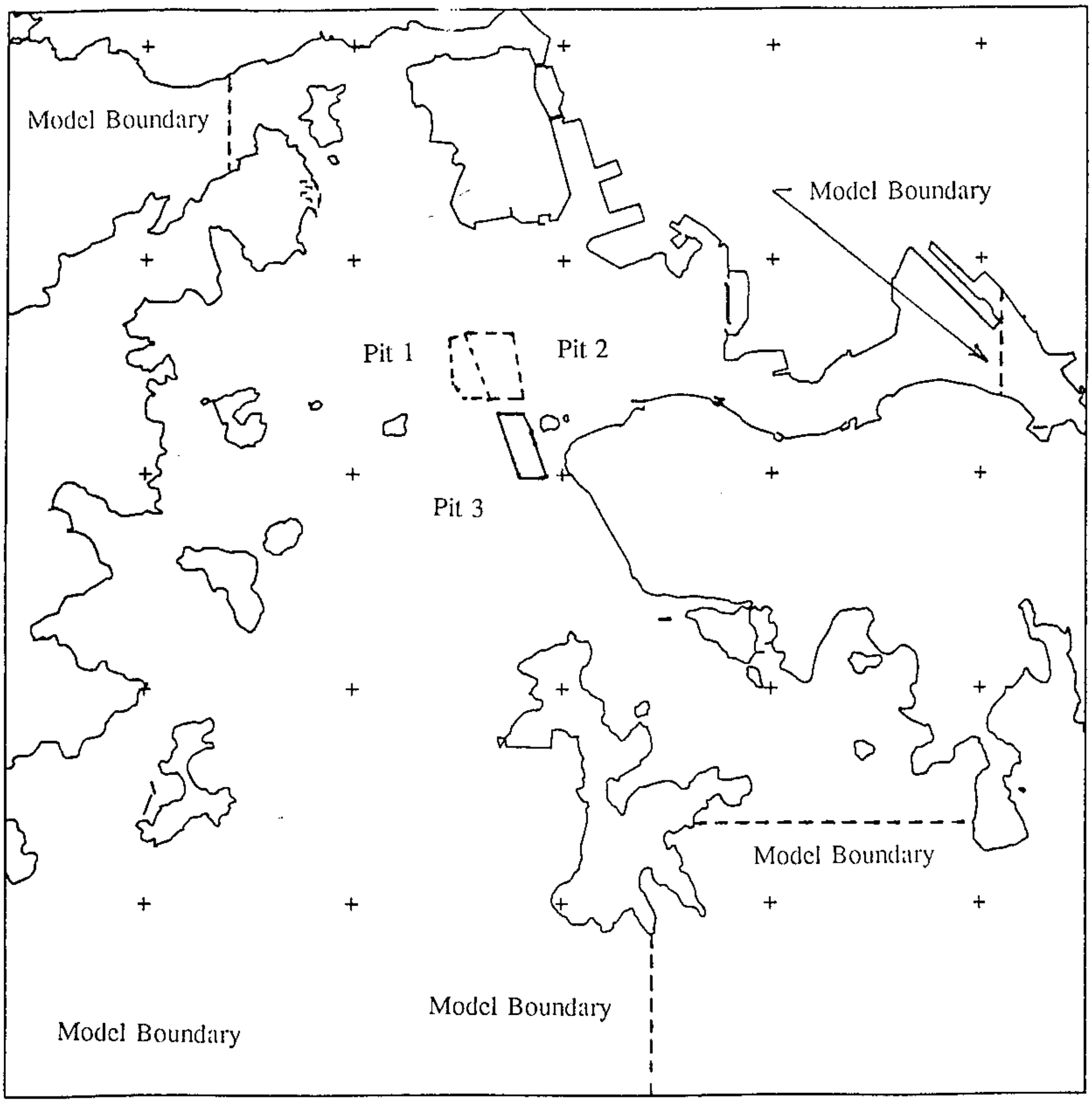
4.17 Fill Management Study - Phase II. Investigation and Development of Marine Borrow Areas. East Lamma Channel Borrow Area - Scoped Environmental Assessment. Final Report, January 1993. Binnie Consultants Limited.

4.18 Disposal of Spoil at South Tsing Yi, An Assessment of the Stability and Losses of Dumped Spoil. Hydraulics and Water Research (Asia) Ltd Report HWR 064, May 1993.

4.19 Works Branch Technical Circular No.22/92 Marine Disposal of Dredged Mud. Ref WB(W)209/32/96(92) Pt.II. 1992.

4.20 Widdows J. Plymouth Marine Laboratory.

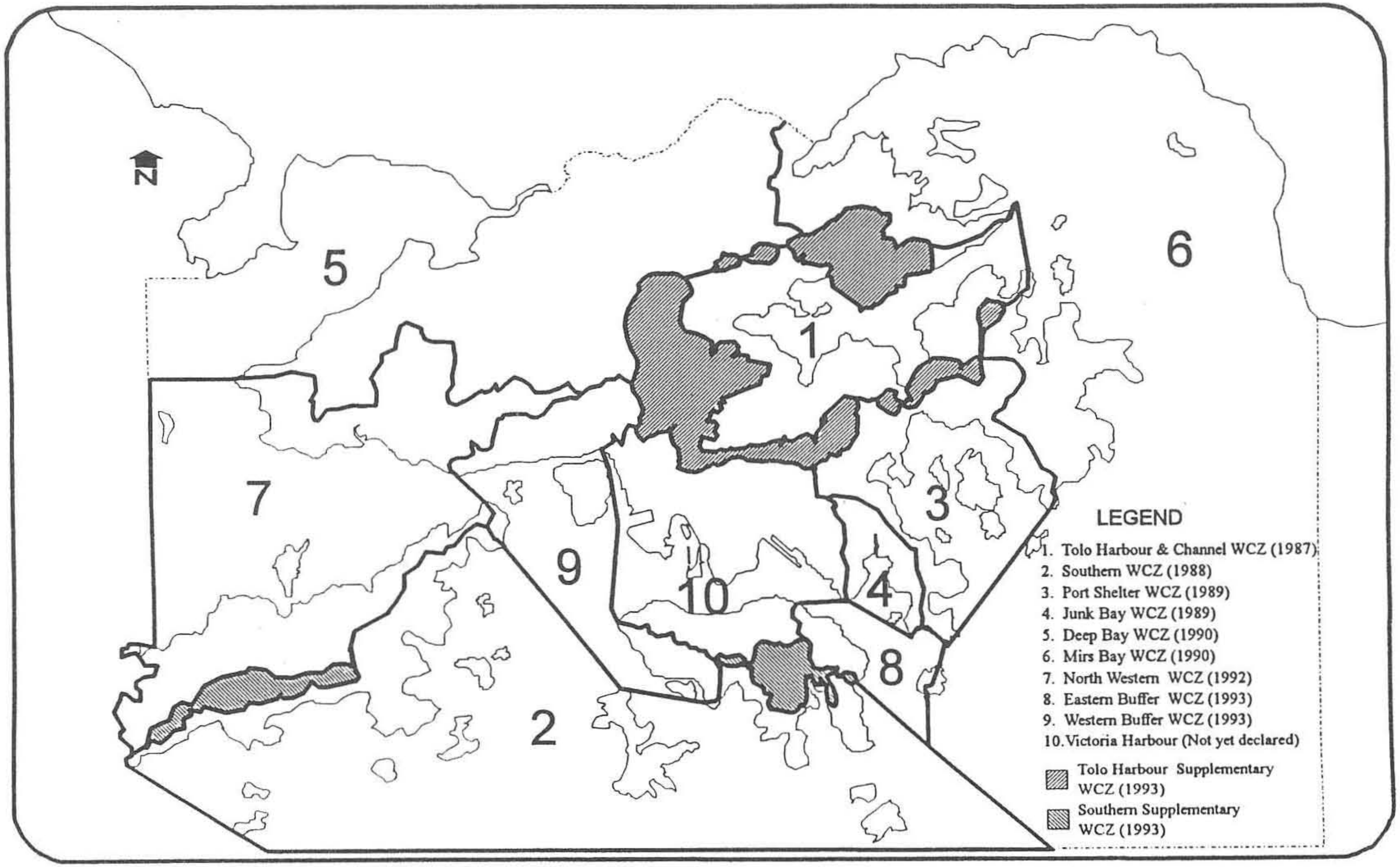
4.21 Alabaster, J.S. and Lloyd, R. (1982) *Water quality criteria for freshwater fish.* FAO, Butterworth Scientific, London.



WEST OF SULPHUR CHANNEL MARINE BORROW AREA
FOCUSED ENVIRONMENTAL IMPACT ASSESSMENT
FINAL REPORT

Figure No.	4.1

Location of Study Area and Model Boundary

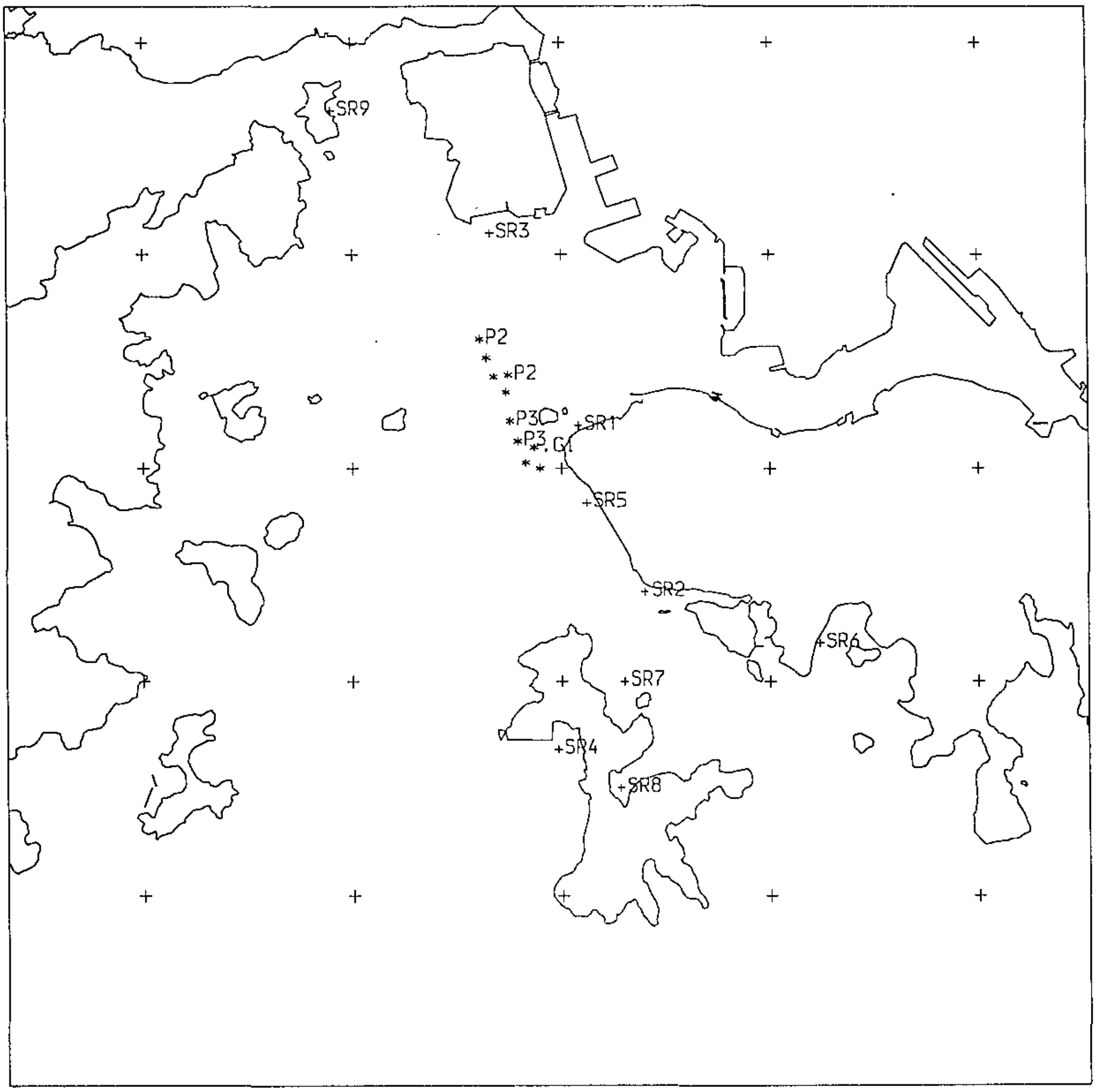


WEST OF SULPHUR CHANNEL MARINE BORROW AREA FOCUSED ENVIRONMENTAL IMPACT ASSESSMENT

Figure No.	4.2

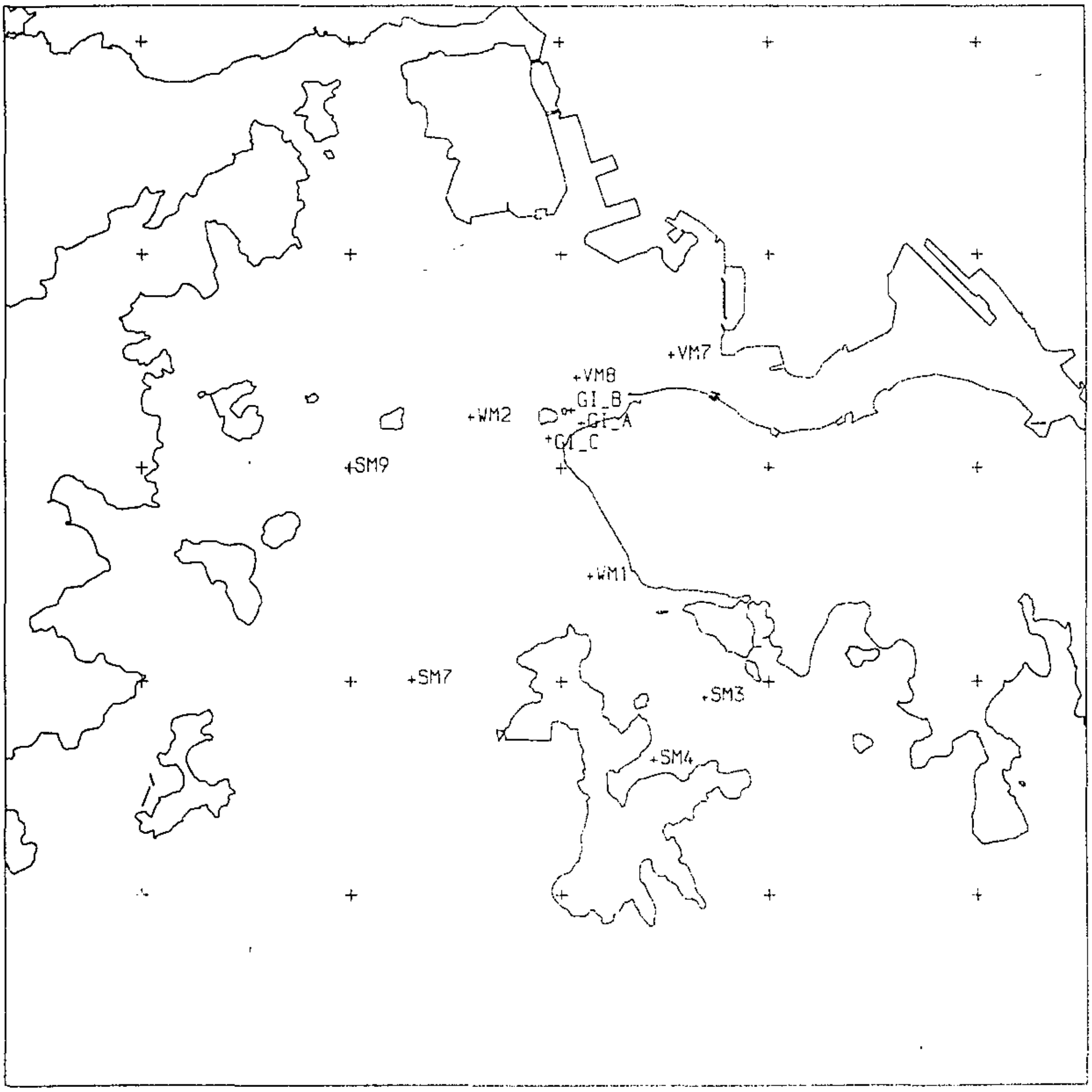
Water Control Zones

Source: EPD 1993, Ref 4.7



SR1 - WSD flushing water intake, Kennedy Town
SR2 - Housing Authority flushing water intake, Wah Fu
SR3 - Tsing Yi Power Station cooling water intake
SR4 - Lamma Island Power Station cooling water intake
SR5 - Queen Mary Hospital cooling water intake
SR6 - Ocean Park seawater intake
SR7 - Lo Tik Wan Mariculture Zone
SR8 - Sok Kwu Wan Mariculture Zone
SR9 - Ma Wan Mariculture Zone

WEST OF SULPHUR CHANNEL MARINE BORROW AREA FOCUSED ENVIRONMENTAL IMPACT ASSESSMENT FINAL REPORT	
Figure No.	4.3
Sensitive Receivers and Dredging Loss Sources	



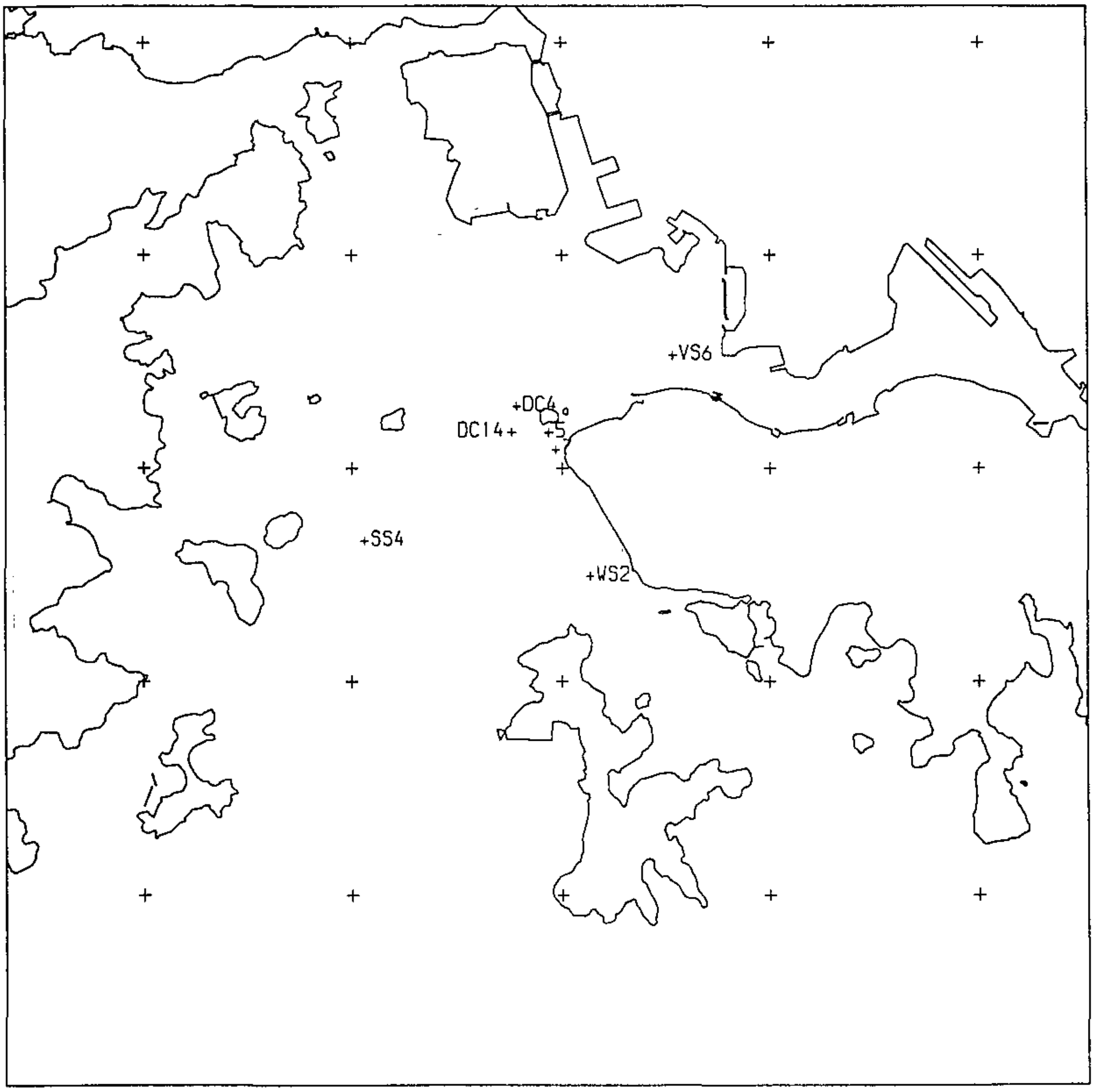
EPD Stations: VM7, VM8, WM1, WM2, SM3, SM4, SM7, SM9

Green Island Public Dump Reclamation survey locations: GI_A, GI_B, GI_C

WEST OF SULPHUR CHANNEL MARINE BORROW AREA
FOCUSED ENVIRONMENTAL IMPACT ASSESSMENT
FINAL REPORT

Figure No.	4.4

EPD Water Quality Monitoring Stations and GIPDR Survey Locations



EPD Stations: VS6, SS4, WS2

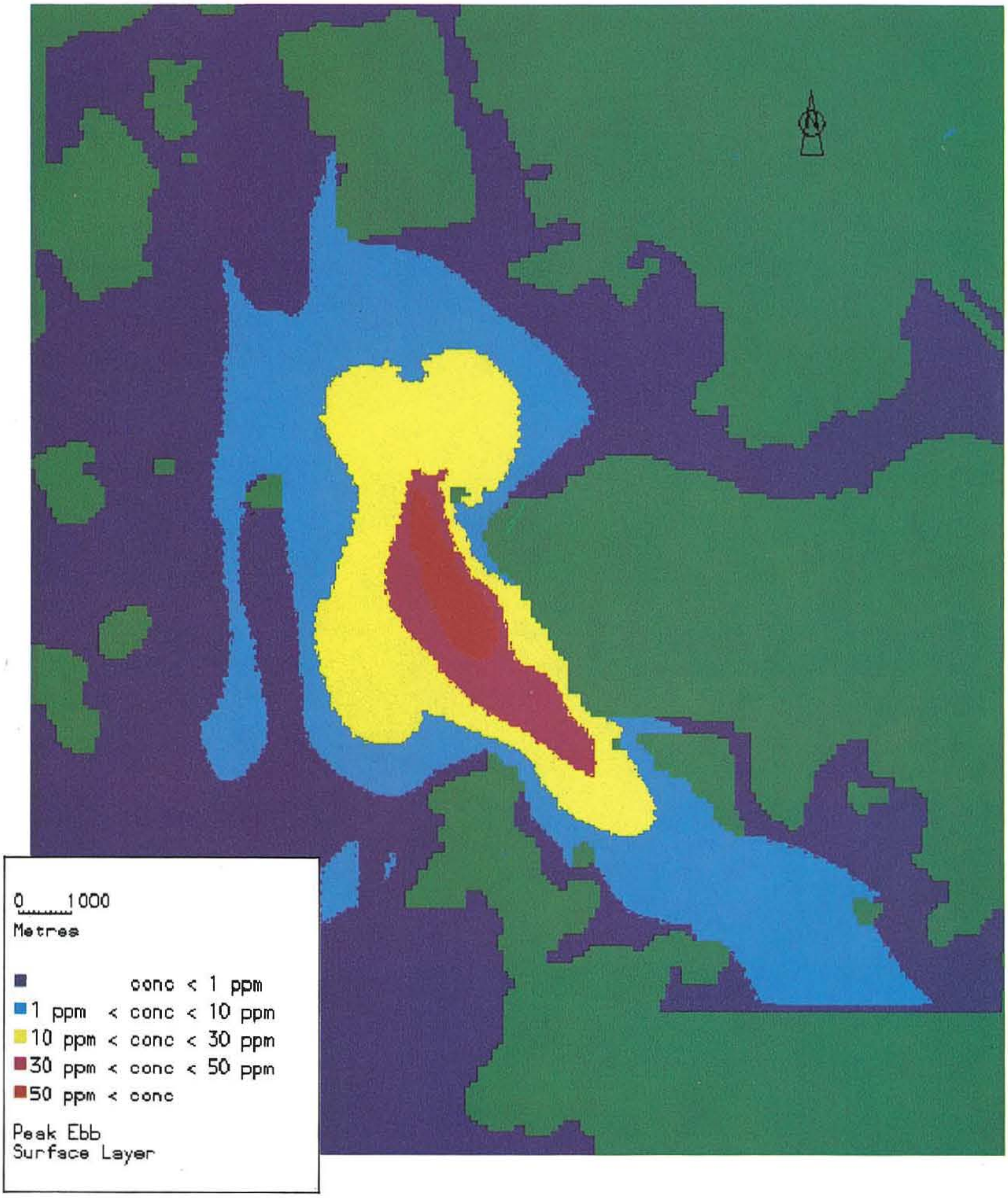
Green Island Link Survey: DC4, DC14

Green Island Public Dump Reclamation Survey: 5,7

WEST OF SULPHUR CHANNEL MARINE BORROW AREA
FOCUSED ENVIRONMENTAL IMPACT ASSESSMENT
FINAL REPORT

Figure No.	4.5

Sediment Sampling Locations

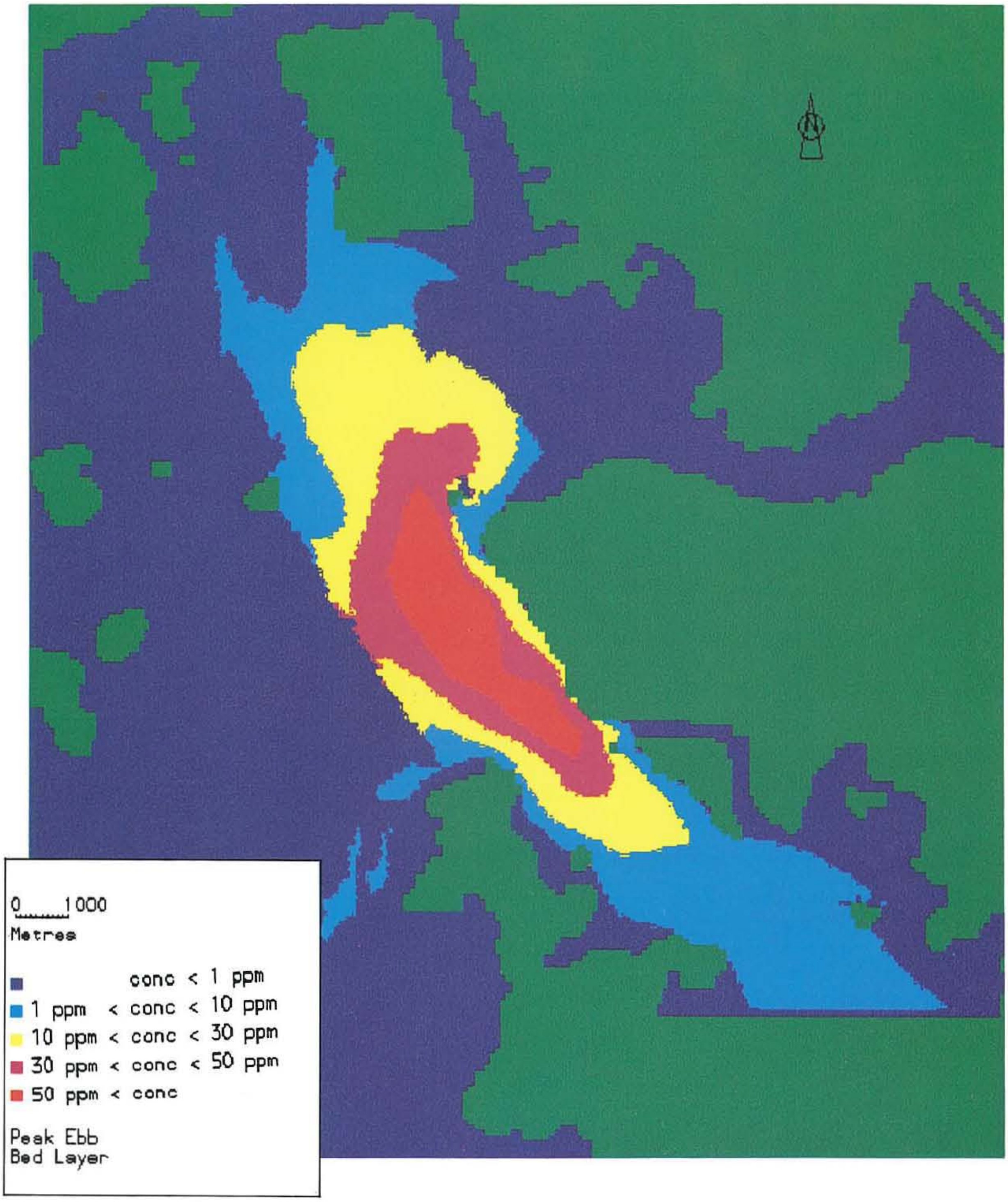


WEST OF SULPHUR CHANNEL MARINE BORROW AREA
FOCUSED ENVIRONMENTAL IMPACT ASSESSMENT
FINAL REPORT

Figure No.	4.6a

Dry Season Spring Tide: Surface Layer

Suspended Solids, Peak Ebb

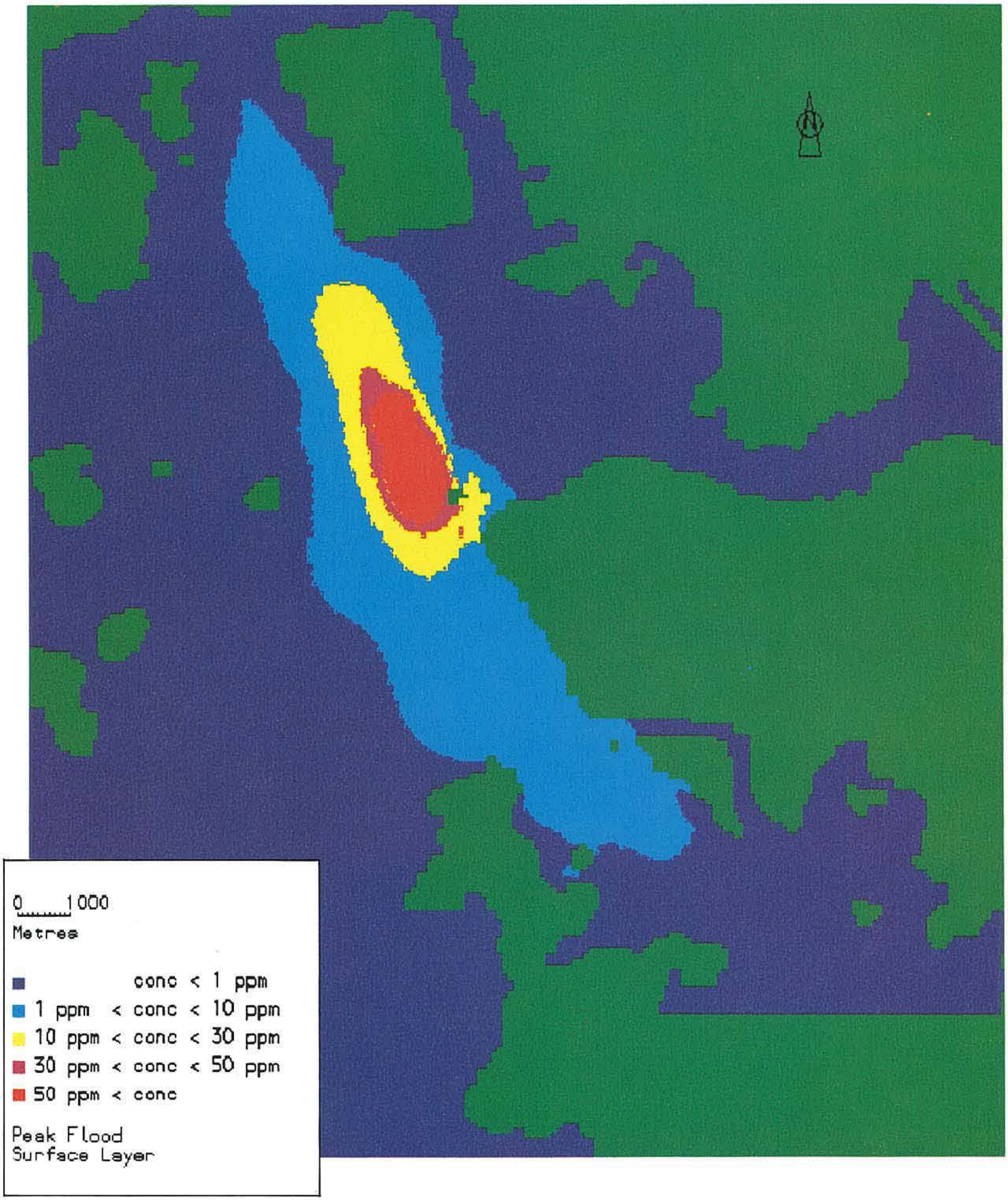


WEST OF SULPHUR CHANNEL MARINE BORROW AREA
FOCUSED ENVIRONMENTAL IMPACT ASSESSMENT
FINAL REPORT

Figure No.	4.6b

Dry Season Spring Tide: Bed Layer

Suspended Solids, Peak Ebb

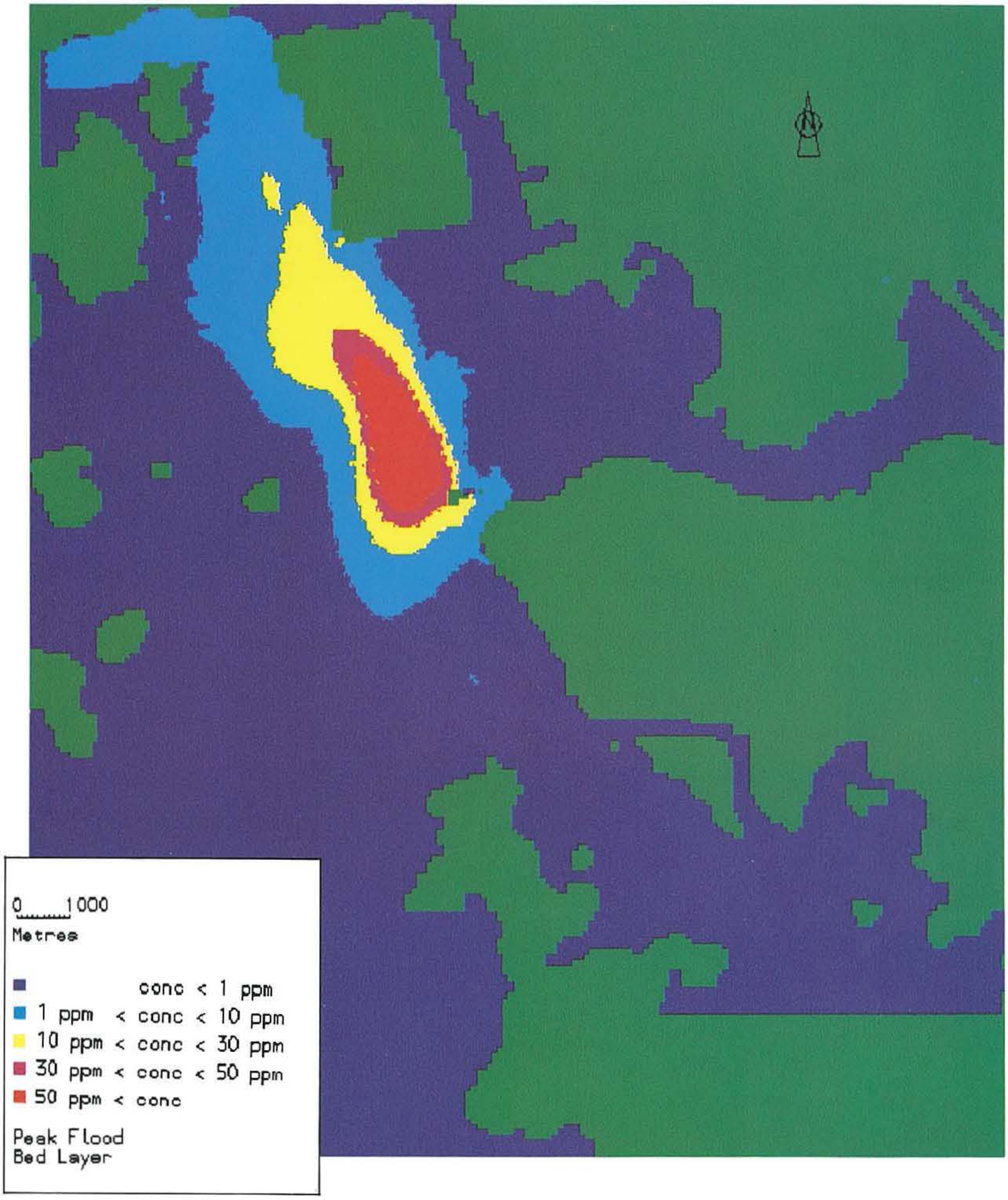


WEST OF SULPHUR CHANNEL MARINE BORROW AREA
FOCUSED ENVIRONMENTAL IMPACT ASSESSMENT
FINAL REPORT

Figure No.	4.6c

Dry Season Spring Tide: Surface Layer

Suspended Solids, Peak Flood

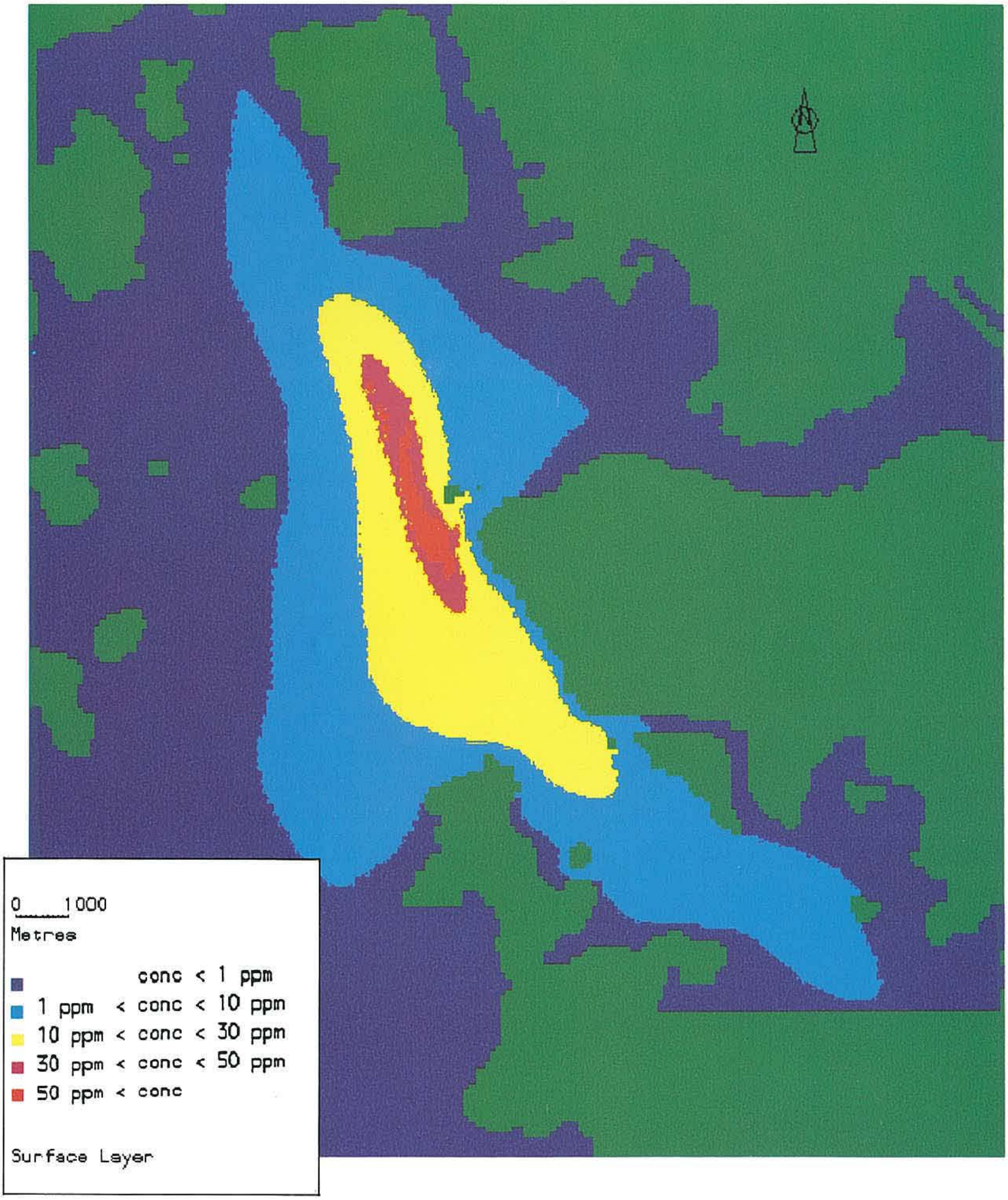


WEST OF SULPHUR CHANNEL MARINE BORROW AREA
FOCUSED ENVIRONMENTAL IMPACT ASSESSMENT
FINAL REPORT

Figure No.	4.6d

Dry Season Spring Tide: Bed Layer

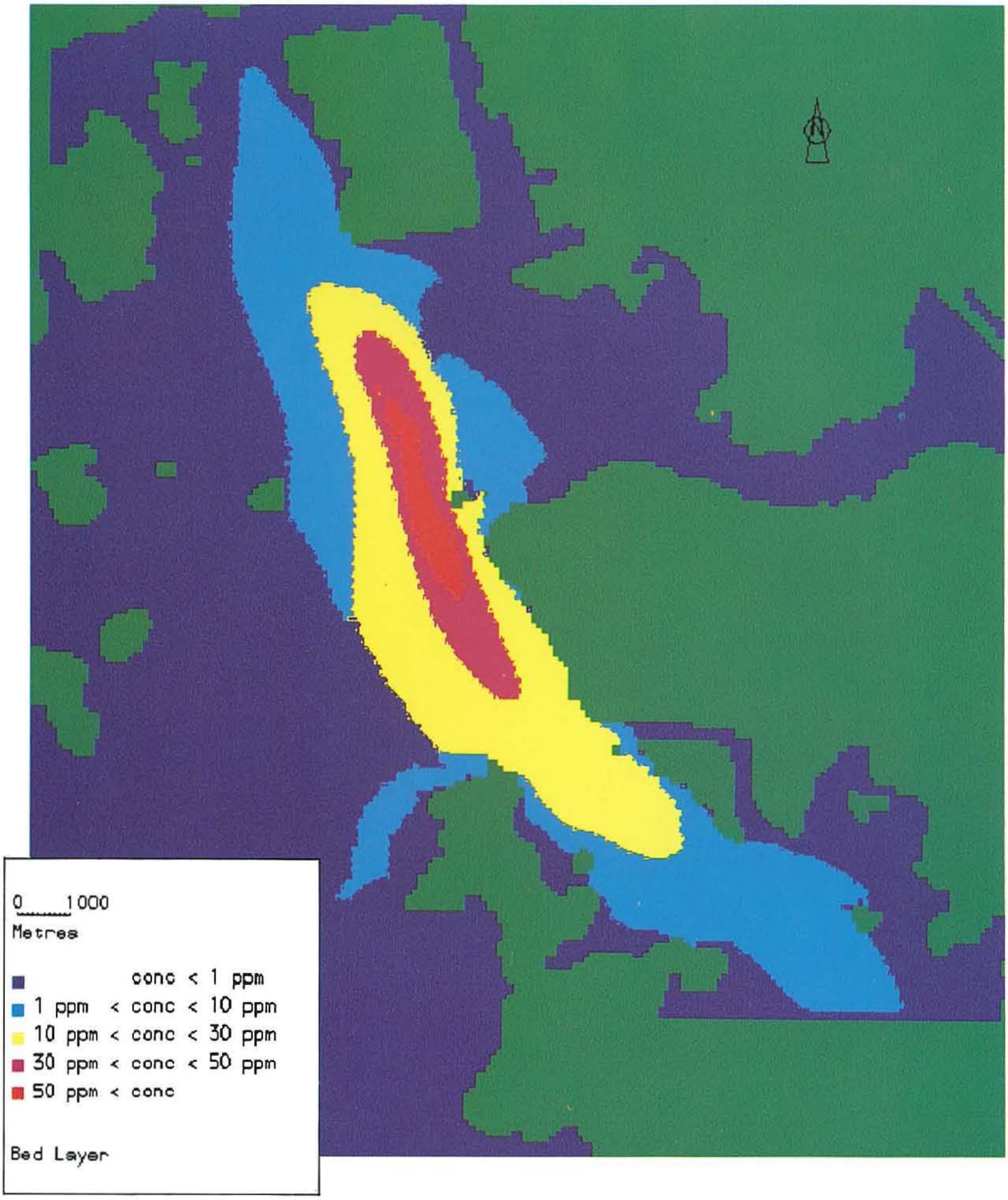
Suspended Solids, Peak Flood



WEST OF SULPHUR CHANNEL MARINE BORROW AREA
FOCUSED ENVIRONMENTAL IMPACT ASSESSMENT
FINAL REPORT

Figure No.	4.6e

Dry Season Spring Tide: Surface Layer
Suspended Solids, Mean Concentrations

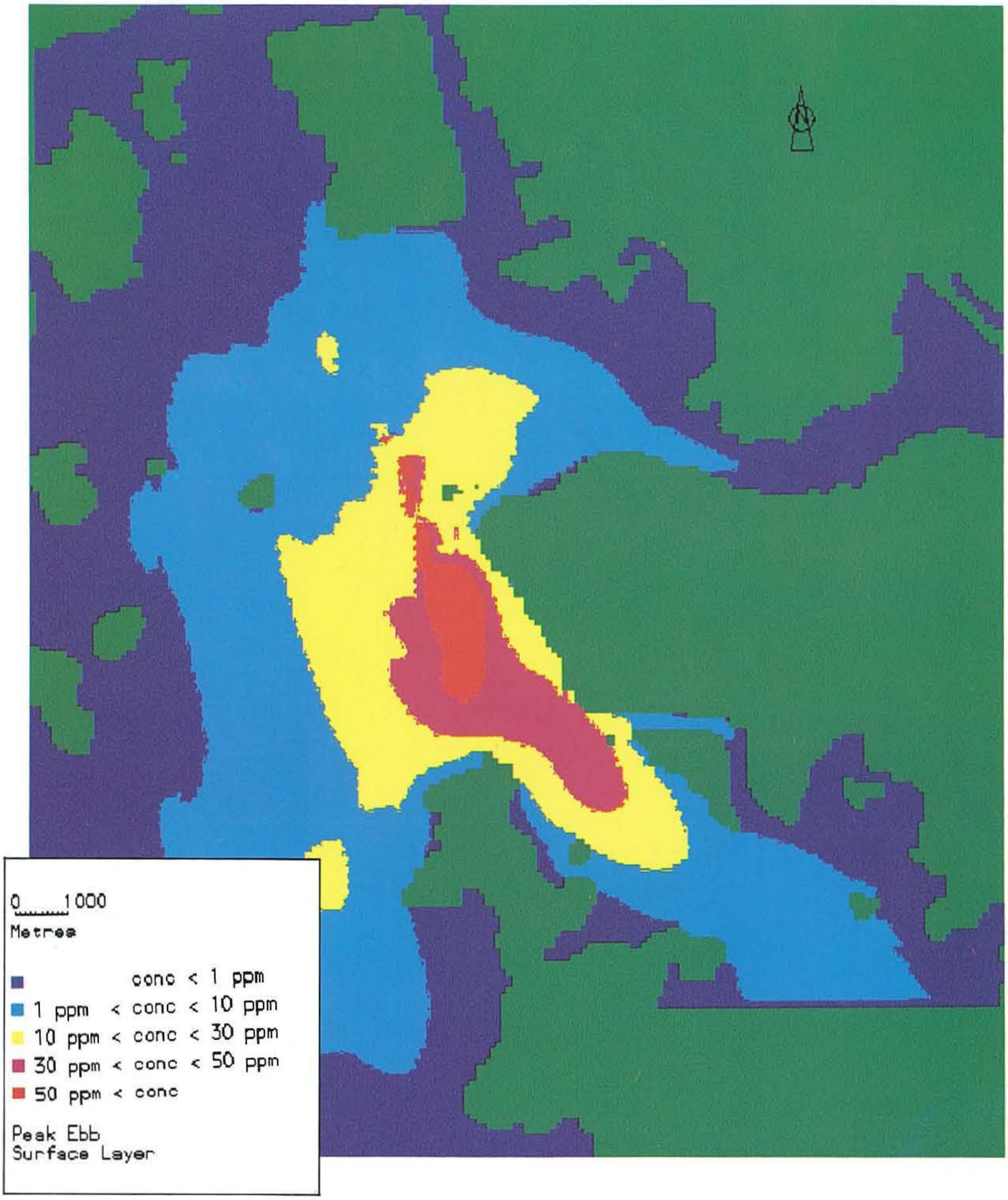


WEST OF SULPHUR CHANNEL MARINE BORROW AREA
FOCUSED ENVIRONMENTAL IMPACT ASSESSMENT
FINAL REPORT

Figure No.	4.6f

Dry Season Spring Tide: Bed Layer

Suspended Solids, Mean Concentrations

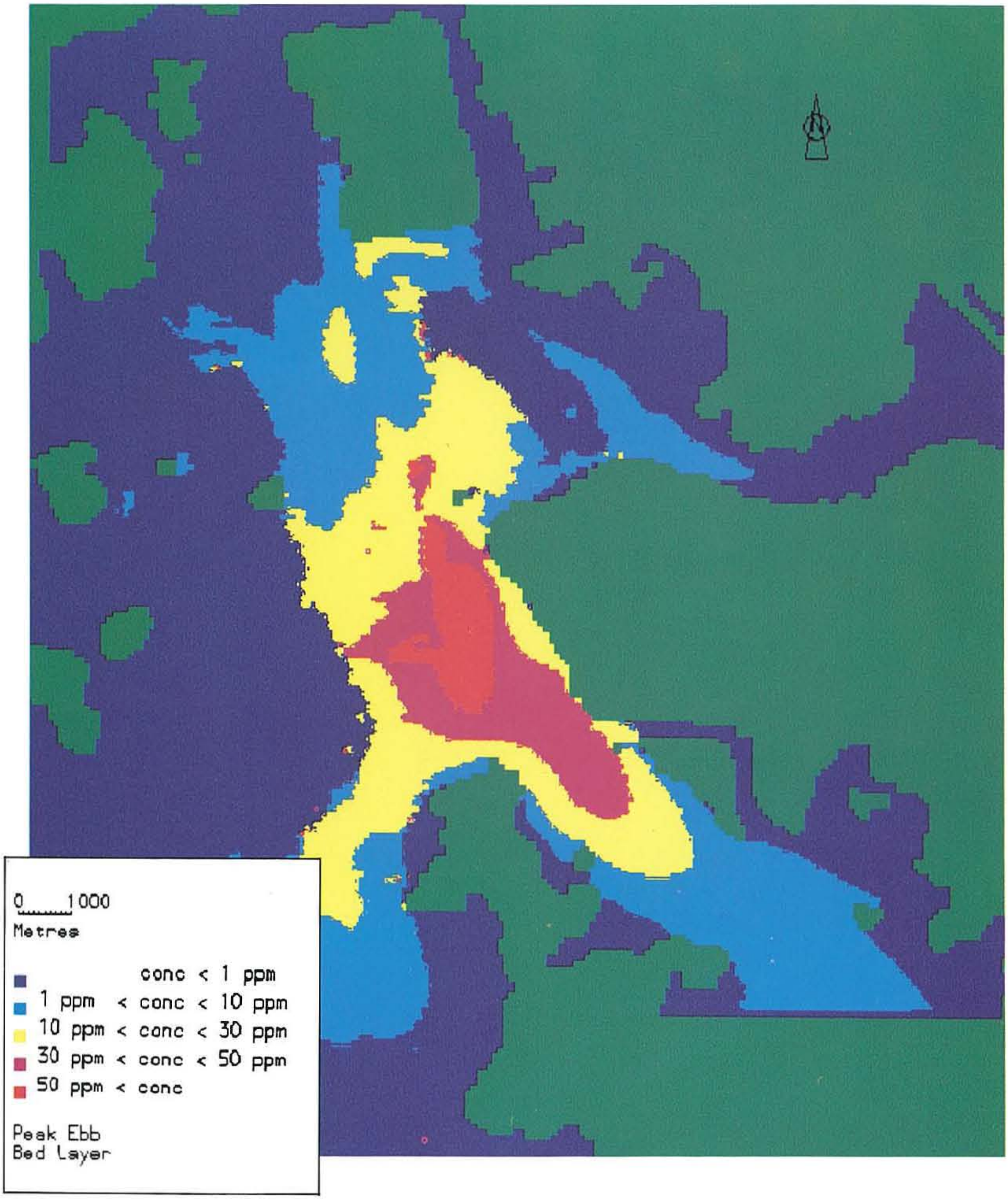


WEST OF SULPHUR CHANNEL MARINE BORROW AREA
FOCUSED ENVIRONMENTAL IMPACT ASSESSMENT
FINAL REPORT

Figure No.	4.7a

Wet Season Spring Tide: Surface Layer

Suspended Solids, Peak Ebb

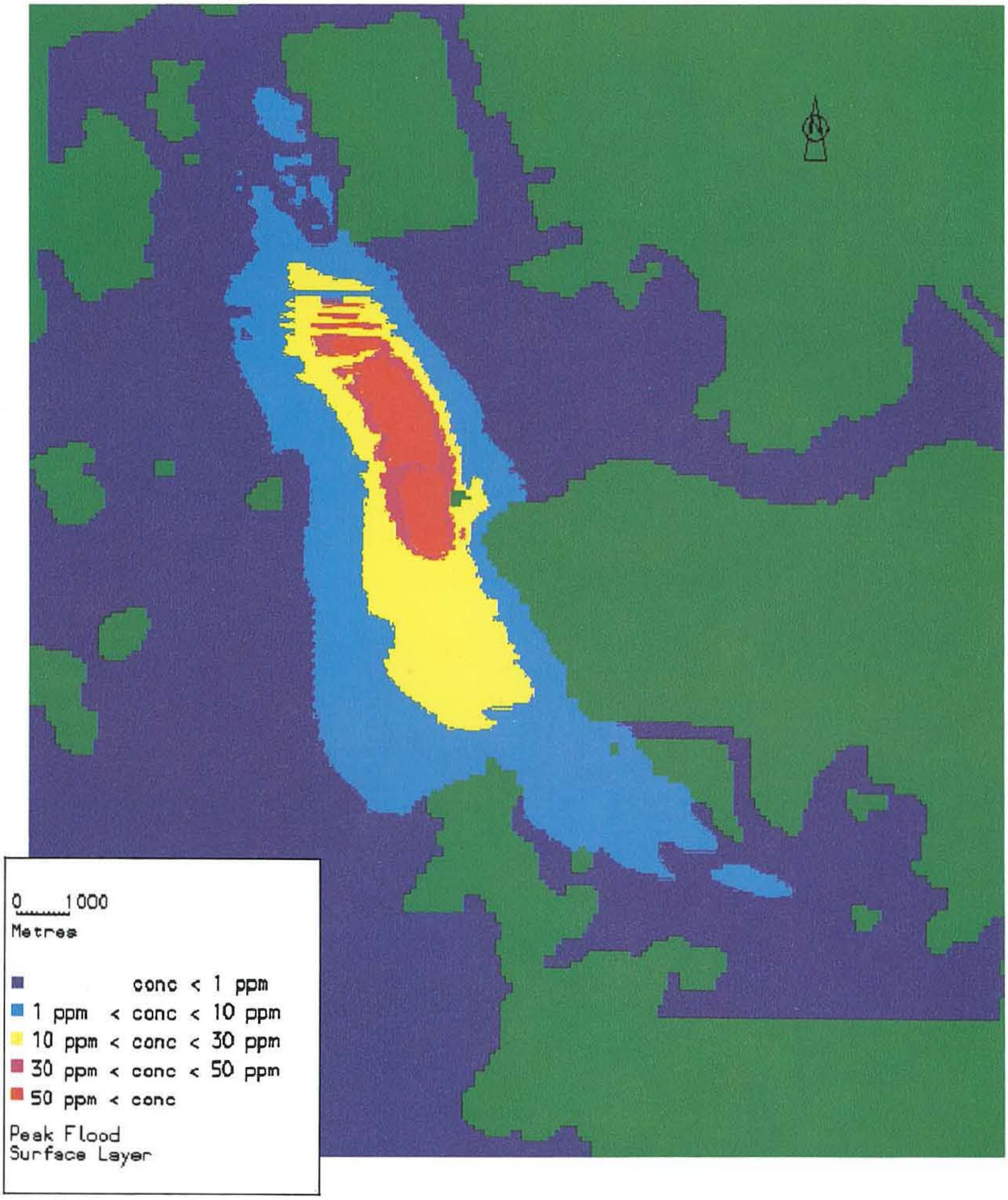


WEST OF SULPHUR CHANNEL MARINE BORROW AREA
FOCUSED ENVIRONMENTAL IMPACT ASSESSMENT
FINAL REPORT

Figure No. 4.7b

Wet Season Spring Tide: Bed Layer

Suspended Solids, Peak Ebb

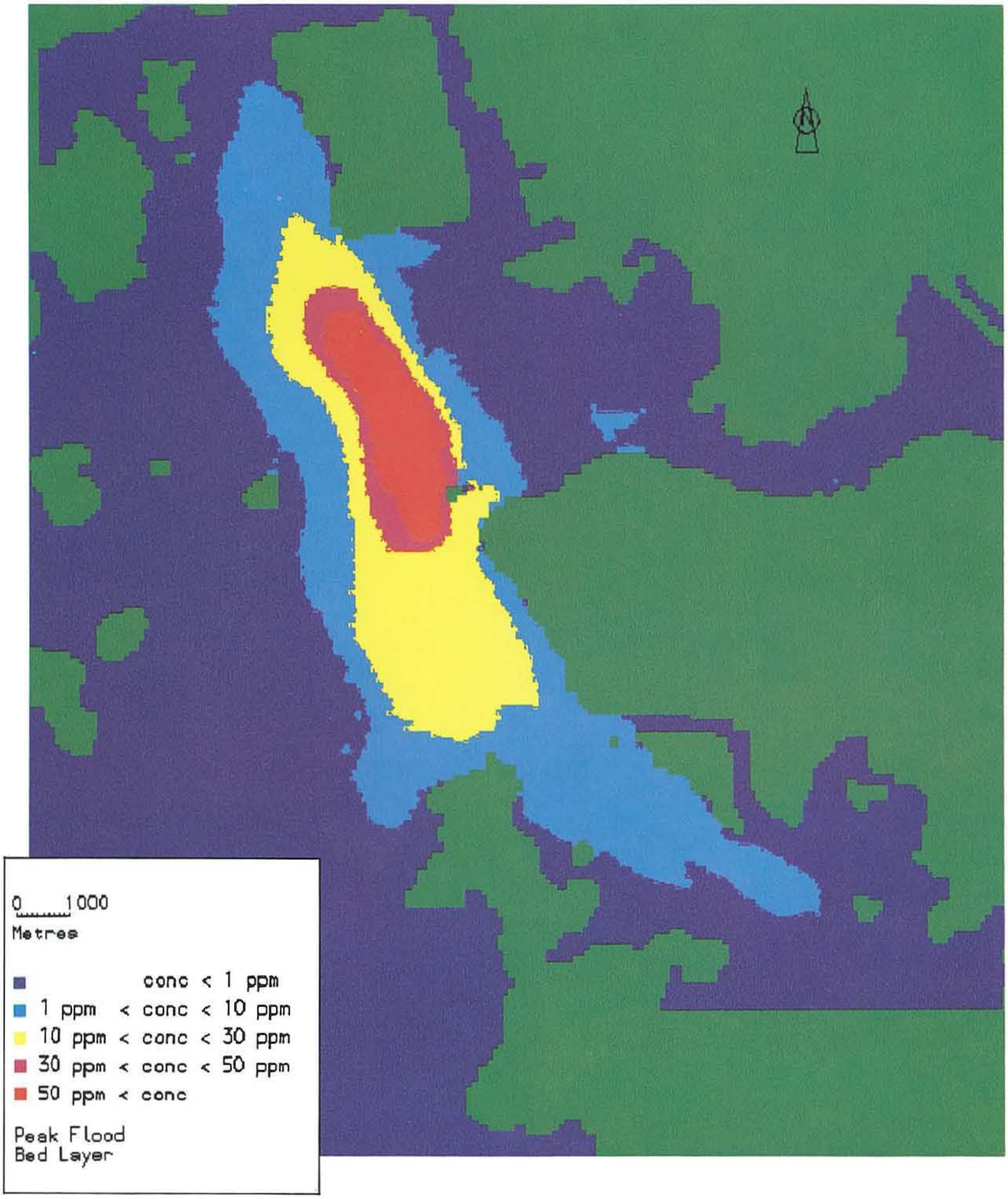


WEST OF SULPHUR CHANNEL MARINE BORROW AREA
FOCUSED ENVIRONMENTAL IMPACT ASSESSMENT
FINAL REPORT

Figure No.	4.7c

Wet Season Spring Tide: Surface Layer

Suspended Solids, Peak Flood

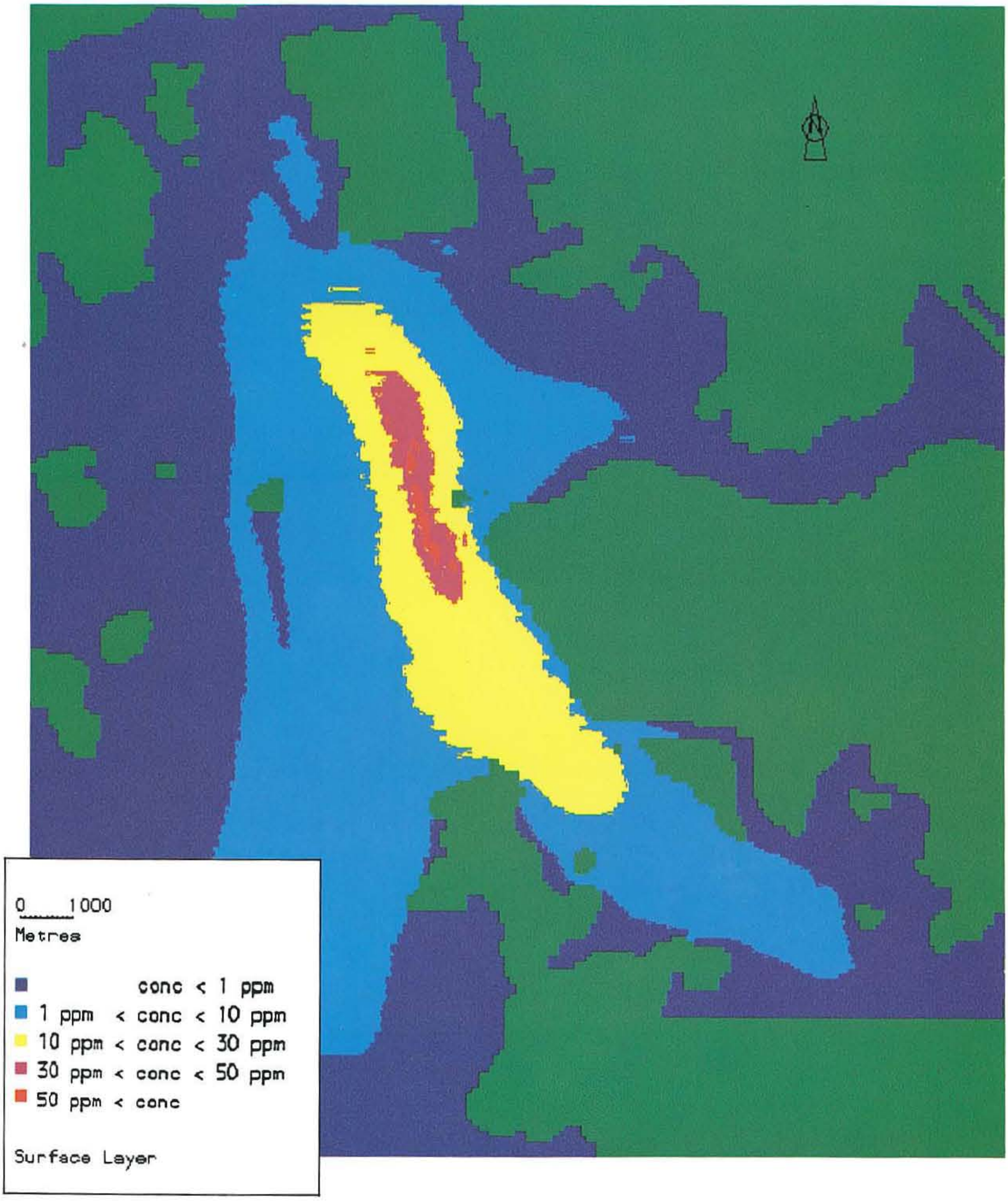


WEST OF SULPHUR CHANNEL MARINE BORROW AREA
FOCUSED ENVIRONMENTAL IMPACT ASSESSMENT
FINAL REPORT

Figure No.	4.7d

Wet Season Spring Tide: Bed Layer

Suspended Solids, Peak Flood

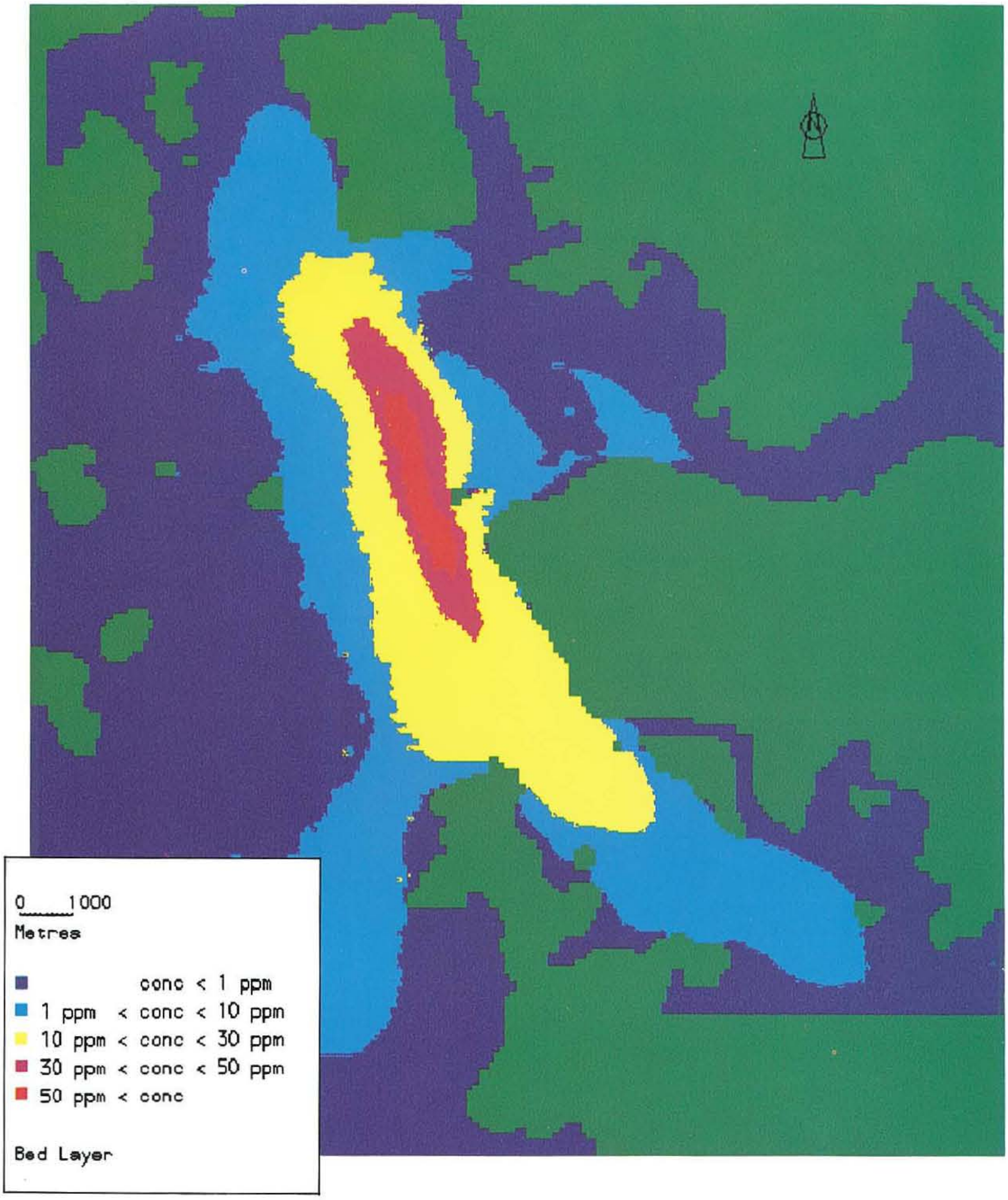


WEST OF SULPHUR CHANNEL MARINE BORROW AREA
FOCUSED ENVIRONMENTAL IMPACT ASSESSMENT
FINAL REPORT

Figure No.	4.7e

Wet Season Spring Tide: Surface Layer

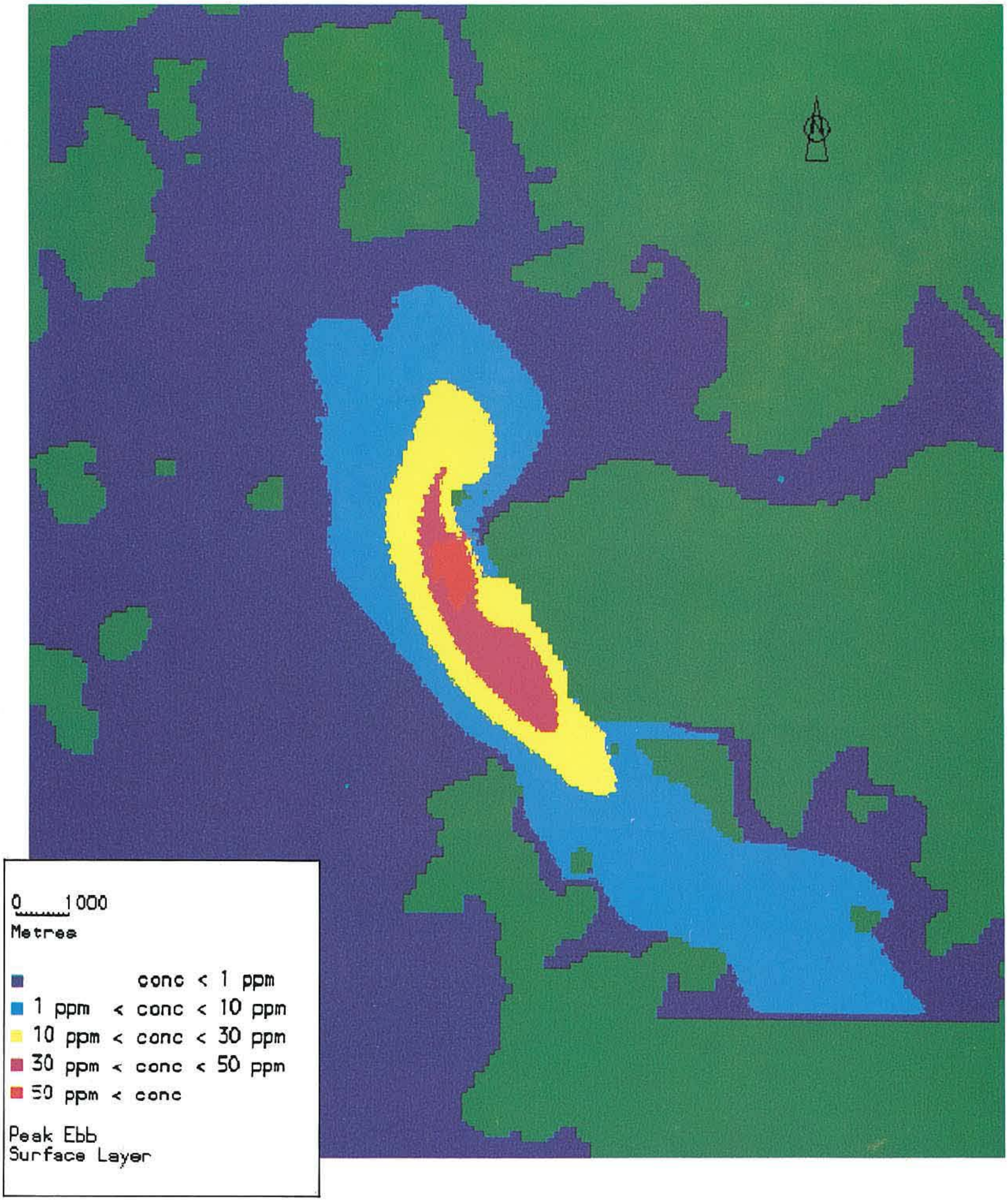
Suspended Solids, Mean Concentrations



WEST OF SULPHUR CHANNEL MARINE BORROW AREA
FOCUSED ENVIRONMENTAL IMPACT ASSESSMENT
FINAL REPORT

Figure No.	4.7f

Wet Season Spring Tide: Bed Layer
Suspended Solids, Mean Concentrations

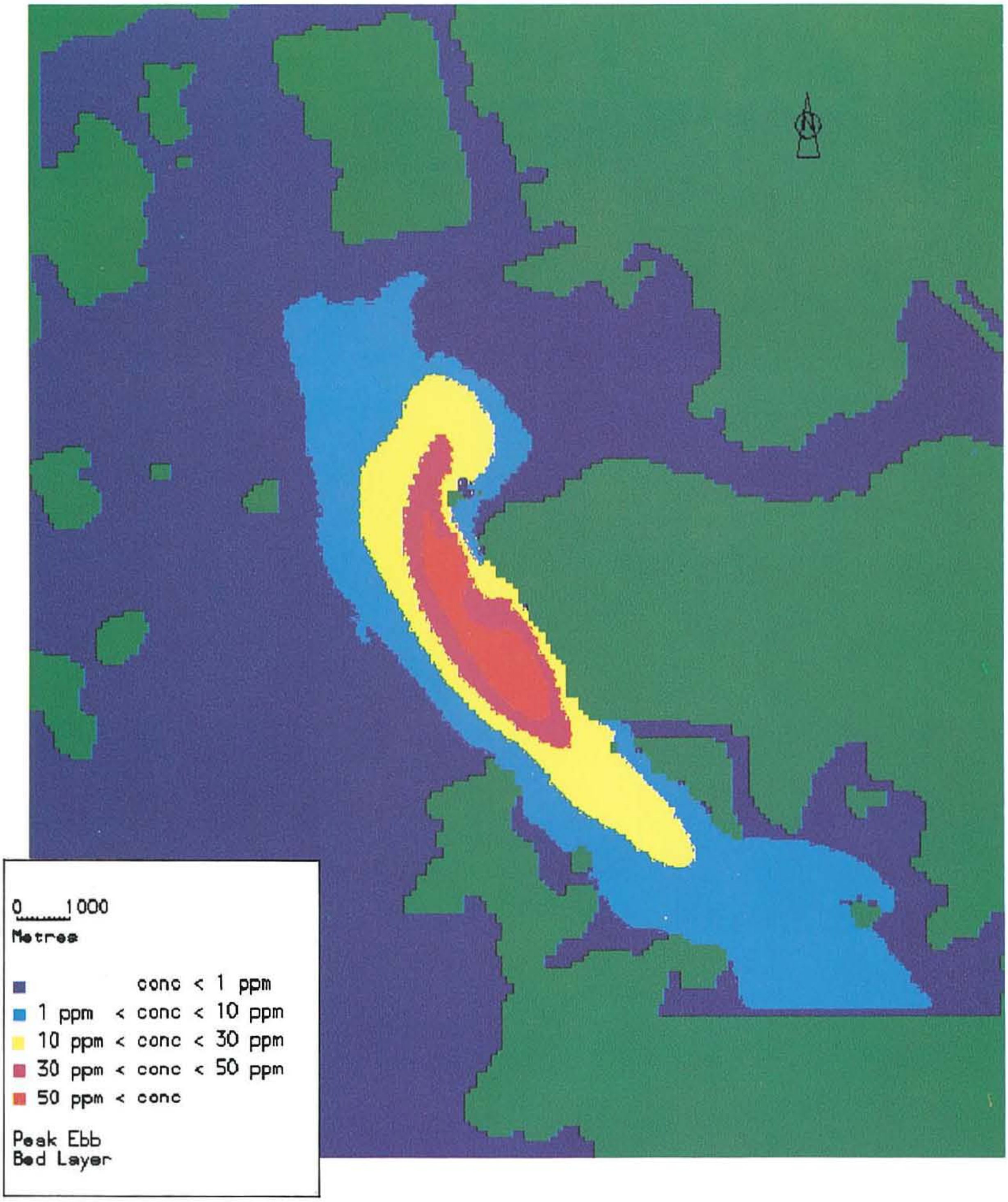


WEST OF SULPHUR CHANNEL MARINE BORROW AREA
FOCUSED ENVIRONMENTAL IMPACT ASSESSMENT
FINAL REPORT

Figure No.	4.8a

Dry Season Neap Tide: Surface Layer

Suspended Solids, Peak Ebb

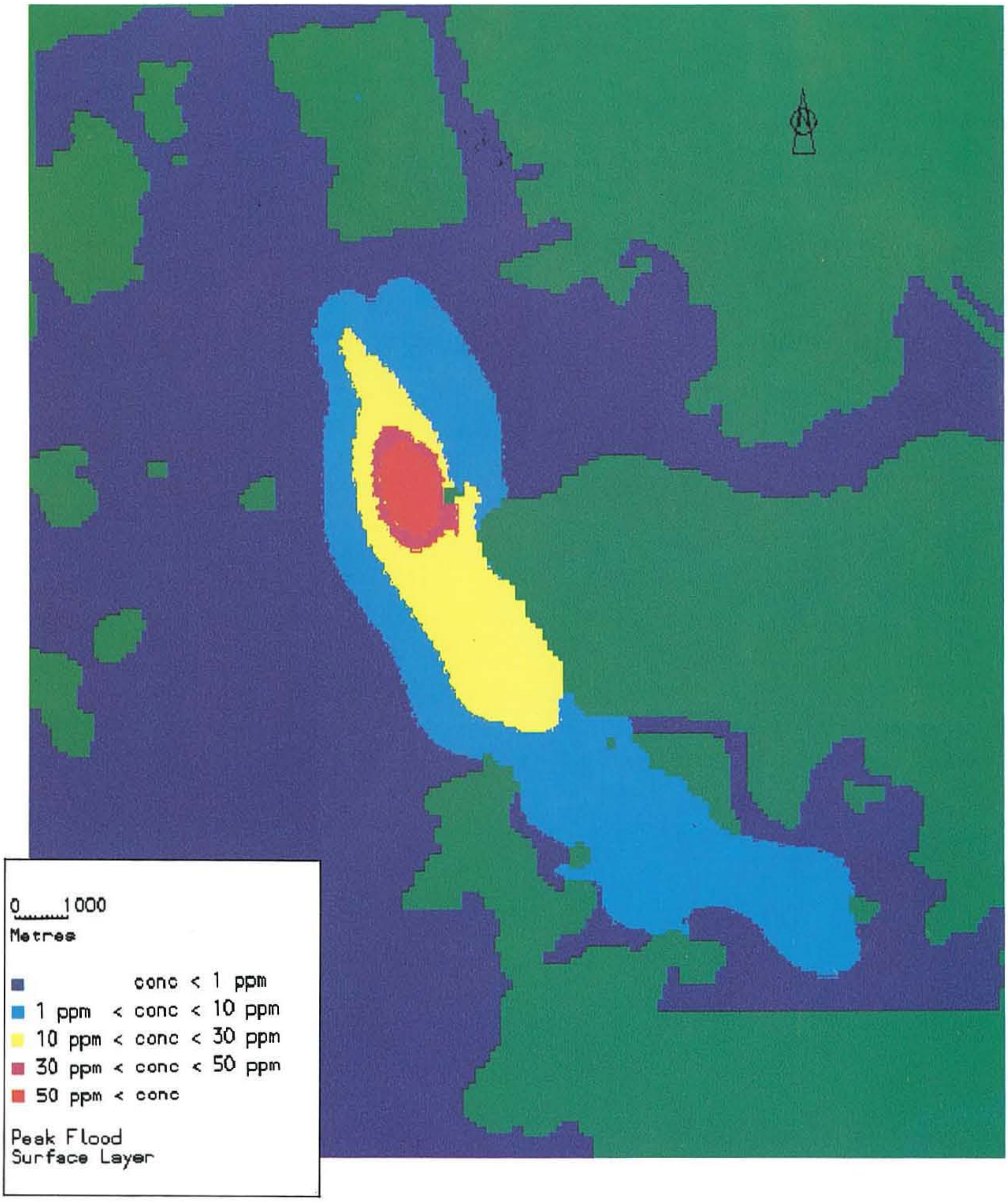


WEST OF SULPHUR CHANNEL MARINE BORROW AREA
FOCUSED ENVIRONMENTAL IMPACT ASSESSMENT
FINAL REPORT

Figure No.	4.8b

Dry Season Neap Tide: Bed Layer

Suspended Solids, Peak Ebb

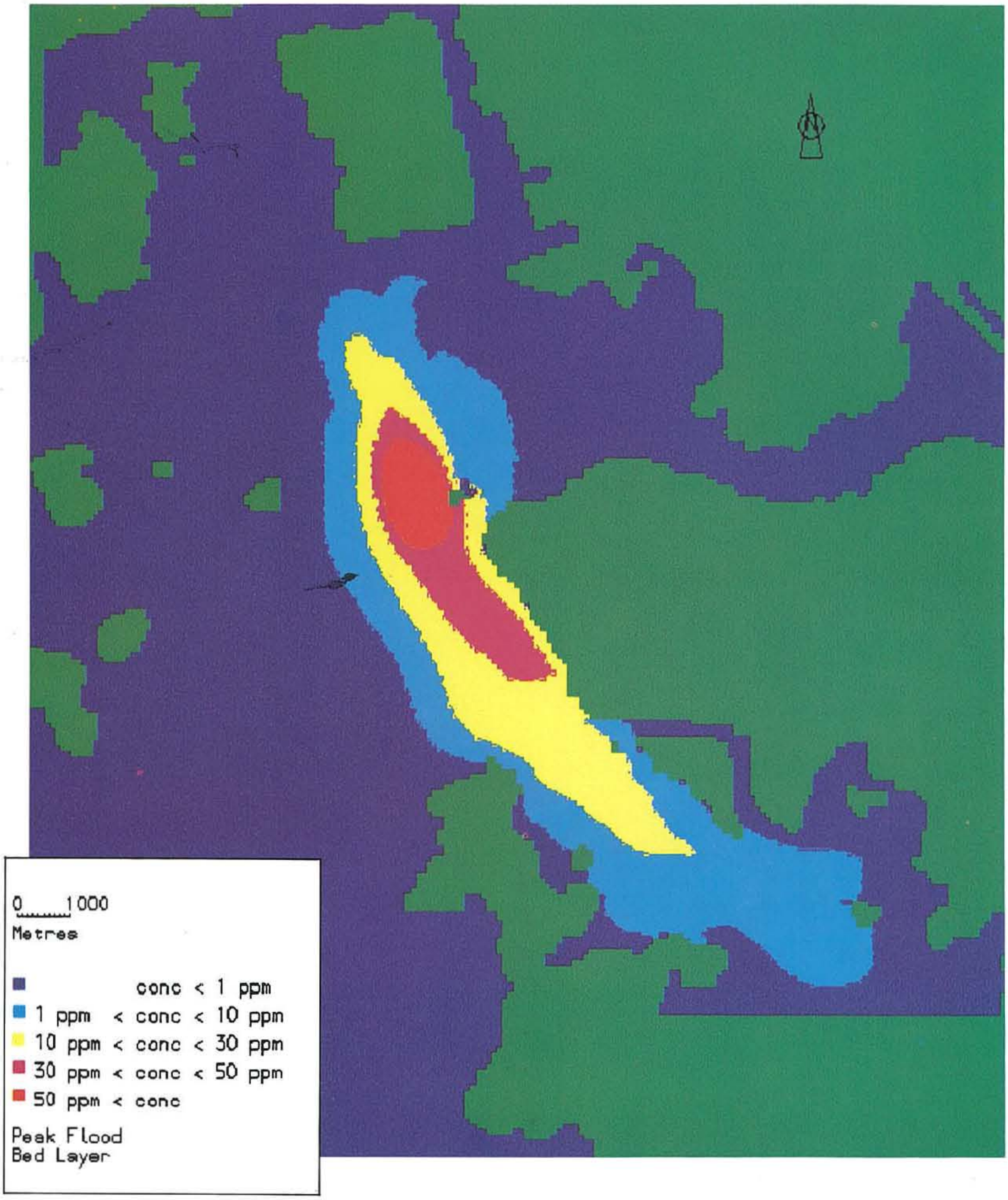


WEST OF SULPHUR CHANNEL MARINE BORROW AREA
FOCUSED ENVIRONMENTAL IMPACT ASSESSMENT
FINAL REPORT

Figure No.	4.8c

Dry Season Neap Tide: Surface Layer

Suspended Solids, Peak Flood

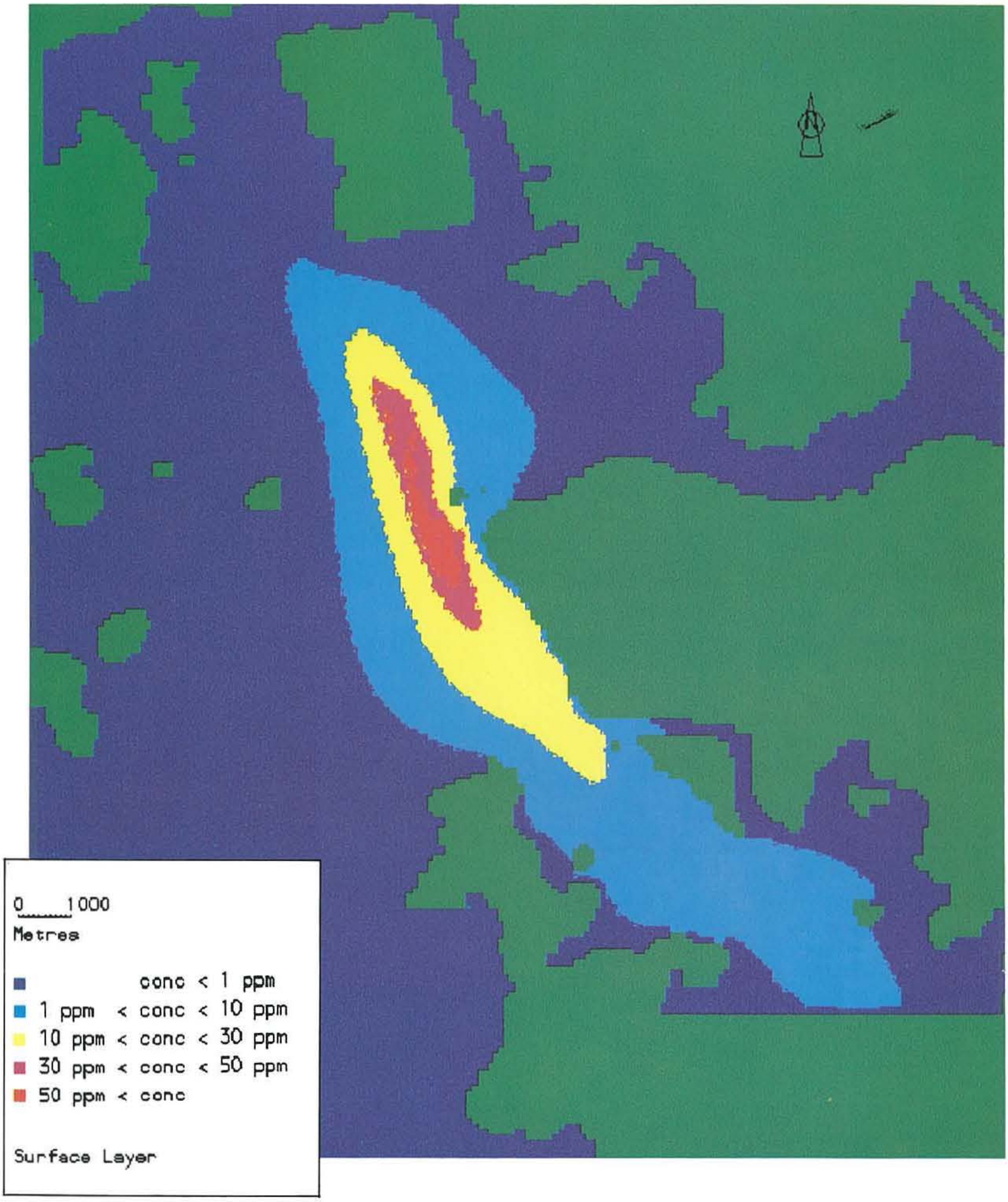


WEST OF SULPHUR CHANNEL MARINE BORROW AREA
FOCUSED ENVIRONMENTAL IMPACT ASSESSMENT
FINAL REPORT

Figure No. 4.8d

Dry Season Neap Tide: Bed Layer

Suspended Solids, Peak Flood

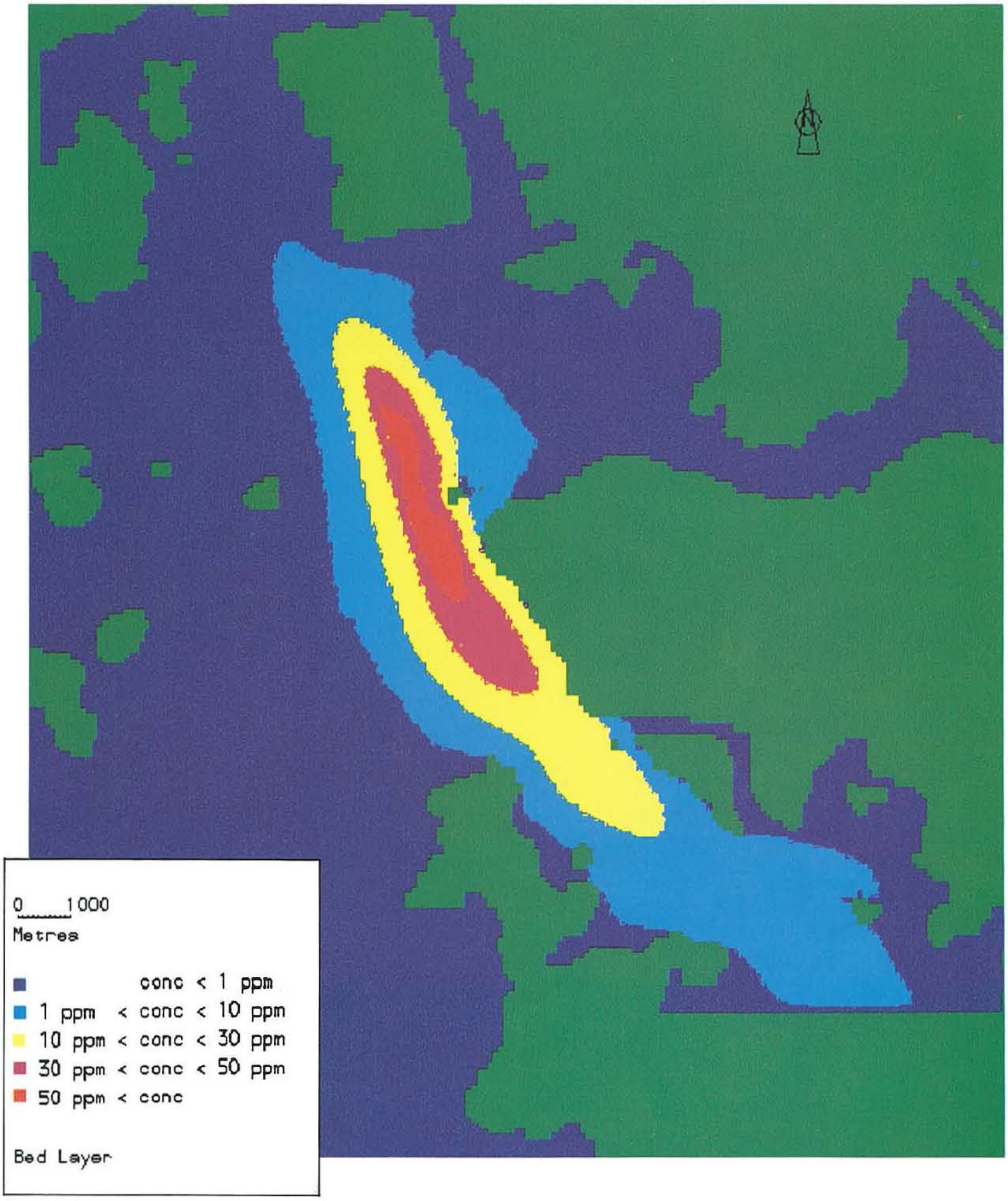


WEST OF SULPHUR CHANNEL MARINE BORROW AREA
FOCUSED ENVIRONMENTAL IMPACT ASSESSMENT
FINAL REPORT

Figure No.	4.8e

Dry Season Neap Tide: Surface Layer

Suspended Solids, Mean Concentrations

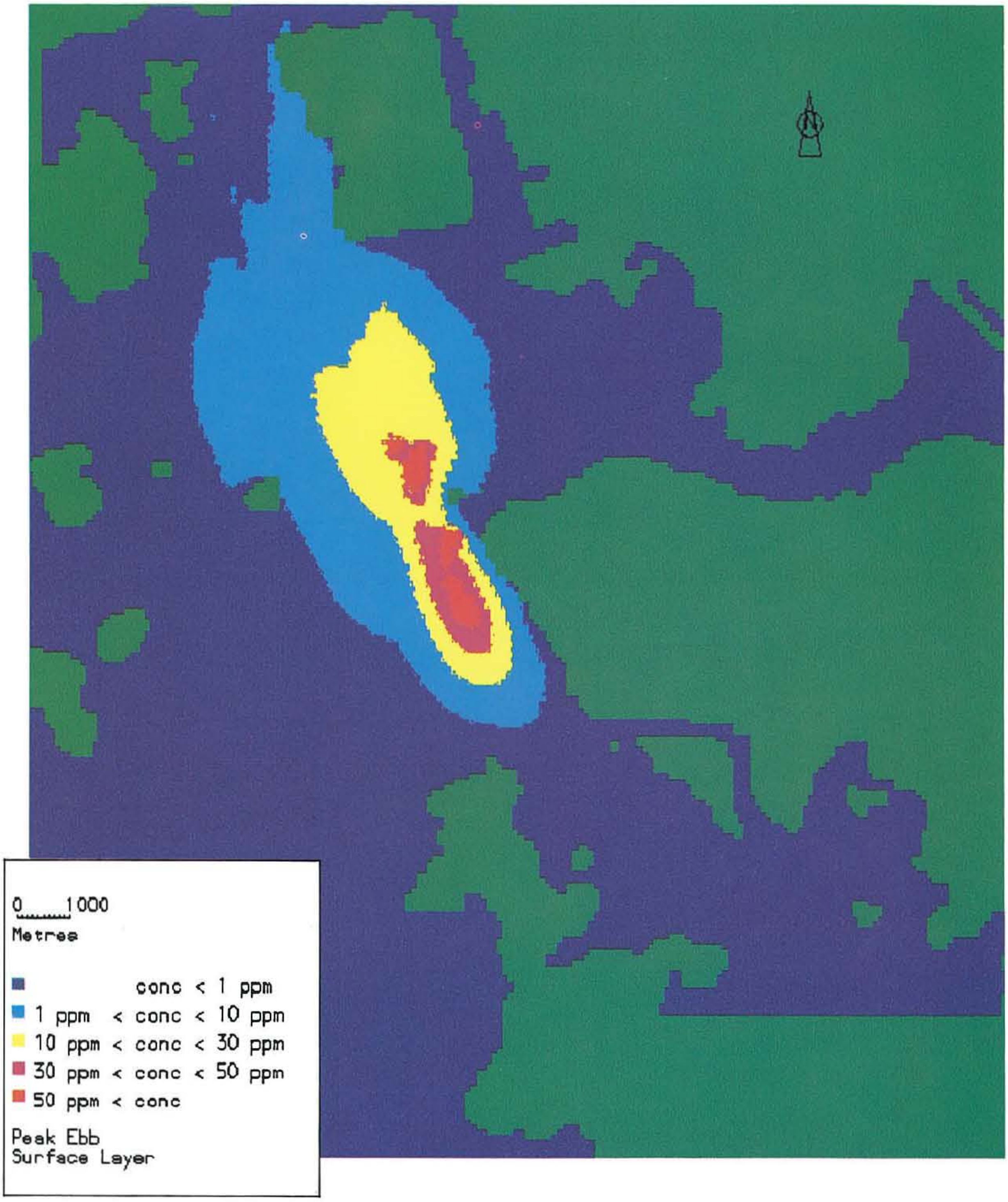


WEST OF SULPHUR CHANNEL MARINE BORROW AREA
FOCUSED ENVIRONMENTAL IMPACT ASSESSMENT
FINAL REPORT

Figure No.	4.8f

Dry Season Neap Tide: Bed Layer

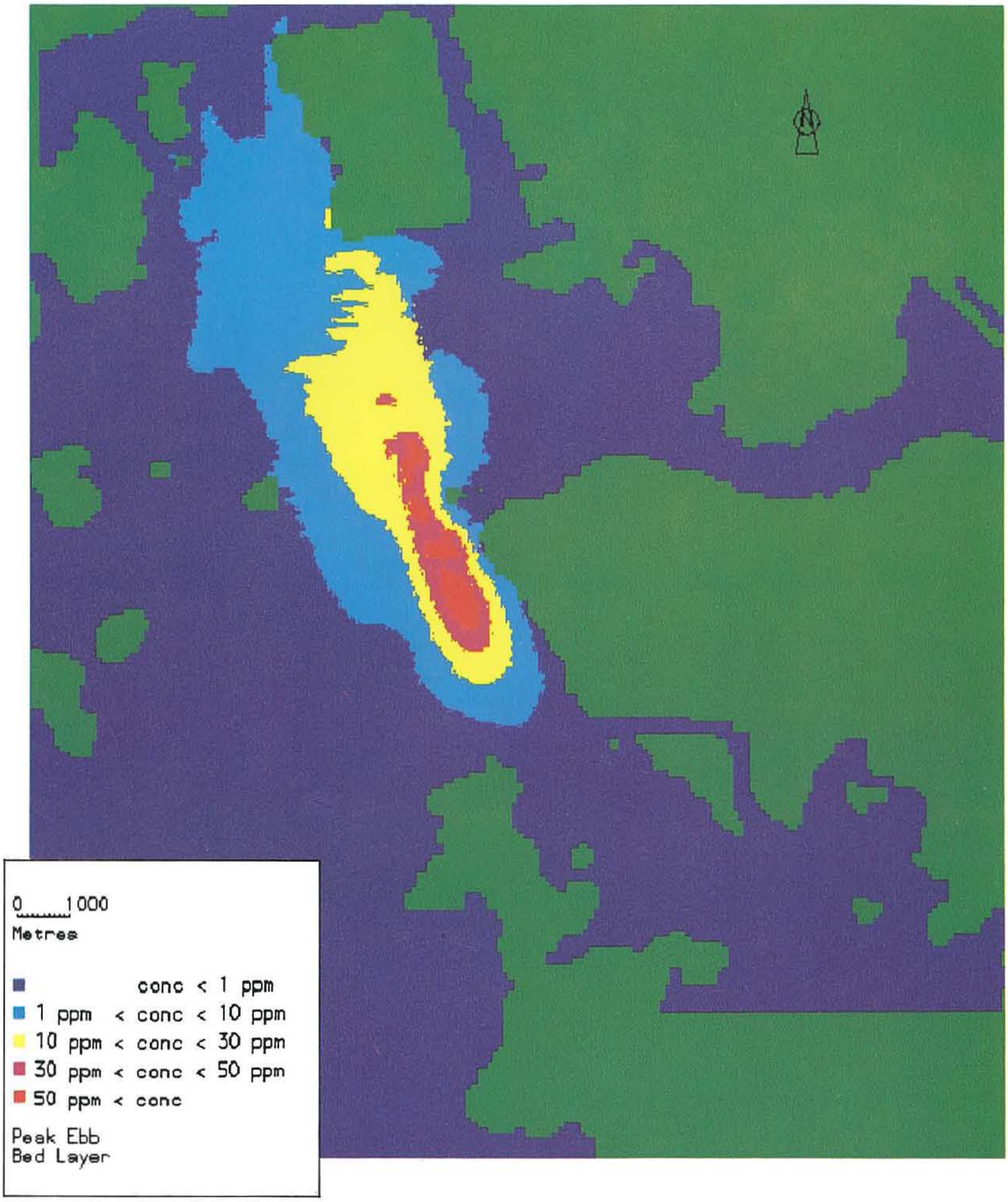
Suspended Solids, Mean Concentrations



WEST OF SULPHUR CHANNEL MARINE BORROW AREA
FOCUSED ENVIRONMENTAL IMPACT ASSESSMENT
FINAL REPORT

Figure No.	4.9a

Wet Season Neap Tide: Surface Layer
Suspended Solids, Peak Ebb

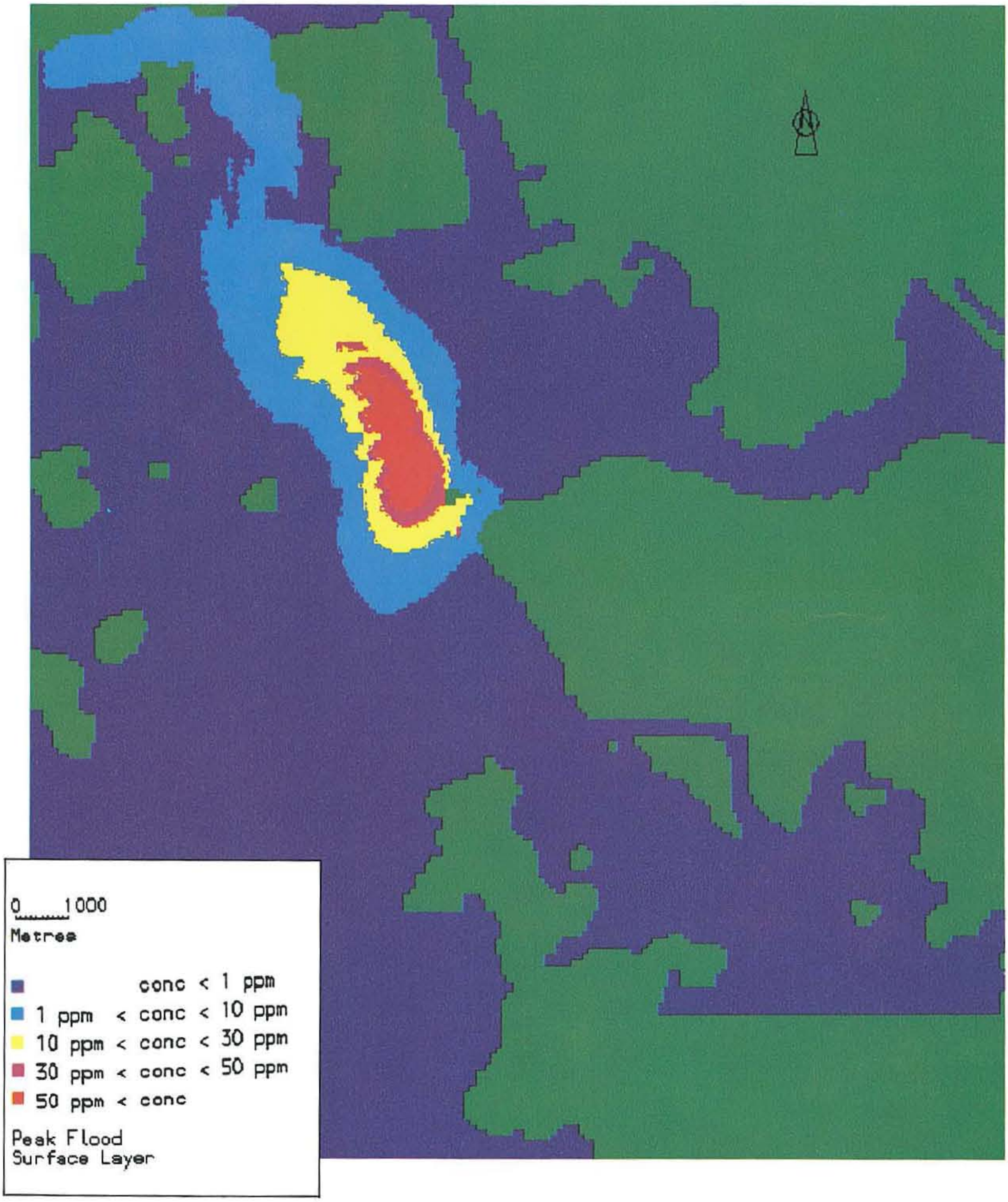


WEST OF SULPHUR CHANNEL MARINE BORROW AREA
FOCUSED ENVIRONMENTAL IMPACT ASSESSMENT
FINAL REPORT

Figure No.	4.9b

Wet Season Neap Tide: Bed Layer

Suspended Solids, Peak Ebb

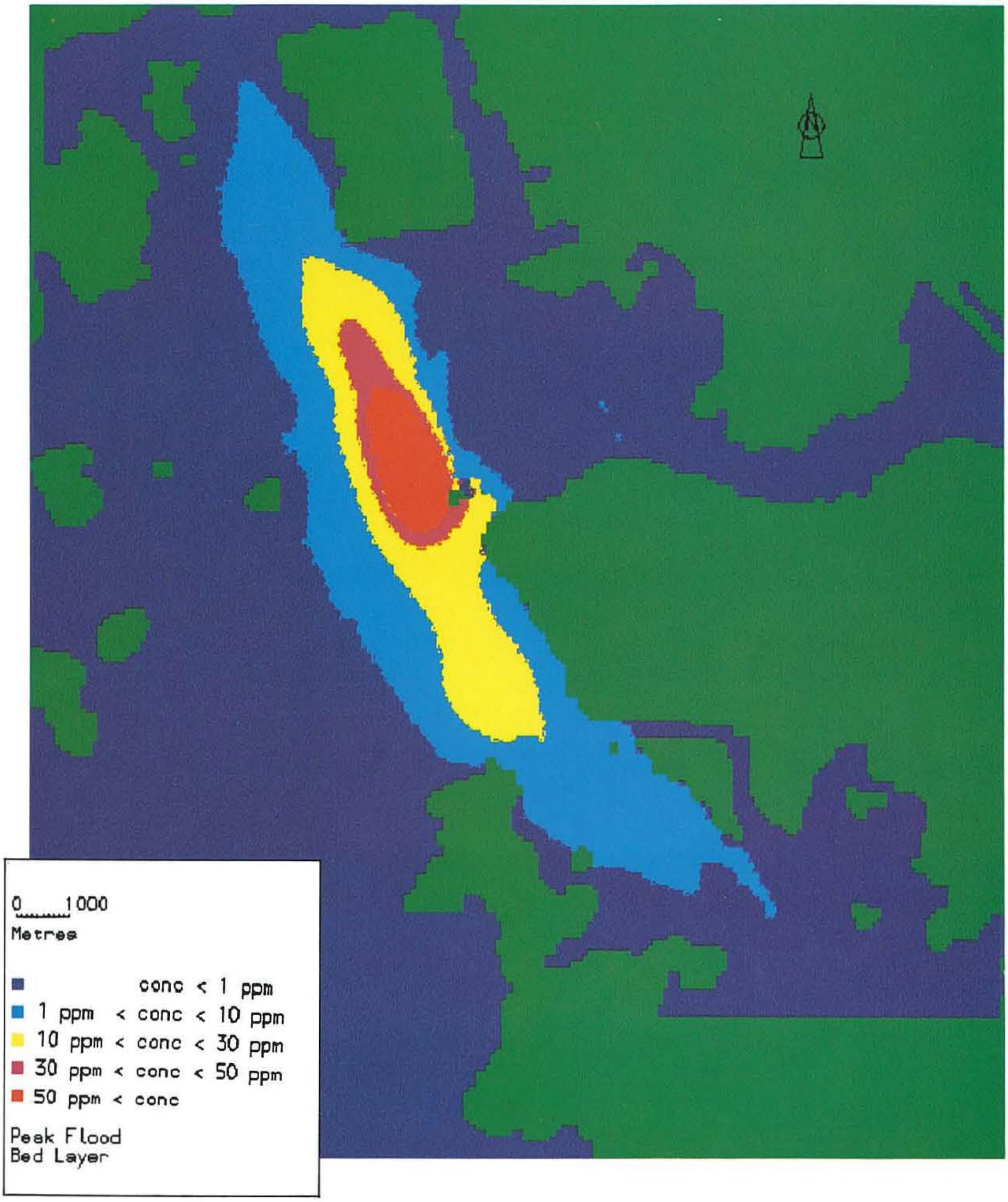


WEST OF SULPHUR CHANNEL MARINE BORROW AREA
FOCUSED ENVIRONMENTAL IMPACT ASSESSMENT
FINAL REPORT

Figure No.	4.9c

Wet Season Neap Tide: Surface Layer

Suspended Solids, Peak Flood

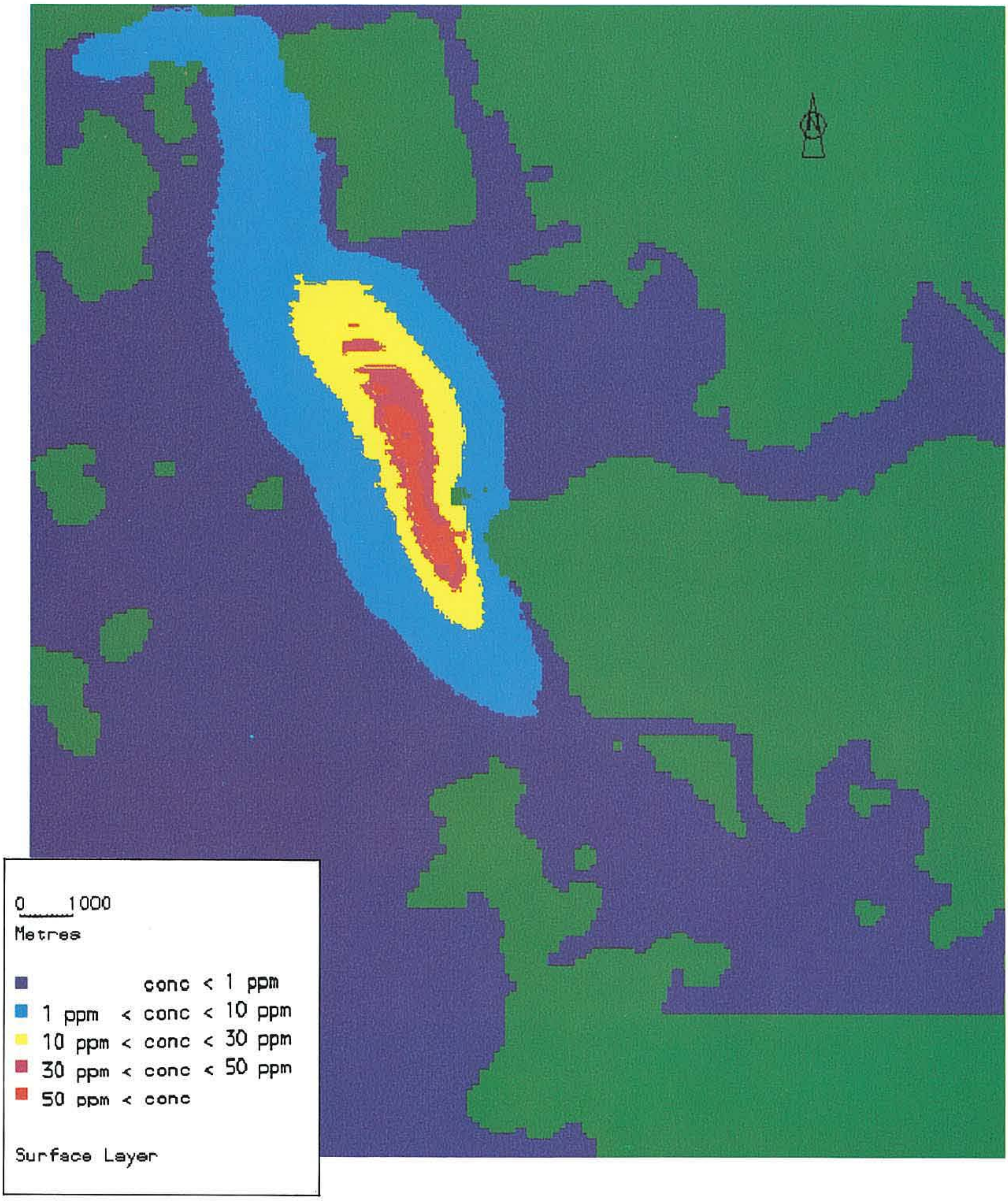


WEST OF SULPHUR CHANNEL MARINE BORROW AREA
FOCUSED ENVIRONMENTAL IMPACT ASSESSMENT
FINAL REPORT

Figure No.	4.9d

Wet Season Neap Tide: Bed Layer

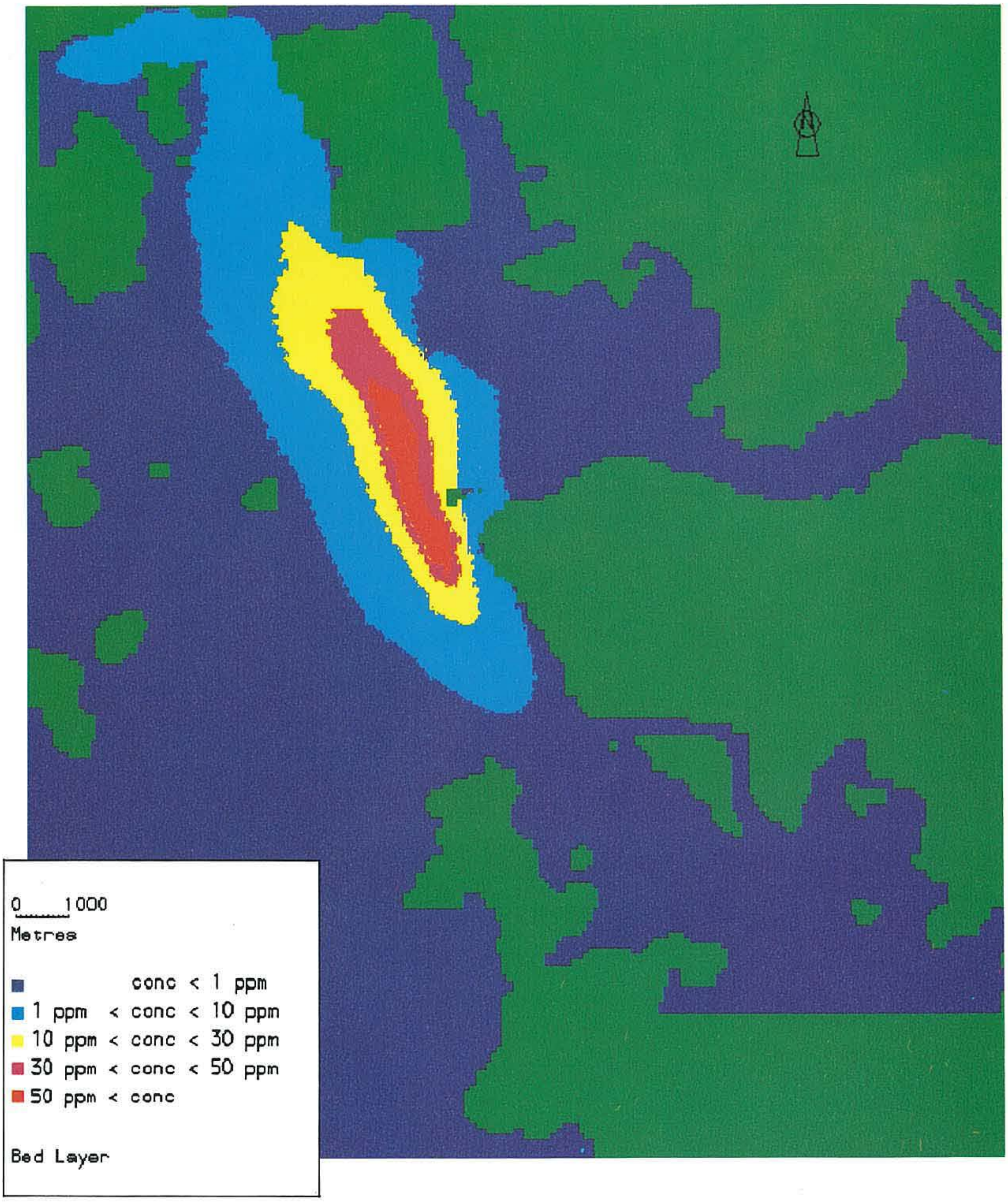
Suspended Solids, Peak Flood



WEST OF SULPHUR CHANNEL MARINE BORROW AREA
FOCUSED ENVIRONMENTAL IMPACT ASSESSMENT
FINAL REPORT

Figure No. 4.9e

Wet Season Neap Tide: Surface Layer
Suspended Solids, Mean Concentrations

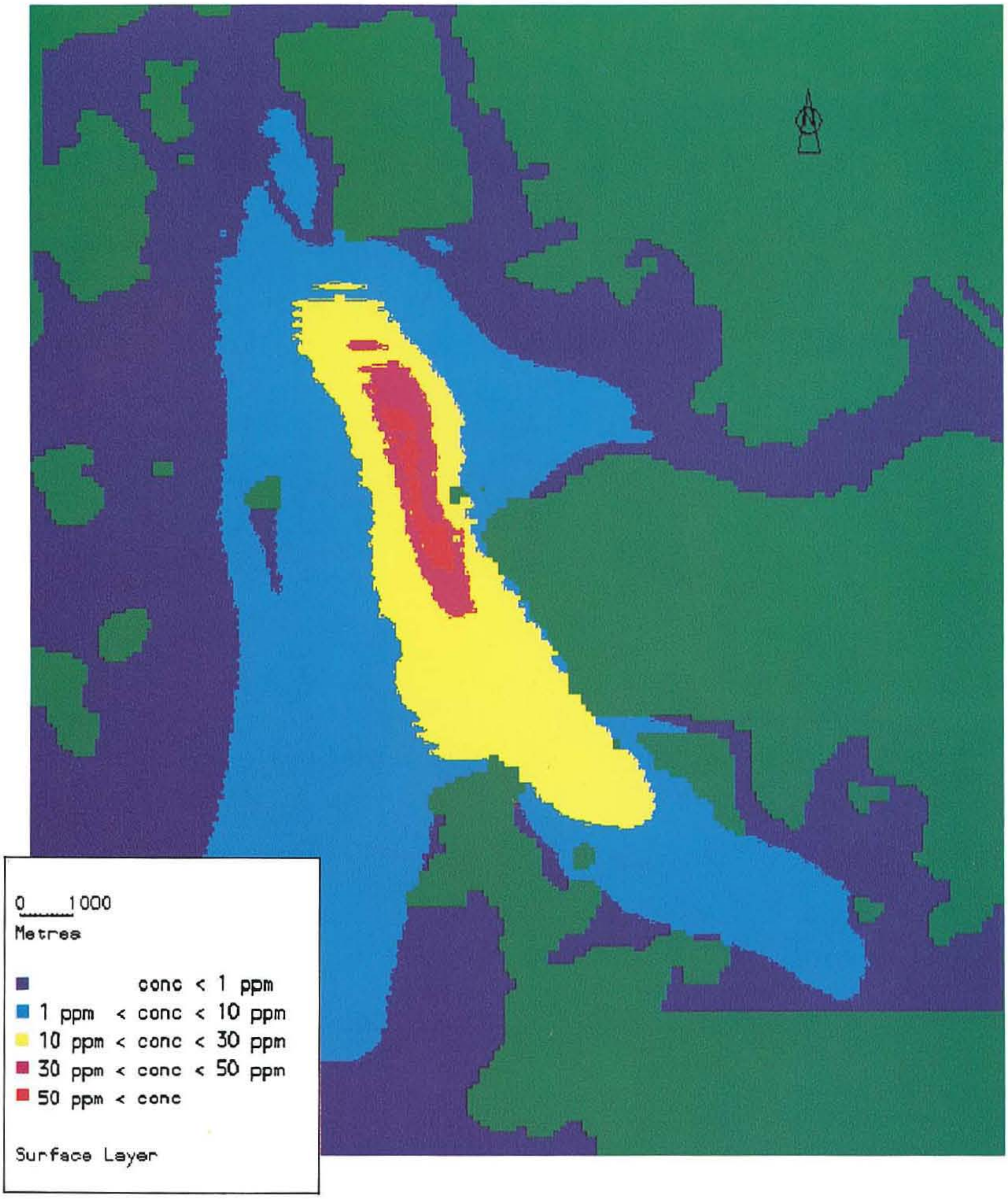


WEST OF SULPHUR CHANNEL MARINE BORROW AREA
FOCUSED ENVIRONMENTAL IMPACT ASSESSMENT
FINAL REPORT

Figure No.	4.9f

Wet Season Neap Tide: Bed Layer

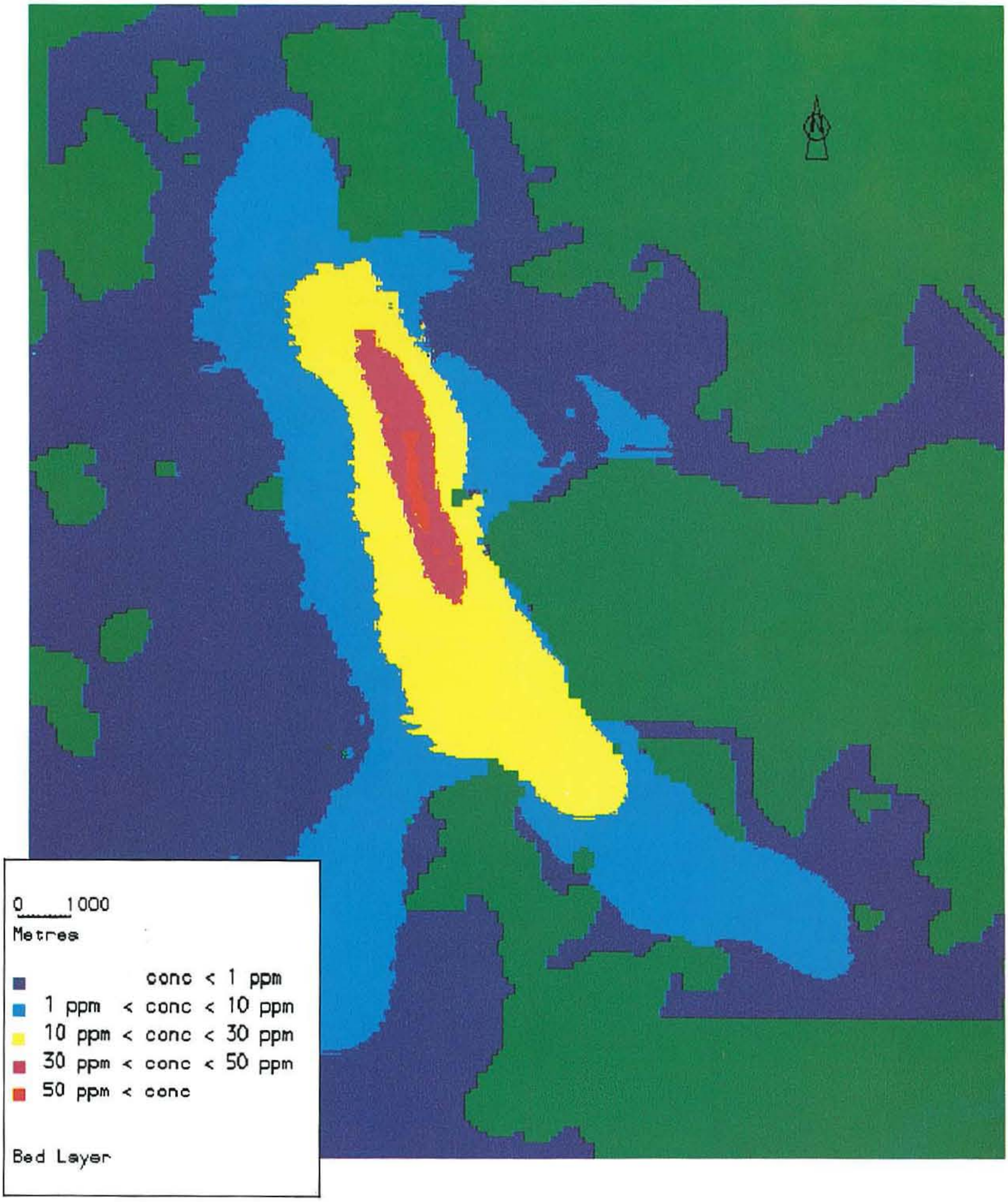
Suspended Solids, Mean Concentrations



WEST OF SULPHUR CHANNEL MARINE BORROW AREA
FOCUSED ENVIRONMENTAL IMPACT ASSESSMENT
FINAL REPORT

Figure No. 4.10a

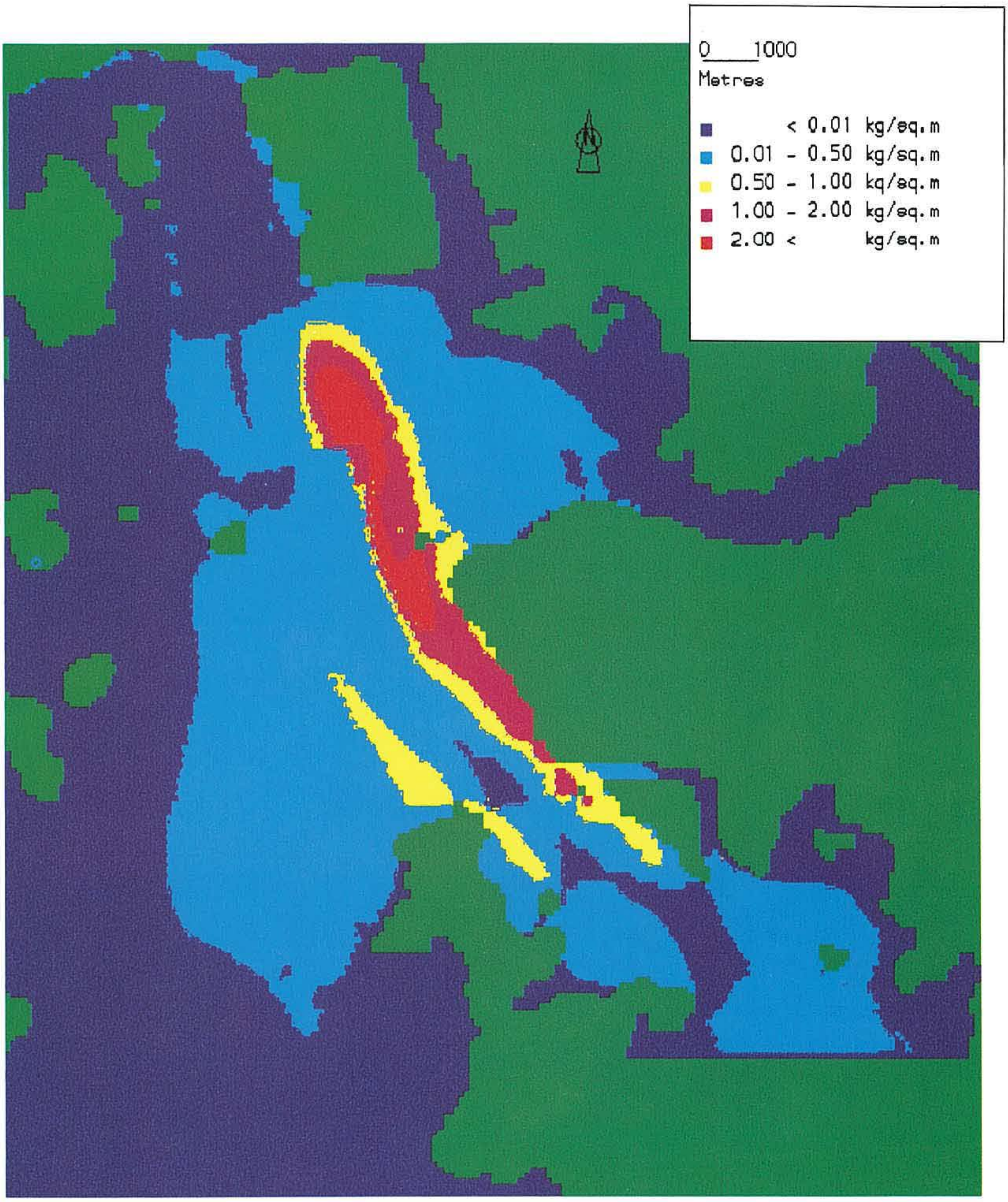
Wet Season Spring Tide: Surface Layer
Mitigated Case
Suspended Solids, Mean Concentrations



WEST OF SULPHUR CHANNEL MARINE BORROW AREA
FOCUSED ENVIRONMENTAL IMPACT ASSESSMENT
FINAL REPORT

Figure No.	4.10b

Wet Season Spring Tide: Bed Layer
Mitigated Case
Suspended Solids, Mean Concentrations

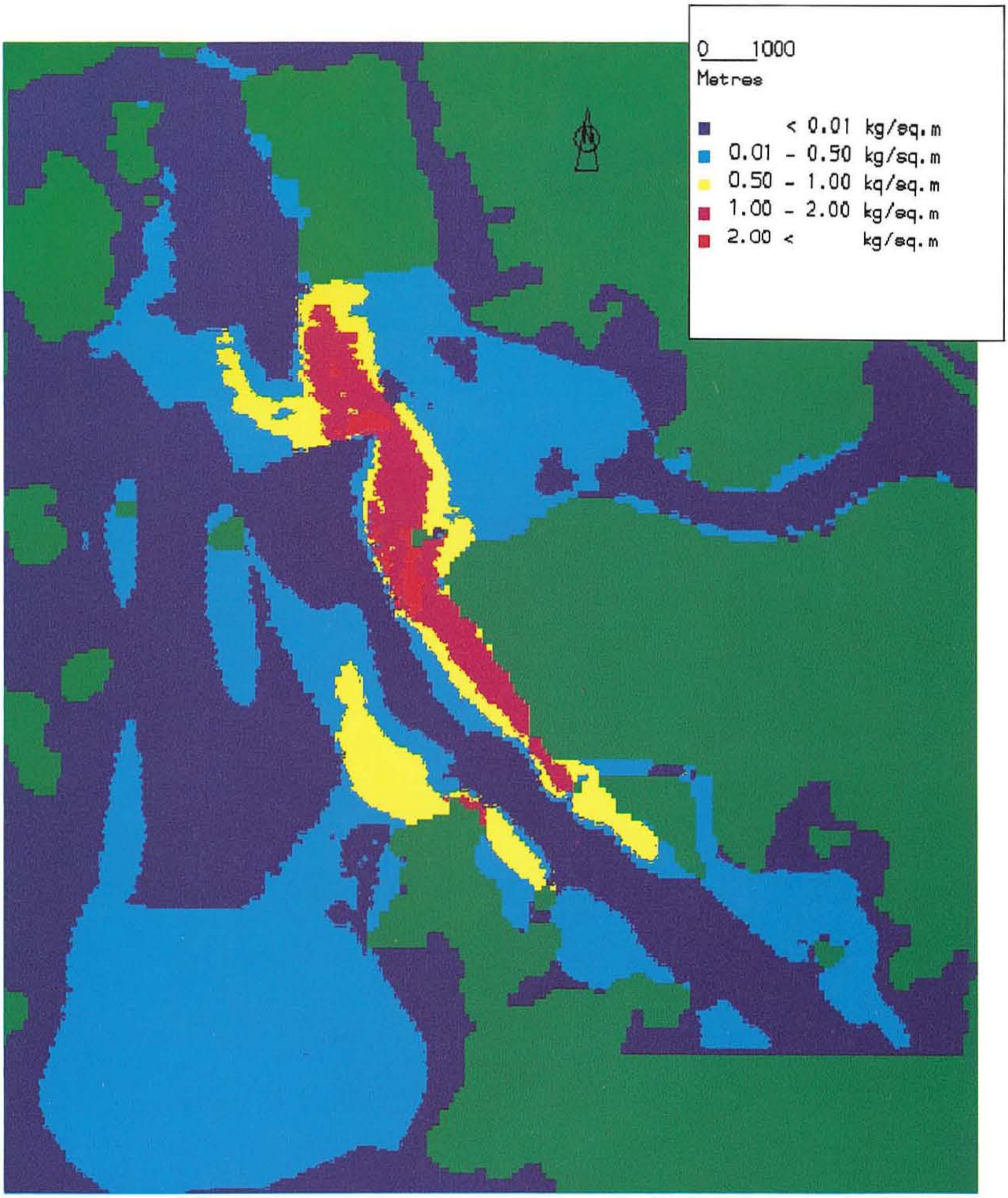


WEST OF SULPHUR CHANNEL MARINE BORROW AREA
FOCUSED ENVIRONMENTAL IMPACT ASSESSMENT
FINAL REPORT

Figure No.	4.11

Dry Season Spring Tide:

Net Mud Deposits over 1 Tide

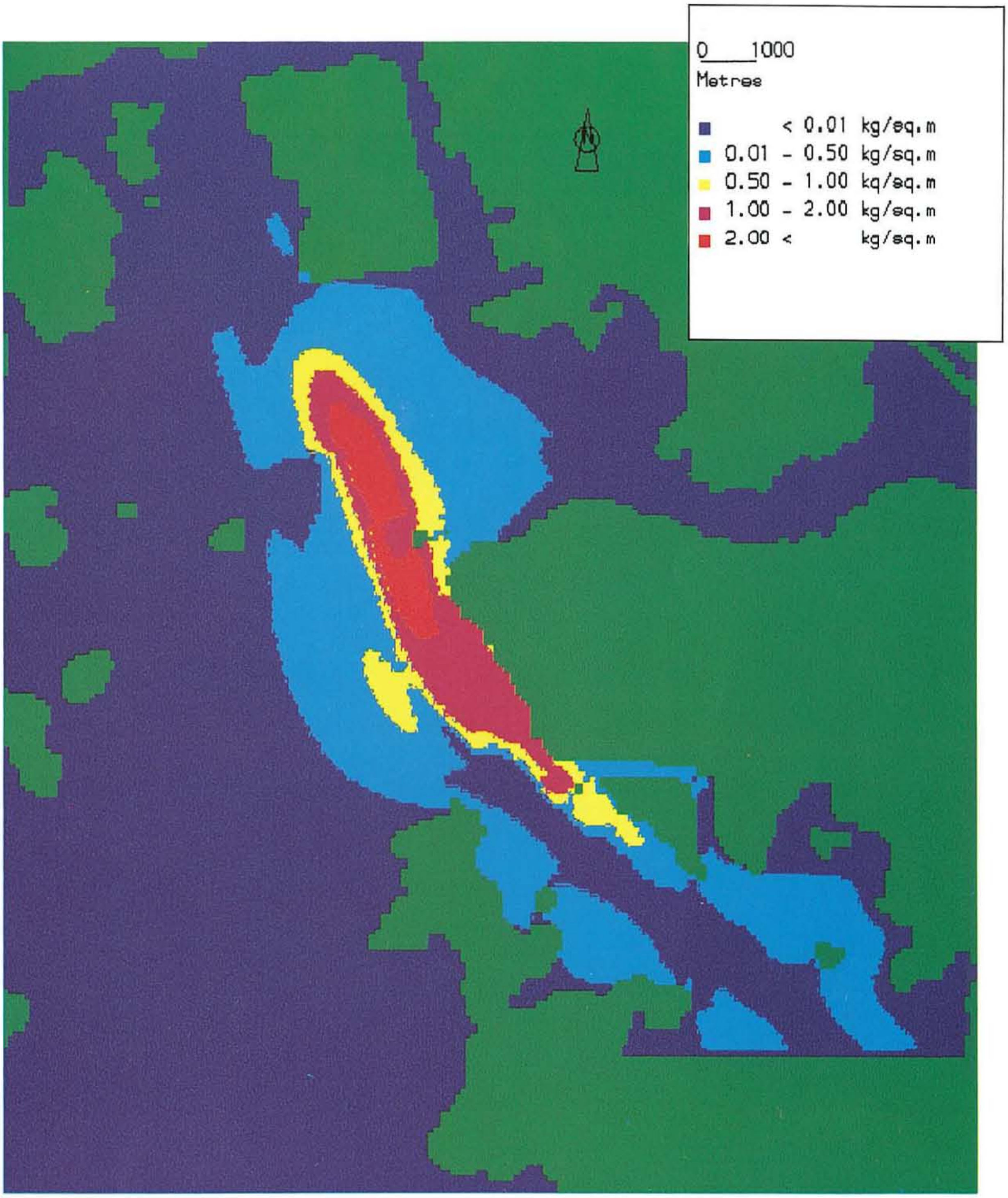


WEST OF SULPHUR CHANNEL MARINE BORROW AREA
FOCUSED ENVIRONMENTAL IMPACT ASSESSMENT
FINAL REPORT

Figure No. 4.12

Wet Season Spring Tide:

Net Mud Deposits over 1 Tide

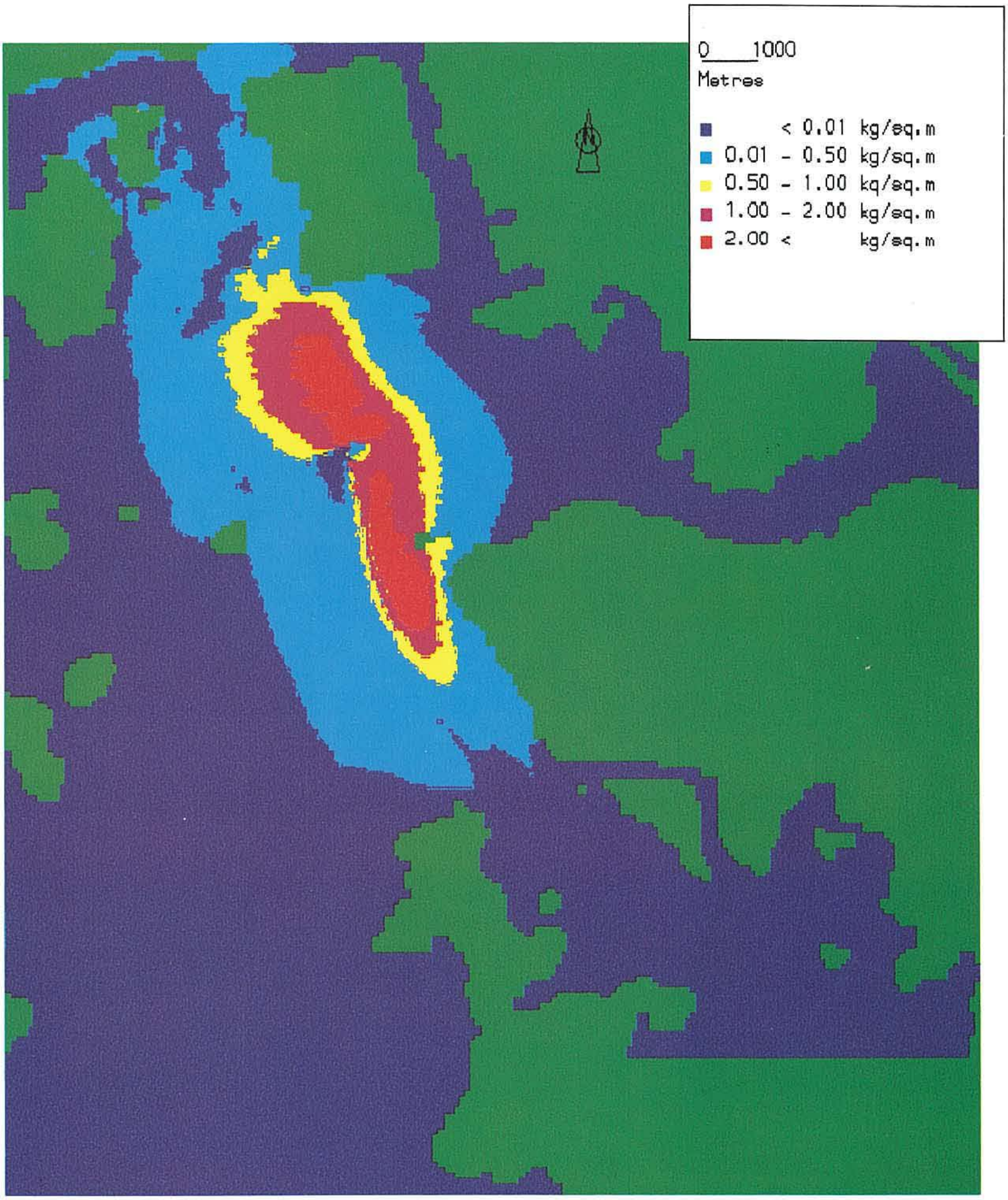


WEST OF SULPHUR CHANNEL MARINE BORROW AREA
FOCUSED ENVIRONMENTAL IMPACT ASSESSMENT
FINAL REPORT

Figure No. 4.13

Dry Season Neap Tide:

Net Mud Deposits over 1 Tide

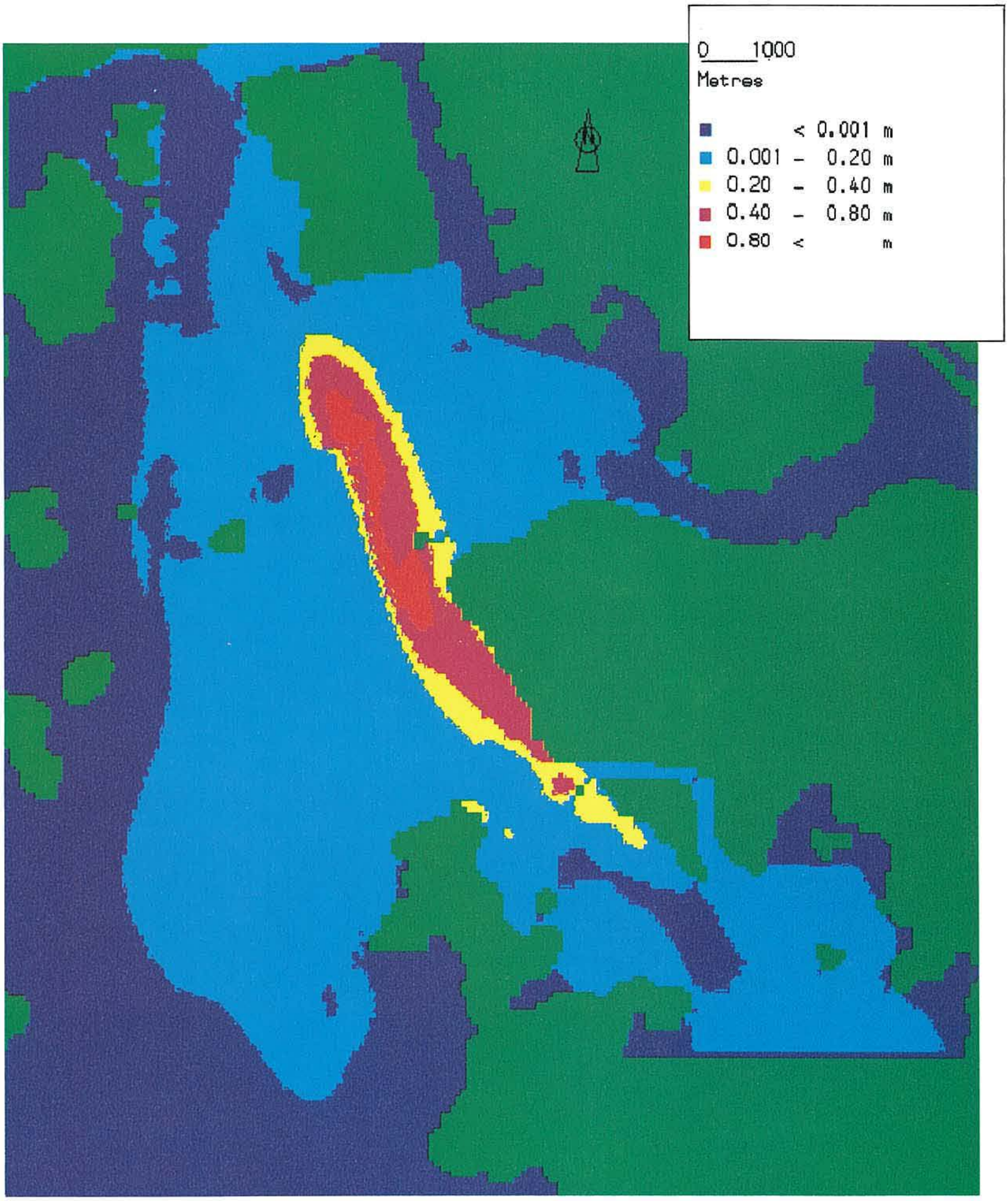


WEST OF SULPHUR CHANNEL MARINE BORROW AREA
FOCUSED ENVIRONMENTAL IMPACT ASSESSMENT
FINAL REPORT

Figure No. 4.14

Wet Season Neap Tide:

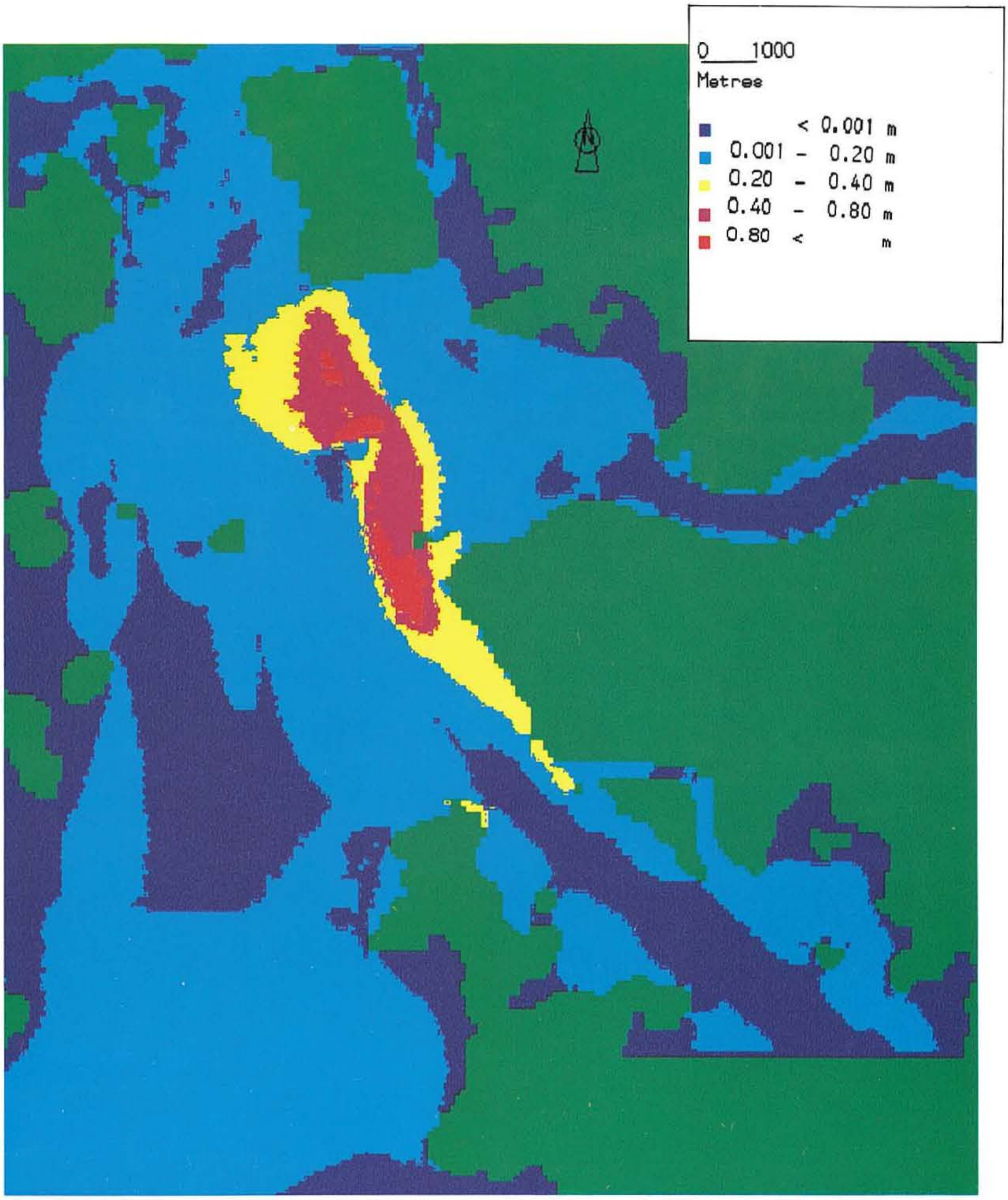
Net Mud Deposits over 1 Tide



WEST OF SULPHUR CHANNEL MARINE BORROW AREA
FOCUSED ENVIRONMENTAL IMPACT ASSESSMENT
FINAL REPORT

Figure No.	4.15

Dry Season: Net Mud Deposits over 6 Months

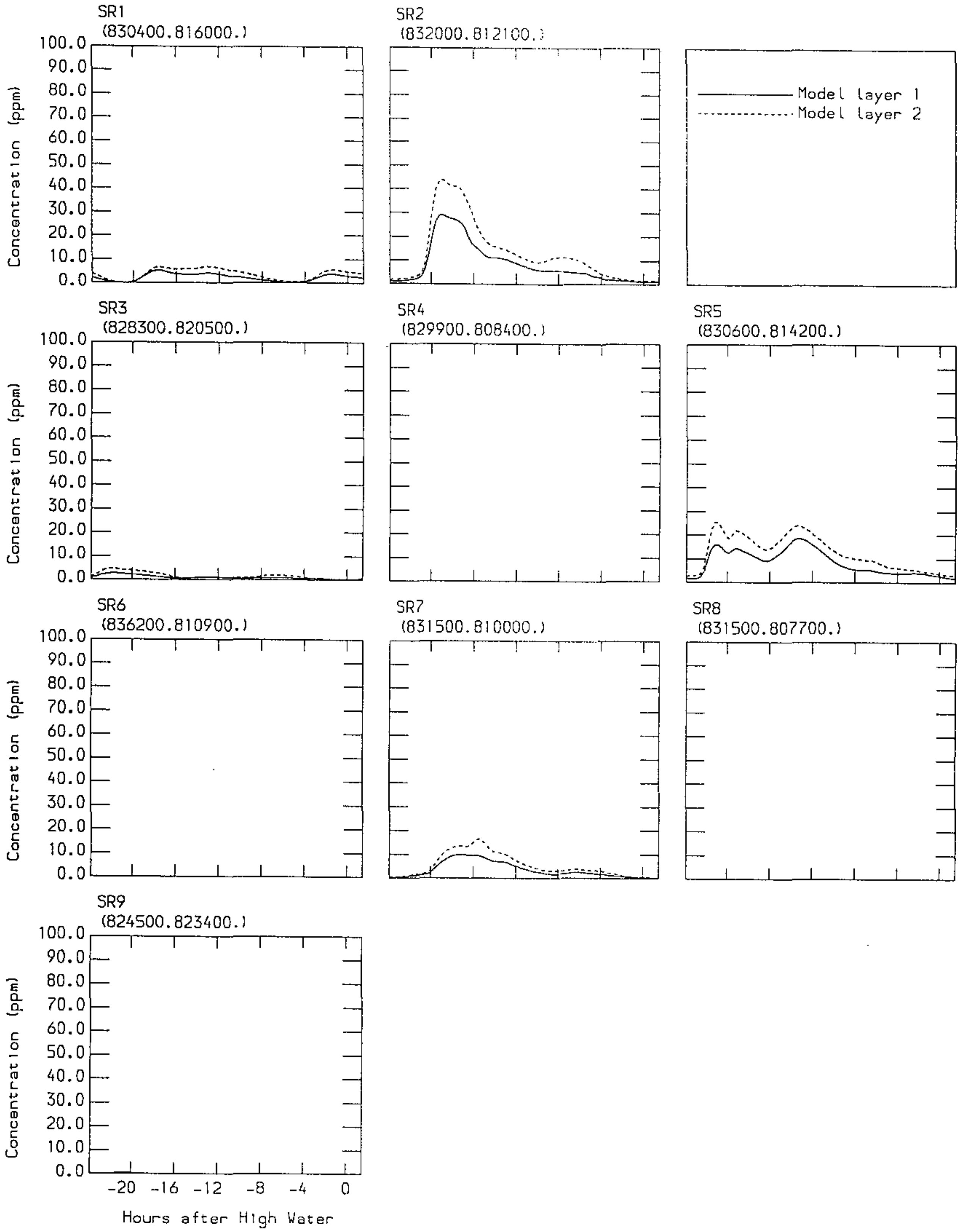


WEST OF SULPHUR CHANNEL MARINE BORROW AREA
FOCUSED ENVIRONMENTAL IMPACT ASSESSMENT
FINAL REPORT

Figure No.	4.16

Wet Season: Net Mud Deposits

over 6 Months

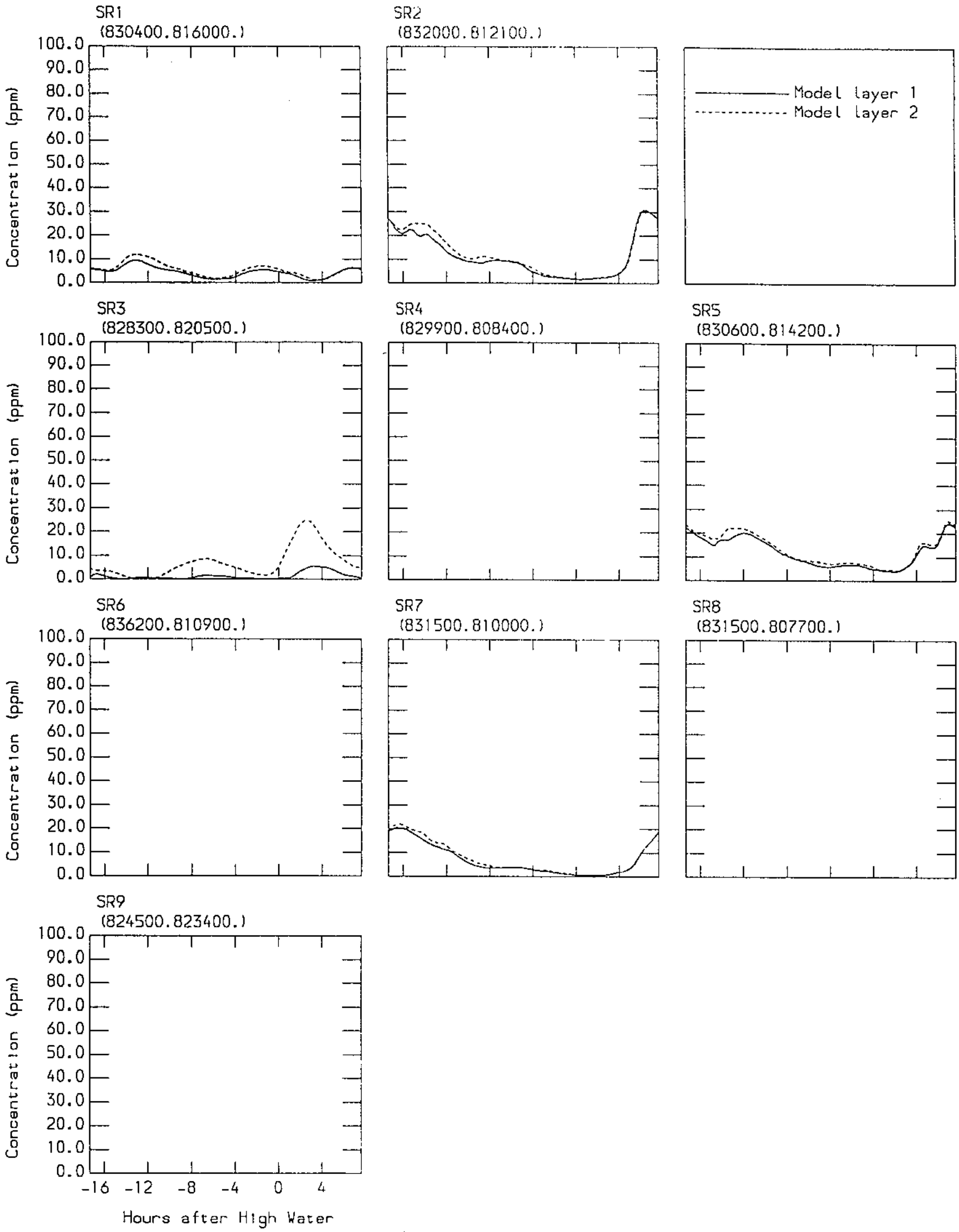


SR1 - WSD flushing water intake, Kennedy Town
SR2 - Housing Authority flushing water intake, Wah Fu
SR3 - Tsing Yi Power Station cooling water intake
SR4 - Lamma Island Power Station cooling water intake
SR5 - Queen Mary Hospital cooling water intake
SR6 - Ocean Park seawater intake
SR7 - Lo Tik Wan Mariculture Zone / Luk Chau Wan Fry Collection Area
SR8 - Sok Kwu Wan Mariculture Zone
SR9 - Ma Wan Mariculture Zone

WEST OF SULPHUR CHANNEL MARINE BORROW AREA
FOCUSED ENVIRONMENTAL IMPACT ASSESSMENT
FINAL REPORT

Figure No.	4.17

Tidal Variations in Suspended Solids Concentrations at Sensitive Receivers: Dry Season Spring Tide

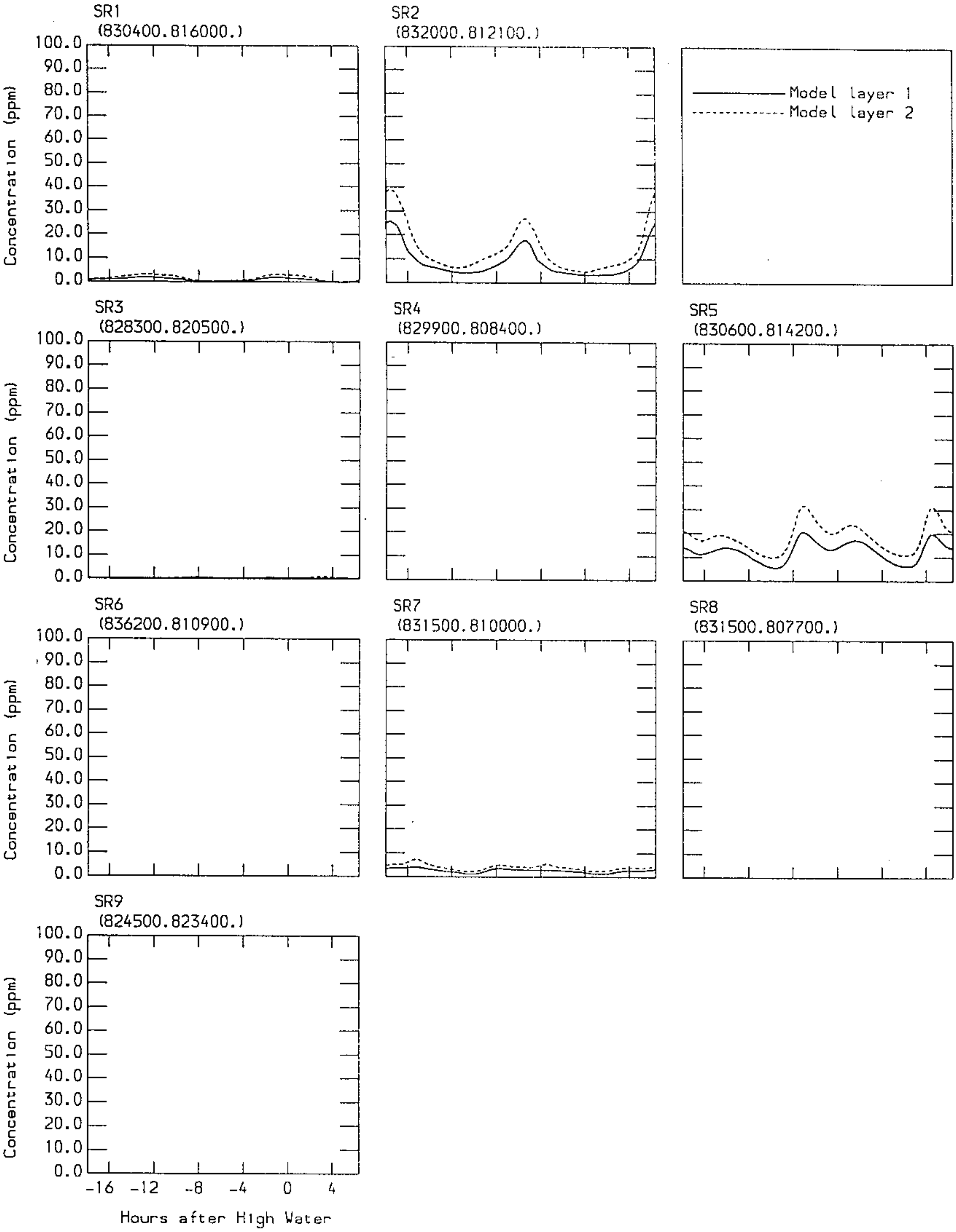


SR1 - WSD flushing water intake, Kennedy Town
SR2 - Housing Authority flushing water intake, Wah Fu
SR3 - Tsing Yi Power Station cooling water intake
SR4 - Lamma Island Power Station cooling water intake
SR5 - Queen Mary Hospital cooling water intake
SR6 - Ocean Park seawater intake
SR7 - Lo Tik Wan Mariculture Zone / Luk Chau Wan Fry Collection Area
SR8 - Sok Kwu Wan Mariculture Zone
SR9 - Ma Wan Mariculture Zone

WEST OF SULPHUR CHANNEL MARINE BORROW AREA
FOCUSED ENVIRONMENTAL IMPACT ASSESSMENT
FINAL REPORT

Figure No. 4.18

Tidal Variations in Suspended Solids Concentrations at Sensitive Receivers: Wet Season Spring Tide

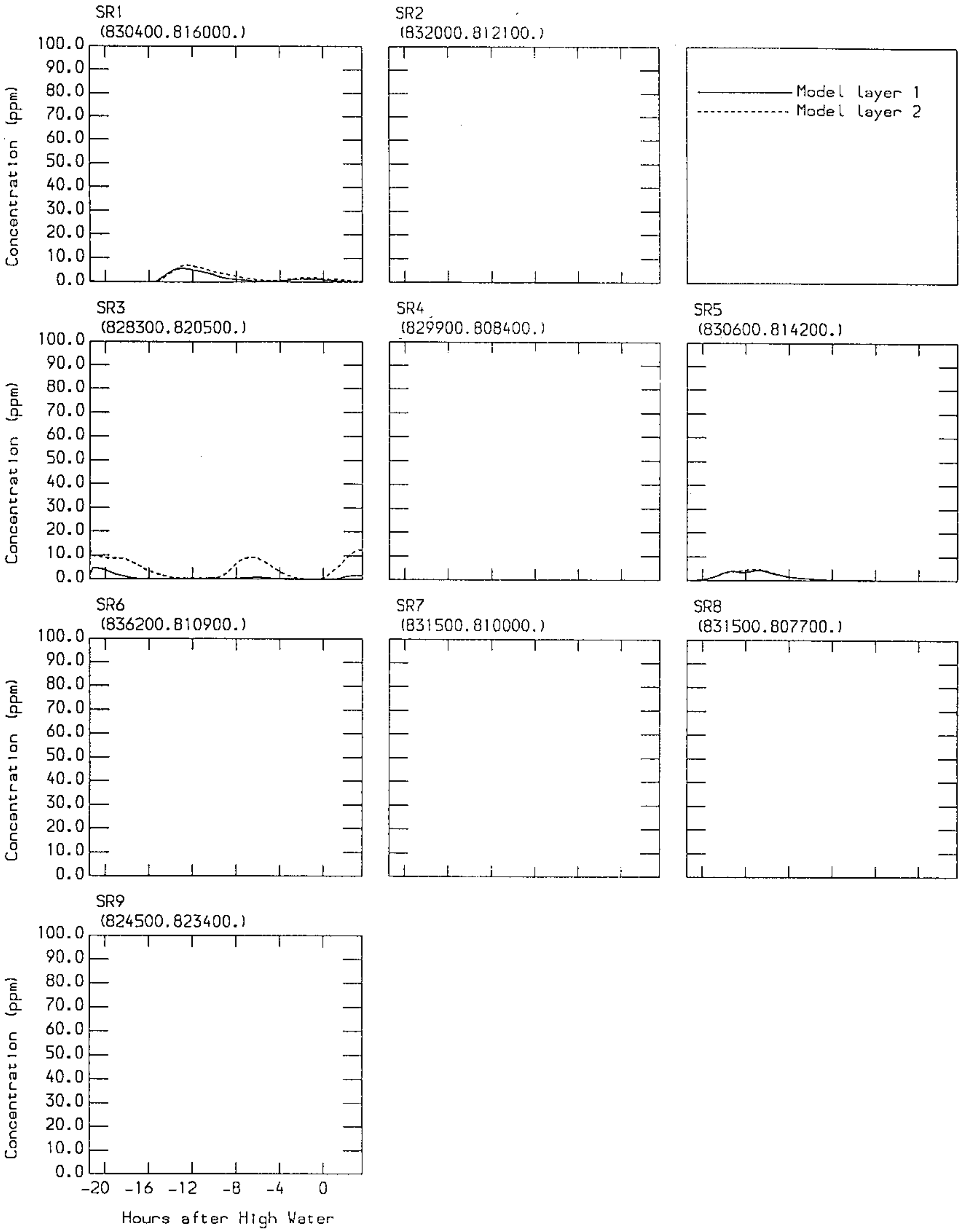


SR1 - WSD flushing water intake, Kennedy Town
SR2 - Housing Authority flushing water intake, Wah Fu
SR3 - Tsing Yi Power Station cooling water intake
SR4 - Lamma Island Power Station cooling water intake
SR5 - Queen Mary Hospital cooling water intake
SR6 - Ocean Park seawater intake
SR7 - Lo Tik Wan Mariculture Zone / Luk Chau Wan Fry Collection Area
SR8 - Sok Kwu Wan Mariculture Zone
SR9 - Ma Wan Mariculture Zone

WEST OF SULPHUR CHANNEL MARINE BORROW AREA
FOCUSED ENVIRONMENTAL IMPACT ASSESSMENT
FINAL REPORT

Figure No.	4.19

Tidal Variations in Suspended Solids Concentrations at Sensitive Receivers: Dry Season Neap Tide

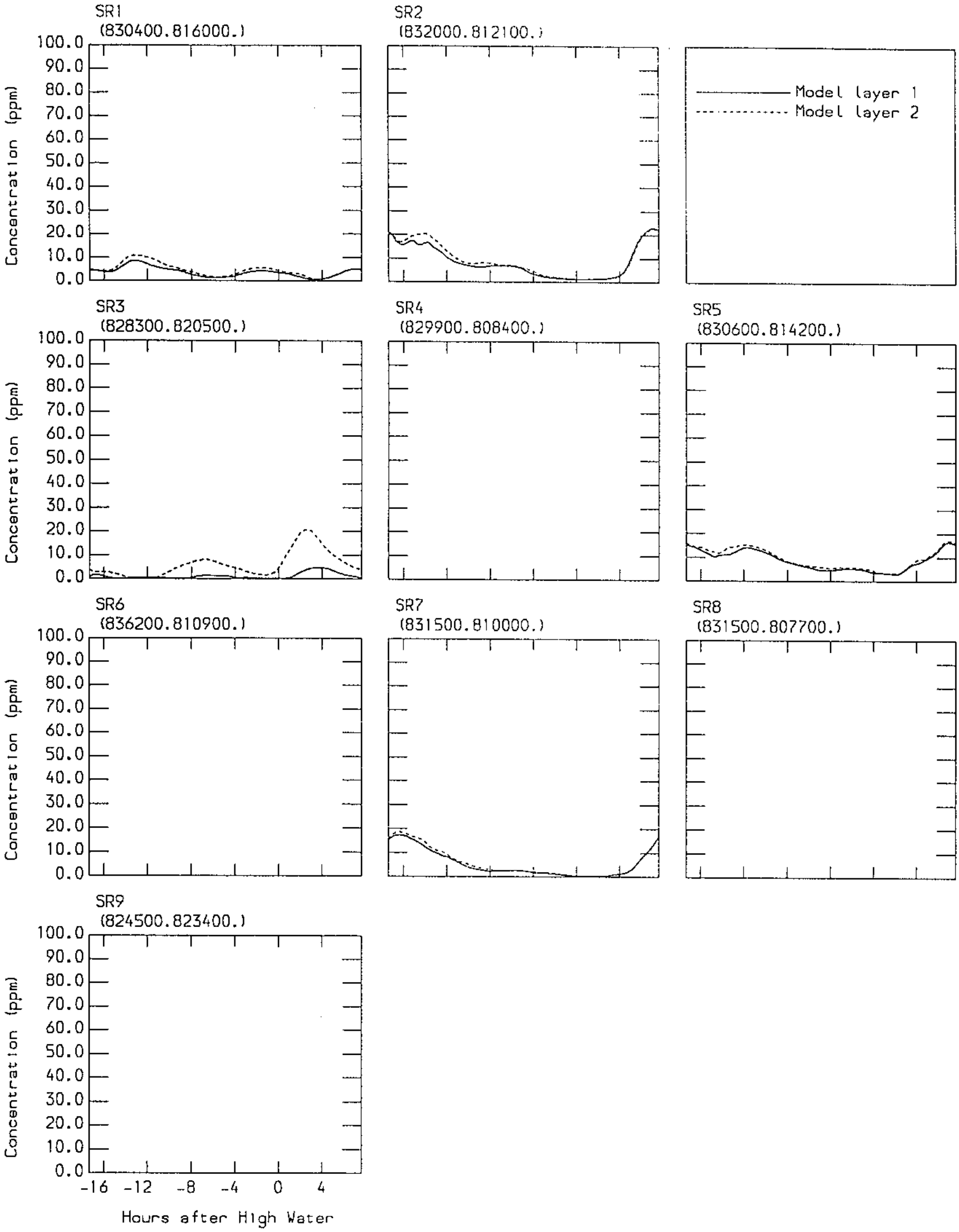


SR1 - WSD flushing water intake, Kennedy Town
SR2 - Housing Authority flushing water intake, Wah Fu
SR3 - Tsing Yi Power Station cooling water intake
SR4 - Lamma Island Power Station cooling water intake
SR5 - Queen Mary Hospital cooling water intake
SR6 - Ocean Park seawater intake
SR7 - Lo Tik Wan Mariculture Zone / Luk Chau Wan Fry Collection Area
SR8 - Sok Kwu Wan Mariculture Zone
SR9 - Ma Wan Mariculture Zone

WEST OF SULPHUR CHANNEL MARINE BORROW AREA
FOCUSED ENVIRONMENTAL IMPACT ASSESSMENT
FINAL REPORT

Figure No.	4.20

Tidal Variations in Suspended Solids Concentrations at Sensitive Receivers: Wet Season Neap Tide

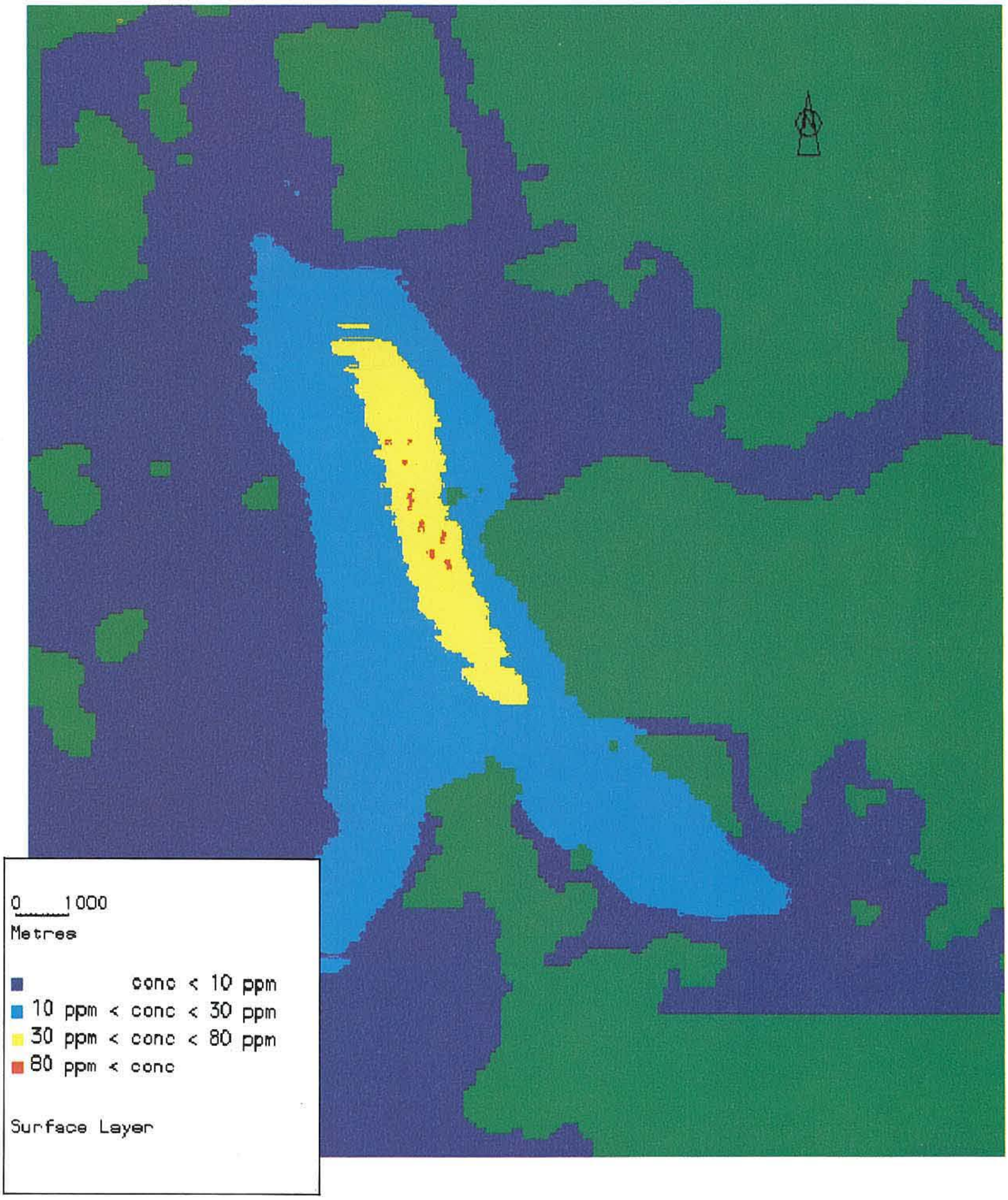


SR1 - WSD flushing water intake, Kennedy Town
SR2 - Housing Authority flushing water intake, Wah Fu
SR3 - Tsing Yi Power Station cooling water intake
SR4 - Lamma Island Power Station cooling water intake
SR5 - Queen Mary Hospital cooling water intake
SR6 - Ocean Park seawater intake
SR7 - Lo Tik Wan Mariculture Zone / Luk Chau Wan Fry Collection Area
SR8 - Sok Kwu Wan Mariculture Zone
SR9 - Ma Wan Mariculture Zone

WEST OF SULPHUR CHANNEL MARINE BORROW AREA
FOCUSED ENVIRONMENTAL IMPACT ASSESSMENT
FINAL REPORT

Figure No.	4.21

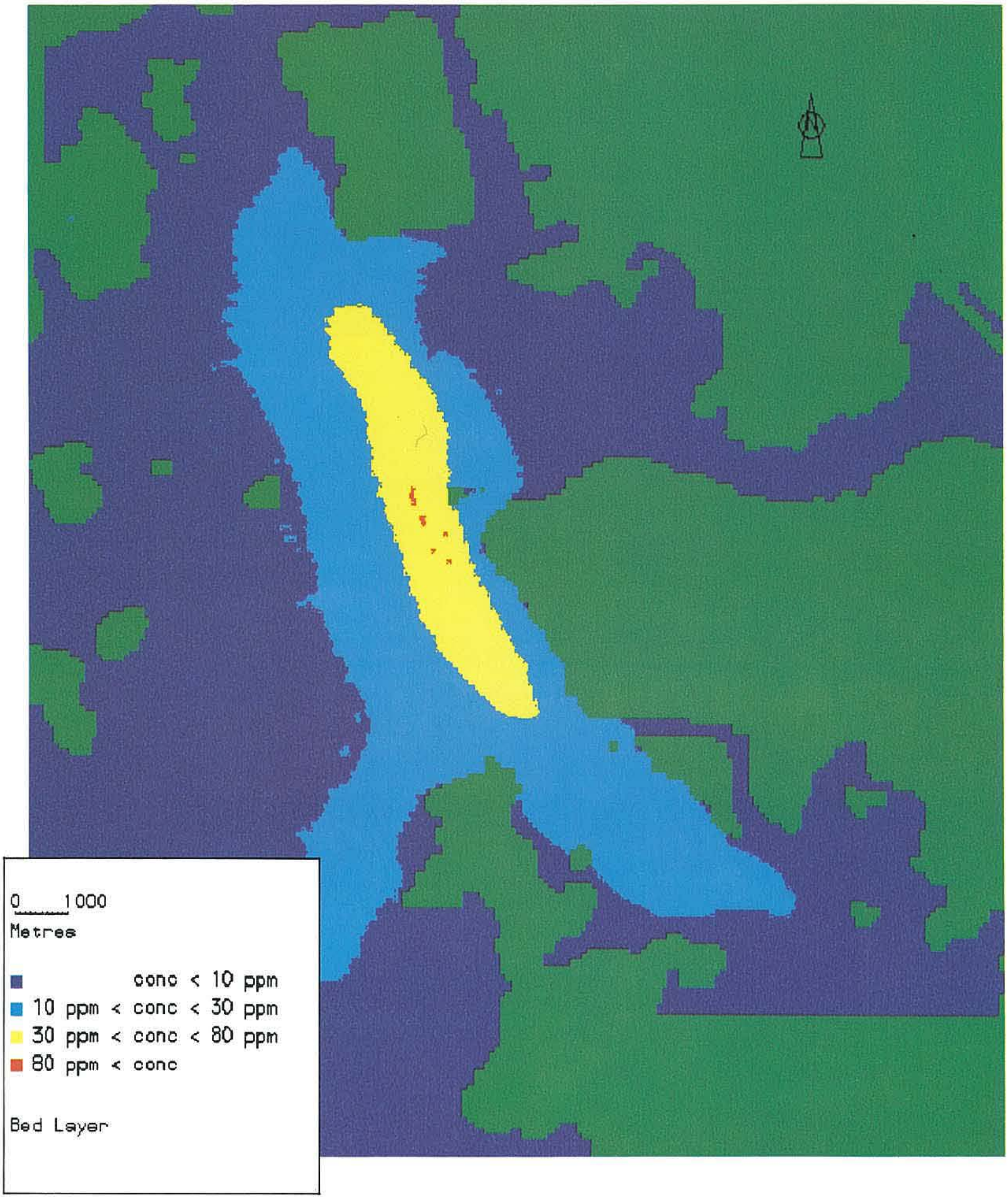
Tidal Variations in Suspended Solids Concentrations at Sensitive Receivers: Wet Season Spring Tide, Mitigated



WEST OF SULPHUR CHANNEL MARINE BORROW AREA
FOCUSED ENVIRONMENTAL IMPACT ASSESSMENT
FINAL REPORT

Figure No.	4.22a

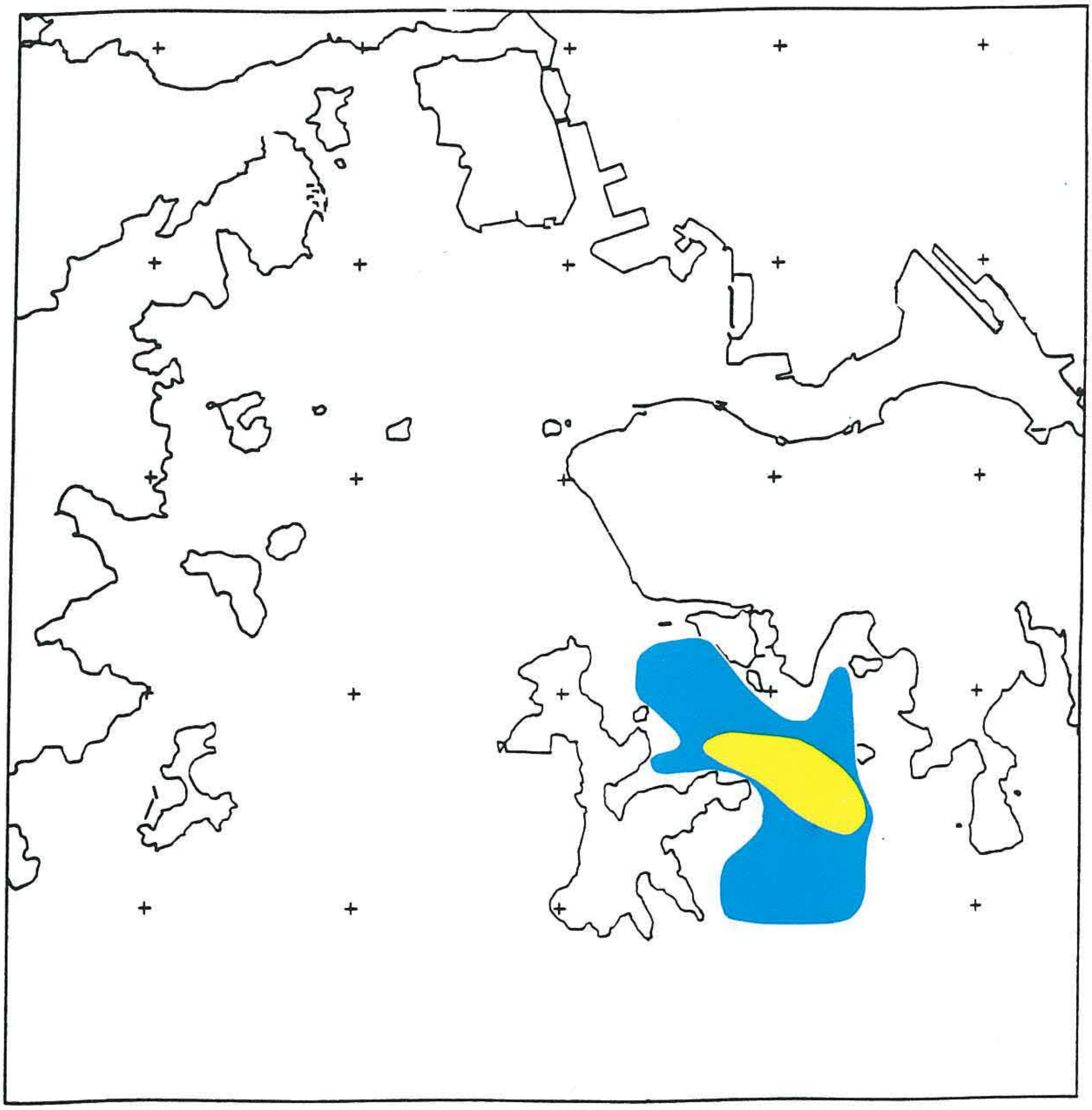
Summary of Suspended Solids Concentrations for Worst Case: Wet Season Spring Tide, Surface Layer



WEST OF SULPHUR CHANNEL MARINE BORROW AREA
FOCUSED ENVIRONMENTAL IMPACT ASSESSMENT
FINAL REPORT

Figure No.	4.22b

Summary of Suspended Solids Concentrations for Worst Case: Wet Season Spring Tide, Bed Layer



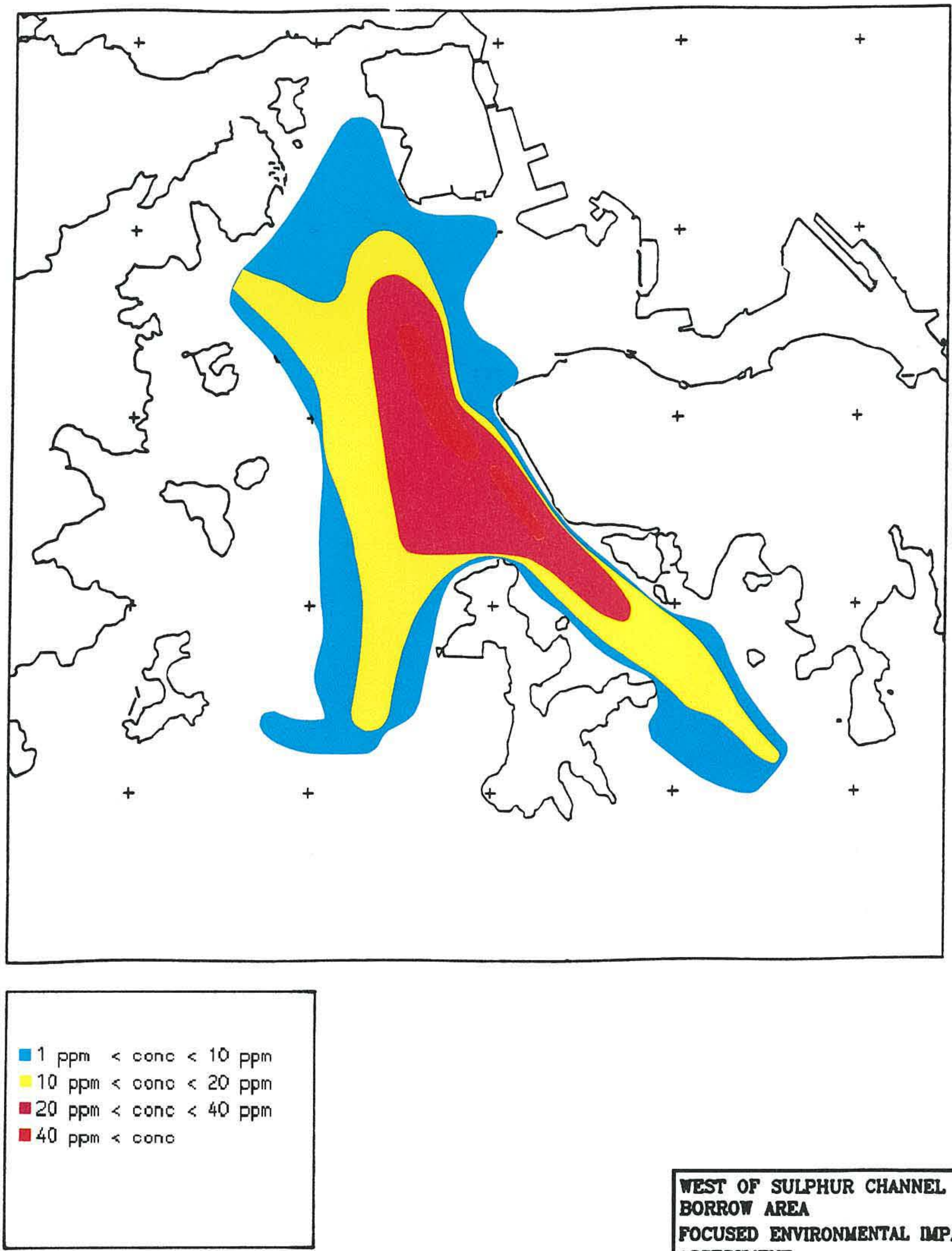
1 ppm < conc < 10 ppm
10 ppm < conc < 20 ppm
20 ppm < conc < 40 ppm
40 ppm < conc

WEST OF SULPHUR CHANNEL MARINE BORROW AREA
FOCUSED ENVIRONMENTAL IMPACT ASSESSMENT
FINAL REPORT

Figure No. 4.23

Cumulative Impacts:

Dry Season Spring Tide, Average



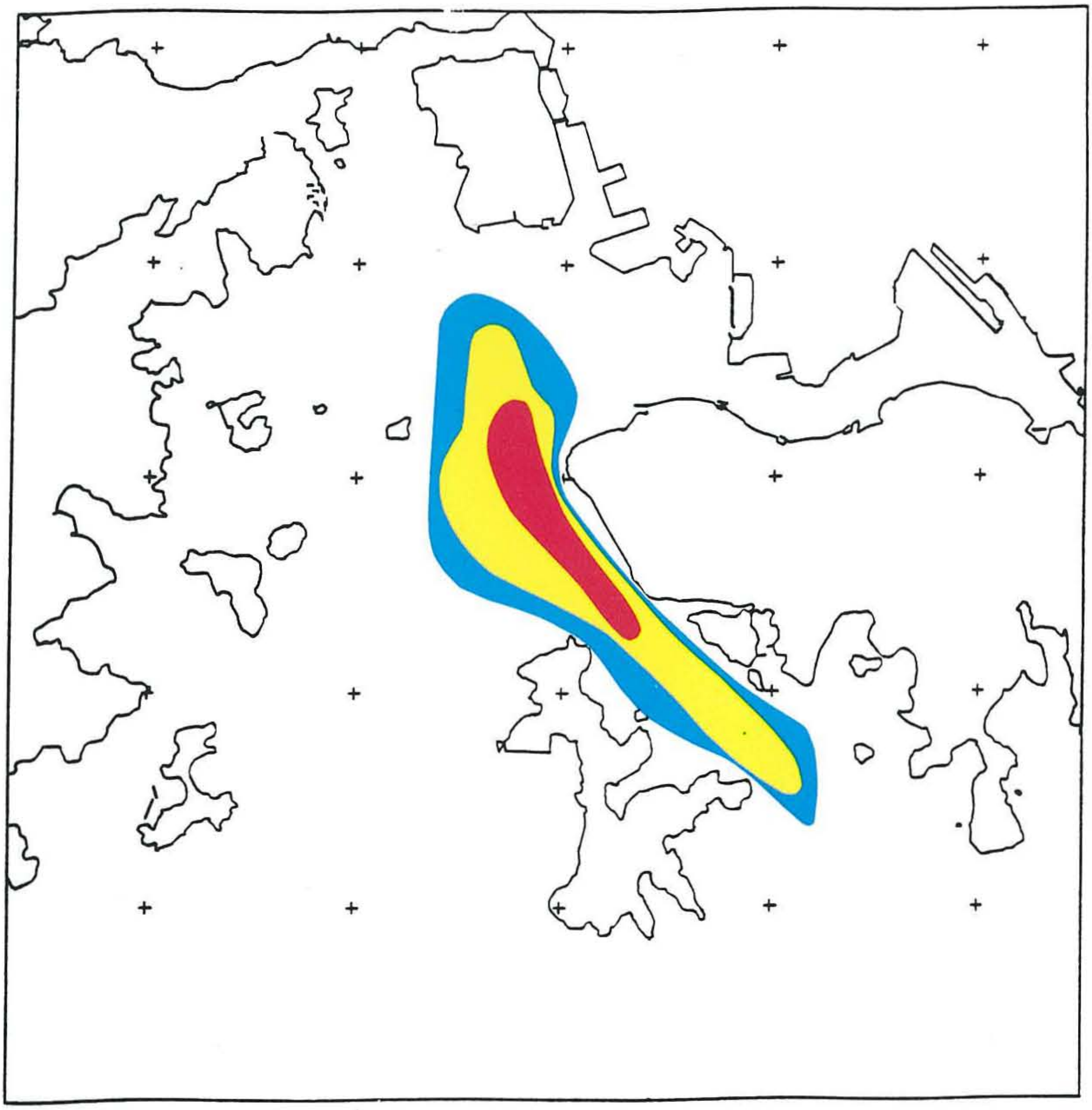
WEST OF SULPHUR CHANNEL MARINE BORROW AREA
FOCUSED ENVIRONMENTAL IMPACT ASSESSMENT
FINAL REPORT

Figure No.	4.24

Cumulative Impacts:

Wet Season Spring Tide,

Bed Layer Average



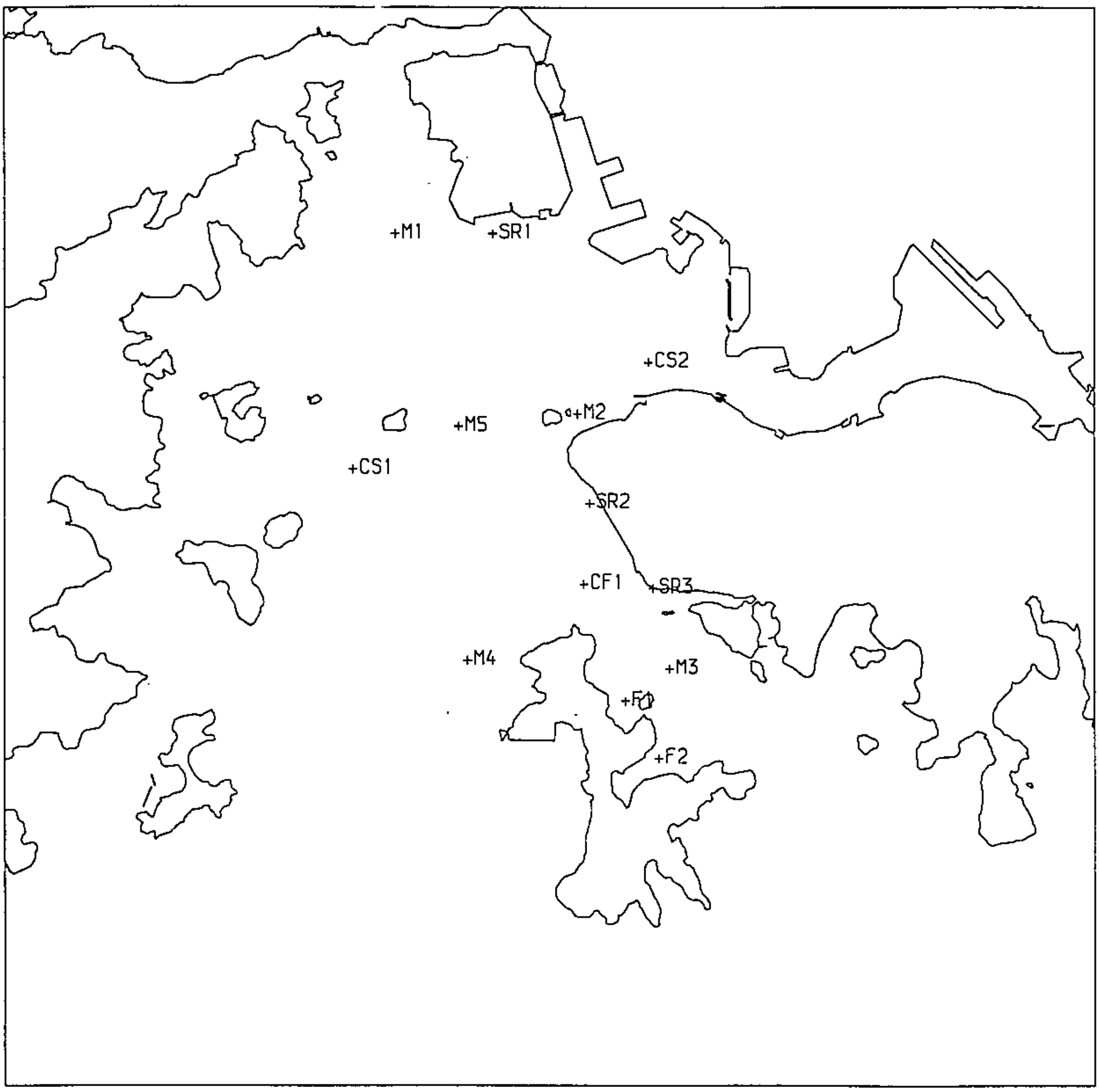
■ 1 ppm < conc < 10 ppm
■ 10 ppm < conc < 20 ppm
■ 20 ppm < conc < 40 ppm
■ 40 ppm < conc

WEST OF SULPHUR CHANNEL MARINE BORROW AREA
FOCUSED ENVIRONMENTAL IMPACT ASSESSMENT
FINAL REPORT

Figure No. 4.25

Cumulative Impacts:

Dry Season Neap Tide, Average



M1 - M5: Monitoring Stations

CS1 & CS2: Control Stations

F1 & F2: Fish Culture Zone Stations

CF1: Fish Culture Zone Control Station (for AFD)

SR1 - SR3: Sensitive Receiver Stations

WEST OF SULPHUR CHANNEL MARINE BORROW AREA FOCUSED ENVIRONMENTAL IMPACT ASSESSMENT FINAL REPORT	
Figure No.	4.26
Proposed Locations of Monitoring Stations	

5. MARINE ECOLOGY AND FISHERIES

Introduction

5.1 This chapter reviews the available information on marine ecology and fisheries (including mariculture zones) in order to assess the potential scope of impacts from the works.

Environmental Standards and Guidelines

5.2 There are no set legislative standards for the assessment of ecological values of communities other than for the protection of locally or globally endangered species and habitats. However, criteria which can be adopted to assess ecological impact include the following:

- the impact, whether beneficial or harmful, on the ecological communities originally associated with the impact area; in particular, the loss or reduction of endangered species through direct habitat destruction or other consequences of habitat alteration.

- the present importance of the existing communities in terms of their values for conservation, education or scientific research both on local and global scales. In this respect, factors such as the uniqueness of the community, ease of rehabilitation and ecological value in maintaining a robust ecosystem can be considered.

5.3 The assessment of impact on fisheries is related to the above criteria, whereby loss of benthic habitat and contamination of the water column can impact upon fish feeding and breeding grounds. The potential impacts can often be more readily evaluated for fisheries as measurements can be taken with respect to stock size, population structure, catch per unit effort and catch revenue. Further, biological parameters can be more readily quantified in mariculture fisheries where the commercial populations are captive and therefore easily monitored.

5.4 A restriction on the concentration of suspended sediments allowed in mariculture zones (MCZs) of 80mg/l is recommended by Agriculture and Fisheries Department.

5.5 In accordance with the Study Brief, no ecological or fisheries monitoring was undertaken for this assessment, and the evaluation has been based on a review of existing information.

Associated Impacts Related to Water Quality

5.6 As identified in Chapter 3 of this report, potentially major impacts associated with the Works relate to the physical removal of sediment material from the sea bed, suspension of that material into the water column and its associated biological impacts on marine ecological communities, commercial fisheries in open waters, and MCZs. Suspended sediments will impact upon the water column in the following principle ways:

- Increased suspended solids concentrations. This has the potential to affect fish physiology and reproduction. Increasing sedimentation rates on the sea bed also have the potential to affect sensitive benthic fauna and flora;

- Decreasing dissolved oxygen levels. This can occur via chemical and biological processes acting upon reduced chemical constituents and/or organic matter in the suspended sediments; and

- Release of contaminants (e.g. heavy metals, organics) associated with the solid and aqueous phase of the suspended sediments. The impact of contaminants is dependent on the levels initially present in the sediments, and they may be associated with acute or chronic effects on marine ecological communities.

Existing Marine Ecological Communities

5.7 The marine environment in the vicinity of WSC Pit 3 is representative of the oceanic transition zone of Hong Kong waters found between the oceanic waters to the east and the estuarine waters of the west. The transition zone is a region of interacting water masses. In summer, the surface waters are of lowered salinity, elevated temperature and are relatively rich in dissolved oxygen. This surface water is separated from cooler, more saline bottom waters which are low in dissolved oxygen. In winter when rainfall is minimal, mixing of the water column creates a relatively uniform water mass.

5.8 The removal of marine silt and clay from WSC Pit 3 will result in the loss of approximately 1 km^2 of benthic marine habitat. Ecological data available for the Sulphur Channel area is limited, although recent data are available from the CED Fill Management Study Phase IV Seabed Ecological Study (Ref 5.1). The main objective of the study was to determine the baseline conditions of benthic communities in the Sulphur Channel, as well as in and around the marine dumping ground at South Cheung Chau. Sampling was undertaken using grab sampling of the macrobenthic surface and sub-surface fauna.

5.9 Survey sampling was undertaken at two locations in the Sulphur Channel and at six locations at South Cheung Chau including four within the dumping ground area and two control sites. The monitoring locations are shown in Figure 5.1.

5.10 The two grab samples taken in the Sulphur Channel included 92 invertebrate macrobenthos belonging to 32 taxa where the dominant groups consisted of polychaetes, molluscs and crustaceans.

5.11 Of the three dominant groups polychaetes were numerically most abundant in the samples (68 %) and comparative analysis to marine spoil dumping monitoring stations at South Cheung Chau indicated a relatively high abundance, suggesting that the Sulphur Channel sites are representative of a relatively undisturbed benthic community. Other ecological indices, including species richness, diversity and evenness, also demonstrated that the Sulphur Channel monitoring stations were representative of undisturbed communities. Faunal biomass was greater than at dumping monitoring stations at South Cheung Chau. Overall the monitoring data indicated that:

- the macrobenthic community in the Sulphur Channel is relatively species rich and diverse, and is relatively unaffected by disturbance of the marine environment;
- marine spoil dumping, as demonstrated by sampling undertaken in the South Cheung Chau marine dumping ground, has a major impact on abundance and diversity of the benthic community; and
- recovery of the benthic community following marine spoil dumping was evident from samples taken from the South Cheung Chau marine dumping ground, albeit at a slow rate.

5.12 The results of the macrobenthos survey for the Sulphur Channel stations are generally supported by results from other benthic surveys undertaken further south in the Lamma Channel which have been assessed with respect to the East Lamma Channel Marine Borrow Area (Ref 5.2). Earlier surveys in the West Lamma Channel showed the presence of large numbers of crabs, shrimp and mollusc.

5.13 Within the East Lamma Channel, few hard corals are present but sea fans, sea whips (gorgonian corals) and soft corals were found to be abundant and exhibited a high species diversity in areas of hard substratum (Ref 5.3). These non-reef building corals were estimated to be present in a relatively narrow band on each side of the channel (as indicated on Figure 5.1), while hard corals were restricted to a zone between 4 and 10 m depth. Hard corals are restricted to the eastern side of Lamma (south of Wong Chuk Kok) and will not be present within the deeper waters of the WSC Pit 3 area.

5.14 More recent survey work (Ref 5.6) undertaken in support of this EIA to determine the type and density of marine life within the areas which may be affected by the dredging operations has shown that the proportion of seabed covered by soft corals is greater than 10% only at Luk Chau and Pak Kok on Lamma Island. The density and diversity of corals in this area is also considered to be high. However, based on the common occurrence of these species of corals in many other parts of Hong Kong, the conservation value is described as medium. The density of coral to the south of Ap Lei Chau was assessed as medium density (ie 6%- 10% cover) and low conservation value. The distribution of coral along the west coast of Hong Kong Island towards Ap Lei Chau and along the north east coast of Lamma Island is considered to be sparse and of low conservation value.

5.15 The nearest Site of Special Scientific Interest (SSSI) is located at South Lamma Island, centred around Sham Wan Beach (Figure 5.1). There is evidence that the beach acts as a turtle hatching ground, although recorded observations are limited (Ref 5.2). The site is approximately 10 km distant from WSC Pit 3 (see Table 3.1).

Potential Ecological Impacts

5.16 Assuming that benthic communities are of a similar composition to the Sulphur Channel monitoring locations used in the Seabed Ecology Survey (Ref 5.1), then removal of the seabed habitat will result in the loss of a relatively undisturbed macrobenthic community.

5.17 Marine silt and clay dredged from WSC Pit 3 will be disposed of in the marine dumping ground at South Cheung Chau. Whilst the dumping of this material in exhausted borrow pits can provide a suitable habitat for the recolonisation of the seabed by marine organisms, it is likely that the positive impact of this will be limited, particularly if material is dumped over existing dumped material which has been partially recolonized. Eventual backfilling of WSC Pit 3 with uncontaminated marine silt and clay from other borrow areas in Hong Kong waters will initiate and enhance recolonisation by the macrobenthos. It is recommended that such action be considered following the completion of works.

5.18 Suspended sediments in the water column from the dredging operation will enhance sedimentation rates down current of the Works. Benthic organisms are capable of sustaining an increased sedimentation rate, where the actual capacity is dependent on the actual rate of deposition, species tolerance, stage of life-cycle (egg, larva, juvenile, adult) and other environmental stress factors (e.g. presence of toxins, water flow and temperature).

5.19 Hong Kong waters are known to contain a broad range of organisms with respect to sediment tolerance, but little is known about the absolute tolerance thresholds of most Hong Kong organisms (Ref 5.5). Sedimentation impacts may last for a relatively short or longer period of time depending on the extent, duration and rate of dredging, as well as environmental factors related to the hydrological regime. Sedimentation impacts may be lethal due to direct smothering of organisms, or indirectly through, for example, decreased light penetration. Non-lethal impacts may impair the functioning of the organism, for example via clogging of feeding and respiratory apparatus, and have the potential to alter community species composition as more tolerant species assume dominance. These impacts have been demonstrated on a range of organisms including crabs, polychaetes, oysters, lobsters and clams (Ref 5.5). Relatively high sediment concentrations, combined with multi-day exposures, were found to be required to injure or kill these organisms. In most cases larvae were found to be more sensitive to high sediment concentrations than adult specimens.

5.20 It is worth noting that many benthic communities in Hong Kong are located on soft muds and sands which are frequently disturbed by storms which create high suspended sediment loads in the water column. Macrobenthic invertebrates are therefore not likely to be adversely affected by dredging activity with respect to sediment suspension and resettlement, and the main impact will relate to direct habitat loss in the WSC Pit 3 area.

5.21 Corals are also highly variable in their tolerance of sediment concentrations, where variations are species-specific and growth-form specific (Ref 5.5). In contrast to other benthic fauna, some of the most common hard coral species in Hong Kong are easily damaged and killed by sedimentation and are therefore considered to be the most sensitive marine organisms to sediment impacts associated with dredging activity. Coral damage can take place rapidly for sensitive species, especially hard corals, from the direct effects of smothering caused by sedimentation and indirectly from increased suspended solids levels which can induce chronic effects. Due to the slow growth rates of corals, full recovery takes many years and coral larvae are known to be inhibited from settling and developing due to the presence of fine sediment (Ref 5.5).

5.22 Potential impacts on the local coral community, in the case of WSC Pit 3, are likely to be restricted to impacts from both increased suspended solids levels and increased sedimentation of the seabed, rather than a direct loss of habitat. However, in considering the potential damage to corals as a result of potential sedimentation account needs to be taken of the type of coral, the rate of sediment deposition and the coral growth position (Ref 5.6).

5.23 Evaluation of sediment impacts on coral has been based on the predicted mass of sediment deposition over a single tide (kg/m^2/tide) and total depth of deposition resulting from a continuous dredging of marine sand over a six month period (Figures 5.3 and 5.4) as generated by the WAHMO model for the water quality assessment (Chapter 4). This has been compared with the distribution corals (shown in Figure 5.1) and the additional information provided by the recent survey (Ref 5.6). In fact, the total sediment deposition is likely to be less as half the total volume of material to be dredged from WSC Pit 3 will be the better quality alluvial sand (see Tables 2.3 and 2.6). Asa result it is likely that the total depth of sediment deposition will be two thirds of that shown on Figures 5.3 and 5.4.

5.24 The predicted mass of sediment deposition over a single tide demonstrates that the soft coral range will be impacted during the dry season spring and neap tides, as well as the wet season spring tide. Tidal deposition rates within the soft coral range are similar for each of these three tidal types for the band of soft coral adjacent to the west coast of Hong Kong Island toward Ap Lei Chau, reaching between 1.0 and 2.0 kg/m^2/tide. Lower deposition rates of between 0.5 and1.0 kg/m^2/tide extend south east toward Ap Lei Chau and the central part of the soft coral range. Tidal deposition rates of 0.5 to 1.0 kg/m^2/tide are also predicted within the band of soft coral adjacent to the coast of north-east Lamma, with isolated areas of deposition of between 1.0 and 2.0 kg/m^2/tide for the wet season spring tide.

5.25 A comparison of the extent and concentration of total sediment deposition (metres) with the distribution of corals (Figure 5.1) demonstrates a potential impact from dredging associated with WSC Pit 3 for both the dry (Figure 5.3) and wet (Figure 5.4) seasons, where the greatest impact is predicted for the dry season. Total accumulation of sediments adjacent to the west coast of Hong Kong Island toward Ap Lei Chau, will be in the order of 0.3 to 0.4 m with isolated areas of deposition of greater than 0.4 m over a six month period. Towards Ap Lei Chau total sediment deposition decreases to between 0.1 to 0.3 m. During the wet season, the accumulated sediment within the soft coral range will be lower reaching a maximum of 0.2 to 0.25 m over a six month period. For both seasonal periods a small area of accumulated sediment of between 0.1 and 0.2 m is predicted adjacent to the north coast of Lamma Island (Pat Kok) and Luk Chau, where a higher density of corals has been indicated.

5.26 A high percentage of the corals at the threatened sites shown on Figure 5.2 have been identified as gorgonian sea fans and sea whips. These corals have flexible skeletons which move in response to water currents and act as a protective mechanism against the deleterious effects of sediment deposition on the surface of the coral.

5.27 Of the areas in the East Lamma Channel which are predicted to experience high rates of sediment deposition only the coral range on the northern coastline of Lamma Island (Pat Kok) and Luk Chau have dense populations of gorgonian corals between -10 and -16 mPD. Based on the growth form of these coral species and the fact that approximately 50% of the corals were found growing from vertical or sub-vertical substrate these corals would not be susceptible to sediment accumulation. As the total deposition is estimated to be less than 0.2 m in the areas concerned, it is also considered that the remainder of these organisms growing on the lower lying seabed would not be at risk of complete burial even if continuous deposition of sediment occur as predicted. The corals in this area are considered to have a medium conservation value (Ref 5.6). Although of high risk of mortality from deposition, the corals in the range adjacent to the west of Hong Kong Island are of low density and low conservation value. It is likely that much of the coral community in this area has already been damaged or destroyed as a result of the amount of shipping and other activities occurring within the East Lamma Channel. Soft coral colonies located in more open and faster flowing waters are more likely to survive due to the flexibility of soft corals and the cleansing action of the faster tidal currents. The actual degree of impact is dependent on the resuspension and redistribution of sediments caused by storm events throughout the duration of works.

5.28 A comparison of the single tide deposition rates associated with the WSC Pit 3 dredging activity and that associated with the East of Lamma Channel MBA indicates that the critical tide for cumulative impacts will be the wet season spring tide. For sediment deposition associated with the East of Lamma Channel dredging activity, deposition rates are highest along the west coast of Hong Kong Island towards Ap Lei Chau, reaching up to 1.0 kg/m^2/tide with isolated areas of between 1.0 and 2.0 kg/m^2/tide. It therefore appears from the respective modelling predictions that the impact of deposited sediment during the wet season spring tide for the two dredging activities are similar. Cumulative impacts are considered likely to increase the risk of mortality of the soft coral community along the north-eastern coastline of Lamma Island.

5.29 Significant impacts on the hard coral community located on the east of Lamma Island (south of Wong Chuk Kok) are considered unlikely due to their remote location from the boundary of WSC Pit 3. It is more probable that the hard coral community will be directly affected by dredging associated with the East of Lamma Channel Marine Borrow Area.

5.30 No toxicological impacts on the benthic fauna are envisaged on the premise that surface sediment taken from WSC Pit 3 and analysed, as part of this study, for heavy metals do not show any significant contamination according to EPD criteria.

Existing Fisheries and Mariculture Zones

5.31 The East Lamma Channel EA (Ref 5.3) reported that 250 fishing vessels are estimated to operate in East Lamma waters producing an annual catch of 540 tonnes of fish valued at HK$ 6.6 million. It is unlikely that these vessels will operate in the WSC Pit 3 area as fishing is prohibited in the fairway.

5.32 A marine fishery baseline survey was conducted for the Lamma Dredging Audit Baseline Survey (Ref 5.2), to determine species diversity and abundance for demersal finfish and shellfish in East Lamma Channel. The fish catch was dominated by gobies, sole and cardinal fish which contrasted with an earlier survey conducted in the mid-1970's where the catch was dominated by croaker, sole and cardinal fish, with bream caught during certain seasons. In the recent survey invertebrates dominated the catch both in weight and number, whereas in the earlier survey invertebrates were generally insignificant. The change in community composition and species abundance in the East Lamma Channel may be due to many factors including an increased intensity of fishing and influences from marine pollution. Whilst it is difficult to extrapolate from the survey findings to the WSC Pit 3 area, it is likely that similar alterations to the marine fisheries have occurred.

5.33 There are two gazetted MCZs along the eastern coastline of Lamma Island (see Figure 5.2) i.e. Lo Tik Wan and Sok Kwu Wan. The MCZs are respectively located approximately 5 km and 7.7 km distant from the boundary of WSC Pit3. Annual income generated from the two zones is approximately HK$ 15 million and HK$ 14.7 million respectively (AFD 1990, 1992 statistics). Four main fish types are farmed in the MCZs (Ref 5.3) including:

- Grouper (Aerolated grouper, Green grouper and other species);
- Purple Amberjack (Yellow tail);
- Russell's Snapper; and
- Gold-lined Sea Bream .

5.34 A small, ungazetted mariculture area is also present at Yung Shue Wan. Fry collection areas for mariculture are located at Yung Shue Wan and Luk Chau Wan on the north west and north east coast of Lamma respectively (Figure 5.2).

Potential Fisheries and Mariculture Impacts

5.35 Loss of seabed habitat from dredging operations associated with WSC Pit 3 will result in the avoidance of the area by adult fish species which are relatively mobile and able to quickly locate to a more congenial environment. The main direct impact of dredging activity will be the loss of feeding grounds for fish species dependent on the benthic fauna, but this can be expected to be limited in extent. The duration of this impact is dependent on the recolonization of the borrow area following the cessation of dredging, whereby backfilling of WSC Pit 3, as recommended in Section 5.16, will result in an enhanced rate of recolonization.

5.36 Commercial fishing activity in the vicinity of WSC Pit 3 will be affected for the duration of the Works, due to restricted access because of the presence of dredging vessels and the aversion of fish species to the area affected by elevated suspended sediment concentrations. The rate of recolonization of the seabed following completion of the Works may also influence the available fish yields in the area to a minor extent as fish feeding and breeding within WSC Pit 3 will be affected..

5.37 Suspended sediments in the water column will have variable effects on the commercial fish and invertebrate population depending on a host of species-specific and environmental factors, as discussed in paragraph 5.17. Vulnerability of fisheries will be greater with respect to Fry CollectionAreas due to the greater sensitivity of juveniles to high suspended sediment concentrations compared to adult fish (Ref. 5.5).

5.38 MCZs are potentially more vulnerable to sediment impacts than open water fisheries as fish populations are captive, and therefore more readily exposed to adverse effects associated with an increased suspended solid concentration. Maturation success of the fish types in the MCZs is dependent on water quality and the prevalence of disease. Fish are known to have a wide range of tolerance to sediment concentrations, where high concentrations may result in direct fish kills due to gill clogging, and lower concentrations may enhance susceptibility to disease. Fish may also be susceptible to the eutrophication of water as a result of sediment disturbance, either directly or indirectly via the proliferation of phytoplankton which can reduce dissolved oxygen levels and produce biochemical toxins.

5.39 Fish species associated with coral tend to be territorial and any sedimentation impacts on coral will also affect dependent fish species by depriving them of food and shelter. Certain fish species are also dependent on visual cues for mating and territorial behaviour and enhanced turbidity may eventually reduce diversity and abundance of fish (Ref 5.5).

5.40 Further evaluation of sedimentation impacts on fisheries and MCZs has been based on the sediment plume modelling results presented in Chapter 4, together with an estimate of predicted deposition rates. The results of EPDs routine monitoring of suspended solids for the monitoring stations closest to the FCZs at Lo Tik Wan and Sok Kwu Wan are summarised in Table 4.3a for the 5-year period 1989 to 1994. Comparing the extent and concentration of sediment plumes with the location of MCZs, it can be demonstrated that sediment concentration under the worst case scenario at the closest MCZ, Lo Tik Wan, will be in the range of 1 to 10 ppm above ambient (7 ppm). Therefore, the maximum concentration of 17 ppm in the vicinity of Lo Tik Wan is well within the recommended guideline of 80 mg/l for the protection of MCZs. Sediment deposition rates in the vicinity of Lo Tik Wan MCZ can be evaluated from Figure 5.3, where it can be seen that a total deposition of between 5 and 20 cm may be expected over the dredging period. Again, the actual accumulation rate is dependent on the resuspension and redistribution of sediments during storm events, and deposited sediments are unlikely to have adverse effects on the MCZ as fish cages are suspended above the seabed.

5.41 Again, no toxicological impacts on the benthic fauna are envisaged on the premise that surface sediment taken from WSC Pit 3 and analysed for heavy metals do not show any significant contamination according to EPD criteria.

References

Ref 5.1 Binnie Consultants Ltd: Fill Management Study - Phase IV. Investigation and Development of Marine Borrow Areas. South Cheung Chau and Sulphur Channel Seabed Ecology Pilot Survey by Grab Sample. Draft Report. GEO, Civil Engineering Department, July 1994.

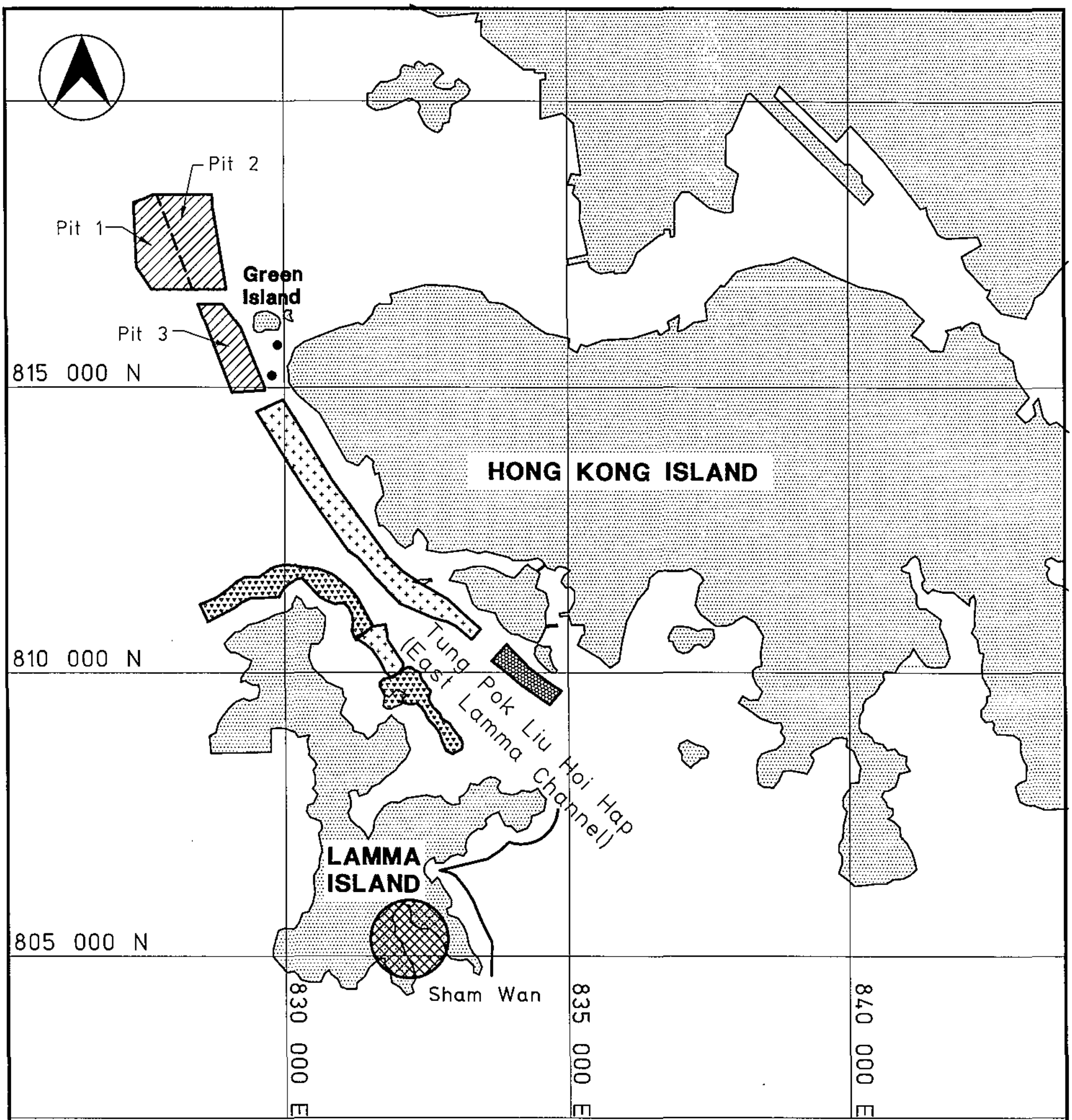
Ref 5.2 Binnie Consultants Ltd: Fill Management Study - Phase IV. Lamma Dredging Audit Baseline Survey Draft Final Baseline Report. GEO, Civil Engineering Department, August 1994.

Ref 5.3 Binnie Consultants Ltd: Fill Management Study - Phase II. East Lamma Channel Borrow Area Scoped Environmental Assessment Final Report. GEO, Civil Engineering Department, Jan 1993.

Ref 5.4 Scott Wilson Kirkpatrick: Green Island Reclamation (Part) Public Dump. Draft Final Report (EIA). Civil Engineering Department, September 1994.

Ref 5.5 G. Hodgson. Environmental Effects of Dredging In Hong Kong. In the Proceedings of Geotechnics and the Environment Conference, HKIE Geotechnical and Environmental Division, Hong Kong, September 1993.

Ref 5.6 Binnie Consultants Ltd: Fill Management Study - Phase IV. Investigation and Development of Marine Borrow Areas, Lamma Channel Underwater Ecological Survey Report. GEO, Civil Engineering Department, December 1994.



Scale = 1 : 100 000

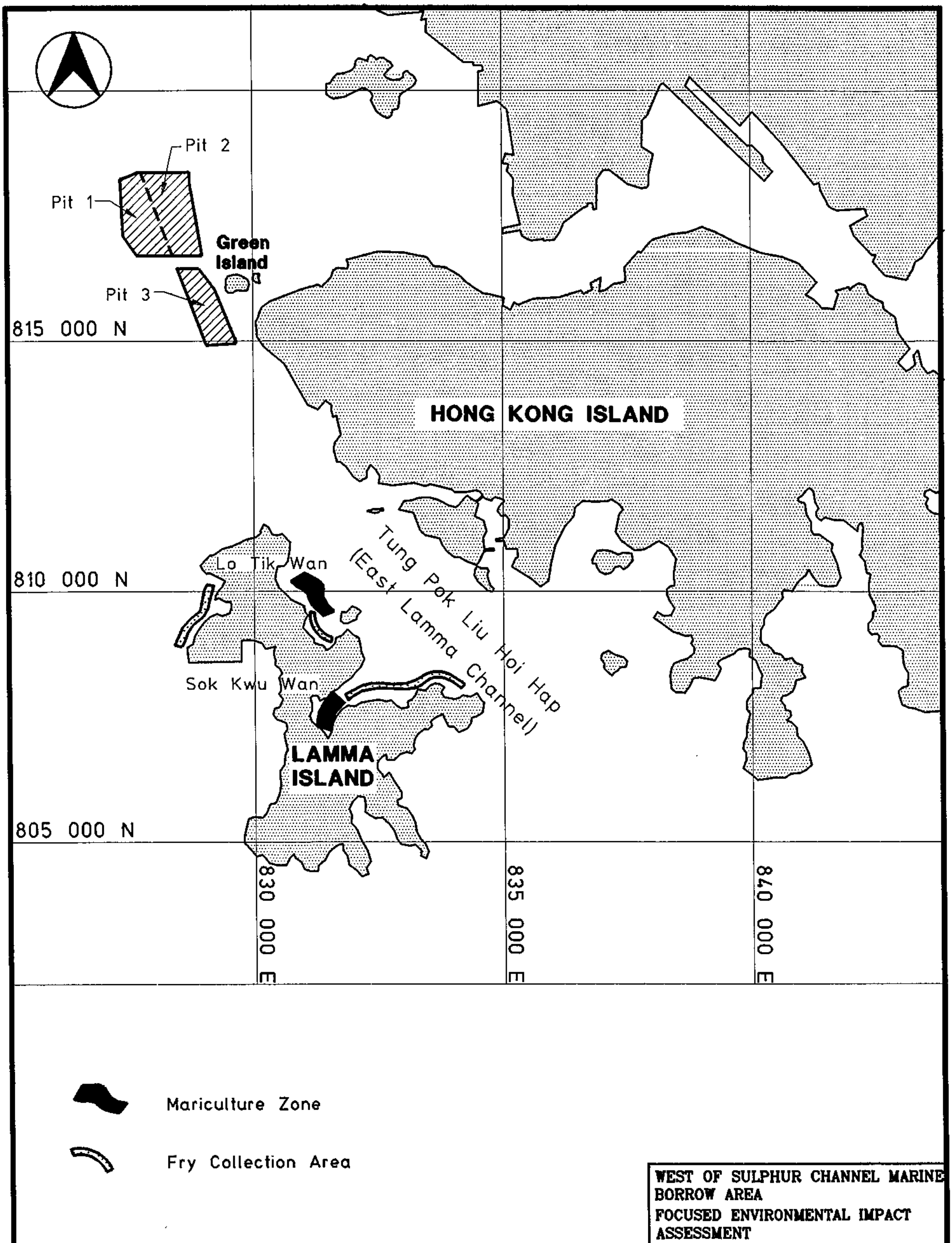
- Benthic Survey Sites, Sulphur Channel (Ref 5.1)
- Proposed Marine Reserve including South Lamma SSSI

Soft Coral Distribution (Ref. 5.6):

- high percentage cover
- medium percentage cover
- low percentage cover

Distribution of Hard Corals (Ref 5.3)

WEST OF SULPHUR CHANNEL MARINE BORROW AREA FOCUSED ENVIRONMENTAL IMPACT ASSESSMENT FINAL REPORT	
Figure No.	5.1
Marine Benthic Survey Monitoring Locations, Marine Reserve and Coral Distribution	

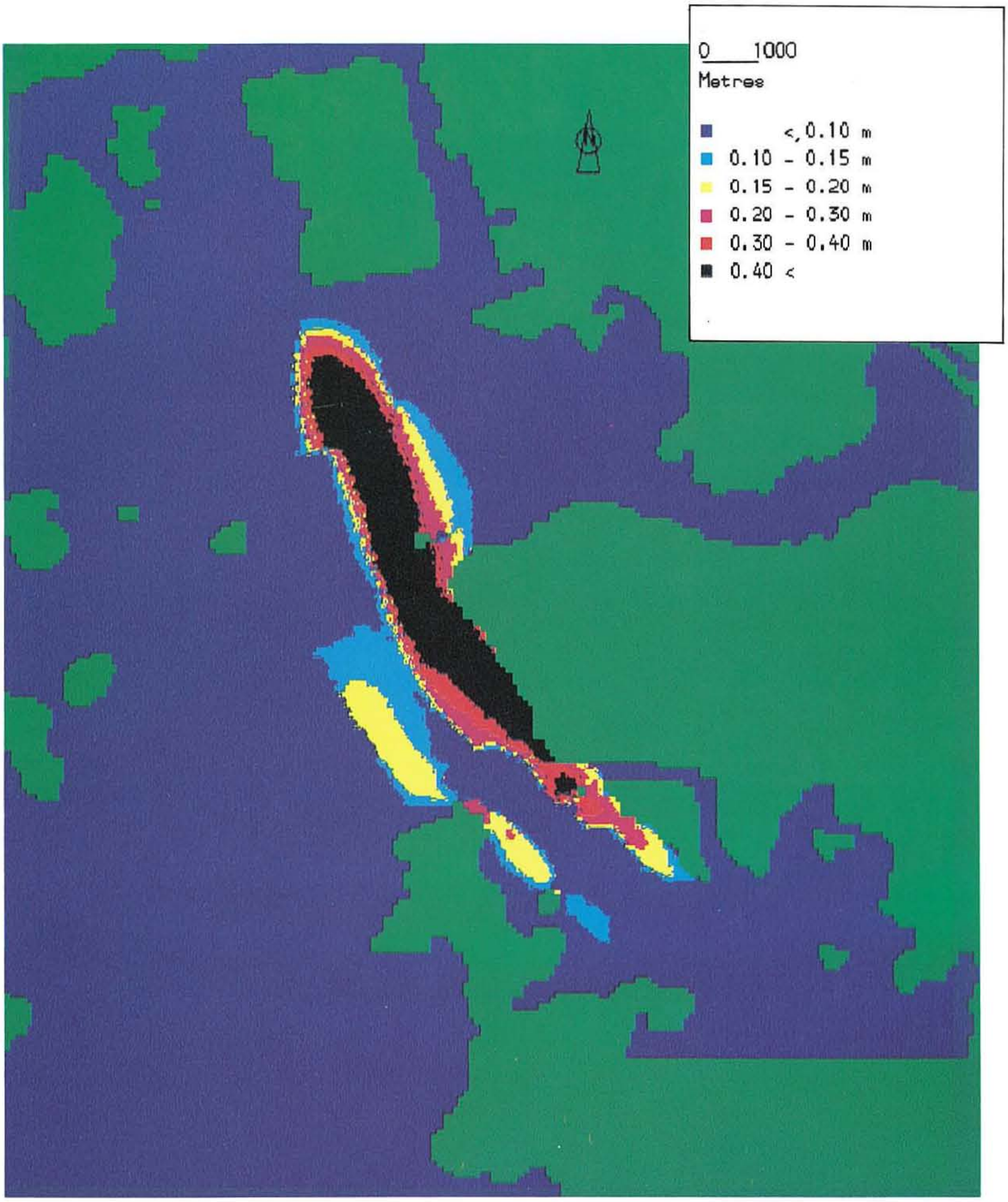


WEST OF SULPHUR CHANNEL MARINE BORROW AREA
FOCUSED ENVIRONMENTAL IMPACT ASSESSMENT
FINAL REPORT

Figure No. 5.2

Locations of Mariculture Zones, and Fry Collection Areas

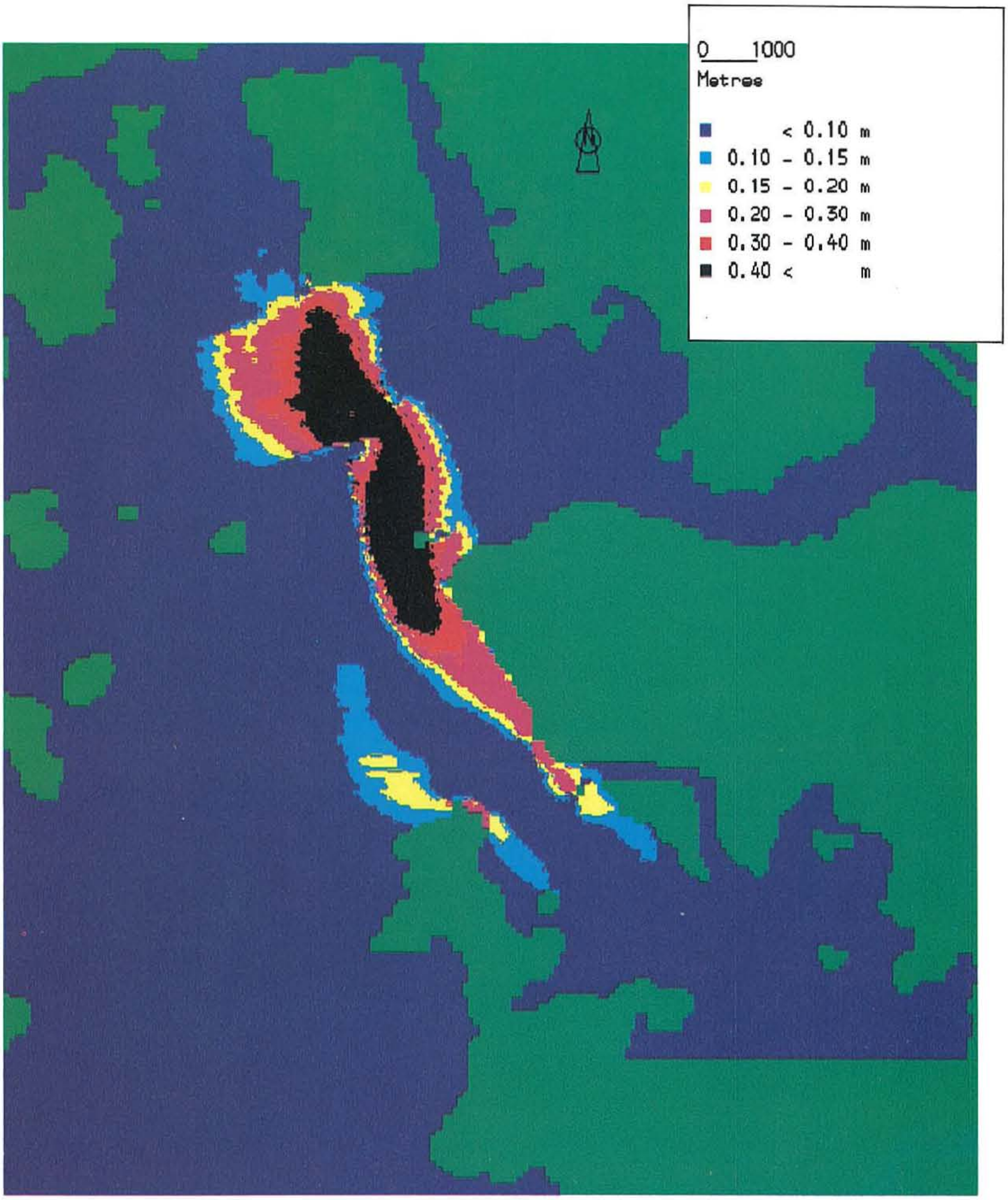
Scale = 1 : 100 000



WEST OF SULPHUR CHANNEL MARINE BORROW AREA
FOCUSED ENVIRONMENTAL IMPACT ASSESSMENT
FINAL REPORT

Figure No.	5.3

Dry Season: Net Mud Deposits over 6 Months



WEST OF SULPHUR CHANNEL MARINE BORROW AREA
FOCUSED ENVIRONMENTAL IMPACT ASSESSMENT
FINAL REPORT

Figure No.	5.4

Wet Season: Net Mud Deposits over 6 Months

6. AIR QUALITY

Introduction

6.1 The chapter details the environmental standards and guidelines for air quality in Hong Kong and examines the meteorological and air quality data measured within the vicinity of Green Island and Kennedy Town. In addition, the air quality impacts arising from the dredging in the West of Sulphur Channel are assessed.

Environmental Standards & Guidelines

6.2 Legislative controls relating to the emission of pollutants are defined under the Air Pollution Control Ordinance as Air Quality Objectives (AQOs) which specify limits on ambient levels of seven common air pollutants. The Air Quality Objectives are reproduced in Table 6.1.

Table 6.1 Hong Kong Air Quality Objectives

Pollutant	Average Time				
	1 Hour	8 Hour	24 Hour	3 Months	1 Year
Sulphur Dioxide	800	-	350	-	80
Total Suspended Particulates	-	-	260	-	80
Respirable Suspended Particulates*	-	-	180	-	55
Nitrogen Dioxide	300	-	150	-	80
Carbon Monoxide	30000	10000	-	-	-
Photochemical Oxidants (as ozone)	240	-	-	-	-
Lead	-	-	-	1.5	-

Nb: All concentrations in micrograms per cubic metre ($\mu g/m^3$), measured at 298°K (25°C) and 101.325kPa(one atmosphere).
1 hour concentrations not to be exceeded more than three times per year.
8 and 24 hour concentrations not to be exceeded more than once per year.
3 month and 1 year concentrations are arithmetic means.
** Respirable suspended particulates (RSP) means suspended particles in air with a nominal aerodynamic diameter of 10 microns (μm) or less.*

Background Information and Monitoring Data

Meteorology

6.3 This section reviews the general climate of Hong Kong and the prevailing meteorological conditions in the Kennedy Town and Green Island area.

6.4 The typical wind regime of Hong Kong is dominated by the northeast monsoon in winter and the southwest monsoon in summer. Wind regimes are further complicated by the topography of Hong Kong. Surface winds may vary in speed and direction over quite short distances. In addition to the normal variations in wind speed and direction, the vertical distortion caused by roughness effects may also be modified by the diurnal thermal effects of daytime anabatic winds enhanced by sea-breeze effects, and the night time katabatic winds enhanced by land breezes.

6.5 Meteorological data for the Kennedy Town locality is limited. Green Island has an anemometer measuring wind data. Figure 6.1 shows the annual wind rose for Green Island for 1974 - 1983 and for January 1990 to December 1992 (Ref. 6.1). Prevailing winds are east - north east, and south. The wind regime is dominated by the northeast monsoon in winter and the south west monsoon in summer. The sensitive receivers identified in Table 3.2 would be affected by westerly winds (225° - 315°). On average these occur approximately 7% of the time (see Figure 6.1).

Air Quality

6.6 A network of EPD fixed monitoring stations measuring ambient air quality has been established systematically over the past decade in Hong Kong. In 1992, there were 11 stations in the network each measuring continuously gaseous and particulate pollutants and meteorological parameters. At a number of locations the level of total suspended particulates (TSP) concentrations exceeded the AQO. In addition, breaches of the AQO for nitrogen (NO_2) and respirable suspended particulates (RSP) occurred at several locations in 1992.

6.7 The nearest EPD continuous air monitoring station to the Green Island/Kennedy Town area is Central and Western at Upper Level Police Station between High Street and Hospital Road. Air pollution levels are measured 18m above ground level. Table 6.2 shows the ambient air quality levels for Western and Central.

Table 6.2 Ambient Air Quality Levels for Western and Central ($\mu g/m^3$) 1986-1992

Sulphur dioxide (SO_2)

Year	50% ile*	98% ile*	Mean	Maximum 1-hour	Maximum 24-hour
1986	8	35	17	545	127
1987	10	67	15	269	75
1988	13	72	19	196	73
1989	9	66	16	236	77
1990	11	99	19	402	142
1991	13	75	18	409	62
1992	15	113	23	727	135

Nitrogen dioxide (NO_2)

Year	50% ile*	98% ile**	Mean	Maximum 1-hour	Maximum 24-hour
1986	54	208	67	743	280
1987	55	184	63	452	227
1988	26	102	32	782	235
1989	51	177	60	573	329
1990	47	120	50	218	152
1991	44	112	46	209	112
1992	47	119	50	206	115

Total suspended particulates (TSP)

1986	81	196	89		215
1987	85	184	90		187
1988	95	188	90		362
1989	81	174	84		192
1990	73	150	75		229
1991			75		200
1992*					153

Respirable suspended particulates (RSP)

1986	53	134	57		169
1987	68	162	68		172
1988	66	156	71		328
1989	48	126	53		144
1990	51	100	54		139
1991			56		131
1992*					142

Nb: * 50 percentile
** 98 percentile

6.8 The results in Table 6.3 show that the sulphur dioxide levels in the area remained within the AQOs between 1986 and 1992. The nitrogen dioxide situation, while improving over the period, showed a number of exceedences of the AQO for both the maximum 1-hour average and 24-hour average period. The suspended particulate results for both the total and respirable classes show a number of years where the yearly means were in excess of the AQO. The results show that the Green Island and Kennedy Town area suffers from poor air quality and any further emissions would be adding to an already impaired environment.

Potential Air Quality Impacts

6.9 The nearest sensitive receptors in relation to potential air quality impacts were given in Table 3.2 and Figure 3.1. The distance from the boundary of the closest receptor to WSC Pit 3 is over 1 km.

6.10 The only conceived impact on air quality is the emissions from trailing suction hopper dredgers (TSHDs) associated with the works. No dust emissions are expected from dredged material, as moisture content will always be great enough to prevent any dispersal of dry particulates.

6.11 The air pollutants emitted by the vessels may consist of:

- nitrogen dioxide;
- total suspended particulates (TSP);
- respirable suspended particulates (RSP); and
- sulphur dioxide

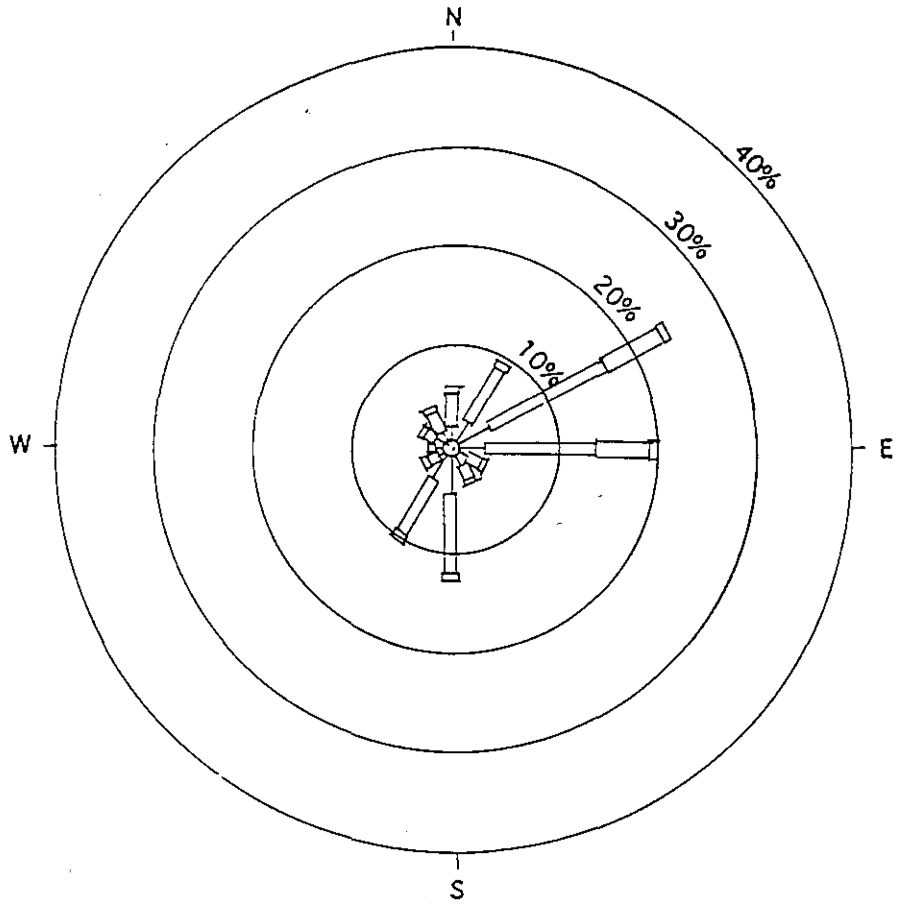
6.12 Nitrogen dioxide will be formed within the combustion chambers of the vessel's engine as nitrogen in the atmosphere is oxidized under the high pressures and temperatures present. Particulate matter will also be emitted in the exhaust of the vessel's engines as a consequence of the incomplete combustion of the diesel fuel. A limited amount of sulphur dioxide may also be emitted in the vessel's exhaust from sulphur present in the diesel fuel.

6.13 It has been estimated that the number of dredgers necessary to complete the marine borrowing for the CT9 reclamation is an average of four 8000cum TSHDs for a period of two years and two 8000cum TSHDs for a period of more than a year. However, in spite of the number of dredgers required for the whole of the CT9 reclamation, no more than two large dredgers will be permitted to dredge at the same time in two of the three pits (i.e. STY Pits 1 and 2 and WSC Pit 3).

6.14 It is unlikely that even in the most adverse meteorological conditions that emissions from two dredgers in the marine borrowing area would have a measurable effect on any of the sensitive receivers. As such, no mitigation measures are required and it is envisaged that no significant cumulative air quality impacts would be associated with the works.

Reference

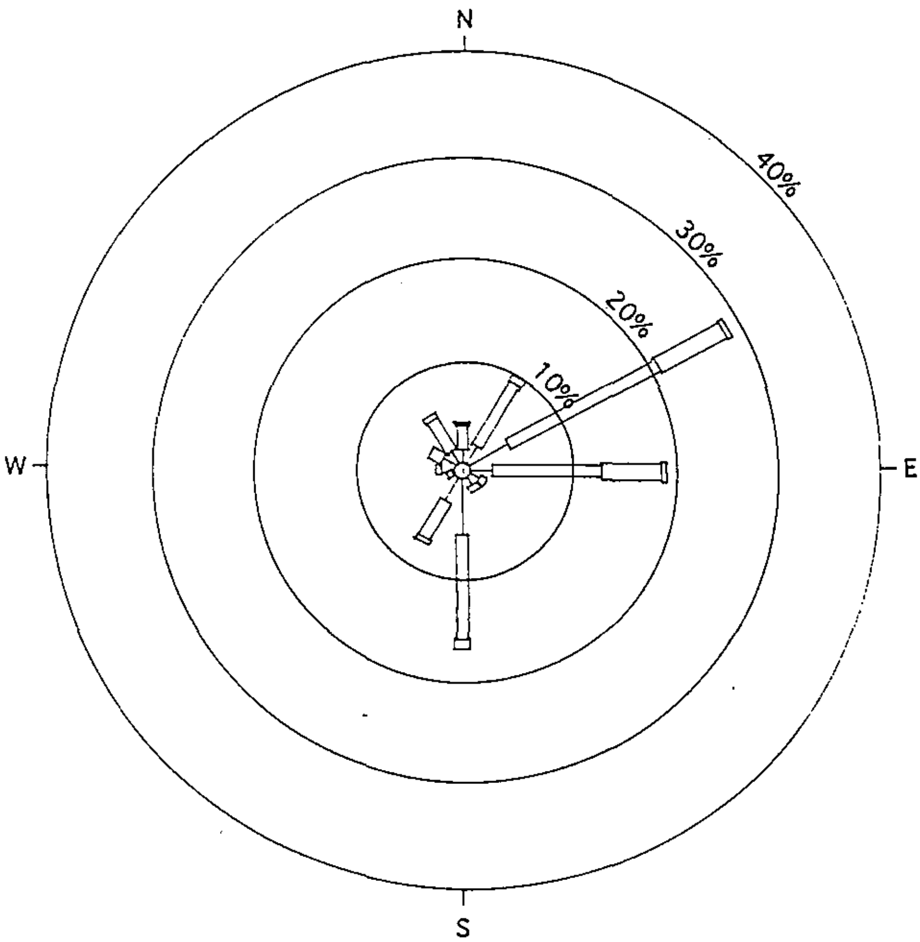
Ref 6.1 Royal Observatory (1993). Meteorological data for Green Island, 1993.



1974-1983

ANNUAL

NO. OF OBSERVATIONS	-	82756	
NO. OF VARIABLE	-	177	(.2%)
NO. OF CALM	-	1115	(1.3%)

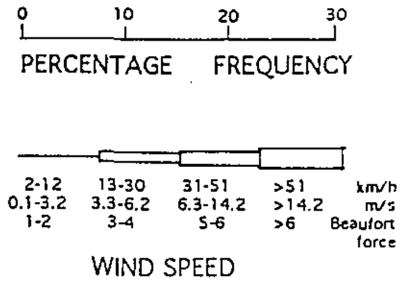


JAN 1990 - DEC 1992

ANNUAL

NO. OF OBSERVATIONS	-	22275	
NO. OF VARIABLE WINDS	-	1	(.0%)
NO. OF CALM WINDS	-	0	(.0%)

LEGEND



WEST OF SULPHUR CHANNEL MARINE BORROW AREA
FOCUSED ENVIRONMENTAL IMPACT ASSESSMENT

Figure No.	6.1

ANNUAL WIND ROSES FOR GREEN ISLAND 1974-1983 AND JAN 1990-DEC 1992

7. NOISE

Introduction

7.1 This chapter details the environmental standards and guidelines for noise control in Hong Kong and examines the available baseline noise level data within the vicinity of Green Island and Kennedy Town. In addition, the noise impacts from the dredging activities associated with WSC Pit 3 are assessed.

Environmental Standards and Guidelines

7.2 The Noise Control Ordinance (NCO) provides a framework on which specific Regulations, Guidelines and Technical Memoranda have been produced. Of particular relevance to this study are the following documents:

- Technical Memorandum on Noise from Construction Work other than Percussive Piling (Ref 7.1; and
- The Hong Kong Planning and Standards Guidelines. Environmental Guidelines for Planning in Hong Kong (Ref 7.2).

7.3 The objective of this guidance and legislation is to prevent noise problems arising, through careful planning, and to provide statutory control over activities which generate noise.

7.4 The NCO gives statutory provision on which noise from specific sources may be controlled in the Technical Memorandum on Noise from Construction Work other than Percussive Piling. Giving the noise sensitive receivers (NSRs) in the vicinity of WSC Pit 3 the highest sensitivity rating, the acceptable noise levels (ANLs) are shown in Table 7.1. Under the existing provisions there is no control of noise from powered mechanical equipment between 0700 and 1900 hours on normal weekdays. However, it is normal practice to use the target guideline of 75 dB (A) Leq 30 mins at the facades of noise sensitive receivers (NSRs).

7.5 As it is intended that the works are conducted on a 24 hour continuous basis (see Section 2.18), the contractor working in the borrow area will be required to obtain a Construction Noise Permit (CNP) under the NCO for working at night time hours of the weekdays and anytime on general holidays (including Sundays).

Table 7.1 Acceptable Noise Levels for NSRs of the Highest Sensitivity Rating

Time Period	ANL (dB(A)) Area Sensitivity Rating: A
All days during the evening (1900 to 2300 hours), and general holidays (including Sundays) during the day-time and the evening (0700 to 2300 hours).	60
All days during the night-time (2300 to 0700 hours)	45

Background Information & Monitoring Data

7.6 This section reviews the available information relating to the prevailing background noise level in the Green Island and Kennedy Town area. Existing information is available for the Green Island Reclamation (Part) Reclamation Study (Ref. 7.3) and is summarised in Table 7.2.

Table 7.2 Background Noise Levels in the Green Island and Kennedy Town Areas.

Location	Noise Levels		Major Noise Sources
	Noise Descriptor*	Noise Level dB (A)	
Singapore International School (830 775E 815 825N)	L_{eq} (30 min)	69.3	Road and marine traffic/ abattoir/ wholesale market.
Kennedy Town Jockey Club Clinic (830 815E 815 885N)	L_{eq} (30 min)	73.5	Road and marine traffic/ abattoir/ wholesale market.
Centenary Mansions (831 100E 815 885N)	L_{eq} (30 min)	74.0	Road and marine traffic/ abattoir/ wholesale market.
Vicinity of Mount Davis	L_{eq} (15 min) / L_{90} (15 min)	67.0 to 75.3 / 57.2 to 68.7	Road traffic/ Road traffic
Serene Court (roof) (830 475E 815 825N)	L_{90} (1 hour)	54.0 to 60.5	Water front activities/ helicopters
51 Kennedy Town Praya (831 025E 816 075N)	L_{90} (1 hour)	61.8 to 65.8	Water front activities / construction activity / air conditioning / traffic / market activities / helicopters
Lung Hong Apartments (roof) (831 180E 815 930N)	L_{90} (1 hour)	63.5 to 65.5	Water front activities/ construction activity/ air conditioning/ traffic/ helicopters

Nb: Noise descriptors are dependent on those used under various monitoring programmes.

7.7 Existing background noise level data for the Kennedy Town area are typical of those of an urban Hong Kong environment. Sensitive receivers identified in Table 3.2 are likely have noise levels which are representative of NSRs in the vicinity of Mount Davis (see Table 7.2) where background noise levels are dominated by road traffic noise.

Potential Noise Impacts

7.8 The impact of the works on noise levels at NSRs is dependent on the prevailing background noise level and the proximity of the NSRs to the source of noise. The NSRs in Table 3.2 are over 1km distance from the boundary of WSC Pit 3, where the closest NSR is a group of low-rise Police Buildings.

7.9 Noise emission sources from dredging vessels may include diesel motors and metallic 'jolt and shock' noise. TSHDs, which are to be used for the works (see Chapter 2) are considered to be one of the quieter types of dredger as the pumps and other equipment are located in the hull.

7.10 Assuming that only a single dredger is located in WSC Pit 3 at any one time (see Section 2.2), with a sound power level of (L_{WA}) of 102 dB(A) (Ref 7.3), then the noise levels (L_{PA}) at the Police Buildings (E 830 144 N 815 142) can be calculated as follows:

$$L_{PA} = L_{WA} - 20 \log d - 8 \text{ dB (A)}$$

Where d = distance to facade of NSR i.e. 1,050 m (i.e. dredger located on the boundary of WSC Pit 3 closest to NSR).

7.11 This gives a noise level of 37 dB (A) accounting for a noise facade effect of + 3 dB (A). An additional TSHD working in one of STY Pits 1 or 2 would not contribute significantly to this noise level. Hence the night time construction ANL of 45 db (A) is achieved. It is also evident from Table 7.2, that background noise levels in the vicinity of identified sensitive receivers may already exceed the night time noise standard, although this cannot be proven without specific noise monitoring. In reality, further attenuation of the noise level associated with the works is likely due to the intervening topography of the foreshore, where the Police Buildings are located 40 m above Principle Datum.

7.12 As the noise level at the closest NSR is lower than the ANL by a margin of more than 5 dB(A), then the Contractor should readily qualify for a CNP.

7.13 The refugee camp on Green Island , located at a distance of 650 m from the boundary of WSC Pit 3, will not be impacted by operational noise from the TSHD as the camp is shielded by the intervening topography of the island, where no direct line of site exists. Noise levels at the refugee camp are likely to be affected by existing shipping and ferry movements in the vicinity and shore based noise sources on Hong Kong Island.

7.14 Based on the above assessment, it is not envisaged that the works will result in any significant exceedance of relevant noise criteria and therefore associated cumulative impacts on prevailing background noise levels are not expected. No special mitigation measures are required beyond good working practices which should include ensuring that all powered mechanical equipment is adequately maintained and that dredging vessels do not operate beyond the eastern boundary of WSC Pit 3, particularly at night.

References

Ref 7.1 Technical Memorandum on Noise from Construction Work other than Percussive Piling. Environmental Protection Department, Hong Kong Government, June 1990.

Ref 7.2 The Hong Kong Planning and Standards Guidelines. Environmental Guidelines for Planning in Hong Kong. Hong Kong Government, 1991.

Ref 7.3 Binnie Consultants Ltd: Fill Management Study - Phase II. East Lamma Channel Borrow Area Scoped Environmental Assessment Final Report. GEO, Civil Engineering Department, January 1993.

8. MONITORING AND AUDIT REQUIREMENTS

Introduction

8.1 The monitoring and audit requirements for the West of Sulphur Channel Marine Borrow Area are detailed in a separate Environmental Monitoring & Audit (EM&A) Manual (Ref 8.1) which acts as the reference document for all monitoring and audit requirements.

8.2 The monitoring and audit requirements should be of a scale and nature that will enable the Contractor to discharge his legal and contractual obligations to ensure compliance with relevant Hong Kong environmental standards whilst, at the same time, will allow the Contractor to maintain sufficient flexibility in the manner in which he undertakes the works.

8.3 The Contractor should be required to comply with and observe all ordinances and associated Technical Memoranda, bye laws, regulations and rules which for the time being, are in force in Hong Kong and which govern the control of any form of pollution including air, noise, water and waste pollution and the protection of the environment. Failure to comply with legal environmental standards during the proposed works will render the Contractor liable to prosecution.

8.4 Monitoring will be necessary to confirm quantitative predictions of environmental impacts and the efficacy of mitigation measures proposed in this Focused EIA report, and will provide data at an early stage which will warn of any reduction in the environmental integrity of the works. The timely implementation of Action Plans in the event of a breach of Trigger, Action and Target (TAT) limits, as indicated in the EM&A Manual, will allow the control of any detected deterioration in the environment and thereby avoid the manifestation of unacceptable impacts.

Objectives and Responsibilities

8.5 The Contractor should be responsible for:

- implementing environmental controls and mitigation measures as specified in the EM&A Manual, and ensuring that appropriate licenses in relation to dredging of fill material and disposal of marine muds are obtained from the relevant Authority; and

- adhering to any reasonable directions given by the Employer's Representative with respect to maintenance of plant and equipment and the implementation of Action Plans in response to a breach of TAT limits specified in the EM&A Manual.

8.6 The Employer's Representative (ER) should be responsible for:

- making provision for a programme of environmental monitoring and auditing in relation to the dredging of material and the disposal of marine muds during the operational and post-operational period of works, in accordance to the requirements of the EM&A Manual;

- ensuring that control and sample stations are suitably located to provide data of sufficient quality to detect any statistically significant effect of the works in relation to TAT limits specified in the EM&A Manual;

- ensuring that environmental reports and data gathered from the monitoring programme is sufficiently interpreted with respect to TAT levels, and are completed and presented to the Employer and EPD in an efficient manner; and

- ensuring that directions given for environmental protection by the Employer and EPD are implemented by the Contractor.

8.7 To achieve the monitoring and audit requirements the ER should arrange two teams i.e.:

- The Monitoring Team
- The Environmental Management & Audit Team

The Monitoring Team

8.8 The Monitoring Team should be responsible for the collection and analysis of samples under the monitoring programme, as specified in the EM&A Manual. Persons undertaking the monitoring work should be suitably qualified, and the sampling, analytical and reporting procedures should be consistent with Hong Kong Laboratory Accreditation Standards (HOKLAS) or similar.

8.9 The environmental monitoring programme should have the following objectives:

- to collect all environmental data necessary to determine any potential impacts identified in previous chapters of this report;
- to ensure continuity and consistency with monitoring surveys undertaken prior to the commencement of the works;
- to collect sufficient data to verify the effectiveness of monitoring stations in determining potentially significant impacts in the vicinity of the works;
- to collect sufficient data to determine the effectiveness of any remedial measures specified in this Focused EIA report to reduce residual (net) environmental impacts to acceptable levels;
- to allow data and information to be retrieved and interpreted throughout the operation of the works to verify compliance with appropriate environmental standards and pollution control requirements specified in this Focused EIA report. Data must be of sufficient quality and quantity to allow the statistical variation to be determined both within and between sampling periods and monitoring stations; and
- to establish a database of monitoring information throughout the control, operational and post-operational monitoring period of the works.

The Environmental Management & Audit Team

8.10 The Environmental Management & Audit Team should be responsible for ensuring that the works comply with appropriate environmental standards and pollution control requirements specified in this Focused EIA report. The roles of monitoring and audit should be distinct to ensure an independent evaluation and reporting procedure of the Contractor's environmental performance.

8.11 The Environmental Management & Audit Team should be independent of the Contractor and the Monitoring Team, and should report to the ER regarding the Contractor's environmental performance and the requirements for the implementation of Action Plans specified in this Manual. The key responsibilities of the team should be as follows:

- to advise the ER during periodic inspections of the works to check working/management practices critical to the environmental integrity and acceptability of the site with respect to:
  - aqueous emissions
  - noise emissions
  - atmospheric emissions

- to check that sampling and analytical procedures used in the monitoring programme are consistent with the requirements specified in the EM&A Manual;

- to ascertain whether any extraneous activities to the works area and any disposal sites for marine muds, unrelated to the works operation, may have influenced the monitoring data;

- to evaluate changes in measured parameters to detect any deterioration in environmental conditions associated with the undertaking of the works;

- to specify the implementation of staged Action Plans based on predetermined TAT limits to avoid a further detected deterioration in a measured environmental parameter for the works area and any disposal sites for marine muds. Implementation of Action Plans may include the specification of an increased frequency of monitoring, revision to operational practices and the application of remedial measures;

- to ensure that Action Plans are properly implemented by the Contractor;

- to review actions taken in response to any complaints received from the general public and consider whether any alterations are required with respect to operation of the works. A clearly defined system should be established to respond promptly to public complaints;

- to review periodically the overall monitoring programme with respect to monitoring locations, frequency, parameters measured, analytical techniques and environmental controls and revise if necessary;

- to conduct review meetings with the Contractor, Monitoring Team, ER and EPD's Representative to consider environmental performance of the proposed works and to identify any improvements in working practices to avoid any exceedance of TAT levels. Such meetings should take place on a regular basis (i.e. fortnightly) with provision for more frequent meetings in the event of a breach of TAT levels; and

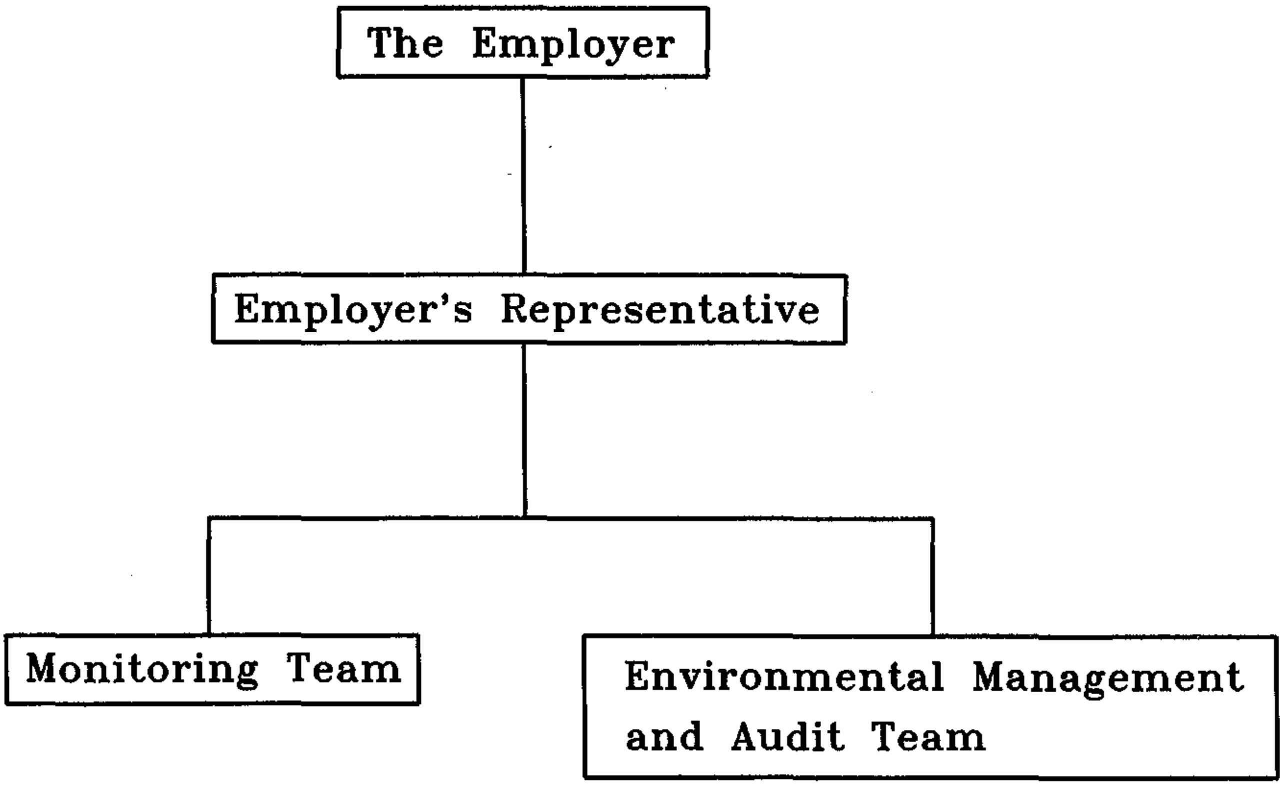
- to submit regular monthly audit reports on the monitoring programme consistent with the requirements specified in the EM&A Manual.

8.12 Specification of baseline and operational monitoring requirements, monitoring protocols, monitoring proforma, reporting procedures, TAT limits, Action Plans and control/mitigation measures are specified in the EM&A Manual. Audit reporting requirements are also given in the EM&A Manual.

8.13 Organisational structure for environmental monitoring and audit is outlined in Figure 8.1.

Reference

Ref 8.1 Scott Wilson Kirkpatrick. West of Sulphur Channel Marine Borrow Area Draft Environmental Monitoring and Audit Manual. Civil Engineering Department, September 1994.



WEST OF SULPHUR CHANNEL MARINE BORROW AREA
FOCUSED ENVIRONMENTAL IMPACT ASSESSMENT
FINAL REPORT

Figure No. 8.1

Organisational Structure for Environmental Monitoring and Audit Requirements

APPENDIX 1:

WSC Pit 3 Sediment Survey: Heavy Metal Analytical Results

GEOTEAM

WEST SULPHUR CHANNEL GRAB SAMPLING

REPORT

August 1994

Contract Number: GE/93/05
Works Order Number : GE/93/05.31

INTRODUCTION

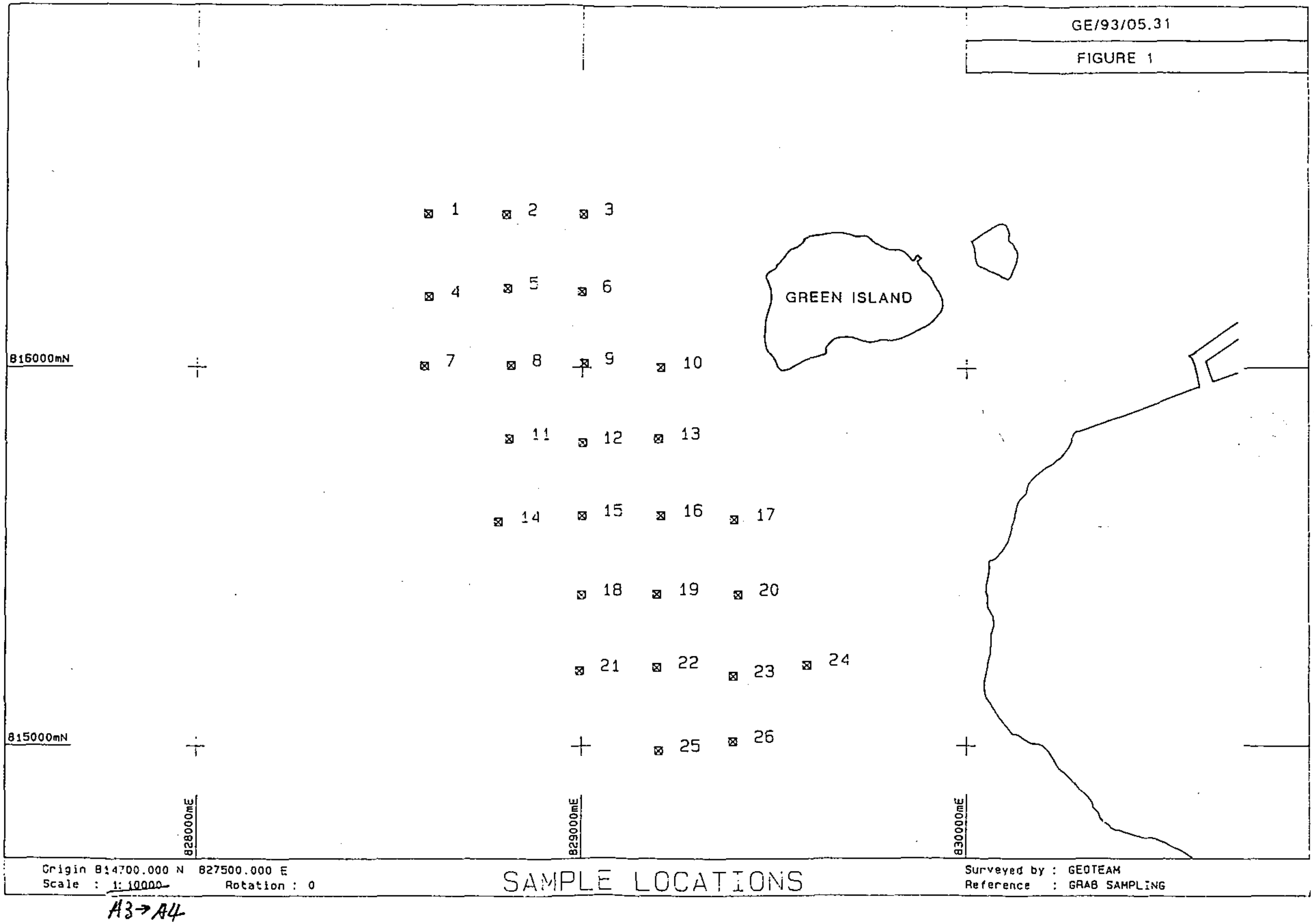
Grab sampling within the West Sulphur Channel was carried out by GEOTEAM (HK) Ltd for the Fill Management Division of the Geotechnical Engineering Office of the Hong Kong Government under Contract Number GE/93/05, Works Order Number GE/93/05.31.

The work was undertaken and completed on the 18th of August 1994, twenty six grab samples were acquired. as per the survey programme, as shown in Figure 1, Sample Location Plan.

Navigation was provided by Ashtech DGPS using a Trimble receiver and Differential Corrections provided by F.T. Sinclair from a base station located at Chek Lap Kok.

Water depths were obtained for each grab sample location using an Atlas Deso 20 echo-sounder.

All positions are given as Eastings and Northings on the Hong Kong (1980) local grid. All depths are referenced to metres below the Hong Kong Principal Datum (mbPD), using predicted tidal reductions supplied by the Royal Observatory for the 18th August 1994.


GE/93/05.31
FIGURE 1
GREEN ISLAND
816000mN
815000mN
828000mE
829000mE
830000mE
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
Origin 814700.000 N 827500.000 E
Scale : 1:10000
A3→A4
Rotation : 0
SAMPLE LOCATIONS
Surveyed by : GEOTEAM
Reference : GRAB SAMPLING

GEOTEAM

RESULTS

Location	Northing	Easting	Water Depth (mbPD).
1	816398	828801	21.5
2	816393	828595	22.7
3	816401	829003	21.6
4	816184	828603	21.2
5	816206	828805	24.0
6	816199	828999	24.1
7	816003	828592	19.8
8	816005	828814	25.0
9	816011	829005	25.8
10	816000	829207	26.0
11	815812	828811	24.5
12	815803	829001	26.3
13	815813	829203	26.9
14	815594	828784	21.7
15	815611	829002	26.9
16	815611	829210	27.5
17	815600	829400	24.7
18	815402	829001	26.1
19	815404	829200	28.1
20	815402	829411	26.2
21	815199	828996	24.9
22	815208	829200	28.5
23	815011	829397	29.0
24	814987	829205	25.4
25	815215	829589	28.7
26	815184	829398	29.8

Heavy Metal Analytical Results

Sample	Copper Content mg/kg	Cad-mium content mg/kg	Chrom-ium content mg/kg	Lead content mg/kg	Nickel content mg/kg	Zinc content mg/kg	Mercury content mg/kg
1	22	<0.2	33	33	16	77	0.10
2	22	<0.2	30	30	14	80	0.10
3	22	<0.2	26	29	12	78	0.12
4	21	<0.2	30	32	14	75	0.09
5	20	<0.2	32	33	15	78	0.08
6	32	<0.2	33	35	16	84	0.15
7	28	<0.2	32	34	15	72	0.11
8	22	<0.2	31	32	14	79	0.09
9	22	<0.2	31	30	15	79	0.09
10	37	<0.2	32	36	16	92	0.17
11	26	<0.2	31	33	15	81	0.14
12	26	<0.2	35	39	17	87	0.11
13	32	<0.2	36	40	17	94	0.12
14	25	<0.2	30	33	15	58	0.06
15	21	<0.2	30	32	14	74	0.09
16	32	<0.2	34	37	16	88	0.12
17	25	<0.2	30	29	15	74	0.15
18	28	<0.2	31	33	16	73	0.13
19	22	<0.2	31	33	15	79	0.09
20	30	<0.2	31	35	16	85	0.18
21	21	<0.2	31	33	16	79	0.08
22	27	<0.2	28	31	14	76	0.21
23	45	<0.2	41	46	20	110	0.18
24	31	<0.2	30	34	15	84	0.13
25	26	<0.2	29	32	14	77	0.11
26	34	<0.2	34	37	17	88	0.14

[illegible]