Hong Kong Government
Territory Development Department
NT North Development Office

Agreement No. CE 10 / 95

Tin Shui Wai Development Engineering Investigations for Development of Areas 3, 30 & 31 of the Development Zone and the Reserve Zone

ENVIRONMENTAL IMPACT ASSESSMENT

FINAL ASSESSMENT REPORT

(Volume 2 of 2)

FEBRUARY 1997

0018/C09/07.2

Binnie Consultants Limited

ENVIRONMENTAL IMPACT ASSESSMENT

FINAL ASSESSMENT REPORT

(Volume 2 of 2)

FEBRUARY 1997

0018/C09/07.2

Report Authorized For Issue By:	.... For and on Behalf of Binnie Consultants Limited

Binnie Consultants Limited
11/F New Town Tower
Pak Hok Ting Street
Shatin, New Territories
Hong Kong

Contents

List of Figures

List of Tables

List of Plates

Appendix A

Environmental Legislation and Planning Guidelines

A ENVIRONMENTAL LEGISLATION AND PLANNING GUIDELINES

Introduction

A.1 One of the Hong Kong Government's overall policy objectives on environmental planning, as outlined in the 1989 *White Paper on Pollution in Hong Kong*, is "to avoid creating new environmental problems by ensuring the consequences for the environment are properly taken into account in site selection, planning and design of all new developments".

A.2 This section highlights the relevant environmental legislation and guidelines which are currently applicable to the proposed project.

Hong Kong Planning Standards and Guidelines

A.3 The *Hong Kong Planning Standards and Guidelines (HKPSG) Chapter 9: Environment* provides guidance for including environmental considerations in the planning of both public and private developments. The environmental suitability of a site for a certain land use is governed by such factors as:

(i) natural environmental characteristics including topography, climate, hydrological and hydrographical characteristics, vegetation, wildlife and habitat, and soil conditions;

(ii) the nature, distribution and consequences of the residuals including aerial emissions, wastes, sewage or noise generated by land uses in the development area;

(iii) the capacity of the environment to receive additional developments; and

(iv) existing land uses.

A.4 The *HKPSG* specifies the Government's overall policy objective for environmental planning to be:

> "to seize opportunities for environmental improvement as they arise in the course of urban redevelopment"; and to ensure that,
>
> "adequate and suitably sited environmental facilities are provided to ensure proper handling and disposal of all wastes and waste water arising from proposed developments."

Conservation

A.5 *HKPSG Chapter 10: Conservation* states that the following four principles should be adopted for the practical pursuit of conservation in land use planning:

(i) retain significant landscapes and ecological attributes and heritage features as conservation zones;

(ii) restrict uses within conservation zones to those which sustain particular landscapes and ecological attributes and heritage features;

(iii) control adjoining use to minimise adverse impacts on conservation zones and optimise their conservation value; and

(iv) create, where possible, new conservation zones in compensation for areas of conservation value which are lost to development.

Items of value which merit conservation are identified in territorial, sub-regional and district planning exercises, special surveys undertaken by other departments or as the result of public views. However, plans which include conservation use have to be seen in a wider context and take into account the need to provide adequate space for development needs. The challenge is to combine these different uses into acceptable and realistic plans which take account of territorial growth and principles of sustainable development.

Protecting Natural Landscapes and Habitats

A.6 Natural landscapes and habitats may be gazetted as Country Parks or Special Areas (*Country Parks Ordinance* Cap 208), Restricted Areas (*Wild Animals Protection Ordinance* Cap 170), Water Gathering Grounds (*Waterworks Ordinance* Cap 102), conservation zones (*Town Planning Ordinance* Cap 131) or listed as Sites of Special Scientific Interest (SSSIs).

A.7 Country Parks and Special Areas are designated under the *Country Parks Ordinance* and managed by the Agriculture and Fisheries Department (AFD) on the advice of the Country Parks Board. At present there are 21 Country Parks (area 40, 833 ha) and 14 Special Areas (area 1,639 ha), 11 of which are within Country Parks. Country Parks are designated for the purposes of nature conservation, countryside recreation and education; Special Areas are areas of government land with special interest and importance by reason of their flora, fauna, geological, cultural or archaeological features. The Country Parks Authority has established criteria for determining whether or not a particular location is suitable for designation as a Country Park or Special Area. The criteria include landscape quality, recreation potential, conservation value, size, land status and the practicality of management.

A.8 The *Wild Animals Protection Ordinance* restricts access to designated areas of wildlife habitat. Restricted Areas under the Ordinance are implemented by the AFD although certain site management activities may be shared by others. Two Restricted Areas have been designated, the Mai Po Marshes and the Yim Tso Ha Egretry. In addition, the Ordinance protects local wildlife through both the prohibition of hunting territory-wide and the possession of scheduled protected wild animals or hunting appliances.

A.9 Areas of conservation use may be declared as conservation zones under clause 4(1)(g) of the *Town Planning Ordinance*. These zones are shown on statutory plans which are approved by the Town Planning Board and this process is further discussed in the subsequent section on preparing plans to conserve natural landscapes and habitats.

A.10 SSSIs may be land based or marine sites which are of special interest because of their flora, fauna, geographical, geological or physiographic features. SSSIs are identified by the AFD and the Planning Department maintains a register of sites. Once identified, SSSIs are shown on statutory and departmental plans prepared by the Planning Department. Inter-relationships between land uses can be quite subtle. An SSSI declared as a wildlife habitat may only be sustainable if the wider surroundings remain rural so as to provide feeding grounds. Similarly, a wetland site may only be sustained if a particular water source is protected.

A.11 The Government recognises the need to protect marine and wetland habitats. AFD is responsible for the implementation of future marine parks/reserves. Important wetlands may be declared as being of international importance under the *Convention on Wetlands of International Importance* Especially as Waterfowl Habitat (known as the *'Ramsar' Convention*). Parties to the Convention may designate sites for inclusion in the *List of Wetlands of International Importance* which is administered by the Bureau of the Convention. The *Ramsar Convention* states that "wetlands should be selected for the List on account of their international significance in terms of ecology, botany, zoology, limnology or hydrology. In the first instance, wetlands of international importance to waterfowl at any season should be included". The Mai Po Marshes (a restricted area and a SSSI) the intertidal mudflat at Inner Deep Bay and the fishponds in Buffer Zone 1 have been designated as a Ramsar Site since September 1995.

Statutory Plans

A.12 The *Town Planning Ordinance* permits statutory land use zones under clause 4(1)(g) for 'country parks, coastal protection areas, sites of special scientific interest, green belts or other specified uses that promote conservation or protection of the environment'. Conservation zones for statutory plans are:

(i)	SSSI	to conserve and to protect fauna and flora and other natural features with special scientific value.
(ii)	Country Park	to encourage recreation and tourism, protect vegetation and wildlife, preserve and maintain buildings and sites of historical or cultural significance within country parks and to provide facilities and services for the public enjoyment of the country. (Note: The term 'Country Parks' includes 'Special Areas' designated under the Country Parks Ordinance.)
(iii)	Coastal Protection Area	to retain natural coastline.
(iv)	Conservation Area	to retain existing natural features and rural use.
(v)	Green Belt	to define the limits of urban development areas by conserving landscape features.

Visual Assessment and Landscaping

A.13 There is no current legislation which specifically relates to landscape and visual impacts of developments in Hong Kong. However, the older *HKPSG Chapter 10: Landscape and Conservation* as well as containing recommendations about developments in agricultural areas, woodlands, water gathering grounds, areas of freshwater fish culture, scenic and potential recreation areas, also provided guidelines for reducing adverse environmental effects of development in rural areas. Recommendations covered:

(i) *Topography and site information:*

Developments on hill tops, scenic ridges and prominent positions should be avoided wherever possible. Site layout, road alignments, etc. should follow and relate to the natural contours. Overall, formation work and site disturbance should be minimised.

In scenic areas, opportunities should be taken to use local landform and any excavated material available to 'fit' the development into the ground form, soften the geometric outline of buildings, and screen ancillary features from view;

Developments should be sited and planned to minimise long term visual impact.

(ii) *Retention of existing vegetation:*

Developments should be sited so as to retain existing woodlands, groups of trees and feature trees wherever possible.

Retention of trees on development sites is made easier if non-building areas are specified to include all significant tree features and suitable conditions to ensure these areas are protected and included in development proposals.

Advice should be sought from Agriculture and Fisheries Department, Buildings Department, Architectural Services Department, Urban Services Department or Regional Services Department on regulations governing the felling of trees, the suitability of trees for retention and the possible occurrence of important flora and fauna.

(iii) *Site layout, overhead services alignments, etc.:*

The appropriate siting and design of development is often crucial for the maintenance of the landscape in rural areas. Building layouts that avoid regular repetitive or geometric forms and that relate well to natural landforms are preferred.

Views from surrounding areas should be taken into account.

Overhead services should be aligned to minimise visual impact and below ground routes should be preferred in sensitive areas.

(iv) *Building design and landscape treatment:*

In areas of scenic importance, building design should be sympathetic with the surrounding landscape and the general rural environment.

The preparation and implementation of landscape plans should be a requirement on all major developments and, as a general rule, for developments in scenic areas. Landscape Plans should include all or most of the following:

(a) A framework of tree planting to separate, screen and complement buildings;

(b) Shrub and ground cover on the periphery of the site where this is open to public view;

(c) Re-vegetation of excavated areas and formed slopes not built upon, consistent with geotechnical requirements; and

(d) Proposals to ensure that the vegetation to be established is maintained or self-sustaining.

A.14 *HKPSG* also provides the following guidelines for roadside planting which are applicable in both the urban and rural context:

(i) Wherever possible, existing trees and woodlands are to be retained. Where this proves impractical, all possible efforts should be made to transplant suitable healthy trees either elsewhere on site or in the near vicinity.

(ii) Wherever possible, footways, median strips and road side areas should be designed to accommodate planting. Transport Department, Highways Department and Fire Services Department should be consulted. In areas where planting is intended, special consideration to the location of utility services may be required.

(iii) Roadside and median plantings can also temper the environment, reduce vehicle pollution to a degree and screen traffic and other uses.

(iv) Major planting belts (structure plantings) should be wide enough to be usable for recreation and be heavily planted. Where a buffer for polluting uses is intended a wide planting is needed (say 45 m).

(v) Intersections (especially grade separated) occupy large areas and present scope for heavy planting and contouring. Care must be taken with sight lines, and the Territory Development Department should be consulted.

(vi) Always consult with future maintenance authorities (Urban Services Department, Regional Services Department).

Noise

A.15 *HKPSG* states that "The basic role of planning against noise is to provide an environment whereby noise impacts on sensitive uses are maintained at acceptable levels."

A.16 Noise control legislation in Hong Kong comes under the *Noise Control Ordinance [Cap 400]* of 1988 regulations and associated Technical Memoranda (TM). The following TM have been issued on:

(i) *The Assessment of Noise from Places other than Construction Sites, Domestic Premises or Public Places* (1988)

(ii) *Noise from Construction Work other than Percussive Piling* (2nd Ed. 1996)

(iii) *Noise from Percussive Piling* (1988)

A.17 New environmental legislation on noise control, the *Noise Control (Construction) Regulation* and the associated *TM on Noise from Construction Work within a Designated Area*, was enacted in 1996. This legislation is designed to control noise from the use of Specified Powered Mechanical Equipment (SPME) and the carrying out of Prescribed Construction Work (PCW) on construction sites within a designated area during restricted hours.

A.18 An amendment to the *TM on Noise from Percussive Piling*, phasing out the use of diesel hammers, is under consideration.

A.19 Noise Sensitive Receivers (NSRs) are defined by the *HKPSG* and *Noise Control Ordinance* as follows:

(i) all domestic premises, including temporary housing accommodation;

(ii) hotels and hostels

(iii) offices

(iv) educational institutions, including kindergartens, nurseries and all others where unaided voice communication is required

(v) places of public worship and courts of law

(vi) hospitals, clinics, convalescences and homes for the aged, diagnostic rooms and wards

(vii) amphitheatres and auditoria, libraries, performing arts centres and Country Parks

A.20 The appropriate Acceptable Noise Level (ANL) for a particular NSR is dependent on the character of the area in which the NSR is located, and the time of day under consideration. The Area Sensitivity Rating (ASR) is a function of the type of area within which the NSR is located and the degree of the effect on the NSR of particular Influencing Factors (IFs). IFs include any industrial area, major roads (ie. those with a heavy and generally continuous flow of vehicular traffic) and the area within the boundary of Hong Kong International Airport. Table A.1 shows the Area Sensitivity Ratings given by the *Noise Control Ordinance*.

Table A.1
Area Sensitivity Ratings

Type of Area containing NSR / Degree to which NSR is affected by IF		Not Affected	Indirectly Affected	Directly Affected
(i)	Rural area, including Country Parks or village type developments	A	B	B
(ii)	Low density residential area consisting of low-rise or isolated high-rise developments	A	B	C
(iii)	Urban area	B	C	C
(iv)	Area other than above	B	B	C

Notes:

'Country Park' means an area that is designated as a country park pursuant to section 14 of the *Country Parks Ordinance*.

'Directly Affected' means that the NSR is at such a location that noise generated by the IF is readily noticeable by the NSR and is a dominant feature of the noise climate of the NSR.

'Indirectly Affected' means that the NSR is at such a location that noise generated by the IF, whilst noticeable at the NSR, is not a dominant feature of the noise climate of the NSR.

'Not Affected' means that the NSR is at such a location that noise generated by the IF is not noticeable at the NSR.

'Urban Area' means and area of high density, diverse development including a mixture of such elements as industrial activities, major trade or commercial activities and residential premises.

Construction Noise

A.21 An emission inventory of the noise sources shall be provided. The consultants shall identify the interactions between the NSRs and construction activities at every stage and determine the extent of potential construction noise impacts. The assessment shall follow the requirements contained in all the Ordinances and their Regulations governing the control of construction noise currently in force in Hong Kong and the guidelines as advised by the Director of Environmental Protection.

A.22 There are no statutory criteria for noise from construction work other than percussive piling generated during the daytime hours of 07:00-19:00, Monday to Saturday, excluding public holidays. However, EPD normally recommends 75 dB(A) L_{eq}(30 min) as the acceptable noise level during daytime hours at the facade of residential sensitive receivers and 70 dB(A) at schools (65 dB(A) during examinations) as outlined in the ProPECC paper (PN 2/93) on *Noise from Construction Activities - Non-Statutory Controls.*

A.23 Noise restrictions are imposed during the evenings (19:00-23:00), night-time (23:00-07:00) and all day on Sunday and public holidays. For construction activities during these hours, a Construction Noise Permit (CNP) is required from the Environmental Protection Department (EPD). The CNP application will be assessed in accordance with the Basic Noise Levels (BNLs) given in the *TM on Noise from Construction Works other than Percussive Piling*. For construction work within a designated area involving the use of SPME other than percussive piling and/or carrying out of PCW, the CNP application will be assessed in accordance with the BNLs given in the *TM on Noise from Construction Work in Designated Area*. These BNLs are shown in Table A.2.

Table A.2
Basic Noise Levels for General Construction Noise

Time Period / ASR	A	B	C
All days during the evening (19:00-23:00), and general holidays (including Sundays) during the daytime and evening (07:00-23:00)	60* 45**	65* 50**	70* 55**
All days during the night-time (23:00-07:00)	45* 30**	50* 35**	55* 40**

* Construction work other than percussive piling in areas, other than a designated area, or when the construction work does not involve the use of SPME nor the carrying out of PCW.

** Construction work within a designated area involving the use of SPME other than percussive piling and/or carrying out of PCW.

A.24 Noise criteria applied to control the noise from percussive piling is detailed in the *TM on Noise from Percussive Piling*. Any percussive piling requires a CNP from EPD. When considering the issue of a CNP, EPD compares the corrected noise level (CNL) with the Acceptable Noise Level (ANL) for the area. Table A.3 shows the ANLs for percussive piling.

Table A.3
Acceptable Noise Levels for Percussive Piling

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

Note: 10 dB(A) is deducted from the ANLs shown above for NSRs such as hospitals, medical clinics, education and other NSRs considered to be particularly sensitive to noise.

A.25 The CNL relates to the tonality, impulsiveness and intermittency of the noise. In the event that the CNL exceeds the ANL, EPD will impose restrictions on the permitted hours of piling operation in accordance with Table A.4.

Table A.4
Permitted Hours of Percussive Piling Operation

Amount by which CNL exceeds ANL	Permitted hours of operation on any day not being a general holiday
more than 10 dB(A)	08:00-09:00 and 12:00-13:00 and 17:00-18:00
between 1 dB(A) and 10 dB(A)	08:00-09:30 and 12:00-14:00 and 16:30-18:00
no exceedance	07:00-19:00

A.26 The information required in an application for a CNP includes:

- a map (preferably 1:1000 scale) showing precise details of the site location, site limits and nearby noise sensitive receivers, e.g. residential buildings, schools, hospitals;
- location of any stationary powered mechanical equipment on site or, in the case of an application for a percussive piling permit, the piling zone or actual pile locations;
- details of time period (time of day, duration in days/weeks/months) for which the CNP is required;
- a description, including two photographs and identification codes, and number of units of each item of powered mechanical equipment to be used or, in the case of piling, details of the piling method and pile type including number of units; and
- details of any particularly quiet items of equipment or piling methods, special noise control measures to be employed on site, or any other information thought to be relevant.

A.27 During daytime works, EPD recommends that the advice in EPD's *Practice Note ProPECC PN2/93* on construction noise abatement practice is followed.

Operational Noise

A.28 *HKPSG* states that noise levels from a new fixed source should be 5 dB(A) below the relevant ANL presented in the *TM on The Assessment of Noise from Places other than Construction Sites, Domestic Premises or Public Places* or the prevailing background noise level, whichever is lower. The ANL from the TM for a given NSR is presented in dB(A) in Table A.5 below.

Table A.5
Acceptable Noise Levels during Operations

Time Period / ASR	A	B	C
Day (07:00-19:00) and Evening (19:00-23:00)	60	65	70
Night (23:00-07:00)	50	55	60

Road Traffic Noise

A.29 As outlined in the *HKPSG*, the severity of road traffic noise impact on sensitive uses depends on many variables, some of which can be controlled or influenced by land use planning. These variables include:

(i) road alignment, ie. providing distance separation between the noise receiver and the vehicles;

(ii) traffic composition and volume, ie. using traffic planning and management to control vehicle movements and type of vehicles at different times of the day;

(iii) line-of-sight, ie. using noise-tolerant buildings to reduce the angle of view of receiver on road traffic;

(iv) shieldings, eg. using barriers, road enclosures or road decking.

A.30 For road traffic noise, the *HKPSG* specifies the acceptable noise limit at the external facade of all domestic premises which rely on open windows for ventilation, including temporary housing areas, as L_{10} (1 hour) of 70 dB(A). See Table A.6.

Rail Noise

A.31 For rail noise, the *HKPSG* specifies the acceptable noise limit at the facades of all noise sensitive buildings, as L_{eq} (24 hours) of 65 dB(A). See Table A.6.

Noise Impact Assessment

A.32 Noise will be assessed using standard techniques acceptable under the *Noise Control Ordinance [Cap 400]* and associated *Technical Memoranda.* Guidance for Construction Noise studies will also be obtained from BS 5228: 1984: *Noise Control on Construction and Open Sites: Part 1: Code of Practice for Base Information and Procedures for Noise Control.* Mitigation will be planned according to the relevant TMs as well as from sources such as *A Practical Guide for the Reduction of Noise from Construction Works.* Operational Noise will be calculated according to the TM and assessed according to the *HKPSG.*

Table A.6
Traffic Noise Standards

Use / Noise Source	Road Traffic Noise L_{10}(1 hr) dB(A)	Rail Noise L_{eq} (24 hours) dB(A)
All domestic premises including temporary housing accommodation	70	65 (or Lmax (2300-0700) = 85 dB(A))
Hotels and houses	70	
Offices	70	
Educational institutions including kindergartens, nurseries and all others where unaided voice communication is required	65	
Places of public worship and courts of law	65	
Hospitals, clinics, convalescences and homes for the aged: diagnostic rooms and wards	55	
Amphitheatres and auditoria, libraries, performing arts centres and Country Parks	depends on locations and construction	

Notes:

1 The above standards apply to uses which rely on open windows for ventilation
2 The above standards should be viewed as the maximum permissable noise levels at the external facade

Air Quality

A.33 The principal legislation regulating air emissions in Hong Kong is the *Air Pollution Control Ordinance (APCO) [Cap 311]* of 1983 and its subsidiary regulations.

A.34 The whole of the Territory has been divided into Air Control Zones. Tin Shui Wai falls within the topographically confined Deep Bay Airshed.

A.35 *HKPSG* states that "Air quality is affected by such factors as the emission rate of air pollutants, the separation distance between emission sources and receptors, topography, height and width of buildings as well as meteorology."

A.36 New environmental legislation entitled *Air Pollution Control (Construction Dust) Regulations* is currently under consultation. These regulations are to control the dust emission from construction sites by a notification and permit procedure.

Operational Emissions

A.37 The Hong Kong Air Quality Objectives (AQOs) state the maximum acceptable concentration of air pollutants. The AQOs for one and 24 hour concentrations of five major pollutants are shown in Table A.7. The Government aims to achieve the AQOs throughout the Territory as soon as 'reasonably practicable'. Efforts are being made to control and reduce air pollution emitters in areas where the AQOs are already exceeded, eg. by controlling new developments. The AQOs will apply to the operational phases of the project.

Construction Dust

A.38 During the construction phase of the project, an hourly average TSP limit of 500 $\mu g/m^3$ is recommended by EPD for assessing construction dust impacts. This limit is not statutory, but nonetheless has been used in many construction works in Hong Kong as a contractual requirement.

A.39 The *HKPSG* recommends that any open storage areas should be located at least 100 m from any air sensitive receiver.

Cement and Concrete

A.40 Cement works in which the total silo capacity exceeds 50 tonnes and in which cement is handled fall under the Specified Processes under the *Air Pollution Control Ordinance*. A licence from EPD is required to operate such a works.

A.41 Technical Memoranda have been issued on:

(i) Specifying Air Quality Objectives for Hong Kong (Table A.7);
(ii) Issuing Air Pollution Abatement Notices to Control Air Pollution from Stationary Pollution Processes.

Other subsidiary regulations issued are as follows:

A1 - Furnaces, Ovens and Chimneys (Installation and Alteration) Regulations.
B1 - Dust and Grit Emission Regulations.
C1 - Smoke Regulations.
D1 - Appeal Board.
E1 - Air Control Zones (Declaration and Consideration) Order.
F1 - Specified Processes.
G1 - Specification of Required Particulars and Information.
H1 - Consolidation Statement of Air Quality Objectives.
I1 - Fuel Restriction
J1 - Vehicle Design Standards (Emission) Regulations.

Table A.7
Air Quality Objectives

Pollutant	Concentration (μg)m³					Health effects of pollutant at elevated ambient levels
	Average Time					
	1hr	8hrs	24hrs	3mths	1yr	
Sulphur Dioxide	800[2]		350[3]		80	Respiratory illness; reduced lung function; morbidity and mortality rates increase at higher levels.
Total Suspended Particulate			260[3]		80	Respirable fraction has effects on health.
Respirable Suspended Particulates			180[3]		55	Respiratory illness; reduced lung function; cancer risk for certain particles; morbidity and mortality rates increase at higher levels.
Nitrogen Dioxide	300[2]		150[3]		80	Respiratory irritation; increased susceptibility to respiratory infection; lung development impairment.
Carbon Monoxide	30000[2]	10000[3]				Impairment of co-ordination; deleterious to pregnant women and those with heart and circulatory conditions.
Photochemical Oxidants as ozone	240[2]					Eye irritation; cough; reduced athletic performance; possible chromosome damage.
Lead				1.5		Affects cell and body processes; likely neuro-psychological effects, particularly in children; likely effects on rates of incidence of heart attacks, strokes and hypertension.

Notes: Concentrations measured at 298°K (25°C) and 101.325 kPA

1 Suspended particles in air with a nominal aerodynamic diameter of 10 μm or smaller
2 Criteria not to be exceeded more than 3 times per year
3 Criteria not to be exceeded more than once per year

A.42 In order to obtain a licence to conduct a Specified Process, EPD may require the applicant to submit an air pollution control plan for the process. This will include:

(i) a description and technical particulars of the plant or equipment that may evolve an air pollutant;

(ii) details of pollution control equipment or measures proposed to minimise emissions and comply with the requirement to use the best practicable means of controlling air pollution;

(iii) a description (with maps) to identify sensitive receivers, eg. residential buildings, schools, hospitals;

(iv) an assessment of the resulting air quality and risk to human health, including supporting calculations and information;

(v) a statement that the best practicable means of controlling air pollution has been adopted or is proposed, including supporting calculations and information;

(vi) a plan for, or scheme of, monitoring the emission at source or the ambient concentration of any air pollutant.

A.43 The *HKPSG* recommends that any concrete batching plants and open storage areas should be located at least 100 m from any air sensitive receiver.

Water Quality

A.44 The principal legislation for controlling water pollution in Hong Kong is the *Water Pollution Control Ordinance (WPCO) [Cap 358]* of 1981 which allows for gazette of Water Control Zones (WCZ) within which the discharge of liquid effluents and the deposit of matter into any water bodies, public sewers and drains are controlled. The WPCO is applicable for construction site discharges as well as for discharges during the operational phase.

A.45 The Study Area falls within the Deep Bay Water Control Zone, which was declared on 1 December 1990. Deep Bay (Hau Hoi Wan) is affected by pollution from various sources both within and outside Hong Kong. The water quality objectives for Deep Bay are presented in Table A.8.

Table A.8
Statement of Water Quality Objectives
(Deep Bay Water Control Zone)

Water Quality Objective			Part or Parts of Zone
A.	AESTHETIC APPEARANCE		
	(a)	Waste discharges shall cause no objectionable odours or discolouration of the water.	Whole Zone
	(b)	Tarry residues, floating wood, articles made of glass, plastic, rubber or of any other substances should be absent.	Whole Zone
	(c)	Mineral oil should not be visible on the surface. Surfactants should not give rise to a lasting foam.	Whole Zone
	(d)	There should be no recognisable sewage-derived debris.	Whole Zone
	(e)	Floating, submerged and semi-submerged objects of a size likely to interfere with the free movement of vessels, or cause damage to vessels, should be absent.	Whole Zone
	(f)	Waste discharges shall not cause the water to contain substances which settle to form objectionable deposits.	Whole Zone
B.	BACTERIA		
	(a)	The level of *Escherichia coli* should not exceed 610 per 100 mL, calculated as the geometric mean of all samples collected in one calendar year.	Secondary Contact Recreation Subzone and Mariculture Subzone *(L.N. 455 of 1991)*
	(b)	The level of *Escherichia coli* should be zero per 100 mL, calculated as the running median of the most recent 5 consecutive samples taken at intervals of between 7 and 21 days.	Yuen Long & Kam Tin (Upper) Subzone, Beas Subzone, Indus Subzone, Ganges Subzone and Water Gathering Ground Sub-zones
	(c)	The level of *Escherichia coli* should not exceed 1000 per 100 mL, calculated as the running median of the most recent 5 consecutive samples taken at intervals of between 7 and 21 days.	Yuen Long & Kam Tin (Lower) Subzone and other inland waters
	(d)	The level of *Escherichia coli* should not exceed 180 per 100 mL, calculated as the geometric mean of all samples collected from March to October inclusive in one calendar year. Samples should be taken at least 3 times in a calendar month at intervals of between 3 and 14 days.	Yuen Long Bathing Beach Subzone *(L.N. 455 of 1991)*

		Water Quality Objective	Part or Parts of Zone
C.	COLOUR		
	(a)	Waste discharges shall not cause the colour of water to exceed 30 Hazen units.	Yuen Long & Kam Tin (Upper) Subzone, Beas Subzone, Indus Subzone, Ganges Subzone and Water Gathering Ground Subzones
	(b)	Waste discharges shall not cause the colour of water to exceed 50 Hazen units.	Yuen Long & Kam Tin (Lower) Subzone and other inland waters
D.	DISSOLVED OXYGEN		
	(a)	Waste discharges shall not cause the level of dissolved oxygen to fall below 4 milligrams per litre for 90% of the sampling occasions during the year; values should be taken at 1 metre below surface.	Inner Marine Subzone excepting Mariculture Subzone
	(b)	Waste discharges shall not cause the level of dissolved oxygen to fall below 4 milligrams per litre for 90% of the sampling occasions during the year; values should be calculated as water column average (arithmetic mean of at least 2 measurements at 1 metre below surface and 1 metre above seabed). In addition, the concentration of dissolved oxygen should not be less than 2 milligrams per litre within 2 metres of the seabed for 90% of the sampling occasions during the year.	Outer Marine Subzone excepting Mariculture Subzone
	(c)	The dissolved oxygen level should not be less than 5 milligrams per litre for 90% of the sampling occasions during the year; values should be taken at 1 metre below surface.	Mariculture Subzone
	(d)	Waste discharges shall not cause the level of dissolved oxygen to be less than 4 milligrams per litre.	Yuen Long & Kam Tin (Upper and Lower) Subzones, Beas Subzone, Indus Subzone, Ganges Subzone, Water Gathering Ground Subzones and other inland waters of the Zone
E.	pH		
	(a)	The pH of the water should be within the range of 6.5-8.5 units. In addition, waste discharges shall not cause the natural pH range to be extended by more than 0.2 units.	Marine waters excepting Yuen Long Bathing Beach Subzone
	(b)	Waste discharges shall not cause the pH of the water to exceed the range of 6.5-8.5 units.	Yuen Long & Kam Tin (Upper and Lower) Subzones, Beas Subzone, Indus Subzone, Ganges Subzone and Water Gathering Ground Subzones
	(c)	The pH of the water should be within the range of 6.0-9.0 units.	Other inland waters
	(d)	The pH of the water should be within the range of 6.0-9.0 units for 95% of samples. In addition, waste discharges shall not cause the natural pH range to be extended by more than 0.5 units.	Yuen Long Bathing Beach Subzone

Water Quality Objective			Part or Parts of Zone
F.	TEMPERATURE		
	Waste discharges shall not cause the natural daily temperature range to change by more than 2.0°C.		Whole Zone
G.	SALINITY		
	Waste discharges shall not cause the natural ambient salinity level to change by more than 10%.		Whole Zone
H.	SUSPENDED SOLIDS		
	(a)	Waste discharges shall neither cause the natural ambient level to be raised by 30% nor give rise to accumulation of suspended solids which may adversely affect aquatic communities.	Marine waters
	(b)	Waste discharges shall not cause the annual median of suspended solids to exceed 20 milligrams per litre.	Yuen Long & Kam Tin (Upper and Lower) Subzones, Beas Subzone, Ganges Subzone, Indus Subzone, Water Gathering Ground Subzones and other inland waters
I.	AMMONIA		
	The un-ionized ammonical nitrogen level should not be more than 0.021 milligram per litre, calculated as the annual average (arithmetic mean).		Whole Zone.
J.	NUTRIENTS		
	(a)	Nutrients shall not be present in quantities sufficient to cause excessive or nuisance growth of algae or other aquatic plants.	Inner and Outer Marine Subzones
	(b)	Without limiting the generality of objective (a) above, the level of inorganic nitrogen should not exceed 0.7 milligram per litre, expressed as annual mean.	Inner Marine Subzone
	(c)	Without limiting the generality of objective (a) above, the level of inorganic nitrogen should not exceed 0.5 milligram per litre, expressed as annual water column average (arithmetic mean of at least 2 measurements at 1 metre below surface and 1 metre above seabed).	Outer Marine Subzone
K.	5-DAY BIOCHEMICAL OXYGEN DEMAND		
	(a)	Waste discharges shall not cause the 5-day biochemical oxygen demand to exceed 3 milligrams per litre.	Yuen Long & Kam Tin (Upper) Subzone, Beas Subzone, Indus Subzone, Ganges Subzone and Water Gathering Ground Subzones
	(b)	Waste discharges shall not cause the 5-day biochemical oxygen demand to exceed 5 milligrams per litre.	Yuen Long & Kam Tin (Lower) Subzone and other inland waters

Water Quality Objective			Part or Parts of Zone
L.	CHEMICAL OXYGEN DEMAND		
	(a)	Waste discharges shall not cause the chemical oxygen demand to exceed 15 milligrams per litre.	Yuen Long & Kam Tin (Upper) Subzone, Beas Subzone, Indus Subzone, Ganges Subzone and Water Gathering Ground Subzones.
	(b)	Waste discharges shall not cause the chemical oxygen demand to exceed 30 milligrams per litre.	Yuen Long & Kam Tin (Lower) Subzone and other inland waters
M.	TOXINS		
	(a)	Waste discharges shall not cause the toxins in water to attain such level as to produce significant toxic carcinogenic, mutagenic or teratogenic effects in humans, fish or any other aquatic organisms, with due regard to biologically cumulative effects in food chains and to toxicant interactions with each other.	Whole Zone
	(b)	Waste discharges shall not cause a risk to any beneficial uses of the aquatic environment.	Whole Zone
N.	PHENOL		
	Phenols shall not be present in such quantities as to produce a specific odour, or in concentration greater than 0.05 milligrams per litre as C_6H_5OH.		Yuen Long Bathing Beach Subzone
O.	TURBIDITY		
	Waste discharges shall not reduce light transmission substantially from the normal level.		Yuen Long Bathing Beach Subzone

A.46 The *TM on Standards for Effluents Discharged into Drainage and Sewerage Systems, Inland and Coastal Waters* was issued in 1991. Under the provisions of this TM, all discharges must be licensed. Tables included within the document identify standards related to effluent flow rates ranging from <10 m^3/day to 6,000 m^3/day, providing guidance on a case-by-case basis. To illustrate this, standards for selected discharges to Deep Bay are shown in Table A.9 a & b.

Table A.9a
Standards for Effluents discharged into Group D inland waters

Flow rate (m^3/day) Determinant	≤200	>200 and ≤400	>600 and ≤800	>1000 and ≤1500	>2000 and ≤3000
pH (pH units)	6-10	6-10	6-10	6-10	6-10
Temperature (°C)	30	30	30	30	30
Colour (lovibound units) (25 mm cell length)	1	1	1	1	1
Suspended solids	30	30	30	30	30
BOD	20	20	20	20	20
COD	80	80	80	80	80
Oil & Grease	10	10	10	10	10
Iron	10	8	5	2.7	1.3
Boron	5	4	2.5	1.5	0.7
Barium	5	4	2.5	1.5	0.7
Mercury	0.1	0.05	0.001	0.001	0.001
Cadmium	0.1	0.05	0.001	0.001	0.001
Other toxic metals individually	1	1	0.8	0.5	0.2
Total toxic metals	2	2	1.6	1	0.4
Cyanide	0.4	0.4	0.3	0.1	0.05
Phenols	0.4	0.3	0.1	0.1	0.1
Sulphide	1	1	1	1	1
Sulphate	800	600	600	400	400
Chloride	1000	800	800	600	400
Fluoride	10	8	8	5	3
Total phosphorus	10	10	8	8	5
Ammonia nitrogen	20	20	20	20	10
Nitrate + nitrite nitrogen	50	50	30	30	20
Surfactants (total)	15	15	15	15	15
E-coli (count/100 ml)	1000	1000	1000	1000	1000

Note: All units in mg/L unless otherwise indicated; all figures are upper limits unless otherwise indicated.

Table A.9b
Standards for Effluents discharged into Group B inland waters

Flow rate (m^3/day) Determinant	≤200	>200 and ≤ 400	>600 and ≤800	>1000 and ≤1500	>2000 and ≤3000
pH (pH units)	6.5-8.5	6.5-8.5	6.5-8.5	6.5-8.5	6.5-8.5
Temperature (^{0}C)	35	30	30	30	30
Colour (lovibound units) (25 mm cell length)	1	1	1	1	1
Suspended solids	30	30	30	30	30
BOD	20	20	20	20	20
COD	80	80	80	80	80
Oil & Grease	10	10	10	10	10
Iron	10	8	5	3	1
Boron	5	4	2.5	1.5	0.5
Barium	5	4	2.5	1.5	0.5
Mercury	0.001	0.001	0.001	0.001	0.001
Cadmium	0.001	0.001	0.001	0.001	0.001
Selenium	0.2	0.2	0.2	0.1	0.1
Other toxic metals individually	0.5	0.5	0.2	0.1	0.1
Total toxic metals	2	1.5	0.5	0.2	0.2
Cyanide	0.1	0.1	0.08	0.05	0.03
Phenols	0.1	0.1	0.1	0.1	0.1
Sulphide	0.2	0.2	0.2	0.2	0.2
Sulphate	800	800	600	400	400
Chloride	1000	1000	800	600	400
Fluoride	10	10	8	5	3
Total phosphorus	10	10	8	8	5
Ammonia nitrogen	5	5	5	5	5
Nitrate + nitrite nitrogen	30	30	20	20	10
Surfactants (total)	5	5	5	5	5
E-coli (count/100ml)	100	100	100	100	100

Note: All units in mg/L unless otherwise indicated; all figures are upper limits unless otherwise indicated.

Water Pollution Control (Sewerage) Regulation

A.47 The *Water Pollution Control (Sewerage) Regulation* was enacted in June 1994 to require owners of ancyroid properties to connect their discharge of wastewater to the public sewerage system and to provide control over operation and maintenance of private treatment facilities. This regulation specifies the gazetted procedures for infrastructure works. This legislation will reduce wastewater discharges direct to environment and lead to water quality improvements in areas served by the public sewerage system. The requirements have been defined in a Technical Circular issued by EPD, *ProPECC PN 1/94 on Construction Site Drainage.*

Construction Site Discharges

A.48 Advice on the handling and disposal of construction site discharges, including site runoff and contaminated wastewaters, is provided in the *ProPECC Paper (PN1/94)* on *Construction Site Drainage.*

A.49 The *Livestock Waste Control Scheme* (LWCS) to the *Waste Disposal (Livestock Waste) Regulations* was implemented on 24th June 1988 under the *Waste Disposal Ordinance* (Cap. 354). The LWCS was reviewed and a new implementation programme was adopted in April 1994 under the *Amendment of the Waste Disposal (Livestock Waste) Regulations.*

Discharge Standards

Restriction Area	Phased Implementation of Discharge Standards@		
	250:250	100:100	50:50
10R, 13R & 14R	1 Jul 1995	1 Jul 1996	1 Jul 1997
11R	1 Jul 1994*	1 Jul 1996	1 Jul 1997
16R, 18R, 19R, 21R, 23R-25R	1 Jan 1996	1 Jan 1997	1 Jan 1998
Control Area			
10, 12-14	1 Jul 1995	1 Jul 1996	1 Jul 1997
11	1 Jul 1994	1 Jul 1996	1 Jul 1997
15-17	1 Jul 1996	1 Jul 1997	1 Jul 1998
18-25	1 Jul 1997	1 Jul 1998	1 Jul 1999

Important Note:

@ in addition to meeting the above phased implementation programme, any farm that is new or restarts business after acceptance of the ex-gratia allowance must immediately comply with the discharge standard of 250:250 as soon as it starts ore restarts its business. Any failure to comply fully with the control requirements would result in enforcement and prosecution action.

* 1 July 1995 for farms on Lantau Island other than in Mui Wo Environs.

Waste Oil

A.50 The disposal of waste oil and other chemicals is controlled by the regulations for chemical waste control under the *Waste Disposal Ordinance*. Chemical wastes must be disposed of at a licensed chemical waste disposal facilities. The Chemical Waste Treatment Centre (CWTC) at Tsing Yi is one of the facilities licensed to allow disposal of waste oil. Waste oil may also be disposed of at other licensed disposal sites.

Solid Waste

A.51 Chapter 9 of HKPSG states, in Section 6 - Waste Management that "The Government's overall objectives for waste management planning are to ensure:

(a) the adequate provision of facilities for cost-effective and environmentally satisfactory disposal of all wastes; and

(b) the availability of and proper enforcement of legislation on storage, collection, transport, treatment and disposal of wastes, to safeguard the health and welfare of the community from any adverse environmental effects."

A.52 Disposal of chemical, household, street, trade and livestock waste is controlled by the *Waste Disposal Ordinance [Cap 354]* of 1980. This legislation covers all aspects of the production, storage, collection and disposal, including the treatment, reprocessing and recycling of waste. In 1989, the formulation of a strategic *Waste Disposal Plan for Hong Kong* was founded on this legislation.

A.53 Construction waste generated during the construction phase should be sorted on site into inert and non-inert fraction for reuse and recycling as far as practical. The non-inert fraction containing no more than 20% by volume of inert content can be disposed of at landfills, whilst the inert fraction should be delivered to public dumps or other reclamation sites. Inert material means soil, rock, asphalt, concrete, brick, cement plaster/mortar, building debris, aggregates, etc.

A.54 Handling and disposal of chemical wastes including oils and grease are covered by the *Waste Disposal (Chemical Waste) (General) Regulations*. Design of oil/fuel storage facilities is covered by the *Code of Practice for Oil Storage Installations, 1992* issued by the Building Authority and the handling of chemical spillages on land is regulated by the Fire Services Department.

A.55 Dredging and dumping for land formation is controlled under the *Foreshore and Sea Bed Reclamations Ordinance [Cap 127]* (1985) and the *Dumping at Sea Act (1974) Overseas Territories Order* (1975) respectively. The former provides for the control of reclamation and use of foreshore and seabed. The latter prohibits dumping at sea without a licence.

A.56 Guidelines and Standards on Contaminated Sediments.

Table A.10
Classification of Sediments by Metal Content (mg/kg dry weight)

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

Note: Tests results should be rounded off to two significant figures before comparing with the table, e.g. Cd to the nearest 0.1 mg/kg, Cr to the nearest 1 mg/kg, and Zn to the nearest 10 mg/kg, etc.

Operational Waste

A.57 Furthermore, waste reception and transfer facilities should be sited so that any adjacent development is very well buffered. For facilities handling the reception and disposal of dusty or odoriferous wastes, special precautions should be taken to avoid nuisance to surrounding areas. Note should be taken of prevailing wind direction and subsequent potential for nuisance.

HKPSG, Chapter 9, Section 6

Refuse Collection Points (Municipal Councils)

Provision in Urban and New Town Areas

A.58 A refuse collection point (RCP) is required to serve the needs of each population of 20,000 persons or areas within 500 m. In industrial or commercial areas, or in areas where adequate private facilities are, or will be available, this level of provision may need to be adjusted to suit anticipated needs. The Director of Urban Services and the Director of Regional Services should be consulted on detailed requirements.

A.59 For road safety reasons, new RCPs should be planned to allow head-in-head-out movements of refuse collection vehicles (RCVs). A gross site area of not less than 294 m^2 with a minimum width of 14 m) is required in the case of island or corner sites.

General Location and Design Guidelines

A.60 RCPs should be sited so as to minimise disruption to traffic or the creation of traffic safety hazards. RCPs should therefore not be located on trunk or primary distributor roads, on steep roads, or locations where turning trucks may create traffic problems.

A.61 Adequate provision of off-street (enclosed) parking of bulk collection vehicles and separate access for the public and private refuse collectors should be provided where appropriate.

A.62 The location and design of RCPs should aim to minimise nuisance to the public and people living and working nearby, where appropriate, by enclosing the whole facility and if necessary, through the provision of odour control equipment and ventilation. Water points should be a minimum requirement for all RCPs for cleaning purposes, design features such as air/exhaust cleaning, high-pressure water cleaning and leachate drainage and disposal should be incorporated. Architectural design of RCPs should also incorporate landscaping wherever possible as visual screening to, and as a buffer from adjacent sensitive land uses.

A.63 Due to difficulties in finding suitable sites for RCPs especially in the built-up areas, RCPs should be incorporated in large-scale developments of both public and private sectors. To reduce the need for waste handling and minimise potential nuisance problems, appropriate waste collection and handling facilities should be included in these large-scale developments and redevelopments.

Provision of Refuse Collection Facilities in Private Residential, Commercial and Composite Building Developments

A.64 The provision of refuse collection facilities in private residential, commercial and composite commercial/residential building developments should comply with the *Building (Refuse Storage Chambers and Chutes) Regulations*. The two Municipal Councils may stipulate certain conditions regarding the removal of household waste from premises under the *Public Cleansing* and *Prevention of Nuisances* (Urban Council/Regional Council) By-laws.

A.65 The floor space and vehicular requirements of refuse storage chambers under the *Building (Refuse Storage Chambers and Chutes) Regulations* are summarised in Table A.11.

Table A.11
Summary of Requirements of Refuse Storage Chambers in Private Residential, Commercial and Composite Building Developments

Description of Building	Total Usable Floor Space (UFS) (m^2)	Description of Storage Chamber	Minimum Floor Space of Storage Chamber
Residential Building	>1,320 to <13,200	Storage chamber	Total UFS in m^2 divided by 440
	>13,200	Storage chamber with vehicular access	
Commercial Building	>3,960 to <39,600	Storage chamber	Total UFS in m^2 divided by 1,320
	>39,600	Storage chamber with vehicular access	
Composite Commercial/ Residential Building	Aggregate of >1,320 to <13,200	Storage chamber	Aggregate of the total UFS of the residential building component in m^2 divided by 440
	Aggregate of >13,200	Storage chamber with vehicular access	Aggregate of the commercial building component in m^2 divided by 1,320

Provision in Public Housing Estates

A.66 Whilst the above standards and guidelines are related to provision of RCPs in urban, new town and rural areas, they do not apply to public housing estates which are subject to separate provision standard and design criteria for refuse collection. The present and proposed refuse collection systems within public housing estates are outlined in the "Guidelines for Refuse Collection in Public Housing Estates" included in this Appendix and described below:

a) Refuse Storage Chambers: standard provision incorporated in each domestic block which provides sufficient daily storage. Depending on the size of the individual block, one refuse bin with a minimum area allowance of 2.0 m^2 should be provided for every 35 flats;

b) Refuse Storage Areas: temporary holding areas designed to accommodate the storage of refuse bins awaiting collection. The location should aim to minimise nuisance to the public and the estate tenants living nearby and should be within the shortest distance practicable from the domestic blocks they serve. The minimum allowance should be 2.5 m^2 per bin;

c) RCPs in Buildings: a totally enclosed structure which allows entry of RCVs for collection of refuse generally associated with commercial centres. They are normally built as part of the commercial centres provision. One centralised RCP should be provided for an estate of 3,000 flats or less.

d) Junk Collection Points: a separate storage area for those items which cannot be handled by the normal refuse collection service. They should be an independently designed structure apart from with the refuse storage chamber or refuse storage area. Normally, an estate with 2,500 flats or less would require one junk collection point of 20 m^2 minimum. An estate of 2,500 flats or more would require two junk points of 20 m^2, or one of 40 m^2 minimum.

Guidelines for Community Facilities with Special Requirements for Waste Disposal

A.67 When planning these community facilities, allowance should be made for adequate space provision for the storage, collection and disposal of solid wastes. This should be in the form of a refuse storage area on the ground floor (or any floor with direct vehicular access). The area should be close to the goods lift and there should be adequate provision for off-street vehicular access for loading of RCVs. The refuse storage chambers should be built to similar standards as those required for residential developments under the *Building (Refuse Storage Chambers and Chutes)* Regulations.

Markets and Cooked Food Stalls

A.68 Many of the wastes produced by these facilities are highly putrescible. Adequate refuse storage area should be provided and located so as to minimise potential nuisance to the public and people living and working nearby. Animal carcasses, commonly generated by the activities within these facilities, should be segregated from other waste streams and separate temporary storage and collection facilities be provided. The facilities should preferably be confined in covered areas and grease traps should be provided to prevent chokage of sewers.

Hospitals/Clinics

A.69 All clinical wastes should be separately collected from other municipal wastes. All clinical wastes must be disposed of in specially designed pathological incinerators.

Refuse Transfer Stations

A.70 A refuse transfer station (RTS) provides a regional and sub-regional destination for unloading of refuse collection vehicles, where the waste is containerised for haulage in bulk to a final disposal facility. A RTS aims primarily at reducing the cost of transporting waste and minimising environmental nuisance by better containment of waste. Consideration should be given to providing such a facility for handling 500-2,000 tonnes a day of waste in the Urban Area, equivalent to 500,000 - 2 million population, or 100 - 1,000 tonnes in the NT, equivalent to 100,000 - 1 million population. A site area of between 1 and 2 hectares is required for each such facility.

A.71 A RTS should be centrally located in the waste catchment it serves, preferably on the water front, with barge access. To minimise incompatibility with adjacent sensitive land uses, a RTS should be sited in an industrial or other non-sensitive area or, if possible, underground. Sufficient space should be provided for reception and queuing of refuse collection vehicles (RCVs). Short vehicular access from and to major transport routes is preferred, to avoid traffic congestion and delays to RCVs. The adequacy of adjoining road capacities for the RCVs should be determined. Considerations should be given to the provision of fully enclosed stations and/or suitable barriers for odour and dust control. Adequate control measures should be provided to minimise the impacts and may include provisions for noise control of the machinery and the structure, leachate treatment/ disposal systems and installation of air/exhaust cleaning systems.

Ecology

Sites of Special Scientific Interest

A.72 There are various legislative and regulatory controls in place for the conservation of species and protection of the environment. Table 1.2 from *HKPSG's Chapter 9: Environment* highlights "ecologically sensitive areas such as Sites of Special Scientific Interest (SSSI) and areas with other particular vegetation and wildlife habitat characteristics" as Environmental Factors influencing Land Use Planning, and states that Nature Reserves and SSSI should be adequately protected from the effects of pollution and from the diversion of natural flows.

A.73 The *HKPSG* also highlight the need for care to be taken in planning and implementation of civil engineering construction works to avoid, minimise or ameliorate the occurrence of pollution from silt, oil and other sources on water bodies in unspoilt areas designated for conservation and in SSSI.

Wild Animals

A.74 Wild animals are protected by the *Wild Animals Protection Ordinance [Cap 170]* (1980), which fall under the authority of the Director of Agriculture and Fisheries. The latest version of Cap 170 is the Second Schedule of the *Wild Animals Protection Ordinance [Cap 170]* has been reviewed in 1996. Protected wild animals listed under the Schedule include mammals, all wild birds, reptiles, amphibians and an insect.

A.75 There are several species of animals found in the area that are specifically protected. The *Animals and Plants (Protection of Endangered Species) Ordinance* (Cap. 187) controls the possession of any endangered species and is designed to prohibit collection, import and export. In addition there are measures which cover the retention, removal and replacement of trees on development sites. The *Wild Animals Protection Ordinance* (Cap. 170) is aimed mainly at hunters and collectors, but does apply to this case under Section 5, "No person shall, except in accordance with a special permit, take, remove, injure, destroy or wilfully disturb a nest or egg of any protected wild animal."

A.76 The protected animals that have been confirmed to inhabit the area are: all species of birds, mongooses, and the barking deer (*Muntiacus reevesi*). It is possible that additional protected species such as the Burmese python, civets and pangolins also inhabit and could breed in the area.

Rare and Endangered Plant Species

A.77 Various species of plants are protected under the Forestry Regulations of the *Forestry and Countryside Ordinance [Cap 96]* (1950) and *Animals and Plants (Protection of Endangered Species) Ordinance [Cap 187]* (1976). The *Forestry and Countryside Ordinance [Cap 96]* and *Forestry Regulations [Cap 96 Sub. leg. A]* were revised in 1993. The *Animals and Plants (Protection of Endangered Species) Ordinance [Cap 187]* has been revised in 1995.

A.78 Regarding the specific protection laws, all Crown forests are protected under Hong Kong's *Forests & Countryside Ordinance*. The law (Cap. 96, section 21), states that:

"Any person who, without lawful authority or excuse, in any forest or plantation:-

b) plucks or damages any bud, blossom or leaf of any tree, shrub or plant;
d) fells, cuts, burns or otherwise destroys any trees or growing plants,

shall be guilty of an offence."

The law defines "forest" to mean, "any area of Crown land covered with selfgrown trees."

Section 3 of the subsidiary *Forestry Regulation* is more specific and provides a list of plants which are protected.

A.79 *Convention on Wetlands of International Importance especially as Waterfowl Habitat - Ramsar, 2.2.1971 as amended by the Protocol of 3.12.1982 and the Regina Amendments of 28.5.1987*

> "The Contracting Parties, recognising the interdependence of Man and his environment; considering the fundamental ecological functions of wetlands as regulators of water regimes and habitats supporting a characteristic flora and fauna, especially waterfowl; being convinced that wetlands constitute a resource of great economic, cultural, scientific, and recreational value, the loss of which would be irreparable; desiring to stem the progressive encroachment on and loss of wetlands now and in the future; recognising that waterfowl in their seasonal migrations may transcend frontiers and so should be regarded as an international resource; being confident that the conservation of wetlands and their flora can be ensured by combining far-sighted national policies with co-ordinated international action; have agreed as follows:
>
> Article 2 - 5. "Any Contracting Party shall have the right ... because of its urgent national interests, to delete or restrict the boundaries of wetlands already included by it in the List and shall, at the earliest possible time, inform the organisation or government responsible for the continuing bureau duties specified in Article 8 of any such changes."
>
> Article 2 - 6. "Each Contracting Party shall consider its international responsibilities for the conservation, management and wise use of migratory stocks of waterfowl, both when designating entries for the List and when exercising its right to change entries in the List relating to wetlands in their territory."

Article 3 - 1. "The Contracting Parties shall formulate and implement their planning so as to promote the conservation of the wetlands included in the List, and as far as possible the wise use* of wetlands in their territory."

Article 3 - 2. "Each Contracting Party shall arrange to be informed at the earliest possible time if the ecological character or any wetland in its territory and included in the List has changed, is changing or is likely to change as the result of technological developments, pollution or other human interference."

Article 4 - 2. "Where a Contracting Party in its urgent national interest, deletes or restricts the boundaries of a wetland included in the List, it should as far as possible compensate for any loss of wetland resources, and in particular it should create additional nature reserves for waterfowl and for the protection, either in the same area or elsewhere, of an adequate portion of the original habitat."

Article 5. "The Contracting Parties shall consult with each other about implementing obligations arising from the Convention especially in the case of a wetland extending over the territories of more than one Contracting Party or where a water system is shared by Contracting Parties. They shall at the same time endeavour to co-ordinate and support present and future policies and regulations concerning the conversation of wetlands and their flora and fauna."

Bonn Convention

A.80 Also through the United Kingdom, Hong Kong is a Party to the Convention on the Conservation of Migratory Species of Wild animals (the *Bonn Convention*). The Bonn Convention has two major objectives:

- to provide strict protection for species listed in Appendix 1 of the Convention (migratory species in danger of extinction throughout all or a significant portion of their range); and
- to encourage Range States for such species to conclude agreements for the conservation and management of Appendix II species (migratory species which have an unfavourable conservation status and require international agreements for their conservation, or which have a conservation status which would significantly benefit from international cooperation).

* The wise use of wetlands concept is defined, in Appendix 9 of the Ramsar Convention Manual, as: "their sustainable utilisation for the benefit of human kind in a way compatible with the maintenance of the natural properties of the ecosystem".

Tree Preservation

A.81 *Works Branch Technical Circular 24/94 (Planning, Environment and Lands Branch Circular 3/94) on Tree Preservation* states that:

"The need to preserve trees must be borne in mind particularly by those in charge of engineering, architectural and landscape projects ..... There are many projects such as ... service reservoirs, formation works and the like where virtually all trees and shrubs within the works area boundary may have to be destroyed. In these cases care should be taken to minimise the extent of the works area and thereby maximise the number of trees to be preserved."

A.82 According to *Lands Administration Office Instruction Section D-12 on Tree Preservation*, Government projects in particular should make "every effort to preserve as many trees as possible and in general, permission to lop or cut down any tree will not be granted unless good cause is shown". Agriculture and Fisheries Department keeps a *Register of Unusual Trees.*

Tree Planting and Landscaping

A.83 General advice on tree planting and landscaping is presented in this section under the heading 'Visual Impact and Landscaping'.

Conservation Area - Buffer Zones

A.84 The Government has created two Buffer Zones around Deep Bay. Buffer Zone 1 (948 ha), new development within this zone should not be allowed unless it is required to support the conservation of the area's natural features and scenic qualities. Buffer Zone 2 (1027 ha) new development within this zone would not be considered unless the applicant could demonstrate the proposed development would have insignificant impact on environment, ecology, drainage, sewerage and traffic in the area including the MPNR and Inner Deep Bay. Any development is also subject to the more detailed Outline Zoning Plans (1994)[1]. These areas are shown in Figure A1.

PRC Relevant Statutes and Bilateral Migratory Bird Agreements

Wildlife Protection Law of the PRC

A.85 According to Chapter 2 Provision 12 an environmental impact assessment should be submitted by the developer for construction projects which potentially result in adverse impacts on wildlife habitat protected by national or local regulations. In the approval process the Environmental Protection Department should consult the wildlife protection agencies at the same administrative level.

1 TPB PG-No. 12A (Revised November 1994). Town Planning Board Guidelines for Application for Developments within Deep Bay Buffer Zones.

PRC Wildlife Protection Implementation Regulations

A.86 According to Chapter 2 Provision 10 preventative measures should be taken by relevant institutions and individuals to preclude potential risk of adverse impacts on wildlife protected by national or local regulations.

PRC Guidelines for Nature Reserves for Forests and Wildlife Species

A.87 According to Provision 11 the natural environment and natural resources in nature reserves should be managed solely by the administrative organization of nature reserves. Without permission of the Ministry of Forestry or the provincial, autonomous regional, or municipal administrative department of forests no institution or individual is allowed to enter the nature conservation area to establish institutions or construct facilities.

PRC Nature Reserve Regulations, Provision 32

A.88 Any construction facility is prohibited in core areas and buffer zones of nature reserves. Construction facilities which may cause environmental pollution, resource destruction, or landscape damage in the experimental areas are also inhibited; pollutants discharged from other construction projects in the experimental areas should obey national or local standards. Time tables should be set up for effluent control for those existing facilities or in the experimental area if the effluents discharged exceed national or local standards; mitigation measures must be taken for any damage.

A.89 Other construction projects surrounding nature reserves should not damage the environmental quality of nature reserves; any damage must be rectified within a definite time.

A.90 Time tables for the rectification will be set up by appropriate administrations authorized by relevant laws and regulations. The responsible enterprises and institutions must accomplish rectification within the specified time.

The National Protection List of Important Wild Animals

A.91 The following mammals which occur in the Shenzhen River catchment and Deep Bay area are listed among species to be protected in PRC (first class protection species are marked with *).

Otter	*Lutra lutra*
Small Indian Civet	*Viverricula indica*
Chinese White Dolphin	*Sousa chinesis*

A.92 The following birds which occur in the Shenzhen River catchment and Deep Bay are listed among species to be protected in PRC (first class protection species are marked with *).

Black-necked Grebe	*Podiceps nigricollis*
Dalmatian Pelican	*Pelecanus (philippensis) crispus*
Reef Egret	*Egretta sacra*
Swinhoe's Egret	*Egretta eulophotes*
Oriental White Stork*	*Ciconia (ciconia) boyciana*

Black Stork*	*Ciconia nigra*
White Ibis	*Threskiornis (aethiopicus) melanocephalus*
Glossy Ibis	*Plegadis falcinellus*
White Spoonbill	*Platalea leucorodia*
Black-faced Spoonbill	*Platalea minor*
Swan	*Cygnus* sp.
Mandarin Duck	*Aix galericulata*
Common Crane	*Grus grus*
Imperial Eagle*	*Aquila heliaca*
Black-shouldered Kite	*Elanus caeruleus*
Black Kite	*Milvus migrans*
White-bellied Sea Eagle	*Haliaeetus leucogaster*
Crested Goshawk	*Accipiter trivirgatus*
Marsh Harrier	*Circus aeruginosus*
Hen Harrier	*Circus cyaneus*
Pied Harrier	*Circus melanoleucos*
Japanese Sparrowhawk	*Accipiter gularis*
Besra	*Accipiter virgatus*
Horsfield's Goshawk	*Accipiter soloensis*
Grey-faced Buzzard-eagle	*Butastur indicus*
Buzzard	*Buteo buteo*
Spotted Eagle	*Aquila clanga*
Bonelli's Eagle	*Hieraaetus fasciatus*
Crested Honey Buzzard	*Pernis ptilorhnychus*
Serpent Eagle	*Spilornis cheela*
Osprey	*Pandion haliaetus*
Kestrel	*Falco tinnunculus*
Peregrine	*Falco peregrinus*
Hobby	*Falco subbuteo*
Saker Falcon	*Falco cherrug*
Little Whimbrel	*Numenius (borealis) minutus*
Spotted Greenshank	*Tringa guttifer*
Relict Gull*	*Larus relictus*
Greater Coucal	*Centropus sinensis*
Lesser Coucal	*Centropus bengalensis*
Rose-ringed Parakeet	*Psittacula krameri*
Short-eared Owl	*Asio flammeus*
Grass Owl	*Tyto capensis*
White-vented Needletail	*Hirundapus cochinchinensis*

A.93 The following reptiles which occur in the Shenzhen River catchment and Deep Bay are listed among species to be protected in PRC.

Water Monitor	*Varanus salvator*
Burmese Python	*Python molurus*

Bilateral Migratory Bird Agreements

'Agreement between the Government of Australia and the Government of the People's Republic of China for the Protection of Migratory Birds and their Environment'

and

'Agreement on the Protection of Migratory Birds and Their Habitats by the Governments of Japan and the People's Republic of China'

A.94 China has entered into a number of bilateral agreements to protect migratory birds. These include agreements with both Japan and Australia. Birds passing through the Deep Bay area are known to migrate to/from both of these countries (see, for example: Melville, D.S. and Galsworthy, A.C. 1993. Report on bird ringing in Hong Kong in 1992. *Hong Kong Bird Report* 1992:81-99) and thus these agreements are relevant in the context of this study. A list of birds occurring in the Deep Bay area protected under bilateral migratory bird agreements between China and Australia/Japan is given below.

Birds occurring in the Deep Bay area protected under bilateral migratory bird agreements between China and Australia/Japan:

Black-necked Grebe	*Podiceps nigricollis*	J
Great Crested Grebe	*Podiceps cristatus*	AJ
Lesser Frigatebird	*Fregata ariel*	AJ
Bittern	*Botaurus stellaris*	J
Cattle Egret	*Bubulcus ibis*	J
Reef Egret	*Egretta sacra*	AJ
Great Egret	*Egretta alba*	AJ
Yellow Bittern	*Ixobrychus sinensis*	AJ
Schrenck's Bittern	*Ixobrychus eurhythmus*	J
Little Green Heron	*Butorides striatus*	J
Intermediate Egret	*Egretta intermedia*	J
Night Heron	*Nycticorax nycticorax*	J
Purple Heron	*Ardea purpurea*	J
Black Stork	*Ciconia nigra*	J
Glossy Ibis	*Plegadis falcinellus*	A
White Spoonbill	*Platalea leucorodia*	J
Black-faced Spoonbill	*Platalea minor*	J
Ruddy Shelduck	*Tadorna ferruginea*	J
Shelduck	*Tadorna tadorna*	J
Pintail	*Anas acuta*	J
Teal	*Anas acrecca*	J
Baikal Teal	*Anas formosa*	J
Falcated Teal	*Anas falcata*	J
Mallard	*Anas platyrhychos*	J
Gadwall	*Anas strepera*	J
Wigeon	*Anas penelope*	J
Garganey	*Anas querquedula*	AJ
Shoveler	*Anas clypeata*	J
Common Pochard	*Aythya ferina*	J
Baer's Pochard	*Aythya baeri*	J
Tufted Duck	*Aythya fuligula*	J
Scaup	*Aythya marila*	J
Red-breasted Merganser	*Mergus serrator*	J
White-bellied Sea-eagle	*Haliaeetus leucogaster*	A
Marsh Harrier	*Circus japonica*	J
Hobby	*Falco subbuteo*	J

Watercock	*Gallicrex cinerea*	J
Moorhen	*Gallinula chloropus*	J
Pheasant-tailed Jacana	*Hydrophasianus chirurgus*	A
Painted Snipe	*Rostratula benghalensis*	AJ
Little Ringed Plover	*Charadrius dubius*	A
Ringed Plover	*Charadrius hiaticula*	A
Lesser Sand Plover	*Charadrius mongolus*	AJ
Greater Sand Plover	*Charadrius leschenaultii*	AJ
Oriental Plover	*Charadrius veredus*	A
Lapwing	*Vanellus vanellus*	J
Grey Plover	*Pluvialis squatarola*	A
Pacific Golden Plover	*Pluvialis fulva*	AJ
Little Whimbrel	*Numenius (borealis) minutus*	A
Whimbrel	*Numenius phaeopus*	J
Curlew	*Numenius arquata*	AJ
Australian Curlew	*Numenius madagascariensis*	AJ
Black-tailed Godwit	*Limosa limosa*	AJ
Bar-tailed Godwit	*Limosa lapponica*	AJ
Spotted Redshank	*Tringa erythropus*	J
Redshank	*Tringa totanus*	AJ
Marsh Sandpiper	*Tringa stagnatilis*	AJ
Greenshank	*Tringa nebularia*	AJ
Green Sandpiper	*Tringa ochropus*	J
Wood Sandpiper	*Tringa glareola*	AJ
Nordmann's Greenshank	*Tringa guttifer*	J
Common Sandpiper	*Tringa hypoleucos*	AJ
Grey-rumped Sandpiper	*Tringa brevipes*	AJ
Terek Sandpiper	*Xenus cinereus*	AJ
Turnstone	*Arenaria interpres*	AJ
Swinhoe's Snipe	*Gallinago megala*	AJ
Pintail Snipe	*Gallinago stenura*	A
Common Snipe	*Gallinago gallinago*	J
Woodcock	*Scolopax rusticola*	J
Asiatic Dowitcher	*Limnodromus semipalmatus*	A
Red Knot	*Calidris canutus*	AJ
Great Knot	*Calidris tenuirostris*	AJ
Red-necked Stint	*Calidris ruficollis*	AJ
Long-toed Stint	*Calidris subminuta*	AJ
Temminck's Stint	*Calidris temminckii*	J
Sharp-tailed Sandpiper	*Calidris acuminata*	AJ
Dunlin	*Calidris alpina*	AJ
Curlew Sandpiper	*Calidris ferruginea*	AJ
Sanderling	*Calidris alba*	AJ
Spoon-billed Sandpiper	*Eurynorynchus pygmaeus*	J
Broad-billed Sandpiper	*Limicola falcinellus*	AJ
Ruff	*Philomachus pugnax*	AJ
Black-winged Stilt	*Himantopus himantopus*	J
Avocet	*Recurvirostra avosetta*	J
Red-necked Phalarope	*Phalaropus lobatus*	AJ
Grey Phalarope	*Phalaropus fulicarius*	AJ
Oriental Pratincole	*Glareola maldivarum*	AJ
Common Gull	*Larus canus*	J

Herring Gull	*Larus argentatus*	J
Slaty-backed Gull	*Larus schistisagus*	J
Black-headed Gull	*Larus ridibundus*	J
Black-legged Kittiwake	*Rissa tridactyla*	J
Common Tern	*Sterna hirundo*	AJ
Little Tern	*Sterna albifrons*	AJ
Ancient Auk	*Synthliboramphus antiquus*	J
Oriental Cuckoo	*Cuculus saturatus*	AJ
Short-eared Owl	*Asio flammeus*	J
White-throated Needletail	*Hirundapus caudacutus*	AJ
Pacific Swift	*Apus pacificus*	AJ
Little Swift	*Apus affinis*	J
Sand Martin	*Riparia riparia*	J
Barn Swallow	*Hirundo rustica*	AJ
Red-rumped Swallow	*Hirundo daurica*	AJ
Asian House Martin	*Delichon dasypus*	J
Forest Wagtail	*Dendronanthus indicus*	J
Yellow Wagtail	*Motacilla flava*	AJ
Citrine Wagtail	*Motacilla citreola*	AJ
White Wagtail	*Motacilla alba*	AJ
Richard's Pipit	*Anthus richardi*	J
Olive-backed Pipit	*Anthus hodgsoni*	J
Pechora Pipit	*Anthus gustavia*	J
Red-throated Pipit	*Anthus cervinus*	J
Water Pipit	*Anthus spinoletta*	J
Ashy Minivet	*Pericrocotus divaricatus*	J
Tiger Shrike	*Lanius tigrinus*	J
Brown Shrike	*Lanius cristatus*	J
Black-naped Oriole	*Oriolus chinensis*	J
Chestnut-cheeked Starling	*Sturnus philippensis*	J
Red-tailed Robin	*Luscinia sibilans*	J
Siberian Rubythroat	*Luscinia calliope*	J
Siberian Blue Robin	*Luscinia cyane*	J
Red-flanked Bluetail	*Tarsiger cyanurus*	J
Daurian Redstart	*Phoenicurus auroreus*	J
Stonechat	*Saxiocola torquata*	J
Siberian Thrush	*Zoothera sibiricus*	J
White's Thrush	*Zoothera dauma*	J
Grey-backed Thrush	*Turdus hortulorum*	J
Grey Thrush	*Turdus cardis*	J
Pale Thrush	*Turdus pallidus*	J
Eye-browed Thrush	*Turdus obscurus*	J
Dusky Thrush	*Turdus naumanni*	J
Short-tailed Bush Warbler	*Urosphena squameiceps*	J
Middendorf's Grasshopper Warbler	*Locustella ochotensis*	J
Lanceolated Warbler	*Locustella lanceolata*	J
Great Reed Warbler	*Acrocephalus orientalis*	AJ
Black-browed Reed Warbler	*Acrocephalus bistrigiceps*	J
Yellow-browed Warbler	*Phylloscopus inornatus*	J
Arctic Warbler	*Phylloscopus borealis*	AJ
Pale-legged Leaf Warbler	*Phylloscopus tenellipes*	J
Eastern Crowned Warbler	*Phylloscopus coronatus*	J

Yellow-rumped Flycatcher	*Ficedula zanthopygia*	J
Narcissus Flycatcher	*Ficedula narcissina*	J
Mugimaki Flycatcher	*Ficedula mugimaki*	J
Blue-and-White Flycatcher	*Cyanoptila cyanomelana*	J
Sooty Flycatcher	*Muscicapa sibirica*	J
Grey-streaked Flycatcher	*Muscicapa griseisticta*	J
Brown Flycatcher	*Muscicapa latirostris*	J
Japanese Paradise Flycatcher	*Terpsiphone atrocaudata*	J
Ruddy Sparrow	*Passer rutilans*	J
Brambling	*Fringilla montifringilla*	J
Siskin	*Carduelis spinus*	J
Black-tailed Hawfinch	*Eophona migratoria*	J
Yellow-breasted Bunting	*Emberiza aureola*	J
Black-faced Bunting	*Emberiza spodocephala*	J
Japanese Yellow Bunting	*Emberiza sulphurata*	J
Chestnut-eared Bunting	*Emberiza fucata*	J
Rustic Bunting	*Emberiza rustica*	J
Little Bunting	*Emberiza pusilla*	J
Tristram's Bunting	*Emberiza tristrami*	J
Pallas's Reed Bunting	*Emberiza pallasi*	J
Reed Bunting	*Emberiza schoeniclus*	J

A.95 These species are listed under:

(A) Agreement between the Government of Australia and the Government of the People's Republic of China for the Protection of Migratory Birds and Their Environment, and

(J) Agreement on the Protection of Migratory Birds and Their Habitats by the Governments of Japan and the People's Republic of China.

The Management Measures for Forests of Guangdong Province, Section 26

A.96 Natural reserves should be protected. Permission of relevant authorities is required for any special-aimed use of the resources within natural reserves.

The Environmental Management Regulations for Construction Projects in Guangdong Province, Section 4

A.97 Any decision on construction projects including their identification, layout, and siting should meet the environmental planning requirements. Consideration should be given to protecting and to enhancing the environmental quality of the whole area. Construction of projects which will cause environmental pollution and ecological damage to water source protection zones, natural reserves, and other special protection areas is prohibited.

Guangdong Provincial Implementary Detailed Regulations for Natural Reserves of Forest and Wildlife Species, Section 12

A.98 Natural environment and resources within the natural reserves should be managed by the administrative organization of nature reserves. Establishment of institutes or facilities is prohibited without approval of the Ministry of Forestry or the provincial authority of forest management.

Non Statutory Guidelines

Deep Bay Guidelines for Dredging, Reclamation and Drainage Works

A.99 The *Deep Bay Guidelines for Dredging, Reclamation and Drainage Works* (DBG) published by ERL (Asia) Ltd in association with Binnie Consultants Ltd for EPD in 1991, defines a large area of Inner Deep Bay and its coastal regions as a Special Measures Zone (SMZ). It encompasses the inner northeast Deep Bay, Mai Po, as well as areas to the north and northeast of the RZ. The area contained within the Buffer Zone 2 boundary in Figure A1 coincides with the SMZ boundary of the DBG in the Tin Shui Wai area.

A.100 Recommendations on acceptable noise levels, sediment quality, water quality and air quality were made for locations within this zone in order to protect the scientific, educational and amenity interest of the SMZ.

A.101 The recommended guidelines for water quality, noise level and air quality within the SMZ are shown in Tables A.12-A.17 for reference. These guidelines, however, are non-statutory and in some instances are now outdated. However, the spirit of the DBG should be retained as it was designed to protect the sensitive ecology of the area.

A.102 The purpose of the DBG is to provide Government project sponsors and construction contractors with general guidance on issues of:

- site selection;
- work methods;
- environmental site investigation needs;
- environmental constraints, criteria and monitoring requirements;
- design procedures, including assessment of impacts and selection of mitigation measures; and
- special conditions of contract and performance specifications to be applied to Deep Bay projects.

A.103 Environmental constraints contained in the Deep Bay Guidelines which may be relevant to this project include:

- water quality objectives for Inner, Middle and Outer Deep Bay;

- noise level limits for construction work;
- measures for minimizing disturbance to the SSSIs and nature reserves in the area;
- prevention of unnecessary destruction to mangroves stands; and
- controls on dumping Deep Bay.

Table A.12
Deep Bay Guidelines - Water Quality Objectives for Inner Deep Bay

Parameter	Water Quality Objective	
Dissolved oxygen	Water column mean concentration of not less than 4 mg/l on 95% of sampling occasions. Minimum concentration of not less than 2 mg/l on all sampling occasions at any depth.	
Un-ionised ammonia	Concentration of less than 20 µg/l, annual arithmetic mean.	
Suspended solids	Natural daily range of concentrations should not be increased by more than 30% (refer to Section 5.3 Control of Water Quality Item (d)).	
Temperature	Natural daily temperature range should not be increased by more than 2°C.	
pH	Between 7.0 and 8.5.	
Oil and grease	No visible trace.	
Other aesthetic	No tarry residues, other floating debris of human origin (bottles, cans, etc.) or recognisable debris from sewage. Surfactants should not be present in quantities sufficient to give lasting foam.	
Metals - annual average dissolved (i)		
Mercury	<	300 ng/l
Cadmium	<	1 µg/l
Copper	<	5 µg/l
Lead	<	10 µg/l
Zinc	<	40 µg/l
Nickel	<	30 µg/l
Chromium	<	15 µg/l
Arsenic	<	25 µg/l

(i) Arithmetic mean. The division between dissolved and particulate metals to be defined by a 0.45 µm filter.

Ref: Deep Bay Integrated Environmental Management Study (By ERL (Asia) Limited).

Table A.13
Deep Bay Guidelines - Water Quality Objectives for Middle and Outer Deep Bay

Parameter	Water Quality Objective	
Dissolved oxygen	Water column mean concentration of not less than 5 mg/l on 95% of sampling occasions. Minimum concentration of not less than 2 mg/l on all sampling occasions at any depth.	
Un-ionised ammonia	Concentration of less than 20 μg/l, annual arithmetic mean.	
Suspended solids	Natural daily range should not be increased by more than 30% (refer to Section 5.3 Control of Water Quality Item (d)).	
Temperature	Natural daily temperature range should not be increased by more than 1°C.	
pH	Between 7.0 and 8.5.	
Oil and grease	No visible trace.	
Other aesthetic	No tarry residues, other floating debris of human origin (bottles, cans, etc.) or recognisable debris from sewage. Surfactants should not be present in quantities sufficient to give lasting foam.	
Bacteria	Guide value for protection of shellfisheries - faecal coliforms should not exceed 300/100 ml. Present standards for bathing water quality should be complied with at all gazetted beaches in Deep Bay.	
Metals - annual average dissolved (ii)		
Mercury	<	300 ng/l
Cadmium	<	1 μg/l
Copper	<	5 μg/l
Lead	<	10 μg/l
Zinc	<	40 μg/l
Nickel	<	30 μg/l
Chromium	<	15 μg/l
Arsenic	<	25 μg/l

(i) To be measured by photometric method using the platinum/cobalt scale.
(ii) Arithmetic mean. The division between dissolved and particulate metals to be defined by a 0.45 μm filter.

Ref: Deep Bay Integrated Environmental Management Study (By ERL (Asia) Limited).

Table A.14
Deep Bay Guidelines - Interim Threshold Guideline Values for Significant Sediments Contamination

Parameter	Limit (mg/kg) (dry wt basis)
Cadmium	15
Chromium	500
Copper	500
Lead	200
Mercury	5
Nickel	500
Zinc	2000

Table A.15
Deep Bay Guidelines - Noise Level Limits for Construction Works Area, within the Deep Bay excluding the Inner Deep Bay Special Measures Zone

Time Period	Acceptable Noise Level (dB(A))(1)
Weekdays 0700-1900 hours (2)	75
Weekdays 1900-2300 hours	60
General Holidays (including Sundays) 0700-2300 hours	60
All Days, 2300-0700 hours	45

(1) (5 min.) Leq measured at the building facade of a Noise Sensitive Receiver (NSR).

(2) Alternative limit for weekdays, 0700-1900 hours, is 10 dB(A) above the ambient noise level (measured as 1-hour L_{90} dB(A)).

Table A.16
Deep Bay Guidelines - Noise Level Limits for Construction Works within Inner Deep Bay Special Measures Zone

Time Period	Acceptable Noise Level (dB(A))(1)
All days, 0700-2300 hours(2)	60
All Days, 2300-0700 hours	45

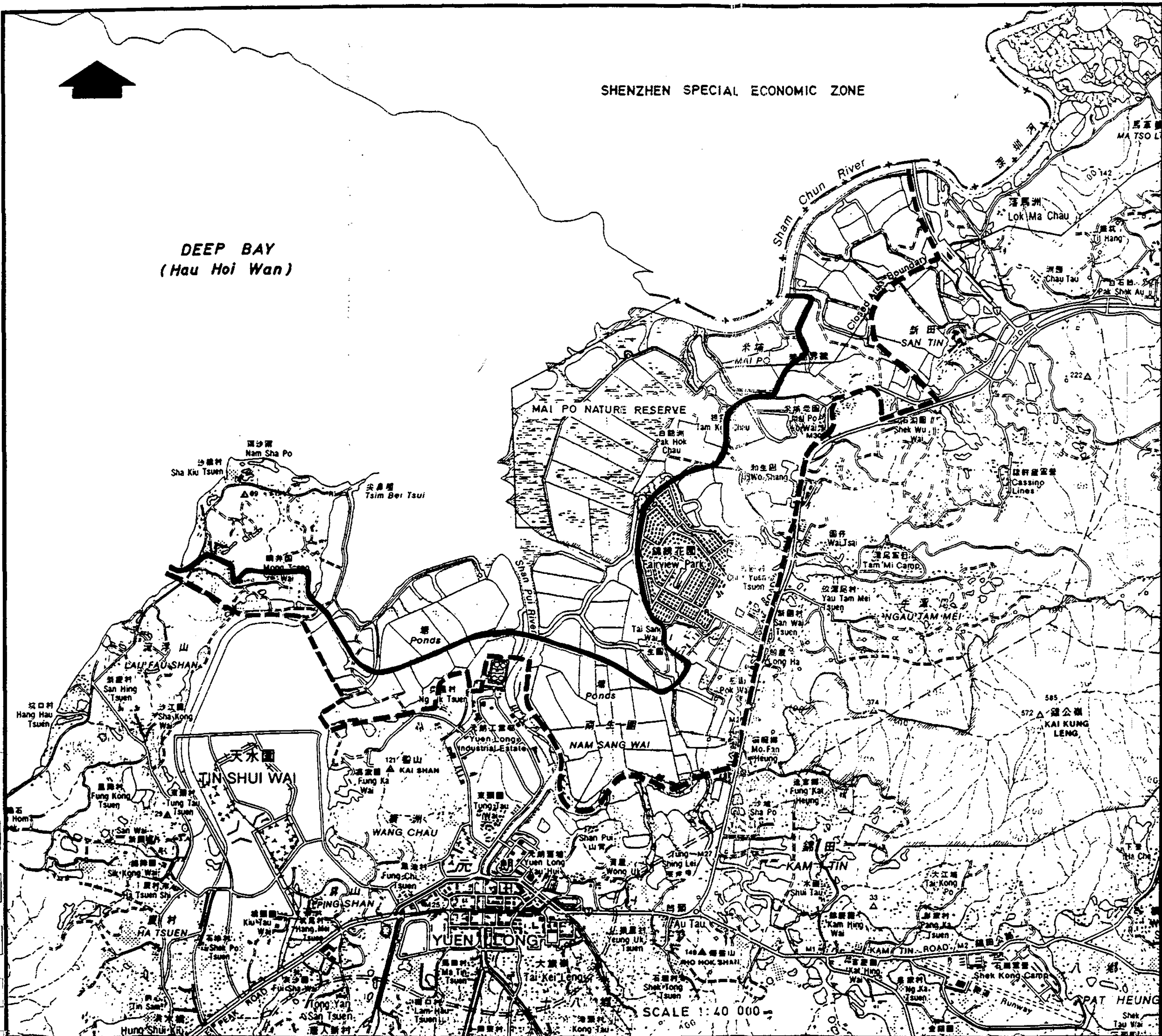
(1) Leq 5 min. measured freefield, 100 m from the site boundary.

(2) Alternative limit for weekdays, 0700-1900 hours, is 5 dB(A) above the ambient noise level (measured as 1-hour L_{90} dB(A)).

Table A.17
Deep Bay Guidelines - Air Quality Objectives for Deep Bay Catchment

Concentration (μg/m^3) for Different Averaging Times (i)				
	1 hr (ii)	8 hr (iii)	24 hr (iii)	1 yr (iv)
SO_2	350-500		150	80
TSP (v)			180	80
RSP (v)			110	55
NO_2	300		150	80
CO	30,000	10,000		
O_3	200	100-120		
Lead			1.5	

(i) Measured at 298°K and 101.325 kPa (one atmos).
(ii) Not to be exceeded more than 3 times per year.
(iii) Not to be exceeded more than once per year.
(iv) Arithmetic means.
(v) TSP = Total Suspended Particulates
RSP = Respirable Suspended Particulates.



NOTATION

BOUNDARY OF BUFFER ZONE 1

BOUNDARY OF BUFFER ZONE 2

LOCATION AND BOUNDARY OF "SPECIAL MEASURES ZONE" (SMZ) AS DEFINED IN THE DEEP BAY GUIDELINES 1991

PLANNING DEPARTMENT

PLAN REF. NO. SRNW-OT93/28 B	FIG. NO.
FILE REF. NO.	A 1
DATE OCT. 1993	

Appendix B

Details of Noise Calculations

Appendix B1

Construction Noise Assessment

APPENDIX B1 CONSTRUCTION NOISE ASSESSMENT

Noise Assessment Criteria

B1.1 The noise assessment criteria used for assessing construction noise impact are given in Table B1.1.

Table B1.1
Construction Noise Assessment Criteria

0700-1900 hrs on normal weekdays	75* dB(A), EPD's ProPECC PN/2	
0700-2300 hrs on holidays; and 1900-2300 hrs on all other days	60/65/70**(1) dB(A)	45/50/55**(2) dB(A)
2300-0700 hrs of next day	45/50/55**(1) dB(A)	30/35/40**(2) dB(A)

* reduce to 70 dB(A) for schools and 65 dB(A) during school examination periods.
** to be selected based on Area Sensitivity Rating.
(1) TM on Noise from Construction Work Other Than Percussive Piling.
(2) TM on Noise from Construction Work in Designated Area.

B1.2 At present evening and night time works (1900-0700) are not expected. However, should works within these hours be required, a Construction Noise Permit (CNP) must be obtained from the relevant Noise Control Authority before works are allowed to take place. Piling works are subject to licensing under the Noise Control Ordinance.

B1.3 Since concurrent works with significant construction noise are expected around the RZ, the day time noise criterion used for assessment of some NSRs has been lowered to 72 dB(A). The limiting of acceptable construction noise level is recommended to prevent the cumulative noise impact exceeding the 75 dB(A) limit.

B1.4 In addition, based on the Deep Bay Guidelines, 60 dB(A) should never be exceeded for all days 0700-2300 hours within the Special Measures Zone, as measured at a point 100 m outside the site boundary.

Emission Inventory

B1.5 The likely type, quantity and the SWL for each type of Powered Mechanical Equipment (PME) used for different construction activities are discussed below. It should be noted that this is an assumption of the likely equipment to be used. The actual construction equipment will be determined by the contractors performing the works. A 50% of time usage on certain mobile equipment has been assumed in the calculations. This is to avoid an overestimation of the PNL since in actual construction it is rare that all construction equipment will be operating at the same time.

B1.6 The sound power level for each type of PME is quoted from the following sources:

(i) *Technical Memorandum on Noise from Construction Work Other Than Percussive Piling, EPD (TM).*
(ii) *BS5228: Part 1: 1984 British Standard Noise Control on Construction and Open Sites, Code of Practice for Basic Information and Procedure for Noise Control.*

Site Formation

B1.7 Site formation is required for the whole RZ. Part of the ETC will need to be filled. The main noise sources are from the cut and fill operation, the transportation of fill material along the haul roads and the dumping of fill materials. Table B1.2 lists the tasks and equipment likely to be used for site formation works.

Table B1.2
Construction Equipment for General Site Formation Works

Equipment	Reference Code	Number	SWL per piece dB(A)	Total SWL dB(A)
Cut and Fill Operation				
Backhoe excavator*	CNP 081	(5)1+	112	(124.0) 118.7+
Bulldozer*	CNP 030	(8)2+	115	
Wheeled loader*	CNP 081	(4)1+	112	
Dump truck*	CNP 067	(2)1+	117	
Vibratory compactor*	CNP 050	(2)1+	105	
Dumping of Materials				
Dump truck*	CNP 067	(4)2+	117	(120.0) 117.0+

( ) Site formation of Areas 101-109a, 110 and 111; more equipment required because of larger site.
\+ Site formation of Area 109b, 112-117 and 120; less fill material to be moved.
* Assuming 50% of time usage.

Roadworks and Associated Drains and Sewers in the RZ

B1.8 Roads and other infrastructure will be constructed within in the RZ. Drainage will be installed along the new road sections in the RZ. Construction of drainage culverts will require excavation of a trench alongside the road. Precast concrete pipes will be lowered into the trench and backfilled before road sections are built. New roads will be levelled and compacted. Flexible pavement with dense bitumen macadam as roadbase will be used for all carriageways. Construction of Road D3 will require site formation prior to the road works. Table B1.3 lists the tasks and equipment likely to be used during roadworks in the RZ.

Table B1.3
Construction Equipment for Roadworks and Associated Drains and Sewers in the RZ

Equipment	Reference Code	Number	SWL per piece dB(A)	Total SWL dB(A)
Provision of Drains and Sewers				
Backhoe excavator*	CNP 081	1	112	113.8
Lorry*	CNP 141	1	112	
Mobile crane*	CNP 048	1	112	
Levelling of New Road				
Grader*	CNP 104	1	113	114.1
Bulldozer*	CNP 030	1	115	
Laying Base and Sub-base				
Dump truck*	CNP 067	1	117	114.5
Road roller*	CNP 185	1	108	
Resurfacing Works (for asphalt surface)				
Asphalt paver	CNP 004	1	109	113.5
Road roller	CNP 185	1	108	
Lorry*	CNP 141	1	112	

* Assuming 50% on time usage.

Junction Improvement in the DZ

B1.9 Existing junctions in the DZ will require upgrading or widening to cope with the increased traffic flow. The work involve local junction widening, provision of additional traffic lanes and modifications of the method of signal control. The work will require breaking of road surfaces, footpaths, planters and roundabouts, widening of road alignment, diversion of utilities and resurfacing works. Improvement works will be concentrated in the southern part of the DZ with some minor improvement work in other areas of the DZ. Table B1.4 lists the tasks and equipments likely to be used during junction improvement in the DZ.

Table B1.4
Construction Equipment for Junction Improvement

Equipment	Reference Code	Number	SWL per piece dB(A)	Total SWL dB(A)
Road Breaking				
Hand-held breaker	CNP 024	1	108	108.6
Air compressor	CNP 001	1	100	
Laying Base and Sub-base				
Dump truck*	CNP 067	1	117	114.5
Road roller*	CNP 185	1	108	
Resurfacing Works (for asphalt surface)				
Asphalt paver	CNP 004	1	109	113.5
Road roller	CNP 185	1	108	
Lorry*	CNP 141	1	112	

* Assuming 50% on time usage.

Widening and Dualling of Roads

B1.10 Existing roads will require widening and dualling to cope with increased traffic flow. The work will require construction of additional carriageways for Tin Ying Road, Tin Tsz Road, Tin Wah Road, Hung Tin Road and Long Tin Road. Site clearance will be conducted to remove unwanted materials for the first couple of months. This is followed by laying of sewers, levelling of roads and laying of base for the new roads. Flexible pavement with dense bitumen macadam as roadbase will be used for all carriageway. Site formation will be necessary during Tin Ying Road dualling as the road will be built on an embankment. Table B1.5 lists the tasks and equipment likely to be used during dualling of roads.

Table B1.5
Construction Equipment for Widening and Dualling of Roads

Equipment	Reference Code	Number	SWL per piece dB(A)	Total SWL dB(A)
Site Clearance				
Backhoe excavator*	CNP 081	1	112	115.2
Dump truck*	CNP 067	1	117	
Provision of Drains and Sewers				
Backhoe excavator*	CNP 081	1	112	113.8
Lorry*	CNP 141	1	112	
Mobile crane*	CNP 048	1	112	
Levelling of New Road				
Grader*	CNP 104	1	113	114.1
Bulldozer*	CNP 030	1	115	
Laying Base and Sub-base				
Dump truck*	CNP 067	1	117	114.5
Road roller*	CNP 185	1	108	
Resurfacing Works (for asphalt surface)				
Asphalt paver	CNP 004	1	109	113.5
Road roller	CNP 185	1	108	
Lorry*	CNP 141	1	112	

* Assuming 50% on time usage.

Bridge Building/Grade Separation of Junction

B1.11 Several channel crossing bridge will be built to provide an alternate route for RZ traffic. Some major junctions will require grade separation and flyovers will be constructed. Percussive piling will be required to provide foundations for the bridge and flyover. Table B1.6 lists the likely tasks and equipment associated with bridge and flyover construction.

Table B1.6
Construction Equipment for Bridge Building/Grade Separation of Junction

Equipment	Reference Code	Number	SWL per piece dB(A)	Total SWL dB(A)
Foundation Works				
Backhoe excavator*	CNP 081	1	112	113.8
Lorry*	CNP 141	1	112	
Mobile crane*	CNP 048	1	112	
Structural Works				
Generator (silenced)	CNP 102	2	100	112.8
Tower crane	CNP 049	1	95	
Bar bender and cutter	CNP 021	1	90	
Lorry*	CNP 141	2	112	
Welding set	-	1	100	
Concreting Works				
Concrete lorry mixer*	CNP 044	1	109	118.1
Vibratory poker	CNP 170	3	113	
Tower crane	CNP 049	1	95	

* Assuming 50% on time usage.

Construction of Sewage Pumping Station

B1.12 A sewage pumping station is proposed in Area 101. Percussive piling will be required for foundation works. Table B1.7 lists the likely equipment associated with the construction of the sewage pumping station.

Table B1.7
Construction Equipment for Construction of Sewage Pumping Station

Equipment	Reference Code	Number	SWL per piece dB(A)	Total SWL dB(A)
Foundation Works				
Backhoe excavator*	CNP 081	1	112	113.8
Lorry*	CNP 141	1	112	
Mobile crane*	CNP 048	1	112	
Structural Works				
Generator (silenced)	CNP 102	2	100	114.3
Mobile crane*	CNP 048	1	112	
Bar bender and cutter	CNP 021	1	90	
Lorry*	CNP 141	2	112	
Welding set	-	1	100	
Concreting Works				
Concrete lorry mixer*	CNP 044	1	109	118.1
Vibratory poker	CNP 170	3	113	

* Assuming 50% on time usage.

Construction of Rising Mains

B1.13 Trunk sewers are required to connect the sewage pumping station in Area 101 to the Ha Tsuen Sewage Pumping Station of NWNT Sewerage Scheme. Pipes will be laid in excavated trenches along the footpath of the WDC. No-dig technique will be used for crossing of the WDC. Table B1.8 lists the likely tasks and equipment associated with the connection of the rising mains.

Table B1.8
Construction Equipment for Construction of Rising Mains

Equipment	Reference Code	Number	SWL per piece dB(A)	Total SWL dB(A)
Excavation of Trenches				
Backhoe excavator	CNP 081	1	112	113.8
Lorry*	CNP 141	1	112	
Laying of Pipes				
Mobile crane*	CNP 048	1	112	112.1
Material hoist (electric)	CNP 122	1	95	
Lorry*	CNP 141	1	112	
Backfill and Resurfacing Works				
Backhoe excavator*	CNP 081	1	112	112.8
Vibratory compactor	CNP 050	1	105	
Lorry*	CNP 141	1	112	

* Assuming 50% on time usage.

Western Drainage Channel Extension

B1.14 The existing WTC is to be upgraded and lined with concrete 500 m downstream from the existing inflatable dam. An inflatable dam will be placed to prevent tidal water from entering the site. Water will be pumped out and the channel sediments excavated. Side slopes will be reinforced using granite blocks. Finally, the extended channel will be lined with concrete. Table B1.9 lists the likely tasks and equipments associated with the construction of the WDCE.

Table B1.9
Construction Equipment for Western Drainage Channel Extension

Equipment	Reference Code	Number	SWL per piece dB(A)	Total SWL dB(A)
Placement of Inflatable Dam				
Mobile crane*	CNP 048	1	112	109.6
Water pump, submersible (electric)	CNP 283	4	85	
Generator (silenced)	CNP 102	1	100	
Pumping of Water				
Water pump, submersible (electric)	CNP 283	4	85	100.5
Generator (silenced)	CNP 102	1	100	
Excavation of Channel Materials				
Backhoe excavator	CNP 081	1	112	118.2
Dump truck*	CNP 067	2	117	
Slope Foundation				
Mobile crane	CNP 048	1	112	113.8
Lorry*	CNP 141	1	112	
Concreting of Channel				
Concrete lorry mixer*	CNP 044	1	109	116.4
Vibratory poker	CNP 170	2	113	

* Assuming 50% on time usage.

Construction Noise Assessment Methodology

B.1.15 The calculation of the noise levels at the RNSR due to the construction activities is based on the methodology in the TM.

B.1.16 Based on the TM, the Notional Noise Source (NNS) positions have been located at the mid points between the geometric centre of the site and the site boundary along the line between the facade of the RNSR and the site's geometric centre.

B.1.17 If the construction site is linear in shape (that is, long, thin and substantially uniform in width, but not necessary straight) with a length to width ratio exceeding 5:1, only the dominant portion of the site shall be considered for the purpose of determining the notional source position.

B.1.18 However, if the NNSs were located at more than 50 metres away from the site boundary, the NNSs have been positioned at the point 50 metres away from the site boundary rather than the midpoints.

B.1.19 All the equipment in the equipment list apart from the dump truck traffic on the haul road have been assumed to be placed at the NNSs. The haul road traffic noise levels have been assessed separately, and added to the predicted noise levels to give the total predicted noise levels at each RNSR.

Haul Road Traffic Calculation

B.1.20 The estimated amount of materials to be moved along haul roads within the site and the number of vehicle movements per hour during site formation works are tabulated below in Table B1.10 and B1.11.

Table B1.10
Haul Road Traffic Volume during Site Formation of Areas 109b, 112-117 and 120

Haul Road	Site Formation Areas	Volume of Materials (m^3)	Construction Period (months)	No. of Vehicle Roundtrips per Hour (veh/hr)
A	Filling of ETC and surrounding Areas	460,000	15	40
B	Filling of Areas around 112	38,000	15	4
C	Tin Ying Road dualling	91,000	12	10
D	Road D3 & Area 121	128,000	12	14

B.1.21 The likely location of the haul roads are shown in Figures 4.1.1, 4.1.4 and 4.1.9.

B.1.22 The calculations assumed the works to proceed for 10 hours per day and 26 days per month. Each dump truck was taken to have a capacity of 6 m^3 and is travelling at a speed of 15 km/hr.

B.1.23 It has been assumed that a dump truck has a SWL of 113 dB when it is travelling along a haul road. This figure was derived by logarithmically averaging the SWL of 35 ton dump trucks in Table 12 of BS5228.

B.1.24 The calculation of haul road traffic was based on the method given in BS5228. The general expression for predicting the L_{Aeq} alongside a haul road used by mobile sources is:

$$L_{Aeq}\ (dB(A)) = L_{WA} - 33 + 10\log_{10}Q - 10\log_{10}V - 10\log_{10}d$$

where:
L_{WA} is the sound power level of the plant;
Q is the number of vehicles per hour;
V is the average vehicle speed in kilometres per hour (assume 15 km/hr);
d is the distance of receiving position from the centre of haul road in metres.

B.1.25 The noise level generated by the haul road traffic noise are tabulated below in Table B1.12 and B1.13.

Table B1.11
Haul Road Traffic Volume during Site Formation of Areas 101-109a, 110 and 111

Area	Works Contract	Haul Road	Volume of Materials (m^3)	Earth Movement Period (months)	Number of Vehicle Roundtrips per Hour (veh/hr)
102	1	H1	55000	4	18
102	1	H2	83000	4	28
102	1	H19	5000	4	2
102	1	H20	6000	4	2
101	2	H9	34000	4	12
103	2	H6	9000	6	2
103	2	H7	8000	6	2
103	2	H21	15000	6	4
104	2	H22	37000	2	24
104	2	H23	38000	2	26
105	2	H12	34000	6	8
105	2	H24	34000	6	8
106	2	H25	7000	6	2
107a	2	H26	15000	8	4
107b	2	H27	10000	9	2
107b	2	H28	24000	9	4
108a	2	H29	6000	6	2
108a	2	H30	14000	6	4
108b	2	H31	4000	9	2
109a	2	H32	3000	8	2
109a	2	H33	72000	8	12
110	2	H15	122000	8	20
110	2	H16	66000	8	12
110	2	H34	20000	8	4
111a	2	H35	37000	2	24
111a	2	H36	1000	2	2
111b	2	H37	26000	8	6
111b	2	H38	19000	8	4

Table B.1.12
Haul Road Traffic Noise Calculation during Site Formation of Areas 109b, 112-117 and 120

RNSR	No. of Vehicle per Hour	Distance (m)	L_{Aeq} (dB(A))
Haul Road A			
1	40	900	57.7
26	40	1380	55.9
65	40	180	64.7
51	40	1170	56.5
56	40	750	58.5
Haul Road B			
1	4	670	49.0
26	4	1400	45.8
65	4	810	48.2
51	4	1250	46.3
56	4	1000	47.3
Haul Road C			
1	10	460	54.6
26	10	350	55.8
68	10	200	58.2
65	10	1000	51.2
72	10	120	60.4
51	10	26	67.1
53	10	220	57.8
73	10	175	58.8
56	10	1150	50.6
Haul Road D			
32	14	180	60.1
29	14	165	60.5
22	14	180	60.1
19	14	160	60.7
26	14	220	59.3
15	14	170	60.4
10	14	240	58.9

Notes:
(1) Assume travelling speed of 15 km/hr.
(2) Assume dump truck SWL of 113 dB.
(3) 3 dB(A) facade correction included in the LAeq.
(4) Haul road A is used during site formation of Areas 109b,112-117 & 120 for filling ETC and adjacent Areas.
(5) Haul road B is used during site formation of Areas 109b,112-117 & 120 for filling part of Area 112.
(6) Haul road C is used for carrying fills for Tin Ying Road dualling.
(7) Haul road D is used during site formation of Road D3 and Area 121.

Table B1.13
Haul Road Traffic Noise Calculation during Site Formation of Areas 101-109a, 110 & 111

NSR	Haul Road	No. of Vehicle/Hour	Distance (m)	L_{Aeq} (dB(A))	T.SWL (dB(A))
66	H22	50	310	63.3	67.2
	H21	8	430	53.9	
	H1	50	780	59.3	
	H9	12	1160	51.4	
	H33	14	530	55.5	
	H30	8	530	53.0	
	H26	10	770	52.4	
	H25	2	980	44.3	
	H12	16	1230	52.4	
	H35	36	1000	56.8	
	H15	36	1040	56.6	
64	H22	50	250	64.2	69.1
	H21	8	130	59.1	
	H1	50	340	62.9	
	H9	12	680	53.7	
	H33	14	470	56.0	
	H30	8	330	55.1	
	H26	10	450	54.7	
	H25	2	650	46.1	
	H12	16	810	54.2	
	H35	36	720	58.2	
	H15	36	890	57.3	
138	H22	50	670	60.0	66.6
	H21	8	560	52.8	
	H1	50	450	61.7	
	H9	12	550	54.6	
	H33	14	890	53.2	
	H30	8	740	51.6	
	H26	10	750	52.5	
	H25	2	870	44.9	
	H12	16	920	53.6	
	H35	36	1000	56.8	
	H15	36	1200	56.0	

Table B1.13 (cont'd)
Haul Road Traffic Noise Calculation during Site Formation of Areas 101-109a, 110 & 111

NSR	Haul Road	No. of Vehicle/Hour	Distance (m)	L_{Aeq} (dB(A))	T.SWL (dB(A))
139	H22	50	920	58.6	66
	H21	8	790	51.3	
	H1	50	530	61.0	
	H9	12	510	55.0	
	H33	14	1010	52.7	
	H30	8	960	50.4	
	H26	10	930	51.6	
	H25	2	990	44.3	
	H12	16	970	53.4	
	H35	36	1030	56.7	
	H15	36	1310	55.6	
27	H22	50	1520	56.4	64.6
	H21	8	1260	49.3	
	H1	50	840	59.0	
	H9	12	630	54.0	
	H33	14	1580	50.7	
	H30	8	1430	48.7	
	H26	10	1250	50.3	
	H25	2	1120	43.8	
	H12	16	930	53.6	
	H35	36	1290	55.7	
	H15	36	1320	55.6	
26	H22	50	1380	56.8	65.5
	H21	8	1100	49.9	
	H1	50	700	59.8	
	H9	12	470	55.3	
	H33	14	1390	51.3	
	H30	8	1250	49.3	
	H26	10	1010	51.2	
	H25	2	860	44.9	
	H12	16	650	55.2	
	H35	36	1000	56.8	
	H15	36	1000	56.8	

Table B1.13 (cont'd)
Haul Road Traffic Noise Calculation during Site Formation of Areas 101-109a, 110 & 111

NSR	Haul Road	No. of Vehicle/Hour	Distance (m)	L_{Aeq} (dB(A))	T.SWL (dB(A))
1	H22	50	1470	56.6	65.1
	H21	8	1310	49.1	
	H1	50	1300	57.1	
	H9	12	1280	51.0	
	H33	14	1040	52.5	
	H30	8	1020	50.2	
	H26	10	1000	51.2	
	H25	2	940	44.5	
	H12	16	840	54.0	
	H35	36	770	57.9	
	H15	36	640	58.7	

Notes :

(1) Assume travelling speed of 15 km/hr.
(2) Assume dump truck SWL of 113 dB.
(3) 3 dB(A) facade correction included in the LAeq.
(4) Number of vehicles per hour for each major haul road.

(Area 102) H1 = sum of H1 to H2 & H19 - H20
(Area 101) H9 = H9
(Area 103) H21 = sum of H6 to H7 & H21
(Area 104) H22 = sum of H22 & H23
(Area 105) H12 = sum of H12 & H24
(Area 106) H25 = H25
(Area 107) H26 = sum of H26 to H28
(Area 108) H30 = sum of H29 to H31
(Area 109) H33 = sum of H32 & H33
(Area 110) H15 = sum of H15 to H16 & H34
(Area 111) H35 = sum of H35 to H38

Construction Noise Calculation

B.1.26 The construction noise level calculations follow the procedures described in the TMs.

Summation of Noise Levels

B.1.27 Summation of noise levels has been calculated based on the following formula:

$$\text{Total SWL (dB(A))} = 10 \log_{10} \Sigma Ni\ 10^{(SWLi/10)}$$

where:
SWL is the sound power level;
SWLi is the SWL of a particular type of powered mechanical equipment (PME);
Ni is the number of that type of PME.

Distance Attenuation

B.1.28 The predicted noise level at the NSR due to distance attenuation has been calculated as follows:

for general construction noise:

$$\text{PNL at the NSR (dB(A))} = \text{Total SWL} - 20 \log_{10} D - 8$$

where:
PNL is the predicted noise level;
D is the distance between the NSR and the noise source in metres.

Correction for Acoustic Reflection

B.1.29 A positive correction of 3 dB(A) is added to the PNL for acoustic reflections from the facade of the NSRs if it is a building.

Barrier Correction

B.1.30 During the construction phase, there are no natural or man-made barriers between the noise sources and receivers hence no barrier correction was considered.

Appendix B2

Operation Noise

TABLE B2.1 DO NOTHING SCENARIO AM PEAK TRAFFIC DATA IN YEAR 2000

Road division	Total no. of vehicles per hour (Veh/hr)	Total percentage of heavy vehicles (HGV%)	A BNL L10, dB(A)	B Speed + HGV% L10, dB(A)	Overall noise level due to A+B
D1.1	1414	91	74	8	81.9
D1.2	1472	89	74	8	82.0
D1.3	1908	33	75	5	79.7
D1.4	1388	20	74	3	76.9
D1.5	2470	15	76	3	78.8
D1.6	400	42	68	5	73.7
D2.1	991	86	72	8	80.2
D2.2	1288	73	73	7	80.7
D2.3	1288	73	73	7	80.7
D2.4	850	49	71	6	77.5
D2.5	625	65	70	7	77.1
D2.6	625	65	70	7	77.1
D2.7	865	47	72	6	77.4
D2.8	963	42	72	5	77.5
D2.9	115	10	63	2	64.6
D2.10	115	10	63	2	64.6
D3.1	-	-	-	-	-
D3.2	-	-	-	-	-
D3.3	-	-	-	-	-
D4.1	-	-	-	-	-
D4.2	-	-	-	-	-
L1.1	1566	11	74	2	76.1
L1.2	1566	11	74	2	76.1
L1.3	953	12	72	2	74.1
L2.1	2522	8	76	1	77.6
L2.2	2237	8	76	1	77.1
L3.1	874	5	72	1	72.4
L3.2	903	16	72	3	74.5
L3.3	1236	13	73	2	75.4
L3.4	1835	13	75	2	77.2
L3.5	-	-	-	-	-
L3.6	-	-	-	-	-
L3.7	-	-	-	-	-
L3.8	2089	5	75	1	76.2
L3.9	1973	4	75	1	75.7
L4.1	868	15	72	3	74.2
L4.2	2507	8	76	1	77.6
L4.3	1014	12	72	2	74.4
L4.4	626	12	70	2	72.3
L4.5	325	22	67	4	70.9
L5.1	1325	9	73	2	75.0
L5.2	433	18	69	3	71.6
L6.1	266	18	66	3	69.5
L6.2	266	18	66	3	69.5
L7	372	14	68	2	70.4
L8.1	1863	7	75	1	76.1
L8.2	1139	5	73	1	73.6
L10.1	921	6	72	1	72.9
L10.2	258	21	66	3	69.8
L12.1	-	-	-	-	-
L12.2	-	-	-	-	-
L12.3	-	-	-	-	-
L12.4	-	-	-	-	-
L12.5	-	-	-	-	-

TABLE B2.1 DO NOTHING SCENARIO AM PEAK TRAFFIC DATA IN YEAR 2000 (cont'd)

Road division	Total no. of vehicles per hour (Veh/hr)	Total percentage of heavy vehicles (HGV%)	A BNL L10, dB(A)	B Speed + HGV% L10, dB(A)	Overall noise level due to A+B
L12.6	-	-	-	-	-
L13.1	-	-	-	-	-
L13.2	-	-	-	-	-
L13.3	-	-	-	-	-
L13.4	-	-	-	-	-
L13.5	-	-	-	-	-
L13.6	-	-	-	-	-
L14.1	-	-	-	-	-
L14.2	-	-	-	-	-
L14.3	-	-	-	-	-
L14.4	-	-	-	-	-
L14.5	-	-	-	-	-
L14.6	-	-	-	-	-
P1	857	72	72	7	78.9
P2.1	2909	16	77	3	79.6
P2.2	846	46	71	6	77.3
22	-	-	-	-	-
33	-	-	-	-	-
Ping Ha Road	1619	22	74	4	77.9
Hung Tin Road	2938	59	77	7	83.5
Long Tin Road	4724	14	79	2	81.4

TABLE B2.2 WORST CASE TRAFFIC DATA AND ASSOCIATED NOISE LEVELS

Road division	Total no. of vehicles per hour (Veh/hr)	Total percentage of heavy vehicles (HGV%)	A BNL L10, dB(A)	B Speed + HGV% L10, dB(A)	Overall noise level due to A+B
D1.1	1383	84	74	8	81.5
D1.2	1441	83	74	8	81.6
D1.3	2778	26	77	4	80.7
D1.4	2654	12	76	2	78.5
D1.5	3480	9	78	2	79.2
D1.6	392	47	68	6	74.0
D2.1	892	83	72	8	79.6
D2.2	1375	57	74	6	80.1
D2.3	1375	57	74	6	80.1
D2.4	3355	11	77	2	79.5
D2.5	951	28	72	4	76.3
D2.6	952	28	72	4	76.3
D2.7	1171	19	73	3	76.0
D2.8	1966	16	75	3	77.9
D2.9	180	26	65	4	68.7
D2.10	180	26	65	4	68.7
D3.1	1566	7	74	1	75.4
D3.2	713	10	71	2	72.6
D3.3	728	10	71	2	72.6
D4.1	1430	8	74	1	75.2
D4.2	1771	6	75	1	75.7
L1.1	2302	9	76	2	77.5
L1.2	2024	10	75	2	77.1
L1.3	1281	13	73	2	75.6
L2.1	3566	7	78	1	79.0
L2.2	3356	7	77	1	78.7
L3.1	890	6	72	1	72.7
L3.2	1377	13	74	2	75.8
L3.3	2207	10	76	2	77.4
L3.4	2581	10	76	2	78.2
L3.5	647	5	70	1	71.0
L3.6	401	9	68	2	69.8
L3.7	300	3	67	0	67.3
L3.8	1577	7	74	1	75.4
L3.9	1794	6	75	1	75.7
L4.1	1866	9	75	2	76.6
L4.2	2924	8	77	1	78.2
L4.3	1232	12	73	2	75.2
L4.4	1041	10	72	2	74.2
L4.5	554	12	70	2	71.8
L5.1	1950	6	75	1	76.1
L5.2	1930	6	75	1	76.2
L6.1	2067	4	75	1	76.0
L6.2	1781	6	75	1	75.6
L7	805	8	71	2	72.8
L8.1	2228	6	76	1	76.7
L8.2	1139	5	73	1	73.7
L10.1	922	5	72	1	72.6
L10.2	1056	6	72	1	73.4
L12.1	2586	6	76	1	77.4
L12.2	1825	6	75	1	75.9
L12.3	1113	7	73	1	73.9
L12.4	1243	7	73	1	74.4
L12.5	1601	7	74	1	75.5

TABLE B2.2 WORST CASE TRAFFIC DATA AND ASSOCIATED NOISE LEVELS (cont'd)

Road division	Total no. of vehicles per hour (Veh/hr)	Total percentage of heavy vehicles (HGV%)	A BNL L10, dB(A)	B Speed + HGV% L10, dB(A)	Overall noise level due to A+B
L12.6	632	3	70	0	70.5
L13.1	1308	8	73	1	74.7
L13.2	1924	7	75	1	76.4
L13.3	1856	6	75	1	76.0
L13.4	1674	7	74	1	75.7
L13.5	602	5	70	1	70.7
L13.6	1882	7	75	1	76.2
L14.1	2506	6	76	1	77.3
L14.2	2615	7	76	1	77.6
L14.3	798	7	71	1	72.5
L14.4	729	7	71	1	72.0
L14.5	869	8	72	1	73.0
L14.6	459	3	69	0	69.1
P1-Flyover	3162	20	77	3	80.5
P1-Left Top	165	1	64	0	64.1
P1-Left Bottom	1187	37	73	5	78.0
P1-Right Top	198	25	65	4	69.1
P1-Right Bottom	1503	37	74	5	79.1
P2.1	4792	10	79	2	80.9
P2.2	3297	12	77	2	79.5
22	1036	5	72	1	73.1
33	546	6	70	1	71
Ping Ha Road	2285	22	76	4	79
Hung Tin Road	5818	28	80	4	84
Long Tin Road	7404	10	81	2	83

Table B2.3 **Unmitigated (except for friction course) and mitigated worst case predicted noise levels (MTNL) at representative noise sensitive facades, $L_{10\,(1\text{-hour})}$ in dB(A) affected by the new roads.**

Area	NSR of Facade ('s' for school)	Floor	New traffic Data Predicted noise levels L10 (1-hour), dB(A) (before mitigation)	New traffic Data Exceeds HKPSG Standards? (before mitigation)	New traffic Data Predicted noise levels L10 (1-hour), dB(A) (after mitigation)	Mitigation provided
3	73a	1	71	Yes	68	Barrier provided
3	73a	10	70		69	
3	73a	20	69		69	
3	73a	30	68		68	
3	73a	40	67		67	
3	73b	1	70		66	
3	73b	10	69		68	
3	73b	20	68		68	
3	73b	30	67		67	
3	73b	40	67		66	
3	74a	1	64		64	
3	74a	10	64		64	
3	74a	20	64		64	
3	74a	30	63		63	
3	74a	40	63		63	
3	74b	1	64		64	
3	74b	10	64		64	
3	74b	20	64		64	
3	74b	30	63		63	
3	74b	40	63		63	
3	75a	1	70		60	
3	75a	10	70		65	
3	75a	20	71	Yes	68	
3	75a	30	71	Yes	69	Barrier provided
3	75a	40	71	Yes	69	
3	75b	1	70		63	
3	75b	10	71	Yes	67	
3	75b	20	71	Yes	69	Barrier provided
3	75b	30	71	Yes	70	
3	75b	40	70		70	
3	75c	1	70		61	
3	75c	10	70		66	
3	75c	20	71	Yes	69	
3	75c	30	71	Yes	69	Barrier provided
3	75c	40	71	Yes	69	
3	77a	1	64		54	
3	77a	10	64		57	
3	77a	20	68		60	
3	77a	30	68		63	
3	77a	40	68		65	
3	77b	1	63		57	
3	77b	10	66		62	
3	77b	20	70		65	
3	77b	30	70		67	
3	77b	40	70		68	
3	78a	1	58		57	
3	78a	10	67		66	
3	78a	20	69		69	
3	78a	30	68		68	
3	78a	40	67		67	
3	78b	1	57		55	
3	78b	10	69		64	
3	78b	20	71	Yes	68	Barrier provided
3	78b	30	70		68	
3	78b	40	70		68	
3	78c	1	66		66	
3	78c	10	66		66	
3	78c	20	66		65	
3	78c	30	65		65	
3	78c	40	65		64	

Careful layout will be needed

Table B2.3 (cont'd) Unmitigated (except for friction course) and mitigated worst case predicted noise levels (MTNL) at representative noise sensitive facades, $L_{10\ (1\text{-hour})}$ in dB(A) affected by the new roads.

Area	NSR of Facade ('s' for school)	Floor	New traffic Data Predicted noise levels L10 (1-hour), dB(A) (before mitigation)	New traffic Data Exceeds HKPSG Standards? (before mitigation)	New traffic Data Predicted noise levels L10 (1-hour), dB(A) (after mitigation)	Mitigation provided
3	87a	1	52		52	
3	87a	10	52		52	
3	87a	20	51		51	
3	87a	30	51		51	
3	87a	40	51		51	
3	87b	1	64		64	
3	87b	10	63		63	
3	87b	20	62		62	
3	87b	30	62		62	
3	87b	40	61		61	
3	140a	1	70		68	
3	140a	10	70		70	
3	140a	20	69		69	
3	140a	30	69		68	
3	140a	40	68		67	
3	141a	1	71	Yes	68	Barrier provided
3	141a	10	70		70	
3	141a	20	69		69	
3	141a	30	68		68	
3	141a	40	67		67	
3	142a	1	70		68	
3	142a	10	70		69	
3	142a	20	69		69	
3	142a	30	68		68	
3	142a	40	67		67	
3	s76a	1	73	Yes	63	Barrier provided
3	s76a	2	73	Yes	63	
3	s76a	3	73	Yes	64	
3	s76a	4	73	Yes	64	
3	s76a	5	73	Yes	65	
3	s76a	6	73	Yes	65	
3	s76b	1	67	Yes	63	
3	s76b	2	67	Yes	63	
3	s76b	3	67	Yes	64	
3	s76b	4	67	Yes	64	
3	s76b	5	67	Yes	64	
3	s76b	6	67	Yes	65	
3	s79a	1	73	Yes	60	
3	s79a	2	73	Yes	62	
3	s79a	3	73	Yes	63	
3	s79a	4	73	Yes	63	
3	s79a	5	74	Yes	64	
3	s79a	6	74	Yes	64	
3	s79b	1	58		58	
3	s79b	2	62		61	
3	s79b	3	69	Yes	63	Barrier provided
3	s79b	4	73	Yes	64	
3	s79b	5	74	Yes	64	
3	s79b	6	74	Yes	64	
3	s80a	1	72	Yes	60	
3	s80a	2	72	Yes	61	
3	s80a	3	72	Yes	61	
3	s80a	4	72	Yes	62	
3	s80a	5	72	Yes	63	
3	s80a	6	73	Yes	64	
3	s80b	1	58		57	
3	s80b	2	60		59	
3	s80b	3	69	Yes	60	Barrier provided
3	s80b	4	71	Yes	60	
3	s80b	5	71	Yes	61	

Careful layout will be needed

Table B2.3 (cont'd) Unmitigated (except for friction course) and mitigated worst case predicted noise levels (MTNL) at representative noise sensitive facades, $L_{10\,(1\text{-hour})}$ in dB(A) affected by the new roads.

Area	NSR of Facade ('s' for school)	Floor	New traffic Data Predicted noise levels L10 (1-hour), dB(A) (before mitigation)	New traffic Data Exceeds HKPSG Standards? (before mitigation)	New traffic Data Predicted noise levels L10 (1-hour), dB(A) (after mitigation)	Mitigation provided
3	s80b	6	72	Yes	61	Barrier provided
8	s72a	1	71	Yes	71	TDD will provide A/C. This school sits next to old bridge, cannot take barrier loading.
8	s72a	2	71	Yes	71	
8	s72a	3	71	Yes	71	
8	s72a	4	71	Yes	71	
8	s72a	5	71	Yes	71	
8	s72a	6	71	Yes	71	
Ha Mei San Tsuen	69a	G	69		69	
Ha Mei San Tsuen	69a	1	69		69	
Ha Mei San Tsuen	69b	G	65		65	
Ha Mei San Tsuen	69b	1	66		66	
13	83b	1	63		63	
13	83b	10	68		68	
13	83b	20	69		69	
13	83b	30	69		69	
13	83b	40	68		68	
13	91a	1	66		66	
13	91a	10	69		69	
13	91a	20	70		70	
13	91a	30	69		69	
13	91a	40	68		68	
13	91b	1	66		66	
13	91b	10	69		69	
13	91b	20	69		69	
13	91b	30	69		69	
13	91b	40	67		67	
16	68b	1	67		67	
16	68b	10	66		66	
16	68b	20	66		66	
16	68b	30	66		66	
16	68b	40	66		66	
16	71c	1	68		68	
16	71c	10	67		67	
16	71c	20	67		67	
16	71c	30	67		67	
16	71c	40	66		66	
16	s165a	1	66	Yes	63	Barrier provided
16	s165a	2	66	Yes	63	
16	s165a	3	66	Yes	63	
16	s165a	4	66	Yes	63	
16	s165a	5	66	Yes	63	
16	s165a	6	66	Yes	63	
16	s165b	1	67	Yes	62	
16	s165b	2	67	Yes	62	
16	s165b	3	67	Yes	62	
16	s165b	4	67	Yes	62	
16	s165b	5	67	Yes	63	
16	s165b	6	67	Yes	63	
24	103a	1	66		66	
24	103a	10	66		66	
24	103a	20	66		66	
24	103a	30	66		66	
24	103a	40	66		66	
24	103b	1	65		65	
24	103b	10	65		65	
24	103b	20	65		65	
24	103b	30	64		64	
24	103b	40	64		64	
24	66a	1	63		61	
24	66a	10	66		64	

Careful layout will be needed

Table B2.3 (cont'd) Unmitigated (except for friction course) and mitigated worst case predicted noise levels (MTNL) at representative noise sensitive facades, $L_{10\ (1\text{-hour})}$ in dB(A) affected by the new roads.

Area	NSR of Facade ('s' for school)	Floor	New traffic Data Predicted noise levels L10 (1-hour), dB(A) (before mitigation)	New traffic Data Exceeds HKPSG Standards? (before mitigation)	New traffic Data Predicted noise levels L10 (1-hour), dB(A) (after mitigation)	Mitigation provided
24	66a	20	68		67	
24	66a	30	68		67	
24	66a	40	68		67	
24	66b	1	64		64	
24	66b	10	66		66	
24	66b	20	68		68	
24	66b	30	68		68	
24	66b	40	68		68	
24	86a	1	64		64	
24	86a	10	70		70	
24	86a	20	70		69	
24	86a	30	69		69	
24	86a	40	68		68	
24	86b	1	66		66	
24	86b	10	70		70	
24	86b	20	69		69	
24	86b	30	68		68	
24	86b	40	68		68	
24	s116a	1	66	Yes	66	TDD will provide A/C. Direct mitigation not effective as noise levels from old road already high
24	s116a	2	66	Yes	66	
24	s116a	3	67	Yes	67	
24	s116a	4	67	Yes	67	
24	s116a	5	67	Yes	67	
24	s116a	6	67	Yes	67	
27	64a	1	72	Yes	66	Barrier provided
27	64a	10	72	Yes	68	
27	64a	20	71	Yes	69	
27	64a	30	69		69	
27	64a	40	69		69	
27	64b	1	72	Yes	69	Barrier provided
27	64b	10	71	Yes	69	
27	64b	20	69		69	
27	64b	30	68		68	
27	64b	40	68		68	
28	137a	1	74	Yes	73	Direct mitigation not possible due to position near junction, but not eligible for indirect measures due to high prevailing noise level
28	137a	10	73	Yes	72	
28	137a	20	72	Yes	70	
28	137a	30	71	Yes	69	
28	137a	40	70		69	
28	137b	1	75	Yes	74	
28	137b	10	74	Yes	72	
28	137b	20	72	Yes	71	
28	137b	30	71	Yes	70	
28	137b	40	70		69	
28	65a	1	74	Yes	64	Barrier provided
28	65a	10	74	Yes	67	
28	65a	20	72	Yes	69	
28	65a	30	71	Yes	69	
28	65a	40	70		69	
28	65b	1	75	Yes	64	Barrier provided
28	65b	10	74	Yes	68	
28	65b	20	72	Yes	69	
28	65b	30	71	Yes	69	
28	65b	40	70		68	
30	50a	1	68		62	
30	50a	10	68		65	
30	50a	20	67		67	
30	50a	30	67		67	
30	50a	40	67		67	
30	50b	1	64		64	

Careful layout will be needed

Table B2.3 (cont'd) Unmitigated (except for friction course) and mitigated worst case predicted noise levels (MTNL) at representative noise sensitive facades, $L_{10\,(1\text{-hour})}$ in dB(A) affected by the new roads.

Area	NSR of Facade ('s' for school)	Floor	New traffic Data Predicted noise levels L10 (1-hour), dB(A) (before mitigation)	New traffic Data Exceeds HKPSG Standards? (before mitigation)	New traffic Data Predicted noise levels L10 (1-hour), dB(A) (after mitigation)	Mitigation provided
30	50b	10	64		64	
30	50b	20	63		63	
30	50b	30	63		63	
30	50b	40	63		63	
30	50c	1	65		63	
30	50c	10	65		64	
30	50c	20	65		65	
30	50c	30	65		65	
30	50c	40	65		65	
30	52a	1	59		59	
30	52a	10	61		61	
30	52a	20	60		60	
30	52a	30	59		59	
30	52a	40	58		58	
30	52b	1	61		61	
30	52b	10	61		61	
30	52b	20	60		60	
30	52b	30	60		60	
30	52b	40	59		59	
30	s51a +	4	70	Yes	70	Not due to new roads HA will provide fixed window.
30	s51a +	5	70	Yes	70	
30	s51a +	6	70	Yes	70	
30	s53a	1	67	Yes	64	Barrier provided
30	s53a	2	67	Yes	64	
30	s53a	3	67	Yes	64	
30	s53a	4	67	Yes	64	
30	s53a	5	67	Yes	64	
30	s53a	6	67	Yes	64	
30	s53b	1	68	Yes	61	
30	s53b	2	68	Yes	61	
30	s53b	3	68	Yes	62	
30	s53b	4	68	Yes	62	
30	s53b	5	68	Yes	63	
30	s53b	6	68	Yes	63	
31	54a	1	64		64	
31	54a	10	66		66	
31	54a	20	65		65	
31	54a	30	64		64	
31	54a	40	63		63	
31	54b	1	68		68	
31	54b	10	69		69	
31	54b	20	68		68	
31	54b	30	67		67	
31	54b	40	66		66	
31	55a	1	46		46	
31	55a	10	48		48	
31	55a	20	64		64	
31	55a	30	63		63	
31	55a	40	63		63	
31	55b	1	59		59	
31	55b	10	62		62	
31	55b	20	68		68	
31	55b	30	68		68	
31	55b	40	67		67	
31	56a	1	67		67	
31	56a	10	68		68	
31	56a	20	66		66	
31	56a	30	65		65	
31	56a	40	64		64	
31	56b	1	68		68	

Careful layout will be needed

Table B2.3 (cont'd) **Unmitigated (except for friction course) and mitigated worst case predicted noise levels (MTNL) at representative noise sensitive facades, $L_{10\,(1\text{-hour})}$ in dB(A) affected by the new roads.**

Area	NSR of Facade ('s' for school)	Floor	New traffic Data Predicted noise levels L10 (1-hour), dB(A) (before mitigation)	New traffic Data Exceeds HKPSG Standards? (before mitigation)	New traffic Data Predicted noise levels L10 (1-hour), dB(A) (after mitigation)	Mitigation provided
31	56b	10	70		70	
31	56b	20	69		69	
31	56b	30	68		68	
31	56b	40	67		67	
31	60a	1	60		60	
31	60a	10	60		60	
31	60a	20	63		63	
31	60a	30	62		62	
31	60a	40	61		61	
31	60b	1	61		61	
31	60b	10	61		61	
31	60b	20	62		62	
31	60b	30	62		62	
31	60b	40	61		61	
31	62a	1	63		63	
31	62a	10	62		62	
31	62a	20	61		61	
31	62a	30	60		60	
31	62a	40	59		59	
31	63a	1	62		62	
31	63a	10	62		62	
31	63a	20	61		61	
31	63a	30	60		60	
31	63a	40	60		60	
31	63b	1	63		63	
31	63b	10	63		63	
31	63b	20	62		62	
31	63b	30	61		61	
31	63b	40	60		60	
31	s57a	1	65		65	
31	s57a	2	65		65	
31	s57a	3	65		65	
31	s57a	4	64		64	
31	s57a	5	64		64	
31	s57a	6	64		64	
31	s57b	1	43		43	
31	s57b	2	43		43	
31	s57b	3	43		43	
31	s57b	4	44		44	
31	s57b	5	46		46	
31	s57b	6	51		51	
31	s57c	1	50		50	
31	s57c	2	52		52	
31	s57c	3	58		58	
31	s57c	4	63		63	
31	s57c	5	64		64	
31	s57c	6	64		64	
31	s59a	1	62		62	
31	s59a	2	64		64	
31	s59a	3	65		65	School classrooms marked with a +' will be protected by HA.
31	s59a +	4	66	Yes	66	
31	s59a +	5	68	Yes	68	
31	s59a +	6	69	Yes	69	
31	s59b	1	44		44	
31	s59b	2	44		44	
31	s59b	3	44		44	
31	s59b	4	44		44	
31	s59b	5	44		44	
31	s59b	6	47		47	
31	s59c	1	51		51	

Careful layout will be needed

Table B2.3 (cont'd) Unmitigated (except for friction course) and mitigated worst case predicted noise levels (MTNL) at representative noise sensitive facades, $L_{10\,(1\text{-hour})}$ in dB(A) affected by the new roads.

Area	NSR of Facade ('s' for school)	Floor	New traffic Data Predicted noise levels L10 (1-hour), dB(A) (before mitigation)	New traffic Data Exceeds HKPSG Standards? (before mitigation)	New traffic Data Predicted noise levels L10 (1-hour), dB(A) (after mitigation)	Mitigation provided
31	s59c	2	53		53	
31	s59c	3	56		56	
31	s59c	4	61		61	School classrooms marked with a '+' will be protected by HA.
31	s59c +	5	66	Yes	66	
31	s59c +	6	66	Yes	66	
31	s61a	1	63		63	
31	s61a	2	63		63	
31	s61a	3	63		63	
31	s61a	4	63		63	
31	s61a	5	63		63	
31	s61a	6	63		63	
31	s61b	1	61		61	
31	s61b	2	61		61	
31	s61b	3	61		61	
31	s61b	4	61		61	
31	s61b	5	61		61	
31	s61b	6	60		60	
101	31a	1	44		44	
101	31a	10	51		51	
101	31a	20	56		56	
101	31a	30	56		56	
101	31a	40	55		55	
101	31b	1	42		42	
101	31b	10	42		42	
101	31b	20	42		42	
101	31b	30	41		41	
101	31b	40	41		41	
101	32a	1	47		47	
101	32a	10	51		51	
101	32a	20	58		58	
101	32a	30	65		65	
101	32a	40	65		65	
101	32b	1	54		54	
101	32b	10	56		56	
101	32b	20	63		63	
101	32b	30	68		68	
101	32b	40	67		67	
101	32c	1	45		45	
101	32c	10	45		45	
101	32c	20	45		45	
101	32c	30	44		44	
101	32c	40	45		45	
101	33a	1	69		69	
101	33a	10	69		69	
101	33a	20	67		67	
101	33a	30	66		66	
101	33a	40	65		65	
101	33b	1	68		68	
101	33b	10	68		68	
101	33b	20	67		67	
101	33b	30	65		65	
101	33b	40	65		65	
101	33c	1	51		51	
101	33c	10	59		59	
101	33c	20	69		69	
101	33c	30	68		68	
101	33c	40	67		67	
101	s29a	1	60		60	
101	s29a	2	60		60	
101	s29a	3	60		60	

Careful layout will be needed

Table B2.3 (cont'd) **Unmitigated (except for friction course) and mitigated worst case predicted noise levels (MTNL) at representative noise sensitive facades, $L_{10\ (1\text{-hour})}$ in dB(A) affected by the new roads.**

Area	NSR of Facade ('s' for school)	Floor	New traffic Data Predicted noise levels L10 (1-hour), dB(A) (before mitigation)	New traffic Data Exceeds HKPSG Standards? (before mitigation)	New traffic Data Predicted noise levels L10 (1-hour), dB(A) (after mitigation)	Mitigation provided
101	s29a	4	60		60	
101	s29a	5	60		60	
101	s29a	6	60		60	
101	s29b	1	44		44	
101	s29b	2	44		44	
101	s29b	3	45		45	
101	s29b	4	45		45	
101	s29b	5	46		46	
101	s29b	6	47		47	
101	s29c	1	59		59	
101	s29c	2	59		59	
101	s29c	3	59		59	
101	s29c	4	59		59	
101	s29c	5	59		59	
101	s29c	6	59		59	
101	s30a	1	55		55	
101	s30a	2	55		55	
101	s30a	3	55		55	
101	s30a	4	55		55	
101	s30a	5	55		55	
101	s30a	6	55		55	
102	150a	1	65		65	
102	150a	10	67		67	
102	150a	20	65		65	
102	150a	30	64		64	
102	150a	40	63		63	
102	150b	1	60		60	
102	150b	10	63		63	
102	150b	20	62		62	
102	150b	30	61		61	
102	150b	40	60		60	
102	151a	1	62		62	
102	151a	10	68		68	
102	151a	20	67		67	
102	151a	30	66		66	
102	151a	40	65		65	
102	151b	1	59		59	
102	151b	10	67		67	
102	151b	20	66		66	
102	151b	30	65		65	
102	151b	40	64		64	
102	152a	1	58		58	
102	152a	10	59		59	
102	152a	20	58		58	
102	152a	30	57		57	
102	152a	40	57		57	
102	152b	1	64		64	
102	152b	10	66		66	
102	152b	20	64		64	
102	152b	30	64		64	
102	152b	40	63		63	
102	152c	1	66		66	
102	152c	10	67		67	
102	152c	20	66		66	
102	152c	30	65		65	
102	152c	40	65		65	
102	153a	1	63		63	
102	153a	10	65		65	
102	153a	20	64		64	
102	153a	30	63		63	

Careful layout will be needed

Table B2.3 (cont'd) Unmitigated (except for friction course) and mitigated worst case predicted noise levels (MTNL) at representative noise sensitive facades, $L_{10\,(1\text{-hour})}$ in dB(A) affected by the new roads.

Area		NSR of Facade ('s' for school)	Floor	New traffic Data Predicted noise levels L10 (1-hour), dB(A) (before mitigation)	New traffic Data Exceeds HKPSG Standards? (before mitigation)	New traffic Data Predicted noise levels L10 (1-hour), dB(A) (after mitigation)	Mitigation provided
102		153a	40	62		62	
102		153b	1	63		63	
102		153b	10	68		68	
102		153b	20	68		68	
102		153b	30	68		68	
102		153b	40	67		67	
102		153c	1	65		65	
102		153c	10	68		68	
102		153c	20	69		69	
102		153c	30	68		68	
102		153c	40	68		68	
102		154a	1	52		52	
102		154a	10	57		57	
102		154a	20	63		63	
102		154a	30	64		64	
102		154a	40	64		64	
102		154b	1	54		54	
102		154b	10	59		59	
102		154b	20	63		63	
102		154b	30	63		63	
102		154b	40	63		63	
102		155a	1	60		60	
102		155a	10	64		64	
102		155a	20	64		64	
102		155a	30	64		64	
102		155a	40	63		63	
102		155b	1	59		59	
102		155b	10	64		64	
102		155b	20	65		65	
102		155b	30	64		64	
102		155b	40	64		64	
102		158a	1	65		65	
102		158a	10	67		67	
102		158a	20	66		66	
102		158a	30	64		64	
102		158a	40	64		64	
102		158b	1	66		66	
102		158b	10	69		69	
102		158b	20	68		68	
102		158b	30	67		67	
102		158b	40	66		66	
102		s159a	1	74	Yes	62	Self-protective building. HA will use a fixed window
102		s159a	2	75	Yes	63	
102		s159a	3	75	Yes	63	
102		s159b	1	75	Yes	63	
102		s159b	2	76	Yes	64	
102		s159b	3	76	Yes	64	
102		s159c	1	73	Yes	61	
102		s159c	2	74	Yes	62	
102		s159c	3	74	Yes	62	
103	#	42a	1	72	Yes	72	Required set back distances given in the Text in Section 4
103	#	42a	10	72	Yes	72	
103	#	42a	20	70		70	
103	#	42a	30	69		69	
103	#	42a	40	68		68	
103	#	42b	1	74	Yes	74	
103	#	42b	10	73	Yes	73	
103	#	42b	20	71	Yes	71	
103	#	42b	30	70		70	
103	#	42b	40	70		70	

Careful layout will be needed

Table B2.3 (cont'd) **Unmitigated (except for friction course) and mitigated worst case predicted noise levels (MTNL) at representative noise sensitive facades, $L_{10\,(1\text{-hour})}$ in dB(A) affected by the new roads.**

Area	NSR of Facade ('s' for school)	Floor	New traffic Data Predicted noise levels L10 (1-hour), dB(A) (before mitigation)	New traffic Data Exceeds HKPSG Standards? (before mitigation)	New traffic Data Predicted noise levels L10 (1-hour), dB(A) (after mitigation)	Mitigation provided
103 #	43a	1	73	Yes	73	Required set back distances given in the Text in Section 4
103 #	43a	10	72	Yes	72	
103 #	43a	20	70		70	
103 #	43a	30	68		68	
103 #	43a	40	67		67	
103 #	43b	1	69		69	
103 #	43b	10	67		67	
103 #	43b	20	65		65	
103 #	43b	30	64		64	
103 #	43b	40	63		63	
103 #	44a	1	75	Yes	75	
103 #	44a	10	74	Yes	74	
103 #	44a	20	72	Yes	72	
103 #	44a	30	71	Yes	71	
103 #	44a	40	70		70	
103 #	44b	1	75	Yes	75	Required set back distances given in the Text in Section 4
103 #	44b	10	75	Yes	75	
103 #	44b	20	73	Yes	73	
103 #	44b	30	71	Yes	71	
103 #	44b	40	70		70	
104 #	45a	1	68		68	
104 #	45a	10	69		69	
104 #	45a	20	68		68	
104 #	45a	30	67		67	
104 #	45a	40	66		66	
104 #	46a	1	78	Yes	78	
104 #	46a	10	76	Yes	76	
104 #	46a	20	74	Yes	74	
104 #	46a	30	72	Yes	72	
104 #	46a	40	71	Yes	71	
104 #	46b	1	76	Yes	76	
104 #	46b	10	74	Yes	74	
104 #	46b	20	72	Yes	72	
104 #	46b	30	71	Yes	71	
104 #	46b	40	70		70	
104 #	47a	1	75	Yes	75	
104 #	47a	10	73	Yes	73	
104 #	47a	20	71	Yes	71	
104 #	47a	30	70		70	
104 #	47a	40	69		69	
104 #	47b	1	78	Yes	78	
104 #	47b	10	75	Yes	75	
104 #	47b	20	73	Yes	73	
104 #	47b	30	72	Yes	72	
104 #	47b	40	71	Yes	71	
105	104a	1	72	Yes	70	New layout from 11/12/96 effectively reduced noise to acceptable levels (Alternatively, a setback of at least 15m from site boundary L13.1 will give the mitigated noise levels shown in this table.) See layouts in Appendix. (carpark also acts as barrier for NSR 104).
105	104a	10	70		69	
105	104a	20	68		68	
105	104a	30	66		66	
105	104a	40	65		65	
105	104b	1	69		68	
105	104b	10	68		68	
105	104b	20	67		67	
105	104b	30	65		65	
105	104b	40	64		64	
105	104c	1	69		69	
105	104c	10	69		68	
105	104c	20	67		67	
105	104c	30	66		66	
105	104c	40	65		65	

Careful layout will be needed

Table B2.3 (cont'd) **Unmitigated (except for friction course) and mitigated worst case predicted noise levels (MTNL) at representative noise sensitive facades, $L_{10\,(1\text{-hour})}$ in dB(A) affected by the new roads.**

Area	NSR of Facade ('s' for school)	Floor	New traffic Data Predicted noise levels L10 (1-hour), dB(A) (before mitigation)	New traffic Data Exceeds HKPSG Standards? (before mitigation)	New traffic Data Predicted noise levels L10 (1-hour), dB(A) (after mitigation)	Mitigation provided
105	20a	1	67		67	
105	20a	10	67		67	
105	20a	20	66		66	
105	20a	30	65		65	
105	20a	40	64		64	
105	20b	1	66		66	
105	20b	10	65		65	
105	20b	20	63		63	
105	20b	30	62		62	
105	20b	40	61		61	
105	20c	1	68		68	
105	20c	10	66		66	
105	20c	20	65		65	
105	20c	30	63		63	
105	20c	40	62		62	
105	s19a	1	62		62	
105	s19a	2	62		62	
105	s19a	3	62		62	
105	s19a	4	62		62	
105	s19a	5	62		62	
105	s19a	6	62		62	
105	s105	4	71	Yes	62	New layout in Appendix.
105	s105	5	70	Yes	62	
105	s105	6	70	Yes	62	
106	160a	1	63		63	
106	160a	10	68		68	
106	160a	20	66		66	
106	160a	30	64		64	
106	160a	40	63		63	
106	160b	1	63		63	
106	160b	10	67		67	
106	160b	20	66		66	
106	160b	30	65		65	
106	160b	40	64		64	
106	161a	1	54		54	
106	161a	10	68		68	
106	161a	20	66		66	
106	161a	30	65		65	
106	161a	40	63		63	
106	161b	1	62		62	
106	161b	10	68		68	
106	161b	20	66		66	
106	161b	30	65		65	
106	161b	40	65		65	
106	161c	1	63		63	
106	161c	10	70		70	
106	161c	20	68		68	
106	161c	30	67		67	
106	161c	40	66		66	
106	162a	1	54		54	
106	162a	10	65		65	
106	162a	20	66		66	
106	162a	30	65		65	
106	162a	40	65		65	
106	162b	1	50		50	
106	162b	10	58		58	
106	162b	20	59		59	
106	162b	30	60		60	
106	162b	40	60		60	
106	163a	1	52		52	

Careful layout will be needed

Table B2.3 (cont'd) Unmitigated (except for friction course) and mitigated worst case predicted noise levels (MTNL) at representative noise sensitive facades, $L_{10\ (1\text{-hour})}$ in dB(A) affected by the new roads.

Area	NSR of Facade ('s' for school)	Floor	New traffic Data Predicted noise levels L10 (1-hour), dB(A) (before mitigation)	New traffic Data Exceeds HKPSG Standards? (before mitigation)	New traffic Data Predicted noise levels L10 (1-hour), dB(A) (after mitigation)	Mitigation provided
106	163a	10	62		62	
106	163a	20	64		64	
106	163a	30	64		64	
106	163a	40	63		63	
106	163b	1	42		42	
106	163b	10	51		51	
106	163b	20	54		54	
106	163b	30	60		60	
106	163b	40	60		60	
106	164a	1	44		44	
106	164a	10	53		53	
106	164a	20	62		62	
106	164a	30	63		63	
106	164a	40	62		62	
106	164b	1	51		51	
106	164b	10	59		59	
106	164b	20	61		61	
106	164b	30	61		61	
106	164b	40	60		60	
106	164c	1	50		50	
106	164c	10	59		59	
106	164c	20	61		61	
106	164c	30	64		64	
106	164c	40	63		63	
108	107a	1	71	Yes	65	Set back 25m from site boundary along L13
108	107a	10	71	Yes	69	
108	107a	20	68		68	
108	107a	30	67		66	
108	107a	40	66		65	
108	107b	1	69		67	
108	107b	10	69		68	
108	107b	20	67		66	
108	107b	30	65		65	
108	107b	40	64		64	
108	108a	1	67		67	
108	108a	10	70		70	
108	108a	20	68		68	
108	108a	30	67		67	
108	108a	40	66		66	
108	108b	1	65		65	
108	108b	10	68		68	
108	108b	20	66		66	
108	108b	30	65		65	
108	108b	40	64		64	
109	109a	1	61		61	
109	109a	2	63		63	
109	109a	3	63		63	
109	109a	4	63		63	
109	109a	5	64		64	
109	109a	6	64		64	
110	10a	1	69		69	
110	10a	10	70		70	
110	10a	20	67		67	
110	10a	30	66		66	
110	10a	40	65		65	
110	10b	1	69		69	
110	10b	10	69		69	
110	10b	20	67		67	
110	10b	30	66		66	
110	10b	40	65		65	

Careful layout will be needed

Table B2.3 (cont'd) **Unmitigated (except for friction course) and mitigated worst case predicted noise levels (MTNL) at representative noise sensitive facades, $L_{10\,(1\text{-hour})}$ in dB(A) affected by the new roads.**

Area	NSR of Facade ('s' for school)	Floor	New traffic Data Predicted noise levels L10 (1-hour), dB(A) (before mitigation)	New traffic Data Exceeds HKPSG Standards? (before mitigation)	New traffic Data Predicted noise levels L10 (1-hour), dB(A) (after mitigation)	Mitigation provided
110	13a	1	63		63	
110	13a	10	68		68	
110	13a	20	67		67	
110	13a	30	66		66	
110	13a	40	65		65	
110	13b	1	63		63	
110	13b	10	69		69	
110	13b	20	67		67	
110	13b	30	66		66	
110	13b	40	65		65	
110	14a	1	66		66	
110	14a	10	66		66	
110	14a	20	64		64	
110	14a	30	63		63	
110	14a	40	62		62	
110	14b	1	64		64	
110	14b	10	67		67	
110	14b	20	66		66	
110	14b	30	65		65	
110	14b	40	64		64	
110	s11a	1	59		59	
110	s11a	2	61		60	
110	s11a	3	63		62	
110	s11a	4	64		63	
110	s11a	5	65		64	
110	s11a	6	65		64	
110	s11b	1	63		57	
110	s11b	2	65		58	
110	s11b	3	66	Yes	60	New layout by HA. See Appendix.
110	s11b	4	67	Yes	61	
110	s11b	5	68	Yes	62	
110	s11b	6	68	Yes	63	
110	s12a	1	59		59	
110	s12a	2	59		59	
110	s12a	3	61		61	
110	s12a	4	62		62	
110	s12a	5	63		63	
110	s12a	6	64		64	
111	16a	1	62		62	
111	16a	10	68		68	
111	16a	20	67		67	
111	16a	30	66		66	
111	16a	40	65		65	
111	16b	1	60		60	
111	16b	10	67		67	
111	16b	20	67		67	
111	16b	30	66		66	
111	16b	40	65		65	
111	16c	1	62		62	
111	16c	10	69		69	
111	16c	20	68		68	
111	16c	30	67		67	
111	16c	40	66		66	
111	17a	1	62		62	
111	17a	10	67		67	
111	17a	20	66		66	
111	17a	30	65		65	
111	17a	40	64		64	
111	17b	1	63		63	
111	17b	10	68		68	

Careful layout will be needed

Table B2.3 (cont'd) Unmitigated (except for friction course) and mitigated worst case predicted noise levels (MTNL) at representative noise sensitive facades, $L_{10\,(1\text{-hour})}$ in dB(A) affected by the new roads.

Area	NSR of Facade ('s' for school)	Floor	New traffic Data Predicted noise levels L10 (1-hour), dB(A) (before mitigation)	New traffic Data Exceeds HKPSG Standards? (before mitigation)	New traffic Data Predicted noise levels L10 (1-hour), dB(A) (after mitigation)	Mitigation provided
111	17b	20	68		68	
111	17b	30	67		67	
111	17b	40	66		66	
111	18a	1	60		60	
111	18a	10	66		66	
111	18a	20	65		65	
111	18a	30	64		64	
111	18a	40	63		63	
111	18b	1	59		59	
111	18b	10	63		63	
111	18b	20	62		62	
111	18b	30	60		60	
111	18b	40	59		59	
111	18c	1	58		58	
111	18c	10	66		66	
111	18c	20	65		65	
111	18c	30	65		65	
111	18c	40	64		64	
112 #	4a	G	71	Yes	71	Required set back distances given in the Text in Section 4
112 #	4a	1	69		69	
112 #	4a	2	70		70	
112 #	6a	G	63		63	
112 #	6a	1	71	Yes	71	
112 #	6a	2	74	Yes	74	
115 #	7a	G	58		58	
115 #	7a	1	72	Yes	72	
115 #	7a	2	74	Yes	74	
115 #	9a	G	70		70	
115 #	9a	1	71	Yes	71	
115 #	9a	2	72	Yes	72	
113 #	s5a	1	70	Yes	70	It is been recommended that schools be relocated.
113 #	s5a	2	73	Yes	73	
113 #	s5a	3	73	Yes	73	
113 #	s5a	4	73	Yes	73	
113 #	s5a	5	73	Yes	73	
113 #	s5a	6	72	Yes	72	
116 #	s8a	1	73	Yes	73	
116 #	s8a	2	75	Yes	75	
116 #	s8a	3	75	Yes	75	
116 #	s8a	4	74	Yes	74	
116 #	s8a	5	74	Yes	74	
116 #	s8a	6	74	Yes	74	
Sha Kong Wai	26	G	59		59	
Sha Kong Wai	26	1	60		60	
Sha Kong Wai	26	2	61		61	
Sha Kong Wai Tsai	27	G	65		65	
Sha Kong Wai Tsai	27	1	65		65	
Sha Kong Wai Tsai	27	2	67		67	
CDA	48a	G	77	Yes	70	Barrier provided
CDA	48a	1	76	Yes	70	
CDA	48a	2	78	Yes	70	
CDA	48b	G	74	Yes	67	
CDA	48b	1	73	Yes	67	
CDA	48b	2	75	Yes	68	
Hung Tin Rd	99	G	74	Yes	70	
Hung Tin Rd	99	1	74	Yes	70	
Long Tin Rd	90	G	78	Yes	69	
Long Tin Rd	95	G	76	Yes	66	
Long Tin Rd	96	G	74	Yes	64	
Long Tin Rd	96	1	74	Yes	65	

Careful layout will be needed

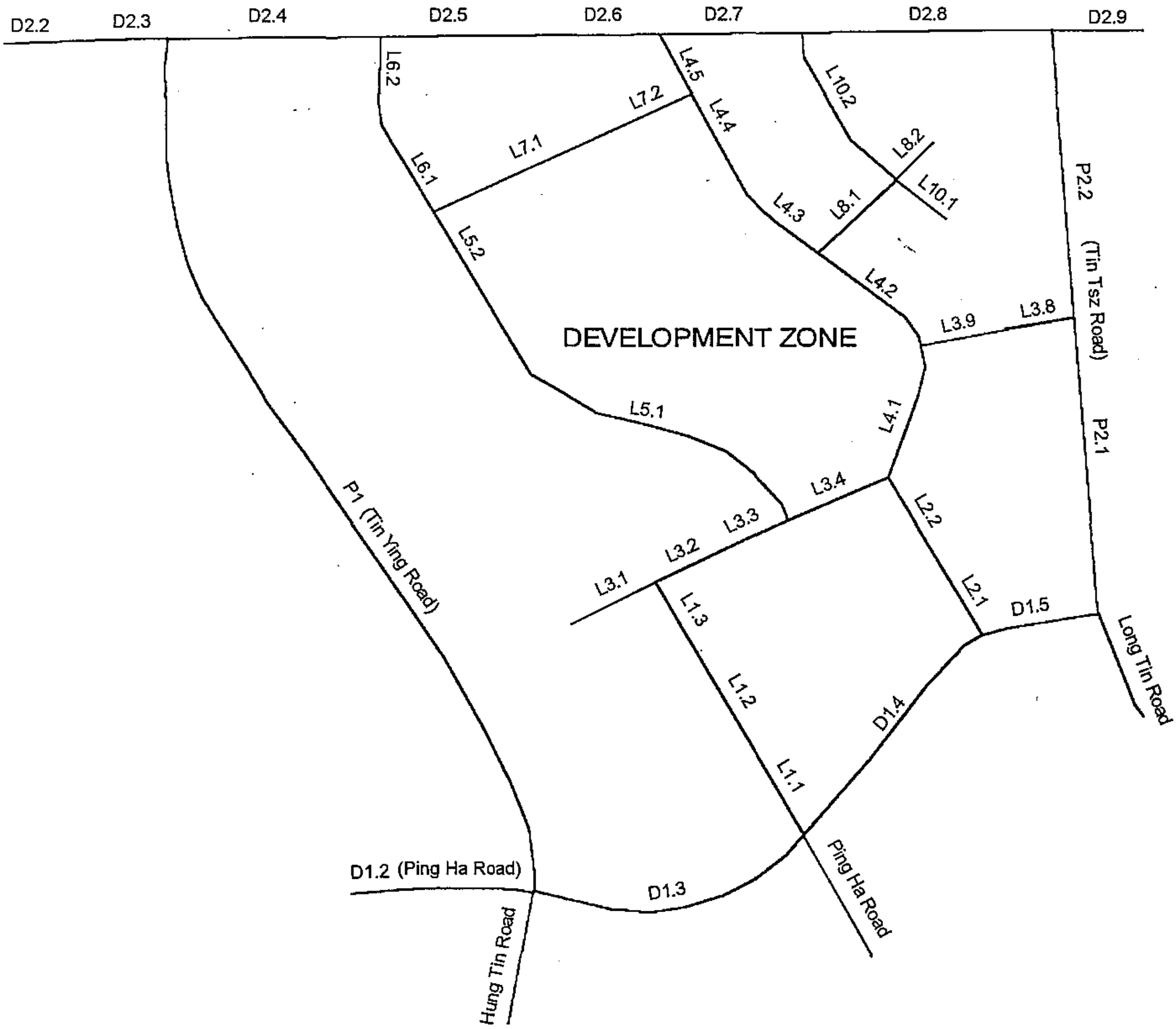
Table B2.3 (cont'd) Unmitigated (except for friction course) and mitigated worst case predicted noise levels (MTNL) at representative noise sensitive facades, $L_{10\,(1\text{-hour})}$ in dB(A) affected by the new roads.

Area	NSR of Facade ('s' for school)	Floor	New traffic Data Predicted noise levels L10 (1-hour), dB(A) (before mitigation)	New traffic Data Exceeds HKPSG Standards? (before mitigation)	New traffic Data Predicted noise levels L10 (1-hour), dB(A) (after mitigation)	Mitigation provided
Long Tin Rd	96	2	74	Yes	65	Barrier provided
Outlying	70	G	75	Yes	66	
Outlying	70	1	76	Yes	67	
Outlying	70	2	76	Yes	67	
Outlying	85	G	70		65	
Outlying	85	1	70		65	
Outlying	85	2	70		65	
Outlying	119	G	68		61	
Outlying	119	1	68		61	
Outlying	119	2	68		61	
Ping Ha Rd	98	G	73	Yes	67	Barrier provided
Ping Ha Rd	98	1	73	Yes	68	
Ping Ha Rd	98	2	73	Yes	69	
Tin Fuk Rd	s89	1	73	Yes	72	TDD will provide A/C. Direct mitigation not effective as noise levels from old road already high
Tin Fuk Rd	s89	2	73	Yes	72	
Tin Fuk Rd	s89	3	73	Yes	72	
Tin Fuk Rd	s89	4	73	Yes	73	
Tin Fuk Rd	s89	5	73	Yes	73	
Tin Fuk Rd	s89	6	73	Yes	73	

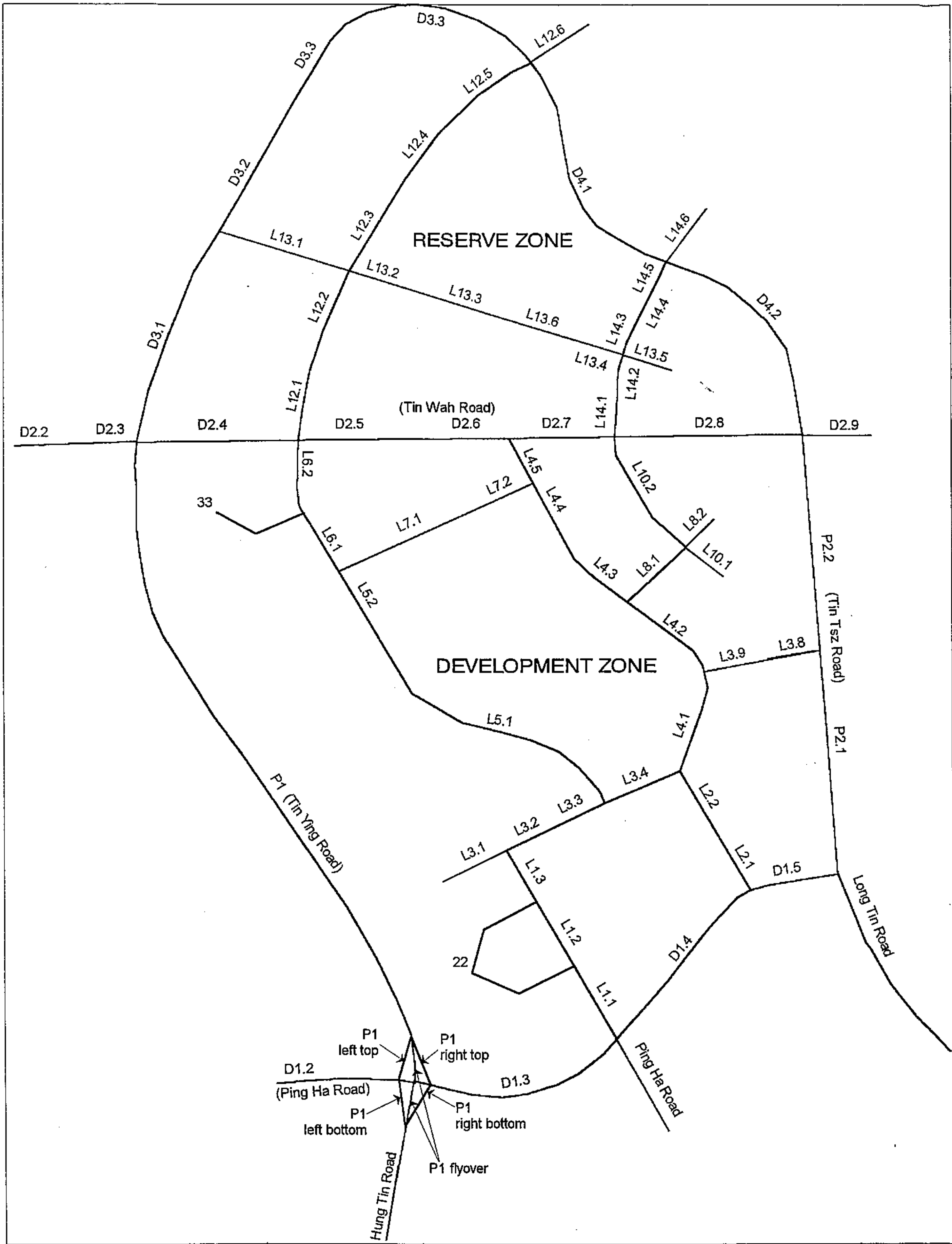
Table B2.4 Schools Recommended by this EIA for Inclusion to Education Department's *Noise Abatement Measures in Schools Programme*

Area	School		Suggested Timing for Protection
5	s81#	Queen Elizabeth School Old Students' Association Primary School	by mid 1998
	s84	Fong Yun Wah Primary School	by mid 1998
11	s118	Ju Ching Chu Secondary School (Yuen Long)	by mid 1998
14	-	School to be built - name unknown	by late 1999
16	s128	The Chinese University of Hong Kong, Federation of Alumni Association, Thomas Cheung Secondary School	by late 1999
19	s129	Tin Shui Wai Government Primary School	by mid 1998
24	s117	Tin Shui Wai Catholic Primary School	by late 1999
27	-	Two newly completed school - names unknown	by late 1999

Already partially protected under Education Department's *Noise Abatement Measures in Schools Programme*.



TIN SHUI WAI DEVELOPMENT AGREEMENT NO. CE 10/95 ENGINEERING INVESTIGATIONS FOR DEVELOPMENT OF AREAS 3, 30 & 31 OF THE DEVELOPMENT ZONE AND THE RESERVE ZONE	Title : ROAD DIVISION BASED ON VARIATION OF TRAFFIC FLOW DATA (DO-NOTHING SCENARIO)	Figure No. B2.1	Revision 0
		Reference No. -	File Name RD_SEG3.PRS
BINNIE CONSULTANTS LIMITED 賓尼工程顧問有限公司 ENGINEERS AND SCIENTISTS 賓尼		Prepared MC	Checked WYC
		Date MAR 97	Scale NTS



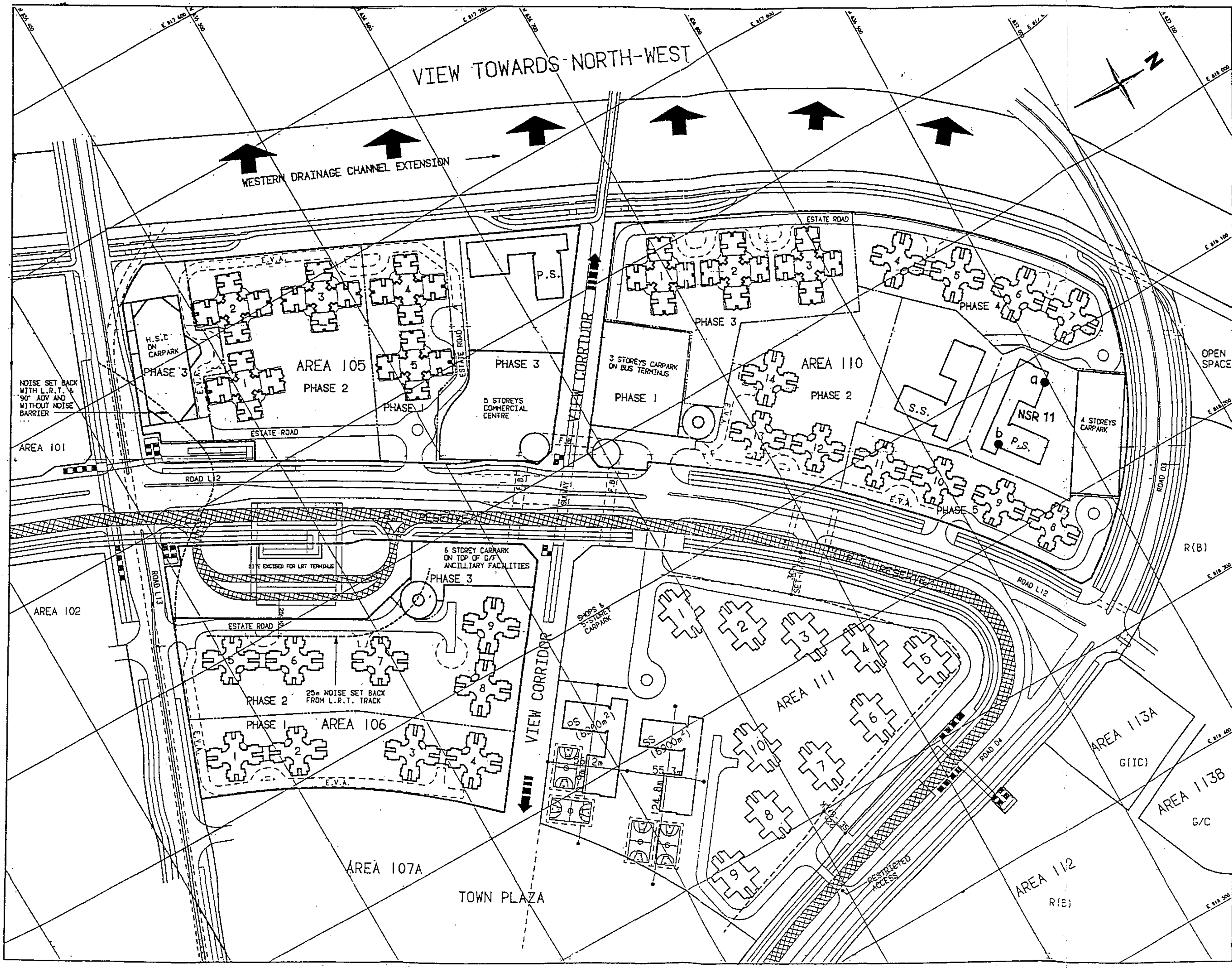
TIN SHUI WAI DEVELOPMENT AGREEMENT NO. CE 10/95 ENGINEERING INVESTIGATIONS FOR DEVELOPMENT OF AREAS 3, 30 & 31 OF THE DEVELOPMENT ZONE AND THE RESERVE ZONE	Title : ROAD DIVISION BASED ON VARIATION OF TRAFFIC FLOW DATA (WORST CASE SCENARIO)	Figure No. B2.2	Revision 0
BINNIE CONSULTANTS LIMITED 賓尼工程顧問有限公司 賓尼 ENGINEERS AND SCIENTISTS		Reference No. -	File Name RD_SEG.PRS
		Prepared MC	Checked WYC
		Date MAR 97	Scale NTS

Figure B2.3 Road Nomenclature

Road division codes	Street names
P1	Tin Ying Road
P2	Tin Tsz Road
D1	Western half is Ping Ha Road, while eastern half is Tin Fuk Road
D2	Tin Wah Road
D3	Not yet available
D4	Not yet available
L1	Tin Yiu Road
L2	Tin Shing Road (south)
L3.1 - L3.4	Tin Wu Road
L4	Tin Shing Road (north)
L5	Tin Shui Road (south)
L6	Tin Shui Road (north)
L7	Tin Wing Road
L8	Tin Lung Road
L10	Tin Kwai Road
L12	Not yet available
L13	Not yet available
L14	Not yet available
Internal Road 22	Tin Shun Lane - Tin Mei Street - Tin Ho Road
Internal Road 33	Tin Tan Street

Appendix C

Details of the Air Quality Assessments



NOTES

PHASING

AREA 105	PH.1	BLOCK 4-6-5
	PH.2	BLOCK 1, 2 & 3
	PH.3	P.S., C.C & CARPORT
AREA 106	PH.1	BLOCK 1 TO 4
	PH.2	BLOCK 5 TO 9
	PH.3	CARPORT
AREA 110	PH.1	BUS TERMINUS & CARPORT
	PH.2	CONCORD BLK. 12, 13, 14 P.S. & S.S.
	PH.3	HARMONY BLK. 1, 2 & 3
	PH.4	CONCORD BLK. 4 TO 7
	PH.5	CONCORD BLK. 8 TO 11

F.B. : PROPOSED FOOT BRIDGE

FIGURE B2.4

HOUSING LAYOUT FOR AREAS 105, 106, 110 AND 111 (Dec 96 layout from HD)

REVISIONS

PROJECT: TIN SHUI WAI AREA RESERVE ZONE

DRAWING TITLE: SITE LAYOUT PLAN

SCALE: NTS

DRAWING NO: TSW/SITE/A/SK-11

WORKS GROUP HOUSING DEPARTMENT

Appendix C1: Background Air Quality Monitoring

Introduction

C1.1 This Appendix presents the methodology and the results of the background air quality monitoring at Tin Shui Wai.

C1.2 Three-week continuous background air monitoring was undertaken by Hong Kong Productivity Council (HKPC) at Mong Tseng Tsuen, Tin Shui Wai from 23 January 1996 to 13 February 1996, measuring the concentrations of sulphur dioxide (SO_2), nitrogen oxides (including nitric oxide (NO), nitrogen dioxide (NO_2)), and total and respirable suspended particulate (TSP and RSP respectively). The air pollutants were monitored at rooftop level of a three storey village house at 1A, Mong Tseng Tsuen (See Figure C1.1).

C1.3 Due to the malfunction of the monitoring instruments during the monitoring period, the monitoring results of SO_2 and NO_x of seven consecutive days were missing. Hence, a supplementary monitoring of SO_2 and NO_x was undertaken by HKPC from 10 to 19 August 1996. The monitoring station was relocated to about 500 m west from the previous monitoring station since the previous site was not available. The air samples were taken at the roof level of an one-storey village house at D.D. 129, Lot No. 853 BRP, Yuen Long. Figure C1.1 shows the locations of the background air monitoring.

Methodology

C1.4 During the first monitoring period from 23 January 1996 to 13 February 1996, gas analyzers were installed to measure the levels of TSP, RSP, NO, NO_2 and SO_2 in real time. A data logger was connected to the gas analyzers for recording the output at 5 minute intervals. The corresponding methods of measurement for each parameter are summarized below in Table C1.1.

Table C.1.1
Methods of Measurement for Air Monitoring

Parameter	Method	Principle of Measurement
TSP	40 CFR 50 App B	24-hour TSP sample is measured by a high volume sampler
RSP	40 CFR 50 App J	24-hour RSP sample with diameter less than 10 μm is measured by a high volume sampler with a PM10 inlet
NO_2, NO	40 CFR 50 App F	A nitrogen oxides analyzer by chemilumineous is employed for continuous monitoring
SO_2	USEPA Equivalent Method for the Determination of Sulphur Dioxide in the Atmosphere	A UV fluorescence SO_2 analyzer is employed for continuous monitoring

C1.5 With Environmental Protection Department endorsement, automatic ambient air sampling system was employed for the supplementary monitoring. The sampling system was programmed to collect the air samples into 12 litres tedlar bags in every hour. The sampled tedlar bags were then delivered to HKPC laboratory for analysis by gas analyzers.

Results

TSP and RSP

C1.6 In order to indicate the current dust levels in Tin Shui Wai, the monitoring dust results are tabulated below in Table C1.2. For TSP and RSP, extra results from 14 to 18 February 1996 were provided.

C1.7 The dust concentrations show day-to-day variations over the monitoring period. Figure C1.2 shows the variation of the daily averages of TSP and RSP concentrations. The concentrations of dust were higher on 31.1.96 and 4.2.96 respectively and gradually declined towards the Chinese New Year. It is likely that the gradual shutting down of industrial activities and decreasing of construction activities at Shenzhen during the Chinese New Year resulted in the decreasing dust concentration.

NO_2 and SO_2

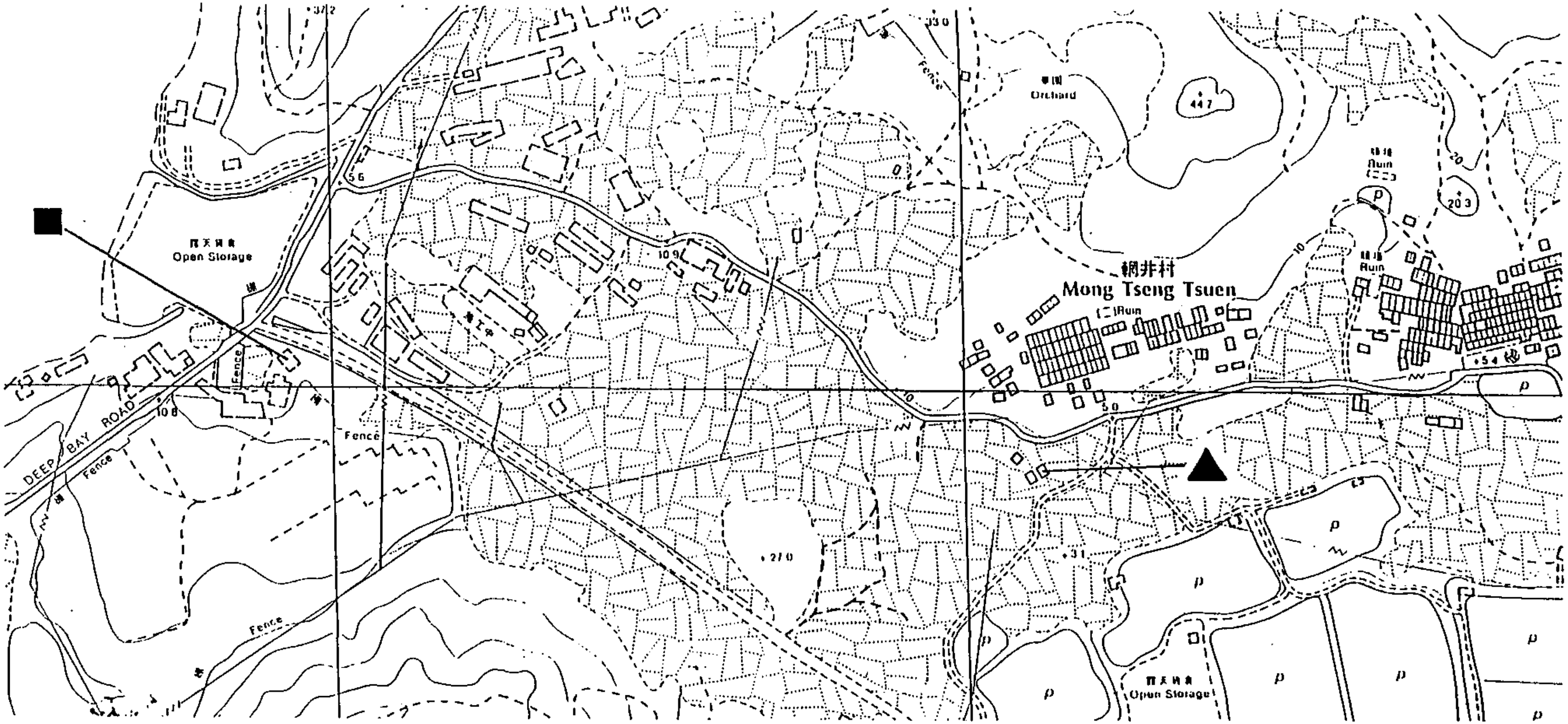
C1.8 Figures C1.3 and C1.4 show the day-to-day variations on 23.1.96 to 18.2.96 and 10.8.96 to 19.8.96 respectively. The concentrations of gases were higher in the months of January and February but much lower in August. Table C1.3 summarises the final NO_2 and SO_2 monitoring results of the background air monitoring. The mean values of NO_2 and SO_2 monitoring results would be used as the background levels in Tin Shui Wai area.

Table C.1.2
Results of TSP and RSP Background Monitoring at Mong Tseng Tsuen

Sample Date	Particulate Concentration (μg/m³)	
	TSP	RSP
23.1.96	151	85
24.1.96	63	45
25.1.96	188	89
26.1.96	117	69
27.1.96	124	70
28.1.96	158	94
29.1.96	154	87
30.1.96	159	96
31.1.96	235	119
1.2.96	No Measurement due to suspension of electricity supply by CLP	
2.2.96		
3.2.96	111	70
4.2.96	192	126
5.2.96	141	92
6.2.96	97	64
7.2.96	134	85
8.2.96	156	89
9.2.96	158	89
10.2.96	113	54
11.2.96	97	69
12.2.96	81	58
13.2.96	54	35
14.2.96	46	29
15.2.96	46	26
16.2.96	51	35
17.2.96	57	28
18.2.96	32	20
geometric means	103	62

Table C1.3
Results of NO_2 and SO_2 Background Monitoring at Mong Tseng Tsuen

Results		NO_2 (μg/m³)	SO_2 (μg/m³)
1 hour average	Mean Value	35.8	9.5
	HKAQO	300	800
24 hour average	Mean Value	34.3	9.4
	HKAQO	150	350



▲ sampling location for monitoring from 23.1.96 to 13.2.96

■ sampling location for supplementary monitoring from 10.8.96 to 19.8.96

TIN SHUI WAI DEVELOPMENT
AGREEMENT NO. CE 10/95
ENGINEERING INVESTIGATIONS FOR DEVELOPMENT OF AREAS 3, 30 & 31 OF THE DEVELOPMENT ZONE AND THE RESERVE ZONE

BINNIE CONSULTANTS LIMITED
賓尼工程顧問有限公司
ENGINEERS AND SCIENTISTS

Title :

SAMPLING LOCATION OF AIR QUALITY BASELINE MEASUREMENT AT TIN SHUI WAI AREA

Figure No. C1.1	Revision 0
Reference No. -	File Name -
Prepared MC	Checked YWL
Date NOV 96	Scale -

Figure C1.2 : Results of TSP and RSP Baseline Monitoring at Tin Shui Wai

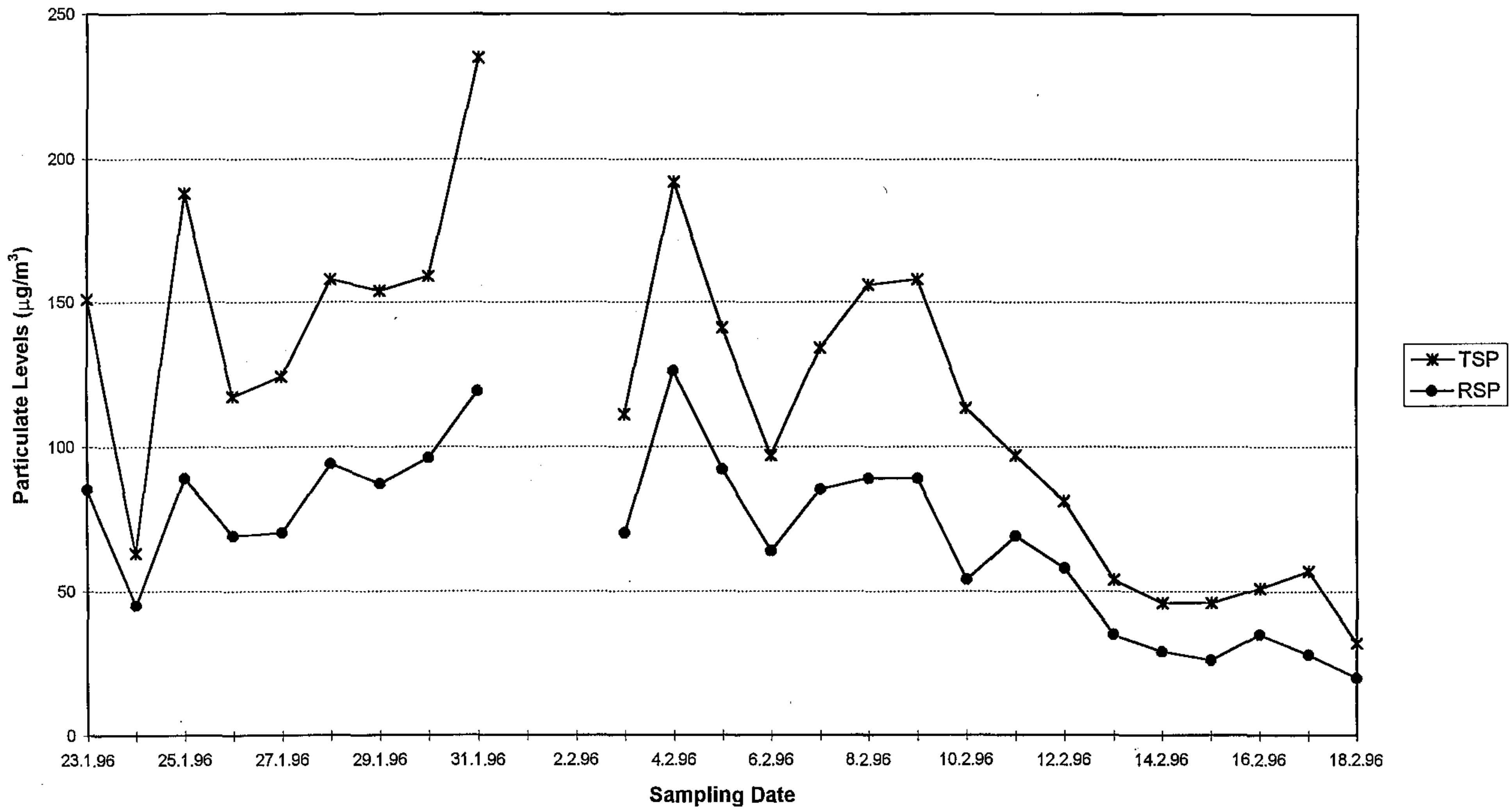


Figure C1.3: Results of NO_2 and SO_2 Baseline Monitoring at Tin Shui Wai

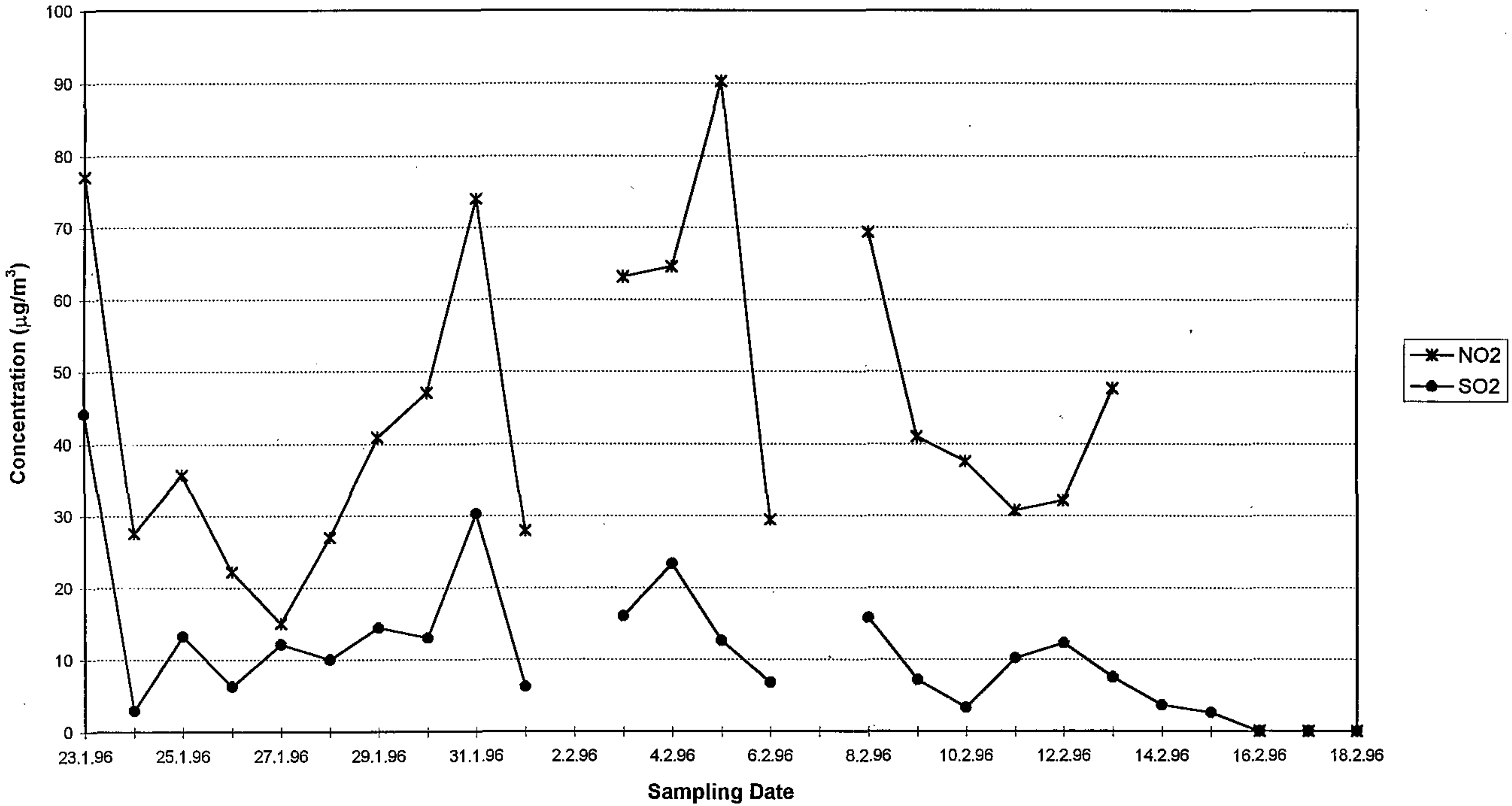
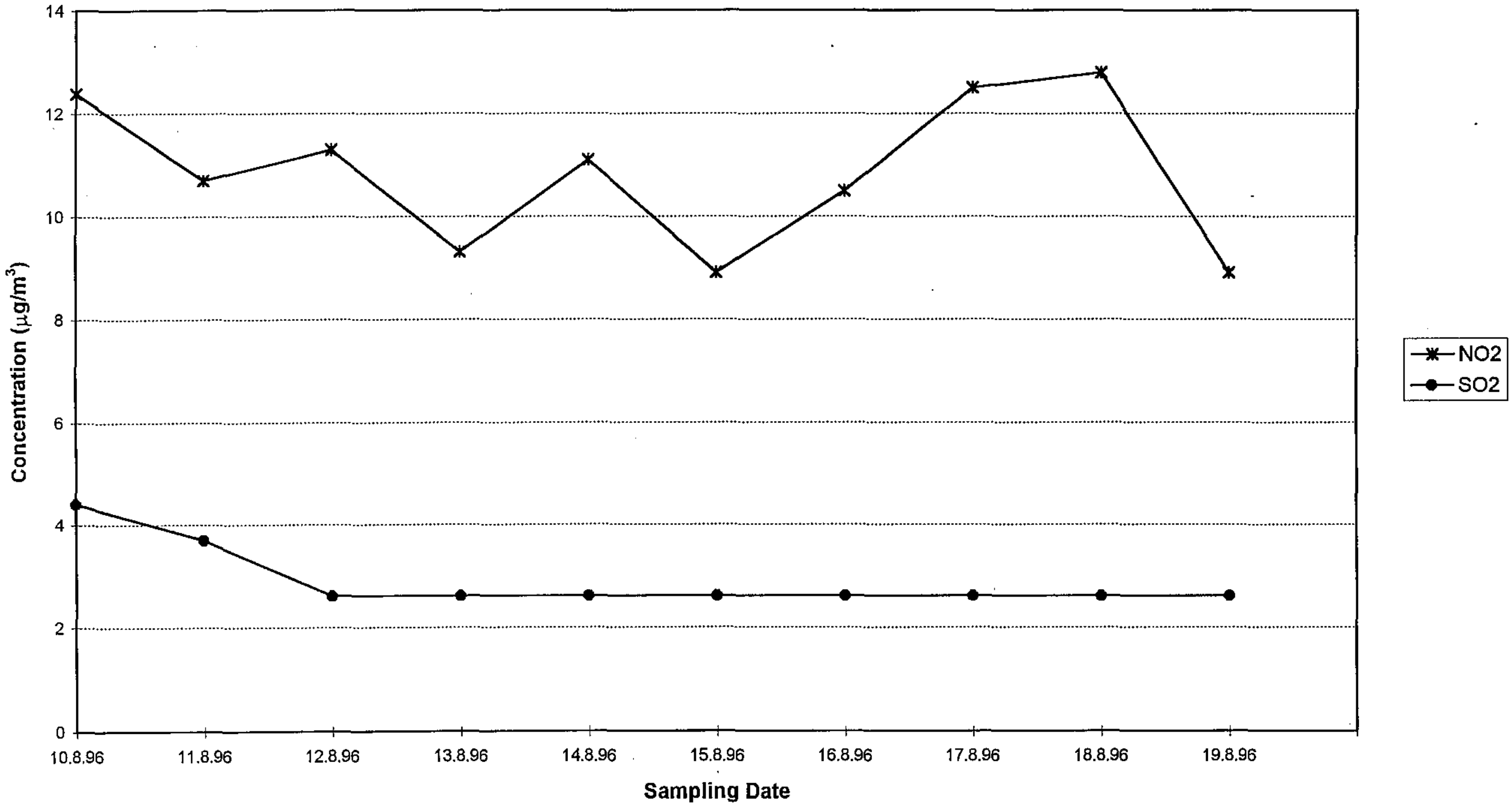


Figure C1.4 : Results of SO_2 and NO_2 Baseline Monitoring at Tin Shui Wai



Appendix C2: The Detailed Calculations of Emission Rates for Each Dust Source

Loading and Unloading

C2.1 The dust sources associated with the loading and unloading at the excavation sites have been considered as area sources. The quantity of particulate emissions generated by a batch drop or continuous drop operation, per ton of material transferred, may be estimated with an emission factor rating of C using the following empirical expression (USEPA 1995; p.13.2.4-4):

$$E = k(0.0016)\frac{(\frac{U}{2.2})^{1.3}}{(\frac{M}{2})^{1.4}}(kg/Mg) \text{ .... } (C2.1)$$

where:

E	=	emission factor
k	=	particle size multiplier (dimensionless)
U	=	mean wind speed, m/s, (mph)
M	=	material moisture content (%)

C2.2 Equation (C2.1) can be rewritten as following:

$$E' = Q_o U'^{w} \text{ .... } (C2.2)$$

where Q_o is the "unadjusted" emission factor which does not consider the change of hourly wind speed and direction, U' is hourly wind speed and w is the wind dependent factor. E is the mean value of E's. It is noted that equation (C2.2) is a general equation for all emission factors. In equation C2.1, the power of U is 1.3, i.e. w is 1.3.

C2.3 Using equation (C2.1) and (C2.2), the emission factors for TSP and RSP can be estimated by the required data listed in Table C2.1.

Table C2.1
Physical Data for Evaluating the Impact of Loading and Unloading

Parameters of Equation (1)	TSP	RSP
Particle Size Multiplier (k)	0.74 (USEPA 1995: page 13.2.4-4)	0.35 (USEPA 1995: page 13.2.4-4)
Material Moisture Content (M)	2% (USEPA 1995: page 13.2.4-4) [1]	2% (USEPA 1995: page 13.2.4-4) [1]

[1] 2% moisture content is assumed for very dry environment.

C2.4 By the use of equation (C2.1), the "unadjusted" emission factor for TSP becomes:

$$Q_o = 0.74(0.0016)\frac{(\frac{1}{2.2})^{1.3}}{(\frac{2}{2})^{1.4}}(kg/Mg) \;...\; (C2.3)$$

= 4.25 x 10^{-4} kg/T

C2.5 The "unadjusted" emission factor for RSP becomes:

$$Q_o = 0.35(0.0016)\frac{(\frac{1}{2.2})^{1.3}}{(\frac{2}{2})^{1.4}}(kg/Mg) \;...\; (C2.4)$$

= 2.01 x 10^{-4} kg/T

The wind dependent factor, w, in this case, is 1.3.

C2.6 Assuming a density of 1.987x10^3 kg/m^3 and 10 hour working day, 26 days a month and for 208 days total, the material to be shifted per hour is 768 T/hr, i.e.,

$$\frac{804000m^3 x1.987x10^3 kg/m^3}{208x10hr} = 768051.9\ (kg/hr) \;...\; (C2.5)$$

C2.7 The unadjusted emission rate for TSP is 0.09 g/sec,

$$\frac{4.25x10^{-4} kg/Tx768T/hr}{3.6} = 0.09\ (g/\text{sec}) \;...\; (C2.6)$$

where 3.6 is the conversion factor for the change of kg/hr to g/sec. The unadjusted emission rate for RSP is 0.043 g/sec.

$$\frac{2.01x10^{-4}kg/Tx768T/hr}{3.6} = 0.043\ (g/\text{sec})\ ...\ (C2.7)$$

C2.8 An area of 908000 m^2 has been used as the loading area for Areas 101-108, 109a & 110-111. Consequently, the unadjusted emission rate per unit area can be calculated from equation (C2.6) and (C2.7) and then substituted into equation (C2.2). The emission rates become:

TSP: = 9.98 X 10^{-8} g/s/m^2,
RSP: = 4.72 X 10^{-8} g/s/m^2.

Unpaved roads and haul routes

C2.9 The top soil and other fill materials at the excavation site will be transported by dump trucks that will cause dust emission when they travel over unpaved roads and haul routes. The emission factor to be used is from AP-42 (USEPA 1995; equation 1, p 13.2.2-1) with emission factor rating A:

$$0E = k(1.7)(\frac{s}{12})(\frac{S}{48})(\frac{W}{2.7})^{0.7}(\frac{w}{4})^{0.5}(\frac{365-p}{365})(kg/VKT)\ ...\ (C2.8)$$

where

E	=	emission factor
k	=	particle size multiplier (dimensionless)
s	=	silt content of road surface material (%)
S	=	mean vehicle speed, km/hr
W	=	mean vehicle weight, Mg(ton)
w	=	mean number of wheels
p	=	number of days with at least 0.254 mm of precipitation per year.
VKT	=	vehicle kilometre travelled

C2.10 The data for estimating the emission rates of unpaved road and haul routes due to site formation are summarized in Table C2.2.

Table C2.2
Physical Data for Evaluating the Impact of Unpaved Roads and Haul Roads

Parameters	TSP	RSP
Particle size Multiplier (k)	0.8	0.36
Maximum Silt Content of Road Surface Material (s)	6%*	6%*
Mean Vehicle Speed (S) km/hr	15	15
Mean Vehicle Weight (W) tonnes	35	35
Mean Number of Wheels (w) (Nissan Motor Co. and Caterpiller Inc. USA)	10	10
Number of Rainy Days per Year (Royal Observatory)	100 days	100 days

* Based on Tin Shui Wai Land Formation Material Testing Data

C2.11 The locations of the haul roads have been based on the cut and fill isopachs. For example, in Area 102, there is a surplus volume of about 94,000 m^3. There are four haul roads likely to be operated in Area 102: haul road H1 corresponds to the internal cut and fill operation within Area 102; H2, H19 and H20 correspond to the transport of fill materials from Area 102 to 101, 107a & 106. Table C2.3 shows the volume of material carried on each haul road and the corresponding number of vehicle roundtrips per hour.

Table C2.3
Predicted Haul Road Traffic for Works Contract 1

Contract	Area	Haul Road	Volume of Materials (m^3)	Construction Period (months)	Number of Vehicle Roundtrips per Hour (veh/hr)
1	102	H1	55000	4	18
1	102	H2	83000	4	28
1	102	H19	5000	4	2
1	102	H20	6000	4	2

C2.12 For example, the calculation of the emission rates due to haul road H2 are described below. The calculations assumed the works to proceed 10 hours per day and 26 days per month. The dump truck was taken to have a capacity of 6 m^3 with a travelling speed of 15 km/hr. The distance that the dump trucks travel on haul road H2 at Area 102 coincide with the length of the haul road: roughly 0.3 km for a single trip. The round trip distances have been simulated by modelling as shown in Section 2 the line sources twice in the FDM run. The dust source due to dump truck traffic on haul roads is identified as a line source.

C2.13 VKT can be expressed as total vehicle movement per hour. Construction vehicle movement per hour has been calculated by dividing the total material to be moved by 6.0 m^3 dump truck. This is the average load carried by the dump trucks planned for the site. The number of vehicle roundtrips per hr is roughly 28 veh/hr (Table C2.3).

C2.14 The wind dependent factor, in this case, is zero. So the emission factor becomes:

$$E=0.8(1.7)(\frac{6}{12})(\frac{15}{48})(\frac{35}{2.7})^{0.7}(\frac{10}{4})^{0.5}(\frac{365-100}{365})(kg/VKT) \quad ... \quad (C2.9)$$

i.e. E = 1.47 kg/VKT.

C2.15 With 28 Veh/hr and kg/VKT in terms of g/m/s, using a conversion factor of

$$(\frac{vehicle/hour}{3.6x1000}),$$

the emission rate for TSP on H2 becomes:

$$(\frac{1.47}{3.6x1000})x28=0.0114g/m/s \quad ... \quad (C2.10)$$

For RSP, the emission rate is 0.00513 g/m/s. The detailed emission rates for all haul roads are listed at Appendix C4 for easy reference.

Stockpile/Aggregate Storage

C2.16 For emissions from wind erosion of active storage piles, the emission rate for TSP is from AP-42 (USEPA 1985, equation 3, p 2.3-5) with rating C for sand and gravel material:

$$E=1.9(\frac{s}{1.5})(\frac{f}{15})(\frac{365-p}{235})(kg/day/hectare) \quad ... \quad (C2.11)$$

where

E	=	emission rate
s	=	silt content of aggregate (%)
f	=	percent of time that wind speed exceeds 5.4 m/s at mean pile height
p	=	number of days with at least 0.254 mm of precipitation per year.

C2.17 The parameter f requires some modification. Royal Observatory (RO) measures the wind speed at a height of 10 metres above ground level. In case of heights less than 10 metres, a log wind profile (Roland 1988) can be used to estimate the wind speed at the top of the pile: pile height (Appendix C5). The ratio between the wind speed at 10 metres and that at pile height is the conversion factor that converts the percentage provided by RO to the percentage at pile height. For example, with a pile height of 5 m, the conversion factor is 83%. Given that the RO percentage is 11.44% when wind speed exceeds 5.4 m/s at mean pile height, the percentage at pile height is thus 11.44% x 0.83 = 7.0 %.

C2.18 With this 7.0 % percentage and a 6.0 % silt content for the stockpile material, and based on Table 11.2.3-1 in AP-42 (mean value for stone processing), the emission rate is 3.99 kg/day/hectare, .

$$E=1.9(\frac{6}{1.5})(\frac{7}{15})(\frac{365-100}{235}) = 3.99(kg/day/hectare) \text{ ... } (C2.12)$$

Given 1 hectare = 10^4 m^2, the emission rate is for TSP = 4.6 E-6 g/s/m^2.

C2.19 Since there is no specified emission rate for RSP given in AP-42, 50% TSP is assumed as the emission for RSP. Thus, the emission rate is for RSP = 2.3 E-6 g/s/m^2. The stockpiles are illustrated on Figure 2.4.

Top soil removal

C2.20 The emission factor for top soil removal is 0.02 kg/Mg (USEPA 1985, Table 11.24-4). For example, the surface area of Areas 101-108, 109a & 110-111 is about 908,000 m^2. Assuming the depth of top soil to be 0.3 metre, the volume of top soil is 272,400 m^3. Assuming the relative density of topsoil is 1.987 x 10^3 kg/ m^3, then the mass of the soil removed is given by

$$Mass(T) = (\frac{272400X1987}{1000}) = 541258.8(T) \text{ ... } (C2.14)$$

C2.21 The total volume of materials handled in Areas 101-108, 109a & 110-111 is roughly 908,000 m^3 while there is only 272400 m^3 top soil material. As the time required for the initial site formation works will be expected to last for eight months, it is likely that all the top soil materials will be removed within 2 months. Thus, the time required is 104 days. So the rate of removal is

$$(\frac{541258.8}{104X10}) = 520.4(T/hr) \text{ ... } (C2.15)$$

C2.22 The TSP emission rate is 0.02 kg/T X 520.4 T/hr = 10.4 kg/hr (2.891 g/s).

C2.23 The emission rates per unit area at site are:

TSP : 3.18 x 10^{-6} g/s/m^2
RSP : 1.59 x 10^{-6} g/s/m^2.

Wind erosion of the whole exposed area

C2.24 The TSP emission factor of wind erosion of exposed areas (USEPA 1985, Table 24-4) is 0.85 Mg/hectare/yr. Given 1 hectare = 10^4 m^2, the emission rate for TSP becomes

$$\frac{0.85x1000}{10^4x365x24x3.6} = 2.69E-6g/s/m^2 \text{ ..... } (C2.16)$$

C2.25 Since the emission rate of RSP is not available in AP-42, 50 % of TSP is assumed to be the emission rate of RSP. Thus the emission rate of wind erosion of the whole exposed area is

for TSP = 2.69×10^{-6} g/s/m^2.
for RSP = 1.34×10^{-6} g/s/m^2.

Appendix C3.1: Emission Rates for Dust Sources (Works Contracts 1 & 2)

Loading & Unloading

	TSP	RSP
Particle size multiplier, k	0.74	0.35
Mean wind speed (m/s), U	1	1
Material moisture content (%), M	2	2
Unadjusted emission rate (kg/T), Qo	0.000425	0.000201
Volume of material (m^3)	804000	804000
Density of material (kg/m^3)	1987	1987
Days of work	208	208
Working hours	10	10
Unadjusted emission rate (g/s)	0.091	0.043
Surface area (m^2)	908000	908000
Unadjusted emission rate ($g/s/m^2$)	9.98E-08	4.72E-08

Unpaved Road and Haul Routes (2 way)

	TSP	RSP
Particle size multiplier, k	0.8	0.36
Silt content of road surface material (%), s	6	6
Mean vehicle speed (km/hr), S	15	15
Mean vehicle weight (T), W	35	35
Mean number of wheels, w	10	10
Number of days with at least 0.254 mm rainfall per year, p	100	100
Number of vehicle roundtrips per hr	*	*
E (kg/VKT)	*	*
E (g/s/m)	*	*

* Detail refer to Appendix C4

Stockpiling

Silt content of aggregate (%), s	6
% of time with wind speed > 5.4 m/s at mean pile height	7
Number of days with at least 0.254 mm rainfall per year, p	100
E (kg/day/hectare)	4.00
E ($g/s/m^2$) for TSP	4.63E-06
E ($g/s/m^2$) for RSP	2.31E-06

Top Soil Removal

Depth of top soil (m)	0.3
Surface area (m^2)	908000
Density of material (kg/m^3)	1987
Mass of material (T)	541258.8
Days of work	104
Working hours	10
Rate of removal (T/hr)	520.4
E (g/s) for TSP	2.89
E (g/s) for RSP	1.45
E ($g/s/m^2$) for TSP	3.18E-06
E ($g/s/m^2$) for RSP	1.59E-06

Wind Erosion

E ($g/s/m^2$) for TSP	2.70E-06
E ($g/s/m^2$) for RSP	1.35E-06

Appendix C3.2: Emission Rates for Dust Sources (Scenario 2 - Contracts 6 & 7)

Loading & Unloading (Areas 114-117, 109b and 120)

	TSP	RSP
Particle size multiplier, k	0.74	0.35
Mean wind speed (m/s), U	1	1
Material moisture content (%), M	2	2
Unadjusted emission rate (kg/T), Qo	0.000425	0.000201
Volume of material (m^3)	460000	460000
Density of material (kg/m^3)	1987	1987
Days of work	390	390
Working hours	10	10
Unadjusted emission rate (g/s)	0.0277	0.0131
Surface area (m^2)	170000	170000
Unadjusted emission rate ($g/s/m^2$)	1.63E-07	7.69E-08

Loading & Unloading (Areas 112-114)

	TSP	RSP
Particle size multiplier, k	0.74	0.35
Mean wind speed (m/s), U	1	1
Material moisture content (%), M	2	2
Unadjusted emission rate (kg/T), Qo	0.000425	0.000201
Volume of material (m^3)	129000	129000
Density of material (kg/m^3)	1987	1987
Days of work	312	312
Working hours	10	10
Unadjusted emission rate (g/s)	0.0097	0.0046
Surface area (m^2)	150000	150000
Unadjusted emission rate ($g/s/m^2$)	6.46E-08	3.06E-08

Loading & Unloading (Tin Ying Road Dualling)

	TSP	RSP
Particle size multiplier, k	0.74	0.35
Mean wind speed (m/s), U	1	1
Material moisture content (%), M	2	2
Unadjusted emission rate (kg/T), Qo	0.000425	0.000201
Volume of material (m^3)	91000	91000
Density of material (kg/m^3)	1987	1987
Days of work	312	312
Working hours	10	10
Unadjusted emission rate (g/s)	0.00684	0.00323
Surface area (m^2)	40000	40000
Unadjusted emission rate ($g/s/m^2$)	1.71E-07	8.09E-08

Unpaved Road and Haul Routes (2 way)

	TSP	RSP
Particle size multiplier, k	0.8	0.36
Silt content of road surface material (%), s	6	6
Mean vehicle speed (km/hr), S	15	15
Mean vehicle weight (T), W	35	35
Mean number of wheels, w	10	10
Number of days with at least 0.254 mm rainfall per year, p	100	100
Number of vehicle roundtrips per hr	*	*
E (kg/VKT)	*	*
E (g/s/m)	*	*

* Detail refer to Appendix C4.2

Stockpiling

Silt content of aggregate (%), s	6
% of time with wind speed > 5.4 m/s at mean pile height	7
Number of days with at least 0.254 mm rainfall per year, p	100
E (kg/day/hectare)	4.00
E ($g/s/m^2$) for TSP	4.63E-06
E ($g/s/m^2$) for RSP	2.31E-06

Top Soil Removal (Areas 114-117, 109b and 120)

Depth of top soil (m)	0.3
Surface area (m^2)	170000
Density of material (kg/m^3)	1987
Mass of material (T)	101337
Days of work	78
Working hours	10
Rate of removal (T/hr)	129.9
E (g/s) for TSP	0.722
E (g/s) for RSP	0.361
E ($g/s/m^2$) for TSP	4.25E-06
E ($g/s/m^2$) for RSP	2.12E-06

Top Soil Removal (Areas 112-114)

Depth of top soil (m)	0.3
Surface area (m^2)	150000
Density of material (kg/m^3)	1987
Mass of material (T)	89415
Days of work	78
Working hours	10
Rate of removal (T/hr)	114.6
E (g/s) for TSP	0.637
E (g/s) for RSP	0.318
E ($g/s/m^2$) for TSP	4.25E-06
E ($g/s/m^2$) for RSP	2.12E-06

Top Soil Removal (Tin Ying Road Dualling)

Depth of top soil (m)	0.3
Surface area (m2)	40000
Density of material (kg/m3)	1987
Mass of material (T)	23844
Days of work	78
Working hours	10
Rate of removal (T/hr)	30.57
E (g/s) for TSP	0.1698
E (g/s) for RSP	0.0849
E (g/s/m2) for TSP	4.25E-06
E (g/s/m2) for RSP	2.12E-06

Wind Erosion

E (g/s/m2) for TSP	2.70E-06
E (g/s/m2) for RSP	1.35E-06

Appendix C4.1: **Haul Road Emission Rates at Reserve Zone (Scenario 1)**

Haul Road	No. of Vehicle Roundtrips per Hour	Emission Rate (g/s/m)		Emission Rate (g/s/m)	
		TSP	RSP	TSP *	RSP *
H1	18	7.33E-03	3.30E-03	3.67E-03	1.65E-03
H2	28	1.14E-02	5.13E-03	5.70E-03	2.57E-03
H6	2	8.15E-04	3.67E-04	4.07E-04	1.83E-04
H7	2	8.15E-04	3.67E-04	4.07E-04	1.83E-04
H9	12	4.89E-03	2.20E-03	2.44E-03	1.10E-03
H12	8	3.26E-03	1.47E-03	1.63E-03	7.33E-04
H15	20	8.15E-03	3.67E-03	4.07E-03	1.83E-03
H16	12	4.89E-03	2.20E-03	2.44E-03	1.10E-03
H19	2	8.15E-04	3.67E-04	4.07E-04	1.83E-04
H20	2	8.15E-04	3.67E-04	4.07E-04	1.83E-04
H21	4	1.63E-03	7.33E-04	8.15E-04	3.67E-04
H22	24	9.77E-03	4.40E-03	4.89E-03	2.20E-03
H23	26	1.06E-02	4.76E-03	5.29E-03	2.38E-03
H24	8	3.26E-03	1.47E-03	1.63E-03	7.33E-04
H25	2	8.15E-04	3.67E-04	4.07E-04	1.83E-04
H26	4	1.63E-03	7.33E-04	8.15E-04	3.67E-04
H27	2	8.15E-04	3.67E-04	4.07E-04	1.83E-04
H28	4	1.63E-03	7.33E-04	8.15E-04	3.67E-04
H29	2	8.15E-04	3.67E-04	4.07E-04	1.83E-04
H30	4	1.63E-03	7.33E-04	8.15E-04	3.67E-04
H31	2	8.15E-04	3.67E-04	4.07E-04	1.83E-04
H32	2	8.15E-04	3.67E-04	4.07E-04	1.83E-04
H33	12	4.89E-03	2.20E-03	2.44E-03	1.10E-03
H34	4	1.63E-03	7.33E-04	8.15E-04	3.67E-04
H35	24	9.77E-03	4.40E-03	4.89E-03	2.20E-03
H36	2	8.15E-04	3.67E-04	4.07E-04	1.83E-04
H37	6	2.44E-03	1.10E-03	1.22E-03	5.50E-04
H38	4	1.63E-03	7.33E-04	8.15E-04	3.67E-04

* 50% reduction of the emission rates.

Appendix C4.2: Haul Road Emission Rates at Reserve Zone (Scenario 2)

Haul Road	No. of Vehicle Roundtrips per Hour	Emission Rate (g/s/m)		Emission Rate (g/s/m)	
		TSP	RSP	TSP *	RSP *
A	40	1.63E-02	7.33E-03	8.15E-03	3.67E-03
B	4	1.63E-03	7.33E-04	8.15E-04	3.67E-04
C	10	4.07E-03	1.83E-03	2.04E-03	9.16E-04

* 50% reduction of the emission rates.

Appendix C5: Log Wind Profile

To estimate the mean wind speed as a function of height z, we use a logarithmic relationship (log wind profile) as following:

$$U = \frac{U^*}{k} \ln \frac{z}{z_o} \quad \text{............} \quad (C5.1)$$

where

U^*	=	friction velocity,
k	=	von Karman constant, 0.4 (dimensionless),
z_o	=	roughness length (10 cm).

The friction velocity can be recalculated from equation (C5.1) by substituting U = 5.4 m/s, z = 10 m in equation (C5.1). The friction velocity is thus 0.46 m/s.

For example, if the pile height is 5 meter, then the mean velocity is thus 4.49 m/s. Hence, the conversion factor is (4.49/5.4) x 100% = 83%. This conversion factor will be used to convert the percentage provided by Royal Observatory to the value (f) used in pile height.

Appendix C6: Chimney Data and Emission Rates for the Industrial Emission Impact Assessment

Table C6.1 Chimney Data for Tin Shui Wai Development (EPD's sources)

No.	Chimney Location		Chimney			Operating Period			Light Industrial Diesel Consumption		Boiler Diesel Oil Consumption	
	Easting	Northing	Height (m)	Diameter (mm)	Exit Temperature (°C)	Time Start	Time Stop	Days per Week	Litres per Week	Litres per Hour (max.)	Litres per Week	Litres per Hour (max.)
1	817426	832256	14.4	381	0	0800	2300	6			3000	81
2	816680	831223	18.3	300	0	0000	0000	0	0	0	0	0
3	816728	831332	24.9	605	181	0730	1730	6	8040	288		
4	816590	831178	24.4	610	0	0700	2300	6	9000	214		
5	816616	831174	0	300	0	0830	1500	0	0	0	0	0
6	816602	831175	0	300	0	0000	0000	0	0	0	0	0
7	817650	832500	5.5	260	0	0000	0000	0	0	0	0	0
8	817650	832500	6	260	0	0000	0000	0	0	0	0	0
9	817650	832500	6	200	0	0000	0000	0	0	0	0	0
10	817650	832500	6	200	0	0000	0000	0	0	0	0	0
11	816360	831088	9.2	305	0	0400	2100	7	420	14.8		
12	816410	831036	8	150	0	0300	1400	7	700	18.2		
13	820480	835535	42	400	204	0000	2400	7	3500	212		
14	820480	835545	42	250	204	0000	2400	7	3500	106		
15	818386	833874	20.2	400	168	0800	2400	6	2400	169		
16	818386	833820	18.5	410	202	0800	2400	6	1998	254		
17	821054	835930	55.5	1100	163	0000	2400	6			78000	1564
18	821040	835930	55.5	610	171	0800	0500	6	2700	235.2	8988	340

19	820550	836030	26.5	762	0	0545	2315	6	16800	532		
20	818235	833345	21.1	610	0	0000	0000	0	0	446		
21	817560	835605	21	300	0	0000	0000	0			0	95.3
22	820940	836080	0	102	0	0000	0000	0	0	34.8		
23	820960	836060	24.4	250	120	0700	2230	5	750	75		
24	819390	833760	29.3	378	0	0730	1730	6	2400	181		
25	821096	834762	15	460	200	0200	0600	7	2184	102.6		
26	821096	834784	15	460	200	0200	0600	7	1694	79.8		
27	821110	834750	16.3	570	400	0700	0900	7	1050	81		
28	820960	832130	7.6	330	0	0000	0000	0	0	0	0	0
29	820960	832133	6	330	0	0000	0000	0	0	0	0	0
30	820950	832130	9	200	0	0800	1800	6	0	0	0	0
31	818270	833680	24.8	600	204	0730	1700	6	0	0	0	0
32	818250	833660	8.5	508	0	0730	1700	6	0	0	0	0
33	818260	833665	8.5	508	0	0730	1700	6	0	0	0	0
34	818270	833760	8.5	508	0	0730	1700	6	0	0	0	0
35	818268	833663	8.5	508	0	0730	1700	6	0	0	0	0
36	818026	832296	14.9	343	0	0800	1700	6			486	120
37	818028	832300	12	241	0	0800	1700	6			204	50
38	818036	832304	11.1	305	0	0800	1700	6			102	25
39	818036	832298	11.1	267	0	0800	1700	6			246	60
40	818034	832296	11.1	267	0	0800	1700	6			246	60
41	818034	832292	11.1	267	0	0800	1700	6			246	60
42	818050	832322	11.1	203	0	0800	1700	6			102	25

43	818062	832338	11.1	241	0	0800	1700	6			102	25
44	818078	832338	9.4	267	0	0800	1700	6			246	60
45	821050	832130	21.5	468	0	0000	0000	0	0	0	0	0
46	819122	833190	24.9	450	0	0000	0000	6			8400	272
47	819530	833580	9	401	0	0000	0000	0	0	0	0	0
48	819530	833575	10.9	508	0	0000	0000	0	0	0	0	0
49	819535	833570	9	254	0	0000	0000	0	0	0	0	0
50	819530	833572	9	254	0	0000	0000	0	0	0	0	0
51	821036	833100	42.9	400	0	0730	1700	6				
52	818840	833160	26.7	708	168	0900	1800	6	0	0	0	0
53	819690	831390	5	564	0	0900	1200	7	0	0	0	0
54	819685	831390	5	564	0	0900	1200	7	0	0	0	0
55	818001	832200	0	305	0	0800	1330	7	910	236		
56	818002	832200	0	305	0	0800	1330	7	0	0	0	0
57	818138	832412	19.8	229	0	0700	2100	6			3564	53
58	819020	833145	22.3	406	204	1000	1830	6			2040	191.1
59	818350	833762	31.9	1016	216	0000	2400	6				
60	819380	833400	29.6	460	199	0000	2400	6	4200	302		
61	819340	833430	40.3	530	189	0000	2400	6	8400	300		
62	821080	834361	60.4	820	160	0000	2400	6	48000	1109.6		
63	821060	834362	58.9	800	126	0000	2400	6	48000	714.7		
64	821120	834318	58.9	530	0	0000	2400	7			21000	436
65	819320	833440	32.8	960	182	0800	0430	7			75600	1280.2
66	819310	833460	32.8	490	0	0830	0430	7	0	73	25200	243.6

67	819330	833470	29.3	650	190	0830	0430	7			21000	540
68	819385	833540	38.1	520	153	0000	2400	6	21000	427		
69	819380	833540	38.1	520	153	0000	2400	6	21000	427		
70	819375	833540	38.1	520	153	0000	2400	6	21000	427		
71	819370	833540	38.1	520	153	0000	0000	0	0	427		
72	819365	833540	38.1	520	153	0000	2400	6	21000	427		
73	819320	833520	32.2	310	153	0000	2400	6	17520	121.8		
74	819320	833505	32.2	310	153	0000	2400	6	17520	121.8		
75	819370	833455	33.7	520	168	0000	2400	6	18000	579		
76	819370	833450	33.7	520	168	0000	2400	6	24000	548.8		
77	820388	835346	25.5	590	0	0000	0000	0	0	227.7		
78	820374	835380	28.2	640	0	0000	0000	0	0	427		
79	821132	834317	61	520	145	0000	2400	6	42000	667		
80	821130	834316	61	520	145	0000	2400	6	42000	667		
81	821133	834322	57.6	540	145	0000	2400	6	0	150	4800	150
82	821104	834198	70.1	320	178	0800	1800	6	3600	102		
83	818516	833802	27.2	715	189	0000	2400	7			42322	730
84	818512	833802	27.2	715	189	0000	2400	7			42322	730
85	818562	833810	32	380	0	0000	2400	7			10885	165
86	816890	833520	21.3	510	165	0730	0500	6	9000	259		
87	818785	832900	26.8	711	188	0800	0400	6			27240	741
88	819005	832615	35.2	711	174	0700	0200	6			32700	643
89	819070	832795	35.2	711	120	0000	0000	0	0	843.3		
90	821215	835780	7.3	150	0	0000	0000	0	0	0	0	0

91	820820	832300	12.2	381	0	0800	1800	6			2400	182
92	821120	834306	61.4	810	0	0700	2000	6	29994	698.9		
93	821278	835388	32	1800	264	0000	2400	6	0	0	0	0
94	821140	835432	32	700	180	0000	2400	6	0	0	0	0
95	821162	835380	32	350	180	0000	2400	6	0	0	0	0
96	816890	833520	18.9	533	150	0000	0000	0				
97	821052	834202	65.9	363	141	0830	0530	6				
98	821052	834202	65.9	318	149	0830	0530	6				
99[1]	820310	835710	49.5	1320	195	0000	2400	7			361200	2500
100[1]	820320	835680	49.5	1320	195	0000	0000	0			0	2500
101	818095	833608	24.6	350	166	0800	1630	6	8400	169.4		
102	818096	833610	24.6	350	166	0000	0000	0	0	158.9		
103	819340	833430	40.3	530	189	0000	2400	7	3500	96.4		
104	819360	833430	34.3	508	218	0000	2400	7	7000	400.4		
105	819370	833430	34.3	864	218	0000	2400	7	14000	840.5		
106	821190	834582	27.4	440	0	0000	0000	0	0	0	0	0
107	821000	835450	19.6	200	0	0000	0000	0	0	0	0	0
108	818170	832350	24.8	686	180	0000	2400	6	6000	530		
109	818170	832374	24.4	560	188	0000	0000	0	0	164		
110	819150	833296	13.3	450	0	0000	2400	7	11130	70		
111	819160	833294	13.3	450	0	0000	0000	0	0	70		
112	817730	831700	24.2	610	0	0000	2400	6			12570	126

[1] Courtesy of Concordia Paper Ltd.

113	817730	831680	22.7	560	0	0000	2400	6			8376	63
114	818434	833864	23	400	200	0000	2400	7	13524	193		
115	818404	833762	27.4	635	149	0000	2400	7				
116	818410	833762	19	381	0	0000	0000	0	0	115.3		
117	818414	833760	19	381	0	0000	0000	0	0	173		
118	820726	835972	41.2	480	120	0000	2400	7	0	665.3		
119	820750	836026	6	250	120	0000	2400	7	0	403.9		
120	820370	836260	45	500	220	0000	2400	7	66255	400		
121	820550	836280	20.4	300	165	0000	2400	7	23940	178		
122	820560	836280	20.4	350	165	0000	2400	7	17164	127		
123	820550	836300	21.4	270	600	0000	2400	7	9100	58		
124	819385	833540	35.8	288	0	0000	0000	0	0	0	0	0
125	819110	833000	19.4	355	0	0630	1600	6	5040	160		
126	819420	833690	30.4	318	0	0800	1700	5	1250	105.9		
127	818540	834550	23.1	508	182	0900	1700	6	3600	365.3		
128	820918	834354	57.9	610	162	0800	2300	6			15000	499
129	816500	833275	12.2	254	0	0000	2400	1			187	100
130	819420	833130	15.3	450	0	0730	1600	6			5940	117
131	818935	832725	18.3	305	204	0000	0000	0	0	94		
132	819170	833260	16.7	406	0	0000	0000	0	0	76.7		
133	818810	832940	15.2	406	0	0000	2400	7	266	2		
134	818805	832960	0	200	0	0900	1800	6	1080	25		
135	821030	835760	16.9	380	0	0830	1730	6				
136	821040	835755	24.9	500	0	0830	1730	6				

137	818225	833520	6.8	430	0	1600	1800	1				
138	821150	835650	15.1	950	245	0700	2200	6	12000	249.5		
139	818252	833820	18.3	457	0	0800	1900	6				
140	818560	833828	20.1	457	0	0800	1900	6				
141	820380	835420	17	533	0	0800	2000	6	7920	166.4		
142	820360	835410	15.4	635	0	0800	2000	1	480	150		
143	818981	833043	18	350	0	0000	2400	7	3318	76		
144	818982	833042	6	342	0	0700	1600	7	182	7.6		
145	819030	833200	6.1	450	0	0800	1800	6	18000	375		
146	818050	833250	0	360	0	0000	0000	0	0	0	0	0
147	819240	833480	31.8	500	120	0830	1700	6	600	147.1		
148	817750	832690	0	150	0	0000	0000	0	0	0	0	0
149	817780	832600	41.1	125	0	0000	0000	0	0	0	0	0
150	821175	834540	22.2	100	575	0000	0000	0	0	0	0	0
151	818770	835750	6.5	125	0	0000	0000	0	0	0	0	0
152	818312	833774	27.1	610	204	0700	2300	6	27276	430		
153	818378	833820	25.9	356	204	0000	0000	0	0	127		
154	821175	833925	49.2	381	0	0600	2200	7				
155	820860	833720	78.6	550	0	0000	0000	0				
156	816370	836491	8.2	153	0	1200	2000	7	476	8.6		
157	816376	836491	8.2	110	0	1200	2000	7	0	0	0	0
158	816375	836462	5	203	0	1200	2100	7	0	15		
159	816373	836461	5	203	0	1200	2100	7	0	0	0	0
160	816371	836459	5	203	0	1200	2100	7	0	0	0	0

161	816378	836460	5	203	0	1200	2100	7	0	0	0	0
162	816250	836525	8	226	0	0000	0000	0	0	0	0	0
163	816251	836525	8	226	0	0000	0000	0	0	0	0	0
164	820886	834063	50	267	0	0400	2400	7	3150	55		
165	820460	834549	118.2	400	152	0000	0000	0	0	145.6		
166	816390	836450	5	200	0	0000	0000	0	0	0	0	0
167	818100	834700	0	1298	0	0000	0000	7	0	0	0	0
168	817500	835200	19.8	957	0	0000	0000	7	0	0	0	0
169	820970	833750	46.9	425	0	0000	0000	0	0	0	0	0
170	821360	833850	0	0	0	0700	2300	7				
171	821106	834190	62.3	305	168	0700	1800	7	2730	100		
172	821110	834180	59.4	300	153	0830	1730	7	5600	93.6		
173	820720	836220	24.4	626	120	0000	2400	6	19800	756		
174	821110	835090	26	710	200	0000	0000	0	0	779.7		
175	817400	832910	5.5	690	0	0000	0000	0				
176	819750	834460	12.3	1270	0	0000	0000	0				
177	821000	835300	17	310	0	0000	0000	0	0	119.2		
178	821030	835250	0	100	0	0000	0000	0	0	59		

Table C6.2 Emission Rate for Chimneys with Light Industrial Diesel Combustion

Chimney No.	Easting	Northing	Height (m)	Diameter (m)	Temperature (K)	Efflux Velocity (m/s)	SO_2 g/s	NO_2 g/s
3	816728	831332	24.9	0.605	454	5.3332	0.6560	0.0384
4	816590	831178	24.4	0.610	413	3.5461	0.4874	0.0285
11	816360	831088	9.2	0.305	413	0.9810	0.0337	0.0020
12	816410	831036	8.0	0.150	413	4.9875	0.0415	0.0024
13	820480	835535	42.0	0.400	477	9.4359	0.4829	0.0283
14	820480	835545	42.0	0.250	477	12.0779	0.2414	0.0141
** 15	818386	833874	20.2	0.400	441	6.9543	0.3849	0.0225
** 16	818386	833820	18.5	0.410	475	10.7154	0.5786	0.0339
* 18	821040	835930	55.5	0.610	444	4.1899	0.5357	0.0314
19	820550	836030	26.5	0.762	413	5.6494	1.2118	0.0709
** 20	818235	833345	21.1	0.610	413	7.3905	1.0159	0.0595
22	820940	836080	0.0	0.102	413	20.6242	0.0793	0.0046
23	820960	836060	24.4	0.250	393	7.0408	0.1708	0.0100
24	819390	833760	29.3	0.378	413	7.8108	0.4123	0.0241
25	821096	834762	15.0	0.460	473	3.4241	0.2337	0.0137
26	821096	834784	15.0	0.460	473	2.6632	0.1818	0.0106
27	821110	834750	16.3	0.570	673	2.5049	0.1845	0.0108
55	818001	832200	0.0	0.305	413	15.6426	0.5376	0.0315
60	819380	833400	29.6	0.460	472	10.0573	0.6879	0.0403
61	819340	833430	40.3	0.530	462	7.3665	0.6833	0.0400
62	821080	834361	60.4	0.820	433	10.6678	2.5274	0.1479
63	821060	834362	58.9	0.800	399	6.6522	1.6279	0.0953
66	819310	833460	32.8	0.490	413	1.8747	0.1663	0.0097
68	819385	833540	38.1	0.520	426	10.0434	0.9726	0.0569
69	819380	833540	38.1	0.520	426	10.0434	0.9726	0.0569
70	819375	833540	38.1	0.520	426	10.0434	0.9726	0.0569
71	819370	833540	38.1	0.520	426	10.0434	0.9726	0.0569
72	819365	833540	38.1	0.520	426	10.0434	0.9726	0.0569
73	819320	833520	32.2	0.310	426	8.0609	0.2774	0.0162
74	819320	833505	32.2	0.310	426	8.0609	0.2774	0.0162
75	819370	833455	33.7	0.520	441	14.0980	1.3188	0.0772
76	819370	833450	33.7	0.520	441	13.3627	1.2500	0.0732
77	820388	835346	25.5	0.590	413	4.0333	0.5187	0.0304

Chimney No.	Easting	Northing	Height (m)	Diameter (m)	Temperature (K)	Efflux Velocity (m/s)	SO_2 g/s	NO_2 g/s
78	820374	835380	28.2	0.640	413	6.4279	0.9726	0.0569
79	821132	834317	61.0	0.520	418	15.3937	1.5193	0.0889
80	821130	834316	61.0	0.520	418	15.3937	1.5193	0.0889
81	821133	834322	57.6	0.540	418	3.2102	0.3417	0.0200
82	821104	834198	70.1	0.320	451	6.7069	0.2323	0.0136
86	816890	833520	21.3	0.510	438	6.5115	0.5899	0.0345
89	819070	832795	35.2	0.711	393	9.7878	1.9209	0.1124
92	821120	834306	61.4	0.810	413	6.5681	1.5919	0.0932
** 101	818095	833608	24.6	0.350	439	9.0634	0.3859	0.0226
** 102	818096	833610	24.6	0.350	439	8.5016	0.3619	0.0212
103	819340	833430	40.3	0.530	462	2.3671	0.2196	0.0129
104	819360	833430	34.3	0.508	491	11.3735	0.9120	0.0534
105	819370	833430	34.3	0.864	491	8.2535	1.9145	0.1121
108	818170	832350	24.8	0.686	453	7.6168	1.2072	0.0707
109	818170	832374	24.4	0.560	461	3.5993	0.3736	0.0219
110	819150	833296	13.3	0.450	413	2.1314	0.1594	0.0093
111	819160	833294	13.3	0.450	413	2.1314	0.1594	0.0093
** 114	818434	833864	23.0	0.400	473	8.5182	0.4396	0.0257
** 116	818410	833762	19.0	0.381	413	4.8975	0.2626	0.0154
** 117	818414	833760	19.0	0.381	413	7.3484	0.3941	0.0231
118	820726	835972	41.2	0.480	393	16.9424	1.5154	0.0887
119	820750	836026	6.0	0.250	393	37.9170	0.9200	0.0539
120	820370	836260	45.0	0.500	493	11.7765	0.9111	0.0533
121	820550	836280	20.4	0.300	438	12.9330	0.4054	0.0237
122	820560	836280	20.4	0.350	438	6.7794	0.2893	0.0169
123	820550	836300	21.4	0.270	873	10.3696	0.1321	0.0077
125	819110	833000	19.4	0.355	413	7.8282	0.3644	0.0213
126	819420	833690	30.4	0.318	413	6.4571	0.2412	0.0141
*** 127	818540	834550	23.1	0.508	455	9.6157	0.8321	0.0487
131	818935	832725	18.3	0.305	477	7.1961	0.2141	0.0125
132	819170	833260	16.7	0.406	413	2.8691	0.1747	0.0102
133	818810	832940	15.2	0.406	413	0.0748	0.0046	0.0003
134	818805	832960	0.0	0.200	413	3.8537	0.0569	0.0033
138	821150	835650	15.1	0.950	518	2.1380	0.5683	0.0333
141	820380	835420	17.0	0.533	413	3.6116	0.3790	0.0222

Table C6.2

Chimney No.	Easting	Northing	Height (m)	Diameter (m)	Temperature (K)	Efflux Velocity (m/s)	SO_2 g/s	NO_2 g/s
142	820360	835410	15.4	0.635	413	2.2937	0.3417	0.0200
143	818981	833043	18.0	0.350	413	3.8254	0.1731	0.0101
144	818982	833042	6.0	0.342	413	0.4006	0.0173	0.0010
145	819030	833200	6.1	0.450	413	11.4184	0.8542	0.0500
147	819240	833480	31.8	0.500	393	3.4523	0.3351	0.0196
** 152	818312	833774	27.1	0.610	477	8.2295	0.9794	0.0573
** 153	818378	833820	25.9	0.356	477	7.1362	0.2893	0.0169
156	816370	836491	8.2	0.153	413	2.2652	0.0196	0.0011
158	816375	836462	5.0	0.203	413	2.2444	0.0342	0.0020
164	820886	834063	50.0	0.267	413	4.7571	0.1253	0.0073
165	820460	834549	118.2	0.400	425	5.7740	0.3316	0.0194
171	821106	834190	62.3	0.305	441	7.0776	0.2278	0.0133
172	821110	834180	59.4	0.300	426	6.6144	0.2132	0.0125
173	820720	836220	24.4	0.626	393	11.3191	1.7220	0.1008
174	821110	835090	26.0	0.710	473	10.9224	1.7760	0.1040
177	821000	835300	17.0	0.310	413	7.6481	0.2715	0.0159
178	821030	835250	0.0	0.100	413	36.3789	0.1344	0.0079

(shaded) Non-existing or non-operational

* Emission rate for combustion of boiler diesel oil is used for modelling instead.

** Chimney located at Kiu Tau Wai.

*** Chimney located at Tin Yiu Estate.

Table C6.2

Table C6.3 Emission Rate for Chimneys with Boiler Diesel Oil Combustion

Chimney No.	Easting	Northing	Height (m)	Diameter (m)	Temperature (K)	Efflux Velocity (m/s)	SO_2 g/s	NO_2 g/s
1	817426	832256	14.4	0.381	413	3.4406	0.1913	0.0108
17	821054	835930	55.5	1.100	436	8.4137	3.6928	0.2085
18	821040	835930	55.5	0.610	444	6.0569	0.8028	0.0453
21	817560	835605	21.0	0.300	413	6.5290	0.2250	0.0127
36	818026	832296	14.9	0.343	413	6.2891	0.2833	0.0160
37	818028	832300	12.0	0.241	413	5.3080	0.1181	0.0067
38	818036	832304	11.1	0.305	413	1.6571	0.0590	0.0033
39	818036	832298	11.1	0.267	413	5.1895	0.1417	0.0080
40	818034	832296	11.1	0.267	413	5.1895	0.1417	0.0080
41	818034	832292	11.1	0.267	413	5.1895	0.1417	0.0080
42	818050	832322	11.1	0.203	413	3.7406	0.0590	0.0033
43	818062	832338	11.1	0.241	413	2.6540	0.0590	0.0033
44	818078	832338	9.4	0.267	413	5.1895	0.1417	0.0080
46	819122	833190	24.9	0.450	413	8.2821	0.6422	0.0363
57	818138	832412	19.8	0.229	413	6.2316	0.1251	0.0071
58	819020	833145	22.3	0.406	477	8.2561	0.4512	0.0255
64	821120	834318	58.9	0.530	413	9.5705	1.0294	0.0581
65	819320	833440	32.8	0.960	455	9.4361	3.0227	0.1707
66	819310	833460	32.8	0.490	413	6.2558	0.5752	0.0325
67	819330	833470	29.3	0.650	463	8.8348	1.2750	0.0720
81	821133	834322	57.6	0.540	418	3.2102	0.3542	0.0200
** 83	818516	833802	27.2	0.715	462	9.8492	1.7236	0.0973
** 84	818512	833802	27.2	0.715	462	9.8492	1.7236	0.0973
** 85	818562	833810	32.0	0.380	413	7.0455	0.3896	0.0220
87	818785	832900	26.8	0.711	461	10.0885	1.7496	0.0988
88	819005	832615	35.2	0.711	447	8.4884	1.5182	0.0857
91	820820	832300	12.2	0.381	413	7.7307	0.4297	0.0243
99	820310	835710	49.5	1.320	468	10.0250	5.9028	0.3333
100	820320	835680	49.5	1.320	468	10.0250	5.9028	0.3333
112	817730	831700	24.2	0.610	413	2.0879	0.2975	0.0168
113	817730	831680	22.7	0.560	413	1.2387	0.1488	0.0084
128	820918	834354	57.9	0.610	435	8.7092	1.1782	0.0665
129	816500	833275	12.2	0.254	413	9.5572	0.2361	0.0133

Chimney No.	Easting	Northing	Height (m)	Diameter (m)	Temperature (K)	Efflux Velocity (m/s)	SO_2 g/s	NO_2 g/s
130	819420	833130	15.3	0.450	413	3.5625	0.2763	0.0156

(shaded box) Non-existing or non-operational
** Chimney located at Kiu Tau Wai.

Appendix C7: Emission Rates for Vehicular Emission Impact Assessment

Table C7.1 Calculation of Vehicular Emission Rates (2001) (based on Jul 1996 traffic data)

Road	Road Segment*	Total Traffic (veh/hr)	% P.Car**	% PuBus**	% HGV**	RSP gm/v-mile	NO_2 gm/v-mile
Ping Ha Road	D1.3	3316	78.7	5.6	15.7	0.460	5.535
Tin Fuk Road	D1.4	2733	88.5	1.3	10.2	0.272	4.093
	D1.5	3184	89.3	1.1	9.6	0.258	3.987
Tin Wah Road	D2.4	3061	88.9	0.3	10.9	0.261	4.017
	D2.5	1287	79.9	3.0	17.2	0.428	5.304
	D2.6	1287	79.9	3.0	17.2	0.428	5.304
	D2.7	1483	85.5	0.0	14.5	0.317	4.463
	D2.8	1940	85.4	0.0	14.6	0.320	4.482
Tin Yiu Road	L1.1	2347	89.6	4.1	6.3	0.266	4.023
	L1.2	2006	88.4	4.8	6.8	0.289	4.200
	L1.3	1244	87.5	7.7	4.7	0.318	4.403
Tin Shing Road	L2.1	2914	93.2	1.1	5.7	0.190	3.454
	L2.2	2764	93.4	1.2	5.5	0.187	3.432
Tin Wu Road	L3.2	1351	88.5	7.1	4.4	0.300	4.262
	L3.3	1755	90.5	5.5	4.0	0.257	3.943
	L3.4	2482	90.9	5.2	3.9	0.248	3.873
	L3.5	285	93.7	0.0	6.3	0.177	3.359
Tin Shing Road	L4.4	851	87.7	8.0	4.3	0.317	4.394
	L4.5	631	88.6	5.1	6.3	0.288	4.187
Tin Shui Road	L5.2	1998	94.0	1.6	4.4	0.179	3.362
	L6.1	1880	94.7	0.4	4.9	0.162	3.236
	L6.2	1426	94.0	0.6	5.5	0.174	3.336
Tin Wing Road	L7.1	535	88.8	7.5	3.7	0.296	4.228
	L7.2	1007	88.6	6.8	4.7	0.296	4.235
L12	L12.1	2396	93.5	1.3	5.1	0.186	3.417
	L12.2	1351	91.9	2.4	5.8	0.219	3.671
	L12.3	1065	95.7	0.0	4.3	0.142	3.089
	L12.4	1127	95.3	0.0	4.7	0.149	3.141
L13	L13.2	1261	94.0	2.5	3.5	0.184	3.390
	L13.3	1438	94.0	2.2	3.8	0.181	3.376
	L13.4	1524	93.2	2.1	4.7	0.194	3.477
	L13.6	1585	93.4	2.0	4.5	0.190	3.448
L14	L14.1	2570	94.6	1.2	4.2	0.167	3.271
	L14.2	2799	94.5	1.1	4.4	0.169	3.286
	L14.3	1017	96.3	0.0	3.7	0.132	3.011
Tin Ying Road	P1	3236	75.2	1.8	23.0	0.503	5.904
Hung Tin Road	-	5724	70.2	0.5	29.3	0.581	6.534
Tin Tsz Road	P2.1	4505	90.4	0.0	9.6	0.234	3.806
	P2.2	3338	89.6	0.0	10.4	0.247	3.913
Long Tin Road	-	6797	90.5	0.5	9.0	0.234	3.801

* The road segments are shown in Figure C7.1.
** Based on EPD traffic control, MOBILE4 model's emission factor in the year 2001.

Table C7.2 Calculation of Vehicular Emission Rates (2011) (based on Jul 1996 traffic data)

Road	Road Segment*	Total Traffic (veh/hr)	% P.Car**	% PuBus**	% HGV**	RSP gm/v-mile	NO_2 gm/v-mile
Ping Ha Road	D1.3	3575	82.2	5.2	12.6	0.223	3.903
Tin Fuk Road	D1.4	2652	89.9	1.4	8.7	0.157	3.168
	D1.5	3259	89.5	1.1	9.4	0.160	3.202
Tin Wah Road Extension	D2.2	1641	71.6	0.5	27.9	0.317	4.918
	D2.3	1641	71.6	0.5	27.9	0.317	4.918
Tin Wah Road	D2.4	2501	91.6	0.3	8.1	0.142	3.005
	D2.5	1416	86.7	2.7	10.6	0.184	3.470
	D2.6	1416	86.7	2.7	10.6	0.184	3.470
	D2.7	1128	87.9	0.0	12.1	0.174	3.355
	D2.8	1973	88.7	0.0	11.3	0.167	3.278
D3	D3.1	1384	92.0	0.0	8.0	0.139	2.969
	D3.2	444	89.9	0.0	10.1	0.157	3.171
	D3.3	458	90.0	0.0	10.0	0.156	3.163
D4	D4.1	1541	92.0	2.1	6.0	0.138	2.970
	D4.2	1940	93.5	0.0	6.5	0.126	2.828
Tin Yiu Road	L1.1	2588	90.5	3.7	5.8	0.151	3.109
	L1.2	2241	89.6	4.3	6.1	0.158	3.189
	L1.3	1148	87.2	8.4	4.4	0.179	3.422
Tin Shing Road	L2.1	3135	94.0	1.0	4.9	0.120	2.772
	L2.2	2912	94.0	1.1	4.9	0.120	2.773
Tin Wu Road	L3.2	1265	88.3	7.6	4.1	0.170	3.317
	L3.3	1412	88.4	6.8	4.8	0.169	3.309
	L3.4	2101	89.0	6.1	4.9	0.164	3.250
Tin Shing Road	L4.4	911	90.0	7.5	2.5	0.155	3.153
	L4.5	562	87.0	5.7	7.3	0.181	3.441
Tin Shui Road	L5.1	1724	92.8	1.9	5.3	0.131	2.889
	L5.2	1589	92.2	2.0	5.8	0.136	2.947
	L6.1	1578	93.9	0.5	5.6	0.122	2.789
	L6.2	1788	95.1	0.4	4.5	0.111	2.672
Tin Wing Road	L7.1	349	85.4	11.5	3.2	0.194	3.594
	L7.2	879	86.7	7.7	5.6	0.184	3.471
L12	L12.1	1621	94.8	2.0	3.2	0.113	2.696
	L12.2	861	95.0	3.7	1.3	0.111	2.677
	L12.3	1351	93.3	2.4	4.4	0.127	2.845
	L12.4	1432	92.9	2.2	4.8	0.130	2.875
	L12.5	1326	92.3	2.4	5.3	0.135	2.936
	L12.6	624	97.3	0.0	2.7	0.092	2.462
L13	L13.1	1203	90.6	0.0	9.4	0.151	3.100
	L13.2	1170	92.5	0.0	7.5	0.134	2.921
	L13.3	1392	90.7	2.3	7.0	0.149	3.087
	L13.4	1528	94.6	0.0	5.4	0.116	2.721
	L13.5	589	94.7	0.0	5.3	0.114	2.705
	L13.6	1715	92.9	1.9	5.2	0.130	2.876
L14	L14.1	2353	93.3	1.4	5.3	0.127	2.839
	L14.2	2527	93.4	1.3	5.4	0.126	2.837
	L14.3	862	92.8	3.7	3.5	0.131	2.888
	L14.4	806	92.8	4.0	3.2	0.131	2.888
	L14.5	948	91.7	3.4	5.0	0.141	2.997
	L14.6	455	97.6	0.0	2.4	0.089	2.433
Tin Ying Road	P1	3207	82.5	1.8	15.7	0.221	3.877
Tin Tsz Road	P2.1	4959	91.8	0.0	8.2	0.140	2.983

Road	Road Segment*	Total Traffic (veh/hr)	% P.Car**	% PuBus**	% HGV**	RSP gm/v-mile	NO_2 gm/v-mile
	P2.2	3571	91.7	0.0	8.3	0.141	2.992
Ping Ha Road	1	2276	80.1	4.6	15.3	0.242	4.103
	2	2272	79.8	4.6	15.5	0.244	4.128
	3	1815	76.3	5.8	18.0	0.275	4.470
	4	1843	75.5	5.7	18.8	0.282	4.545
	5	1877	75.4	5.6	19.0	0.282	4.548
Hung Tin Road	1	5829	80.2	0.5	19.3	0.241	4.092
	2	1120	93.1	0.0	6.9	0.128	2.859
	3	4095	74.3	0.7	25.1	0.293	4.664
	4	619	96.1	0.0	3.9	0.102	2.573
	6	1570	83.6	0.0	16.4	0.212	3.768
	7	699	79.7	0.0	20.3	0.246	4.145
	8	568	75.5	0.0	24.5	0.282	4.543
	9	1433	82.1	0.0	17.9	0.225	3.917
	10	867	86.4	0.0	13.6	0.187	3.504
	11	873	86.8	0.0	13.2	0.184	3.462
	12	832	85.7	0.0	14.3	0.193	3.570
	13	5360	75.1	0.5	24.3	0.286	4.581
Long Tin Road	1	6950	91.2	0.5	8.3	0.145	3.041
	2	6950	91.2	0.5	8.3	0.145	3.041
	3	3469	93.1	0.0	6.9	0.129	2.864
	4	1509	96.6	0.0	3.4	0.098	2.531
	5	2922	86.1	0.8	13.1	0.190	3.531
	6	218	72.5	0.0	27.5	0.309	4.835
	7	1973	83.9	1.8	14.3	0.209	3.743
	8'	1385	71.9	1.6	26.5	0.314	4.888
	8"	1493	96.9	0.0	3.1	0.095	2.496
	9	717	71.8	0.0	28.2	0.315	4.897
	10	686	71.6	3.2	25.2	0.317	4.919
	11	317	83.0	0.0	17.0	0.217	3.831
	12	1034	75.8	3.3	20.9	0.279	4.513
	16	3311	78.2	3.8	17.9	0.258	4.283
Long Ping Road	-	3508	92.0	0.0	8.0	0.138	2.963
Ma Wang Road	-	1348	77.5	2.5	20.0	0.265	4.351
Wang Tat Road	-	2922	86.1	0.8	13.1	0.190	3.531
Castle Peak Road	1	3027	77.2	10.0	12.8	0.266	4.374
	2	3250	77.1	6.4	16.5	0.268	4.388
	3	4044	75.4	5.2	19.4	0.282	4.548
	4	2431	76.0	8.4	15.6	0.277	4.495
	5	2389	76.3	8.5	15.2	0.274	4.464
	6	2717	78.3	7.5	14.2	0.257	4.275

* The road segments are shown in Figures C7.1 - C7.2.
** Based on EPD traffic control, MOBILE4 model's emission factors in the year 2011.
' East-bound traffic flow.
" West-bound traffic flow.

Table C7.2

Table C7.3 Calculation of Vehicular Emission Rates (2011) (based on Dec 1996 traffic data)

Road	Road Segment*	Total Traffic (Veh/hr)	% P.Car**	% PuBus**	% HGV**	RSP gm/v-mile	NO2 gm/v-mile
Ping Ha Road	D1.3	3400	83.7	4.3	11.9	0.210	3.754
Tin Fuk Road	D1.4	3650	91.3	1.3	7.4	0.145	3.037
	D1.5	2750	86.6	2.9	10.5	0.185	3.482
Tin Yiu Road	L1.1	2400	91.8	4.0	4.1	0.139	2.980
	L1.2	1900	90.7	5.0	4.3	0.149	3.090
Tin Shing Road	L2.1	3200	92.7	1.0	6.3	0.132	2.897
Tin Ying Road	P1	3500	86.0	0.0	14.0	0.191	3.545
Hung Tin Road	1	6300	80.1	0.8	19.1	0.242	4.104
	2	1750	91.8	0.0	8.2	0.140	2.987
	3	3850	72.3	0.7	26.9	0.310	4.847
	4	650	96.7	0.0	3.3	0.098	2.521
Tin Tsz Road	P2.1	5950	92.3	0.0	7.7	0.136	2.938
Long Tin Road	1	7500	90.4	1.1	8.5	0.152	3.117
	2	7450	91.0	0.5	8.6	0.147	3.066
Ping Ha Road	1	2350	84.0	4.5	11.6	0.208	3.734

* The road segments are shown in Figure C7.1-C7.2.

** Based on EPD traffic control, MOBILE4 model's emission factor in the year 2011.

Table C7.4 Calculation of Vehicular Emission Rates (2011) (based on Mar 1997 traffic data)

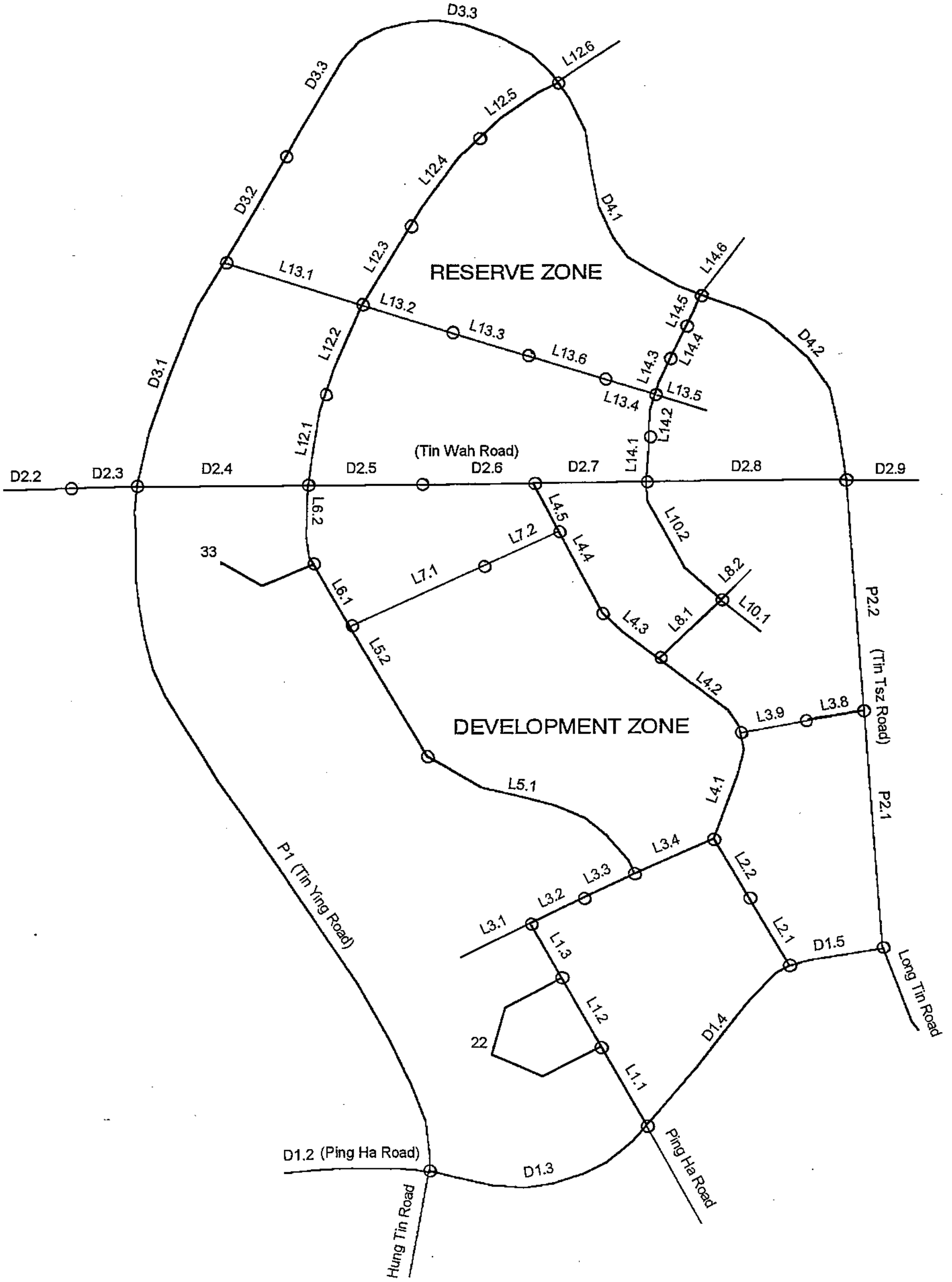
Road	Road Segment*	Total Traffic (veh/hr)	% P.Car**	% PuBus**	% HGV**	RSP gm/v-mile	NO_2 gm/v-mile
Tin Wah Road	D2.5	1181	83.5	3.2	13.3	0.212	3.780
	D2.6	1175	83.4	3.2	13.4	0.213	3.788
	D2.7'	584	86.0	0.0	14.0	0.191	3.545
	D2.7"	570	87.5	0.0	12.5	0.177	3.393
	D2.8'	1274	89.4	0.0	10.6	0.161	3.215
	D2.8"	733	84.9	0.0	15.1	0.201	3.650
D4	D4.2	1750	93.4	0.0	6.6	0.126	2.833
Tin Shing Road	L4.5	580	90.0	5.5	4.5	0.155	3.155
Tin Kwai Road	L10.2	979	93.2	3.3	3.6	0.128	2.855
L14	L14.1	2333	93.0	1.4	5.6	0.129	2.869
Tin Tsz Road	P2.2	3472	91.0	0.0	9.0	0.147	3.061

* The road segments are shown in Figures C7.1 - C7.2.

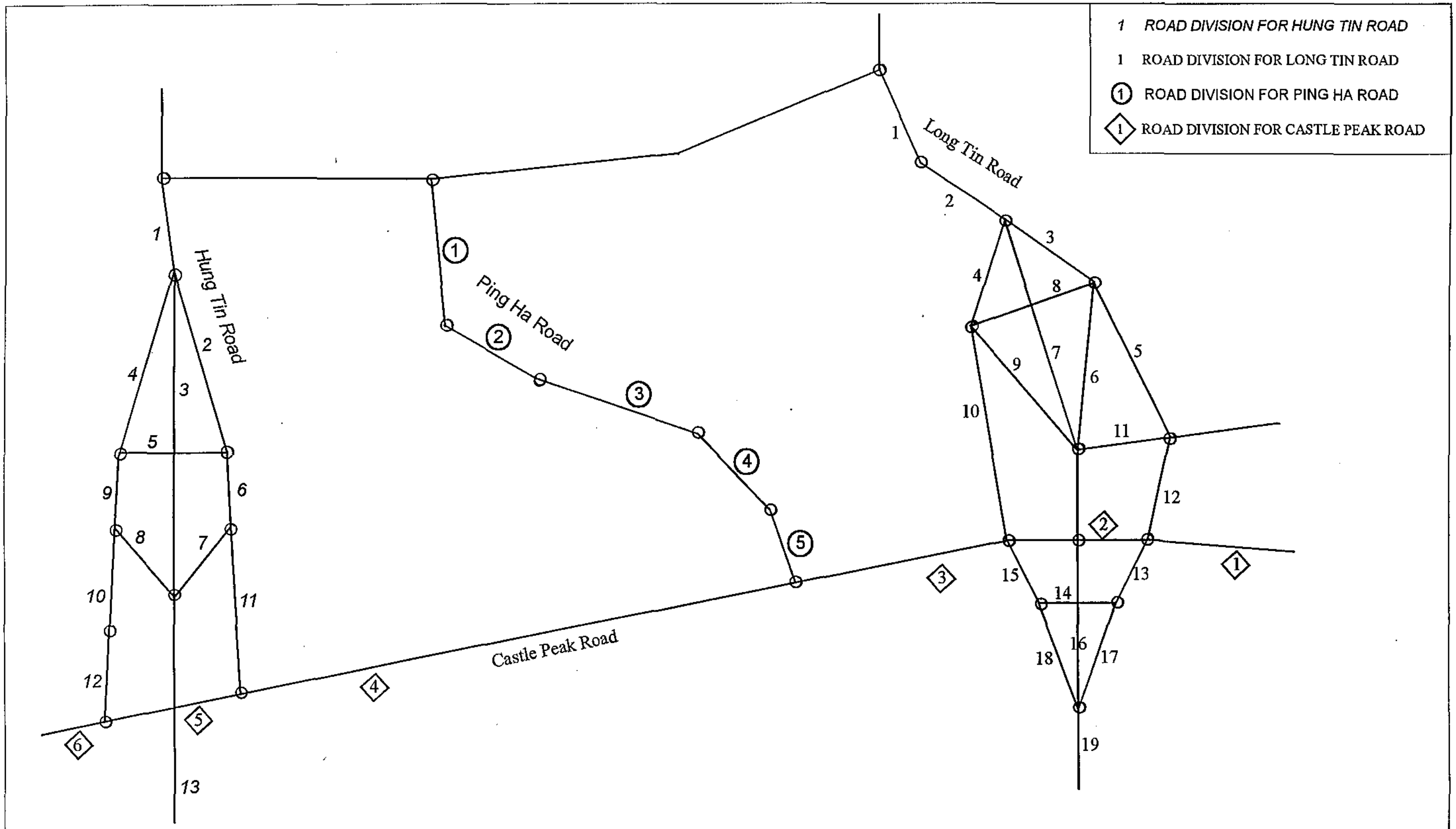
** Based on EPD traffic control, MOBILE4 model's emission factors in the year 2011.

' East-bound traffic flow.

" West-bound traffic flow.



TIN SHUI WAI DEVELOPMENT AGREEMENT NO. CE 10/95 ENGINEERING INVESTIGATIONS FOR DEVELOPMENT OF AREAS 3, 30 & 31 OF THE DEVELOPMENT ZONE AND THE RESERVE ZONE	Title :	Figure No. C7.1	Revision 0
	ROAD DIVISION BASED ON VARIATION OF TRAFFIC FLOW DATA (RZ and DZ)	Reference No. -	File Name RD_SEG.PRS
BINNIE CONSULTANTS LIMITED 賓尼工程顧問有限公司 賓尼 ENGINEERS AND SCIENTISTS		Prepared MC	Checked WYC
		Date AUG 96	Scale NTS



TIN SHUI WAI DEVELOPMENT AGREEMENT NO. CE 10/95

ENGINEERING INVESTIGATIONS FOR DEVELOPMENT OF AREAS 3, 30 & 31 OF THE DEVELOPMENT ZONE AND THE RESERVE ZONE

BINNIE CONSULTANTS LIMITED 賓尼工程顧問有限公司 ENGINEERS AND SCIENTISTS 賓尼

Title :

ROAD DIVISION BASED ON VARIATION OF TRAFFIC FLOW DATA (south of DZ)

Figure No.	C7.2	Revision	0
Reference No.	-	File Name	RD_SEG2.PRS
Prepared	MC	Checked	WYC
Date	NOV 96	Scale	NTS

Appendix D

Details of Water Quality Assessment

Appendix D1

Water and Sediment Data

Table D1.1
Particle Size Analysis Cumulative Percentage Retained

Location: Western Outfall Area   Sampling Date: 14.12.95

Location/depth	Sieve size							
	-63 μm	63 μm	75 μm	106 μm	150 μm	300 μm	710 μm	2000 μm
I4/D								
0-280 mm	100	68.3	67.3	64.1	60.4	47.6	24.2	12.6
280-560 mm	100	23.2	22.1	18.1	16.7	10.7	5.9	3.5
560-850 mm	100	5.4	4.7	3.5	2.9	1.4	0.7	0.4
I3/D								
0-280 mm	100	17.3	13.3	6	3.5	2	1.4	0.9
280-560 mm	100	81.6	69.7	59	48.2	34.6	29.2	25.1
560-850 mm	100	11.9	8.3	6.3	5.8	5.2	3.4	2.7
I2/D								
0-280 mm	100	11.7	4	4	2.4	0.8	0.3	0
280-560 mm	100	10.1	8.7	6.9	6	4.5	3.3	2.2
560-850 mm	100	67.9	66.8	63.6	59.8	50.1	40.5	22.7
I1/D								
0-280 mm	100	8.5	8.2	7.5	6.9	4.5	1.5	0.2
280-560 mm	100	17.9	9.2	6.2	5.7	3.3	2.7	2.3
560-850 mm	100	11.5	10.2	8.1	6.4	4.2	2.5	1.5
780-1030 mm	100	8.6	7.3	5.2	4.1	2.8	2	1

Source: Acer Consultants (Far East) Ltd data 1995: presented by courtesy of DSD.

Table D1.2
Location DS1 Inner Deep Bay - EPD Particle Size Data[1]

Year	63 µm	125 µm	250 µm	500 µm	1000 µm	2000 µm	4000 µm	Total rainfall cm	Monthly max. cm
1988	89.66	91.41	92.9	94.07	94.81	95.61	97.11	168.5	50.5
1989	95.28	96.67	97.11	97.47	97.86	98.38	99.28	194.4	77.2
1990								204.7	44.8
1991	75.95	77.5	86.23	92.99	95.27	97.25	99.74	163.9	37.1
1992	80.61	84.35	89.33	98.95	96.21	97.5	99.36	267.8	60.2
1992	90.01	93.23	96.67	97.56	97.9	98.25	99.01	267.8	60.2
1992	75.31	82.77	90.71	95.06	96.25	97.24	98.94	267.8	60.2
1993	86	91.69	95.04	95.99	96.64	97.5	99.64	234.4	65.5
1993	84.16	86.51	89.64	91.64	92.99	94.67	97.79	234.4	65.5
1993	90.02	91.94	93.4	94.76	95.65	96.54	98.27	234.4	65.5
1994	83.32	89.24	95	98.25	99.03	99.44	99.74	272.5	114.7
1994	85.13	94.6	98.73	99.18	99.47	99.62	99.72	272.5	114.7
1995	40.98	60.71	77.21	81.36	84.79	89.63	95.01	275.4	109.1

1 Presented by courtesy of EPD.

Table D1.3
Groundwater Quality Comparison in the Tin Shui Wai Area - 1984 and 1996

Well No.		Depth (feet)		Temperature (° C)		pH		DO (%)		Conductivity (mS/cm)		Turbidity (NTU)		Ammonia (mg/l)		Colour	
		1996	1984	1996	1984	1996	1984	1996	1984	1996	1984	1996	1984	1996	1984	1996	1984
west	24	1.2	1	19.9	24	6.6	5.9	53	37	0.5	0.6	0.4	5	0	0.1	2	2.5
	25	1.2	0.9	20.8	25.5	6.7	6.6	79	36	0.4	0.2	0.7	20	2.4	1.6	33	35
	26	4.7	3.8	21.6	23.5	6.4	6.5	105	98	0.3	0.3	0.3	45	0	0.2	5	20
	131	0.8	0.8	20.1	26	6.6	6.9	62	81	0.7	0.5	2.1	2.5	0.7	0.2	14	15
	132	1.0	1.2	20.5	26	6:4	6.6	74	56	0.5	0.7	3.5	25	2.1	0.7	11	5
north	31	0.4	0.6	-	26	-	6.9	-	18	-	0.3	-	25	-	6.8	-	55
	32	0.6	1.7	20.3	24.5	5.8	5.9	59	52	0.3	0.4	0.2	13	0	0.1	3.5	17
	33	0.8	3.2	20.3	24.2	5.7	6	117	78	0.1	0.1	0.7	45	0	0.7	4	70
	34	1.1	0.9	21.1	24	5.4	6.1	92	35	1.3	0.9	0.6	2.5	0	0.1	5	20
	111	0.3	0.4	20.9	24	5.8	6.4	84	49	0.8	0.9	0.3	2.5	0	0.1	7	2.5
	112	0.6	1.8	20.6	25	5.3	7.2	70	71	0.6	1.0	0.2	2.5	0.3	0.1	10.5	8
	114	1.2	1.2	19.3	26	6.4	7.1	87	30	0.1	0.7	2.5	20	0	0.7	14.5	75
	115	1.2	0.9	19.1	26	6.4	6.9	51	57	0.4	0.4	0.5	2.5	0.2	0.1	10.5	5
	118	1.2	0.9	-	25	-	7.1	-	88	-	0.4	-	2.5	-	0.1	-	2.5

Table D1.4
General Water Quality Results - Suspended Solid Level (mg/l)

Date	Station W1			Station W2			Station W3		
	S	M	B	S	M	B	S	M	B
12.2.88	15	16	15	N	N	N	6	6	6
29.2.88	26	31	24	N	N	N	10	10	14
21.3.88	-	19	-	N	N	N	19	19	38
7.4.88	48	57	61	N	N	N	27	24	34
22.4.88	61	67	54	N	N	N	11	9	10
6.5.88	57	58	67	N	N	N	24	26	38
20.5.88	94	17	13	N	N	N	20	13	21
7.6.88	24	25	33	N	N	N	14	14	15
21.6.88	50	51	70	N	N	N	47	54	51
7.7.88	99	77	53	N	N	N	107	56	47
21.7.88	97	65	85	N	N	N	23	105	23
8.8.88	N	N	N	N	N	N	71	-	-
22.8.88	N	N	N	N	N	N	80	-	121
7.9.88	179	N	377	N	N	N	53	45	62
23.9.88	34	34	28	N	N	N	30	30	31
7.10.88	17	16	22	N	N	N	9	12	56
21.10.88	153*	129*	173*	N	N	N	172*	181*	143*
7.11.88	49	42	41	N	N	N	27	24	49
21.11.88	57	54	79	N	N	N	113	55	113
7.12.88	626	N	69	N	N	N	73	N	61
28.12.88	119	N	129	N	N	N	53	N	62
5.1.89	58	N	68	N	N	N	43	N	72
18.1.89	N	53	N	N	N	N	38	N	41
2.2.89	38	21	26	N	N	N	14	23	21
16.2.89	63	N	97	N	N	N	36	N	35
2.3.89	126	N	119	N	N	N	40	36	40
16.3.89	35	N	41	N	N	N	16	N	33
30.3.89	36	N	41	N	N	N	36	38	38
6.4.89	81	N	125	N	N	N	59	60	76
19.4.89	38	N	58	N	N	N	27	N	30
4.5.89	27	N	33	N	N	N	23	24	36
18.5.89	34	35	48	N	N	N	29	N	35
1.6.89	63	N	65	N	N	N	44	N	45
15.6.89	120	N	123	N	N	N	11	N	20
18.7.90	58	N	63	N	N	N	32	N	36

Source : Tin Shui Wai Development (TDD Contract No. NTDB 33/85)
Legend : S - sample taken 0.5m below water surface
M - sample taken in middle of water surface and seabed
B - sample taken 0.5m above seabed
Remarks : * Typhoon signal no.1 and 3 hoisted on 21 Oct 1988
No monitoring has been carried out since August 1990

Table D1.5
Results of Sediment Analysis (Metals) - Term Contract

Sample Identif.	Copper Content mg/kg	Cadmium Content mg/kg	Chromium Content mg/kg	Lead Content mg/kg	Nickel Content mg/kg	Zinc Content mg/kg	Mercury Content mg/kg	Class. criteria of contamin. level (*)
T1	22	<0.2	16	19	7.3	130.	<0.05	A
T2	26	<0.2	20	26	6.3	110	<0.05	A
T3	21	<0.2	38	33	8.3	99	<0.05	A
T4	19	<0.2	14	95	4.8	96	<0.05	C
T5	35	<0.2	22	25	8.1	170	<0.05	B
T6	22	<0.2	17	17	7.0	97	<0.05	A
T7	29	<0.2	27	24	9.8	120	<0.05	A
T8	19	<0.2	15	19	6.6	97	<0.05	A
T9	32	<0.2	29	50	12	160	<0.05	B
T10	22	<0.2	29	34	12	90	<0.05	A
T11	18	<0.2	39	45	15	84.	<0.05	A
T12	13	<0.2	23	36	8.6	51	<0.05	A
T13	29	<0.2	44	46	16	130	<0.07	A
T14	22	<0.2	35	49	12	96	<0.06	A
T15	25	<0.2	36	44	14	100	<0.06	A
T16	22	<0.2	37	48	16	120	<0.08	A
T17	17	<0.2	20	39	9.9	80	<0.05	A
T18	15	0.49	14	19	9.0	91	<0.05	A
T19	22	<0.2	41	47	18	110	<0.06	A
T20	20	<0.2	37	39	16	98	<0.05	A
T21	13	<0.2	16	21	9.0	68.	<0.05	A
T22	16	<0.2	12	20	7.6	69	<0.05	A
T23	22	<0.2	40	45	18	110	0.06	A
T24	30	<0.2	35	39	15	150	0.07	B
T25	67	0.30	57	67	24	320	0.15	C
T26	86	0.30	140	50	36	340	0.12	C
T27	69	0.29	88	57	28	300	0.13	C
T28	51	0.25	58	43	23	240	0.09	C
T29	53	0.29	50	53	22	250	0.12	C
T30	26	<0.2	26	31	12	120	<0.05	A

Table D1.5 (cont'd)

Sample Identif.	Copper Content mg/kg	Cadmium Content mg/kg	Chromium Content mg/kg	Lead Content mg/kg	Nickel Content mg/kg	Zinc Content mg/kg	Mercury Content mg/kg	Class. criteria of contamin. level (*)
T31	26	<0.2	32	40	13	110	0.06	A
T32	24	<0.2	34	39	13	120	0.06	A
T33	19	<0.2	28	35	12	90	<0.05	A
T34	22	<0.2	26	31	11	120	<0.05	A
T35	24	<0.2	24	31	10	110	<0.05	A
T36	23	<0.2	18	22	9.3	110	<0.05	A
T37	21	<0.2	16	21	7.8	100	<0.05	A
T28	31	<0.2	40	45	14	182	0.06	B
T39	31	<0.2	28	53	12	150	0.05	B
T40	16	<0.2	30	33	16	74	<0.05	A
T41	29	<0.2	42	49	15	180	0.07	B
T42	27	<0.2	46	49	16	170	0.09	B
T43	24	<0.2	45	48	16	120	0.06	A
T44	28	<0.2	43	46	15	180	0.07	B
T45	43	0.30	64	47	18	410	0.10	C
T46	41	0.22	37	48	12	260	0.07	C
T47	25	<0.2	41	43	15	130	0.07	A
T48	72	0.33	43	64	15	380	0.11	C
T49	100	0.39	28	54	15	450	0.11	C
T50	92	0.37	39	52	15	410	0.11	C
T51	100	0.37	38	48	15	420	0.13	C
T52	43	0.33	31	37	12	330	0.06	C
T53	100	0.39	41	53	14	470	0.11	C
T54	47	0.33	40	51	14	430	0.13	C
T55	19	<0.2	24	31	11	160	0.10	B
T56	21	0.22	31	34	11	280	0.06	C
T57	100	0.54	46	50	16	580	0.11	C
T58	120	0.46	45	49	11	430	0.14	C
T59	20	<0.2	42	45	14	95	0.06	A
T60	31	<0.2	18	40	7.2	150	<.05	B

Table D1.6
Results of Sediment Analysis (pH) - Term Contract

Sample ID	pH	Sample ID	pH	Sample ID	pH
T1	7.8	T21	6.6	T41	7.6
T2	7.5	T22	7.7	T42	7.4
T3	6.8	T23	7.0	T43	4.7
T4	8.2	T24	7.2	T44	7.8
T5	7.0	T25	7.5	T45	7.6
T6	7.2	T26	7.4	T46	7.3
T7	7.1	T27	7.3	T47	7.4
T8	7.3	T28	7.2	T48	7.3
T9	7.1	T29	7.3	T49	8.0
T10	7.5	T30	7.3	T50	7.5
T11	6.9	T31	7.9	T51	7.4
T12	6.8	T32	7.8	T52	7.8
T13	7.1	T33	7.6	T53	7.4
T14	7.0	T34	7.8	T54	7.3
T15	7.0	T35	7.7	T55	7.3
T16	7.1	T36	7.7	T56	7.3
T17	7.7	T37	8.0	T57	7.1
T18	8.1	T38	7.6	T58	6.8
T19	6.9	T39	5.8	T59	7.6
T20	7.2	T40	3.8	T60	7.5

Table D1.7
Results of Elutriate Analysis - Term Contract

Parameter	T10	T30	T49	T58	Water Quality Objectives for Inner Deep Bay[1]
pH	7.7	7.2	7.6	6.4	7.0-8.5
Cu (mg/l)	<0.1	<0.1	<0.1	<0.1	0.005
Cd (mg/l)	<0.05	<0.05	<0.05	<0.05	0.001
Ni (mg/l)	<0.1	<0.1	<0.1	<0.1	0.03
Pb (mg/l)	<1	<1	<1	<1	0.01
Cr (mg/l)	<0.1	<0.1	<0.1	<0.1	0.015
Zn (mg/l)	<0.05	<0.05	<0.05	**0.06**	0.04
Hg (mg/l)	<0.001	<0.001	<0.001	<0.001	0.0003
Ammonia Total (mg/l)	23	22	400	78	--
Ammonia Unionised[2] (µg/l)	**640**	**180**	**9,520**	**132**	20

1 Deep bay Guidelines for Dredging, Reclamation and Drainage Works, ERL (Asia) Ltd and Binnie Consultants Ltd, September 1991.

2 Calculated with reference to pH and temperature

Table D1.8
Suspended Solids Levels (mg/l) during Land Reclamation Operations of Tin Shui Wai

Date	Sampling locations										Deep Bay	Target Level
	L1	L2	L3	L4	L5	L6	L7	L8	L9	L10	average	
10.6.88	520	-	-	-	569	708	-	-	-	-	44	100
28.6.88	111	31	31	25	652	78	-	-	-	-	44	100
11.7.88	34	28	30	32	27	36	-	-	-	-	44	100
13.9.88	72	72	59	59	74	68	65	60	47	71	44	100
27.9.88	60	45	31	32	39	38	-	-	-	-	44	100
11.10.88	35	68	30	92	60	60	-	-	-	-	44	100
11.5.89	32	41	57	40	40	37	34	34	33	34	44	100
25.5.89	93	51	60	46	72	73	91	107	104	121	44	100
22.6.89	64	34	35	43	42	44	38	31	33	32	44	100
6.7.89	53	40	34	38	62	48	56	64	45	48	44	100
20.7.89	36	40	40	42	38	33	39	34	35	37	44	100
2.8.89	28	34	34	41	43	31	42	34	37	31	44	100
17.8.89	26	30	23	29	23	24	27	23	23	38	44	100
14.9.89	45	41	43	39	40	45	42	41	41	39	44	100
27.9.89	36	44	37	40	38	40	34	38	37	40	44	100
11.4.90	157	146	144	156	146	152	165	161	153	167	44	100
26.4.90	76	82	64	79	78	77	79	85	88	95	44	100
10.5.90	27	24	41	25	33	34	42	24	33	26	44	100
24.5.90	71	254	81	281	77	64	80	59	57	55	44	100
7.6.90	31	836	376	32	26	26	52	44	37	33	44	100
21.6.90	24	18	23	17	25	28	27	20	22	24	44	100

Source : Binnie & Partners archive data

Table D1.8
Suspended Solids Levels (mg/l) during Land Reclamation Operations of Tin Shui Wai (cont'd)

Date	Sampling locations										Deep Bay	Target Level
	L1	L2	L3	L4	L5	L6	L7	L8	L9	L10	average	
5.7.90	30	118	57	305	359	106	114	140	80	81	44	100
19.7.90	55	68	51	49	65	62	41	28	41	41	44	100
4.8.90	48	34	32	40	44	57	41	33	34	30	44	100
23.8.90	155	179	186	167	175	146	146	136	133	128	44	100
6.9.90	79	119	94	46	45	97	71	43	43	189	44	100
20.9.90	33	42	42	45	45	37	37	37	40	38	44	100
3.10.90	24	28	36	30	32	23	22	22	31	35	44	100
18.10.90	57	32	37	42	39	44	34	51	46	49	44	100
15.11.90	35	35	35	32	36	33	32	31	32	50	44	100
20.12.90	52	46	55	51	62	63	66	60	71	74	44	100
31.1.91	150	109	148	100	89	108	134	187	192	196	44	100
21.2.91	72	68	79	78	69	73	71	77	79	81	44	100
21.3.91	164	143	137	136	139	108	135	166	234	253	44	100
17.4.91	38	25	41	45	43	39	47	33	40	41	44	100
25.4.91	30	26	30	30	30	33	37	41	24	26	44	100
16.5.91	40	28	31	43	37	34	38	39	39	40	44	100
30.5.91	34	38	42	37	37	37	40	38	49	48	44	100

Source : Binnie & Partners archive data

Table D1.9
Concentration of PAHs for five sampling stations in Tin Shui Wai District (μg/kg)

	TSW1	TSW3	TSW4	TSW5
Naphthalene	82 J P	160 U	110 J P	160 U
Acenaphthylene	120 U	120 U	120 U	120 U
Fluorene	110	240	180	42
Acenaphthene	75 U	75 U	75 U	75 U
Phenanthrene	65	65	45	40
Anthracene	120	44 P	36 P	19 P
Fluoranthene	57 P	140	63	21 J P
Pyrene	79 P	110 P	31 P	31 P
Chrysene	27	14 U	26 P	20
Benzo (a) anthracene	7	6 U	9.8 P	11 P
Benzo (b) fluoranthene	9 U	9 U	9 U	9 U
Benzo (k) fluoranthene	7.4	18 P	8.2 P	10 P
Benzo (a) pyrene	9 P	14	13 P	26
Dibenzo (ah) anthracene	14 U	14 U	17 P	14 U
Indeno (123cd) pyrene	64	1.7 U	5.1	13
Benzo (ghi) perylene	49 P	20 P	22 P	25 P

U = unreliable because close to detection limit.
J = regarded as an estimate.
P = two results differ by more than 25%.

Table D1.10
Concentration of PCB congeners for five sampling stations in Tin Shui Wai District (μg/kg)

	TSW1	TSW2	TSW3	TSW4	TSW5
BZ028	8 U	8 U	8 U	8 U	8 U
BZ052	10 U	10 U	10 U	10 U	10 U
BZ049	8.5 U	8.5 U	8.5 U	8.5 U	8.5 U
BZ044	9 U	9 U	9 U	9 U	9 U
BZ066	2.8 U	2.8 U	2.8 U	2.8 U	2.8 U
BZ088	2.5 U	2.5 U	2.5 U	2.5 U	2.5 U
BZ101	2.8 U	2.8 U	2.8 U	0.84 J P	2.8 U
BZ077	5.5 U	5.5 U	5.5 U	5.5 U	5.5 U
BZ110	4 U	4 U	4 U	4 U	4 U
BZ123	1.7 U	1.7 U	1.7 U	1.7 U	1.7 U
BZ118	2.3 U	2.3 U	2.3 U	1.5 J	2.3 U
BZ114	3.4 U	3.4 U	3.4 U	3.4 U	3.4 U
BZ105	3.4 U	3.4 U	3.4 U	3.4 U	3.4 U
BZ153	3.4 U	3.4 U	3.4 U	0.92 J	3.4 U
BZ138	3.4 U	3.4 U	3.4 U	3.4 U	3.4 U
BZ187	3.4 U	3.4 U	3.4 U	3.4 U	3.4 U
BZ128	3.4 U	3.4 U	3.4 U	3.4 U	3.4 U
BZ156	3.4 U	3.4 U	3.4 U	3.4 U	3.4 U
BZ157	3.4 U	3.4 U	3.4 U	3.4 U	3.4 U
BZ180	3.4 U	3.4 U	3.4 U	3.4 U	3.4 U
BZ170	2.2 U	2.3 U	2.4 U	1.7 U	1.7 U

U = unreliable because close to detection limit.
J = regarded as an estimate.
P = two results differ by more than 25%.

Table D1.11 (cond't) Results of Water Quality Surveys in Rivers Entering Inner Deep Bay : Dry Season and Wet Season 1996+

Name of River	Date	Time	Salinity g/kg	Conductivity (uS/cm)	pH	SS (mg/L)	BOD_5 (mg/L)	COD (mg/L)	$NH_4(N)$ (mg/L)	$NO_3(N)$ (mg/L)	$NO_2(N)$ (mg/L)	TKN (mg/L)	TN (mg/L)	TOC (mg/L)	TIC (mg/L)	TC (mg/L)	SiO_2 (mg/L)	$PO_4(P)$ (mg/L)	TP (mg/L)	Chlorophyll-a (mg/m^3)	Dissolved Cu (mg/L)	Total Cu (mg/L)	Cl^- (mg/L)
Dasha River	19-Aug-96	18:00	0.10	266	7.40	158	6.18	69.00	2.42	1.899	0.187	3.01	6.07	3.8	-	-	12.83	0.169	0.953	4.91	0.0008	0.0069	13.3
Dasha River	19-Aug-96	19:00	0.10	259	7.45	182	6.48	49.40	2.64	1.898	0.185	3.41	5.91	2.8	-	-	12.12	0.159	0.993	3.66	0.0007	0.0069	13.0
Dasha River	19-Aug-96	20:00	0.10	260	7.50	208	6.48	54.60	2.90	1.877	0.186	3.78	6.48	2.0	-	-	12.29	0.168	1.128	3.18	0.0007	0.0074	13.2
Dasha River	20-Aug-96	18:00	0.10	278	7.65	104	8.74	30.00	3.25	1.542	0.176	4.37	5.84	3.2	-	-	16.27	0.128	0.738	12.06	0.0018	0.0078	14.7
Dasha River	20-Aug-96	19:00	0.10	276	7.50	107	7.34	13.80	3.33	1.538	0.165	4.59	6.23	3.6	-	-	15.96	0.126	0.617	8.24	0.0009	0.0086	14.8
Dasha River	20-Aug-96	20:00	0.10	274	7.55	116	6.34	38.00	3.55	1.535	0.166	3.63	5.61	3.8	-	-	16.27	0.123	0.658	12.70	0.0008	0.0081	15.7
Dasha River	21-Aug-96	7:00	0.10	267	7.42	58	6.48	38.00	4.06	1.433	0.154	4.91	6.26	3.1	-	-	14.24	0.198	0.987	3.77	0.0035	0.0187	12.9
Dasha River	21-Aug-96	8:00	0.10	269	7.40	148	7.48	58.80	3.76	1.461	0.156	4.85	6.35	2.8	-	-	14.08	0.192	0.973	3.66	0.0024	0.0156	12.9
Dasha River	21-Aug-96	9:00	0.10	270	7.41	173	5.48	46.20	3.54	1.497	0.152	4.38	5.89	3.9	-	-	14.32	0.184	1.201	2.60	0.0039	0.0184	13.3
Dasha River	21-Aug-96	19:00	0.10	282	7.48	87.5	4.90	49.60	3.36	1.460	0.166	4.49	5.66	3.7	-	-	15.49	0.140	0.742	7.04	0.0028	0.0074	17.0
Dasha River	21-Aug-96	20:00	0.10	284	7.56	97	4.60	43.20	3.50	1.437	0.168	4.26	5.05	3.2	-	-	15.49	0.132	0.805	12.60	0.0036	0.0080	16.6
Dasha River	21-Aug-96	21:00	0.10	287	7.58	105	6.50	49.60	3.52	1.381	0.166	5.20	5.40	3.5	-	-	15.49	0.157	0.886	9.85	0.0041	0.0087	17.7
Shawan River	21-Mar-96	15:00	0.30	527	7.30	152	73.50	27.86	17.54	0.006	0.030	20.61	-	58.6	-	-	17.90	0.158	2.740	13.50	0.0050	0.0910	41.7
Shawan River	23-Mar-96	10:00	0.20	502	7.00	112	58.03	26.47	19.89	0.038	0.016	19.98	-	41.4	-	-	15.20	1.882	3.440	6.60	0.0020	0.0730	38.3
Shawan River	24-Mar-96	9:00	0.30	694	7.50	82	71.89	28.21	26.69	0.036	0.008	28.12	-	63.6	-	-	17.00	2.354	4.453	10.80	0.0010	0.0350	49.3
Shawan River	24-Mar-96	11:00	0.30	676	7.10	401	73.84	24.73	29.99	0.027	0.015	30.72	-	54.8	-	-	15.90	3.099	4.700	12.90	0.0030	0.0400	55.2
Shawan River	24-Mar-96	13:00	0.40	732	7.40	158	73.79	34.47	28.38	0.078	0.020	29.13	-	77.8	-	-	17.40	2.975	4.327	20.60	0.0050	0.0070	49.8
Shawan River	24-Mar-96	15:00	0.30	619	7.00	114	71.99	27.51	23.77	0.048	0.006	26.40	-	64.4	-	-	17.80	2.484	5.767	16.20	0.0020	0.0580	47.8
Shawan River	18-Aug-96	17:00	0.20	489	7.51	30	29.65	95.20	9.50	0.003	0.002	9.42	12.80	17.6	-	-	11.96	0.745	1.738	2.05	0.0003	0.0027	36.2
Shawan River	18-Aug-96	18:00	0.20	514	7.49	48	36.50	94.60	10.06	0.001	0.001	10.37	12.30	21.9	-	-	10.80	0.893	1.899	2.83	0.0003	0.0037	41.4
Shawan River	18-Aug-96	19:00	0.20	483	7.42	18	47.85	93.00	8.21	0.010	0.001	9.05	11.60	19.0	-	-	11.86	0.517	1.436	2.12	0.0009	0.0026	40.2
Shawan River	19-Aug-96	18:00	0.30	567	7.35	56	88.28	96.40	14.89	0.036	0.004	16.87	18.60	32.0	-	-	13.15	1.873	2.530	2.83	0.0017	0.0140	43.8
Shawan River	19-Aug-96	19:00	0.30	572	7.38	40	81.68	106.00	16.23	0.001	0.001	18.19	18.90	36.2	-	-	13.26	2.070	2.738	2.70	0.0013	0.0076	37.2
Shawan River	19-Aug-96	20:00	0.30	578	7.40	46	74.68	100.80	16.91	0.001	0.001	16.99	18.10	29.8	-	-	13.38	2.121	2.752	4.45	0.0011	0.0060	44.6
Shawan River	20-Aug-96	18:00	0.30	535	7.48	50	101.54	111.20	10.63	0.019	0.014	10.85	13.10	49.6	-	-	15.96	1.199	2.315	10.50	0.0010	0.0390	50.1
Shawan River	20-Aug-96	19:00	0.30	610	7.57	55	64.54	120.60	16.32	0.018	0.016	18.87	21.10	35.4	-	-	15.49	2.248	3.057	12.10	0.0010	0.0104	47.7
Shawan River	20-Aug-96	20:00	0.30	604	7.60	54	73.04	106.80	16.77	0.003	0.013	19.34	20.40	24.4	-	-	19.96	2.323	2.497	7.12	0.0012	0.0084	46.5
Shawan River	21-Aug-96	7:00	0.20	522	7.42	32	35.48	108.00	13.10	0.003	0.006	14.95	18.00	18.5	-	-	14.94	1.403	2.040	2.19	0.0003	0.0029	36.8
Shawan River	21-Aug-96	8:00	0.20	454	7.48	36	32.08	97.80	8.88	0.002	0.005	12.72	14.10	20.9	-	-	14.78	0.639	1.578	9.85	0.0003	0.0080	32.6
Shawan River	21-Aug-96	9:00	0.30	535	7.50	48	34.88	115.20	13.06	0.002	0.003	15.33	18.80	27.2	-	-	14.40	0.967	1.859	3.08	0.0003	0.0049	38.7
Shawan River	21-Aug-96	19:00	0.30	605	7.48	44	118.80	123.60	16.31	0.001	0.001	21.19	20.40	53.8	-	-	12.12	1.959	3.168	9.43	0.0058	0.0107	54.7
Shawan River	21-Aug-96	20:00	0.30	599	7.45	34	100.50	110.60	16.36	0.001	0.001	17.83	19.70	51.8	-	-	12.44	2.037	3.128	11.40	0.0068	0.0103	53.6
Shawan River	21-Aug-96	21:00	0.30	605	7.40	42	79.10	116.40	16.86	0.001	0.001	18.68	20.90	36.9	-	-	12.12	2.015	3.188	12.50	0.0014	0.0072	54.2
Shenzhen River	25-Mar-96	15:00	8.22	-	7.50	167	15.00	37.00	15.30	<0.01	<0.01	19.10	19.10	13.0	51	64	13.00	2.590	4.210	5.00	0.0060	0.0190	4560
Shenzhen River	18-Aug-96	17:00	-	-	-	88	10.00	64.00	8.10	0.110	<0.01	11.90	12.00	13.0	35	48	8.30	1.980	3.180	49.00	0.0030	0.0310	115
Shenzhen River	18-Aug-96	18:00	-	-	-	116	10.00	59.00	9.30	0.110	<0.01	11.60	11.70	14.0	36	50	9.30	2.110	3.220	43.00	0.0040	0.0330	126

+ Courtesy of EPD : " Deep Bay Water Quality Regional Control Strategy Study " - Interim Data

Table D1.11 (cond't) Results of Water Quality Surveys in Rivers Entering Inner Deep Bay : Dry Season and Wet Season 1996+

Name of River	Date	Time	Salinity g/kg	Conductivity (uS/cm)	pH	SS (mg/L)	BOD_5 (mg/L)	COD (mg/L)	NH_4(N) (mg/L)	NO_3(N) (mg/L)	NO_2(N) (mg/L)	TKN (mg/L)	TN (mg/L)	TOC (mg/L)	TIC (mg/L)	TC (mg/L)	SiO_2 (mg/L)	PO_4(P) (mg/L)	TP (mg/L)	Chlorophyll-a (mg/m^3)	Dissolved Cu (mg/L)	Total Cu (mg/L)	Cl^- (mg/L)
Yuen Long River	20-Aug-96	19:00	-	-	-	72	14.00	39.00	7.50	<0.01	<0.01	10.50	10.50	8.0	31	39	10.90	2.010	2.680	20.00	0.0040	0.0210	98
Yuen Long River	20-Aug-96	20:00	-	-	-	64	12.00	42.00	7.50	<0.01	<0.01	10.00	10.00	7.0	31	38	11.30	1.990	2.700	24.00	0.0030	0.0230	99
Yuen Long River	21-Aug-96	7:00	-	-	-	68	14.00	54.00	7.90	0.050	<0.01	10.20	10.30	7.0	33	41	11.30	2.120	2.930	30.00	0.0030	0.0160	105
Yuen Long River	21-Aug-96	8:00	-	-	-	74	14.00	41.00	8.20	0.070	<0.01	10.20	10.30	8.0	32	40	11.10	2.140	2.930	30.00	0.0030	0.0120	105
Yuen Long River	21-Aug-96	9:00	-	-	-	72	15.00	29.00	8.00	0.050	<0.01	10.70	10.80	7.0	33	41	10.80	2.190	2.930	27.00	0.0030	0.0080	102
Yuen Long River	21-Aug-96	19:00	-	-	-	146	15.00	33.00	3.30	0.040	<0.01	9.50	9.50	9.0	34	42	15.50	1.880	2.640	49.00	0.0020	0.0110	139
Yuen Long River	21-Aug-96	20:00	-	-	-	146	9.00	35.00	6.70	0.020	<0.01	9.60	9.60	8.0	34	43	15.90	1.890	2.640	48.00	0.0020	0.0210	139
Yuen Long River	21-Aug-96	21:00	-	-	-	128	15.00	35.00	6.90	0.060	<0.01	9.50	9.60	8.0	35	43	15.40	1.910	2.620	38.00	0.0020	0.0190	136
Buji River	21-Mar-96	14:00	0.40	776	9.10	581	72.85	28.21	26.49	0.002	0.008	28.18	-	30.6	-	-	13.60	1.727	3.553	27.70	0.0009	0.2270	66.0
Buji River	23-Mar-96	9:00	0.30	572	7.10	307	37.18	23.69	20.31	0.002	0.008	23.73	-	49.6	-	-	19.60	1.932	3.267	3.30	0.0010	0.2040	53.2
Buji River	23-Mar-96	11:00	0.30	595	7.10	130	39.43	20.90	23.58	0.012	0.008	23.73	-	42.8	-	-	18.90	1.593	3.053	3.29	0.0020	0.0970	60.2
Buji River	23-Mar-96	12:00	0.30	601	7.20	110	41.78	20.90	23.94	0.030	0.020	23.79	-	36.3	-	-	18.90	1.348	2.833	3.71	0.0010	0.0580	57.7
Buji River	23-Mar-96	16:00	0.30	702	7.00	1800	71.78	102.00	28.38	0.018	0.024	29.33	-	58.4	-	-	20.70	2.870	10.300	28.20	0.0020	0.5800	59.2
Buji River	24-Mar-96	16:00	0.30	709	7.30	886	75.09	42.82	29.19	0.037	0.013	32.00	-	65.0	-	-	37.00	2.559	5.673	10.80	0.0020	0.2040	59.2
Buji River	18-Aug-96	17:00	0.20	450	7.62	152	31.05	95.20	8.08	0.001	0.001	11.98	15.30	14.3	-	-	13.27	0.071	1.356	1.42	0.0015	0.0105	41.8
Buji River	18-Aug-96	18:00	0.20	450	7.63	164	25.05	92.80	8.14	0.001	0.001	12.22	12.80	15.5	-	-	12.29	0.104	1.215	4.24	0.0013	0.0096	41.5
Buji River	18-Aug-96	19:00	0.20	482	7.60	104	26.65	88.00	8.21	0.001	0.001	9.06	13.10	14.3	-	-	12.83	0.080	1.195	1.42	0.0009	0.0085	41.1
Buji River	19-Aug-96	18:00	0.30	524	7.60	76	23.88	91.80	13.10	0.001	0.001	14.17	14.40	34.7	-	-	16.58	0.598	1.611	5.18	0.0021	0.0258	53.1
Buji River	19-Aug-96	19:00	0.30	523	7.62	64	25.08	92.80	14.14	0.001	0.001	14.80	15.10	17.5	-	-	15.80	0.552	1.510	2.19	0.0036	0.0551	52.9
Buji River	19-Aug-96	20:00	0.30	574	7.65	54	72.28	96.80	14.16	0.001	0.002	16.90	18.85	33.1	-	-	15.64	0.512	1.768	2.31	0.0090	0.0979	56.9
Buji River	20-Aug-96	18:00	0.30	554	7.65	78	42.14	82.40	13.14	0.045	0.014	15.63	16.10	21.1	-	-	15.96	0.718	1.644	7.11	0.0084	0.0938	52.1
Buji River	20-Aug-96	19:00	0.30	553	7.70	64	36.74	92.80	13.52	0.001	0.009	14.80	16..35	19.8	-	-	14.94	0.691	1.577	5.20	0.0043	0.0798	51.7
Buji River	20-Aug-96	20:00	0.30	565	7.72	90	41.34	90.60	13.13	0.007	0.008	14.80	15.91	21.3	-	-	15.64	0.644	1.691	3.18	0.0232	0.1084	55.3
Buji River	21-Aug-96	7:00	0.20	451	7.68	124	23.28	61.00	9.87	0.395	0.108	9.95	11.80	9.3	-	-	12.99	0.106	0.711	4.04	0.0008	0.0094	41.5
Buji River	21-Aug-96	8:00	0.20	448	7.76	122	30.88	80.00	9.72	0.382	0.142	12.15	12.80	12.9	-	-	13.07	0.146	0.942	3.18	0.0003	0.0098	41.1
Buji River	21-Aug-96	9:00	0.20	448	7.78	92	30.48	80.80	10.29	0.601	0.168	10.30	15.63	11.2	-	-	13.46	0.162	0.913	4.23	0.0003	0.0058	42.0
Buji River	21-Aug-96	19:00	0.30	556	7.59	72	29.30	103.00	15.83	0.001	0.001	16.07	16.90	16.0	-	-	11.96	0.589	1.839	3.82	0.0052	0.0558	59.3
Buji River	21-Aug-96	20:00	0.30	539	7.60	54	35.90	102.80	11.59	0.007	0.003	13.80	14.97	20.2	-	-	11.96	0.591	1.705	5.95	0.0187	0.0730	54.5
Buji River	21-Aug-96	21:00	0.30	533	7.62	58	34.40	92.80	12.31	0.001	0.001	13.59	14.20	18.2	-	-	12.36	0.673	1.832	6.16	0.0258	0.0728	54.2
Dasha River	21-Mar-96	9:00	0.20	364	7.40	452	21.25	16.56	11.59	0.252	0.060	13.61	-	22.5	-	-	17.10	0.345	2.033	18.10	0.0020	0.0800	30.1
Dasha River	21-Mar-96	15:00	0.20	341	7.40	265	10.55	9.95	10.45	0.437	0.029	11.96	-	12.9	-	-	17.20	0.469	2.193	27.10	0.0006	0.0620	25.2
Dasha River	23-Mar-96	9:00	0.20	324	7.10	890	40.08	69.25	10.33	0.001	0.005	13.55	-	31.8	-	-	17.20	0.161	8.900	34.80	0.0010	0.1380	53.2
Dasha River	24-Mar-96	9:00	0.10	274	6.90	316	58.49	17.43	7.37	0.790	0.232	9.60	-	15.8	-	-	18.10	0.211	2.840	29.60	0.0020	0.0930	20.9
Dasha River	18-Aug-96	17:00	0.10	234	7.58	187	5.05	41.20	1.83	2.412	0.168	2.25	5.67	3.2	-	-	12.68	0.293	1.174	3.29	0.0062	0.0217	9.8
Dasha River	18-Aug-96	18:00	0.10	233	7.60	179	5.25	58.80	1.92	2.404	0.168	2.98	4.87	4.5	-	-	12.52	0.232	1.040	2.36	0.0073	0.0264	10.5
Dasha River	18-Aug-96	19:00	0.10	242	7.40	167	5.05	61.80	2.00	2.451	0.177	3.56	6.67	4.5	-	-	12.05	0.252	1.154	2.17	0.0066	0.0259	10.8

+ Courtesy of EPD : " Deep Bay Water Quality Regional Control Strategy Study " - Interim Data

Table D1.11 Results of Water Quality Surveys in Rivers Entering Inner Deep Bay : Dry Season and Wet Season 1996⁺

Name of River	Date	Time	Salinity g/kg	Conductivity (uS/cm)	pH	SS (mg/L)	BOD_5 (mg/L)	COD (mg/L)	NH_3(N) (mg/L)	NO_3(N) (mg/L)	NO_2(N) (mg/L)	TKN (mg/L)	TN (mg/L)	TOC (mg/L)	TIC (mg/L)	TC (mg/L)	SiO_2 (mg/L)	PO_4(P) (mg/L)	TP (mg/L)	Chlorophyll-a (mg/m^3)	Dissolved Cu (mg/L)	Total Cu (mg/L)	Cl^- (mg/L)
TSW-Western Channel	22-Mar-96	8:00	6.29	-	7.00	24	6.00	40.00	12.20	0.130	<0.01	12.50	12.60	14.0	45	59	7.40	3.020	4.380	15.00	0.0040	0.0050	3480
TSW-Western Channel	22-Mar-96	11:00	9.33	-	7.50	34	10.00	52.00	13.90	0.050	<0.01	16.00	16.00	16.0	51	67	7.60	3.080	4.020	10.00	0.0040	0.0050	5170
TSW-Western Channel	22-Mar-96	14:00	8.94	-	7.00	26	6.00	57.00	13.00	0.070	<0.01	15.00	15.10	19.0	49	68	7.00	3.070	4.230	80.00	0.0040	0.0050	4950
TSW-Western Channel	22-Mar-96	17:00	10.13	-	7.80	16	4.00	91.00	11.00	0.030	<0.01	15.30	15.30	13.0	54	67	6.70	3.290	3.990	20.00	0.0030	0.0040	5620
TSW-Western Channel	25-Mar-96	14:00	8.88	-	7.90	25	4.00	35.00	14.10	0.010	<0.01	16.40	16.40	15.0	53	68	6.20	3.420	4.420	35.00	0.0040	0.0050	4930
TSW-Western Channel	18-Aug-96	17:00	-	-	-	148	5.00	38.00	1.70	0.740	0.050	3.60	4.40	8.0	14	23	10.00	0.620	0.950	5.00	0.0050	0.0360	12
TSW-Western Channel	18-Aug-96	18:00	-	-	-	152	4.00	26.00	1.70	0.840	0.060	3.40	4.30	7.0	14	21	14.50	0.620	0.930	3.00	0.0050	0.0260	12
TSW-Western Channel	18-Aug-96	19:00	-	-	-	184	4.00	29.00	1.80	0.530	0.130	3.20	3.90	6.0	13	19	13.50	0.470	0.910	3.00	0.0040	0.0370	14
TSW-Western Channel	19-Aug-96	18:00	-	-	-	52	7.00	28.00	3.90	0.020	<0.01	5.40	5.60	8.0	26	34	11.40	0.970	1.750	11.00	0.0020	0.0210	111
TSW-Western Channel	19-Aug-96	19:00	-	-	-	28	5.00	17.00	2.80	<0.01	<0.01	3.50	3.50	5.0	37	42	12.70	0.540	1.600	5.00	0.0010	0.0230	271
TSW-Western Channel	19-Aug-96	20:00	-	-	-	30	5.00	14.00	1.80	<0.01	<0.01	3.50	3.50	4.0	37	41	12.60	0.570	1.600	5.00	0.0020	0.0130	278
TSW-Western Channel	20-Aug-96	18:00	-	-	-	52	38.00	61.00	9.30	<0.01	<0.01	12.50	12.50	13.0	40	53	10.60	3.070	3.320	8.00	0.0050	0.0300	58
TSW-Western Channel	20-Aug-96	19:00	-	-	-	56	40.00	81.00	11.20	<0.01	<0.01	13.50	13.50	12.0	39	52	10.60	3.120	3.920	3.00	0.0050	0.0340	56
TSW-Western Channel	20-Aug-96	20:00	-	-	-	62	42.00	74.00	11.00	<0.01	<0.01	14.20	14.20	12.0	41	52	10.70	3.200	3.850	7.00	0.0060	0.0340	60
TSW-Western Channel	21-Aug-96	7:00	-	-	-	60	22.00	51.00	6.60	0.040	<0.01	9.50	9.50	7.0	33	40	9.20	2.080	2.880	9.00	0.0080	0.0150	39
TSW-Western Channel	21-Aug-96	8:00	-	-	-	62	25.00	48.00	6.60	0.040	<0.01	8.50	8.50	8.0	32	40	9.80	1.990	2.830	11.00	0.0080	0.0150	40
TSW-Western Channel	21-Aug-96	9:00	-	-	-	62	21.00	48.00	6.70	0.040	<0.01	9.30	9.30	8.0	30	37	10.50	2.030	2.830	13.00	0.0070	0.0160	39
TSW-Western Channel	21-Aug-96	19:00	-	-	-	40	16.00	42.00	6.30	<0.01	<0.01	8.60	8.60	7.0	35	43	9.10	1.870	2.660	29.00	0.0040	0.0140	81
TSW-Western Channel	21-Aug-96	20:00	-	-	-	38	16.00	45.00	2.40	<0.01	<0.01	8.60	8.60	8.0	35	42	9.00	1.880	2.670	32.00	0.0050	0.0140	81
TSW-Western Channel	21-Aug-96	21:00	-	-	-	40	13.00	42.00	6.30	0.020	<0.01	8.80	8.80	8.0	35	43	9.00	1.850	2.700	32.00	0.0050	0.0140	82
Indus River	22-Mar-96	10:00	0.20	-	5.80	22	8.00	48.00	7.80	0.900	0.190	8.20	9.30	12.0	20	31	6.90	1.610	3.410	20.00	0.0070	0.0080	57
Indus River	22-Mar-96	13:00	0.20	-	6.80	17	8.00	41.00	8.50	2.100	0.200	9.40	11.70	13.0	35	48	6.50	1.940	2.920	15.00	0.0060	0.0070	66
Indus River	22-Mar-96	16:00	0.10	-	7.20	29	8.00	33.00	4.60	1.700	0.130	7.30	9.10	10.0	24	34	6.10	1.840	2.850	15.00	0.0060	0.0080	60
Indus River	22-Mar-96	17:00	0.20	-	4.50	47	8.00	50.00	7.10	5.900	0.380	10.80	17.10	12.0	23	35	6.60	2.190	3.820	15.00	0.0060	0.0090	64
Indus River	25-Mar-96	16:00	2.10	-	7.00	25	11.00	44.00	6.80	2.500	0.280	9.60	12.40	14.0	30	43	7.40	2.650	3.140	10.00	0.0070	0.0090	58
Indus River	18-Aug-96	17:00	-	-	-	74	3.00	24.00	1.80	1.890	0.060	3.50	5.50	6.0	8	13	6.40	0.004	0.990	4.00	0.0010	0.0220	58
Indus River	18-Aug-96	18:00	-	-	-	62	4.00	26.00	1.70	1.890	0.060	3.00	5.10	6.0	8	14	6.60	0.003	0.890	6.00	0.0010	0.0150	63
Indus River	18-Aug-96	19:00	-	-	-	60	2.00	36.00	1.80	2.020	0.070	3.60	5.60	5.0	12	16	6.40	0.004	0.900	4.00	0.0010	0.0130	65
Indus River	19-Aug-96	18:00	-	-	-	40	11.00	26.00	1.80	2.030	0.080	2.80	4.90	7.0	18	25	6.90	0.670	1.250	2.00	0.0030	0.0190	27
Indus River	19-Aug-96	19:00	-	-	-	30	9.00	28.00	1.80	1.820	0.090	2.90	4.80	7.0	18	25	6.50	0.600	1.240	5.00	0.0030	0.0120	27
Indus River	19-Aug-96	20:00	-	-	-	50	4.00	30.00	1.70	2.370	0.100	2.60	5.10	7.0	17	24	6.90	0.600	1.290	3.00	0.0030	0.0130	28
Indus River	20-Aug-96	18:00	-	-	-	32	5.00	28.00	3.20	1.010	0.110	5.20	6.30	6.0	22	28	7.70	1.100	1.730	10.00	0.0030	0.0090	27
Indus River	20-Aug-96	19:00	-	-	-	30	8.00	28.00	3.00	1.090	0.130	5.20	6.40	6.0	20	26	7.60	1.110	1.690	11.00	0.0030	0.0070	28
Indus River	20-Aug-96	20:00	-	-	-	24	9.00	32.00	3.30	0.840	0.130	5.40	6.40	5.0	22	27	7.40	1.100	1.720	16.00	0.0030	0.0070	27
Indus River	21-Aug-96	7:00	-	-	-	36	10.00	22.00	2.80	0.980	0.020	4.60	5.60	5.0	19	24	6.90	0.860	1.370	18.00	0.0040	0.0100	26
Indus River	21-Aug-96	8:00	-	-	-	40	13.00	19.00	2.80	1.020	0.020	4.50	5.50	5.0	18	23	7.10	0.880	1.360	5.00	0.0050	0.0100	26

+ Courtesy of EPD : " Deep Bay Water Quality Regional Control Strategy Study " - Interim Data

Table D1.11 (cond't) Results of Water Quality Surveys in Rivers Entering Inner Deep Bay : Dry Season and Wet Season 1996+

Name of River	Date	Time	Salinity g/kg	Conductivity (uS/cm)	pH	SS (mg/L)	BOD_5 (mg/L)	COD (mg/L)	NH_4(N) (mg/L)	NO_3(N) (mg/L)	NO_2(N) (mg/L)	TKN (mg/L)	TN (mg/L)	TOC (mg/L)	TIC (mg/L)	TC (mg/L)	SiO_2 (mg/L)	PO_4(P) (mg/L)	TP (mg/L)	Chlorophyll-a (mg/m^3)	Dissolved Cu (mg/L)	Total Cu (mg/L)	Cl^- (mg/L)
Indus River	21-Aug-96	9:00	-	-	-	32	10.00	40.00	2.80	0.860	<0.01	4.90	5.80	8.0	3	11	6.80	1.240	1.460	<1	0.0100	0.0080	26
Indus River	21-Aug-96	19:00	-	-	-	42	13.00	27.00	3.90	1.160	0.070	5.50	6.70	6.0	21	27	6.70	0.850	1.460	16.00	0.0050	0.0170	34
Indus River	21-Aug-96	20:00	-	-	-	32	11.00	27.00	3.70	1.620	0.070	5.60	7.30	6.0	21	27	6.60	0.950	1.450	8.00	0.0060	0.0180	38
Indus River	21-Aug-96	21:00	-	-	-	30	11.00	28.00	3.50	0.810	0.070	5.30	6.10	6.0	22	28	6.70	0.920	1.450	9.00	0.0050	0.0130	36
Ganges River	22-Mar-96	10:00	0.30	-	7.20	164	56.00	278.00	41.20	0.040	<0.01	50.50	50.50	55.0	88	143	10.00	11.300	16.900	35.00	0.0070	0.1300	37
Ganges River	22-Mar-96	13:00	0.40	-	7.50	192	66.00	263.00	40.30	0.050	0.020	45.70	45.70	75.0	104	178	12.00	14.900	20.000	30.00	0.0620	0.0960	50
Ganges River	22-Mar-96	16:00	0.50	-	7.70	230	92.00	276.00	60.90	0.030	0.020	69.20	69.20	54.0	127	180	12.00	18.500	23.700	20.00	0.0220	0.1300	56
Ganges River	22-Mar-96	20:00	0.40	-	7.60	14	70.00	182.00	49.90	0.150	0.020	97.40	97.60	48.0	113	160	14.00	15.200	43.200	25.00	0.0680	0.1600	41
Ganges River	25-Mar-96	16:00	0.30	-	7.50	185	41.00	128.00	28.30	<0.01	<0.01	35.80	35.80	34.0	74	108	1.10	11.700	12.700	<5	0.0030	0.1100	46
Ganges River	18-Aug-96	17:00	-	-	-	74	7.00	40.00	3.80	0.860	0.110	6.00	7.00	12.0	22	34	7.50	1.480	2.040	4.00	0.0050	0.0290	15
Ganges River	18-Aug-96	18:00	-	-	-	89	5.00	42.00	4.40	0.990	0.100	6.40	7.50	12.0	21	32	7.70	1.490	1.770	<1	0.0050	0.0310	14
Ganges River	18-Aug-96	19:00	-	-	-	99	6.00	42.00	4.30	0.870	0.100	6.30	7.30	11.0	22	33	7.70	1.500	2.320	2.00	0.0060	0.0220	14
Ganges River	19-Aug-96	18:00	-	-	-	70	6.00	31.00	5.30	0.320	0.100	7.00	7.40	11.0	22	42	7.90	1.320	2.250	2.00	0.0040	0.0330	15
Ganges River	19-Aug-96	19:00	-	-	-	70	7.00	24.00	5.80	0.250	0.100	7.40	7.80	9.0	23	32	8.10	1.680	2.210	2.00	0.0030	0.0260	14
Ganges River	19-Aug-96	20:00	-	-	-	64	9.00	28.00	5.50	0.190	0.090	6.90	7.20	9.0	23	32	7.80	1.390	1.900	2.00	0.0030	0.0260	14
Ganges River	20-Aug-96	18:00	-	-	-	212	6.00	27.00	5.90	0.230	0.130	8.10	8.50	8.0	24	31	12.00	1.670	2.590	2.00	0.0040	0.0170	13
Ganges River	20-Aug-96	19:00	-	-	-	230	6.00	38.00	6.40	0.210	0.140	8.20	8.60	6.0	24	30	13.00	1.640	2.810	4.00	0.0030	0.0210	11
Ganges River	20-Aug-96	20:00	-	-	-	172	6.00	29.00	5.50	0.200	0.140	7.30	7.60	6.0	24	30	12.00	1.740	2.580	<1	0.0030	0.0180	14
Ganges River	21-Aug-96	7:00	-	-	-	186	17.00	53.00	7.90	0.160	<0.01	11.20	11.40	9.0	19	28	11.60	2.370	3.360	7.00	0.0040	0.0150	13
Ganges River	21-Aug-96	8:00	-	-	-	210	16.00	51.00	7.60	0.180	<0.01	10.90	11.10	9.0	26	35	12.50	2.170	3.290	6.00	0.0040	0.0150	12
Ganges River	21-Aug-96	9:00	-	-	-	344	18.00	51.00	7.10	0.160	<0.01	9.90	10.10	9.0	27	35	13.30	2.170	3.080	1.00	0.0040	0.0140	12
Ganges River	21-Aug-96	19:00	-	-	-	128	11.00	29.00	6.40	0.170	0.005	9.50	9.70	7.0	25	32	7.60	1.430	2.210	5.00	0.0030	0.0120	14
Ganges River	21-Aug-96	20:00	-	-	-	90	8.00	29.00	6.20	0.180	0.050	7.70	7.90	7.0	24	31	7.50	1.400	2.210	1.00	0.0030	0.0110	13
Ganges River	21-Aug-96	21:00	-	-	-	260	11.00	37.00	6.90	0.160	0.040	8.70	8.90	7.0	26	33	13.80	1.630	2.780	6.00	0.0050	0.0220	13
Yuen Long River	22-Mar-96	9:00	3.91	-	7.60	38	40.00	107.00	23.00	0.020	<0.01	26.10	26.10	27.0	75	102	9.40	6.100	7.210	20.00	0.0080	0.0210	2140
Yuen Long River	22-Mar-96	12:00	7.83	-	7.40	26	12.00	69.00	15.00	0.040	<0.01	16.60	16.60	21.0	61	81	8.20	4.580	5.340	20.00	0.0020	0.0060	4340
Yuen Long River	22-Mar-96	15:00	4.82	-	7.70	34	26.00	84.00	19.50	0.030	<0.01	24.10	24.10	22.0	71	93	8.70	5.480	6.920	10.00	0.0060	0.0130	2660
Yuen Long River	22-Mar-96	18:00	2.50	-	6.90	18	36.00	101.00	11.90	0.020	<0.01	31.80	31.80	25.0	72	98	9.40	6.500	8.050	20.00	0.0040	0.0220	1400
Yuen Long River	25-Mar-96	15:00	6.50	-	7.50	43	17.00	66.00	16.80	<0.01	<0.01	20.90	20.90	20.0	66	85	8.00	2.100	2.540	10.00	0.0020	0.0080	3600
Yuen Long River	18-Aug-96	17:00	-	-	-	130	5.00	39.00	3.30	0.940	0.120	5.10	6.20	9.0	19	28	12.50	1.080	1.620	11.00	0.0040	0.0250	51
Yuen Long River	18-Aug-96	18:00	-	-	-	120	5.00	34.00	3.30	0.780	0.110	5.10	6.00	8.0	20	28	10.70	1.110	1.660	10.00	0.0050	0.0340	52
Yuen Long River	18-Aug-96	19:00	-	-	-	82	7.00	39.00	4.10	0.300	0.340	6.40	7.00	9.0	23	32	9.40	0.010	0.010	13.00	0.0040	0.0260	49
Yuen Long River	19-Aug-96	18:00	-	-	-	92	13.00	35.00	4.80	<0.01	<0.01	6.60	6.60	10.0	27	37	12.40	1.340	2.110	17.00	0.0030	0.0270	98
Yuen Long River	19-Aug-96	19:00	-	-	-	42	11.00	33.00	5.90	<0.01	<0.01	7.40	7.40	11.0	27	38	11.60	1.380	2.100	11.00	0.0020	0.0270	65
Yuen Long River	19-Aug-96	20:00	-	-	-	46	10.00	33.00	5.90	<0.01	<0.01	7.50	7.50	10.0	28	38	8.90	1.370	2.130	16.00	0.0020	0.0230	62
Yuen Long River	20-Aug-96	18:00	-	-	-	66	16.00	40.00	7.60	<0.01	<0.01	10.00	10.00	7.0	31	38	10.30	1.950	2.710	21.00	0.0030	0.0160	101

+ Courtesy of EPD : " Deep Bay Water Quality Regional Control Strategy Study " - Interim Data

Table D1.11 (cond't) Results of Water Quality Surveys in Rivers Entering Inner Deep Bay : Dry Season and Wet Season 1996+

Name of River	Date	Time	Salinity g/kg	Conductivity (uS/cm)	pH	SS (mg/L)	BOD_5 (mg/L)	COD (mg/L)	NH_4(N) (mg/L)	NO_3(N) (mg/L)	NO_2(N) (mg/L)	TKN (mg/L)	TN (mg/L)	TOC (mg/L)	TIC (mg/L)	TC (mg/L)	SiO_2 (mg/L)	PO_4(P) (mg/L)	TP (mg/L)	Chlorophyll-a (mg/m^3)	Dissolved Cu (mg/L)	Total Cu (mg/L)	Cl^- (mg/L)
Shenzhen River	18-Aug-96	19:00	-	-	-	150	10.00	94.00	7.50	0.080	0.020	12.00	12.10	14.0	33	48	9.70	2.220	3.710	59.00	0.0050	0.0340	137
Shenzhen River	19-Aug-96	18:00	-	-	-	88	13.00	49.00	8.00	0.020	<0.01	10.20	10.40	14.0	32	46	7.60	1.190	1.960	19.00	0.0030	0.0260	105
Shenzhen River	19-Aug-96	19:00	-	-	-	58	13.00	41.00	8.10	<0.01	<0.01	10.40	10.40	14.0	33	48	8.00	1.230	1.960	47.00	0.0020	0.0180	98
Shenzhen River	19-Aug-96	20:00	-	-	-	64	16.00	46.00	8.20	0.010	<0.01	9.90	10.00	12.0	35	48	7.60	1.190	1.970	22.00	0.0030	0.0160	102
Shenzhen River	20-Aug-96	18:00	-	-	-	94	17.00	58.00	11.00	0.010	0.010	14.90	14.90	9.0	36	45	9.30	1.930	2.730	19.00	0.0030	0.0200	92
Shenzhen River	20-Aug-96	19:00	-	-	-	92	16.00	55.00	11.60	0.010	<0.01	14.50	14.50	9.0	38	47	9.50	2.030	2.610	16.00	0.0040	0.0220	94
Shenzhen River	20-Aug-96	20:00	-	-	-	30	17.00	56.00	11.90	0.020	<0.01	14.70	14.70	9.0	37	47	8.70	1.980	2.630	23.00	0.0030	0.0200	94
Shenzhen River	21-Aug-96	7:00	-	-	-	334	23.00	97.00	13.10	0.030	<0.01	17.10	17.10	10.0	39	48	21.50	1.550	3.200	13.00	0.0030	0.0530	81
Shenzhen River	21-Aug-96	8:00	-	-	-	468	23.00	86.00	13.60	0.040	<0.01	17.50	17.50	9.0	40	49	24.90	1.520	3.310	16.00	0.0030	0.0750	83
Shenzhen River	21-Aug-96	9:00	-	-	-	312	22.00	75.00	13.80	0.020	<0.01	16.50	16.50	9.0	39	48	19.50	1.550	3.050	15.00	0.0060	0.0530	82
Shenzhen River	21-Aug-96	19:00	-	-	-	90	18.00	51.00	10.80	0.040	<0.01	13.30	13.40	10.0	34	44	9.40	0.970	1.910	7.00	0.0040	0.0300	128
Shenzhen River	21-Aug-96	20:00	-	-	-	114	23.00	48.00	10.60	<0.01	<0.01	13.50	13.50	11.0	35	46	12.40	0.950	1.980	6.00	0.0030	0.0310	127
Shenzhen River	21-Aug-96	21:00	-	-	-	188	38.00	50.00	10.40	0.030	<0.01	13.20	13.20	10.0	35	45	14.20	0.900	2.040	6.00	0.0020	0.0330	128

+ Courtesy of EPD : " Deep Bay Water Quality Regional Control Strategy Study " - Interim Data

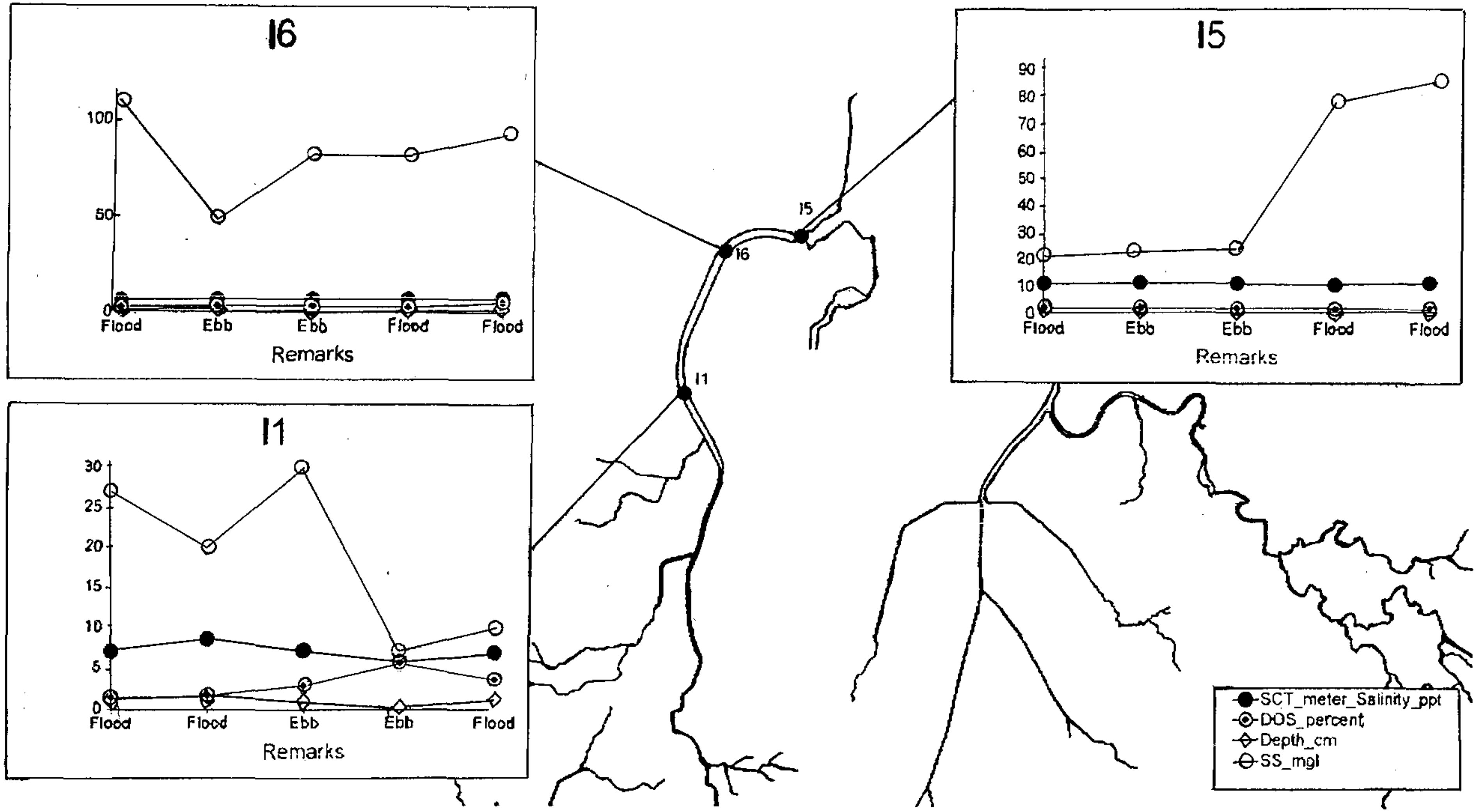
Table D1.12 Survey Results from The River Sedimentation Study - Tin Shui Wai Western Temporary Channel+

Location	Date	Time	Salinity ppt	Temp. ^0C	D.O. mg/L	D.O. %	Current m/s	Depth m	Cond. ms	Tide	SS mg/L	BOD_5 mg/L	$NH_4(N)$ mg /L	Total Oxidised N mg /L	*Total Copper (Cu) mg/L	*Dissolved Copper (Cu) mg/L	*Nickel (Ni) mg/L	Zinc (Zn) mg/L	*Lead (Pb) mg/L	*Cadmium (Cd) mg/L	*Chromium (Cr) mg/L	*Mercury (Hg) mg/L
I1	16-Apr-96	7:00	7.20	21.5	0.13	1.5	0.023	1.35	1.62	Flood	27	14.5	12.0	0.040	0.050	0.050	0.050	0.060	0.250	0.025	0.025	0.500
I1	16-Apr-96	10:03	8.60	21.6	0.15	1.7	0.025	1.55	1.84	Flood	20	19.5	12.0	0.030	0.050	0.050	0.050	0.025	0.250	0.025	0.025	0.500
I1	16-Apr-96	13:02	7.20	23.0	0.25	2.9	0.036	0.90	11.81	Ebb	30	20.5	9.2	0.030	0.050	0.050	0.050	0.080	0.250	0.025	0.025	0.500
I1	16-Apr-96	16:02	5.80	24.2	0.49	5.6	0.032	0.30	5.76	Ebb	7	20.0	5.8	0.170	0.050	0.050	0.050	0.160	0.250	0.025	0.025	0.500
I1	16-Apr-96	19:01	6.90	23.6	0.35	3.0	0.037	1.20	5.13	Flood	10	6.0	5.8	0.360	0.050	0.050	0.050	0.200	0.250	0.025	0.025	0.500
I6	16-Apr-96	7:25	8.10	21.3	0.33	3.3	0.031	1.75	1.95	Flood	110	6.5	8.1	0.005	0.010	0.050	0.050	0.025	0.250	0.025	0.025	0.500
I6	16-Apr-96	10:31	8.20	21.4	0.35	3.5	0.043	1.98	2.02	Ebb	49	7.0	8.6	0.005	0.050	0.050	0.050	0.025	0.250	0.025	0.025	0.500
I6	16-Apr-96	13:32	7.20	22.9	0.36	4.0	0.045	1.30	12.81	Ebb	82	6.5	9.8	0.005	0.050	0.050	0.050	0.050	0.250	0.025	0.025	0.500
I6	16-Apr-96	16:30	7.10	23.9	0.31	3.2	0.031	0.50	1.70	Flood	82	16.0	12.0	0.005	0.050	0.050	0.050	0.025	0.250	0.025	0.025	0.500
I6	16-Apr-96	19:33	7.80	23.2	0.32	5.7	0.042	1.70	6.25	Flood	92	16.5	12.0	0.005	0.010	0.050	0.050	0.050	0.250	0.025	0.025	0.500
I5	16-Apr-96	7:58	11.80	20.7	0.21	2.5	0.042	1.65	2.37	Flood	22	13.5	11.0	0.040	0.050	0.050	0.050	0.050	0.250	0.025	0.025	0.500
I5	16-Apr-96	11:01	12.10	20.8	0.23	2.7	0.035	1.90	2.53	Ebb	24	25.0	9.2	0.030	0.050	0.050	0.050	0.390	0.250	0.025	0.025	0.500
I5	16-Apr-96	14:03	12.10	21.4	0.24	2.7	1.230	1.20	2.54	Ebb	25	21.0	6.3	0.030	0.050	0.050	0.050	0.025	0.250	0.025	0.025	0.500
I5	16-Apr-96	16:59	11.50	23.7	0.21	2.5	0.048	0.70	2.03	Flood	79	19.0	14.0	0.030	0.050	0.050	0.050	0.025	0.250	0.025	0.025	0.500
I5	16-Apr-96	20:06	12.40	23.1	0.23	2.7	0.067	1.60	5.02	Flood	87	18.5	12.0	0.030	0.050	0.050	0.050	0.050	0.250	0.025	0.025	0.500

+Courtesy of DSD and Hyder Environmental Ltd. : " Sedimentation Study " - Interim Data

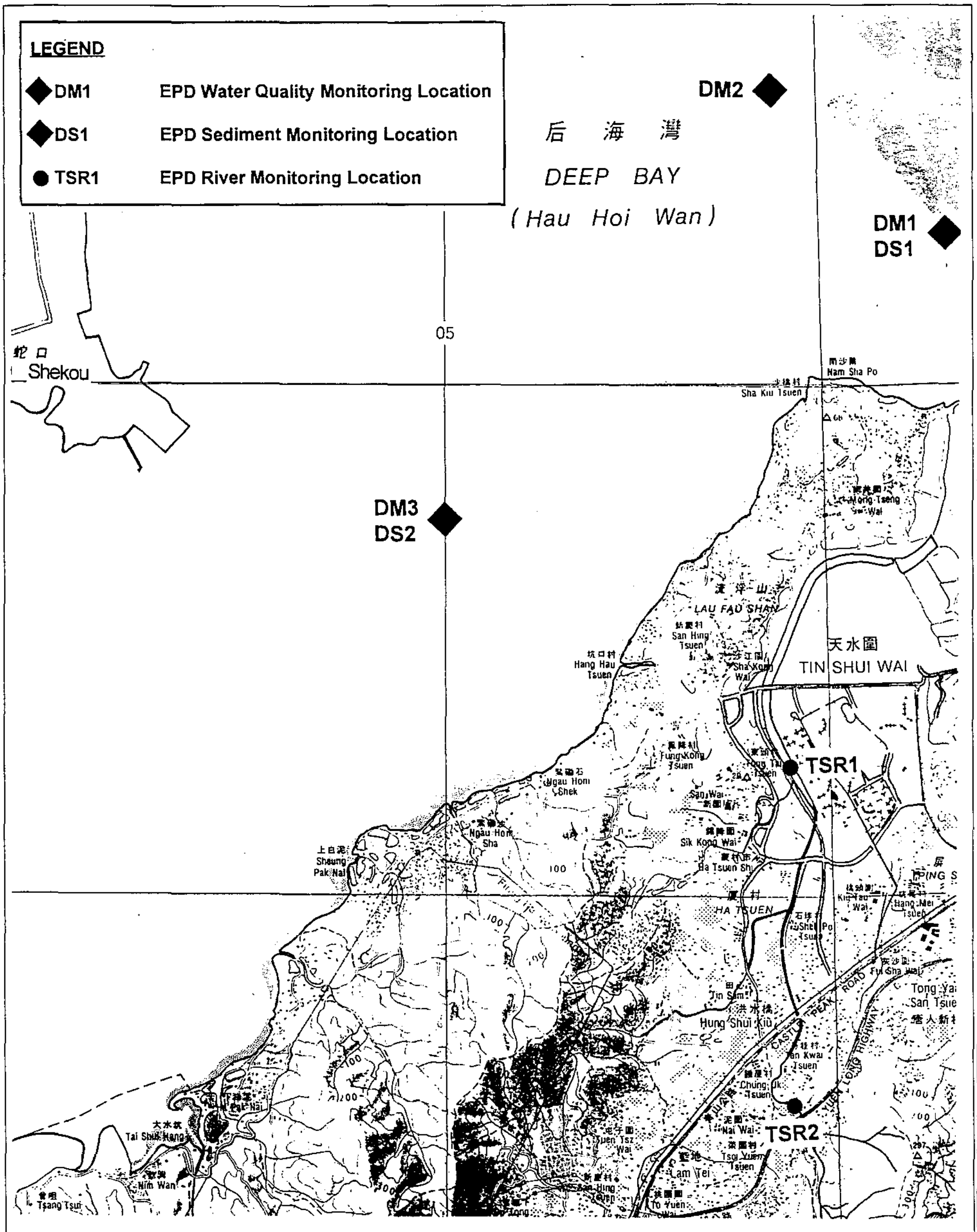
*Detection limits appear to be rather high. These values offer upper limits only.

Sampling Location is shown in Figure D1.1



(SOURCE : INTERIM DATA SUPPLIED COURTESY OF DSD AND HYDER'S SEDIMENTATION STUDY)

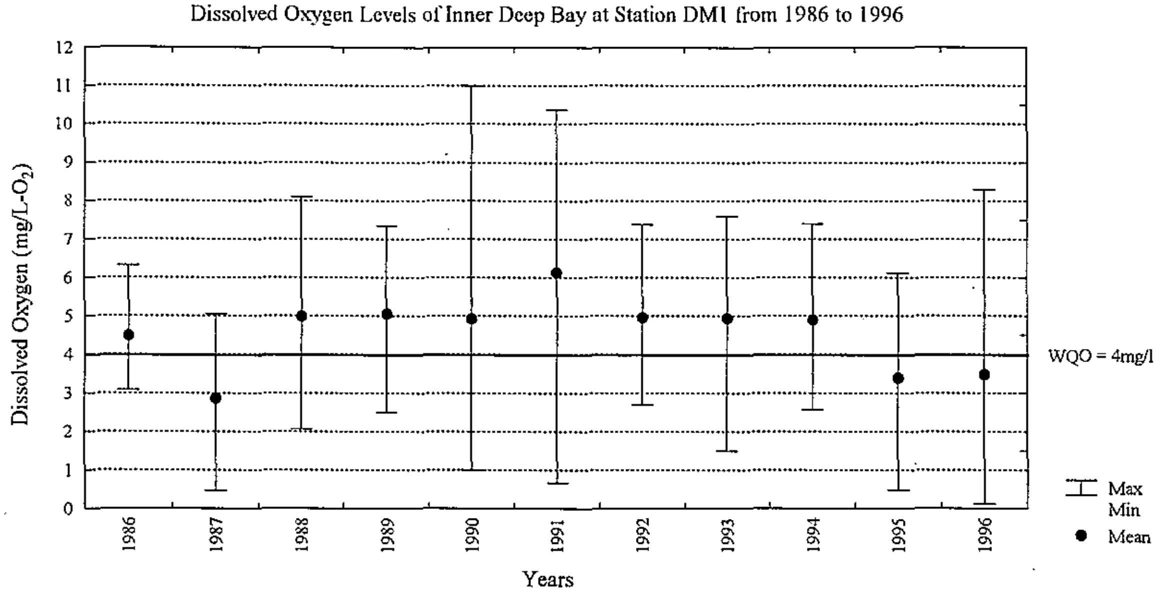
TIN SHUI WAI DEVELOPMENT AGREEMENT NO. CE 10/95 ENGINEERING INVESTIGATIONS FOR DEVELOPMENT OF AREAS 3, 30 & 31 OF THE DEVELOPMENT ZONE AND THE RESERVE ZONE	Title : TIN SHUI WAI WESTERN DRAINAGE CHANNELS - WATER QUALITY OVER A 12 hr PERIOD (16/4/96)	Figure No. D1.1	Revision 0
		Reference No. HYDER DATA	File Name -
BINNIE CONSULTANTS LIMITED 賓尼工程顧問有限公司 ENGINEERS AND SCIENTISTS 賓尼		Prepared MC	Checked PS
		Date FEB 97	Scale -

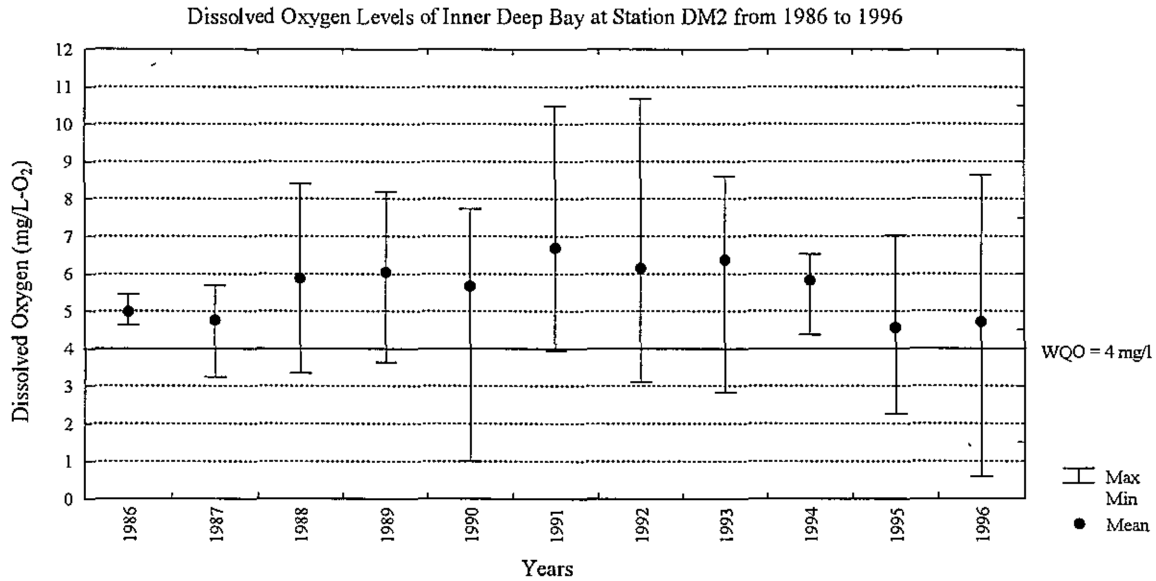


(SOURCE : EPD MONITORING REPORTS)

TIN SHUI WAI DEVELOPMENT AGREEMENT NO. CE 10/95 ENGINEERING INVESTIGATIONS FOR DEVELOPMENT OF AREAS 3, 30 & 31 OF THE DEVELOPMENT ZONE AND THE RESERVE ZONE	Title : EPD WATER QUALITY MONITORING STATIONS	Figure No. D1.2	Revision 0
		Reference No. EPD REPORTS	File Name -
BINNIE CONSULTANTS LIMITED 賓尼工程顧問有限公司 ENGINEERS AND SCIENTISTS 賓尼		Prepared MC	Checked JC
		Date APR 96	Scale 1 : 50000

Figure D1.3 Annual Average of Dissolved Oxygen Levels of Inner Deep Bay at Stations DM1, DM2 & DM3 from 1986 to 1996





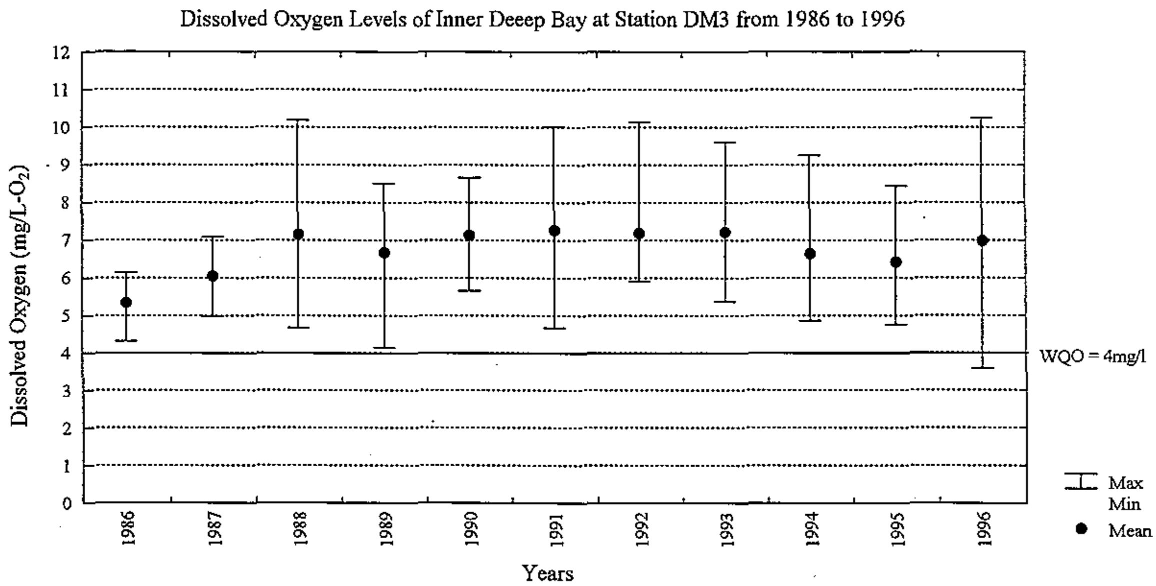
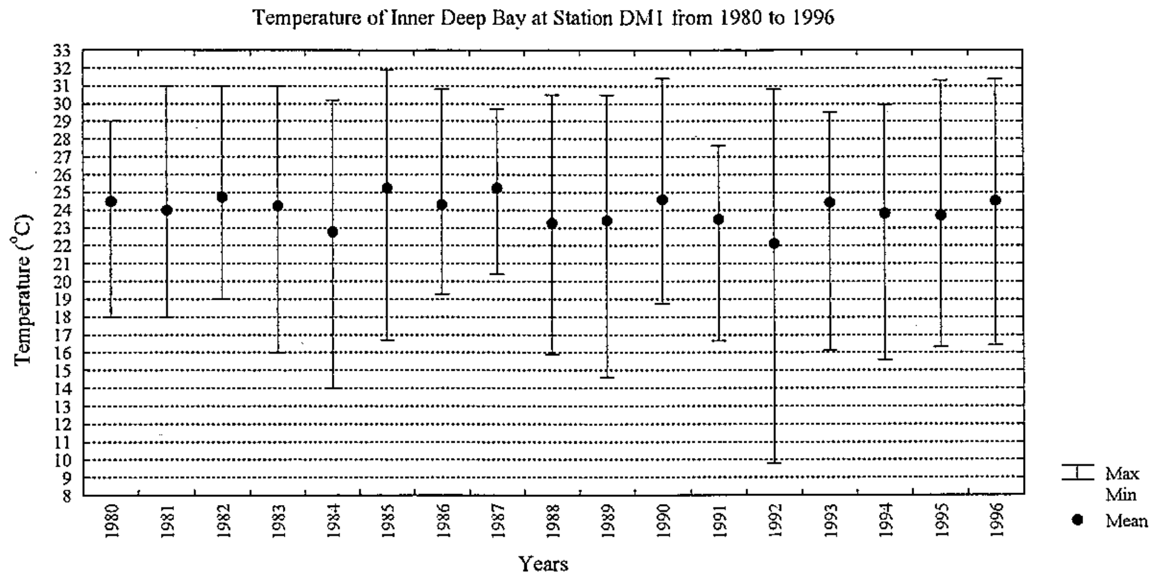
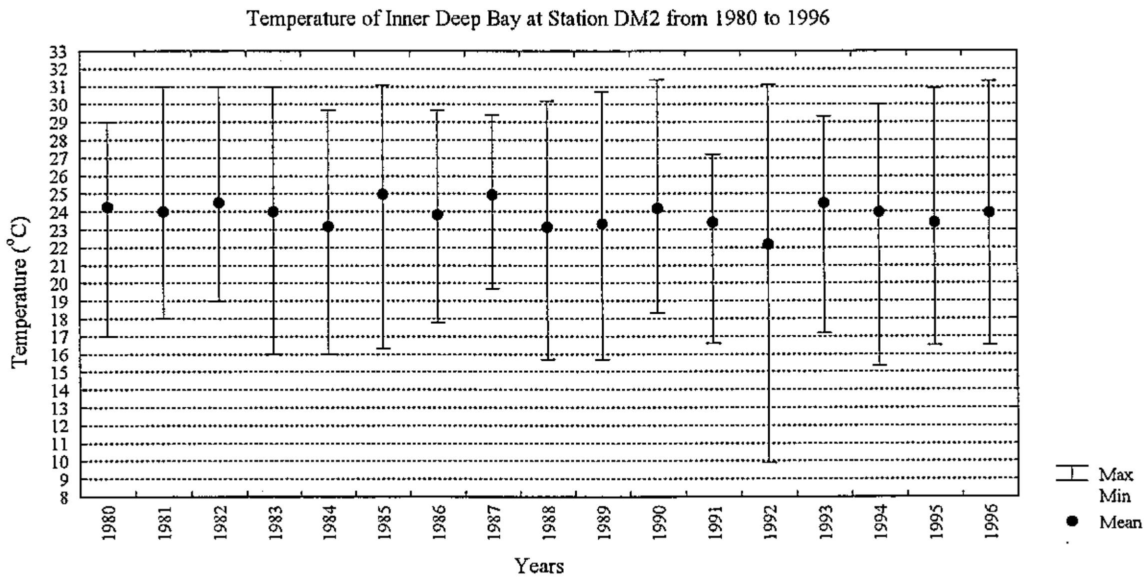


Figure D1.4 Annual Average of Temperature of Inner Deep Bay at Stations DM1, DM2 & DM3 from 1986 to 1996





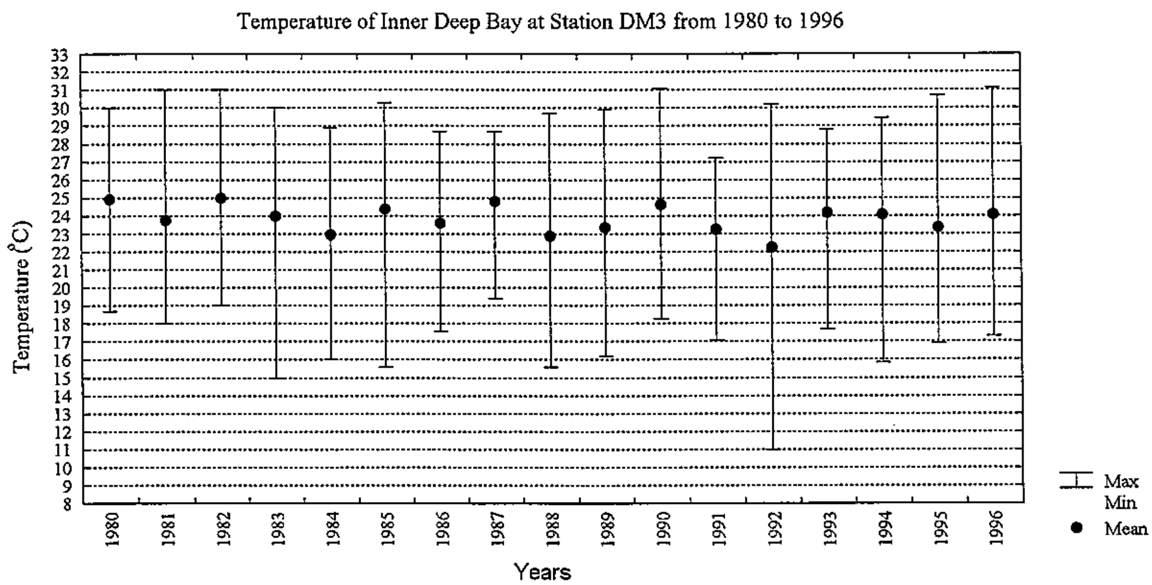
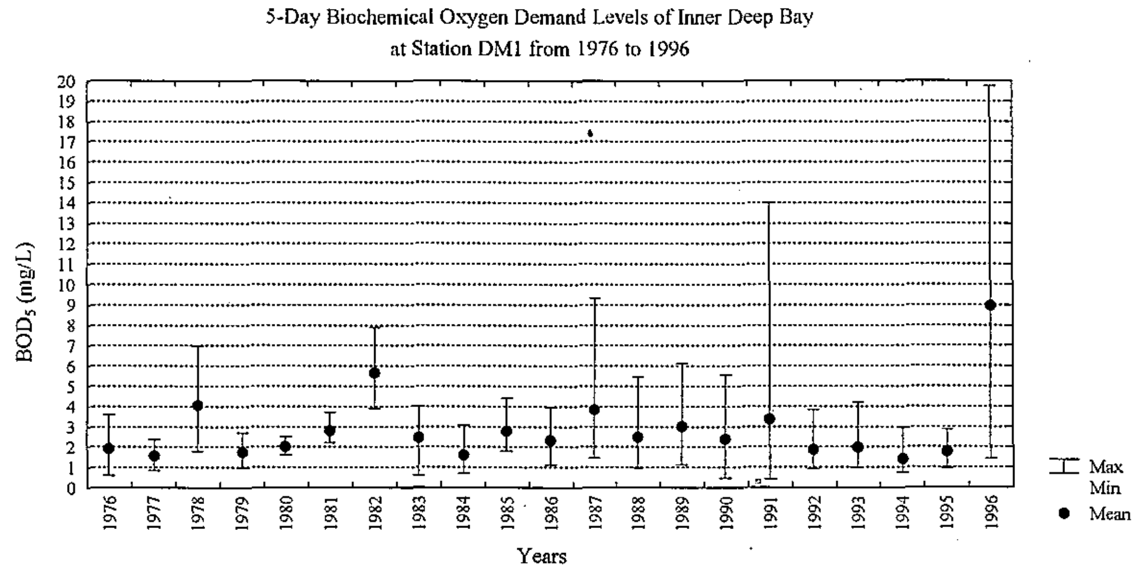
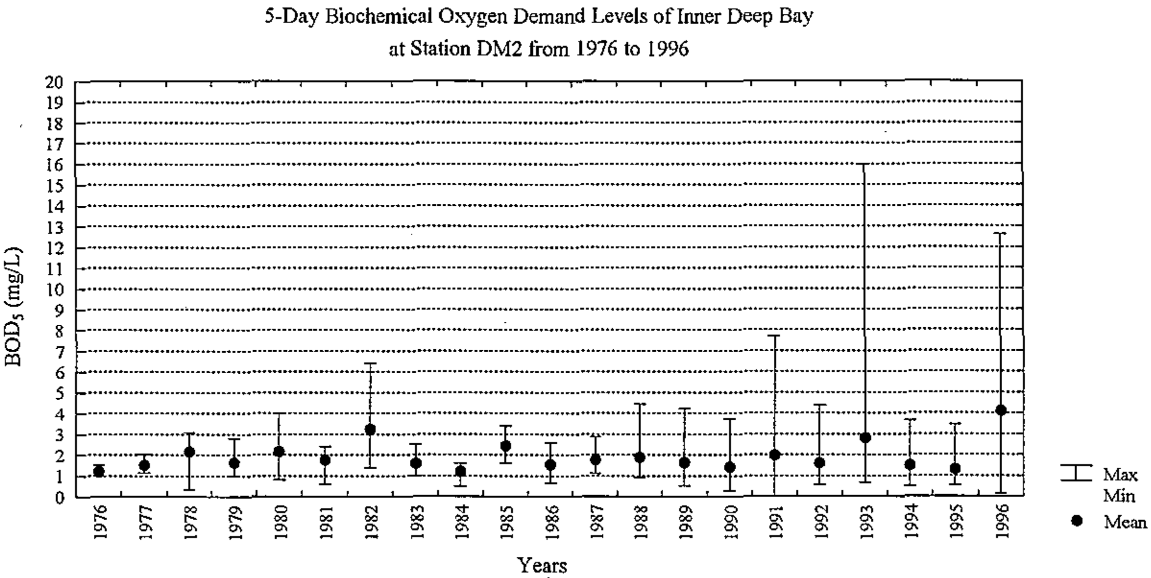


Figure D1.5 Annual Average of 5-Day Biochemical Oxygen Demand Levels of Inner Deep Bay at Stations DM1, DM2 & DM3 from 1986 to 1996





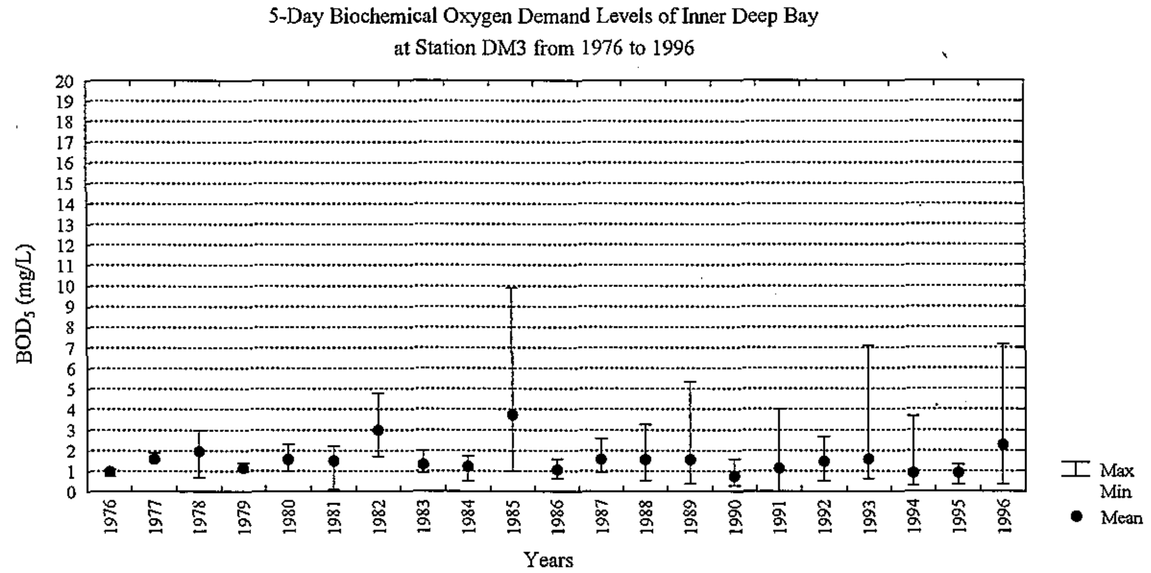
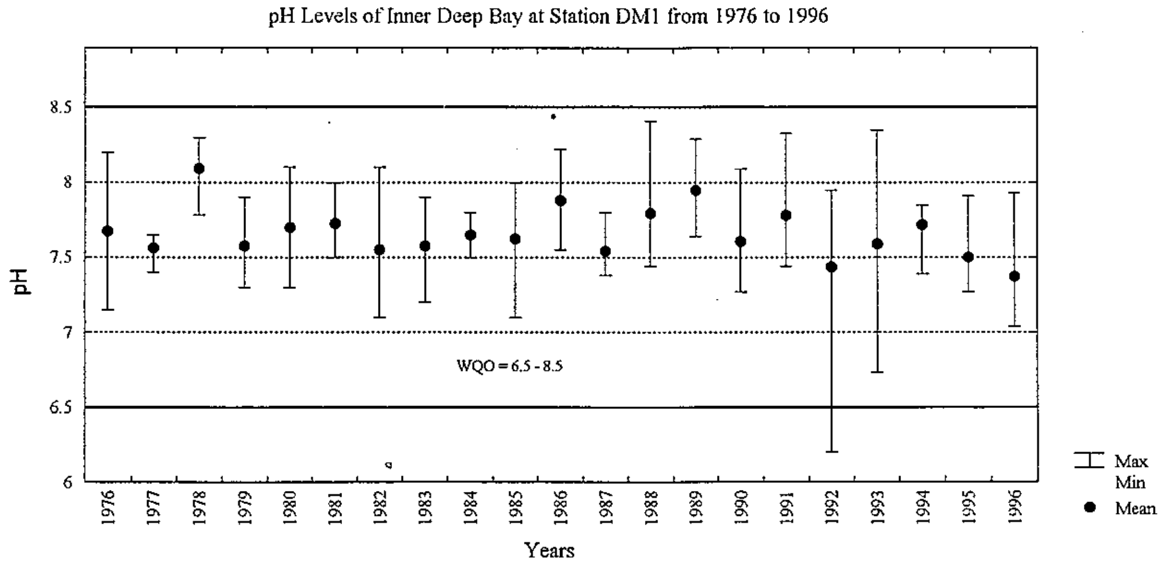
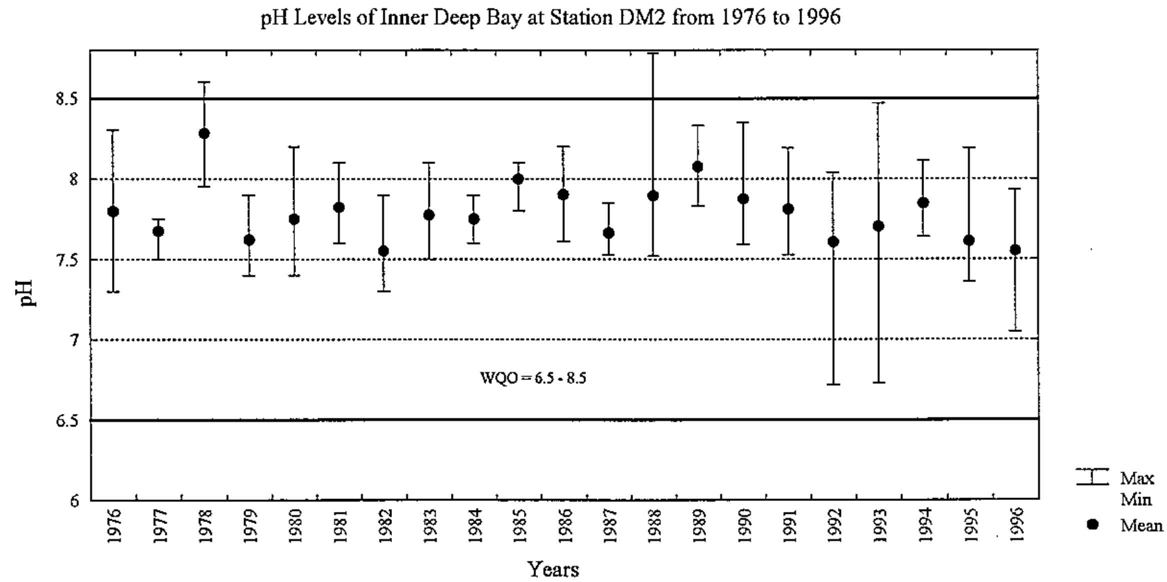


Figure D1.6 Annual Average of pH Levels of Inner Deep Bay at Stations DM1, DM2 & DM3 from 1986 to 1996





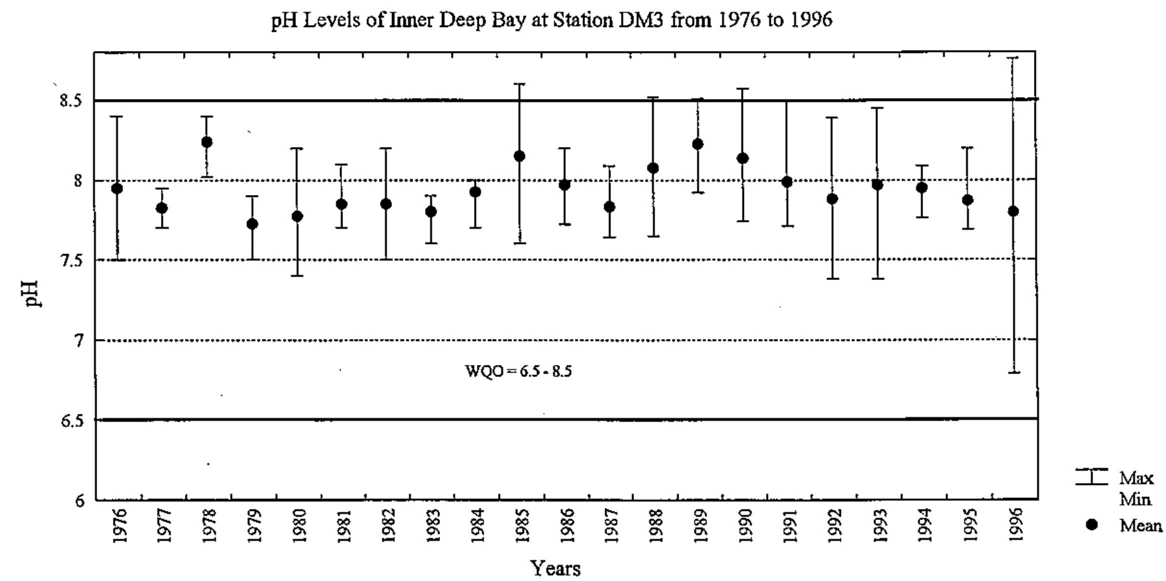
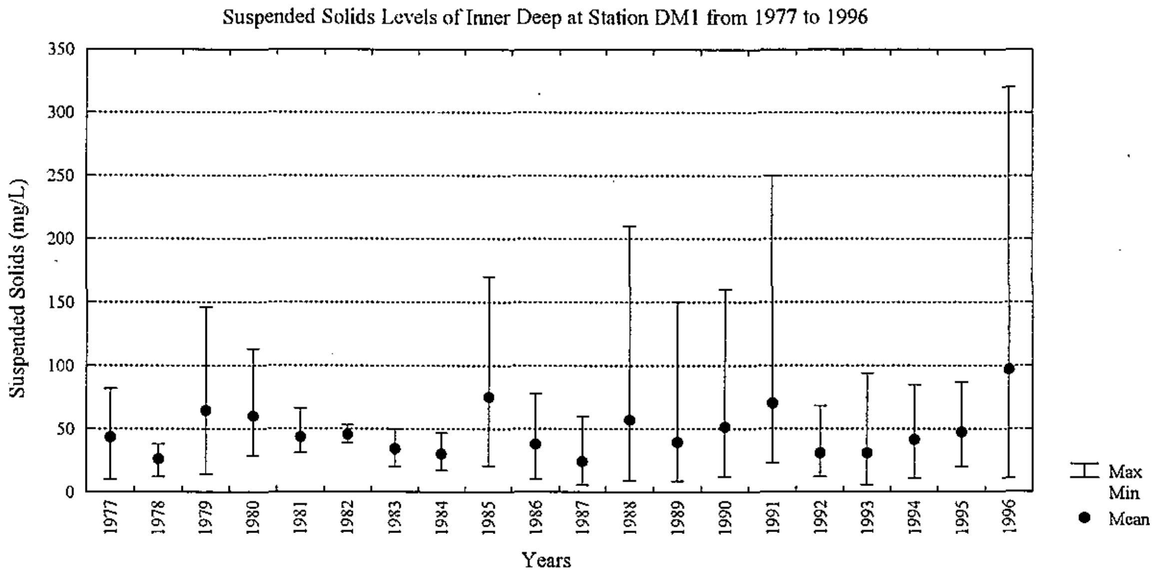
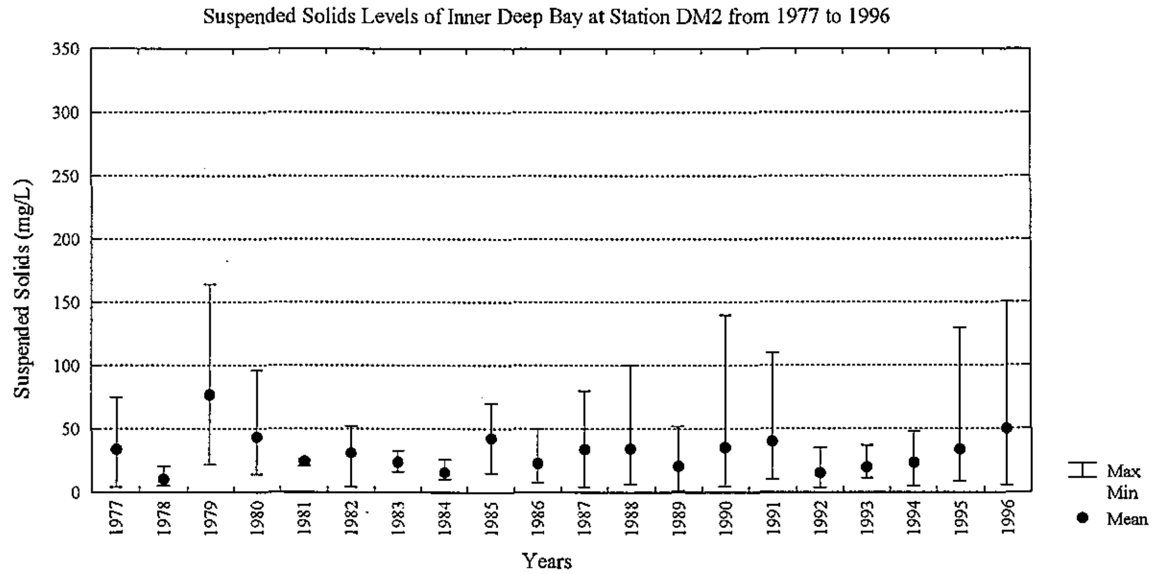


Figure D1.7 Annual Average of Suspended Solids Levels of Inner Deep Bay at Stations DM1, DM2 & DM3 from 1986 to 1996





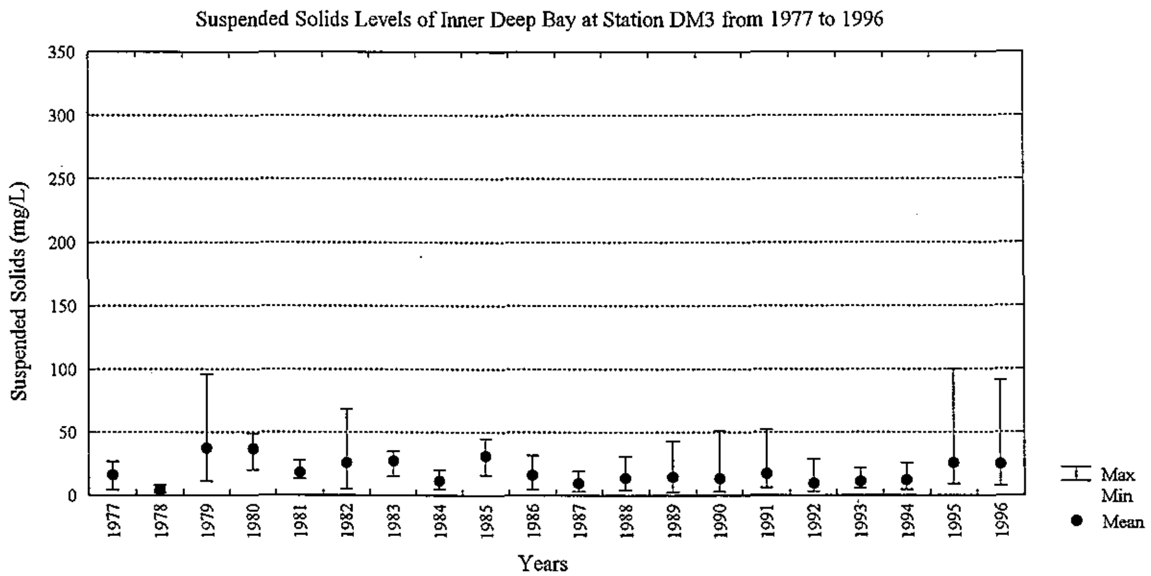
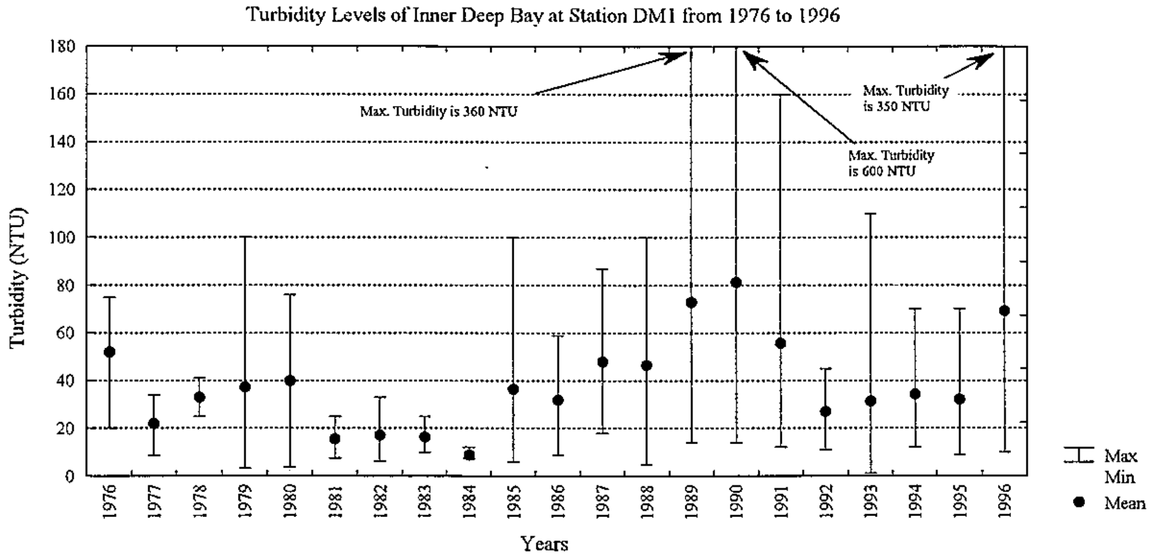
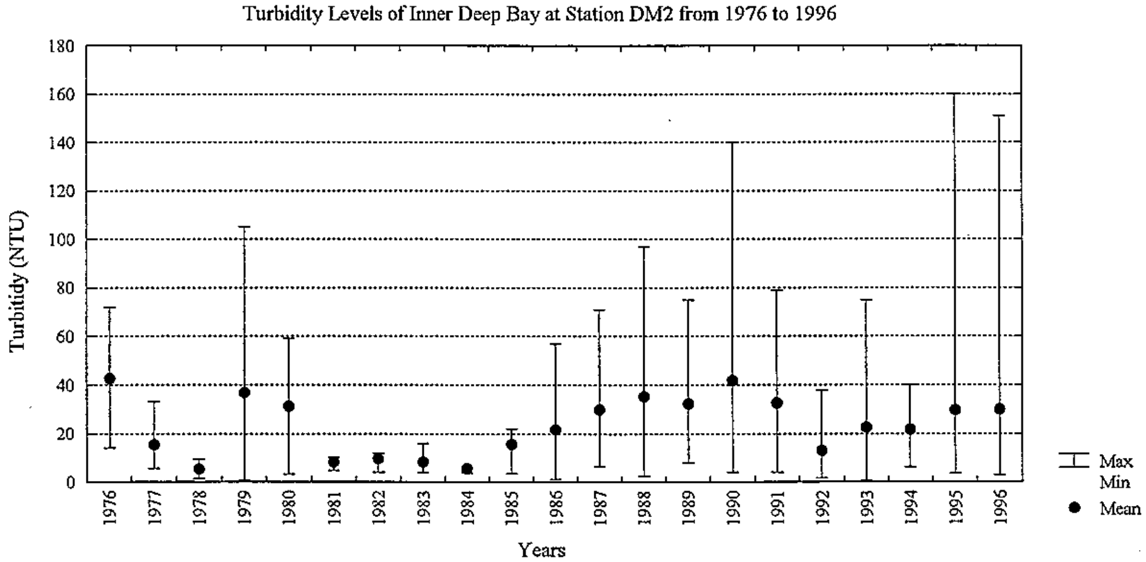


Figure D1.8 Annual Average of Turbidity Levels of Inner Deep Bay at Stations DM1, DM2 & DM3 from 1986 to 1996





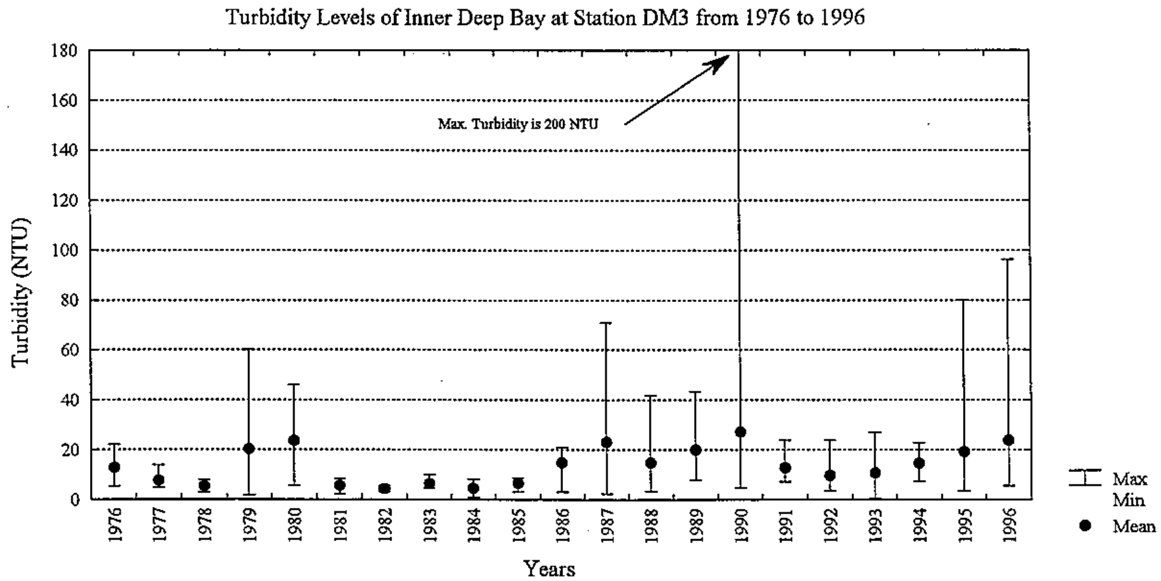
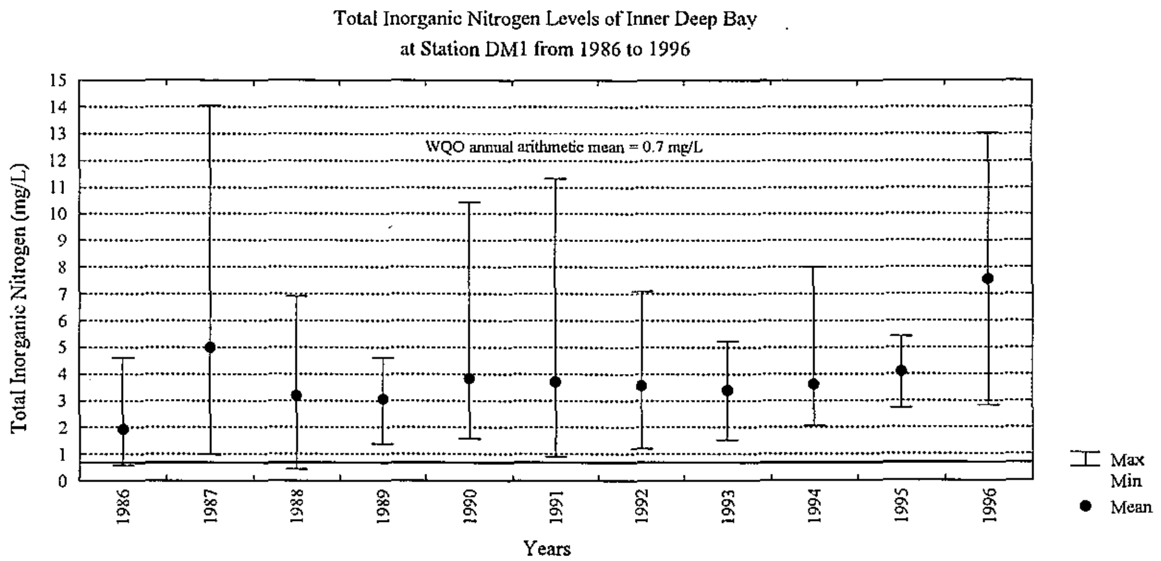
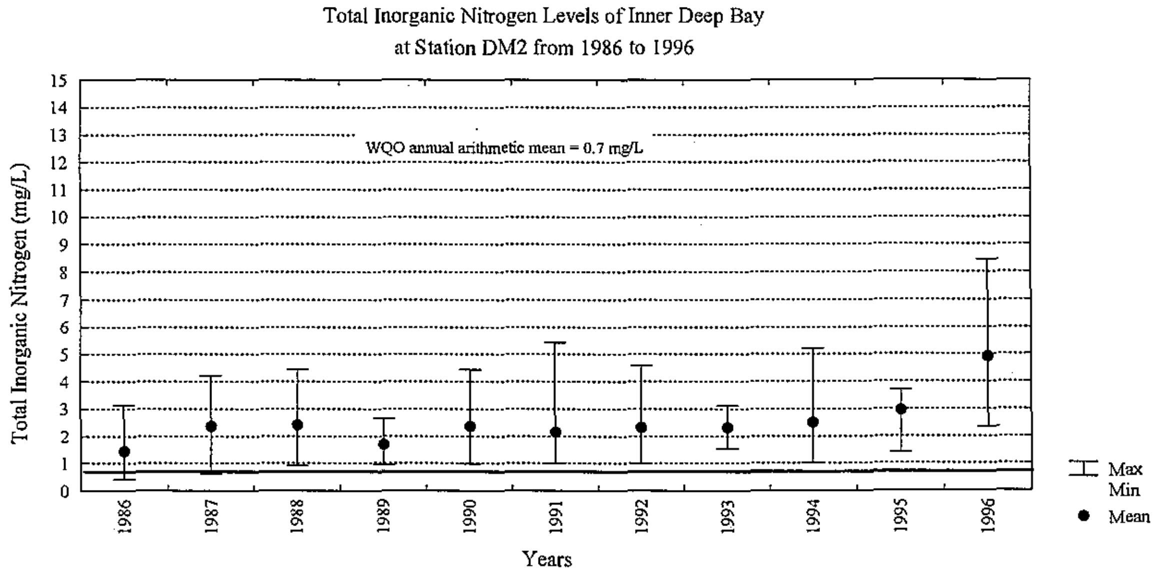


Figure D1.9 Annual Average of Total Inorganic Nitrogen Levels of Inner Deep Bay at Stations DM1, DM2 & DM3 from 1986 to 1996





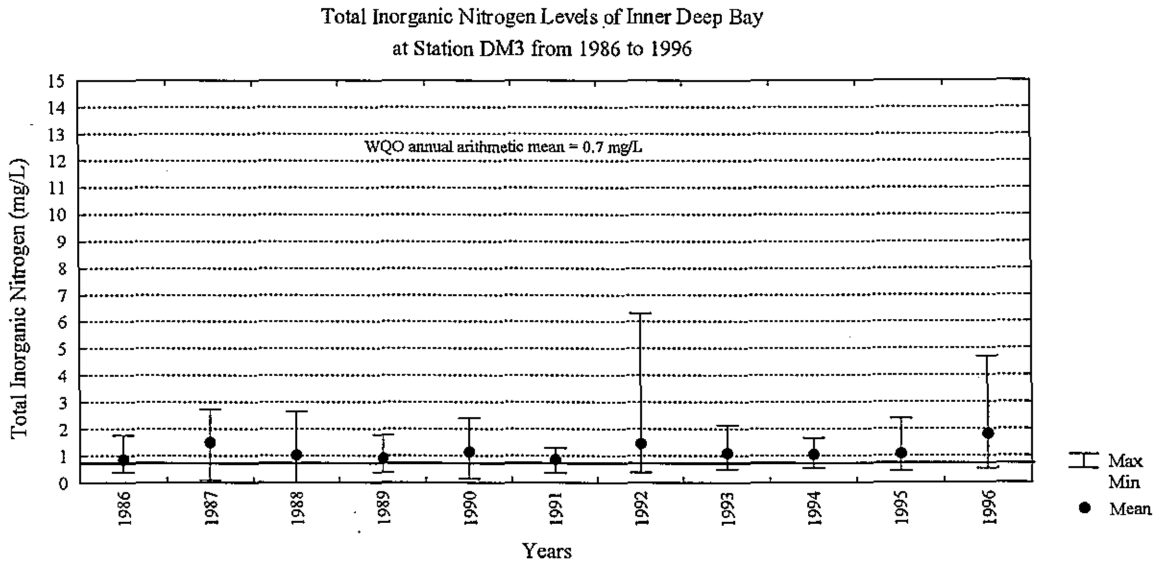
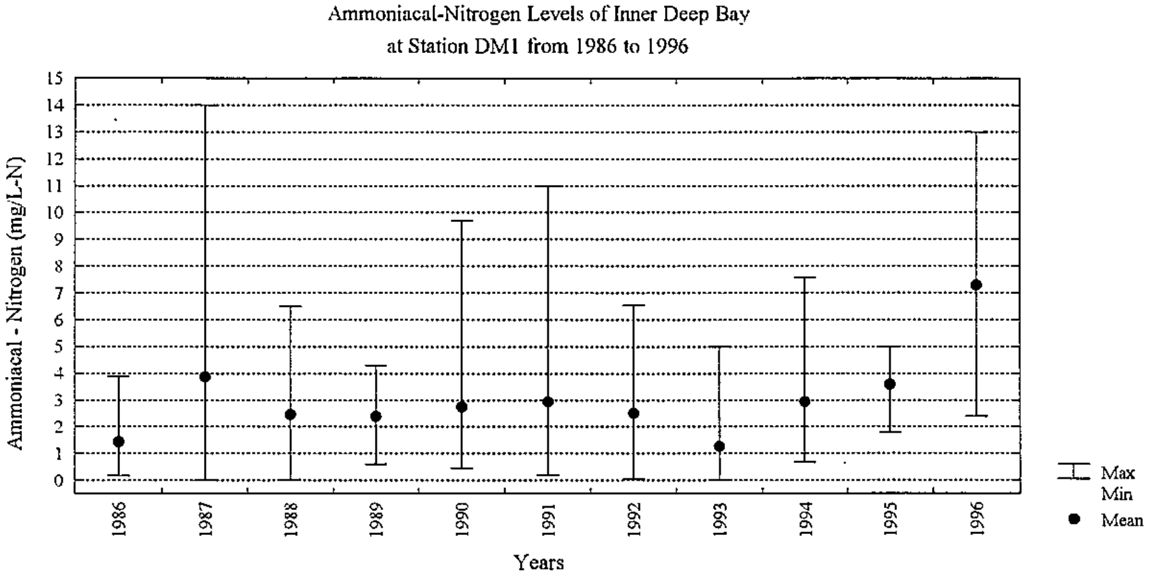
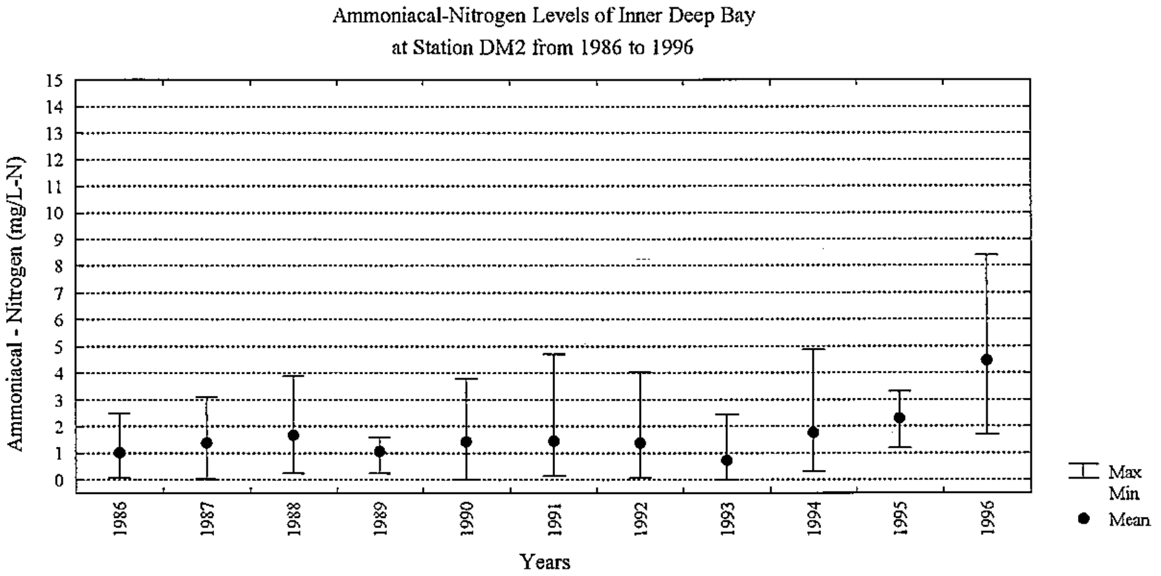


Figure D1.10 Annual Average of Ammoniacal-Nitrogen Levels of Inner Deep Bay at Stations DM1, DM2 & DM3 from 1986 to 1996





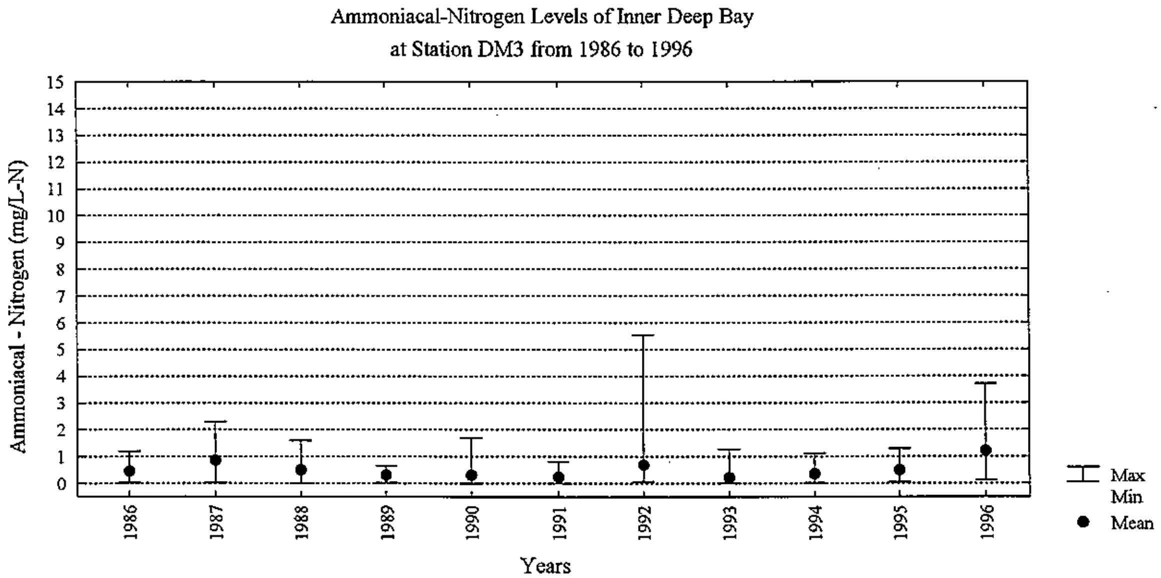
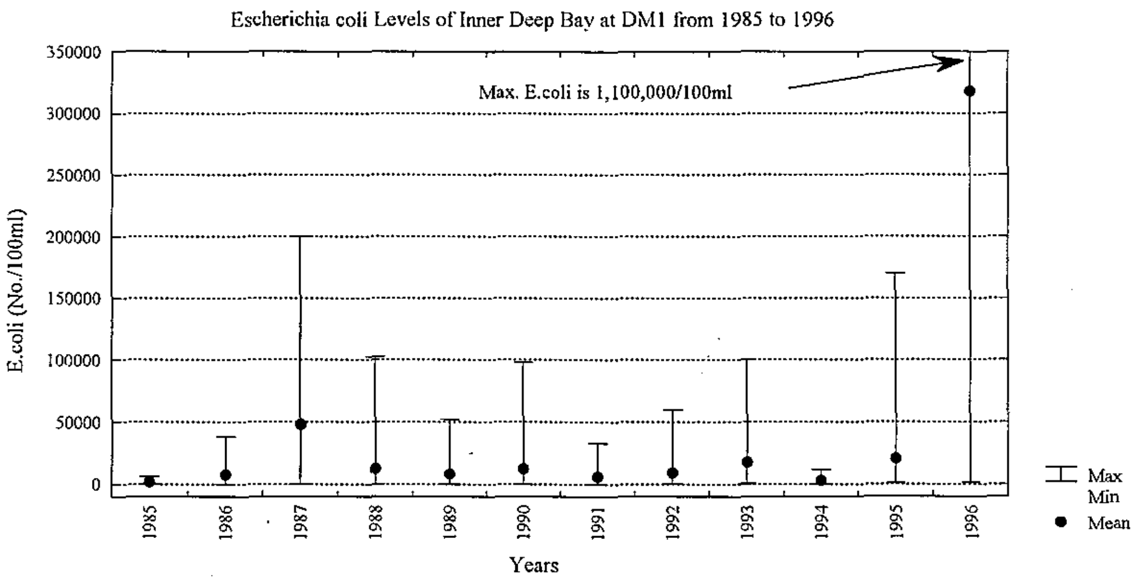
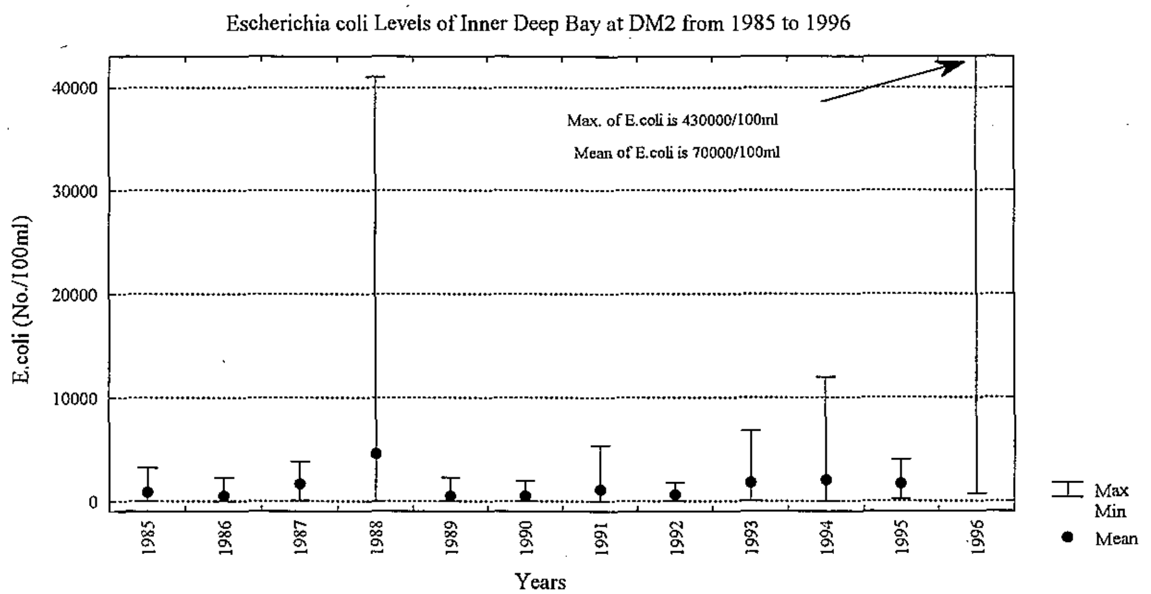


Figure D1.11 Annual Average of *Escherichia coli* Levels of Inner Deep Bay at Stations DM1, DM2 & DM3 from 1986 to 1996





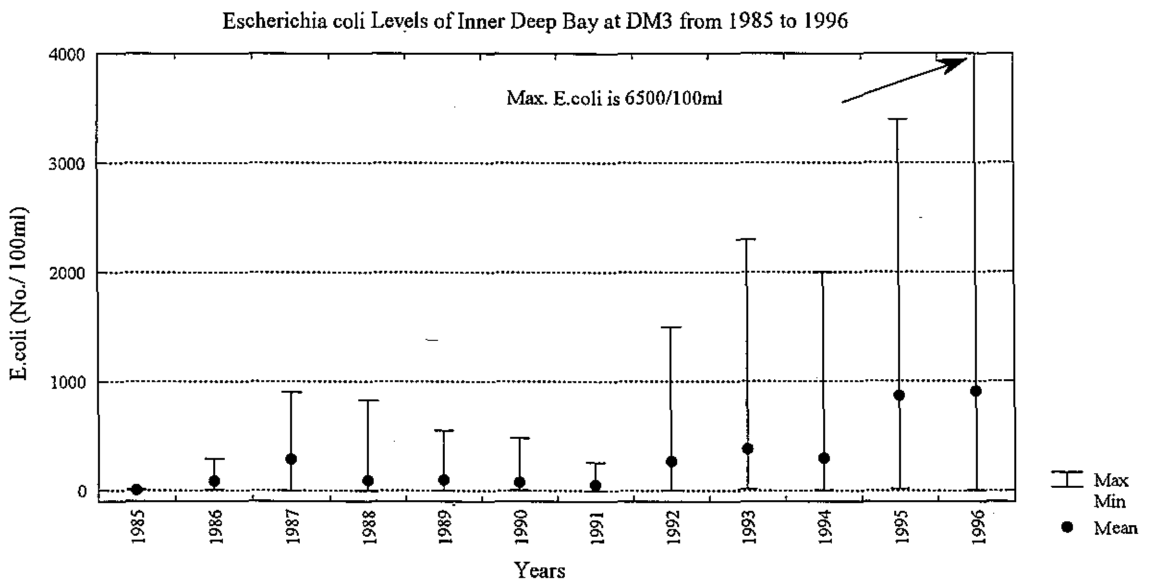
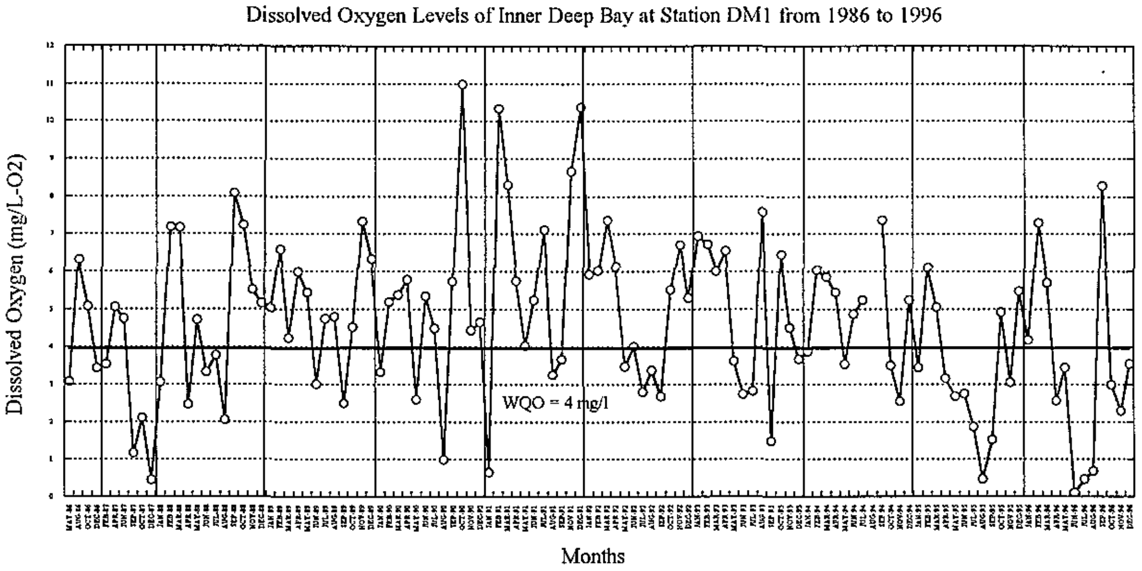
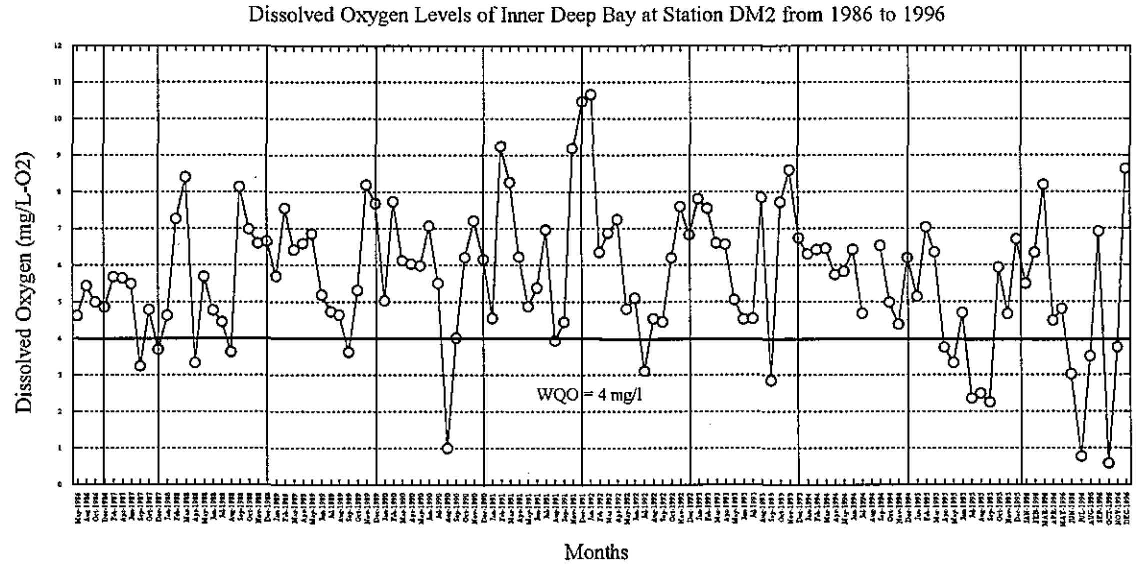


Figure D1.12 Monthly Plots of Dissolved Oxygen Levels of Inner Deep Bay at Stations DM1, DM2 & DM3 from 1986 to 1996





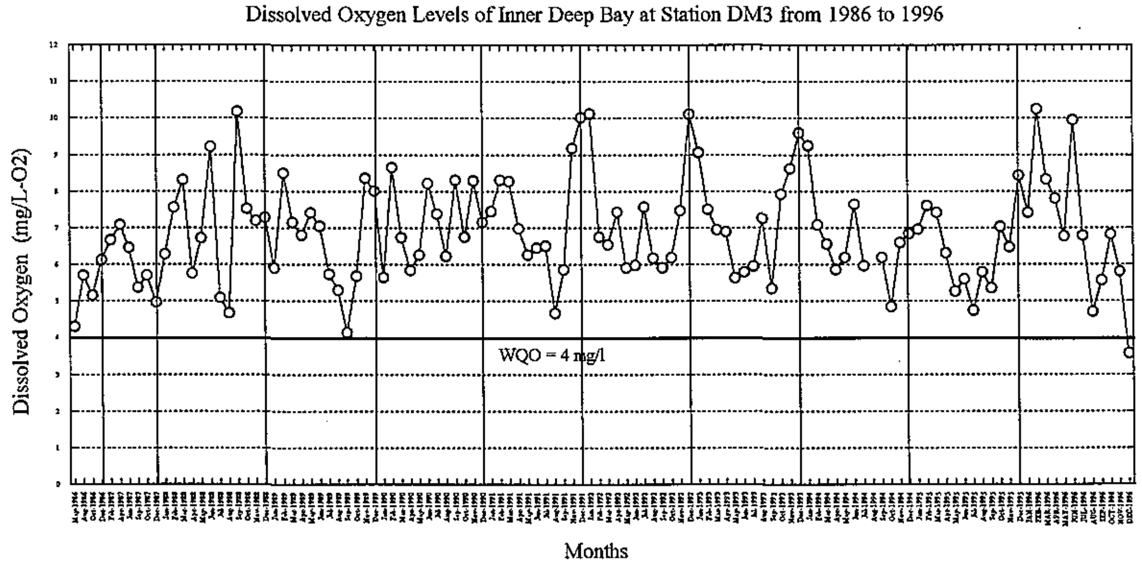
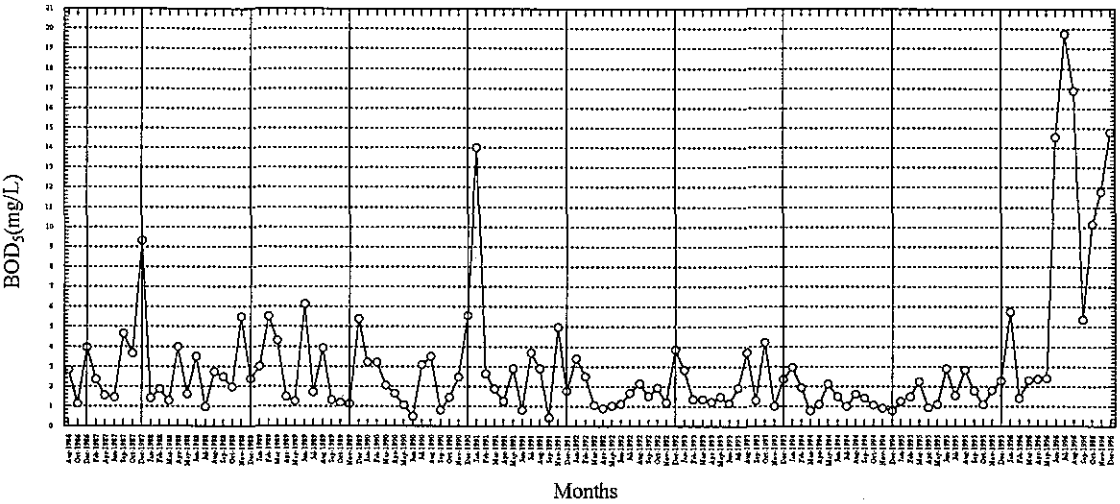
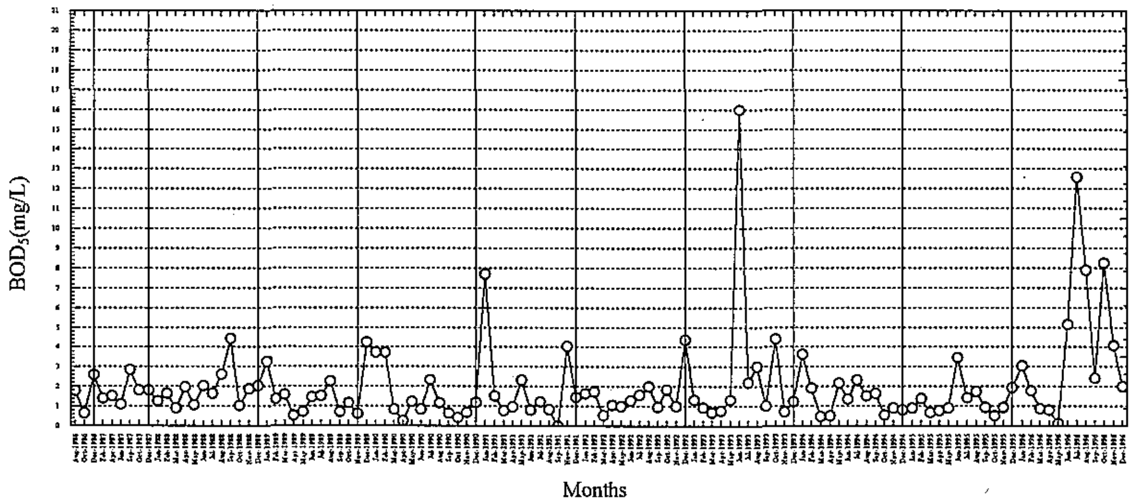


Figure D1.13 Monthly Plots of 5-Day Biochemical Oxygen Demand Levels of Inner Deep Bay at Stations DM1, DM2 & DM3 from 1986 to 1996

5-Day Biochemical Oxygen Demand Levels of Inner Deep Bay
at Station DM1 from 1986 to 1996



5-Day Biochemical Oxygen Demand Levels of Inner Deep Bay
at Station DM2 from 1986 to 1996



5-Day Biochemical Oxygen Demand Levels of Inner Deep Bay
at Station DM3 from 1986 to 1996

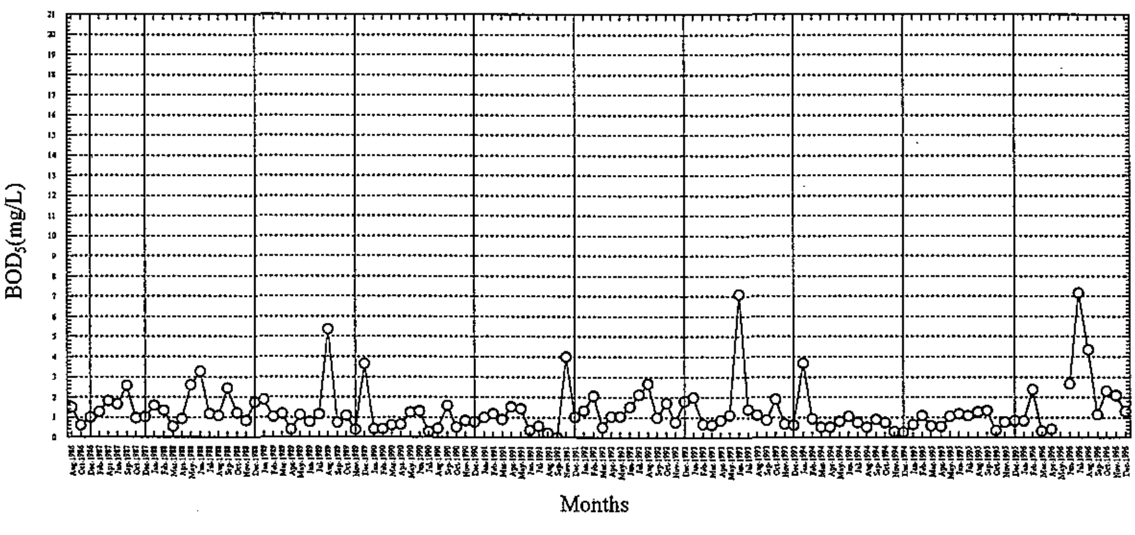
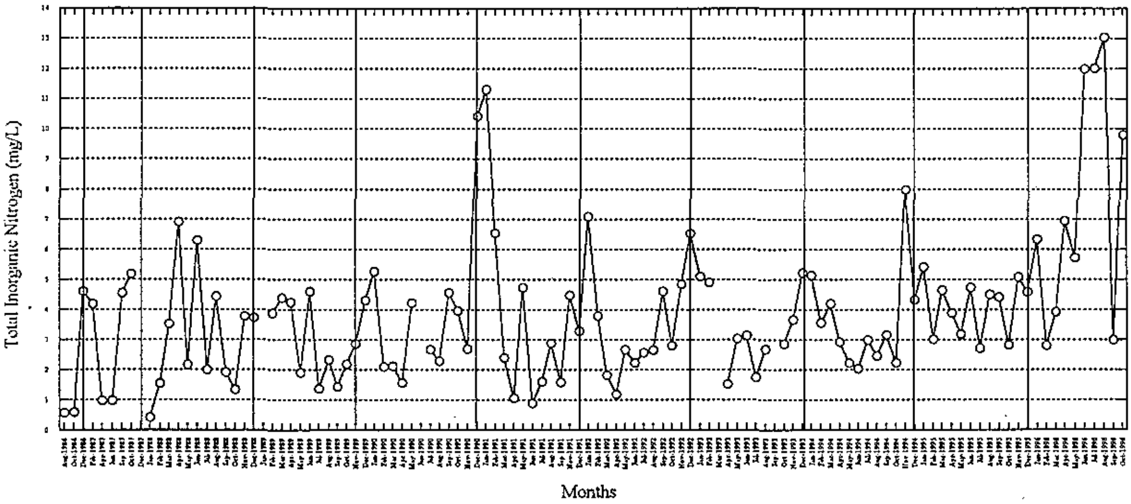
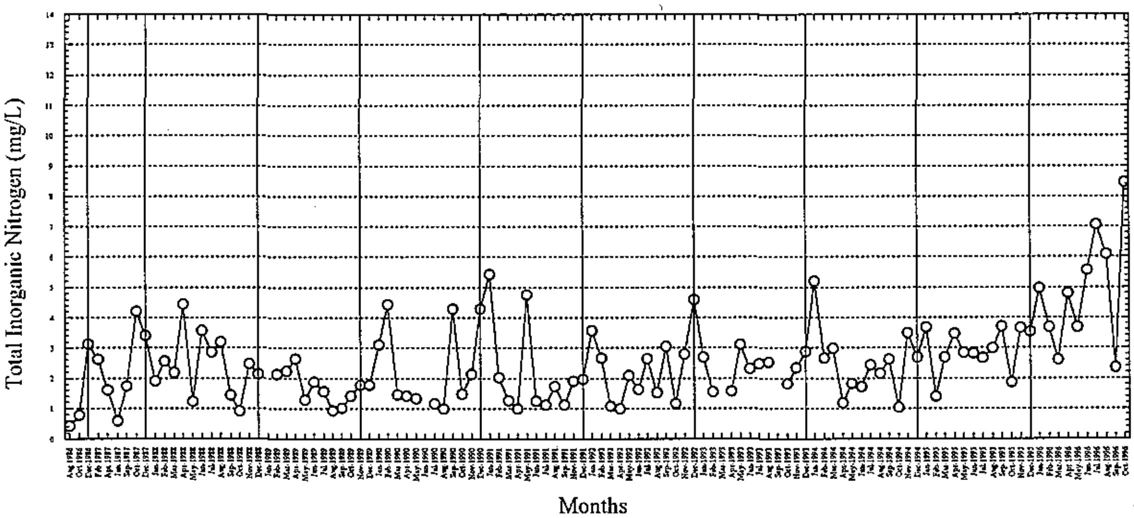


Figure D1.14 Monthly Plots of Total Inorganic Nitrogen Levels of Inner Deep Bay at Stations DM1, DM2 & DM3 from 1986 to 1996

Total Inorganic Nitrogen Levels of Inner Deep Bay at Station DM1 from 1986 to 1996



Total Inorganic Nitrogen Levels of Inner Deep Bay at Station DM2 from 1986 to 1996



Total Inorganic Nitrogen Levels Of Inner Deep Bay at Station DM3 from 1986 to 1996

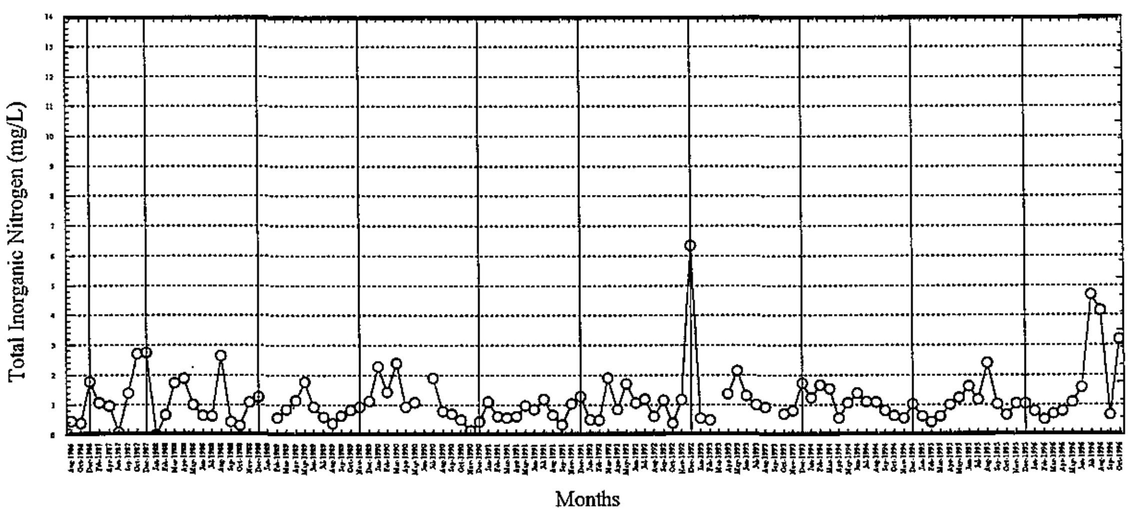
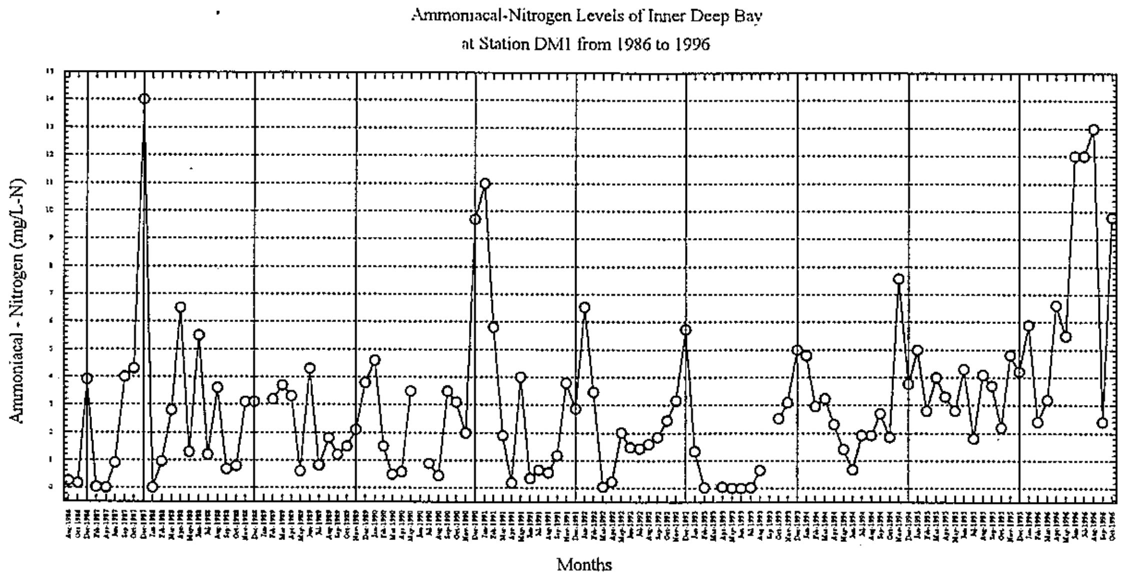
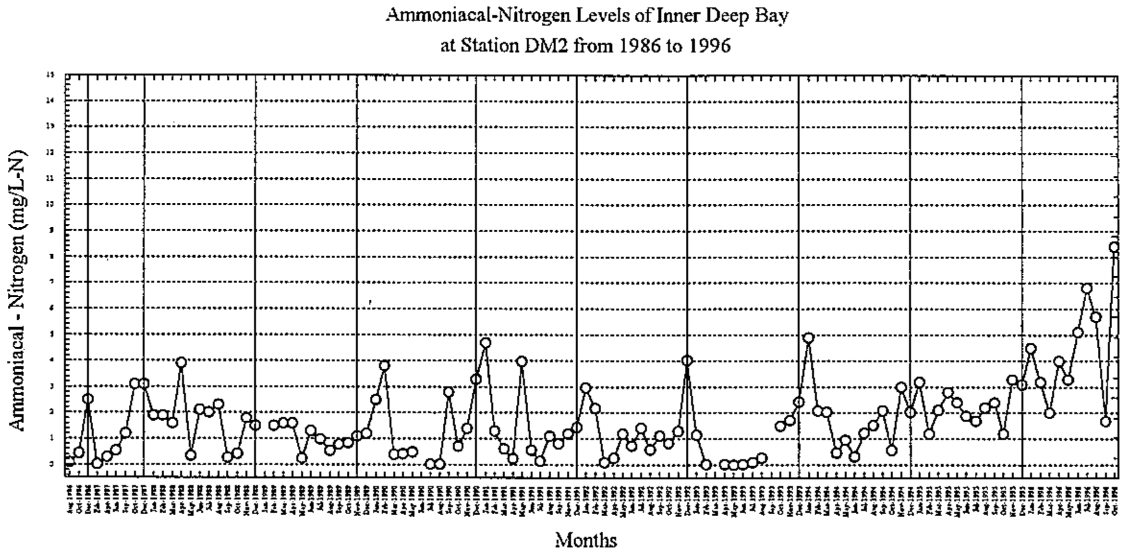


Figure D1.15 Monthly Plots of Ammoniacal-Nitrogen Levels of Inner Deep Bay at Stations DM1, DM2 & DM3 from 1986 to 1996





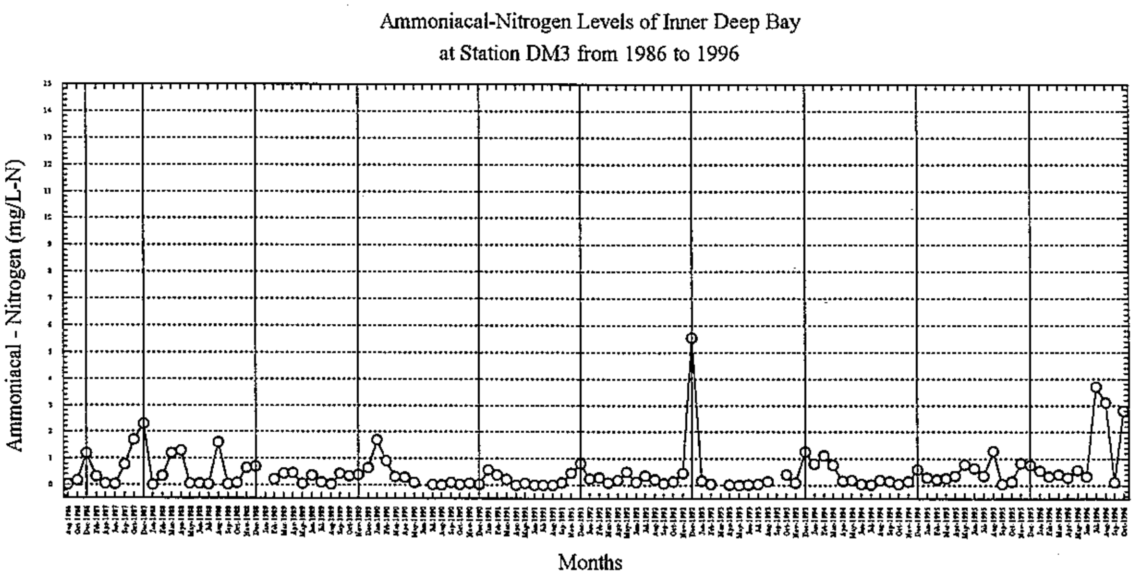
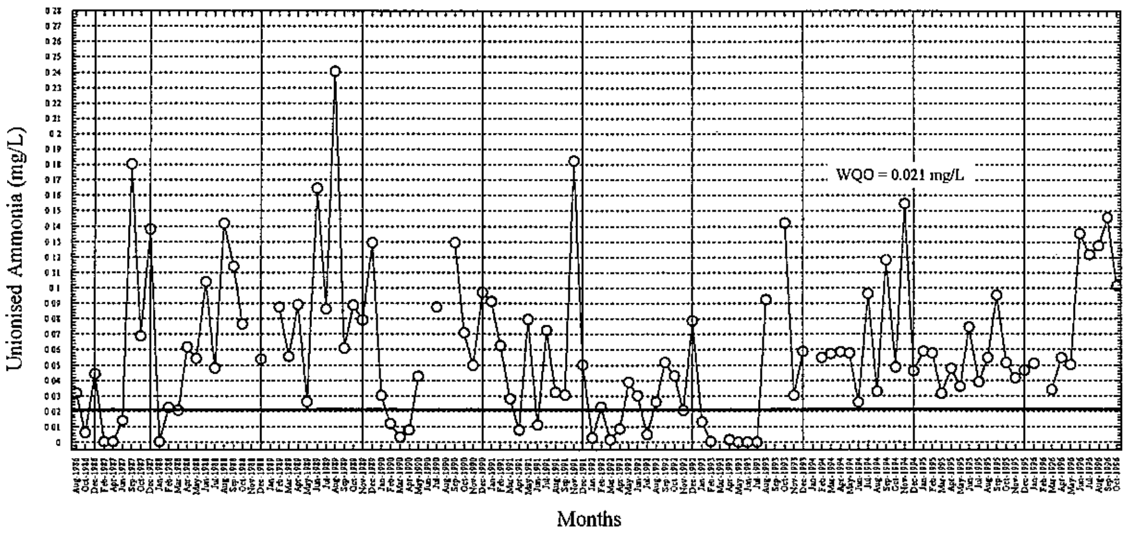
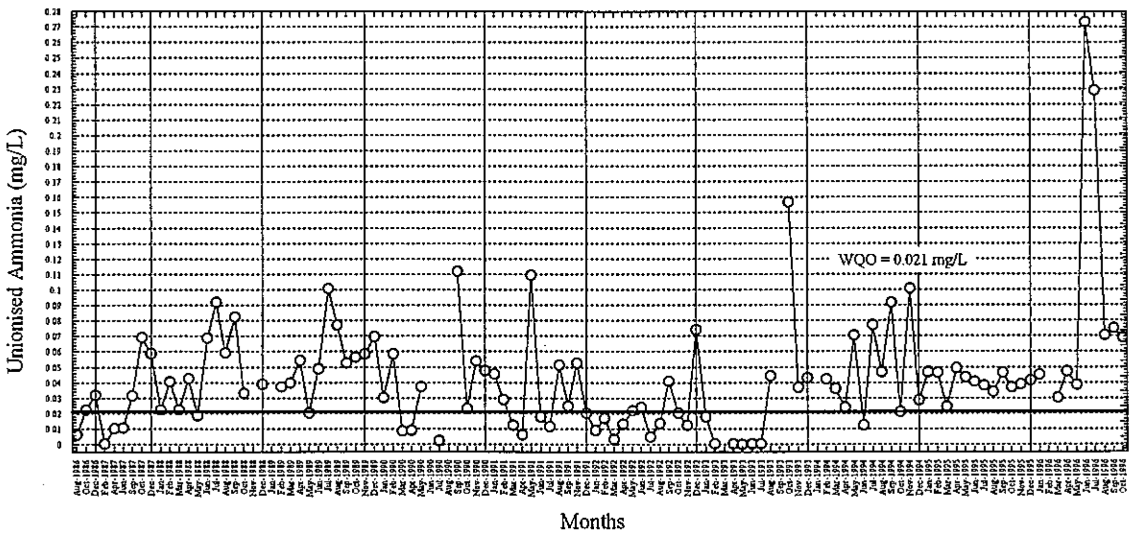


Figure D1.16 Monthly Plots of Unionised Ammonia Levels of Inner Deep Bay at Stations DM1, DM2 & DM3 from 1986 to 1996

Unionised Ammonia of Levels of Inner Deep Bay at Station DM1 from 1986 to 1996



Unionised Ammonia Levels of Inner Deep Bay at Station DM2 from 1986 to 1996



Unionised Ammonia Levels of Inner Deep Bay at Station DM3 from 1986 to 1996

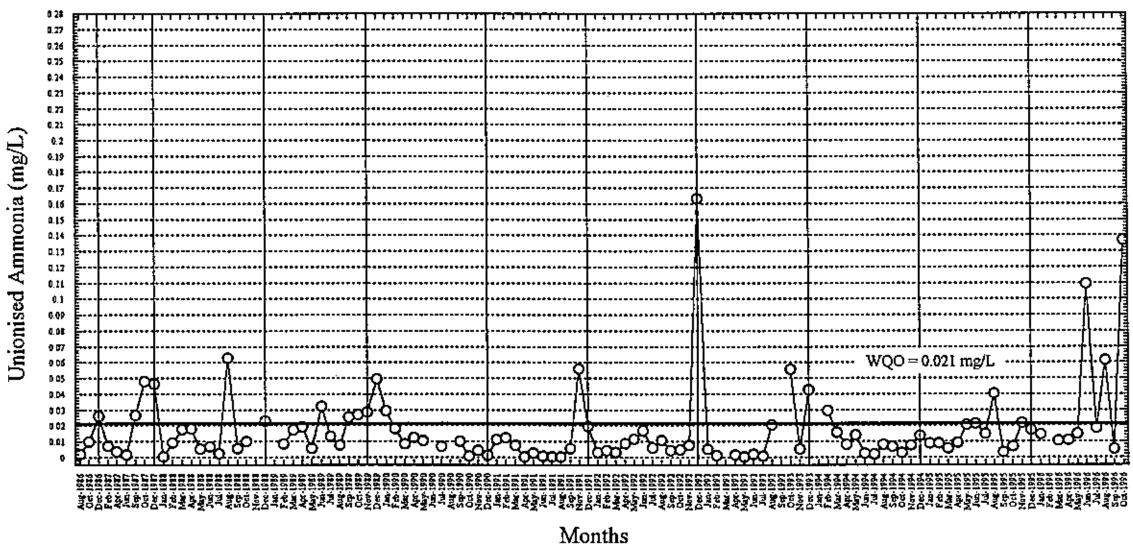
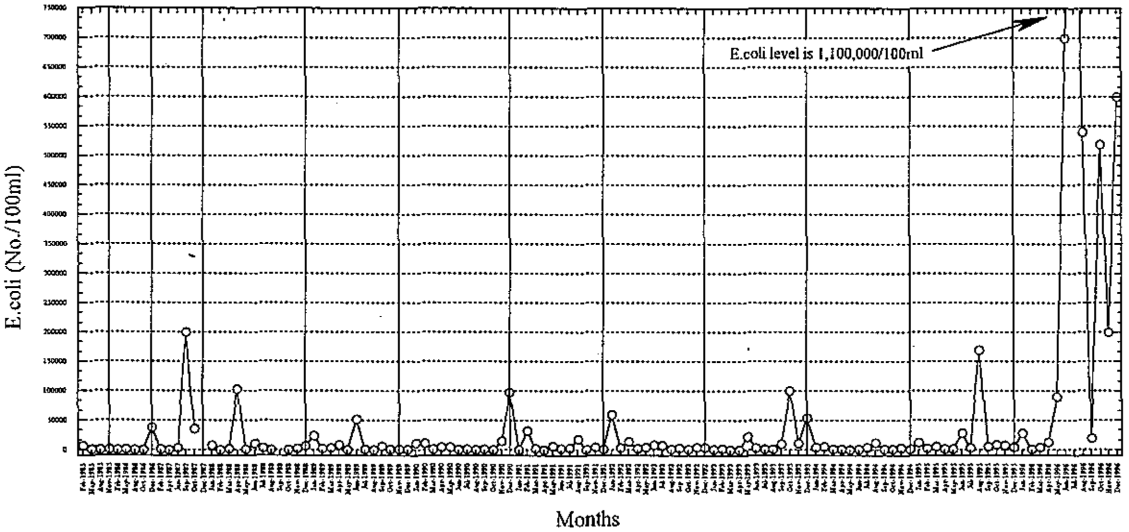
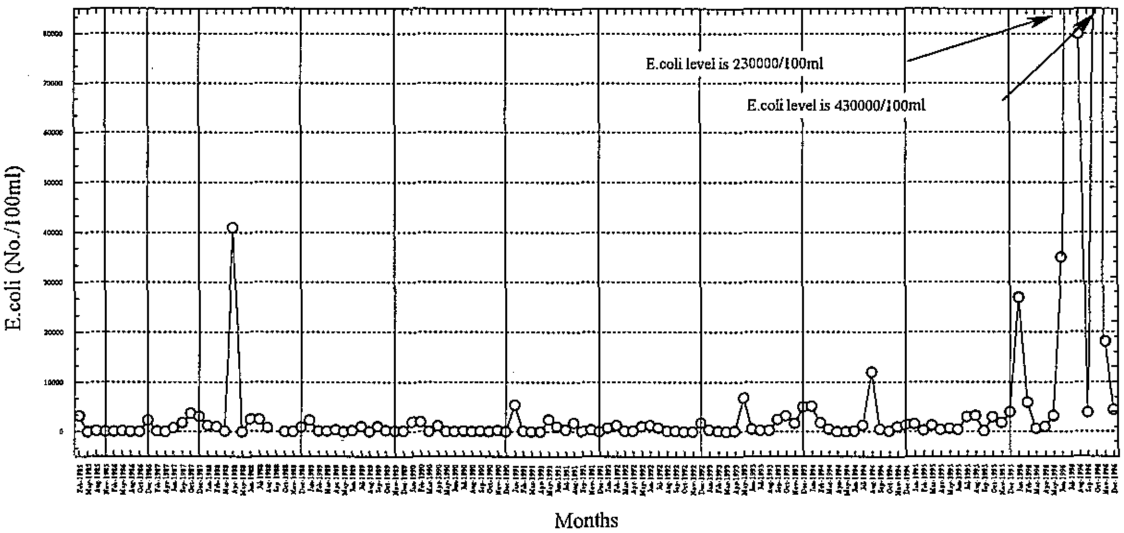


Figure D1.17 Monthly Plots of *Escherichia coli* Levels of Inner Deep Bay at Stations DM1, DM2 & DM3 from 1986 to 1996

Escherichia coli Levels of Inner Deep Bay at DM1 from 1985 to 1996



Escherichia coli Levels of Inner Deep Bay at DM2 from 1985 to 1996



Escherichia coli Levels of Inner Deep Bay at DM3 from 1985 to 1996

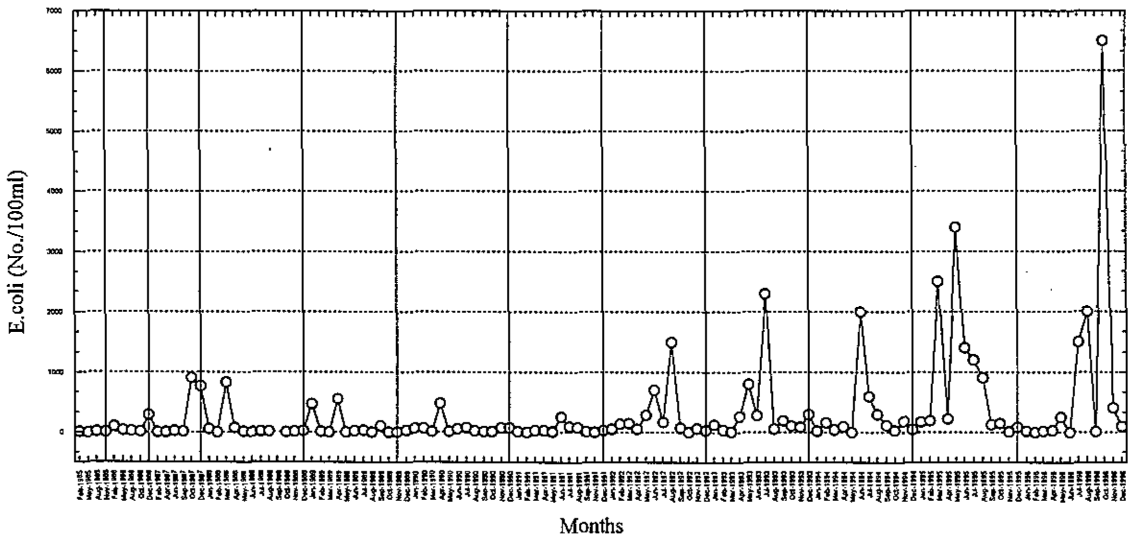


Figure D1.18 Dissolved Oxygen Levels of TSW-Western Channel at Stations TSR1 & TSR2 from 1992 to 1996

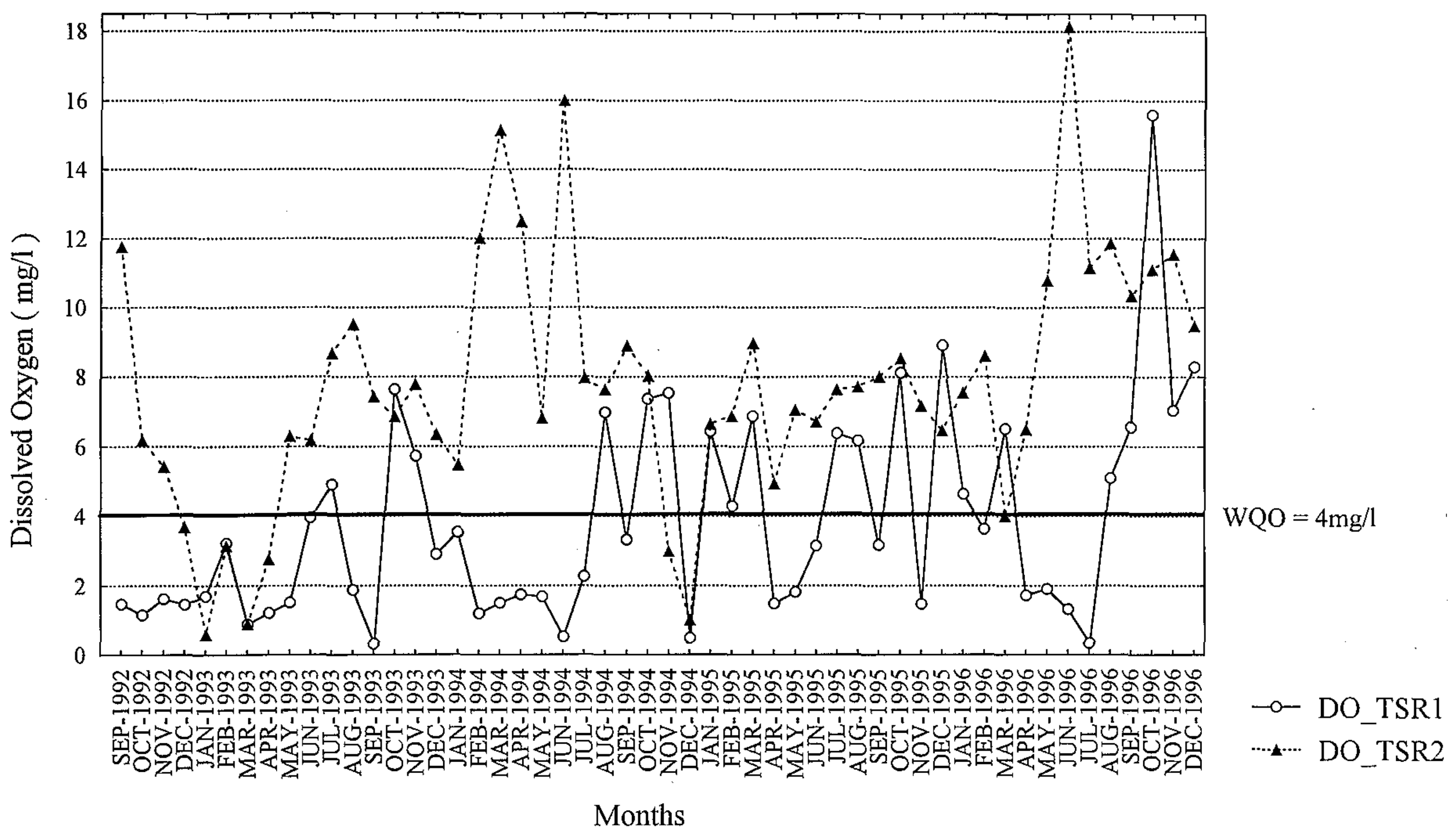


Figure D1.19 Biochemical Oxygen Demand Levels of TSW-Western Channel at Stations TSR1 & TSR2 from 1992 to 1996

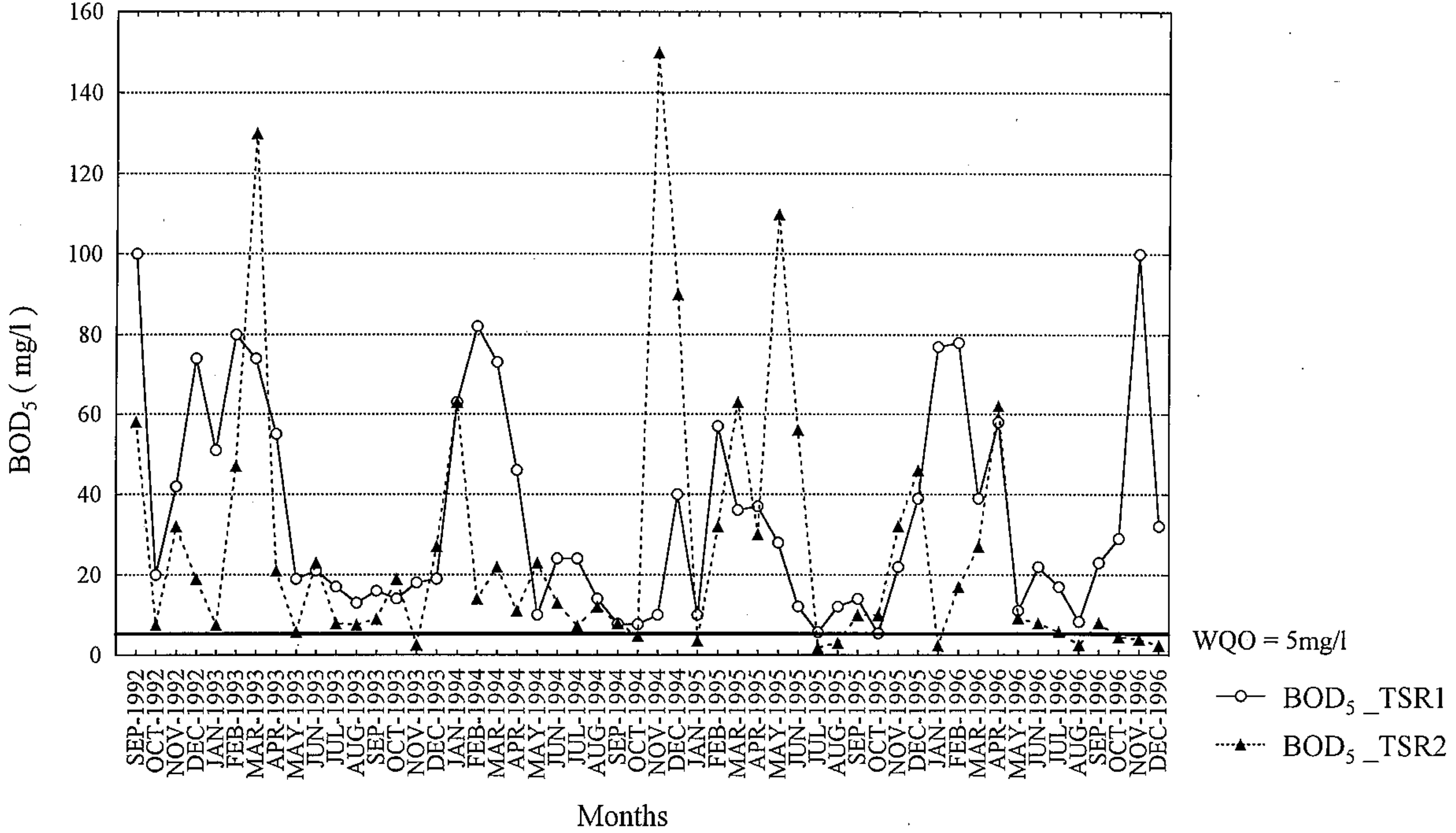


Figure D1.20 Chemical Oxygen Demand Levels of TSW-Western Channel at Stations TSR1 & TSR2 from 1992 to 1996

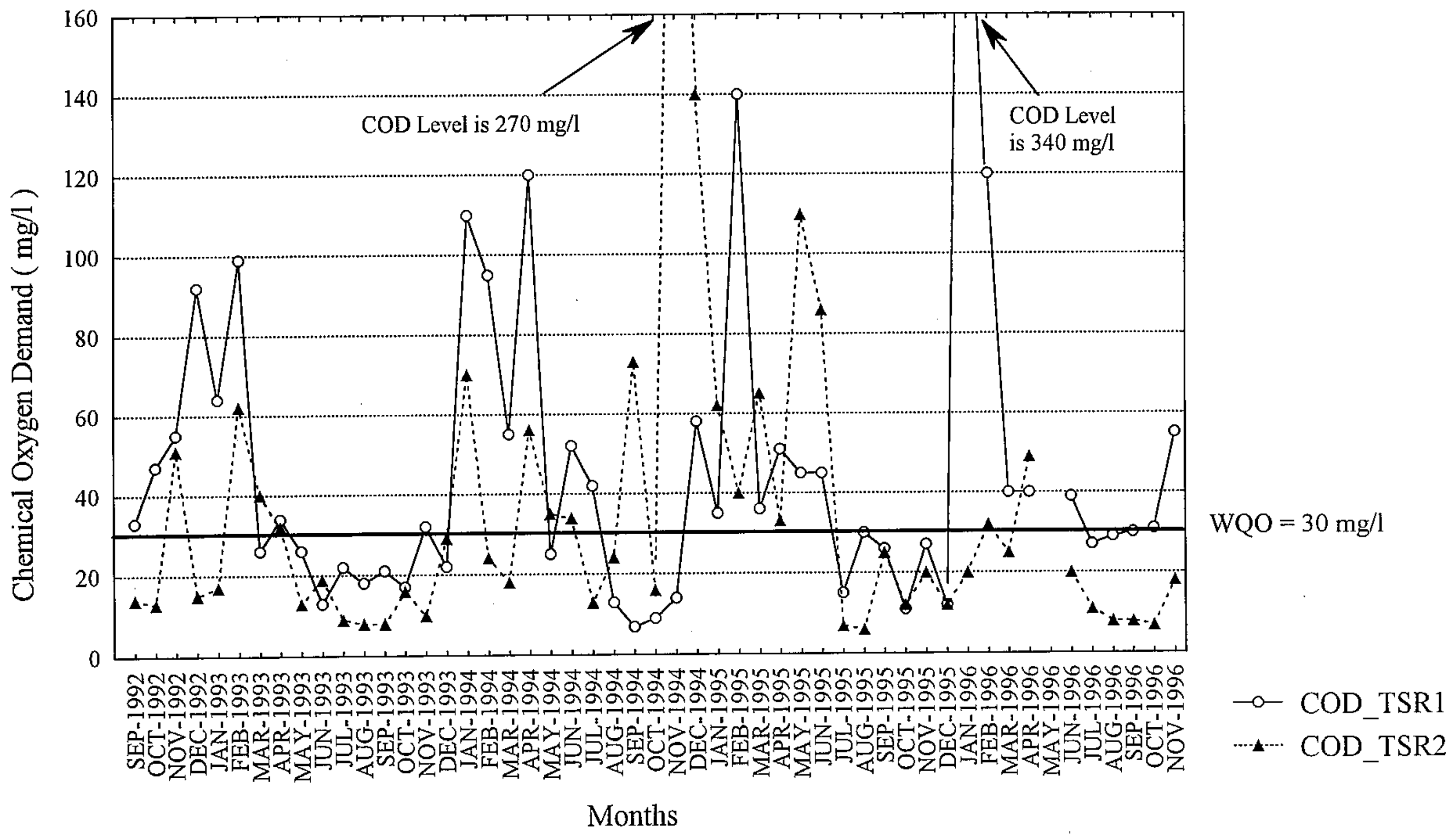


Figure D1.21 pH Levels of TSW-Western Channel at Stations TSR1 & TSR2 from 1992 to 1996

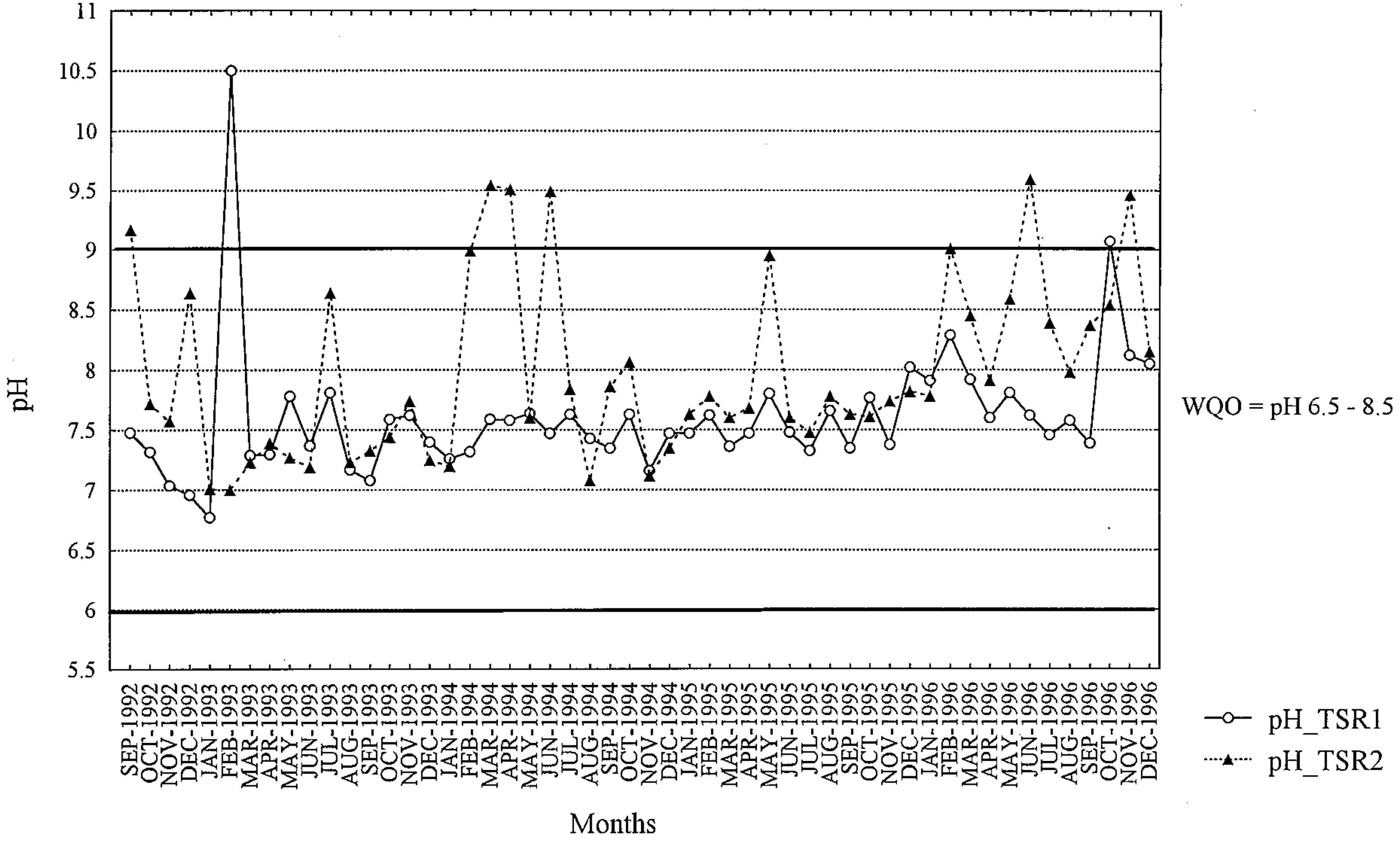


Figure D1.22 Suspended Solids Levels of TSW-Western Channel at Stations TSR1 & TSR2 from 1992 to 1996

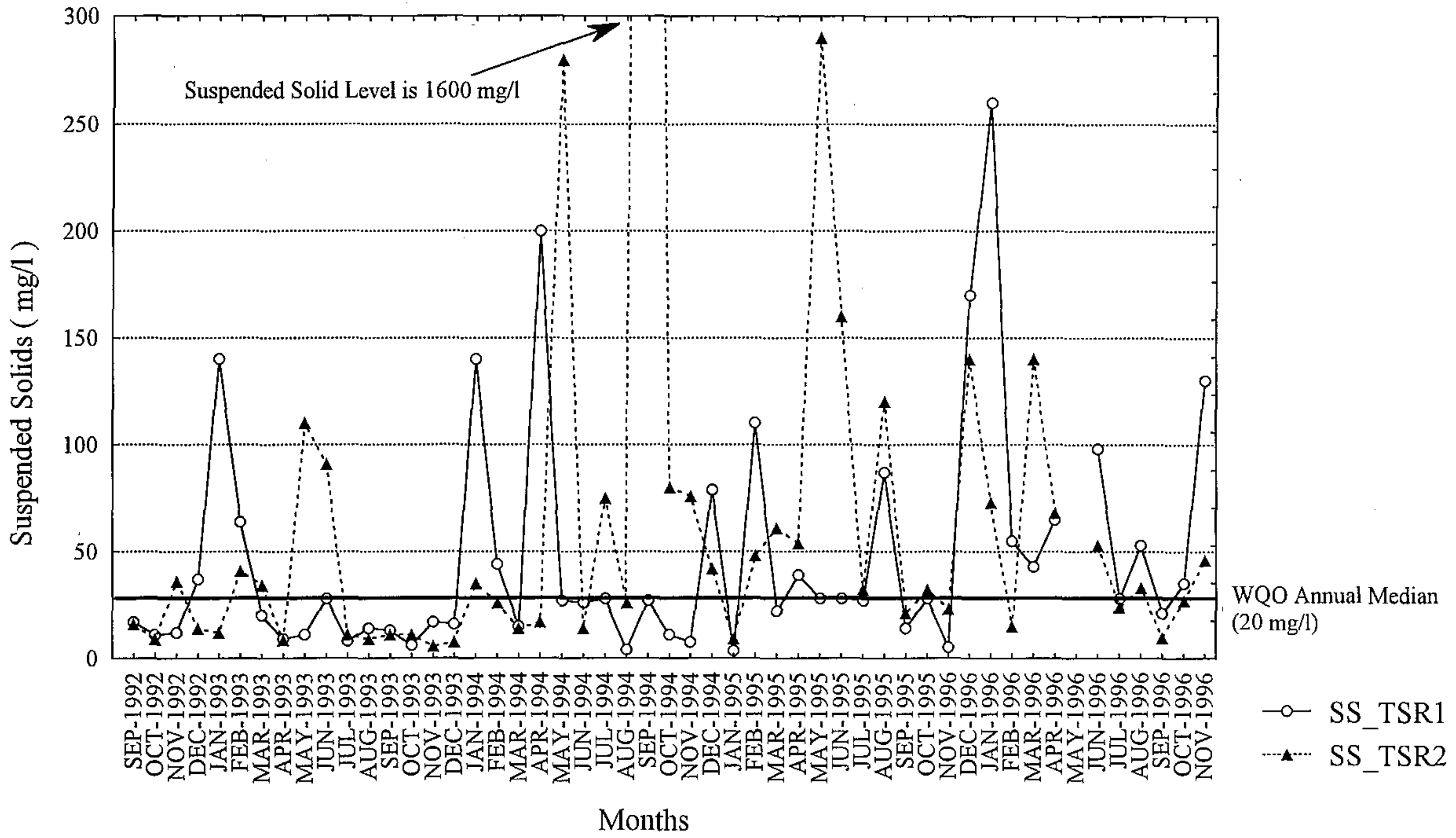


Figure D1.23 Turbidity Levels of TSW-Western Channel at Stations TSR1 & TSR2 from1992 to1996

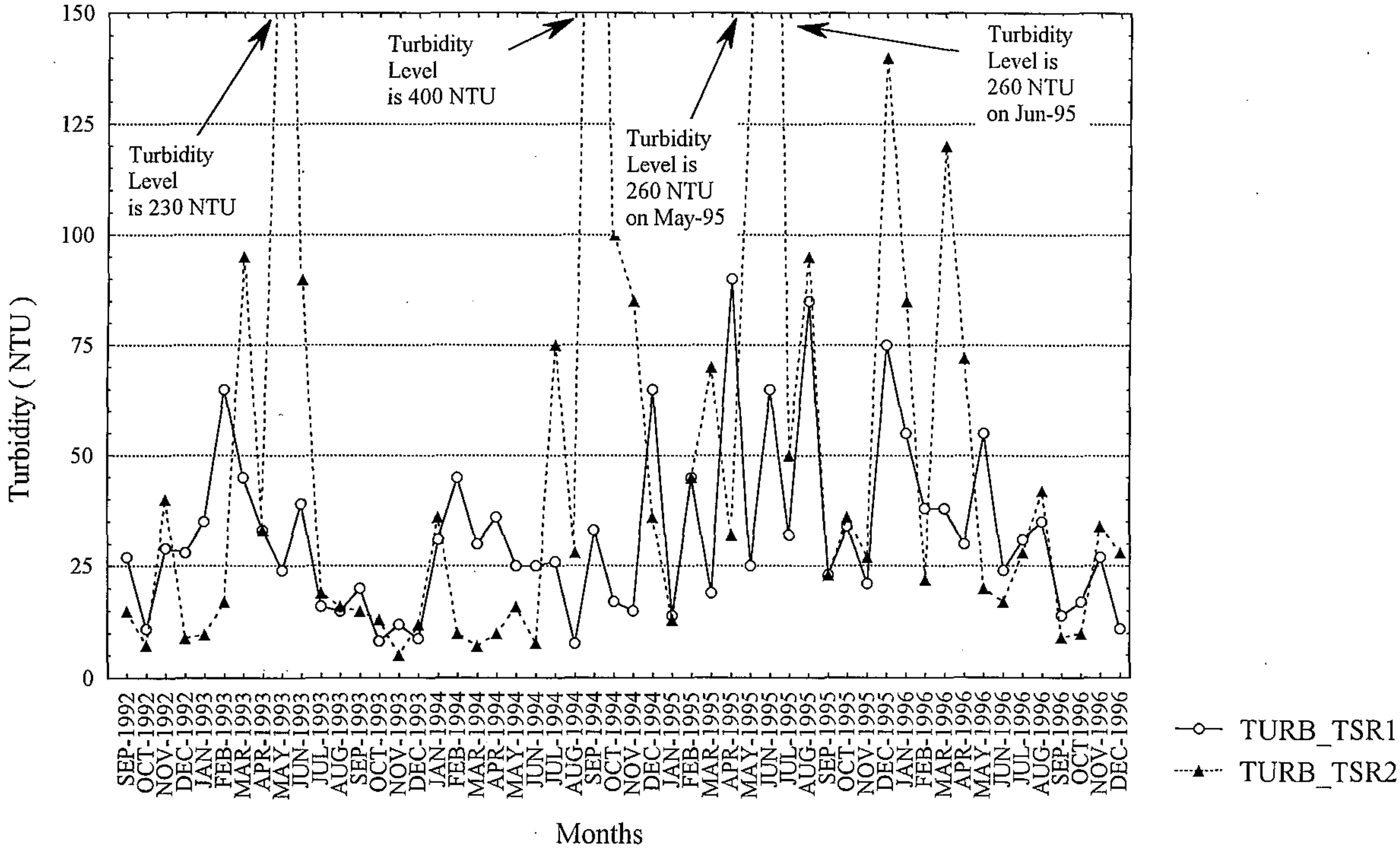


Figure D1.24 Zinc Levels of TSW-Western Channel at Stations TSR1 & TSR2 from 1992 to 1996

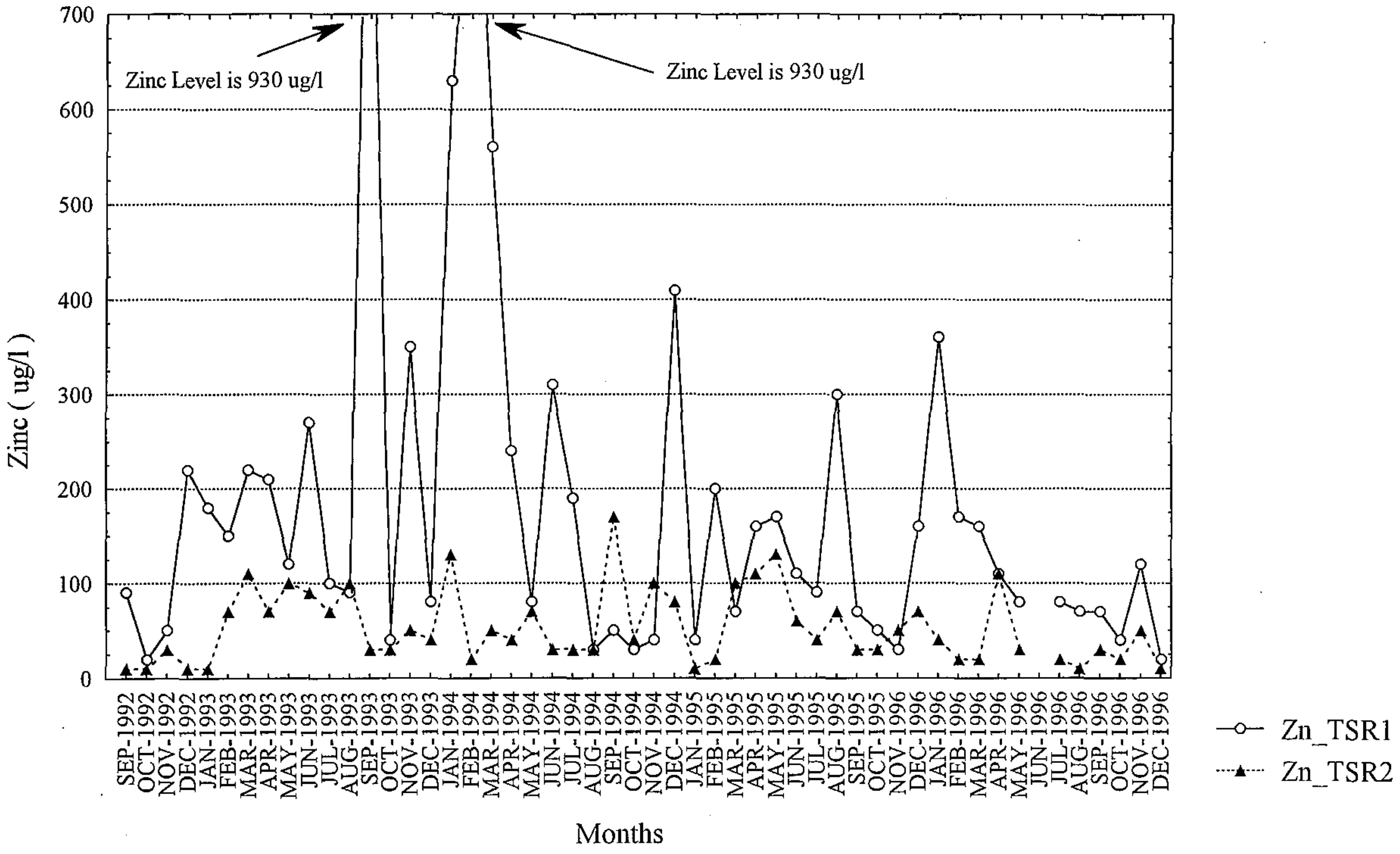


Figure D1.25 Ammoniacal Nitrogen Levels of TSW-Western Channel at Stations TSR1 & TSR2 from 1992 to 1996

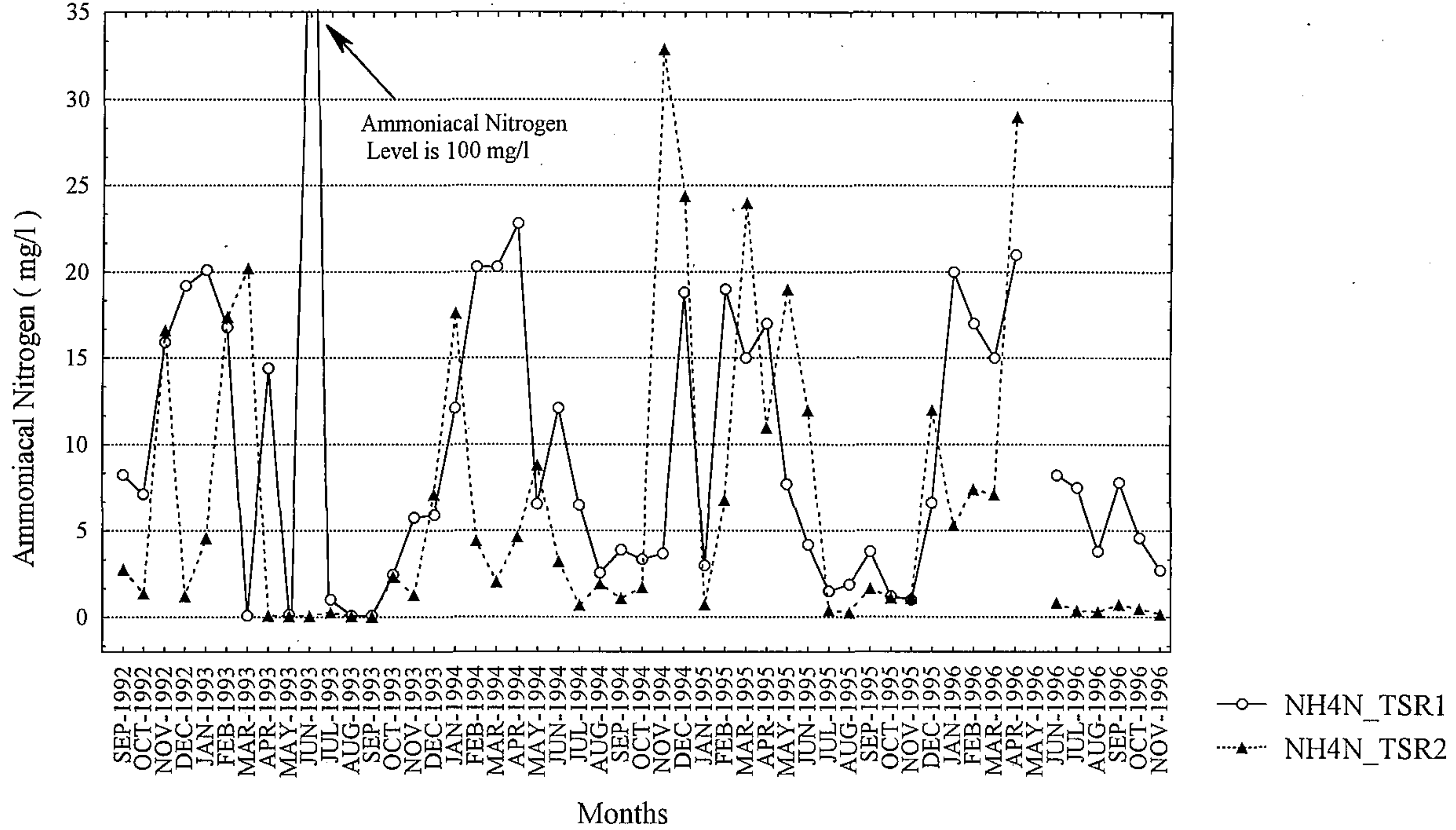


Figure D1.26 Escherichia coli Levels of TSW-Western Channel at Stations TSR1 & TSR2 from 1992 to 1996

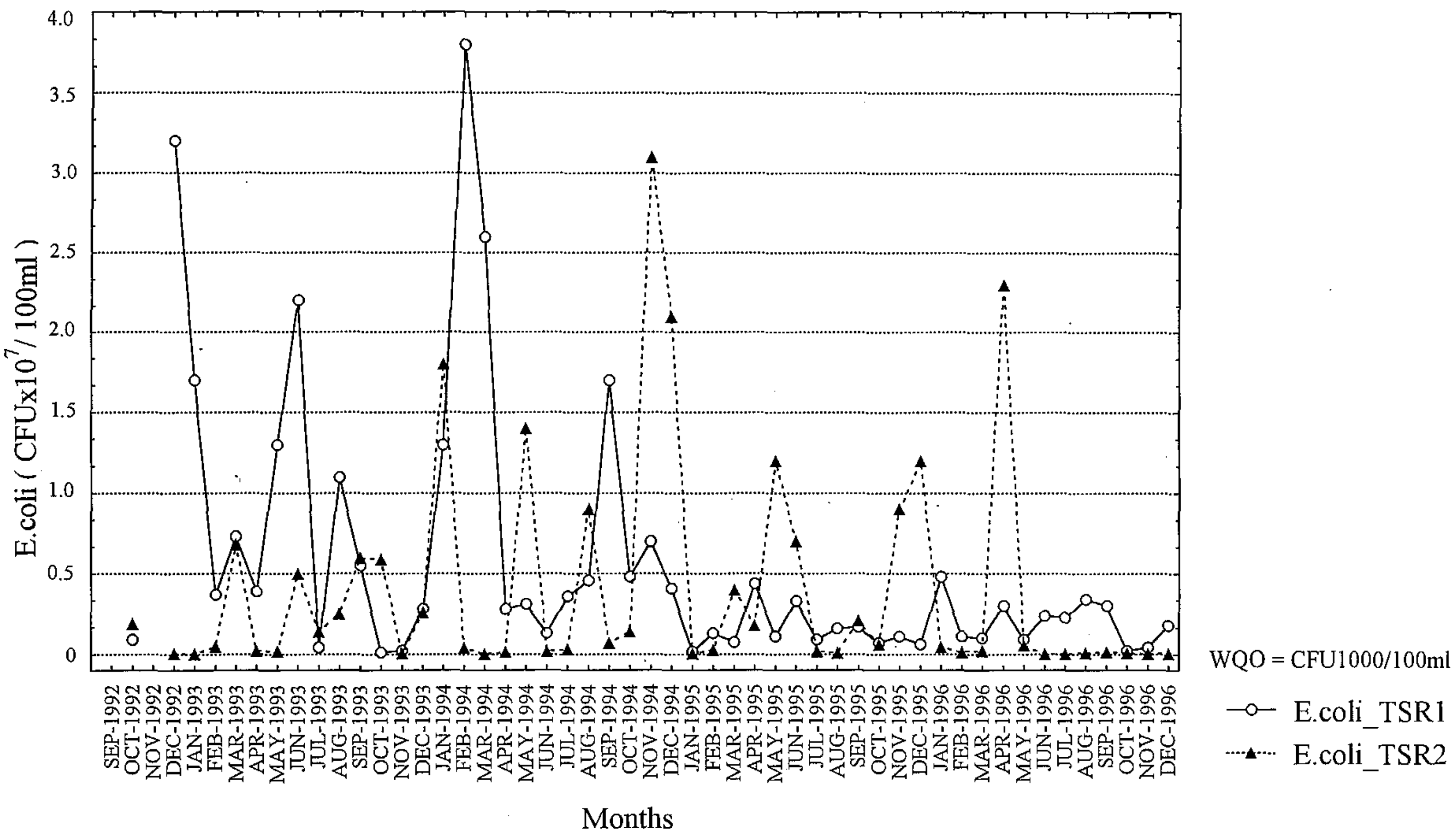


Figure D1.27 Oil and Grease Levels of Tin Shui Wai at Station TSR1 & TSR2 from 1992 to 1996

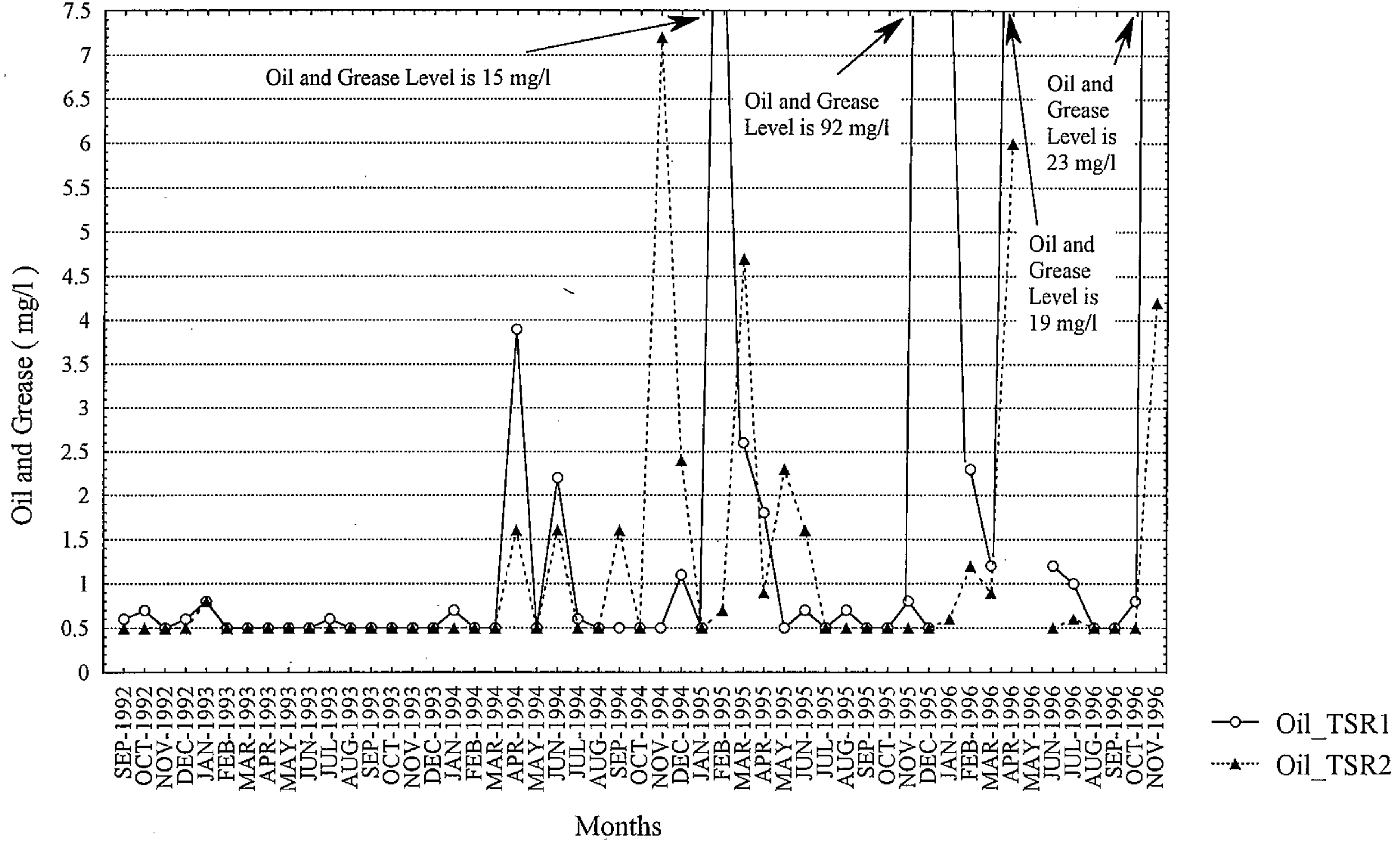


Figure D1.28 Copper Levels of TSW-Western Channel at Stations TSR1 & TSR2 from 1992 to 1996

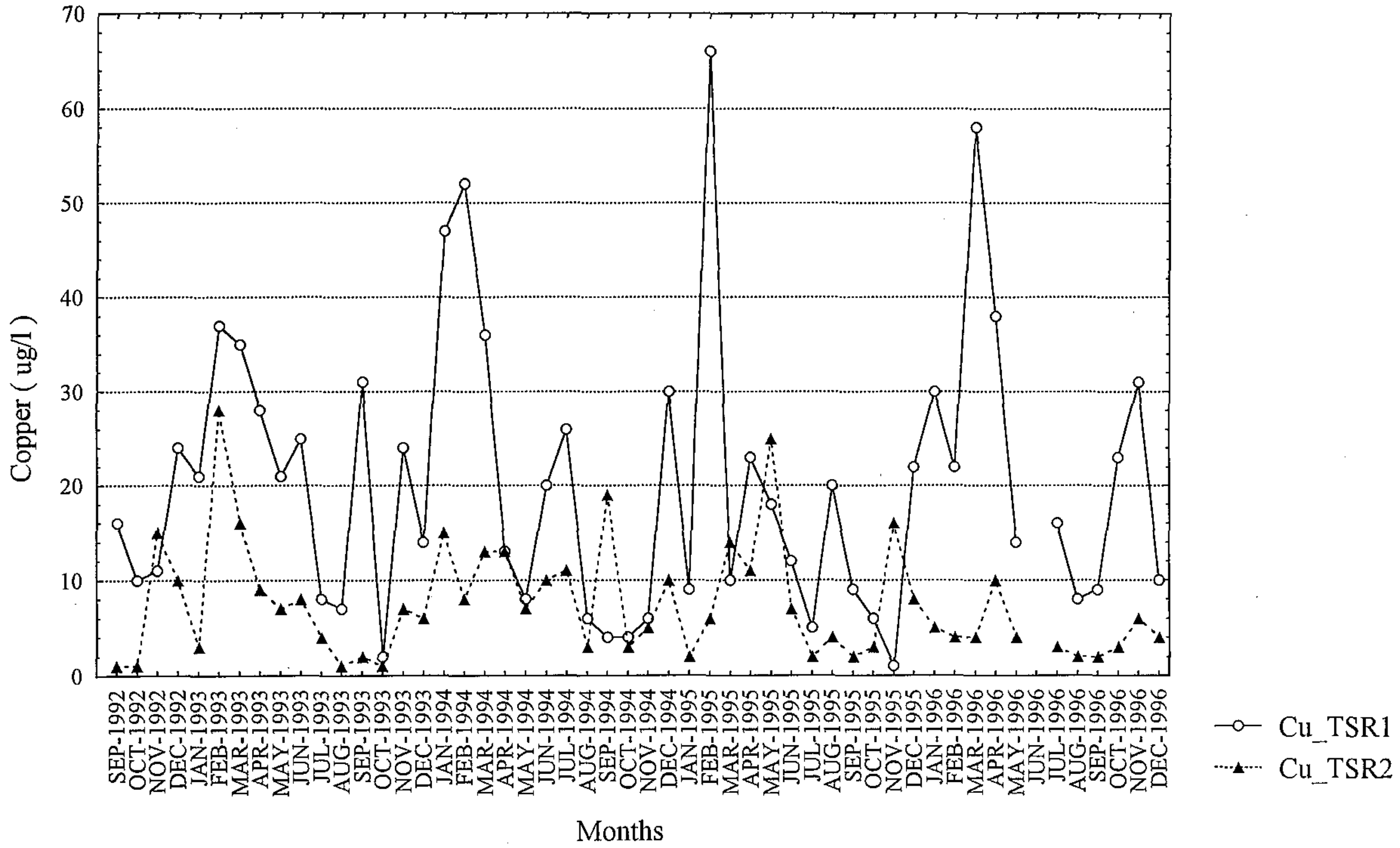


Figure D1.29 Nickel Levels of TSW-Western Channel at Stations TSR1 & TSR2 from 1992 to 1996

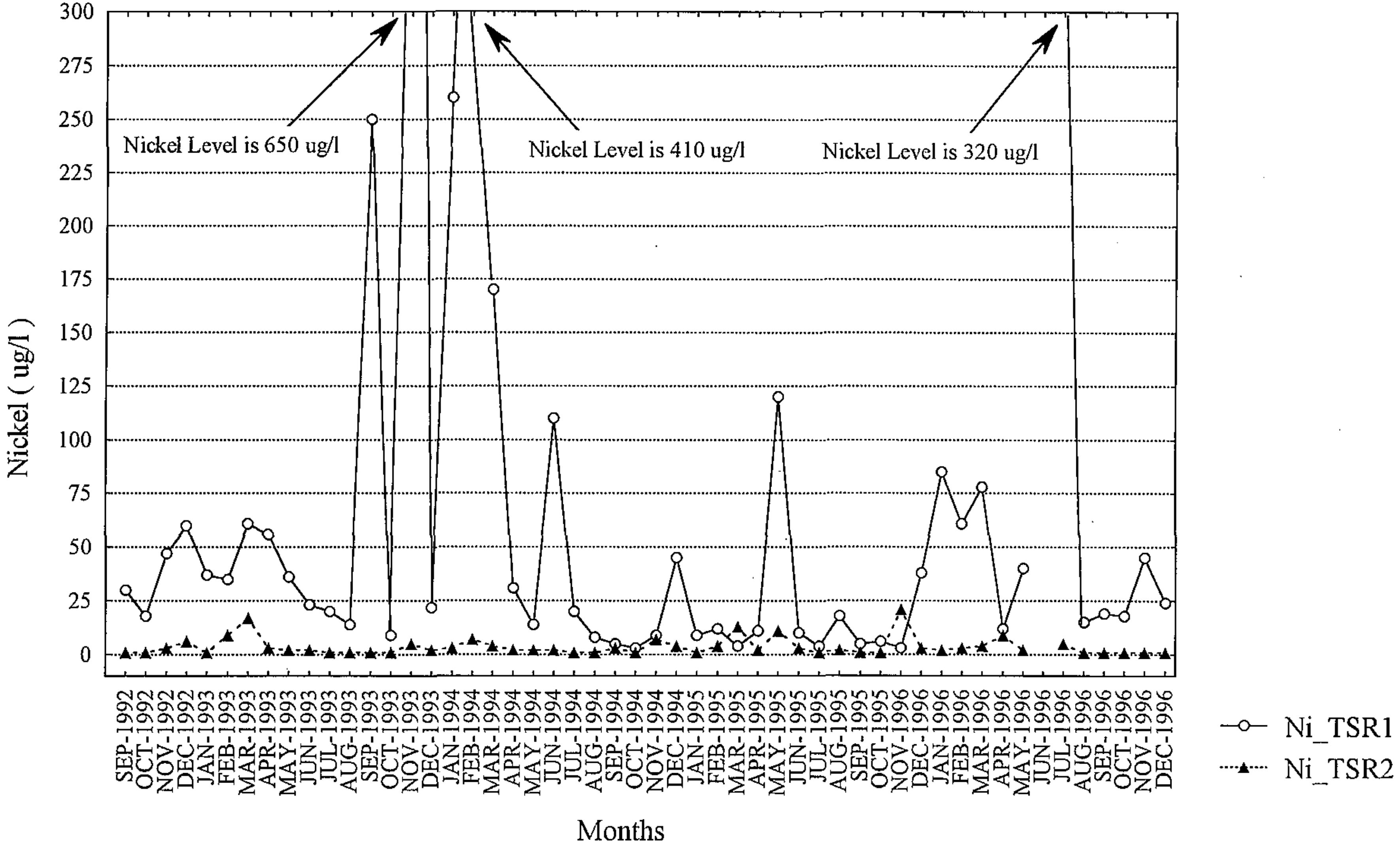


Figure D1.30 Lead Levels of TSW-Western Channel at Stations TSR1 & TSR2 from 1992 to 1996

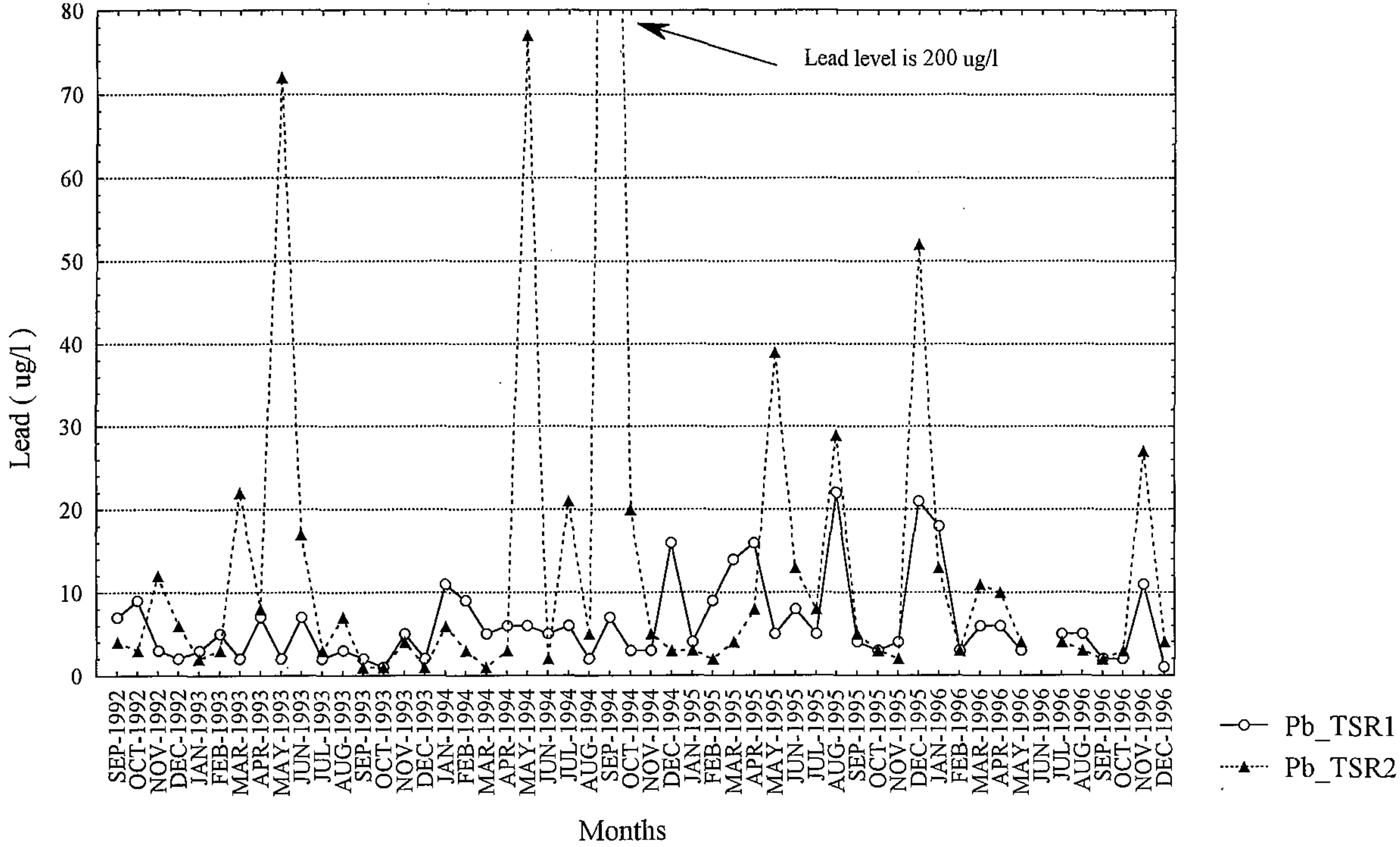


Figure D1.31 Cadmium Levels of Marine Sediment in Inner Deep Bay at Stations DS1 & DS2 from 1987 to 1995

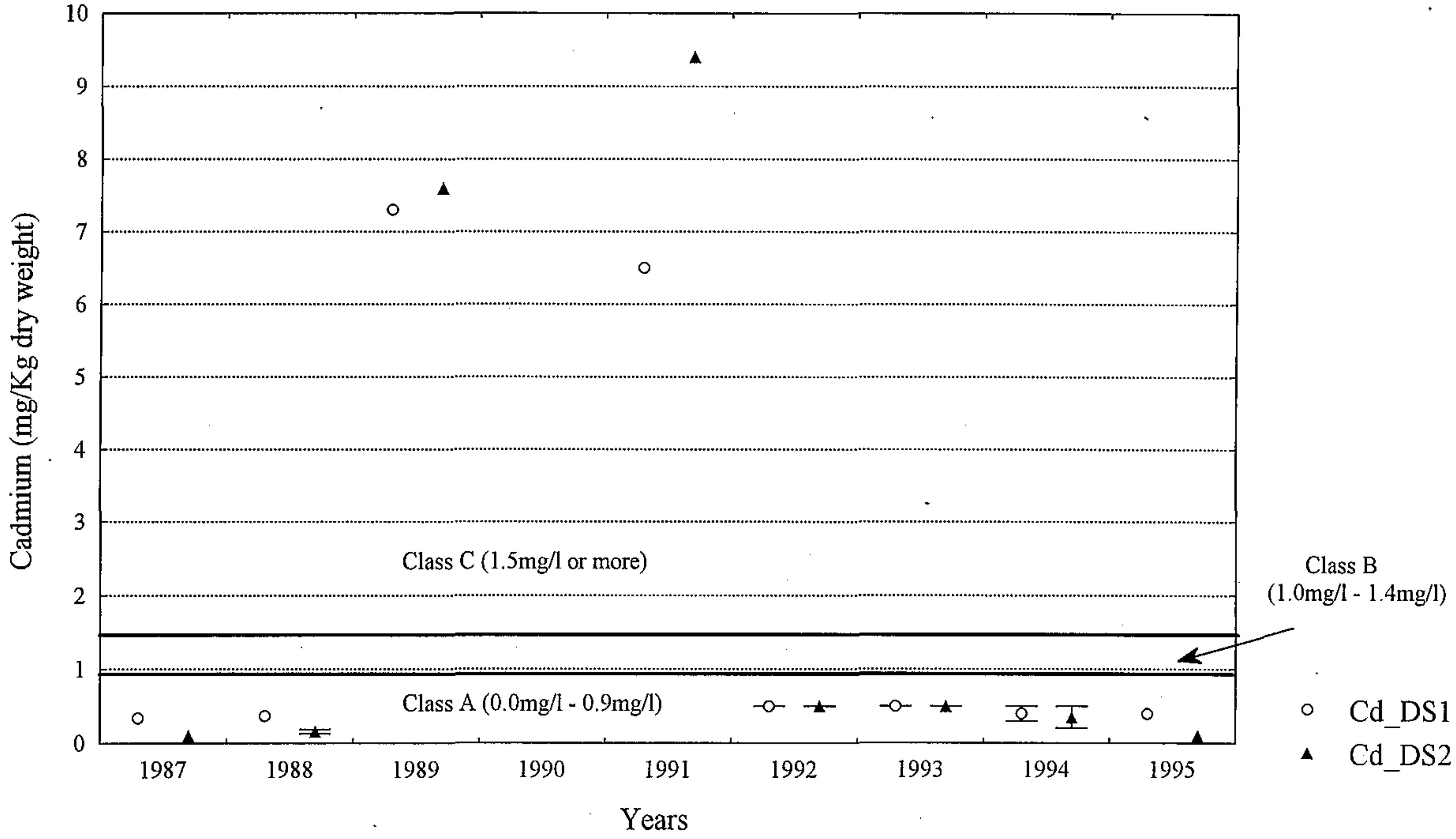


Figure D1.32 Chromium Levels of Marine Sediment in Inner Deep Bay at Stations DS1 & DS2 from 1987 to 1995

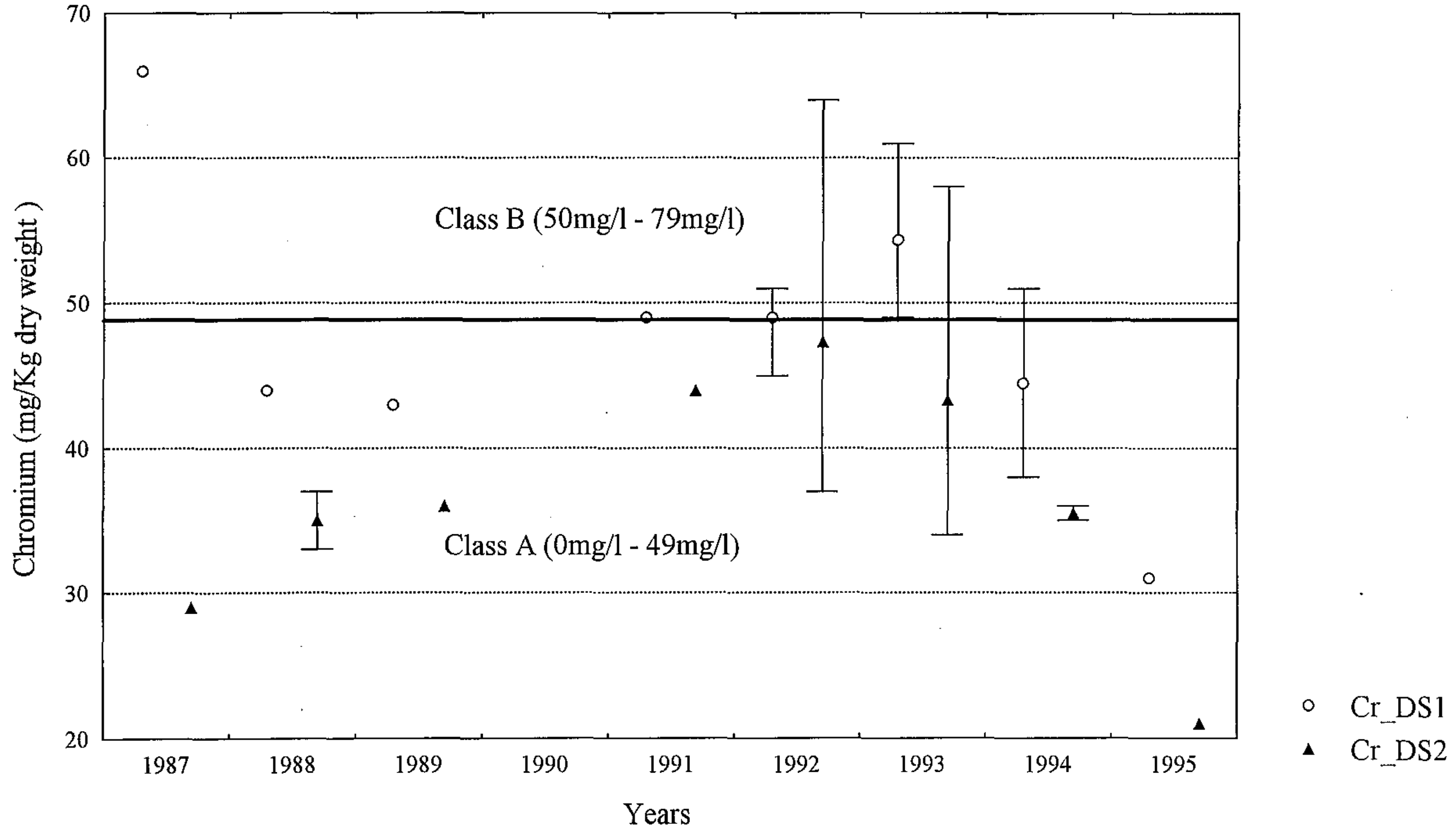


Figure D1.33 Copper Levels of Marine Sediment in Inner Deep Bay at Stations DS1 & DS2 trom 1987 to 1995

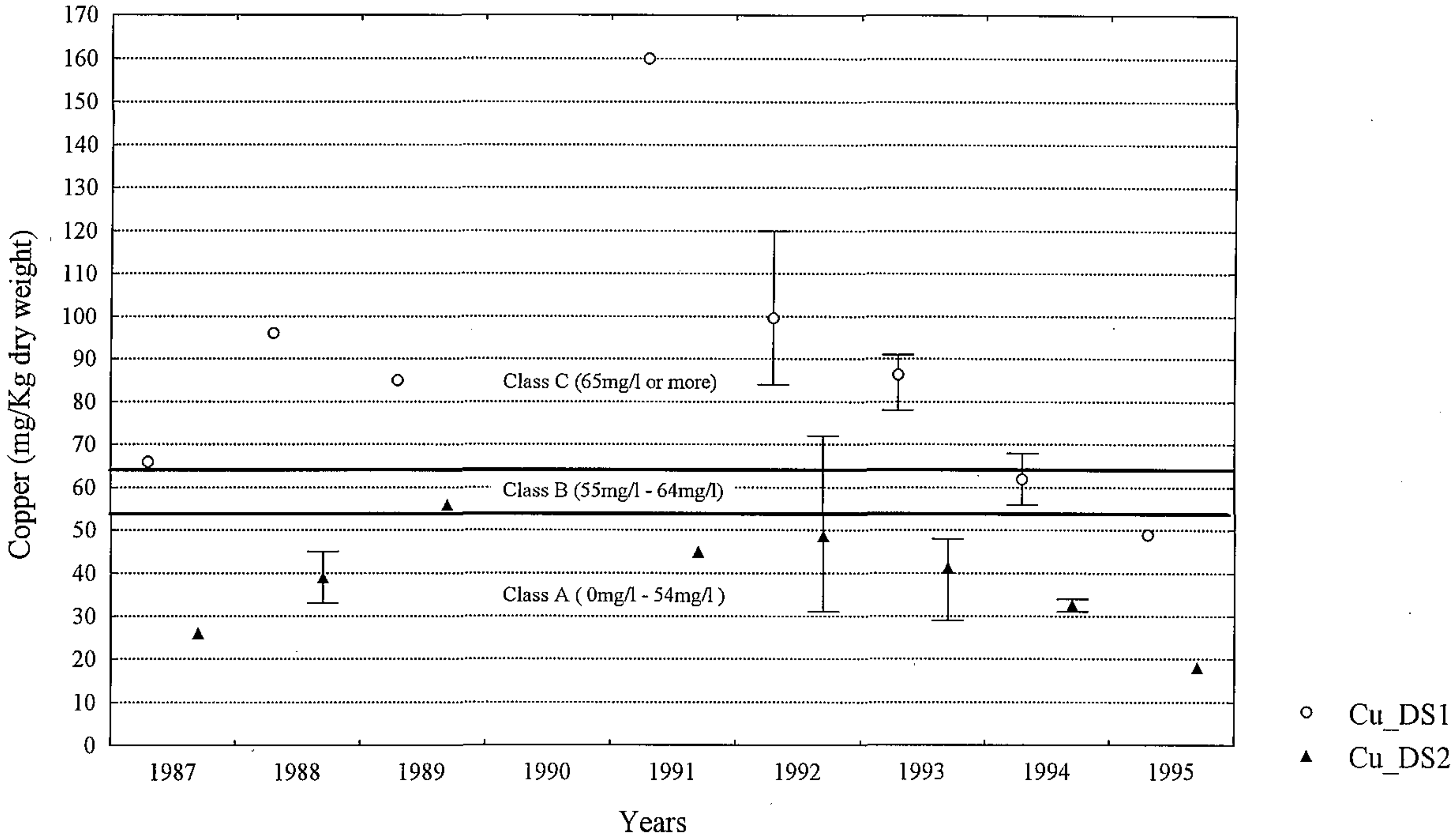


Figure D1.34 Lead Levels of Marine Sediment in Inner Deep Bay at Stations DS1 & DS2 from 1987 to 1995

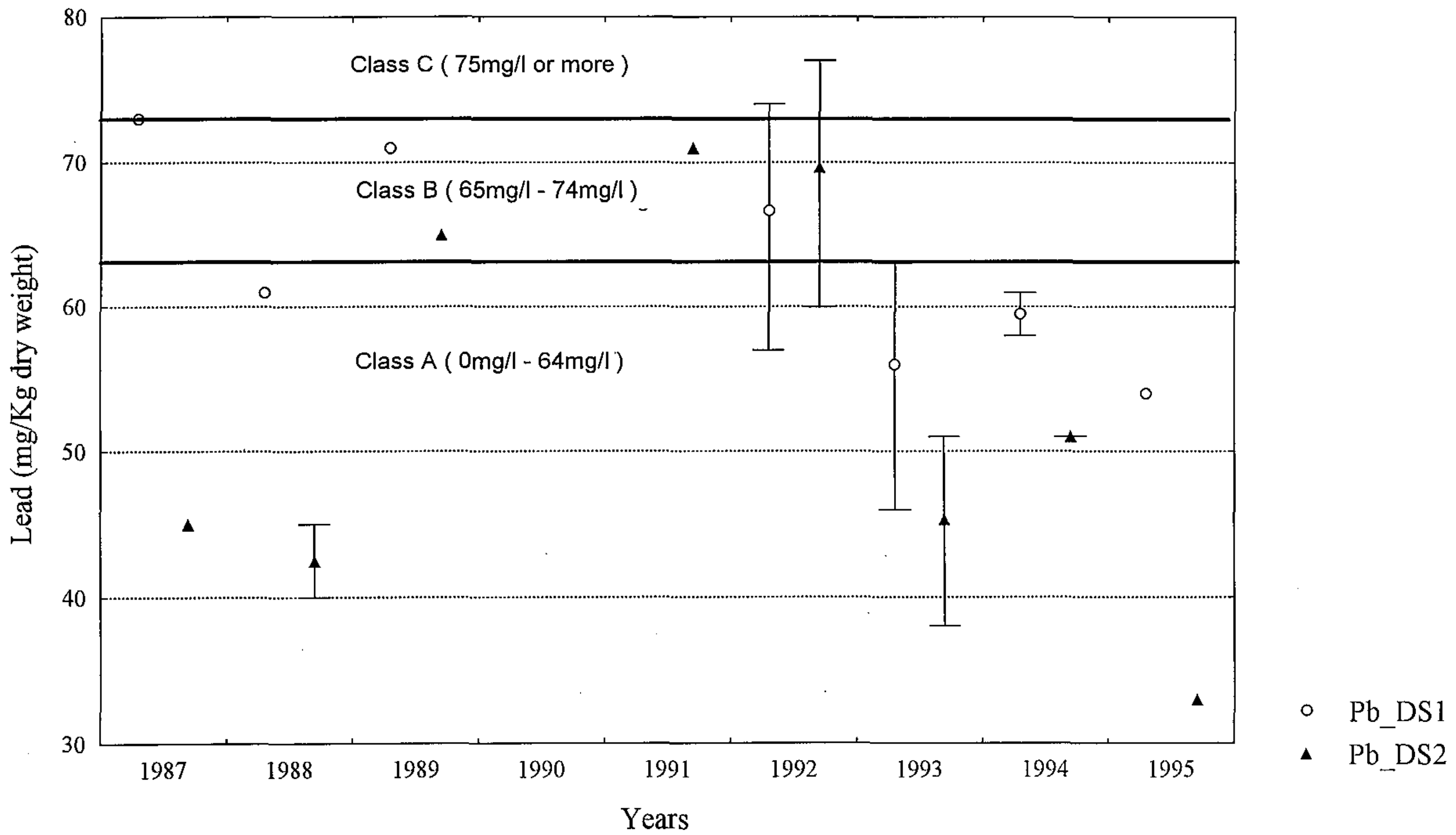


Figure D1.35 Mercury Levels of Marine Sediment in Inner Deep Bay at Stations DS1 & DS2 from 1987 to 1995

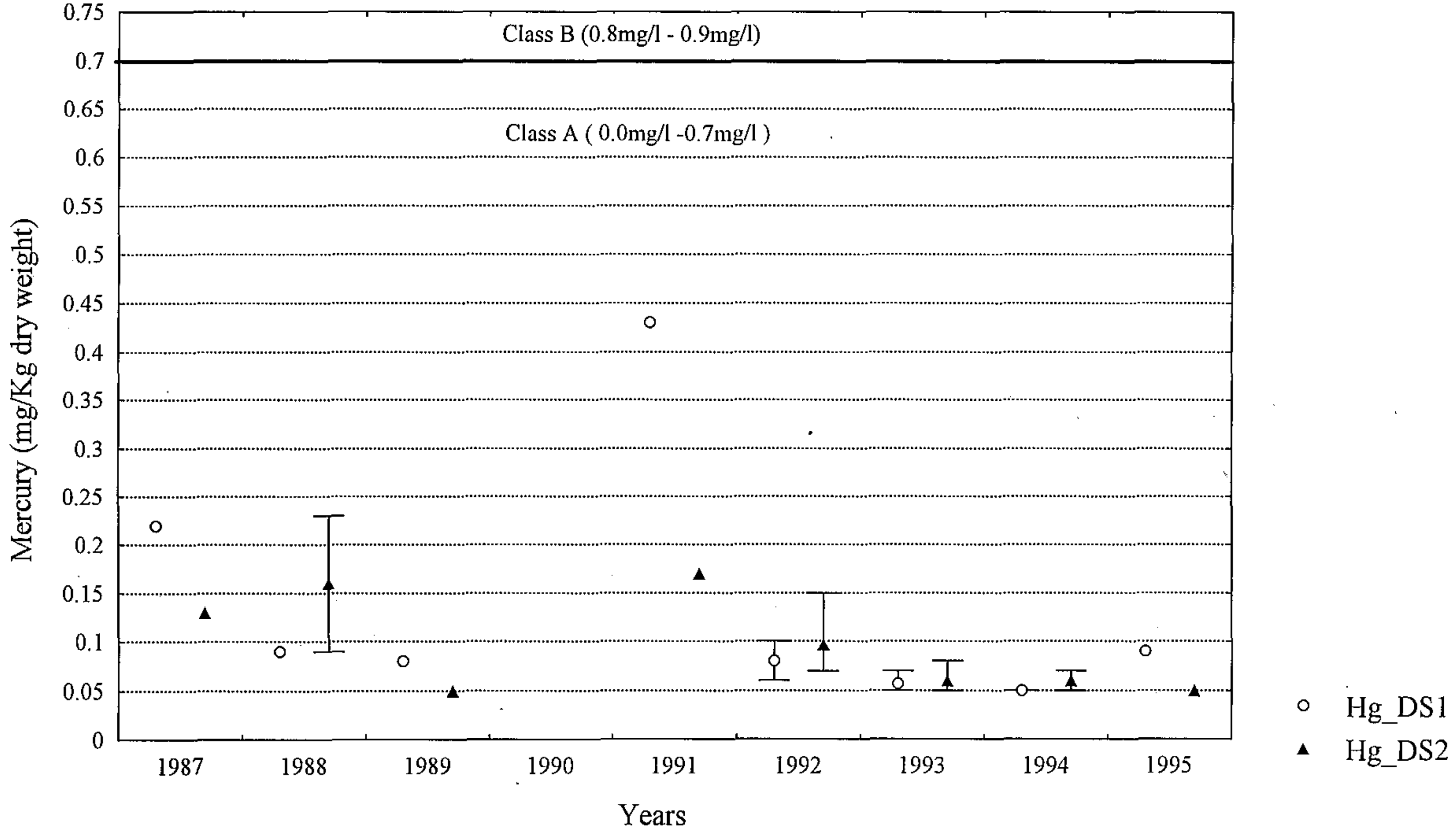


Figure D1.36 Nickel Levels of Marine Sediment in Inner Deep Bay at Stations DS1 & DS2 from 1987 to 1995

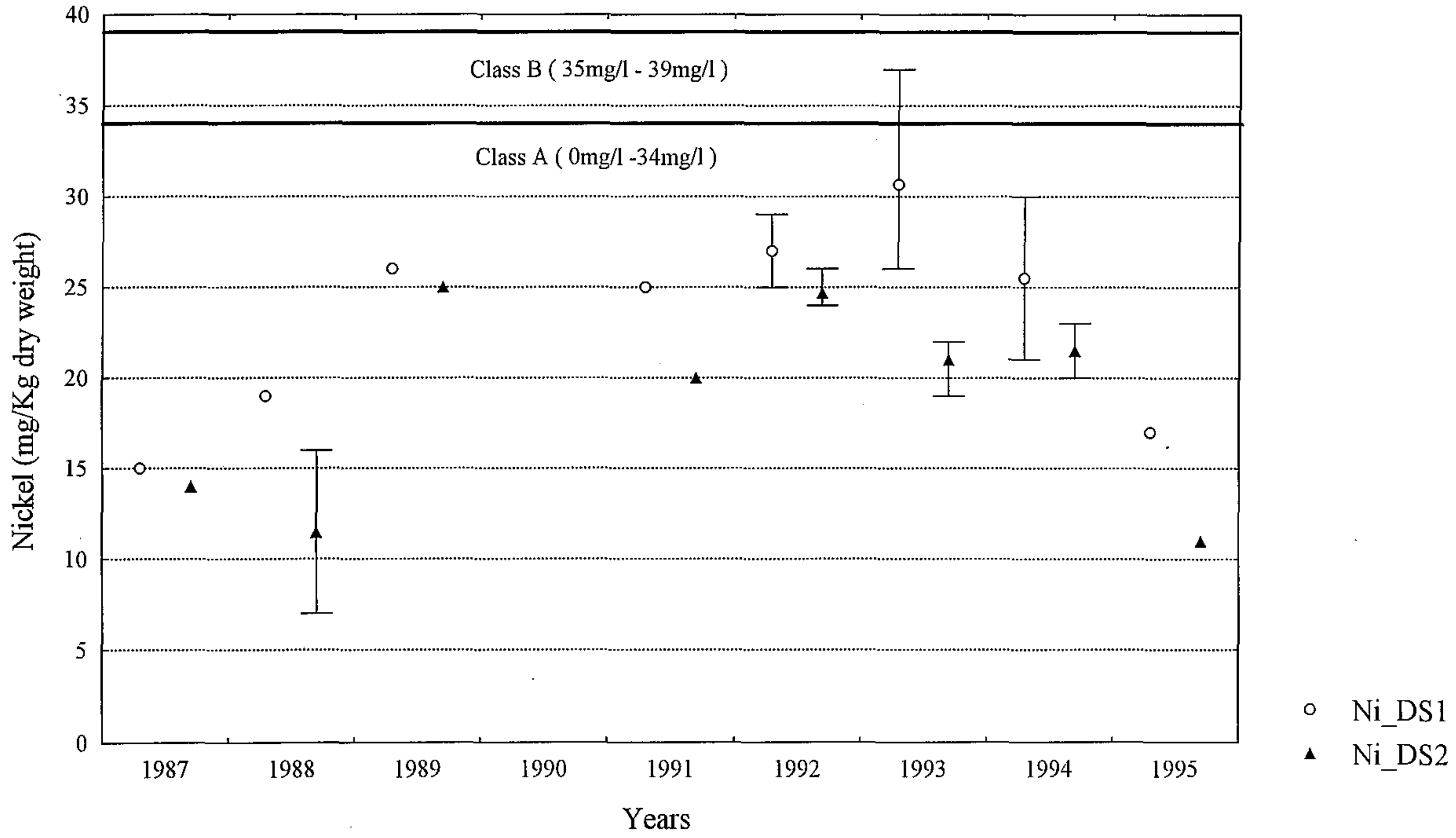


Figure D1.37 Zinc Levels of Marine Sediment in Inner Deep Bay at Stations DS1 & DS2 from 1987 to 1995

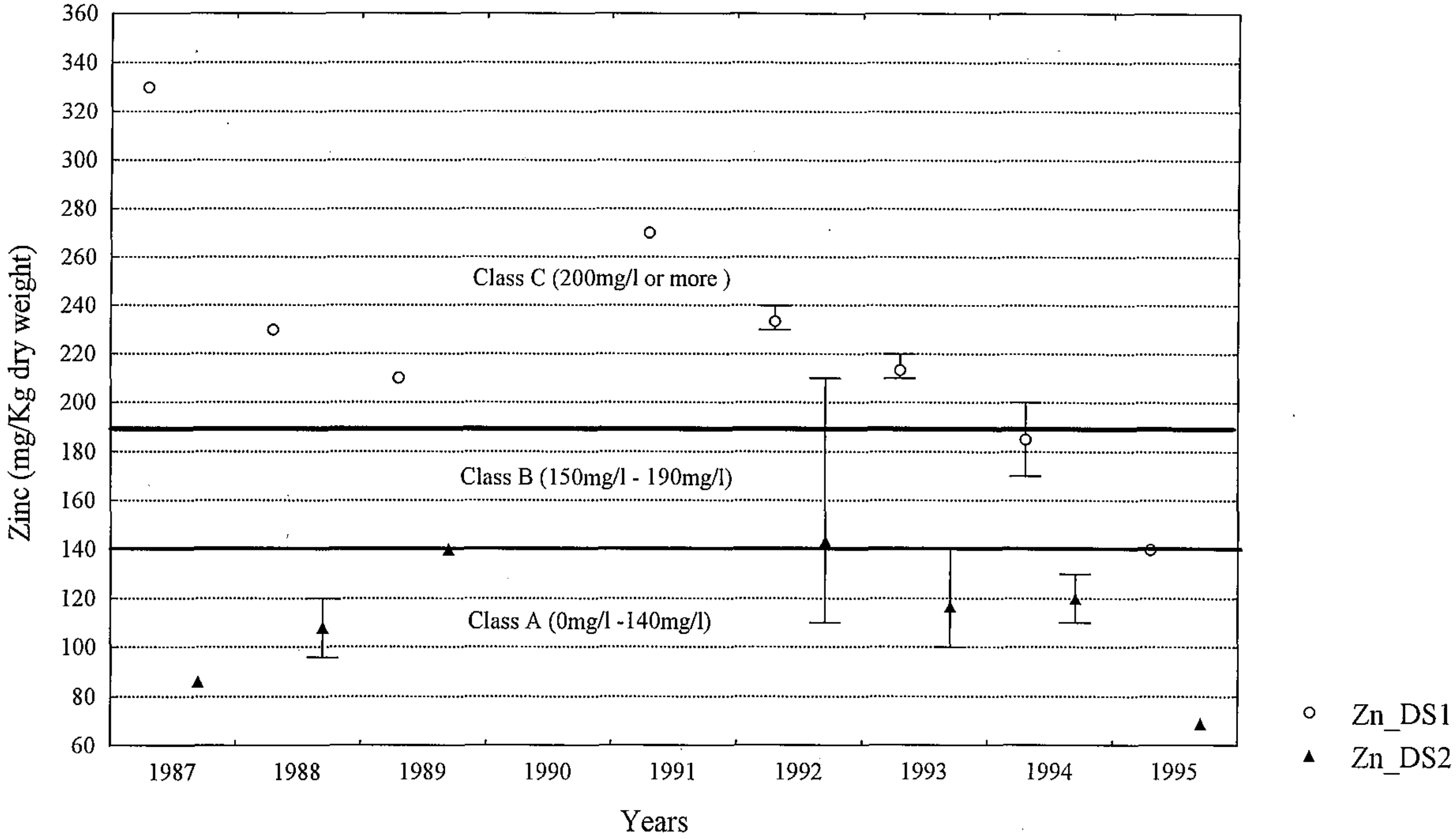


Figure D1.38 Ammoniacal Nitrogen Levels of Marine Sediment in Inner Deep Bay at Stations DS1 and DS2 from 1987 to 1995

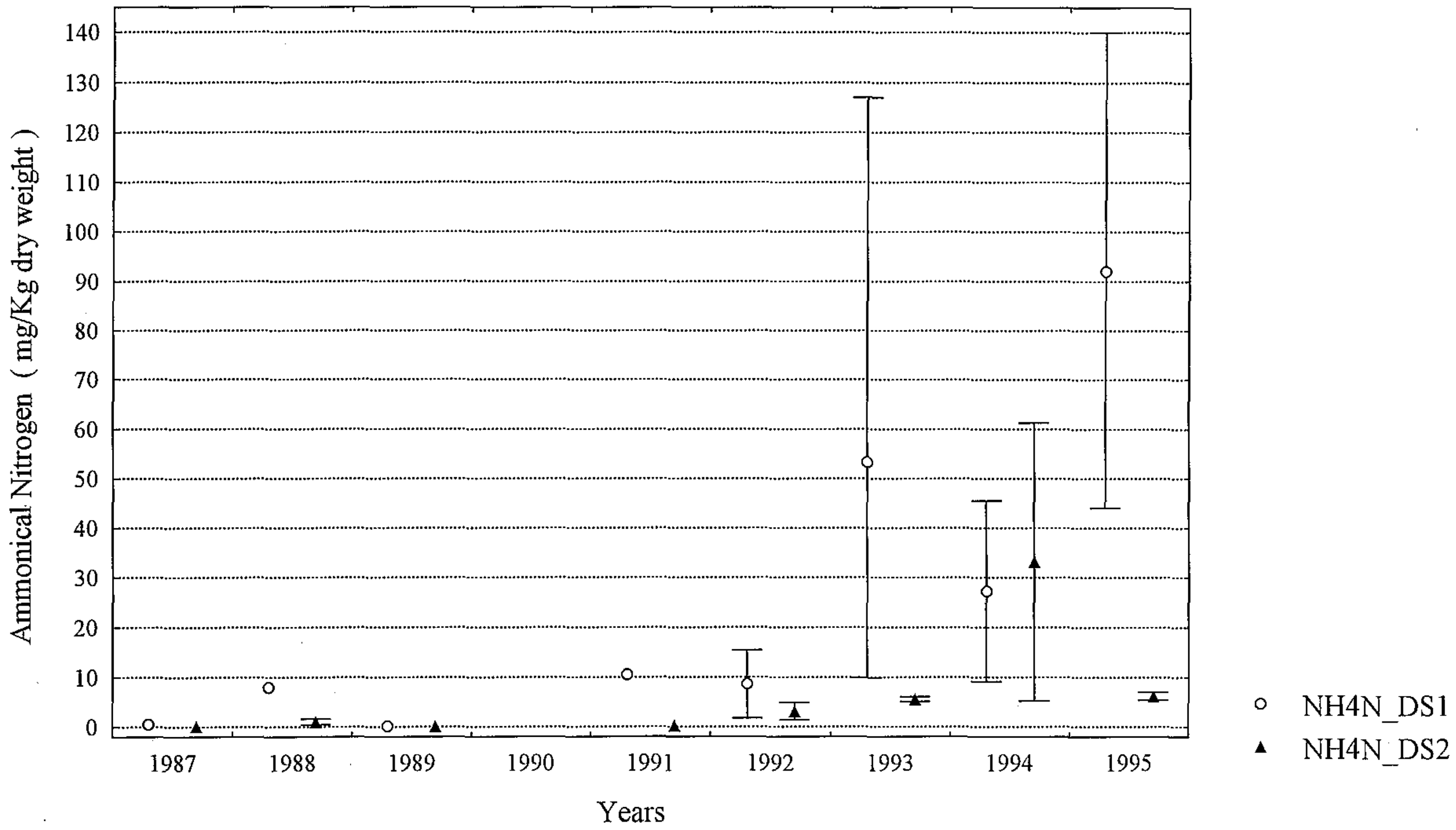


Figure D1.39 Total Phosphorus Levels of Marine Sediment in Inner Deep Bay at Stations DS1 & DS2 from 1987 to 1995

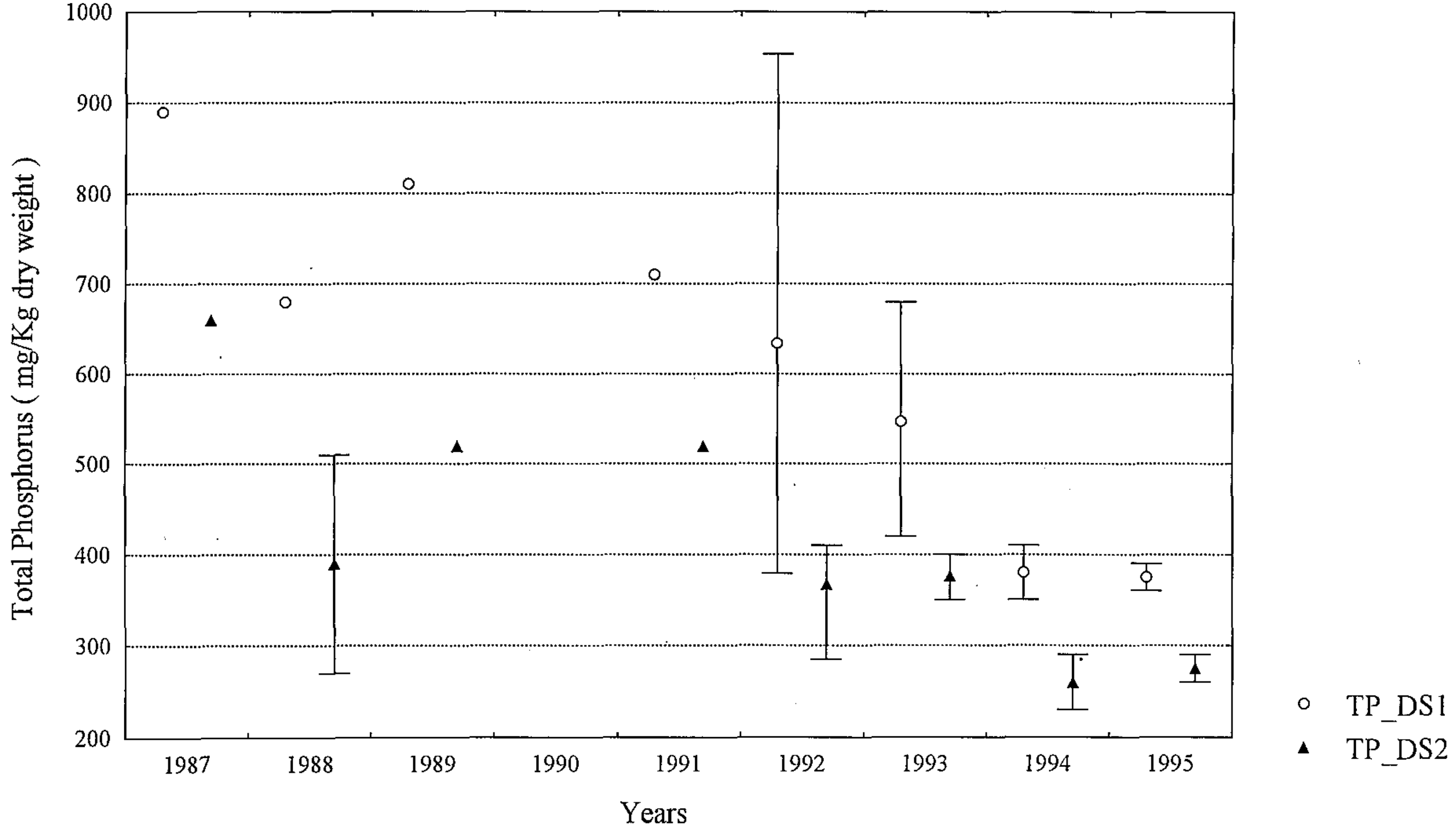


Figure D1.40 Total Kjeldahl Nitrogen Levels of Marine Sediment in Inner Deep Bay at Stations DS1 & DS2 from 1987 to 1995

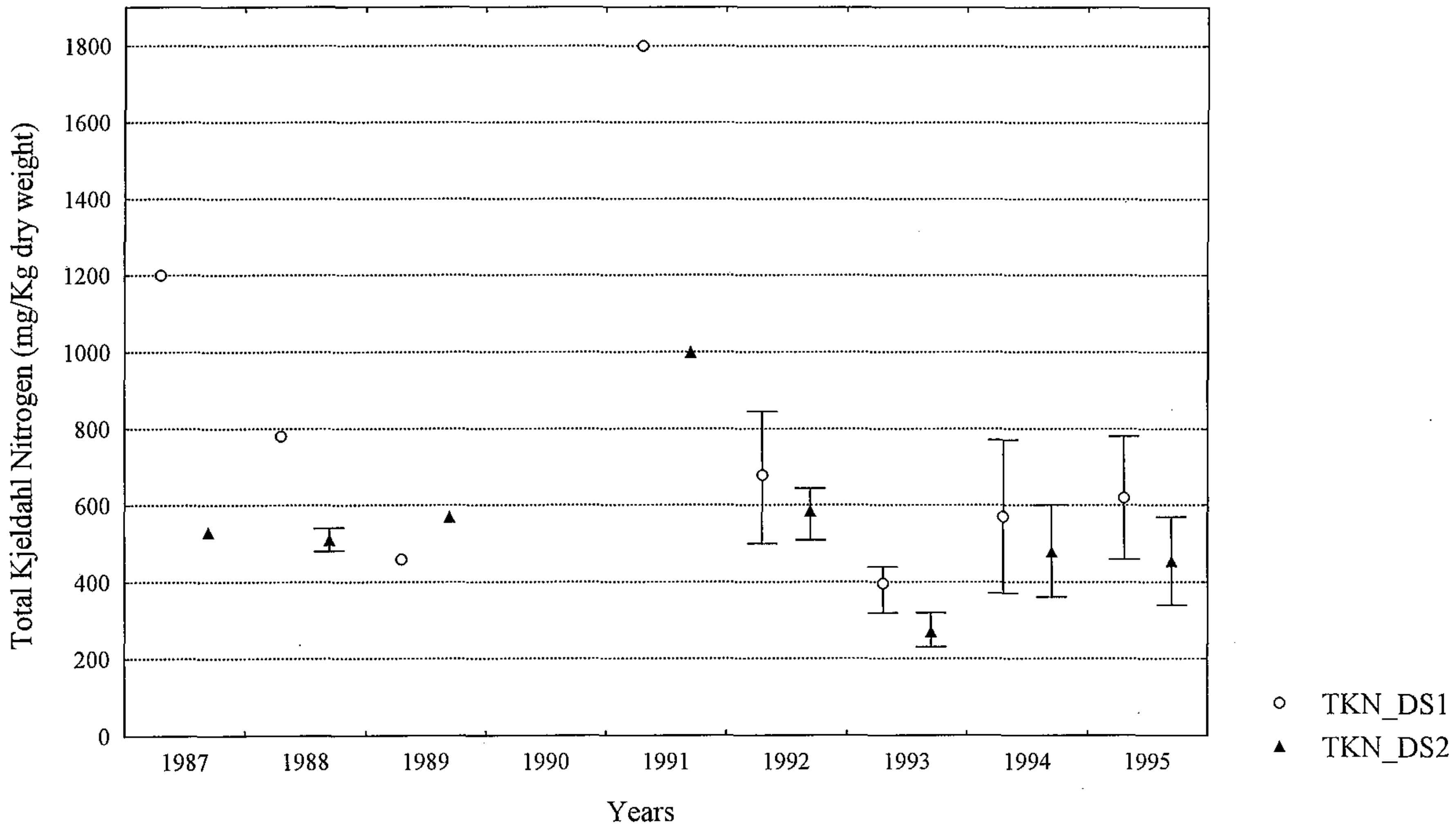
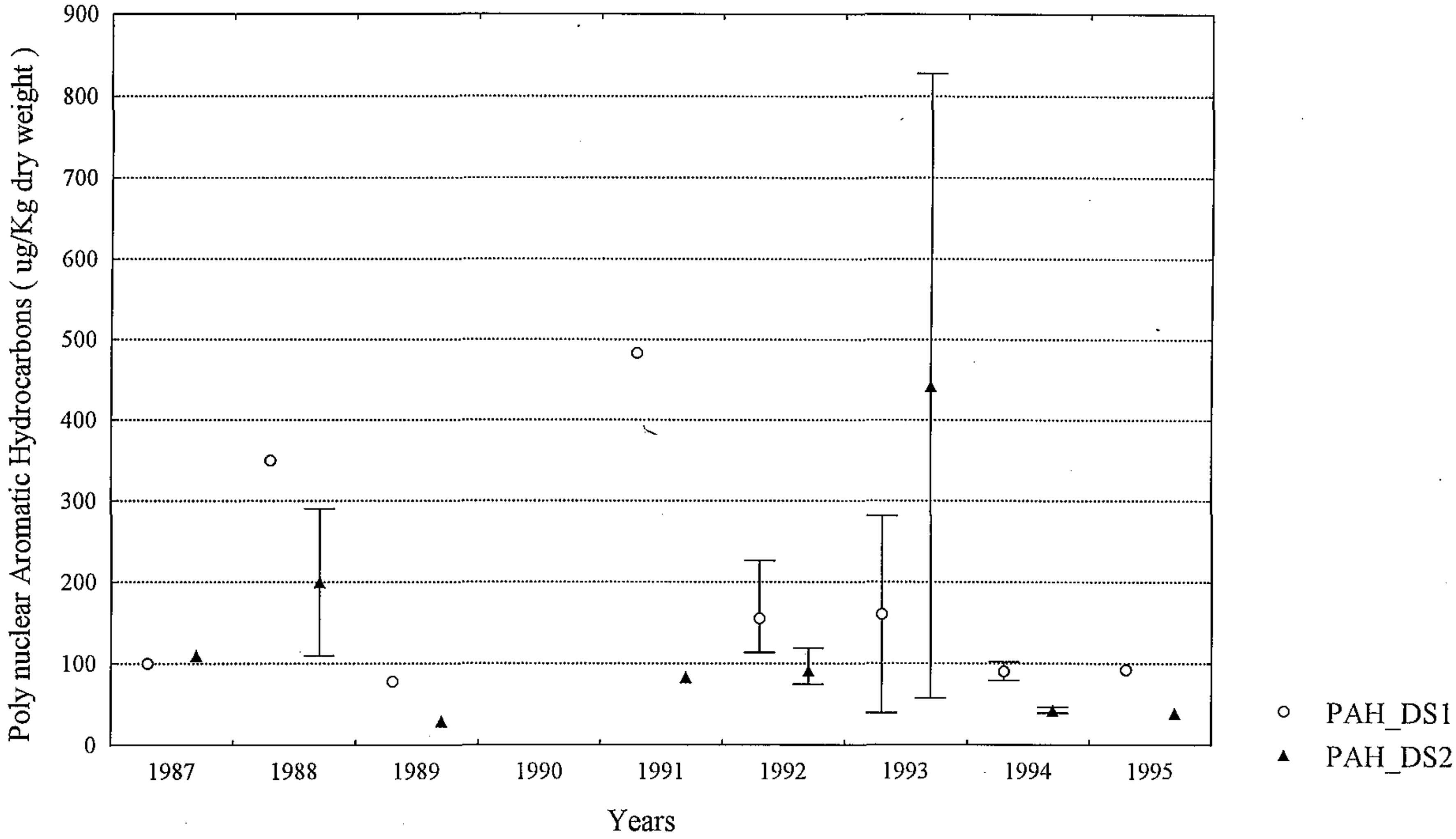


Figure D1.41 Polynuclear Aromatic Hydrocarbons (PAH) Levels of Marine Sediments in Inner Deep Bay at Stations DS1 & DS2 from 1987 to 1995



Water Quality Data for Deep Bay (Dry Season) 1996

supplied by courtesy of EPD Water Policy and Planning Group
reproduced from the field survey report

(Ref. Deep Bay Water Quality Regional Control Strategy Study - Agreement No. CE 17 - 95 - Axis/CES - July 1996)

(Interim report result. Final report of the study yet to be issued.)

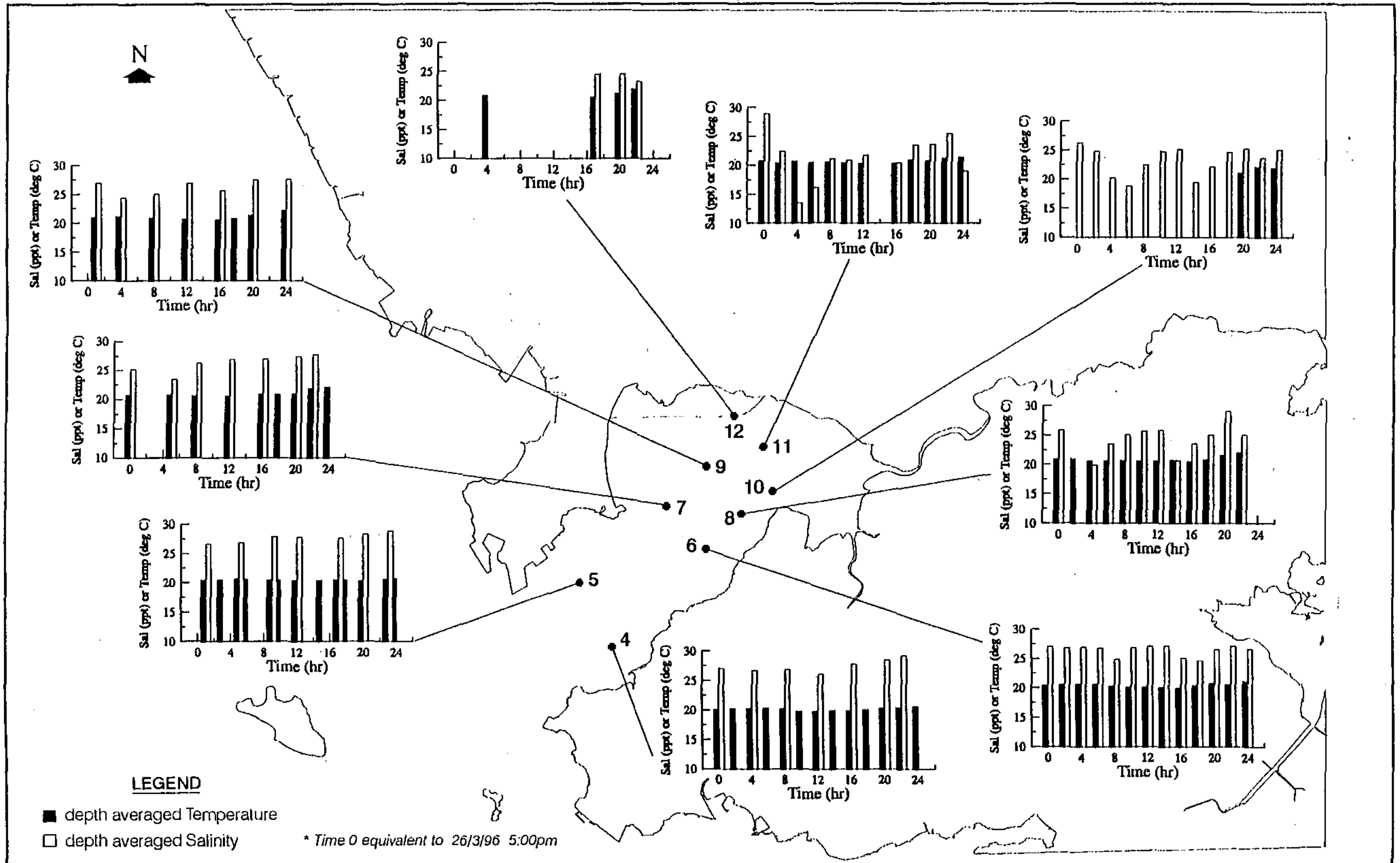


Figure 4.1 Temperature and Salinity Distribution at Primary Stations

AXIS Environmental

CES

97112

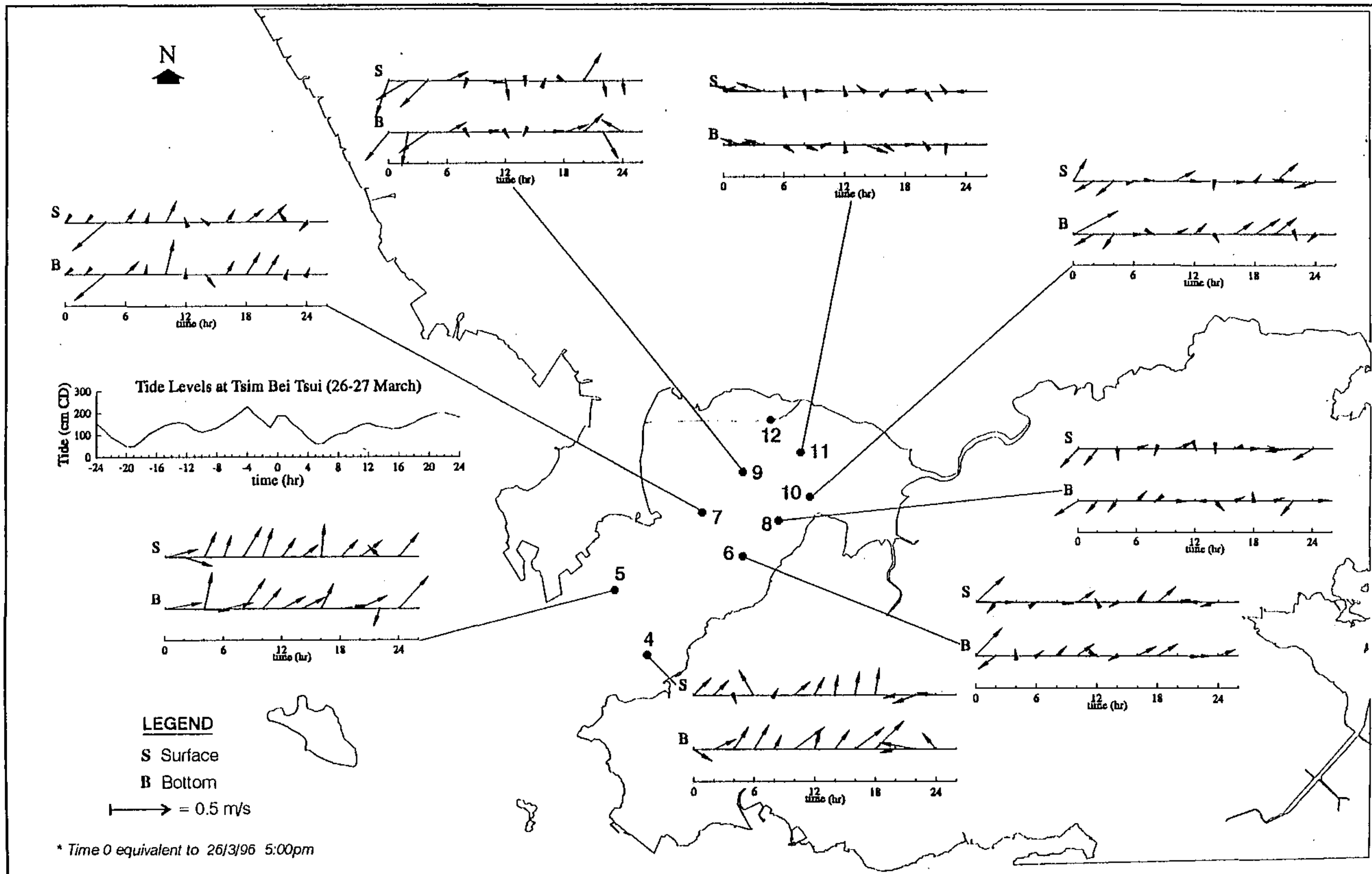


Figure 4.2 Current Measurements at Primary Stations

AXIS Environmental

CES

97112

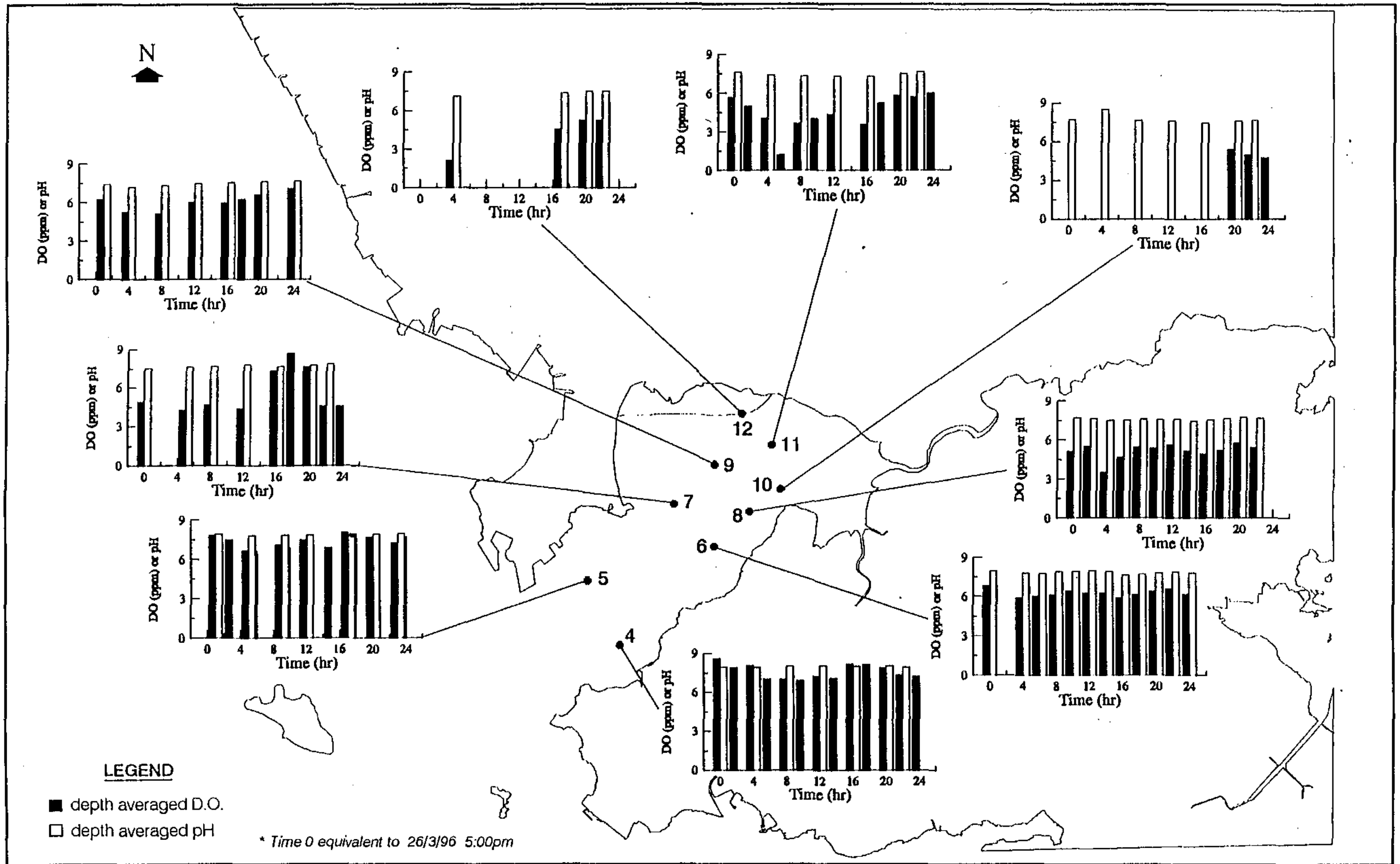


Figure 4.3 Dissolved Oxygen (D.O.) and pH Distribution at Primary Stations

AXIS Environmental

CES

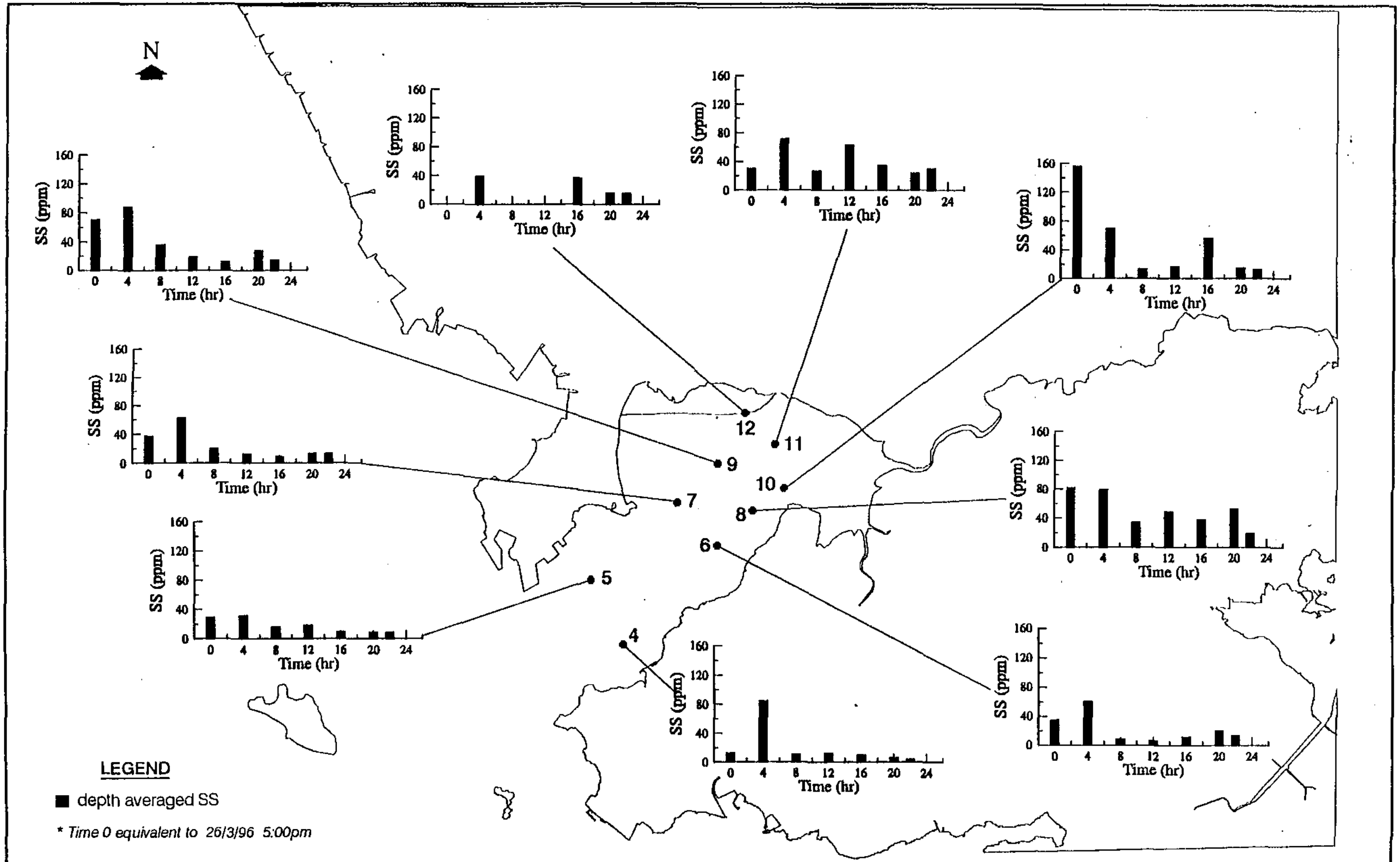


Figure 4.4 Suspended Solids (SS) Distribution at Primary Stations

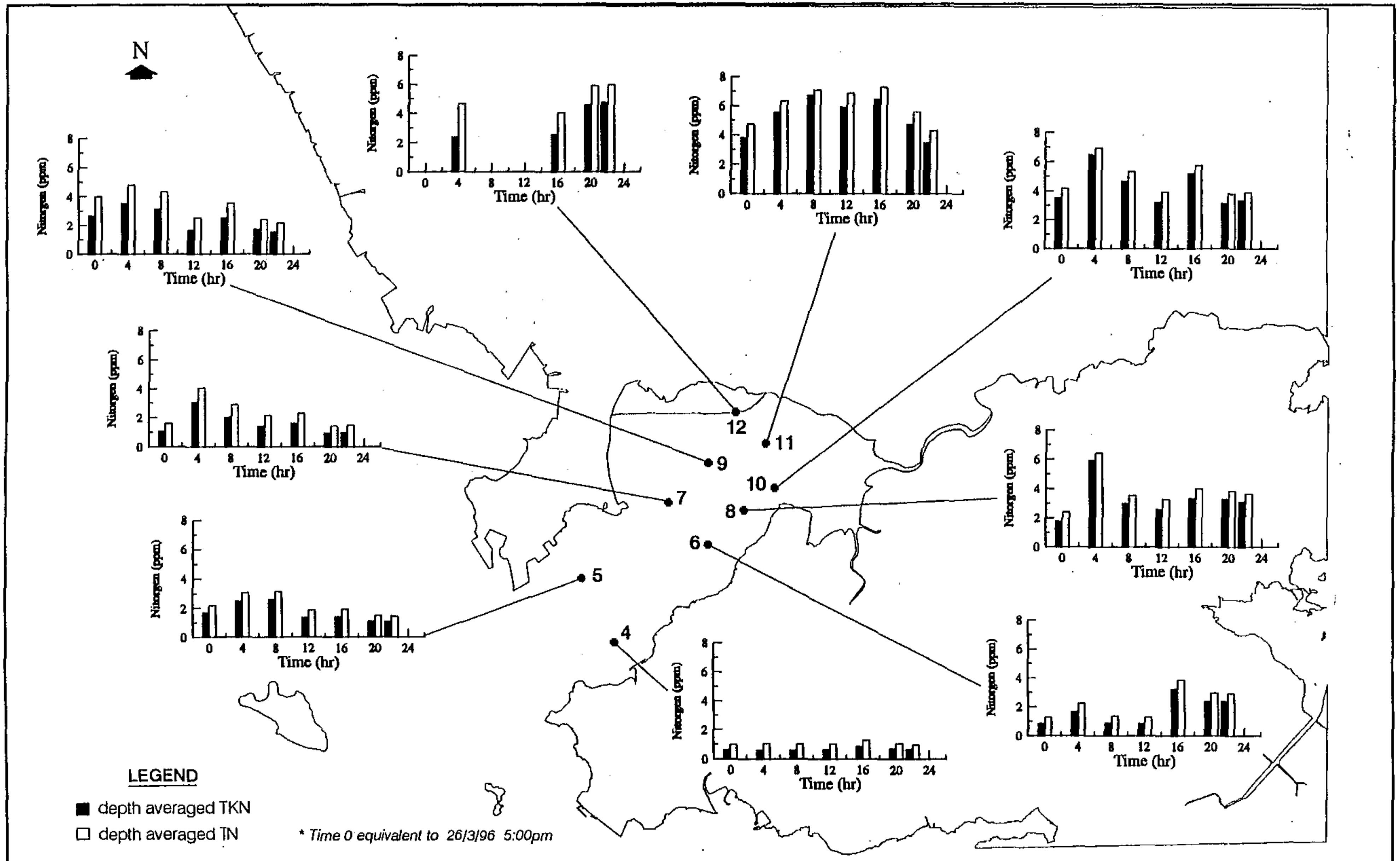


Figure 4.5 Nitrogen Distribution at Primary Stations

AXIS Environmental

CES

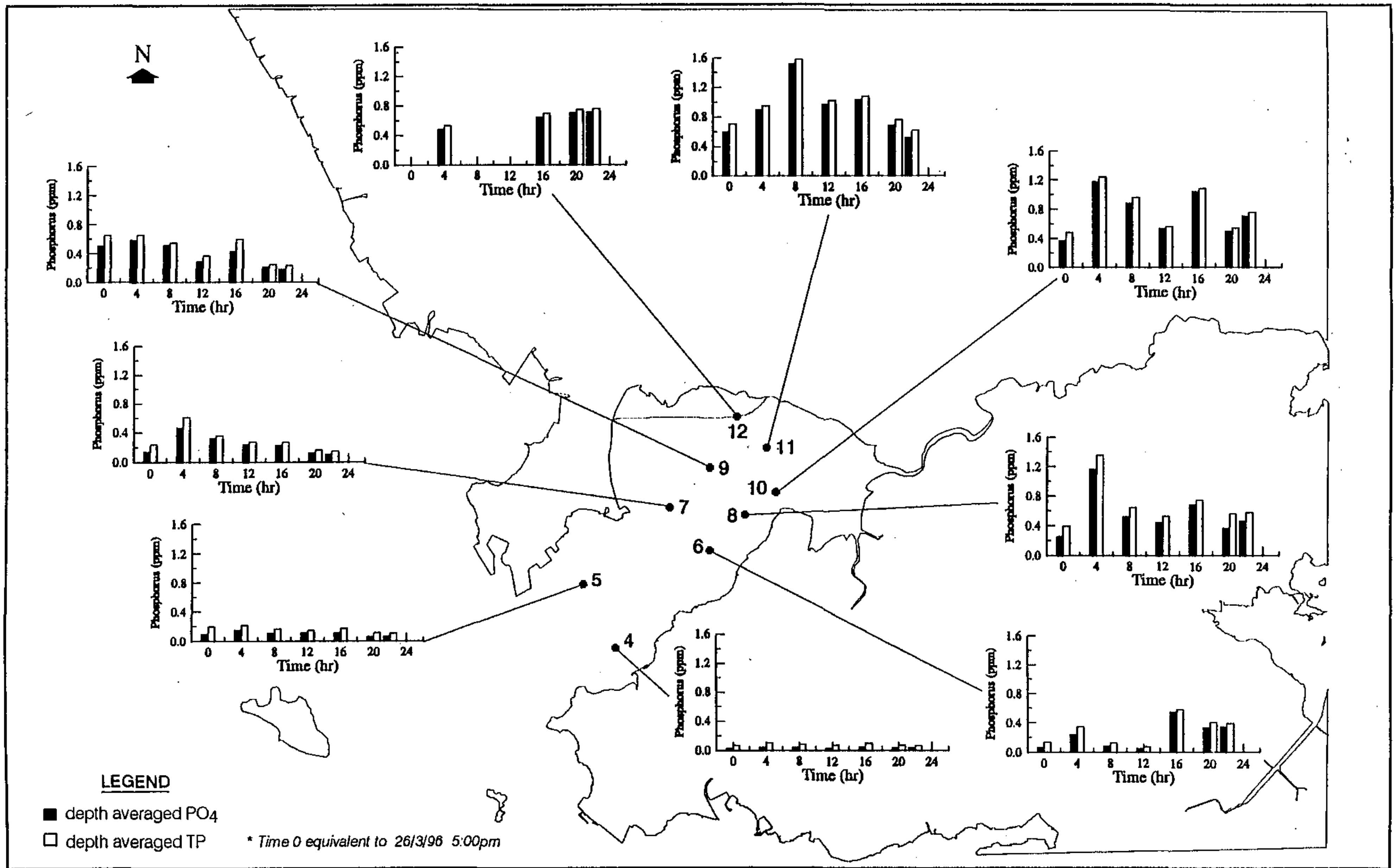


Figure 4.6 Phosphorus Distribution at Primary Stations

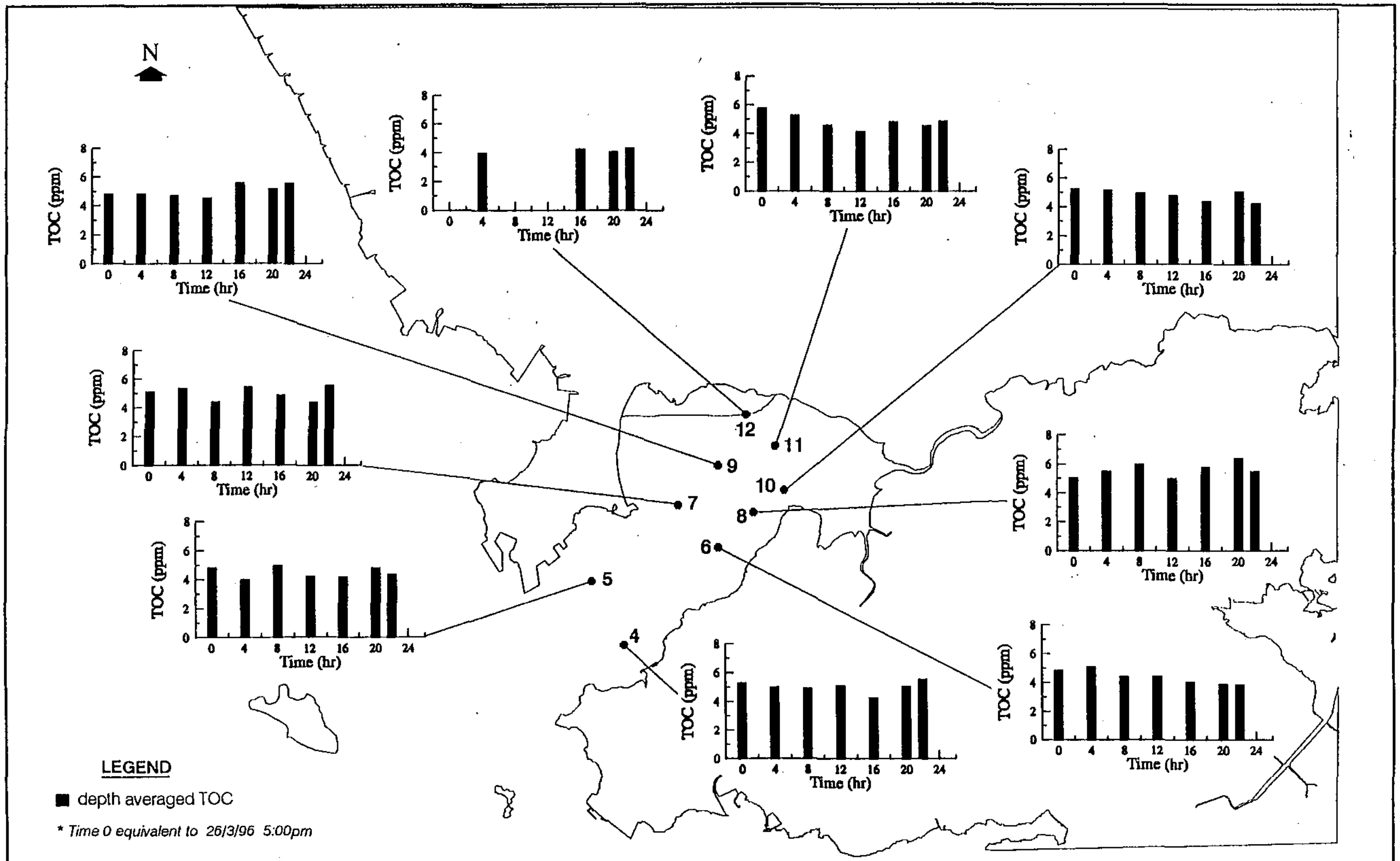


Figure 4.7 Total Organic Carbon (TOC) Distribution at Primary Stations

AXIS Environmental

CES

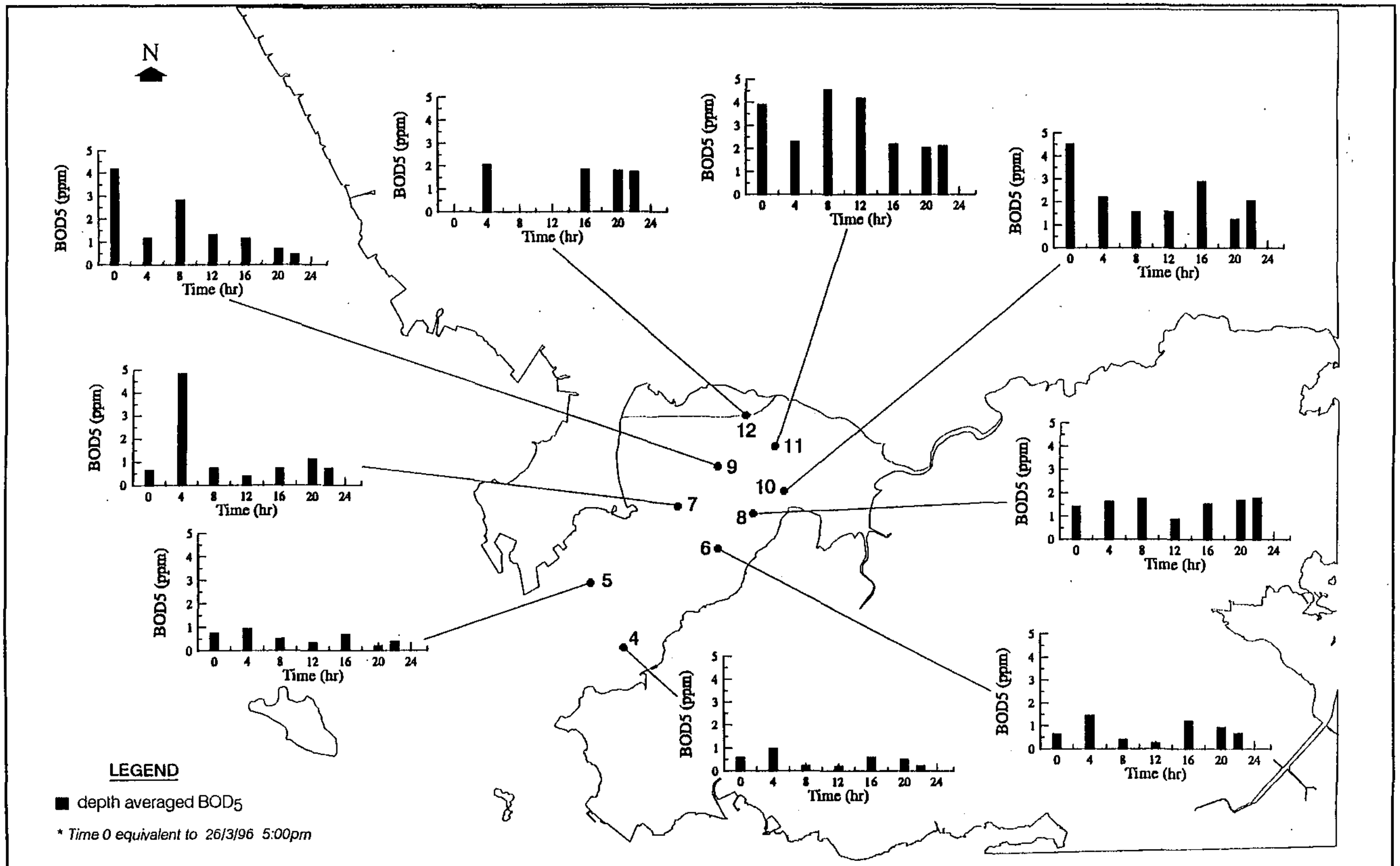


Figure 4.8 Biochemical Oxygen Demand (BOD_5) Distribution at Primary Stations

AXIS Environmental

CES

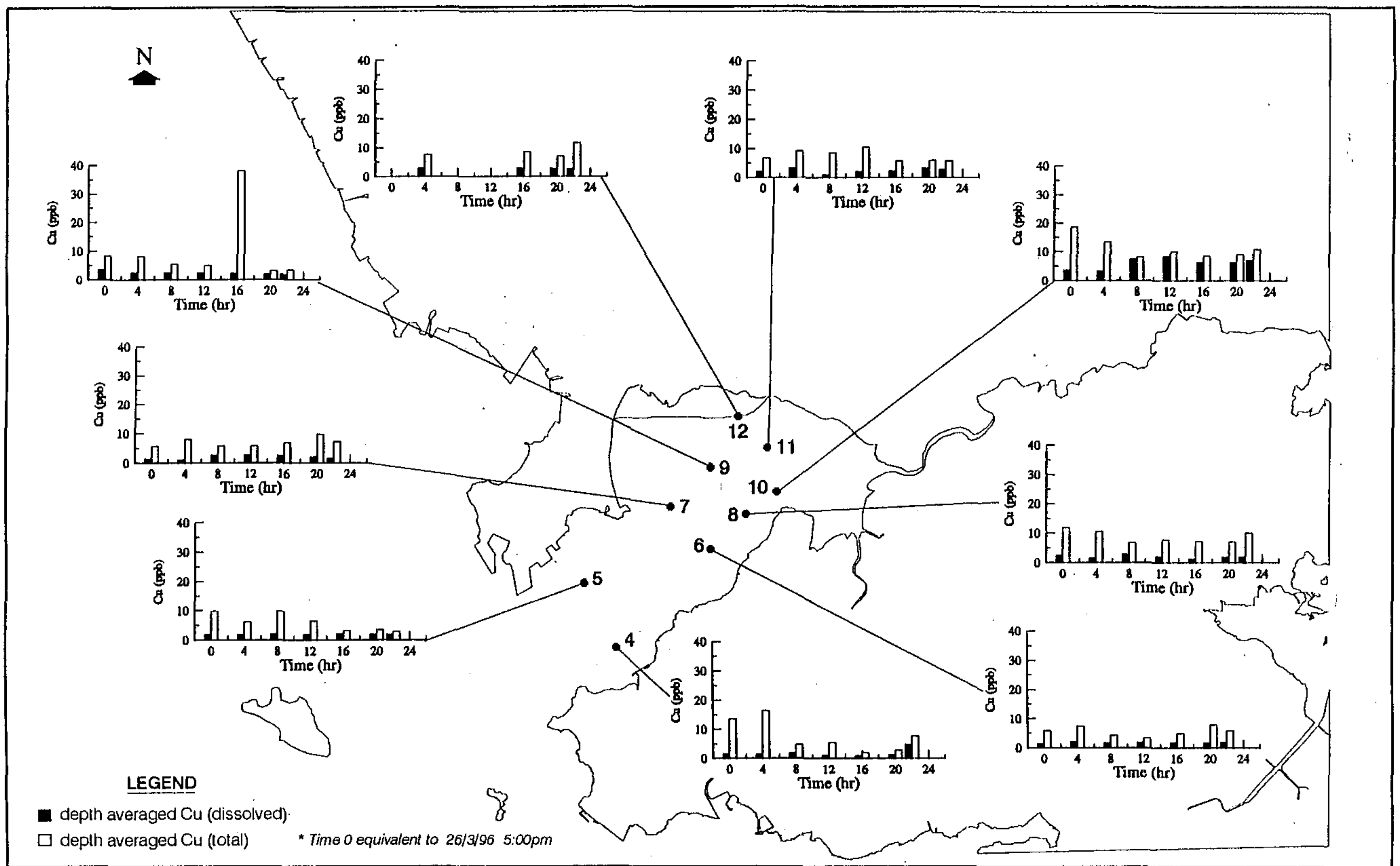


Figure 4.9 Copper Distribution at Primary Stations

AXIS Environmental

CES

97112

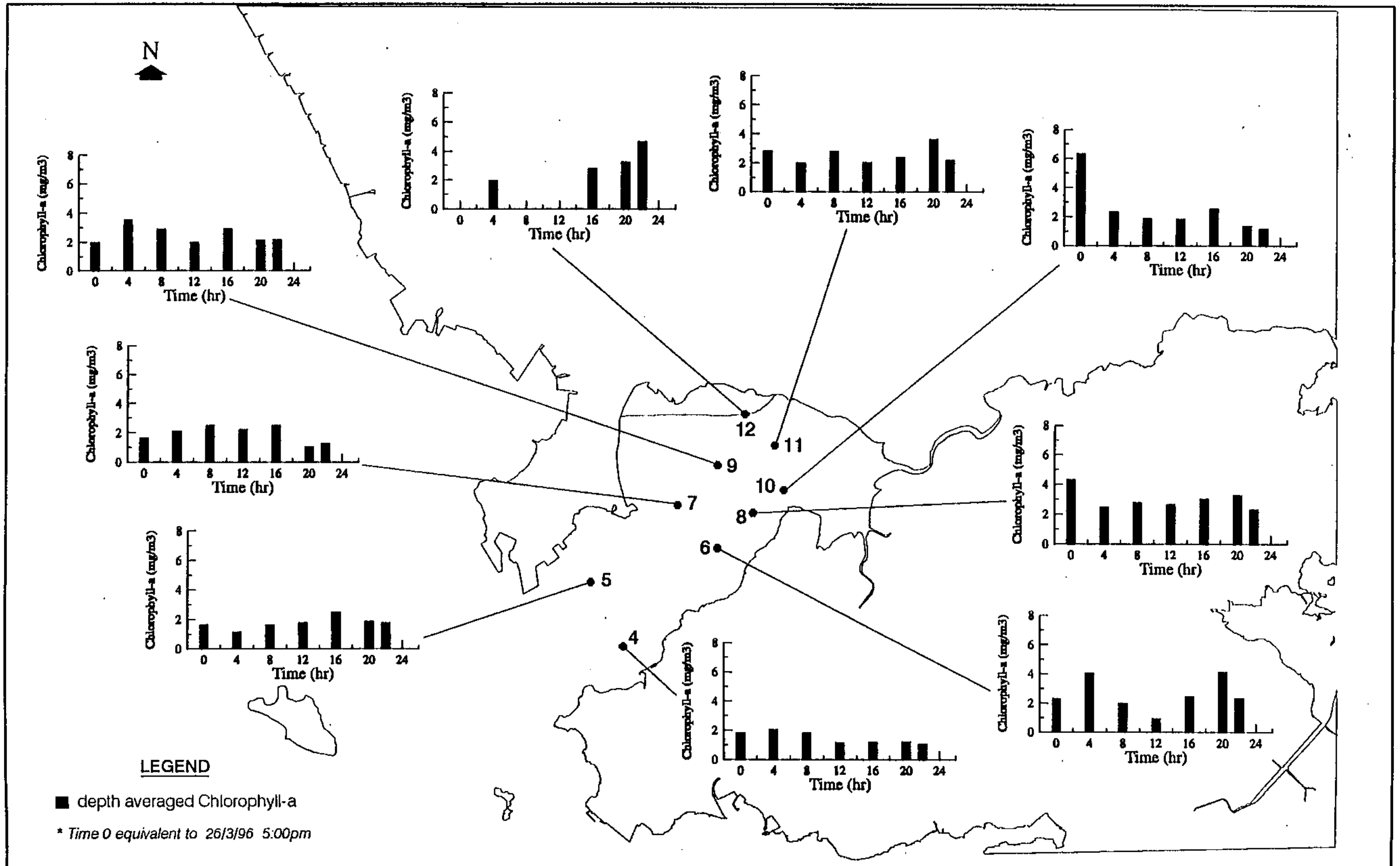


Figure 4.10 Chlorophyll-a Distribution at Primary Stations

AXIS Environmental

CES

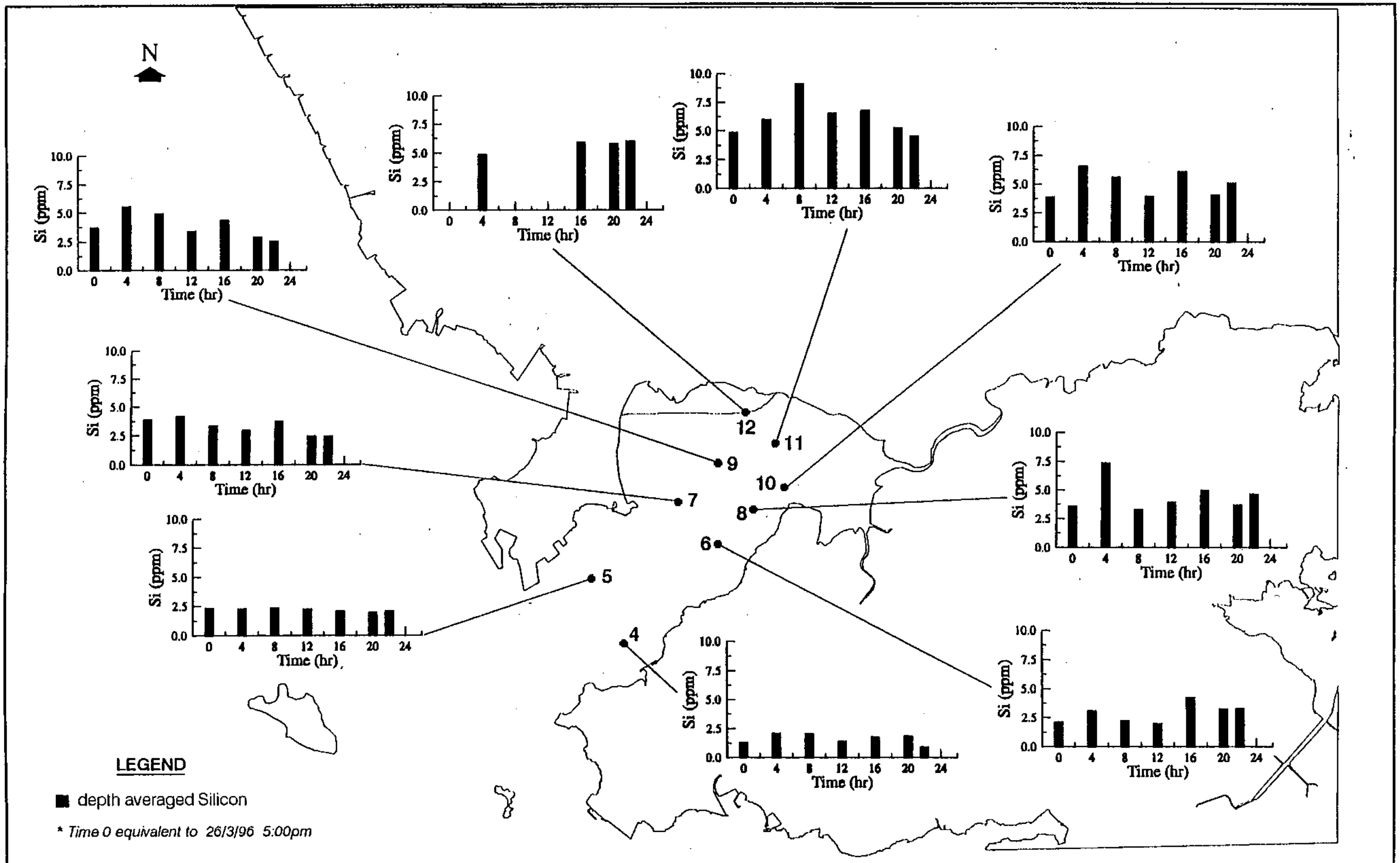


Figure 4.11 Silicon Distribution at Primary Stations

AXIS Environmental

CES

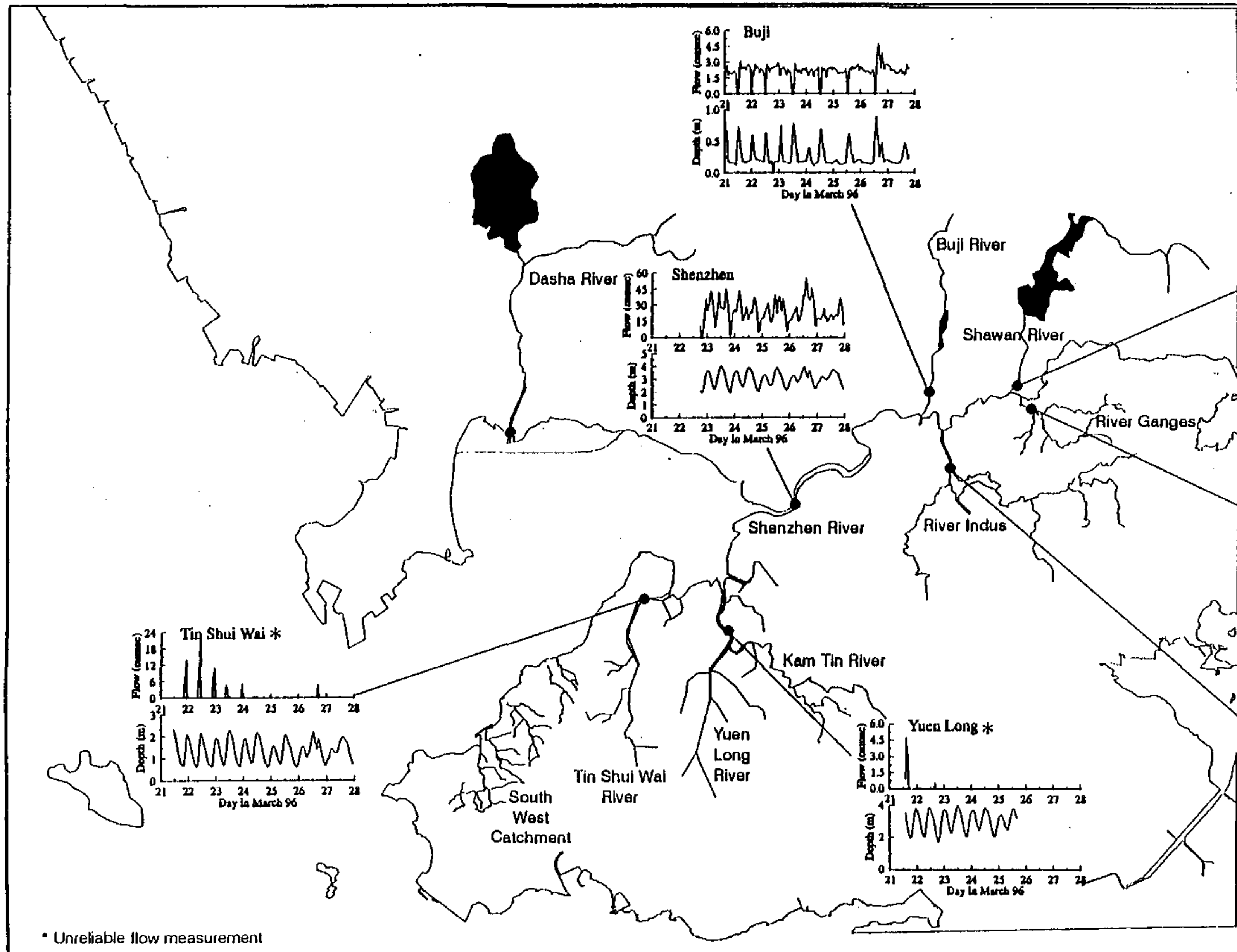


Figure 4.12 River Flow Measurements

AXIS Environmental

C E S

97112

Water Quality Data for Deep Bay (Wet Season) 1996

supplied by courtesy of EPD Water Policy and Planning Group reproduced from the field survey report

(Ref. Deep Bay Water Quality Regional Control Strategy Study - Agreement No. CE 17 - 95 - Hyder/CES - December 1996)

(Interim report result. Final report of the study yet to be issued.)

Appendix D2

Urban Stormwater

D2.1 The Concept

D2.1.1 The main features of the wetland concept are described in this section. The concept involves a winding channel approximately 2.7 km in length and 30 m wide consisting of alternate deep and shallow pools to encourage habitat and species diversity. The convoluted edge of the channel will increase the treatment area and its aesthetic value.

D2.1.2 It is anticipated that the majority of the treatment will be carried out within the first section of the channel, prior to the first weir, which is positioned away from the public access area as shown on the conceptual plan.

D2.1.3 The treatment capacity of the system depends not only on the size of the wetland but also on the flowrate of water into the system, the BOD loading and the temperature.

D2.1.4 The results of calculations based on the flowrates during the dry season and in rainfall events up to 15,000 m^3/day, show that the residence time in the wetland remains above the recommended 5 days and treatment efficiency is good even at lower temperatures (over 75% at 10°C) (Appendix D2.2).

D2.1.5 During higher rainfall events, treatment efficiency begins to decrease, especially at lower temperatures. During the maximum rainstorm event predicted, where flowrates of 450,000 m^3/day may occur, treatment efficiency will decrease to 60% or less.

D2.1.6 Since most storms occur when temperatures are higher, the low temperature limitation is not considered to be as critical as displayed in the design calculations. Flows in severe storms will bypass the wetland and flow into adjacent channels and wetland areas to avoid flooding of the residential area.

D2.1.7 The value of the constructed wetland as a habitat for wildlife will be described in more detail in Section 9.5.

D2.1.8 Maintenance requirements are an important consideration in achieving the designed removal efficiency. Recommended preventative measures described earlier include construction of a sediment pond to trap sediments prior to the passage of stormwater into the wetland. Dredging of an accessible sedimentation pond greatly facilitates overall management of the wetland facility.

D2.2 Calculations for Conceptual Wetland as A Water Treatment System

D2.2.1 The wetland to be constructed in the north-east of the RZ can best be described as a Free Water Surface System (FWS) as defined by the USEPA in their Wetland Design Manual[1]. A preliminary design has been prepared to illustrate the capability of the constructed wetland in treating urban stormwater run-off. The wetland will consist of a highly convoluted channel 2,690 m in length, averaging 30 m in width and with an overall surface area of 80,700 m^2 or 8 ha. Depth will vary from a deep settlement pond at the inlet to shallow reedbeds and occasional deep pools for fish throughout the length of the channel. The average depth of the system is approximately 1 m.

D2.2.2 The USEPA Wetland Design Manual gives many criteria for the successful design and operation of a constructed wetland and many of the assumptions, design criteria, equations and case studies are relevant to this study. The main considerations when designing a constructed wetland are the removal of BOD_5; the BOD_5 loading rate and the consequent oxygen requirements; and the hydraulic loading rate.

D2.2.3 Each of the above criteria will be considered with reference to the above design parameters. The following calculations give an indication of the expected performance of the wetland with regard to stormwater treatment.

BOD5 Removal

D2.2.4 BOD5 removal is accomplished by microbial action and is related to available oxygen. Based upon information in the USEPA Wetland Design Manual, BOD5 removal can be described by a first order model as in equation 1:

$$[Ce/Co]=\exp(-K_T t) \qquad (1)$$

where,

Ce = effluent BOD5, mg/l
Co = influent BOD5, mg/l
K_T = temperature-dependant first-order reaction rate constant, d^{-1}
t = hydraulic residence time, d

Hydraulic residence time is described by the following equation:

$$t = (L.W.d)/Q \qquad (2)$$

where,

L = length, m
W = Width, m
d = Depth, m
Q = Average flow rate, m^3/d

[1] USEPA Design Manual, Constructed Wetlands and Aquatic Systems for Municipal Wastewater Treatment, EPA/625/1-88/022, September 1988

D2.2.5 In a wetland, a portion of the available volume will be occupied by vegetation and so the actual detention time will be a function of the porosity (n) which can be defined as the remaining cross-sectional area available for flow.

$$n=Vv/V \quad (3)$$

Where Vv and V are the volume of voids and total volume respectively.

By combining equations 1,2 and 3 we get:

$$Ce/Co=A.\exp[(-0.7.K_T(Av)^{1.75}.L.W.d.n)/Q] \quad (4)$$

Where,

A	=	fraction of BOD5 not removed as settleable solids near the head of the system (as decimal fraction)
Av	=	specific surface area for microbial activity, m^2/m^3
L	=	length of system, m
W	=	width of system, m
d	=	depth of system, m
n	=	porosity of system (as decimal fraction)
Q	=	average hydraulic loading on system, m^3/d

K_T = Temperature corrected rate constant, where

$$K_T=K_{20}(1.1)^{(T-20)} \quad (5)$$

D2.2.6 Whilst many of the parameters can be calculated, some such as A, K_{20} Av and n must be estimated. The following values were recommended by the USEPA Wetland Design Manual

A	=	0.52
K_{20}	=	0.0057 d^{-1}
Av	=	15.7 m^2/m^3
n	=	0.75

Based upon the preliminary design described previously above:

W	=	30 m
d	=	1 m
L	=	2690 m

Temperature, T, is assumed to very from 10°C to 35°C.

D2.2.7 Q is the main variable which varies greatly depending upon the specific flood conditions. From Royal Observatory data, Tin Shui Wai receives between 600 and 2400mm/year, averaging 2000mm/year (data from isohyets maps of mean annual rainfall distribution between 1961 and 1990). The total volume of rain per day is shown in Table D2.1.

Table D2.1
Volumes of rainfall in Tin Shui Wai

Rainfall mm/year	Total Annual Volume (m^3 $year^{-1}$)	Q m^3 d^{-1}	Volume per second m^3 s^{-1}
600	1,406,725	3,854	0.0446
2,000	4,689,082	12,847	0.1487
2,400	5,626,898	15,416	0.1784

D2.2.8 No run-off data is available for Tin Shui Wai, however, RO provides data for other sites which can be used as reference (Table D2.2)

Table D2.2
Run-off data for other catchments within the New Territories

	Max m^3 $ha^{-1}d^{-1}$	Wet m^3 $ha^{-1}d^{-1}$	Dry m^3 $ha^{-1}d^{-1}$	Average m^3 $ha^{-1}d^{-1}$
Shek Pi Tau	3,098	52.3	9.5	31.5
Kam Tin	709	145.9	91.2	118.6
Yuen Long A	1,416	31.8	6.0	19.2
Yuen Long B	2,718	139.0	42.4	91.1
Nim Wan	2,001	66.9	9.4	35.9
Average	1,988	87	31	59

D2.2.9 The catchment area for the designed constructed wetlands is 2,344,415 m^2, or 234.5 ha. Based upon this value, the total volumes of rain expected for the New Territory sites is shown in Table D2.3.

Table D2.3
Rainfall volumes based on catchment area of 234.5 ha

	Max m^3 d^{-1}	Wet m^3 d^{-1}	Dry m^3 d^{-1}	Average m^3 d^{-1}
Shek Pi Tau	726,481	12,264	2,227	7,386
Kam Tin	166,260	34,213	21,386	27,811
Yuen Long A	332,052	7,457	1,407	4,502
Yuen Long B	637,371	32,595	9,942	21,362
Nim Wan	469,234	15,688	2,204	8,418
Average, Q	466,279	20,443	7,433	13,895

D2.2.10 Flow rates vary considerably between wet and dry seasons with occasional very high but short duration flows during exceptional storm events. Assuming the average values can be applied to the Tin Shui Wai area (Table D2.4), the contaminant removal values (Ce/Co) can be calculated for each flowrate (Table D2.5).

Table D2.4
Average seasonal rainfall volumes for New Territories catchments

	$Q\ m^3\ d^{-1}$
Wet Season	21,000
Dry Season	7,500
Annual Average	15,000
Minimum	4,000
Maximum	450,000

Table D2.5
Contaminant removal (Ce/Co) values under different flowrate and temperature conditions

Q	Residence Time (Days)	T=10°C	T=35°C
4,000	20.2	0.029	0
7,500	10.8	0.112	0
15,000	5.4	0.241	0
21,000	3.8	0.300	0.001
450,000	0.18	0.507	0.394

D2.2.11 The best results are obtained with low flow and high temperatures. The residence time varies between 4.5 hours and 20 days. The optimum is considered to be about 5.5 days (Gersberg 1985).

Oxygen Requirements and BOD5 Loading Rates

D2.2.12 The oxygen requirements for the system are defined as follows:

$$\text{Required Oxygen (RO)} = 1.5.\text{BOD5} \tag{7}$$

$$\text{Available Oxygen (AO)} = (\text{TrO2}).(\text{As})/1000 \tag{8}$$

where,

O_2 = oxygen required
BOD_5 = organic loading, kg/d
TrO2 = oxygen transfer rate for vegetation, 20 g/m^2/d
As = surface area, m^2

D2.2.13 Following the experience of previous studies, a BOD_5 loading of 30 mg/l was used with the calculated flowrates to determine the AO and RO values under each set of flow conditions (Table D2.6).

Table D2.6
Available and required oxygen levels under different flow conditions

Q m^3/day	BOD5 kg/day	BOD Loading Rate kg ha^{-1}d^{-1}	RO	AO	AO/RO
4,000	120	15	180	1,614	8.97
7,500	225	28.13	338	1,614	4.78
15,000	450	56.25	675	1,614	2.39
21,000	630	78.75	945	1,614	1.71
450,000	13,500	1,687.5	20,250	1,614	0.08

D2.2.14 Ideally the available oxygen (AO) should exceed the required oxygen (RO) by a factor of 2. In this case, flows up to 21,000 m^3/d will produce acceptable AO/RO ratios. Upper limit BOD5 loading rates of 133 kg BOD_5/ha-d have been given as guideline value based upon an oxygen transfer rate of 20 g/m^2-d. Based on the above values for Q, BOD_5 loading rates can be expected to vary between 15 and 1,688 kg BOD_5/ha-d. However, it should be noted that the very high flow rates and high BOD_5 loading rates represent exceptional storm events. The average wet weather flow rates will produce BOD_5 loading rates well within recommended levels. In addition, it should be noted that the levels of pollutants will be much greater during the initial phase of the storm, declining exponentially throughout the duration of the storm. Therefore, during a severe storm the majority of the pollutant load may be captured by the wetland whilst the remainder is diverted. Detailed analysis of the actual operating conditions should conducted during the detailed design phase.

Hydraulic Loading Rates

D2.2.15 Using an area of 8 ha for the wetland, hydraulic loading rates can be expected to vary from 500 m^3/ha-d to 56,250 m^3/ha-d. Wet season levels can be expected to be around 2,625 m^3/ha-d whilst dry season levels will be around 938 m^3/ha-d. During high storm flows, much of the water can be diverted by allowing overflow of the weir at the entrance to the constructed wetland. The placement of weirs at intervals along the course of the wetland channel should be considered during the detailed design stage.

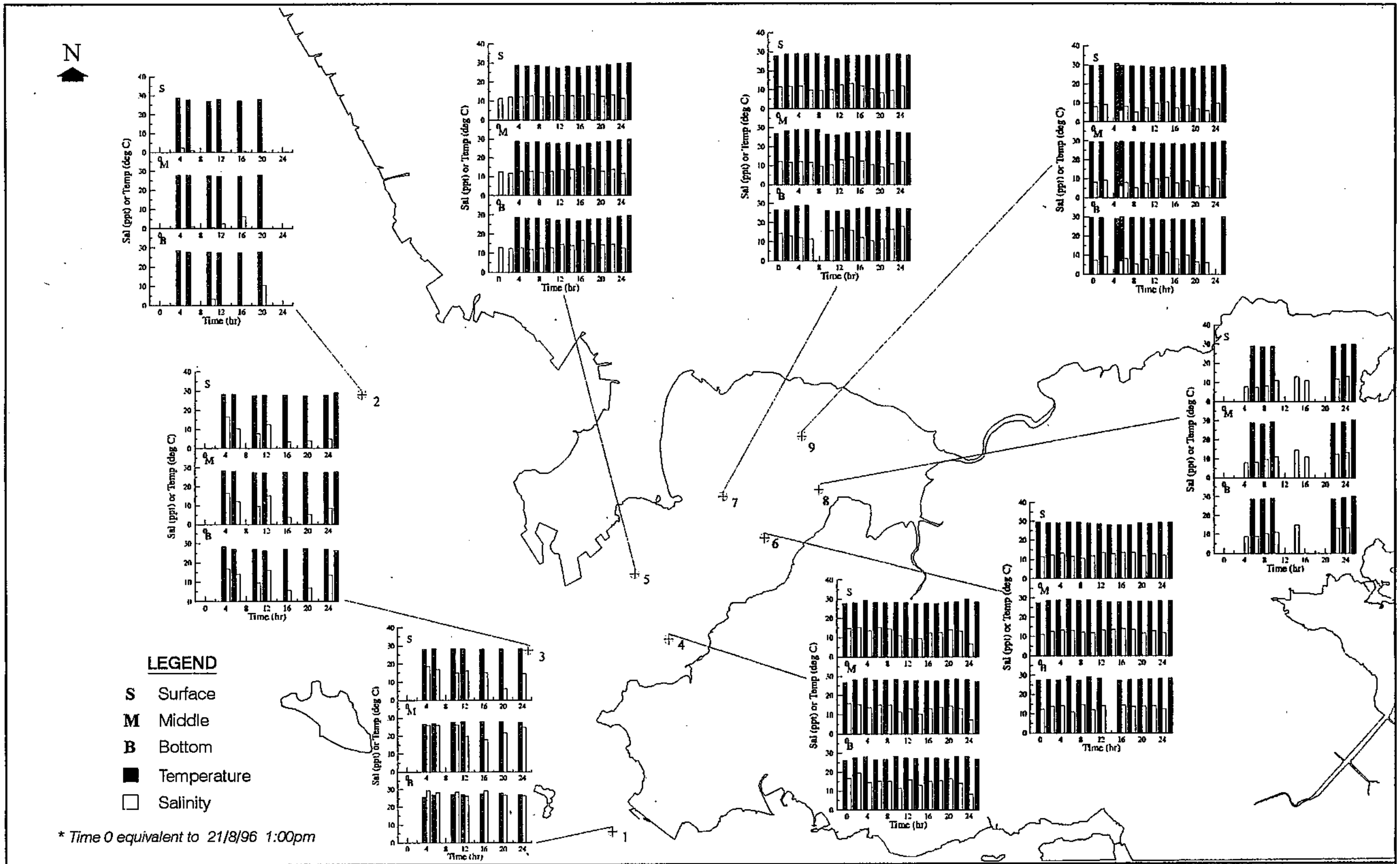


Figure 4.1 Temperature & Salinity Distribution at Primary Stations

Hyder Consulting

CES

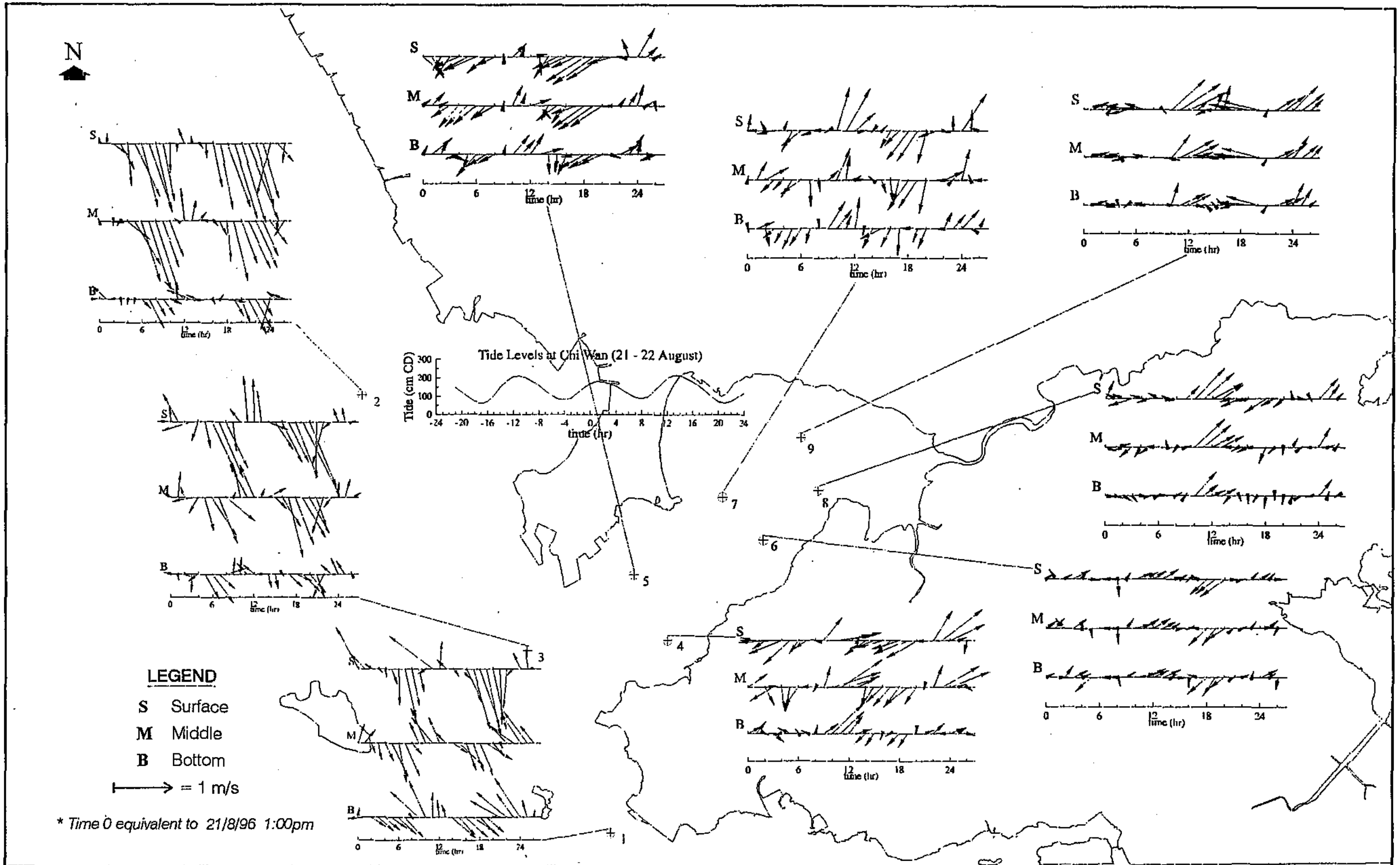


Figure 4.2 Current Measurements at Primary Stations

Hyder Consulting

CES

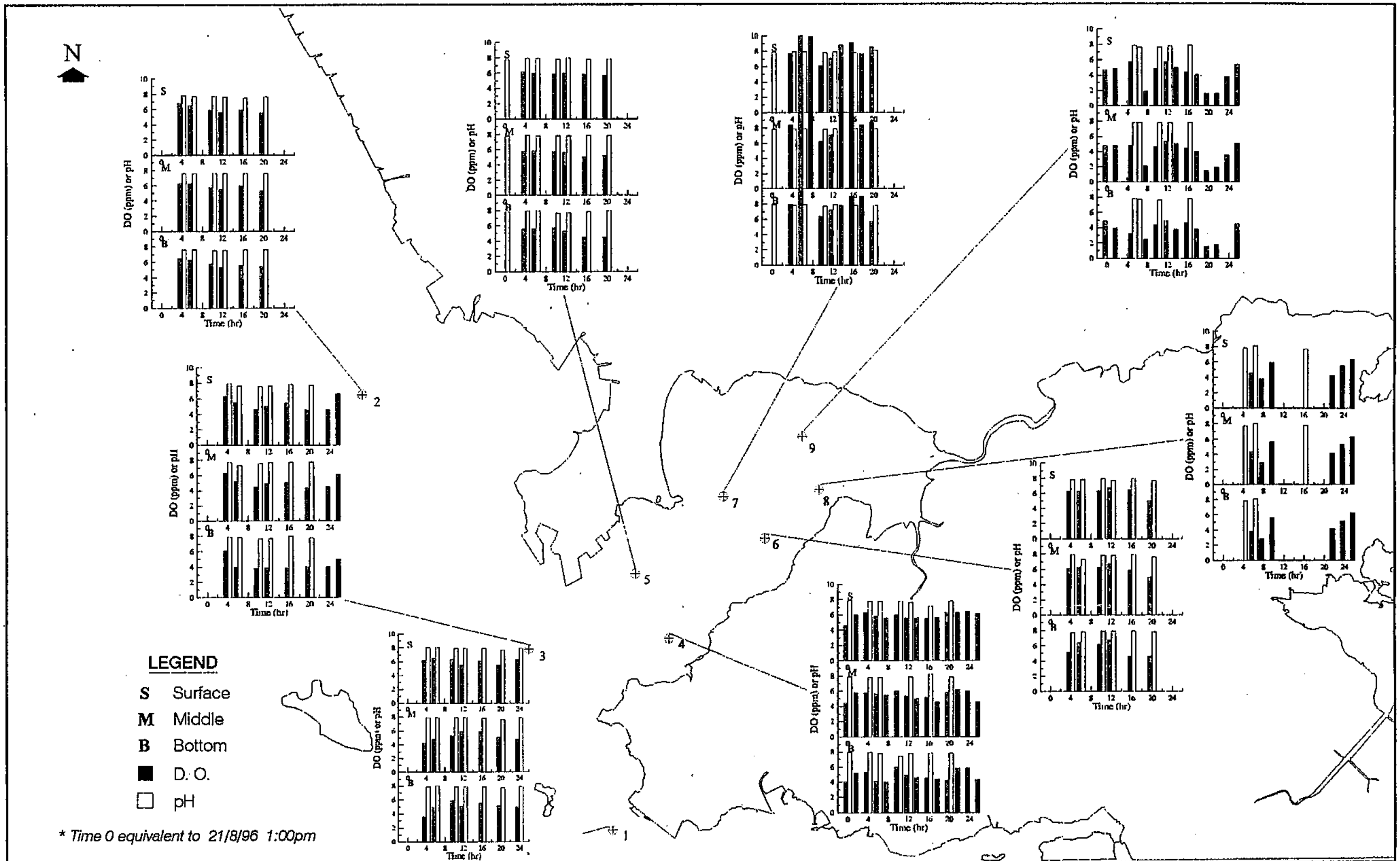


Figure 4.3 Dissolved Oxygen (D.O.) and pH Distribution at Primary Stations

Hyder Consulting

CES

97114

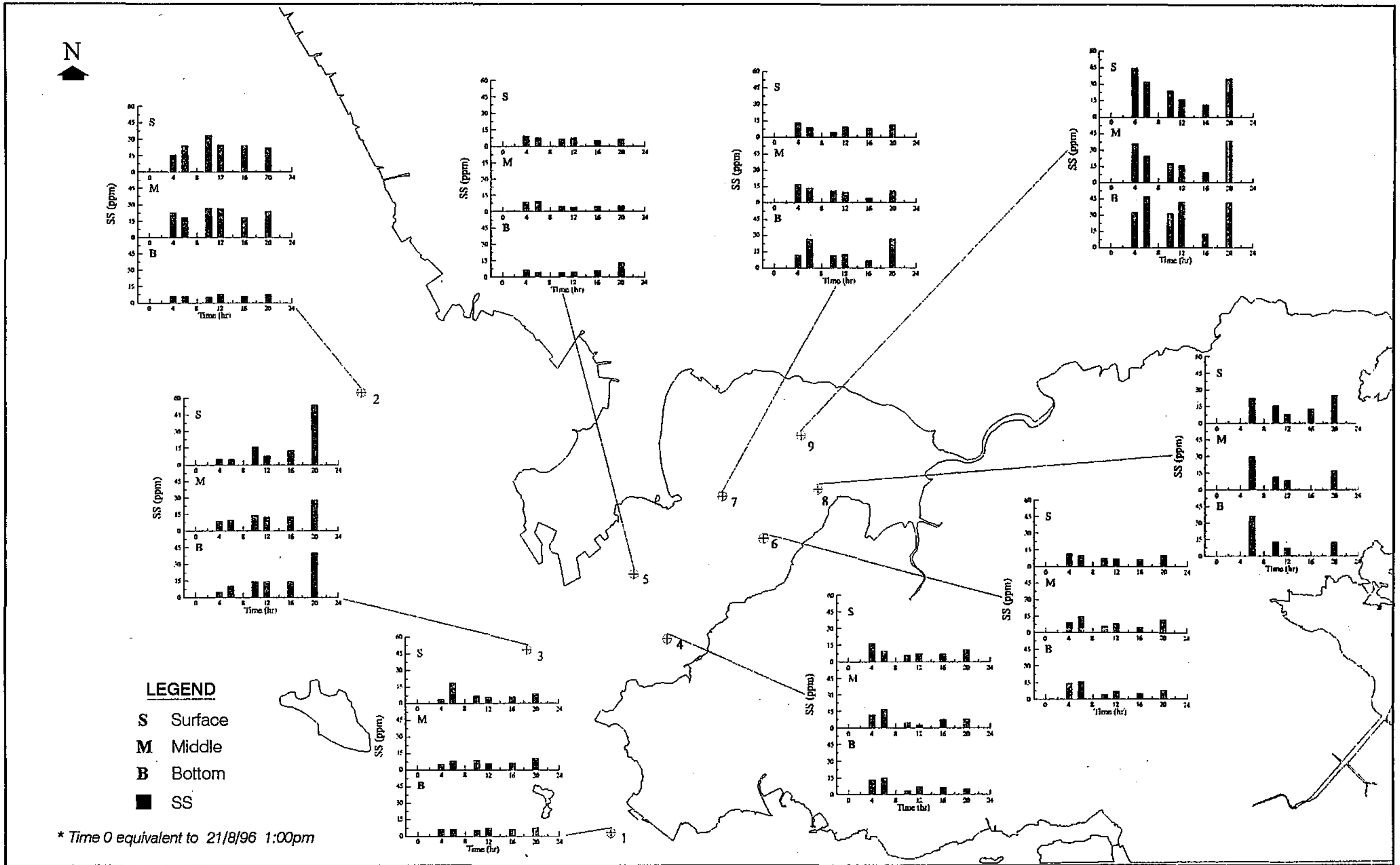


Figure 4.4 Suspended Solids (SS) Distribution at Primary Stations

Hyder Consulting

CES

97114

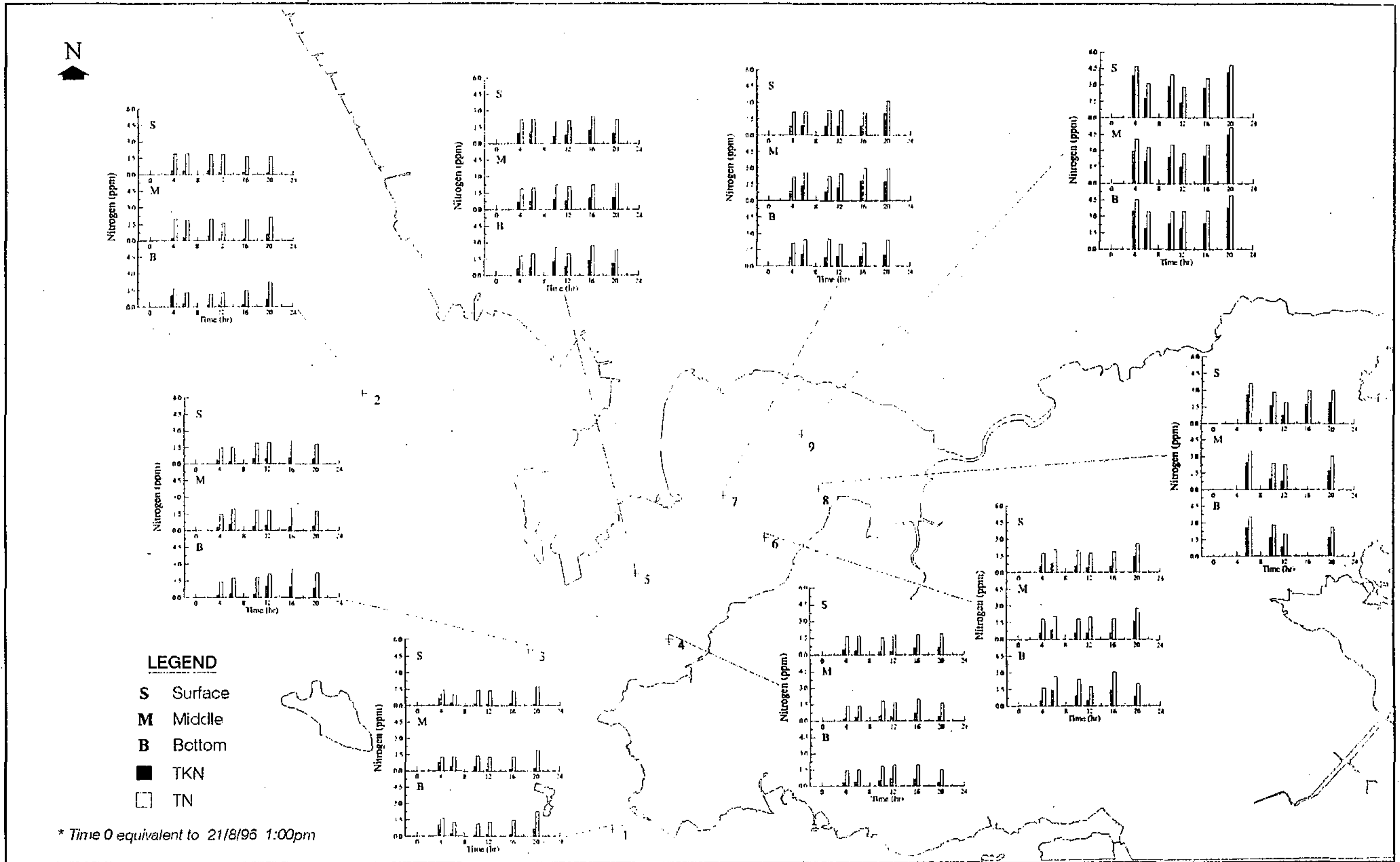


Figure 4.5 Nitrogen Distribution at Primary Stations

Hyder Consulting

CES

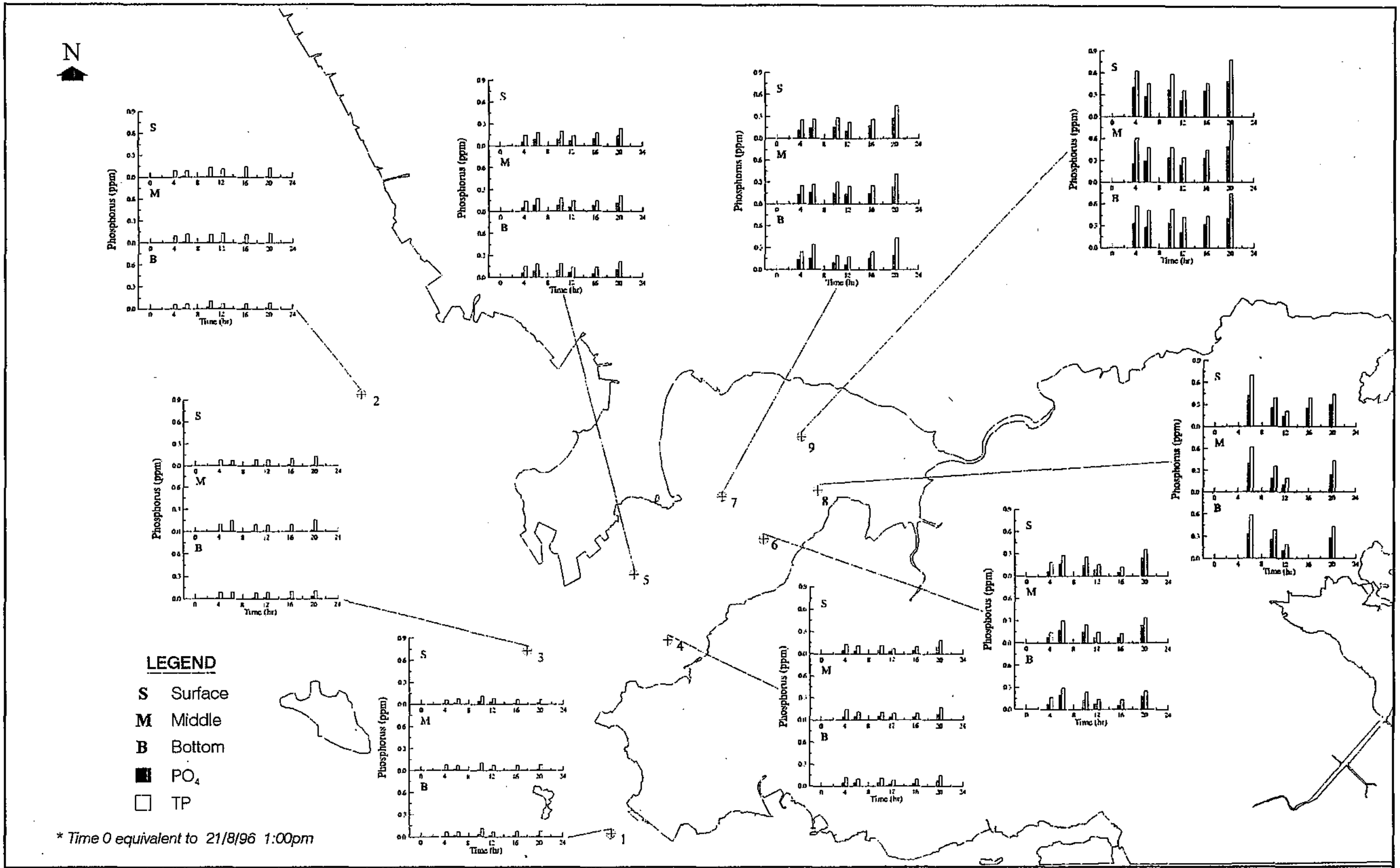


Figure 4.6 Phosphorus Distribution at Primary Stations

Figure 4.7 Total Organic Carbon (TOC) Distribution at Primary Stations

Hyder Consulting

CES

97114

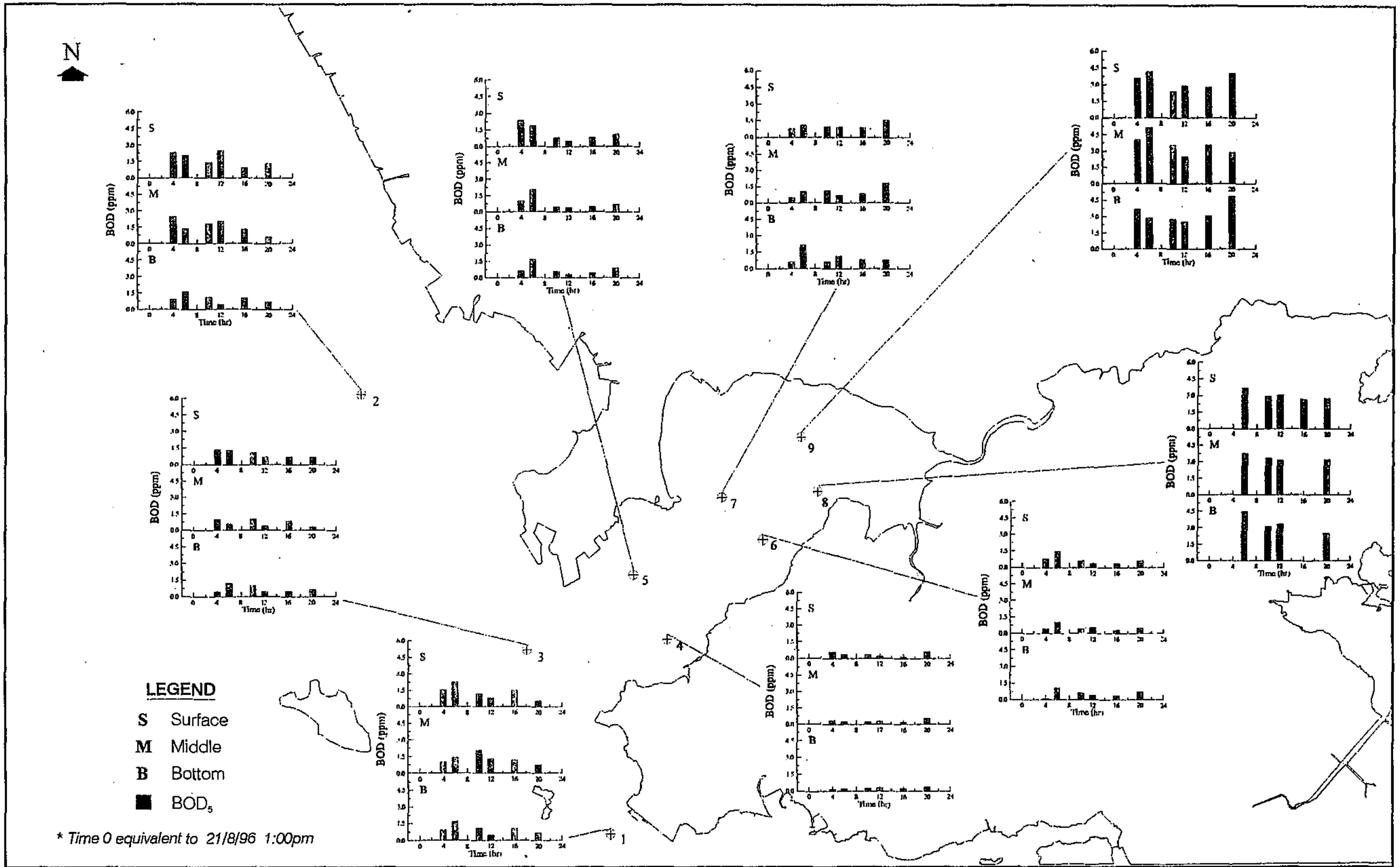


Figure 4.8 Biochemical Oxygen Demand (BOD_5) Distribution at Primary Stations

Hyder Consulting

CES

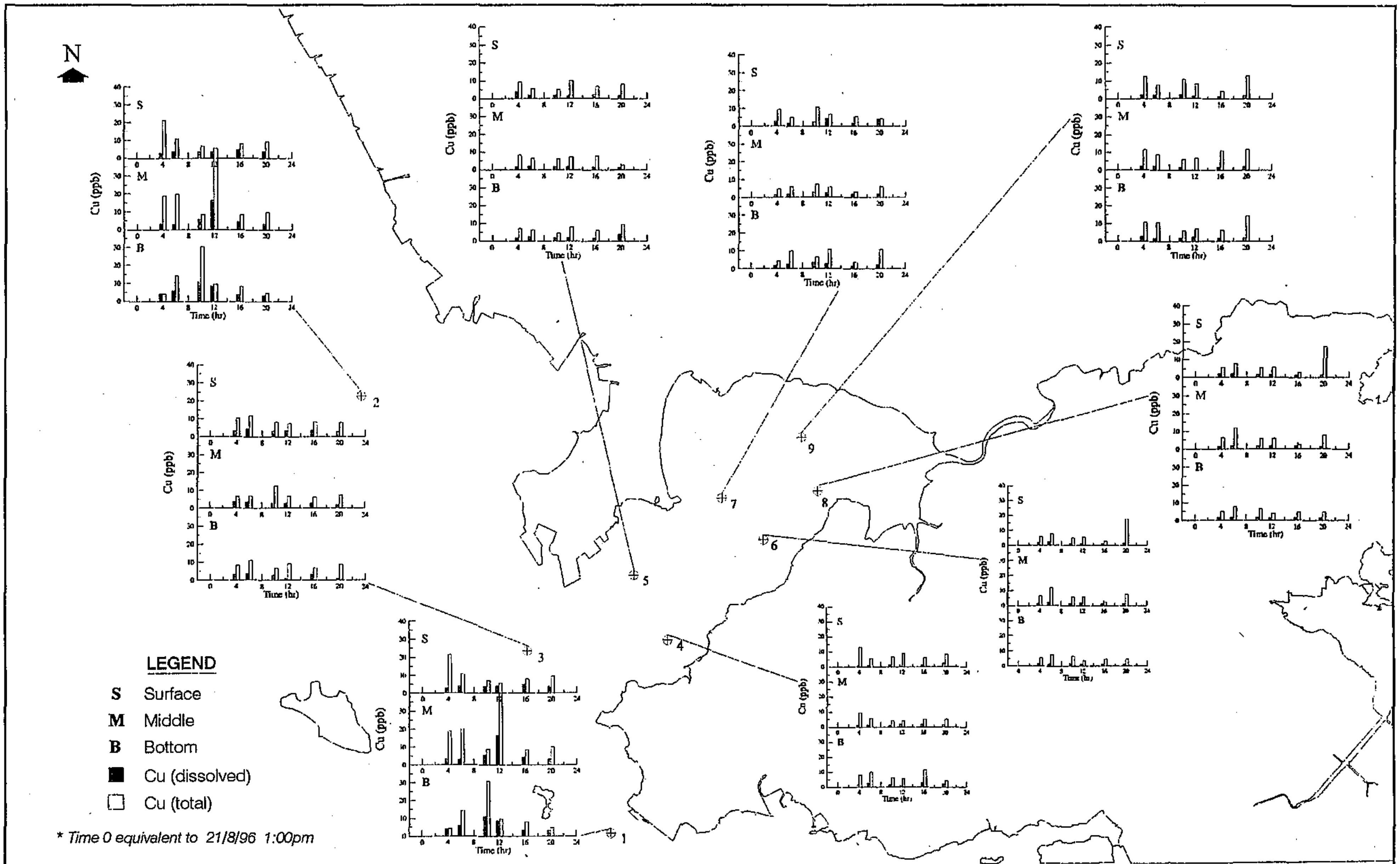


Figure 4.9 Copper Distribution at Primary Stations

Hyder Consulting

CES

97114

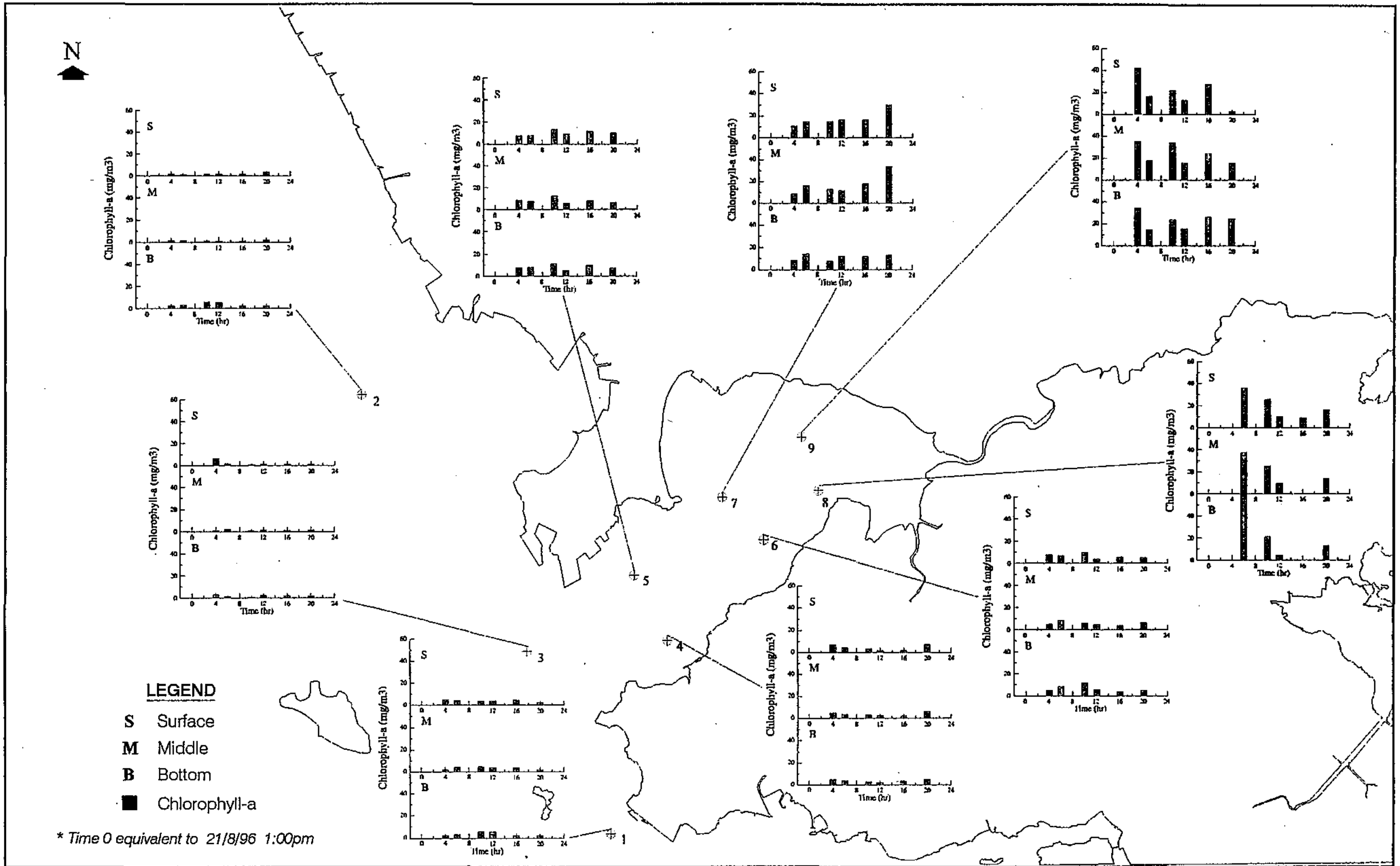


Figure 4.10 Chlorophyll-a Distribution at Primary Stations

Hyder Consulting

CES

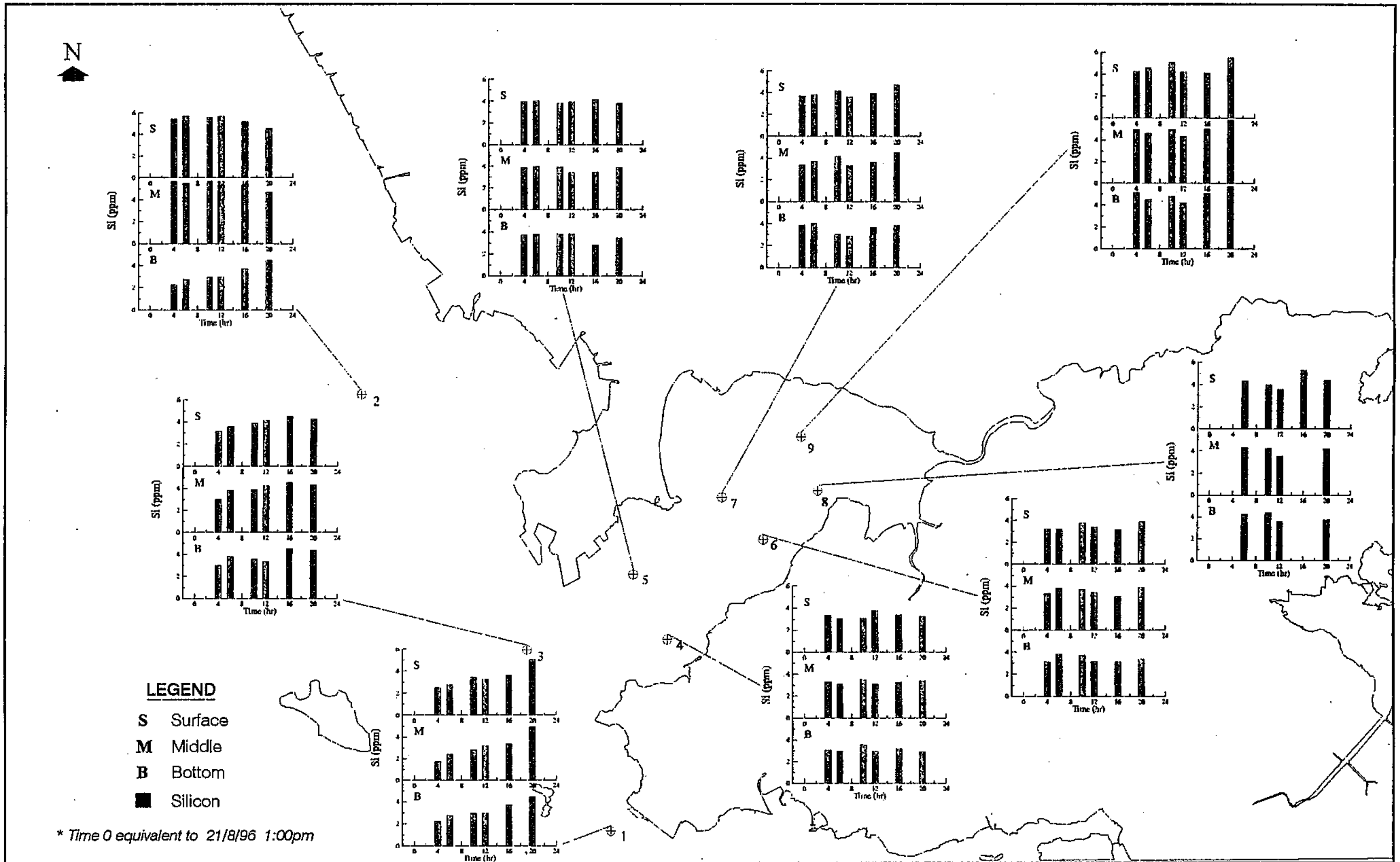


Figure 4.11 Silicon Distribution at Primary Stations

Hyder Consulting

CES

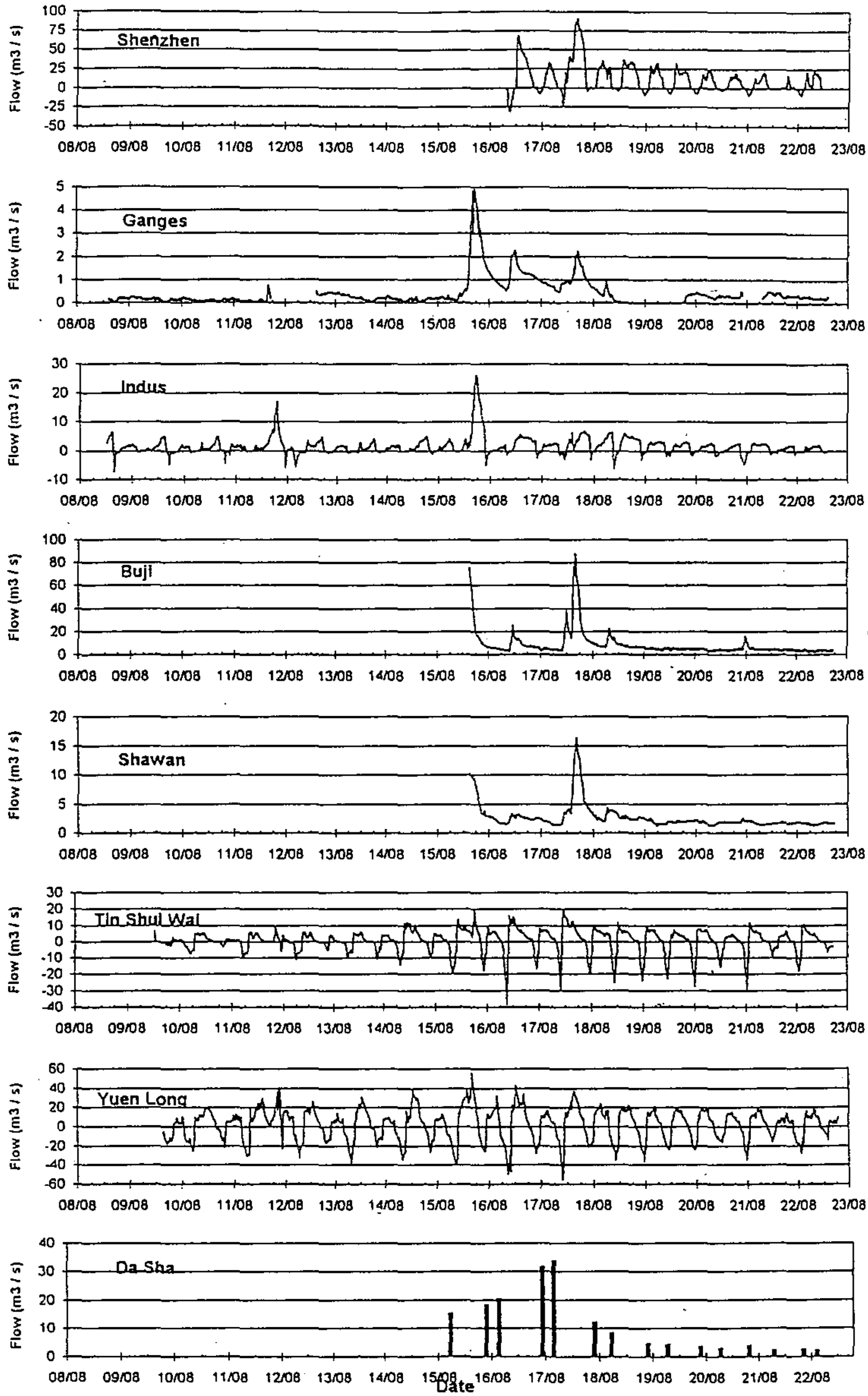


Figure 4.12 River Flow measurements

Appendix E

Ecology

Appendix E1

Literature Review

APPENDIX E1 LITERATURE REVIEW

Introduction

E1.1 The purpose of this Literature Review is to locate pertinent information about the ecology of the Study Area, and to review it in sufficient detail to determine where data gaps exist and the gaps which should be filled. The product of the Literature Review is a summary of available ecological information on the Study Area given below. This is followed by a description of the data gaps.

E1.2 The sources of information used for this Review include: the bibliography of marine science (Morton, 1990), related EIAs, newsletters e.g. Hong Kong University's "Porcupine," magazines, The Worldwide Fund for Nature's "About Life" and technical reports from the Agriculture and Fisheries Department, Environmental Protection Department and Binnie Consultants Limited libraries, in addition to scientific publications.

Ecosystems

E1.3 The Study Area covers 38 km^2 and includes five Sites of Special Scientific Interest (SSSIs) which have been selected based on ecological grounds: Inner Deep Bay, the Mai Po Marshes, Mai Po Egretry, Tsim Bei Tsui Egretry, and Tsim Bei Tsui. The Study Area includes most of the Ramsar Site, designated in September 1995, based on the importance of the mudflats as a feeding ground for international migratory birds, several of which are rare or endangered species.

E1.4 There are several interlinked ecological systems within the Study Area including a subtidal estuarine ecosystem (Deep Bay); freshwater ecosystems comprising reedbeds and ponds; the intertidal ecosystem (the mudflats and mangals); and the terrestrial ecosystem. The links between these systems are evident in the transport of air, water and sediment carried by the water, as well as the movement of organisms.

Study Area Habitats

E1.5 The habitats in the Study Area are conveniently divided into terrestrial and estuarine. Terrestrial habitats in the Study Area comprise grasslands dominated by the hydroseeded landbank, fishponds, freshwater reedbeds, ephemeral (vernal) wetlands, and plantation and native woodlands. Estuarine habitats include the subtidal seabed and the water column itself, and the intertidal mudflat, mangrove, and gei wai.

Terrestrial Geography

E1.6 Fishponds dominate the terrestrial habitat region of the Study Area. The next largest area is the urbanized environment, followed by grasslands with occasional bare patches, cultivated fields and abandoned agricultural areas. Woodlands (plantation, orchard, and native) make up the remaining area. Some freshwater habitats support reedbeds (Ashworth *et al.* 1993) while the ephemeral (vernal) wetlands occur within the grassland habitat.

Seasonality

E1.7 The annual weather pattern in Hong Kong is monsoonal. Normally between October and March, high pressure weather systems on the Asian continent bring an east-northeasterly air flow to the Territory. At this time, the weather is characterized by cool temperatures, low humidity and rainfall. Between April and September, relatively low pressure weather systems above Asia reverse the flow, and the southwest monsoon dominates the Hong Kong weather, bringing hot, humid weather, and most of the annual average rainfall.

E1.8 Some of the obvious seasonal patterns in Hong Kong terrestrial ecology include the regular migration pattern of birds. Other seasonal patterns such as leaf drop in deciduous trees, flowering and fruiting of plants are not synchronized with climatic seasonality among all species in Hong Kong (Dudgeon and Corlett 1994). For example, many grasses flower in the period from October to December when the strongest mean wind speeds promote pollination, while most other plants in Hong Kong show a flowering maximum in May (Dudgeon and Corlett 1994).

Geology and Soils

E1.9 Most of the Study Area comprises flat and low-lying marshy land, with a few hills, notably those at Lau Fau Shan, Ping Shan, and the rocky outcrops at Mai Po Marshes Nature Reserve. The lowlands are underlain by less-resistant Devonian - Permian sedimentary bedrock, and the hills are formed from more resistant Jurassic - Cretaceous granites, or silicified sedimentary rock.

E1.10 The low-lying flat marshlands have thick Quaternary deposits overlying the Palaeozoic bedrock. These Quaternary deposits reflect rising sea level at the end of the last Ice Age. Coarse bouldery colluvial deposits flank the solid bedrock hills. The colluvium grades laterally into sandy alluvial deposits. The rise in sea level caused the deposition of marine clays on top of these colluvial/alluvial deposits. Finally, recent deposits of silt and mud prograded across marine muds, and form the surface throughout most of the low-lying area.

E1.11 The soils developed on the granites in the hills along Lau Fau Shan tend to be silty-sand soil (Dudgeon and Corlett 1994). The soils developed on the marine deposits are finer-grained silty clay soils. In places where mangroves prograded across the surface, acid-sulphate soils develop (Gong and Zhang 1996). It is these acid-sulphate soils that make liming fishponds essential to neutralize pH when refilling.

Environmental History

E1.12 Only a small proportion of the terrestrial habitats currently present in the Study Area were terrestrial at the turn of the 20th century. The woodlands and grasslands surrounding Lau Fau Shan were terrestrial then, but the areas of fishponds today were mostly either mangrove forest or saltmarsh (Melville *et al.* 1989). These coastal habitats were converted first to rice paddy and then to *gei wai* and/or fishponds (Chan 1970, Cheung 1979, Leung 1986, Irving and Morton 1988).

Estuarine Geography and Oceanography

E1.13 Deep Bay is the largest estuary in Hong Kong and includes the border between Hong Kong and China in the extreme north-western quadrant of the New Territories. It covers a total area of 112 square kilometres but is quite shallow, with an average depth of only 3 metres (Irving and Morton, 1988). About 2700 ha of mudflat is exposed at the lowest tide. The maximum tidal range is approximately 2.8 metres.

E1.14 The Deep Bay water shed is drained by the Shenzhen River from the north-east, the Shan Pui River and the TSW channels from the south, and a number of other small streams from the north side of the Bay. The Bay in turn opens into the main Pearl River estuary which occupies an area of 8,000 km^2 (Fu *et al.* 1995) and has an annual flow of around 349.2 billion cubic metres (Chen and Wei, 1995).

E1.15 Deep Bay supports one of the largest remaining stands of the mangroves in China and is the habitat for many species of invertebrates new to science (Lee, 1993). It also supports 13 species of globally threatened waterbirds (Young and Melville, 1995) (see Table E1.1). Hong Kong Government has also appreciated the importance of Inner Deep Bay, and established a site of the Special Scientific Interest (SSSI) there in March 1986. Furthermore, the government subsequently included a large portion of Inner Deep Bay in the Ramsar List of Wetlands of International Importance. The Ramsar site is included as a wetland in the Asian-Australasian Flyway Reserve Network (March 1996). Inner Deep Bay is also eligible for protection under the Bonn Convention on the Conservation of Migratory Species of Wild Animals (WWF, 1993).

E1.16 Water movement patterns and sediment distribution in the Pearl River Estuary are dominated by an annual inflow of water and sediment from the Pearl River. The flow in the estuary is very complex. In the summer wet season, the estuary stratifies when a layer of freshwater flows out over a layer of brackish water (Figure E1.1). Gravity circulation currents are set up which cause the more saline bottom waters to flow landwards. In winter a partially mixed regime exists (Binnie *et al.*, 1985).

E1.17 The hydrography of Deep Bay itself is also very complex. The wet season runoff exceeds that of the dry season by a factor of four and the seaward perimeter experiences constant changes in water quality due to the mixing of the coastal and estuarine waters in the Urmston Road area.

E1.18 Binnie *et al.* (1985) used float tracking to define water movement. Tidal vector charts based on the dry season data produced for spring and neap tides are shown in Figures E1.2a and b and E1.3a and b. The spring tide flows in and out of the bay along a northeast/southwest axis. A clockwise rotation is just discernible at HHW and LHW in Inner Deep Bay. The neap tides are similar although the circulation is not apparent. In general the wet season float tracks were similar to the dry season movements.

E1.19 Measurements of water temperature and salinity made during the dry season show the water column to be well mixed particularly within Inner Deep Bay. A maximum bed to surface salinity variation of 0.5 g/kg was found in the Outer Bay. Tidal variations were not detected in Inner Deep Bay but a maximum of 2 g/kg existed in the Outer Bay.

Table E1.1
Waterfowl species for which Deep Bay is important (Source: Young and Melville, 1995)

	Bonn (1)	ICBP (2)	% World (3)	% Flyway (4)
Dalmatian Pelican	I	*	1	
Chinese Egret	I	*		
Black Stork	II			
Oriental White stork	I	*	10	
European Spoonbill	II			
Black-faced Spoonbill		*	24	
Baikal Teal		*		
Baer's Pochard		*		
Anatidae	II			
Black Vulture		*		
Imperial Eagle		*		
Osprey	II			
Lesser Sand Plover				1+
Greater Sand Plover				1+
Curlew Sandpiper				1+
Broad-billed Sandpiper				1+
Spoon-billed Sandpiper				1+
Asiatic Dowitcher		*		1+
Black-tailed Godwit		*	1+	
Marsh Sandpiper				1+
Greenshank				1+
Spotted Greenshank		*	1	1+
Recurvirostridae	II			
Phalaropidea	II			
Charadriidae	II			
Scolopacidae	II			
Saunders' Gull	I	*	5	
Relict Gull	I	*		

(1) Species listed in Appendix I or II of the Bonn Convention on the Conservation of Migratory Wild Animals.
(2) Species listed as "threatened" (Collar & Andrew 1988).
(3) Estimated % of world population of each species regularly occurring in Deep Bay (various sources).
(4) Estimated % of East Asian/Australasian Flyway population regularly occuring in Deep Bay (various sources - flyway population estimates after Watkins 1993).

E1.20 In 1986 a two-dimensional flow model suggested that there were a number of small residual current circulation cells, both clockwise and anti-clockwise, in the outer and inner bay areas (Binnie & Partners, 1986) (Figure E1.4). Residual currents give a guide to the net movements of water as they are an integration of flows over a tide at a single point. The spring tide residual current pattern from the above model, shown on Figure E1.4, depicts a relatively strong clockwise cell in the region of WENT, suggesting that there is no net drift towards Inner Deep Bay. The 1986 study also indicated that the main flood and ebb flows in Deep Bay occur in the main channel (Figure E1.5), not in different areas of the Bay as previously suggested, and that the ebb tide is stronger than the flood. This study (Binnie & Partners, 1986) was followed by an investigation in the following year (Binnie & Partners, 1987a) which used the water movements from the model to create synthetic float tracks and the data sets compatible with the models, used for the 1985 Tin Shui Wai EIA to determine the distribution of sediment resulting from dredging borrow areas in Deep Bay.

Water Quality in Deep Bay

E1.21 Monitoring of water quality conditions in Deep Bay between September 1985 and August 1987 established a baseline (Binnie & Partners, 1987b) so that any impacts from activities in the Bay associated with the Tin Shui Wai Land Formation and Drainage Contract could be assessed. The baseline was established with two surveys each month, and measurements were carried out at surface, mid-depth and near-bottom locations at 14 stations shown in Figure E1.6. Dissolved oxygen, salinity, temperature and suspended solids were measured in situ and samples collected were sent to the Environmental Protection Department (EPD) laboratory for testing of suspended solids and turbidity. Results quoted below are from this report unless otherwise indicated.

E1.22 Water quality parameters in the Shenzhen River and Inner Deep Bay were also measured for the Shenzhen River Project EIA (Peking University 1995).

E1.23 Temperature is generally uniform over the whole Bay during the wet and dry seasons. Variation between seabed and surface temperatures is negligible in the dry season and up to 1.7°C in the wet season.

E1.24 Annual average concentrations of dissolved oxygen in Deep Bay between 1985 and 1987 decreased towards the head of Deep Bay (Table E1.2). This trend has continued, with dissolved oxygen levels falling to critically low levels (below 2 mg/L) (Peking University 1995). The level of suspended solids levels was found to be much higher in Inner Deep Bay than Outer Deep Bay and higher at the seabed than the surface. The SS levels in Outer Deep Bay appeared to be decreasing whilst they remained fairly constant in Inner Deep Bay during the study period (Table E1.3). The data from Outer Deep Bay were similar to those from the recent studies (Binnie and CES, 1995).

Table E1.2
Annual Average Concentrations of Dissolved Oxygen in Deep Bay

Location	Sample Location(s)	Annual average concentration of dissolved oxygen (mg/l)	
		1985/86	1986/87
Mouth of Shenzhen River	W1	4.8	2.5
Mouth of San Pui River	W2	2.4	0.7
Outfalls of TSW streams	W6	3.1	1.7
Inner Deep Bay	W3, W4, W5	5.8	4.0
Lau Fau Shan Foreshore	W9, W11	6.8	6.2
Outer Deep Bay	W7, W8, W10, W12, W13, W14	6.9	6.9

Source: Binnie & Partners (Hong Kong), December 1987a.

E1.25 The waters of Deep Bay are currently covered by the EPD marine water quality and sediment monitoring programme. Monthly readings of dissolved oxygen, pH, salinity, temperature, BOD and a number of other parameters have been taken by EPD at four sites within Deep Bay (Figure E1.7) since 1988. The latest data released by EPD (1994) are shown in Table E1.4. Additional water quality data has been obtained from the recently completed study on Deep Bay Water Quality (Axis/CES, 1996).

Table E1.3
Average Levels of Suspended Solids in Deep Bay (mg/L)

Period	Seabed	Surface	All
Whole Bay			
Sep 85 to Jan 86	71	46	58
Feb 86 to Jul 86	50	39	44
Aug 86 to Jan 86	57	38	47
Feb 87 to Jul 87	56	36	46
Inner Deep Bay			
Sep 85 to Jan 86	68	47	58
Feb 86 to Jul 86	48	39	43
Aug 86 to Jan 87	59	36	45
Feb 87 to Jul 87	77	47	61
Stream outfalls			
Sep 85 to Jan 86	88	56	73
Feb 86 to Jul 86	76	43	60
Aug 86 to Jan 87	82	35	58
Feb 87 to Jul 87	98	60	79
Outer Deep Bay			
Sep 85 to Jan 86	66	42	54
Feb 86 to Jul 86	39	37	39
Aug 86 to Jan 87	44	40	42
Feb 87 to Jul 87	28	22	25

*Source: Binnie & Partners (Hong Kong), December 1987*a.

Table E1.4
Summary statistics of 1993 water quality of Deep Bay WCZ (EPD, 1994)

Determinand		Inner Deep Bay			Outer Deep Bay
		DM1	DM2	DM3	
Number of samples		12	12	12	12
Temperature (°C)	Surface	24.4 (16.1-29.5)	24.5 (17.2-29.3)	24.2 (17.7-28.8)	24.2 (18.1-29.1)
	Bottom	NM	NM	NM	23.6 (18.3-27.0)
Salinity (ppt)	Surface	17.0 (3.3-28.1)	18.3 (4.7-28.7)	20.9 (8.5-30.7)	22.1 (10.5-32.2)
	Bottom	NM	NM	NM	26.6 (20.0-32.6)
D.O. (% saturation)	Surface	62 (19-113)	83 (38-116)	94 (72-125)	99 (81-128)
	Bottom	NM	NM	NM	84 (70-109)
pH value		7.6 (6.7-8.3)	7.7 (6.7-8.5)	8.0 (7.4-8.4)	8.0 (7.4-8.4)
Secchi disc (m)		0.5 (0.2-1.0)	0.6 (0.4-1.0)	1.1 (0.5-1.6)	1.1 (0.5-1.6)
Turbidity (NTU)		33.2 (66.4-110.0)	23.8 (8.3-75.0)	11.3 (5.6-27.0)	11.2 (2.5-24.5)
Suspended solids (mg/L)		32.0 (5.5-94.0)	18.7 (10.0-37.0)	10.6 (5.5-22.0)	12.3 (1.0-25.0)
BOD (mg/L)		2.0 (1.0-4.2)	1.5 (0.5-4.4)	1.0 (0.6-2.0)	0.7 (0.4-1.7)
Inorganic N (mg/L		3.54 (1.54-5.23)	2.43 (1.55-3.56)	1.01 (0.01-2.15)	0.89 (0.39-2.13)
Total N (mg/L)		4.56 (1.77-7.41)	3.12 (2.05-4.17)	1.47 (0.97-2.46)	1.24 (0.85-2.14)
PO_4-P (mg/L)		0.31 (0.10-0.67)	0.19 (0.10-0.30)	0.07 (0.01-0.17)	0.05 (0.04-0.07)
Total P (mg/L)		0.47 (0.17-1.09)	0.28 (0.17-0.44)	0.11 (0.06-0.21)	0.08 (0.05-0.10)
Chlorophyll-a (µg/L)		8.19 (0.20-63.00)	7.23 (0.20-64.00)	2.92 (0.30-16.00)	2.25 (0.30-10.65)
E. coli (No./100 mL)		3520 (200-100000)	690 (50-6800)	160 (15-2300)	160 (29-3530)

Note:
1. Except as specified, data presented are depth-averaged data.
2. Data presented are annual arithmetic means except for *E. coli* data which are geometric means.
3. Data enclsoed in brackets indicate the ranges.
4. NM - not measured.

Pollution

E1.26 Deep Bay was traditionally a major agriculture area with paddy fields, livestock and freshwater fish farming. In 1984 the area housed 5,262 livestock farms on the Hong Kong side with the following populations: pigs - 400,800; chickens - 5,649,000; ducks - 616,600; quails and pigeons - 883,400 (Melville *et al.* 1989).

E1.27 Most of the waste entered the Bay without any pretreatment. Agricultural waste was thought to account for about 75% of the total B.O.D. loading discharged into the Bay.

E1.28 From June 1988 keeping livestock in the Urban Council areas and in new towns in the New Territories was prohibited under the Livestock Waste Control Scheme. Furthermore, Phases I and II of the Livestock Waste Control Policy (LWCP) were completed in June 1993, covering the whole of the NWNT. Interim enforcement of the LWCP resulted in significant reduction in the number of active farms in the region (Applied Sciences Limited, 1993).

E1.29 Deep Bay is exposed to increasing pollution due to the rapid industrialisation occurring in the Shenzhen River valley (Nelson, 1992; Melville *et al.* 1995) and the new development in the NWNT. A recent study on water pollution (Wei *et al.* 1995) indicated that inorganic N & P and COD (chemical oxygen demand) in Inner Deep Bay was much higher then those parameters in the outer Deep Bay.

Flora and Fauna in the Study Area

Terrestrial Flora

Freshwater Marsh Vegetation

Reedbeds

E1.30 "Wetland" habitat types include freshwater wetlands, and comprise 325 ha in Hong Kong (Ashworth *et al.* 1993). Examples include fields used for the cultivation of water spinach which provide habitat for amphibians.

E1.31 The infilled fishponds adjacent to the new housing developments adjacent to Mai Po (Palm Springs) are beginning to support reedbeds. These reeds are within areas of earmarked for development

E1.32 Ephemeral wetlands occur in low spots that fill up with rain water, providing habitat for amphibians. This wetland type is also known as vernal wetland (Schilling 1996). Ephemeral wetlands are more suitable habitat for amphibians than permanent water bodies containing fish which predate tadpoles (Ashworth *et al.* 1993).

Grasslands, Cultivation, and Abandoned Agricultural Areas

E1.33 The Tin Shui Wai landbank comprises a large area marked "High Density Urban" on the Hong Kong Vegetation Map (Ashworth *et al.* 1993), but which is currently hydroseeded grassland. Patches of grassland, abandoned agriculture, and rare actively cultivated land are interspersed with urbanized land in the Study Area in the vicinity of Lau Fau Shan (Ashworth *et al.* 1993). Hong Kong has more than 100 species of grasses and sedges (Griffiths 1983), in addition to more than 50 other vascular freshwater plants (Hodgkiss 1983).

E1.34 The succession of shrubs and woodland onto previous agricultural land is slow, probably because of the presence of a compacted soil layer formed from wet cultivation techniques (Ashworth *et al.* 1993). Abandoned agricultural land can have considerable ecological value, particularly freshwater wetlands occupying abandoned paddy fields (Ashworth *et al.* 1993). One such site is the Sha Lo Tung basin which hosts nearly fifty species of dragonflies as well as two of the three endemic amphibians in Hong Kong (Dudgeon and Corlett 1994).

Shrubland

E1.35 Grasses grow from the base rather than from the tip, making them both fire resistant and fire-promoting because dry grass is good fuel that ignites easily. If grasslands are protected from fire and cutting for a long enough period, shrublands emerge. Patches of shrubland and mixed grassland-shrubland are present in the Study Area (Ashworth *et al.* 1993).

E1.36 There are more than 120 species of shrubs in Hong Kong (Thrower 1984). Shrublands comprise some of the richest plant communities in Hong Kong, with some sites containing more than 30 species (Ashworth *et al.* 1993).

Woodlands

E1.37 Small patches of woodland habitat are present in the Study Area, designated as both woodland and plantation woodland (Ashworth *et al.* 1993). With an adequate depth of soil, shrubland converts to secondary woodland after about 40 years (Ashworth *et al.* 1993). Patches of fung shui woodlands are present adjacent to villages.

E1.38 There are over 300 species of trees in Hong Kong, and over 50% are native species (Thrower 1988).

Estuarine Flora

E1.39 In Hong Kong reed beds comprise approximately 58 ha (Young 1995) of which Mai Po Marshes Nature Reserve hosts the largest area with 46 ha (Young and Melville 1995). Reedbeds at Mai Po form dense, typically monodominant stands comprising *Phragmites australis* (Reels 1994).

E1.40 Young and Melville (1995) summarised the conservation value of the Mai Po Marshes, and stated that for many groups of wildlife found in Hong Kong, a high proportion of the species can be found in Mai Po (Table E1.5). The avifauna diversity at Mai Po is very important, with 72% of all the birds recorded in Hong Kong found at Mai Po. The reserve also holds large numbers of internationally important bird species, some of which are endangered (Table E1.1). Of prime ecological importance today is the role of the Mai Po area as a wintering and staging area for tens of thousands of migratory and residential birds, including some globally threatened species, and for breeding resident birds, including regionally important numbers of herons and egrets.

Table E1.5
Species diversity at Mai Po (Source: Young and Melville, 1995)

	No. of species (and % of Hong Kong total)	
	Mai Po	Hong Kong
Plants	138 (5)	2723
Mammals	17 (37)	46
Birds	320 (72)	428
Frogs, snakes	27 (28)	98
Butterflies	57 (29)	200
Dragonflies	44 (44)	103
Reedbed invertebrates	400	-
Mudflat invertebrates	80	-

Table E1.6
Habitat diversity at Mai Po (Source: Young and Melville, 1995)

Habitat	Area (ha) and % of Hong Kong total	
	Mai Po	Hong Kong
Mangrove	132.5 (45)	276
Reedbed	46 (>80)	-
Gei wai	272 (100)	272

E1.41 Apart from holding important numbers and species of wildlife, the approximately 1,400 ha of wetland habits around Mai Po (i.e. the intertidal mudflat and mangroves, reedbeds, traditional prawn ponds (*gei wai*) and fish ponds) are also locally and regionally important. Of the 330 ha of mangrove forest remaining around Deep Bay, Mai Po contains approximately 40%. This is the sixth largest protected stand in China (Fan, 1993). The 46 ha of reedbeds in the reserve is probably the largest remaining in Guangdong Province. The *gei wai* are probably the only ones still being operated in the traditional way along the entire coast of China (Young and Melville, 1995).

Mangroves

E1.42 The dominant species in the Inner Deep Bay, including Mai Po Marshes and the wetland near Tin Shui Wai, are *Kandelia candel, Avicennia marina, Bruguiera gymnorhiza* and *Exoecaria agallocha*. Deep Bay is the only known locality for the seagrass *Halophila beccarrii* in Hong Kong (Applied Sciences Limited, 1993). Mangrove communities tend to be dwarf varieties, with a maximum height of 7.0 m. *Kandelia* has been related to the high level of organic pollution in the area.

E1.43 The mangrove community of Inner Deep Bay is not as diverse as other tropical mangal communities (Binnie Consultants Limited, 1992). Changes in community structure have been due to forest cutting to provide wood. Some previous mangrove stands in gei wai were destroyed when management changed from shrimp to fish production. This has caused co-dominance in some areas with the reed *Phragmites communis*. Quite often, following the destruction of mangrove communities, this reed quickly colonizes the existing area (Lee, 1995).

E1.44 In the 1980's, 50 to 60 ha of mangal were lost due to the construction of fish ponds. Recent planting of mangrove droppers (by WWF-HK along the bunds of Mai Po in the mid-80s, and near TSW 1990-91), particularly *K. candel*, was carried out over an area of 1,000 square metres. Rehabitation of mangroves has been quite successful as the survival rate was high and the natural colonization of mangroves has been accelerated (Applied Sciences Limited, 1993).

Other Vegetation

E1.45 The mangroves of Deep Bay are relatively well-documented, compared to the other vegetation around the Bay. The plant checklist for the region, particularly Mai Po Marshes is considered to be out of date.

Fauna

Mammals, Reptiles and Amphibians

E1.46 The mammal fauna in Mai Po (Table E1.7) includes some extremely rare animals. The Otter was considered extinct in Hong Kong until rediscovered in 1990 at Deep Bay. Javan Mongoose (*Herpestes javanicus*) was first recorded in 1990 (Chan *et al.* 1992). The Ryukyu Mouse was first discovered in Hong Kong in 1992 on fishpond bunds adjacent to Mai Po (Goodyer, 1992). The Otter and Crab-eating Mongoose are apparently restricted to the Deep Bay wetland areas within Hong Kong. The fishponds also provide particularly attractive habitat for Leopard Cat and Seven-banded Civet. The least-studied mammal group, the bats, achieve exceptional abundance over the fishponds, and there are probably more unrecorded species (Ades 1995).

Table E1.7
A list of mammals found around the fishponds in Mai Po

Felis bengalensis	Leopard Cat
Viverricula indica	Seven-banded Civet
Herpestes javanicus	Javan Mongoose
Herpestes urva	Crab-eating Mongoose
Lutra lutra	Otter
Pipistrellus abramus	Japanese Pipistrella Bat
Nyctalus noctula	Noctule Bat
Rousettus leschenaulti	Leschenault's Fruit Bat
Suncus murinus	Musk Shrew
Mus caroli	Ryukyu Mouse
Rattus rattus flavipectus	Buff-breasted Rat

Sources: *G. Ades (unpublished data); Chandrasekar-Rao, A. 1985. Distribution and Ecology of Hong Kong Small Mammals, with Special Reference to Seasonality. M.Phil. Thesis, H.K.U.; Goodyer, N.J. 1992. Notes on the land mammals of Hong Kong. Mem. Nat. Hist. Soc. 19, 71-78; M. Lau (unpublished data); G. Walthew (unpublished data).*

E1.47 Within the study area, a total of seven rare mammal species have been sighted from Mai Po and Tsim Bei Tsui. The mammal species from each of the two areas are as follows:

Mai Po

Species	**Common name**
Mus carolo	Ryukyu Mouse
Herpestes javanicus	Javan Mongoose
Viverricula indica	Small Indian Civet
Felis bengalis	Leopard Cat
Lutra lutra chinensis	Chinese Otter

Tsim Bei Tsui

Species	**Common name**
Herpestes urva	Crab-eating Mongoose
Herpestes javanicus	Javan Mongoose

E1.48 According to Karsen *et al.* (1986) and Lau's unpublished data there have been 16 species of reptile found in and around the fishponds of Deep Bay, i.e. one fifth of the known Hong Kong reptile fauna. They included of Chinese soft-shelled turtle, Burmese python and copperhead turtle, which are uncommon in Hong Kong (Table E1.8).

E1.49 One third of the known Hong Kong amphibian species (see Table E1.9) have been recorded near the Deep Bay fishponds. Most of these 8 species have become less abundant in recent years due to the loss of wetland habitats (Karsen *et al.*, 1986; Lau, unpublished data).

Table E1.8
A list of reptiles found near the fishponds in Mai Po

Chinemys reevesi	Reeves Terrapin
Pelodiscus sinensis	Chinese Soft-shelled Turtle
Hemidactylus bowringi	Bowring's Gecko
Scincella reevesi	Reeves Smooth Skink
Eumeces chinensis	Chinese Skink
Takydromus sexlineatus	Grass Lizard
Ramphotyphlops braminus	Common Blink Snake
Python molurus	Burmese Python
Elaphe radiata	Copperhead Racer
Ptyas mucosus	Common Rat Snake
Ptyas korros	Indo-chinese Rat Snake
Oligodon formosanus	Taiwan Kukri Snake
Xenochrophis piscator	Checkered Keelback
Enhydris chinensis	Chinese Water Snake
Bungarus multicinctus	Many-banded Krait
Naja naja	Chinese Cobra

Sources: *Karsen,* et al.; M. Lau *(unpublished data).*

Table E1.9
A list of amphibians found in the fishponds in Mai Po

Bufo melanostictus	Asian Common Toad
Rana regulosa	Chinese Bullfrog
Rana guentheri	Gunther's Frog
Rana limnocharis	Paddy Frog
Polypedates megacephalus	Brown Tree Frog
Kaloula pulchra	Asiatic Painted Frog
Microhyla ornata	Ornate Pygmy Frog
Kalophrynus pleurostigma	Narrow-mouthed Frog

Sources: *Karsen,* et al.; *M. Lau (unpublished data).*

Birds

E1.50 Deep Bay, including Mai Po marshes, supports a wide variety of birdlife. Over three hundred species have been recorded in the area. Of these birds at least 26 species are listed as "threatened" or "endangered" (Applied Sciences Limited, 1993; Young and Melville, 1995; Melville 1995). In addition, the area is also an important wintering and staging site for migratory birds (Young and Melville, 1995). The up-to -date species list of special conservation importance in the region is shown in Table E1.10 while a more comprehensive species list is given in Table E1.11.

Table E1.10
Bird Species of Special Conservation Importance in Mai Po and Deep Bay

Common name	Scientific name	Endangered/ threatened	Represents significant % of regional/global populations
Asiatic Dowitcher	*Limnodromus semipalmatus*	*	
Baer's Pochard	*Aythya baeri*	*	
Baikal Teal	*Anas formosa*	*	
Chestnut-cheeked Starling	*Sturnus philippensis*	*	
Christmas Island Frigatebird	*Fregata andrewsi*	*	
Chinese Pond Heron	*Ardeola baccus*		*
Cinereous Vulture	*Aegypius monachus*	*	
Cormorant	*Phalacrocorax carbo*		*
Curlew Sandpiper	*Calidris ferruginea*		*
Dalmatian Pelican	*Peleconus crispus*	*	
Far Eastern Curlew	*Numenius madagascariensis*	*	
Fukian Niltava	*Niltava davidi*	*	
Greater Sand-plover	*Charadrius lescchenaultii*		*
Greater Spotted Eagle	*Aquila clanga*	*	
Grey-headed Lapwing	*Vanellus cinerous*	*	
Imperial Eagle	*Aquila heliaca*	*	
Japanese Night-heron	*Gorsachius goisagi*	*	
Japanese Waxwing	*Bombycilla japonica*	*	
Lesser Sand-plover	*Charadrius mongolus*		*
Lesser Spoonbill (Black-faced)	*Platalea minor*	*	*
Little Egret	*Egretta garzetta*		*
Long-billed Plover	*Charadrius placidus*	*	
Mandarin Duck	*Aix galericulata*	*	
Marsh Sandpiper	*Tringa stagnatilis*		*
Nordmann's Greenshank	*Tringa guttifer*	*	
Oriental White Stork	*Ciconia ciconia*	*	
Relict Gull	*Larus relictus*	*	
Saunder's Gull	*Larus saundersi*	*	
Schrenck's Bittern	*Ixobrychus eurhythmus*	*	
Silky Starling	*Sturnus sericeus*	*	
Spoon-billed Sandpiper	*Eurynorhynchus pygmaeus*	*	
Swinhoe's Egret	*Egretta eulophotes*	*	
Yellow Bunting	*Emberiza sulphurata*	*	

Sources: Melville (1995); Young and Melville (1995).

Table E1.11
Bird Species Appearing at Mai Po Marshes and Deep Bay

Group	Common name	Scientific name
Avocets, Stilts	Blackwinged stilt	*Himantopus himantopus*
	Avocet	*Recurvirostra avosetta*
Bitterns, Herons, Egrets	Grey Heron	*Ardea cinerea*
	Purple Heron	*Ardea purpurea*
	Chinese Pond Heron	*Ardeola bacchus*
	Great Bittern	*Botaurus stellaris*
	Cattle Egret	*Bubulcus ibis*
	Little Green Heron	*Butorides striatus*
	Great Egret	*Casmerodius alba*
	Swinhoe's Egret*	*Egretta eulophotes*
	Little Egret**	*Egretta garzetta*
	Chestnut Bittern	*Ixobrychus cinnamomeus*
	Yellow Bittern	*Ixobrychus sinensis*
	Intermediate Egret	*Mesophoyx intermedia*
	Night Heron	*Nycticorax nycticorax*
Bulbuls	Crested Bulbul	*Pycnonotus jocosus*
	Red-vented Bulbul	*Pycnonotus aurigaster*
	Chinese Bulbul	*Pycnonotus sinensis (sinensis)*
	Anderson's Bulbul	*Pycnonotus xanthorrhous*
Bunting	Little Bunting	*Emberiza pusilla*
	Masked Bunting (Black-faced Bunting)	*Emberiza spodocephala*
	Yellow - breasted Bunting	*Emberiza aureola*
	Pallas's Reed Bunting	*Emberiza pallasi*
	Japanese Yellow Bunting	*Emberiza sulphurata*
	Chinese Reed Bunting	*Emberiza yessoensis*
Chats, Thrushes	Magpie Robin	*Copsychus saularis*
	Black - faced Laughing - thrush	*Garrulax perspicillatus*
	Siberian Rubythroat	*Luscinia calliope*
	Bluethroat	*Luscinia svecica (svecica)*
	Daurian Redstart	*Phoenicurus auroreus*
	Siberian Stonechat	*Saxicola maura*
	Grey - backed Thrush	*Turdus hortulorum*
	Blackbird	*Turdus merula (mandarinus)*
Cisticolas, Prinias	Fantail Warbler	*Cisticola juncidis (tinnabulans)*
	Yellow - bellied Prinia	*Prinia flaviventris*
	Plain Prinia	*Prinia inornata (extensicauda)*
Cormorant	Cormorant**	*Phalacrocorax carbo*
Coucals	Greater Coucal	*Centropus sinensis*
	Lesser Coucal	*Centropus bengalensis*
Crows	Daurian Jackdaw	*Corvus dauuricus*
	Blue Magpie	*Urocissa erythrorhyncha*
	Jungle Crow	*Corvus macrorhynchus*
	Collared Crow	*Corvus torquatus*
	Magpie	*Pica pica (sericea)*
Cuckoos	Oriental Cuckoo	*Cuculus saturatus*
	Koel	*Eudynamis scolopacea*
	Large Hawk Cuckoo	*Cuculus sparverioides*
	Plaintive Cuckoo	*Cacomantis merulinus*
	Indian Cuckoo	*Cuculus micropterus*

Table E1.11 (cont'd)

Group	Common name	Scientific name
Drongos	Black Drongo Hair-crested Drongo	*Dicrurus macrocercus* *Dicrurus hottentottus*
Ducks, Swans, Geese	Mallard Gadwall Tufted duck Scaup Pintail Shoveler Teal Falcated Teal Baikal Teal Wigeon Yellow-nib Duck Garganey Baer's Pochard Common Pochard Goldeneye Lesser Whistling - Duck Red - breasted Merganser Ruddy Shelduck Shelduck	*Anas platyrhyncos* *Anas strepera* *Aythya fuligula* *Aythya marila* *Anas acuta* *Anas clypeata* *Anas crecca* *Anas falcata* *Anas formosa* *Anas penelope* *Anas poecilorhyncha* *Anas querquedula* *Aythya baeri* *Aythya ferina* *Bucephala clangula* *Dendrocygna javanica* *Mergus serrator* *Tadorna ferruginea* *Tadorna tadorna*
Eagles, Hawks	Crested Goshawk Japenese Sparrowhawk Spotted Eagle Imperial Eagle* Grey - faced Buzzard Crested Honey Buzzard Buzzard Pied Harrier Eastern Marsh Harrier Crested Sergpent Eagle Black - shouldered Kite White - bellied Sea - eagle Black - eared Kite Bonelli's Eagle Osprey	*Accipiter trivirgatus* *Accipiter gentilis* *Aquila clanga* *Aquila heliaca* *Butastur indicus* *Pernis ptilorhynchus* *Buteo buteo* *Circus cyaneus* *Circus spilonotus* *Spilornis cheela* *Elanus caerulens* *Haliaeetus leucogaster* *Milvus lineatus* *Hieraaetus fasciatus* *Pandion haliaetus*
Falcons	Peregrine Falcon Saker Falcon Hobby Kestrel	*Falco peregrinus* *Falco cherrug* *Falco subbuteo* *Falco tinnunculus*
Finches	Black - tailed Hawfinch	*Eophona migratoria*
Flycatchers	Yellow - rumped Flycatcher Asian Brown Flycatcher Grey-streaked Flycatcher	*Ficedula zanthopygia* *Muscicapa dauurica* *Muscicapa griseisticta*
Grebes	Great crested Grebe Black - necked Grebe Little Grebe	*Podiceps cristatus* *Podiceps nigricollis* *Tachybaptus ruficolis*
Gulls, Terns	Whiskered Tern White - winged Black Tern Caspian Tern Herring Gull Yellow - legged Gull Black - tailed Gull	*Chlidonias hybrida* *Chlidonias leucoptera* *Hydroprogne caspia* *Larus argentatus* *Larus cachinnans* *Larus crassirostris*

Table E1.11 (cont'd)

Group	Common name	Scientific name
	Glaucous - winged Gull	*Larus glaucescens*
	Great Black- headed Gull	*Larus ichthyaetus*
	Black headed Gull	*Larus ridibundus*
	Saunders Gull*	*Larus saundersi*
	Vega Gull	*Larus vegae*
	Relict Gull*	*Larus relictus*
	Black - legged Kittiwake	*Rissa tridactyla*
	Little Tern	*Sterna albifrons*
	Caspian Tern	*Sterna caspia*
	Common Tern	*Sterna hirundo*
	Gull - billed Tern	*Sterna nilotica*
Ibises, Spoonbills	Glossy Ibis	*Platalea falcinellus*
	European Spoonbill	*Platalea leucorodia*
	Lesser Spoonbill (Black - faced)*	*Platalea minor*
	White Ibis	*Threskiornis melanocephalus*
Kingfishers	Common Kingfisher	*Alcedo atthis*
	Pied Kingfisher	*Ceryle rudis*
	Black - capped Kingfisher	*Halcyon pileata*
	White- breasted Kingfisher	*Halcyon smyrnensis*
	Collared Kingfisher	*Todirhamphus chloris*
Munias	Chestnut Munia	*Lonchura malacca*
	Spotted Munia	*Lonchura punctulata*
Old World Warblers	Paddyfield Warbler	*Acrocephalus agricola*
	Black - browed Reed - warbler	*Acrocephalus bistrigiceps*
	Blyth's Reed Warbler	*Acrocephalus dumetorum*
	Oriental Reed - warbler (Great Reed Warbler)	*Acrocephalus orientalis*
	Chinese Bush Warbler	*Cettia canturians*
	Yellow - bellied Bush Warbler	*Cettia robustipes*
	Pallas's Grasshopper Warbler	*Locustella certhiola*
	Styan's Grasshopper Warbler	*Locustella pleskei*
	Common Tailorbird	*Orthotomus sutorius*
	Arctic Warbler	*Phylloscopus borealis*
	Lanceolated Warbler	*Locustella lanceolata*
	Pallas's Warbler	*Phylloscopus proregulus*
	Dusky Warbler	*Phylloscopus fuscatus*
	Yellow - browed Warbler	*Phylloscopus inornatus*
Orioles	Black - naped Oriole	*Oriolus chinensis*
Owl	Barred Owlet	*Glaucidium cuculoides*
Parrots	Rose - ringed Parakeet	*Psittacula krameri*
Pelicans	Dalmatian Pelican*	*Peleconus crispus*
Pigeons, Doves	Spotted Dove	*Streptopelia chinensis*
	Rufous Tutle - Dove	*Streptopelia orientalis*
	Red Turtle - Dove	*Streptopelia tranquebarica*
Pipits, Wagtails	Red - throated Pipit	*Anthus cervinus*
	Olive - backed Pipit	*Anthus hodgsoni*
	Richard's Pipit	*Anthus richardi*
	White Wagtail	*Motacilla alba*
	Grey Wagtail	*Motacilla cinerea*
	Citrine Wagtail	*Motacilla citreola*
	Yellow Wagtail	*Motacilla flava*
Plovers	Lapwing	*Vanellus vanellus*
	Kentish Plover	*Charadrius alexandrinus*

Table E1.11 (cont'd)

Group	Common name	Scientific name
	Little Ringed Plover	*Charadrius dubius*
	Ringed Plover	*Charadrius hiaticula*
	Greater sand - plover**	*Charadrius lescchenaultii*
	Lesser Sand - plover**	*Charadrius mongolus*
	Oriental Plover	*Charadrius veredus*
	Asiatic Golden Plover	*Pluvialis dominica*
	Pacific Golden Plover	*Pluvialis fulva*
	Grey Plover	*Pluvialis squatarola*
	Grey - headed Lapwing	*Vanellus cinereus*
Pratincoles	Oriental Pratincole	*Glareola maldivarium*
Rails, Coots, Moorhens	White breasted Waterhen	*Amaurornis phoenicurus*
	Coot	*Fulica atra*
	Watercock	*Gallicrex cinerea*
	Moorhen	*Gallinula chloropus*
	Ruddy Crake	*Porzana fusca*
	Water Rail	*Rallus aquaticus*
	Banded rail	*Rallus striatus*
Sandpipers, Snipe, Curlews & allies	Common Sandpiper	*Actitis hypoleucos*
	Turnstone	*Arenaria interpres*
	Sharp - tailed Sandpiper	*Calidris acuminata*
	Sanderling	*Calidris alba*
	Dunlin	*Calidris alpina*
	Red Knot	*Calidris canutus*
	Curlew Sandpiper**	*Calidris ferruginea*
	Pectoral Sandpiper	*Calidris melanotus*
	Little Stint	*Calidris minuta*
	Red - necked Stint	*Calidris ruficollis*
	Long-toed Stint	*Calidris subminuta*
	Temmincks Stint	*Calidris temminckii*
	Great Knot	*Calidris tenuirostis*
	Spoon - billed Sandpiper*	*Eurynorhynchus pygmaeus*
	Black-winged Stilt	*Himantopus himantopus*
	Fantail Snipe	*Gallinago gallinago*
	Swinhoe's Snipe	*Gallinago megala*
	Snipe	*Gallinago spp.*
	Pintail Snipe	*Gallinago stenura*
	Broad - billed Sandpiper	*Limicola falcinellus*
	Painted Snipe	*Rostratula benghalensis*
	Asiatic Dowitcher*	*Limnodromus semipalmatus*
	Long - billed Dowitcher	*Limnodromus scolopaceus*
	Bar - tailed Godwit	*Limosa lapponica*
	Black-tailed Godwit*	*Limosa limosa*
	Curlew	*Numenius arquata*
	Australian Curlew	*Numenius madagascariensis*
	Little Whimbrel	*Numenius minutus*
	Whimbrel	*Numenius phaeopus*
	Red - necked Phalarope	*Phalaropus lobatus*
	Ruff	*Philomachus pugnax*
	Grey - tailed Tattler	*Tringa brevipes*
	Spotted Redshank	*Tringa erythropus*
	Lesser Yellowlegs	*Tringa flavipes*
	Wood Sandpiper	*Tringa glareola*
	Nordmann's Greenshank*	*Tringa guttifer*

Table E1.11 (cont'd)

Group	Common name	Scientific name
	GreenShank	*Tringa nebularia*
	Green Sandpiper	*Tringa ochropus*
	Marsh Sandpiper**	*Tringa stagnatilis*
	Redshank	*Tringa totanus*
	Terek Sandpiper	*Xenus cinerus*
Shrikes	Brown Shrike	*Lanius cristatus*
	Rufous - backed Shrike	*Lanius schach*
Sparrows	Yellow - crowned Bishop	*Euplectes afer*
	Red Bishop	*Euplectes orix*
	Russet Sparrow	*Passer rutilans*
	Tree Sparrow	*Passer montanus*
	Baya Weaver	*Ploceus philippinus*
Starlings, Mynas	Crested Myna	*Acridotheres cristatellus*
	White - vented Myna	*Acridotheres grandis*
	Grey Starling	*Sternus cineraceus*
	Silky Starling	*Sternus sericeus*
	Chinese Starling	*Sternus sinensis*
	Black - necked Starling	*Sturnus nigricollis*
	Chestnut - cheeked Starling	*Sternus philippensis*
	Rosy Starling	*Sternus roseus*
	Daurian Starling	*Sturnus sturninus*
	Common Starling	*Sternus vulgaris*
Storks	Oriental White Stork*	*Ciconia ciconia*
	Black Stork	*Ciconia nigra*
Swallows, Martins	Asian House Martin	*Delichon dasypus*
	Red - rumped Swallow	*Hirundo daurica*
	Barn Swallow	*Hirundo rustica (gutturalis)*
	Sand Martin	*Riparia riparia*
Swifts	House Swift	*Apus nipalensis*
	Pacific Swift	*Apus pacificus*
	White - throated Needletail	*Hirundapus caudacutus*
	White - vented Needletail	*Hirundapus cochinchinensis*
Tits	Chinese Penduline Tit	*Remiz consobrinus*
	Great Tit	*Parus major*
White - eyes	White - eye	*Zosterops spp.*
Woodpeckers	Eurasian Wryneck	*Jynx torquilla*

* : endangered or threatened birds
** : Deep Bay holds a significant % of regional or global populations

Sources:
Chalmers, M.L. (1986).
Viney, C., Phillipes, K. and Lam Chiu Ying (1994); The Hong Kong Bird Watching Society, 1989.
E.P.D., (1993).
Young L. and Melville D.S. (1995).

E1.51 Every year, shorebirds, e.g. plovers and sandpipers, migrate along the coast of China from their breeding grounds in the Northern China, Mongolia and Siberia, to their wintering grounds in Southeast Asia and Australia. Along their migration route, these birds depend on a number of staging posts where they can rest, feed and build up their energy reserves again. The wetland around Deep Bay and Mai Po is one such site. Counts of up to 12,000 waders use the area during spring and autumn migration (McChesney, 1996), whilst a total of 66,000 waterbirds, e.g. ducks, gulls, waders, cormorants and herons use the area to overwinter before flying back north in spring to their breeding sites (Hong Kong Bird Watching Society, 1991, 1994).

E1.52 In this Study, the category "wading birds" has been defined to include some birds that are not strictly considered waders, but that utilise the same habitat, and often forage and roost side by side with waders. The wading bird category used in this Study includes: shorebirds, storks, egrets, herons, spoonbills, grebes, ducks and pelicans.

E1.53 In addition to being a refuelling stop during migration, some waders also remain during the autumn for post-breeding moult. This is physiologically demanding time when good food supplies are needed to promote new feather growth. Moulting may take several months and so a dependable food supply is required, as well as a suitable high tide roosting site.

Fish

E1.54 Deep Bay is recognised by AFD as a fish nursery ground. Production of fish in Deep Bay accounts for 1% of the local capture fishery production (Applied Sciences Limited, 1993). Fish caught in the bay include sole, sea bass, snapper, sea bream, yellow croaker, white herring, green pilchard, shrimp scad, white pomfret, hair tail, stone fish, mackerel, rabbit fish and mullet (Morton, 1989). Mullets spawn in the open sea during November and the fry swim back to Deep Bay where they are numerous between December to March.

E1.55 In a recent fisheries survey conducted by Binnie and CES (1995), sixty-eight species of demersal fish were recorded from June to November in the outer Deep Bay (Table E1.12). Of these gobiids (Family Gobiidae) were dominant in the catch.

E1.56 Within Mai Po itself, the perchlet *Ambassis gymnocephalus* (Lacèpëde), was found to be the most abundant fish, particularly on the mudflat to the seaward side of the mangroves and at the mangrove fringe (Vance, in press). The introduced cichlid, *Oreochromis mossambica* (Pters), was only caught in a channel draining the mangrove forest (Table E1.12). *Tilapia mossambica*, a great nuisance, is now widely dominant in *gei wais* (Chan, 1994). Juveniles of several species of fish were present in the catch and the largest numbers occurred at the mangrove sites (Vance, in press).

Table E1.12
A fish species list in Outer Deep Bay (Binnie and CES, 1995)

Family	Species	Family	Species
Apogonidae	*Apogon kiensis*	Soleidae	*Solea ovata*
Bothidae	*Psettina tosana*		*Zebrias quagga*
	Pseudorhombus levisquamis	Sparidae	*Evynnis cardinalis*
Callionymidae	*Callionymus richardsoni*	Stromateidae	*Pampus argentata*
Carangidae	*Decapterus maruadsi*		*Pampus argentata*
Centropomidae	*Ambassis urotaenia*	Synanceiidae	*Polycaulus uranoscopa*
Clupeidae	*Ilisha elongata*	Syngnathidae	*Corythoichthys flavofasciatus*
	Nematalosa come	Synodontidae	*Saurida elongata*
	Nematalosa come	Teraponidae	*Terapon theraps*
	Sardinella melanura	Tetraodontidae	*Takifugu bimaculatus*
	Sardinella sindensis		*Takifugu bimaculatus*
Congridae	*Bathymyrus simus*		*Takifugu oblongus*
Cynoglossidae	*Cynoglossus arel*		*Takifugu occellatus*
	Cynoglossus joyneri		*Takifugu occellatus*
	Cynoglossus lighti		*Takifugu xanthopterus*
	Cynoglossus puncticeps	Triacanthodidae	*Triacanthus biaculeatus*
Engraulididae	*Stolephorus hamitonii*	Triodontidae	*Triodontidae spp.*
	Stolephorus indicus	Platycephalidae	*Platycephalus indicus*
	Thryssa hamiltonii	Plotosidae	*Plotosus lineatus*
	Thryssa thefuensis	Polynemidae	*Polynemus sextarius*
Gerreidae	*Gerres abbreviatus*	Sciaenidae	*Collichthys lucidus*
Gobiidae	*Amblygobius albimaculatus*		*Johnius amblycephalus*
	Awaous ocellaris		*Johnius belengerii*
	Cryptocentrus filifer	Scorpaenidae	*Parascorpaena picta*
	Gobiidae sp.	Signidae	*Siganus fuscescens*
	Gobiidae sp.1	Sillagnidae	*Sillago sihama*
	Gobiidae sp.2		
	Gobiidae sp.2		
	Oxyurichthys tentacularis		
	Parachaeturichthys polynema		
	Taenioides cirratus		
	Trypauchen vagina		
	Yongeichthys nebulosus		
Leiognathidae	*Leiognathus brevirostris*		
	Leiognathus nuchalis		
Lutjanidae	*Lutjanus johnii*		
Muglidae	*Valamugil cunnesius*		
Mullidae	*Parupeneus ciliatus*		
	Upeneus quadrilineatus		
Muraenesocidae	*Muraenecox bagio*		
Ophichthidae	*Ophichthus apicalis*		
	Ophichthus cephalzona		

Table E1.13
Total catch of fishes, mean size ± sd., size range, and their distribution measured by the trapping study at mangrove in Mai Po (Vance, in press)

Species	Total no.	Mean size	Size range	Inner mangrove		Mangrove fringe		Mudflat		Channel
				Day	Night	Day	Night	Day	Night	Night
Ambassis gymnocephalus	1839	34.3±0.4	17.1-45.4	0	0	1128	3	680	28	0
Oreochromis mossambica	40	81.5±3.7	39.0-125.4	0	0	0	0	0	0	40
Unidentified juvenile teleosts	372	17.9±0.3	9.4-77.0	35	6	199	56	9	5	62
Liza dussumieri (Valenciennes)	8	68.3±6.4	30.2-97.2	0	2	0	2	0	4	0
Mugilogobius abei (Jordan et snyder)	24	23.2±1.7	15.4-58.0	4	0	2	15	0	0	3
Periophthalmus cantonensis	125	38.2±0.9	13.1-59.4	3	0	37	83	0	0	2
Boleophthalmus pectinirostris	8	62.4±8.2	22.6-90.7	0	0	3	3	2	0	0
Scartelaos viridis	4	70.8±6.1	61.1-94.1	0	0	2	0	1	0	1
Total fish				42	8	1371	162	692	37	108

Invertebrates associated with the Terrestrial Habitats

E1.57 There has been little documented work on the insects in the Inner Deep Bay area. Insect larvae found at the WENT Landfill site were included together with freshwater benthic data. Species of interest have been the dipteral flies and mosquitos. These species are potential vectors for diseases malaria, filariasis and Japanese encephalitis (Chau, 1982).

E1.58 Mosquito species colonise streams and fishponds and are controlled to a certain degree by the salinity of the water. *Aedes togoi* and *Culex siticens* are a biting nuisance to residents but have not been found to carry disease in Hong Kong. The mosquito fish *Gambusia* is a natural predator of mosquito larvae.

E1.59 The invertebrate fauna of fishponds was summarized in Appendix 10.13 of the Shenzhen River EIA (Peking University 1995) and an assessment of fishpond invertebrate fauna will be included in the Planning Department's fishpond study (Aspinwall in prep.).

E1.60 Fishponds at Pak Hok Chau, which is adjacent to the Study Area and next to the Mai Po Marshes Nature Reserve, supported benthic invertebrates, providing a source of bird food throughout the year (Anon 1993b cited in Peking University 1995). In addition they support the free-swimming shrimp *Macrobrachium nipponense* used by ardeid birds as food (Crosby 1991, Wong 1991, Young 1994), as well as free swimming insects (Anon 1993b cited in Peking University 1995). Abandoned fishponds provide good numbers of the common Asian dragonfly species (Wilson 1995).

E1.61 One damselfly species is of particular conservation interest in Hong Kong: *Mortonagrion hirosei*. This species is a Red Data Book endangered species (Groombridge, 1993), because of its small range (either fragmented or no more than five locations) and declining habitat. It is confined to dense *Phragmites* reed beds (Wilson 1995). At Mai Po, it was the 12th most abundant species trapped in Malaise traps (Reels 1994). It was absent in winter, most abundant in summer, and present in spring and autumn. It has also been observed at Luk Keng in April (Wilson 1995).

E1.62 Another Hong Kong dragonfly species of conservation importance is *Orthetrun poecilops pocilops*. The synonymous *O.p. miyajimaense* (K. Wilson pers. comm.) is listed as a Red Data Book species, due to its range being limited by fragmentation and declining habitat. *O.p.poecilops* is present at Nam Cheng in Hong Kong where a fresh water stream discharges into a mangrove. Very similar habitat occurs in the Reserve Zone where the Eastern Temporary Channel discharges fresh water from the check valves into a mangrove.

E1.63 The common and abundant dragonfly genus *Pantala* is noticeable because it forms swarms. It occupies puddles as soon as they are formed, and the larvae and adults are beneficial as they are predatory on mosquitos (K. Wilson, pers. comm.).

Estuarine Invertebrates

E1.64 The estuarine invertebrate community at Mai Po has been well documented. Lee (1993) surveyed the area and recorded 67 species, and 13 of these species were not identified. A list of invertebrate species recorded as of November 1990 is listed in Table E1.14 which includes species new to science.

E1.65 Vance (in press) investigated the distribution of shrimp associated with the mangrove forest in Mai Po and found that the palaemonid shrimp, *Exoplaemon styliferus* (Milne Edwards), was the most abundant in all catches (maximum catch = 3240) with large numbers taken at the inner mangrove site. The penaeid shrimps, *Metapenaeus ensis* (de Haan) and *M. affinis* (Milne Edwards), were less abundant overall but a large proportion of the total number caught were taken in the mangrove forest (Table E1.15).

E1.66 Fiddler crabs common to Mai Po and the Futien Nature Reserve are *Uca arcuta* and *Uca arcuata*. The sesarmid crab, *Chiromanthes maipoensis*, is unique to the Mai Po marshes. Organic pollution was found to be beneficial to the adult, but detrimental to juvenile recruitment (Choi, 1991).

E1.67 Compared with marine zooplankton, only a few species of zooplankton occur in the Mai Po wetland. Copepods, mainly Calanoids and Cyclopoids, were the most abundant species, which comprised more than 80% of the total abundance (Leung, 1994).

E1.68 Three species of intertidal mudskippers are present at Mai Po (Chan 1990) which are the preferred food of some birds (for example, the Chinese Pond Heron from January to April, Young 1994). Mudskippers spawn mainly between April and June (Chan 1990, Cai 1996). During the spawning season, displaying males may be particularly available as prey to foraging birds (Young 1994).

E1.69 Mudskippers are also trapped as food by artisanal fishing methods. This is described in Section E1.74 on socioeconomic industries.

E1.70 The benthic community in the mudflat in Mai Po has been studied by McChesney (1996). The taxonomic list of the community is shown in Table E1.16. It appears the community was quite diverse with many species to be identified. The biomass-dominant species in the region are *Dendronereis pinnaticirrus* and *Neanthes glandicincta*. Numerical abundance is dominated by *Pseudopythina maipoensis*, with members of family Capitellidae particularly dominating near the polluted river mouths (Peking University 1995; McChesney 1996). Higher concentration of heavy metals in Mai Po mudflat annelids was found closer to the Shan Pui River and the Shenzhen River (Tsang, 1993).

E1.71 Intertidal infauna comprise two major communities: a mudflat community distinct from a mangrove community (Peking University 1995). The mangrove community infauna contained lower biomass than the mudflat infauna assemblage. The mangrove crabs have been studied by Lee (1989) and Kwok (1995), but the mangrove epifaunal crab assemblage has not been compared to the mudflat epifaunal assemblage. The mangrove epifaunal crab assemblage contains the endemic *Chiromanthes maipoensis* and the rare *Uca paradussumieri*.

Table E1.14
A list of invertebrate species at Mai Po Marshes (Lee, 1993)

Class/Order	Species
Nermetea	
Heteronemertea	*Dendrorhynchus sinensis*
	Procephalothrix orientalis sp. nov.
Annelida	
Oligochaeta	*Limnodriloides biforis sp. nov.*
	L. fraternus sp. nov.
	Tectidrilus achaetus
	Doliodrilus tener
	Rhizodrilus russus
Hirudinea	Unidentified leach
Polychaeta	*Dendronereis pinnaticirrus*
	Laonome sp. A
	Laonome sp. B
	Ceratonereis sp.
	Ceratonereis cf. burmensis
	Aglaophamus sp.
	Polydora sp.
	Neanthes sp.
	Namalycastis aibiuma
	Unidentified Capitellid
Mollusca	
Gastropoda	*Sermyla tornatella*
	Dostia violacea
	Cerithideopsilla cingulata
	Assiminea sp. 1
	Assiminea sp. 2
	Iravadia (Iravadia) ornata
	I. (Fairbankia) bombayana
	Stenothyra sp. 1
	Stenothyra sp. 2
	Clenchiella sp.
	Salinator fragilis
	Salinator sp.
	Ellobium pilotum
	Ellobium sp.
	Melanoides tuberculata
Bivalvia	*Pseudophythina maipoensis sp. nov.*
	Musculista senhausia
	Glauconome chinensis
	Placuna sp.
	Crassostrea gigas
	Mytilopsis sallei

Table E1.14 (cont'd)

Class/Order	Species
Arthropoda	
Crustacea	
Decapoda	*Metapenaeus ensis*
	M. affinis
	Penaeus monodon
	P. merguiensis
	P. penicillatus
	Macrobrachium nipponense
	Exopalaemon cf. styliferus
	Coutierella tonkinensis
	Caridina nilotica gracilipes
	Alpheus sp.
	Scylla serrata
	Chasmanthes maipoensis sp. nov.
	C. bidens
	Varuna litterata
	clistocoeloma merguiensis
	Chasmagnathus convexum
	Helice tridens
	Metaplax longipes
	Uca arcuata
	Uca acuta
	Macrophthalmus convexus
Amphipoda	*Talorchestia sp. nov.*
	Grandidierella sp. nov.
	Kamaka sp. nov.
	Melita sp. nov.
	Victoriopisa sp. nov.
Tenaidacea	*Discapseudes sp. nov.*
Acarida	*Dometorina rostrata sp. nov.*

Table E1.15
Total catch of shrimp mean size ± sd., size range, and their distribution measured by the trapping study at mangrove in Mai Po (Vance, in press) shrimp size is the carapace length (mm)

Species	Total no.	Mean size	Size range	Inner mangrove		Mangrove fringe		Mudflat		Channel
				Day	Night	Day	Night	Day	Night	Night
Exopalaemon styliferus	8526	4.4±0.1	2.0-13.0	153	1036	1272	2128	135	3240	562
Metapenaeus ensis	139	7.1±0.2	2.0-13.0	12	11	7	21	0	0	88
Metapenaeus affinis	161	3.7±0.1	2.0-10.0	4	10	101	12	18	0	16
Coutierella tonkinensis	785	3.8±0.1	2.0-5.0	14	4	0	0	2	1	764
Macrobrachium nipponense	308	5.0±0.2	2.0-10.0	0	0	0	8	0	0	300
Total shrimp				183	1061	1380	2169	155	3241	1730

Table E1.16
A list of morphospecies codes, and the taxonomical determination in the mudflat in Mai Po (McChesney, 1996)

code	Phylum	Class	Subclass	Order	(Super)Family	Genus	species
abre	Mollusca	Gastropoda	Prosobranchia	Mesogastropoda	Assimineidae	*Assiminea*	*brevicula*
acon	Annelida	Polychaeta	Errantia		Pilargiidae	*Ancistrosyllis*	*constricta*
amat	Mollusca	Gastropoda	Prosobranchia	Mesogastropoda	Amathinidae	*n. gen*	*n. sp*
anem	Coelenterata	Anthozoa	Zoantharia	Actiniaria			
asp	Mollusca	Gastropoda	Prosobranchia	Mesogastropoda	Assimineidae	*Assiminea*	*sp.*
asp1	Mollusca	Gastropoda	Prosobranchia	Mesogastropoda	Assimineidae	*Assiminea*	*sp.1*
asp2	Mollusca	Gastropoda	Prosobranchia	Mesogastropoda	Assimineidae	*Assiminea*	*sp.2*
asp3	Mollusca	Gastropoda	Prosobranchia	Mesogastropoda	Assimineidae	*Assiminea*	*sp.3*
asp4	Mollusca	Gastropoda	ProsobrPanchia	Mesogastropoda	Assimineidae	*Assiminea*	*sp.4*
bivl	Mollusca	Bivalvia	Lamellibranchia	Heterodonta			
blon	Mollusca	Gastropoda	Opisthobranchia	Cephalaspidea			
brog	Annelida	Oligochaeta					
cap?	Annelida	Polychaeta	Sedentaria		Capitellidae		
ccap	Annelida	Polychaeta	Sedentaria		Capitellidae	*Capitella*	*capitata*
ceph	Mollusca	Gastropoda	Opisthobranchia	Cephalaspidea			
clen	Mollusca	Gastropoda	Prosobranchia	Mesogastropoda	Hydrobiidae		
dost	Mollusca	Gastropoda	Prosobranchia			*Dostia*	*sp.*
dpin	Annelida	Polychaeta	Errantia		Nereidae	*Dendronereis*	*pinnaticirrus*
glau	Mollusca	Bivalvia	Lamellibranchia	Heterodonta	(Galeommatacea)		
euni	Annelida	Polychaeta	Errantia		Eunicidae		
goby	Vertebrata		Teleostei				
gly1	Annelida	Polychaeta	Errantia		(Glyceracea)		
gra1	Arthropoda	Crustacea	Malacostraca	Decapoda	Grapsidae		
hsim	Annelida	Polychaeta	Sedentaria		Capitellidae	*Heteromastus*	*similis*
ibom	Mollusca	Gastropoda	Prosobranchia	Mesogastropoda	Iravidiidae	*Iravadia*	*bombayana*
iljv	Arthropoda	Crustacea	Malacostraca	Decapoda	Ocypodidae	*Ilyoplax*	*sp.1*
ils2	Arthropoda	Crustacea	Malacostraca	Decapoda	Ocypodidae	*Ilyoplax*	*sp.2*
inin	Arthropoda	Crustacea	Malacostraca	Decapoda	Ocypodidae	*Ilyoplax*	*ningpoensis*
ins1	Arthropoda	Insecta					
	Arthropoda	Insecta					

Table E1.16 (cont'd)

code	Phylum	Class	Subclass	Order	(Super)Family	Genus	species
iorn	Mollusca	Gastropoda	Prosobranchia	Mesogastropoda	Iravidiidae	*Iravadia*	*ornata*
irs2	Mollusca	Gastropoda	Prosobranchia	Mesogastropoda	Iravidiidae	*Iravadia*	*sp.2*
itan	Arthropoda	Crustacea	Malacostraca	Decapoda	Ocypodidae	*Ilyoplax*	*tanshuiensis*
laem	Mollusca	Gastropoda	Prosobranchia	Mesogastropoda		*Laemodonta*	*sp.*
laon	Annelida	Polychaeta	Sedentaria		Sabellidae	*Laonome*	*sp.*
lgog	Annelida	Polychaeta					
lin1	Mollusca	Gastropoda	Prosobranchia	Mesogastropoda	Pyramidellidae	*Linopygra*	*sp.1*
lin2	Mollusca	Gastropoda	Prosobranchia	Mesogastropoda	Pyramidellidae	*Linopygra*	*sp.2*
mac	Mollusca	Bivalia	Lamellibranchia	Heterodonta		*Macoma*	*sp.*
mald	Annelida	Polychaeta	Sedentaria		Maldanidae		
mcro	Arthropoda	Crustacea	Malacostraca	Decapoda	Ocypodidae	*Macrophthalamus*	*sp.*
mncp	Annelida	Polychaeta			Capitellidae		
msan	Annelida	Polychaeta			Eunicidae	*Marphysa*	*sanguinea*
msen	Mollusca	Bivalvia	Lamellibranchia	Anisomyaria		*Musculista*	*senhausia*
nam1	Annelida	Polychaeta	Errantia		Nereidae	*Namalycastis*	
nam2	Annelida	Polychaeta	Errantia		Nereidae	*Namalycastis*	
nema	"nematoda"						
neme	Nemertean						
ngla	Annelida	Polychaeta	Errantia		Nereidae	*Neanthes*	*glandicincta*
nmn2	Annelida	Polychaeta	Errantia		Nereidae		
npol	Annelida	Polychaeta	Errantia		Syllidae	*Nephthys*	*polybranchiat*
odos	Mollusca	Gastropoda	Prosobranchia	Mesogastropoda	Pyramidellidae	*Odostomia*	*sp.*
olig	Annelida	Oligochaeta					
owen	Annelida	Polychaeta	Sedentaria		Oweniidae		
pcir	Annelida	Polychaeta	Sedentaria		Spionidae	*Prionospio*	*cirrifera*
phyl	Annelida	Polychaeta	Errantia		Phyllodocidae		
plan	Platyhelminthes						
plep	Annelida	Polychaeta	Sedentaria		Sabellidae	*Potamilla*	*leptochaeta*
ply1	Annelida	Polychaeta	Errantia		Polynoidae		
ply2	Annelida	Polychaeta	Errantia		Polynoidae		
plyd	Annelida	Polychaeta	Sedentaria		Spionidae	*Polydora*	*sp.*

Table E1.16 (cont'd)

code	Phylum	Class	Subclass	Order	(Super)Family	Genus	species
pmai	Mollusca	Bivalvia	Lamellibranchia	Heterodonta	(Galeommatacea)	*Pseudopythina*	*maipoensis*
poto	Mollusca	Bivalvia	Lamellibranchia	Heterodonta		*Potomocorbula*	*sp.*
pull	Annelida	Polychaeta	Sedentaria		Capitellidae		
pyr2	Mollusca	Gastropoda	Prosobranchia	Mesogastropoda	Pyramidellidae		
sab?	Annelida	Polychaeta	Sedentaria		Sabellidae		
scon	Mollusca	Bivalvia	Lamellibranchia	Heterodonta	(Solenacea)	*Sinonovacula*	*constricta*
serm	Mollusca	Gastropoda	Prosobranchia	Mesogastropoda		*Sermyla*	*tornatella*
sesr	Arthropoda	Decapoda	Malacostraca	Decapoda	Grapsidae		
sfra	Mollusca	Gastropoda	Prosobranchia	Mesogastropoda	Amphibolidae	*Salinator*	*fragilis*
spi1	Arthropoda	Arachnida		Araneae			
spi2	Arthropoda	Arachnida		Araneae			
spio	Annelida	Polychaeta	Sedentaria		Spionidae		
ste1	Mollusca	Gastropoda	Prosobranchia	Mesogastropoda	Stenothyridae	*Stenothyra*	*sp.1*
ste2	Mollusca	Gastropoda	Prosobranchia	Mesogastropoda	Stenothyridae	*Stenothyra*	*sp.2*
ste3	Mollusca	Gastropoda	Prosobranchia	Mesogastropoda	Stenothyridae	*Stenothyra*	*sp.3*
tcfi	Mollusca	Bivalvia	Lamellibranchia	Heterodonta		*Theora*	*cf. iridescens*
thar	Annelida	Polychaeta	Sedentaria		Cirratulidae	*Tharyx*	*sp.*
tlat	Mollusca	Bivalvia	Lamellibranchia	Heterodonta		*Theora*	*lata*
uca	Arthropoda	Crustacea	Malacostraca	Decapoda	Ocypodidae	*Uca*	*sp.*
	Arthropoda	Crustacea	Malacostraca	Tanaipoda	(Tanaidacea)	*Discapseudes*	*sp. nov*

E1.72 The mudflat community shows apparent gradational changes in relative abundance and body size of its component animals as sampling sites approach pollution sources such as the Shenzhen River and San Pui River (Chiu 1992, Peking University 1995, Lee 1995). The mudflat community also changes with time probably owing to predictable seasonal spawning and recruitment signalled by salinity decreases and temperature increases during the rainy season (Mok 1973, McChesney 1996).

E1.73 The density of intertidal infauna can be correlated with their avian predators (Goss-Custard *et al.* 1977, Yates *et al.* 1993).

Socio-Economic Industries

Capture Fishing

E1.74 The number of vessels operating has been recorded as 63 in Inner Deep Bay and 91 vessels in Outer Deep Bay. Total catch for the Inner Deep Bay is 70.5 tonnes, valued at HK$2.3 million and 33.5 tonnes for the Outer Deep Bay, valued at HK$1.2 (Applied Sciences Limited, 1993).

E1.75 No information, unfortunately, exists on craft over 15 feet in length, including shrimp and hang trawlers in Deep Bay.

E1.76 Capture fishing in Deep Bay includes traditional artisanal methods of trapping mangrove crabs (*Scylla serrata*) and intertidal mudskippers. An estimate of the effect of fishing indicated that about 5% of the total mudskipper population could be removed during the breeding season from April to June, and that the individuals captured are likely to be the large, breeding adults (Young and Melville 1993).

E1.77 In addition to the effect of fishing on the food resources for migratory birds, mudskipper fishing has the additional effect of disturbance. The carrying capacity of the area, i.e. the number of birds that can be supported by the habitat, may be limited by changes in food resource quality or by disturbance. In Massachusetts, the carrying capacity of an intertidal mud/sandflat and adjacent beach was limited by the amount of available area for birds to rest. This resource was diminished by human disturbance, in particular, by their unleashed dogs (Pfister *et al.* 1992).

Marine Culture Industry

<u>Fish</u>

E1.78 Marine fish culture in Hong Kong plays an important role in supplying high quality fish to the territory. In 1993, the amount of live marine fish was estimated at 3,010 tonnes valued approximately at HK$193 million (AFD, 1994). Fish farming has been found to cause high organic loadings to the Deep Bay area (Lam, *et al.* 1988).

E1.79 Pond fish culture in Hong Kong is mainly located in the northwestern New Territories. The total area used for pond fish culture in February, 1990 was 1380 ha, 70 of which was developed at Tin Shui Wai (AFD, 1994). Carp species belonging to the family, Cyprinidae, are the basis of fish farming in the region.

E1.80 Fish farming is very profitable in the Deep Bay area. Although the initial costs to build a fishpond are high, it can operate profitably for 3-4 years (Grant, 1981). The production values for this area have increased from HK$1 million to HK$6 million (Applied Science Limited, 1993).

Oysters

E1.81 The annual production of oysters in Hong Kong was found to drop in the five years from 1988 to 1993 (Table E1.17, from AFD, 1994). There are approximately 1,000 oyster farmers in the Deep Bay area. Recent reports of health risks associated with consuming oysters has caused a reduction in this industry.

Table E1.17
The Decline of Oyster Meat Production in Recent Years (AFD, 1994)

Year	Oyster Meat Production in Tonnes	Value HK$ Million
1988	160	6.80
1989	137	4.81
1990	151	6.32
1991	120	5.40
1992	100	4.25
1993	100	4.67

Shrimp

E1.82 Shrimp farming in Deep Bay is common due to an abundant food supply in the estuarine conditions. Species dominant in the area include both Genus of *Metapenaeus* and *Penaeus*. The popular shrimp is the Gei Wai Ha, *Metapenaeus ensis*, which is highly prized for its sweet taste.

E1.83 Shrimp cultivation was probably started due to the paddy fields lying fallow much of the year (Irving , 1985). Shrimp farming is carried out when the ponds are flooded. *Gei wai* are intertidal ponds of up to 10 ha, which have been enclosed by a man-made dyke. A sluice gate allows *gei wai* to be flooded at high tide and drained at low tide, and also keeps out the predatory fish present in the area.

E1.84 *Metapenaeus ensis* is a primary species cultured in *gei wai*, and comprise approximately 54% of the catch (Leung 1991). Leung (1991) found *M. ensis* to suffer a high degree of mortality (34.55% per month) and show stunted growth in polluted conditions. Lee (1988) determined that increased siltation of the *gei wai* and the cultural practices of the *gei wai* operators added to the environmental stress imposed on the shrimp.

E1.85 The harvesting season occurs from April to October. For a pond of 10 ha, shrimp yields can approximate 1800 kg. The average catch per night is about 16 kg per pond. Each pond provides an annual revenue of about HK$100,000. The market price for shrimp will vary depending on season and quality, and can reach to HK$230 per kg (Applied Science Limited, 1993).

E1.86 The 270 ha of *gei wai* at Mai Po are the only shrimp ponds left in Hong Kong (Young and Melville, 1995), and they are probably the only ones still being operated in the traditional manner in China (Irving and Morton, 1988; Young and Melville, 1993).

Bibliography

Ades, Gary, 1995. Bats and Fishponds. Porcupine. 13:IV.

Agriculture and Fisheries Department (AFD), 1994. Annual Department Report 1993-1994. Hong Kong Government.

Applied Sciences Limited, 1993. WENT Supplementary Environmental Impact Assessment - Ecology for Swire BFI Waste Services Ltd.

Anderson, C. In prep. Shenzhen River regulation project mudflat manipulation experiments.

Ashworth, J.M., R.T. Corlett, D. Dudgeon, D.S. Melville, W.S.M. Tang. 1993. Hong Kong flora and fauna: computing conservation. Worldwide Fund for Nature Hong Kong, Hong Kong.

Axis & CES, 1996. Deep Bay Water Quality Regional Control Strategy Study. Agreement CE 17-95, EPD, Hong Kong Government.

Baker-Gabb, D. 1989. Kites, Goshawks, Eagles, Harriers. Pages 293 - 295 *in* K. Simpson and N. Day (editor and illustrator). Field Guide to the Birds of Australia. Viking O'Neil, Victoria, Australia.

Binnie Consultants Limited, (October 1992). South Mirs Bay Borrow Area EIA, Initial Assessment Report, Fill Management Study - Phase II

Binnie Consultants Limited, 1995. Fisheries survey of Hong Kong waters: gill-net, trawl, ichthyoplankton and reproductive assessment report. Fill Management Study - Phase II.

Binnie Consultants Limited, and Consultants in Environmental Sciences (Asia) Ltd, 1995. Environmental monitoring and audit contaminated mud pits-East of Sha Chau. Progress Reports, June - October, 1995.

Binnie & Partners (Hong Kong) and Shankland Cox, 1985. Tin Shui Wai Development - environmental impact assessment of land preparation aspects. Evaluation Report.

Binnie & Partners (Hong Kong), 1986. Tin Shui Wai Development Land Formation Working Paper No.12 - Silt Deposition Predictive Model stage I report.

Binnie & Partners (Hong Kong), 1987a. Tin Shui Wai Development Land Formation Working Paper No.14 - Silt Deposition Predictive Model stage II report.

Binnie & Partners (Hong Kong), 1987b. Tin Shui Wai Development Land Formation Working Paper No.16 - Water Quality Monitoring, Final Report.

Bones, L.A. 1983 The behaviour and ecology of the Hong Kong fiddler crabs with special reference to *Uca lactea* and *Uca vocans*. Ph.D. Thesis, University of Hong Kong.

Cai Zeping. 1996. Population structure and reproductive characteristics of mudskipper *Boleophthalmus pectinirostris*, in Shenzhen Bay, China. Acta Ecologica Sinica 16:77-82.

Chalmers, M. L. 1986. Annotated checklist of the birds of Hong Kong. Fourth edition. Hong Kong Bird Watching Society, Hong Kong.

Chan, C.K. 1994. Try to increase the richness of benthic invertebrates in shallow water ponds (Gei Wais) by several artificial treatments. Project Report, City University of Hong Kong.

Chau, G.W. 1982. The mosquitoes of Hong Kong. Urban Council Publication, Hong Kong.

Chan, K.Y. 1990 The ecology of mudskippers (Pisces: Periophthalmidae) in the Mai Po Marshes Nature Reserve, Hong Kong. M.Phil.thesis, University of Hong Kong.

Chan, S.Y. 1970. The changing landuse pattern in Tin Shui Wai - an example of the reclamation of marshes for agricultural purposes in the New territories. B.A. Thesis, University of Hong Kong.

Chan, S.Y., J. Au, and L. Young. 1992. A new species of mammal for Hong Kong: the Javan Mongoose (*Herpestes javanicus*). Memoirs of the Hong Kong Natural History Society 19:137-138.

Chandraseker-Rao, A. 1995. Distribution and ecology of Hong Kong small mammals, with special reference to seasonality. M.Phil. Thesis, Hong Kong University.

Chen, Z. and Wei, S. 1995. Ecological characteristics of the distribution of ichthyoplankton in the waters of the Zhujiang (Pearl River). In Wong *et al.* eds: Environmental Research in Pearl River and Coastal Areas. Guangdong Higher Education Press.

Cheung, Y.H. 1979. Studies on Kei Wai. I. Evaluation of productivity. Final year project. Chinese University of Hong Kong.

Chiu, K.T. 1992. An Assessment of the Water Pollution Status of the Mai Po Marshes Nature Reserve, Hong Kong. Unpublished PhD thesis, University of Hong Kong.

Choi, K.C. 1991. The ecology of fiddler crabs (Crustaced: Ocypodidae) at the Mai Po Marshes Nature Reserve, Hong Kong. Unpublished Thesis, University of Hong Kong.

Cramp, S. and K.E.L. Simmons. 1977. Handbook of the Birds of Europe, the Middle-East, and North Africa: The Birds of the Western Palaearctic. Oxford University Press, Oxford, U.K.

Crosby, S. 1991. Ecology of *Macrobrachium*. Unpublished report, WWF-HK, Hong Kong.

Dudgeon, D. and R. Corlett. 1994. Hills and streams, an ecology of Hong Kong. Hong Kong University Press, Hong Kong.

Environmental Protection Department. 1993. Environment Assessment and Planning Group Conservation Database. Report EPD/ITP 21/93, Hong Kong Government, Hong Kong.

Environmental Protection Department, 1994. Marine water quality in Hong Kong. Hong Kong Government.

Enderlein, R. 1994. 1993 breeding population survey of the little ringed plover (*Charadrius dubious*), bird of the year, in the Waldeck-Frankenberg administrative district. Vogelkundliche Hefte Edertal 20: 37-38.

ERM. 1996. Main Drainage Channels for Ngau Tam Mei, Yuen Long and Kam Tin: Environmental Impact Assessment. Territory Development Department, NTN Development Office.

Fan, H.Q. 1993. Necessity of establishing China Mangrove Research Centre and its task. *Journal of the Guangxi Academy of Sciences* **9(2)**: 122-129

Fu, Y.Y., Yin, J.Q., Chen, Q.C., Hung, L.M. and Wong, C.K., 1995. Distribution and seasonality of marine zooplankton in the Pearl River Estuary. In Wong *et al.* eds: Environmental Research in Pearl River and Coastal Areas. Guangdong Higher Education Press.

Gong Zitong and Zhang Xiaopu. 1996. Acid sulphate soil in China : its distribution and classification. In Information, Programme, Participants, and Abstracts of Presentations, The Third International Conference on the Marine Biology of the South China Sea. The University of Hong Kong.

Goodyer, N.J., 1992. Notes on the land mammals of Hong Kong. Mem. Nat. Hist. Soc. **19**: 17-78.

Goss-Custard, J.D., D.G. Kay, and R.M. Blindell, 1977. The density of migratory and overwintering redshank *Tringa totanus* (L.) and curlew *Numenius arquata* (L.) in relation to the density of their prey in south-east England. Estuarine and Coastal Shelf Science 5: 497-510.

Grant, C.J., 1981. Fish farming in Hong Kong. In Deyer, D.J. ed. The Changing Face of Hong Kong. Ye Olde Printerie Limited, Hong Kong

Griffiths, D.A. 1983. Grasses and sedges of Hong Kong. The Urban Council, Hong Kong.

Groombridge, B. (editor). 1993. 1994 IUCN Red List of Threatened Animals. IUCN, Gland, Switzerland and Cambridge,U.K.

Hodgkiss, I.J., 1983. Hong Kong Freshwater Plants. Urban Council, Hong Kong.

Hong Kong Bird Watching Society, 1990. Hong Kong Bird Report 1989, Hong Kong.

Hong Kong Bird Watching Society, 1991. Hong Kong Bird Report 1990, Hong Kong.

Hong Kong Bird Watching Society, 1994. Hong Kong Bird Report 1993, Hong Kong.

Irving, R.T.A. 1985. The Deep Bay Shrimp Farming Industry - a Preliminary Survey. Annuals of the C.G.A.S. Pp:13. Hong Kong University Press.

Irving, R. and Morton, B. 1988. A geography of the Mai Po Marshes. Hong Kong: *Hong Kong University Press.*

Karsen, S.J., Lau, M.W.N. and Bogadek, A., 1986. Hong Kong amphibian & reptiles, Urban Council, Hong Kong.

Kwok, W., 1995. Mangrove crabs at Mai Po. Unpublished PhD, University of Hong Kong.

Lam, W.Y. , Lui, P.H. and Kong, M.F. 1988. Marine water quality in Hong Kong. Technical Report No. EP/TR3/88, Published by the Environmental Protection Department, Hong Kong.

Lee, S.Y., 1988. The ecology of a traditional tidal shrimp pond in Hong Kong: the production and the fate of macrodetritus and implications for management. Unpublished Thesis, Hong Kong University.

Lee, S.Y. 1990. Primary productivity and particulate organic matter flow in an estuarine mangrove, wetland in Hong Kong. *Marine Biology* **106**: 453-463

Lee, S.Y. 1993. Invertebrate species new to science recorded from the Mai Po Marshes, Hong Kong. Department of Zoology and the Swire Marine laboratory, University of Hong Kong.

Lee, S.Y. 1995. Macrobenthic community structure of a polluted tidal river in Deep Bay, Hong Kong. Pages 43-51 in Proceeding of The 2nd International Conference of The Marine Biology of the South China Sea.

Leung, C.Y.W. 1994. Population -dynamics of zooplankton in Mai Po, with emphasis on Copepoda. Project Report, City University of Hong Kong.

Leung, S.F. 1991. The population dynamics of *M. ensis* (*Penaeidae*) and *Exopalaemon styliferas* (*Palaemonidae*) in a traditional tidal shrimp pond at the Mai Po Marshes Nature Reserve, Hong Kong. Unpublished Thesis, University of Hong Kong.

Lee, S.Y. 1989. The importance of the sesarminae crabs *Chiromanthes* spp. and inundation frequency on mangrove (Kandelia candel (L) Druce) leaf litter turnover in a Hong Kong tidal shrimp pond. Journal of Experimental Marine Biology and Ecology 131: 23-43.

Lee, W.H. 1995. Distribution and structure of reedbeds community in *Gei Wai* 14 of Mai Po Marshes. BSc. Thesis, City University of Hong Kong.

Leung, K.W. 1986. Landuse and landuse changes in the Deep Bay area. B.A. Thesis, University of Hong Kong.

Leven, M.R. and G.J. Carey. 1993. Systematic list. Hong Kong Bird report 1992. Hong Kong Bird Watching Society.

McChesney, S.M. 1996. The benthic invertebrate community of the intertidal mudflat at the Mai Po Marshes Nature reserve, with special reference to resources for migrant shorebirds. Unpublished M. Phil. thesis, University of Hong Kong.

Melville, D.S. 1981. Spring measurements, weight and plumage status of *Calidaris ruficollis* and *C. ferruginea* in Hong Kong. Wader Study Group Bulletin 33: 18-21

Melville, D.S., Lee, S.Y. and Cheng, W.W. 1989. Some aspects of the management of the Mai Po Marshes, Deep Bay, Hong Kong. In Parish and Prentic (eds): Wetland and Waterfowl Conservation in Asia, Wetland Bureau/IWRB, Kuala Lumpur.

Melville, D.S., McChesney, S., Anderson, C., and Leader, J. 1995. Predicted impacts of the Shenzhen river regulation project on waterfowl in Deep Bay, Hong Kong. The 10th International Waterfowl Ecology Symposium. Aveiro, Portugal.

Mok, T.K. 1973. Studies on spawning and settling of the oyster in relation to seasonal environmental changes in Deep Bay, Hong Kong. Hong Kong Fisheries Bulletin 3: 89-101.

Morton, B. 1989. The marine flora and fauna of Hong Kong and the Southern China III (Volume 2). Hong Kong University Press, Hong Kong.

Morton, B. 1990. A bibliography of Hong Kong Marine Science: 1982-1990. *Hong Kong University Press*, Pp. 123

Nelson, J.G. 1992. The Mai Po Marshes; Hong Kong, a case of conservation issue in East Asia. World Wide Fund for Nature

Peking University. 1995. Environmental Impact Assessment Study on Shenzhen River Regulation Project. Final EIA Study Report. 3 Volumes. Shenzhen River Regulation Office of Municipal Government.

Pfister, C., B. A. Harrington, and M. Lavine. 1992. The impact of human disturbance on shorebirds at a migration staging area. Biological Conservation 60: 115-126.

Reels, G. 1994. Management strategies for the reed *Phragmites australis* (Cav.) Steud. at Mai Po Marshes Nature Reserve, Hong Kong, with observations on the associated insect fauna. Unpublished M. Phil. thesis, University of Hong Kong.

Roberts, T. J. 1965. The birds of Pakistan. Volume 2. Oxford University Press.

Schilling, M.R. 1996. Vernal pools: an overview.Wetland Journal 8:6-7.

Spaans, B. 1994. The breeding birds of the Volkrak-Zoommeer during the first five years after embankment. Limosa 67: 15-26.

Thrower, S.L. 1984. Hong Kong Shrubs, Vol. II. Urban Council, Hong Kong.

Thrower, S.L. 1988. Hong Kong Trees, Omnibus Volume. Urban Council, Hong Kong.

Tsang, S.C. 1993. To monitor the heavy metals contents in the polychaeta, *D. pinnaticirrus* in Mai Po Mudflat. Project Report, City University of Hong Kong.

Vance, D.J. (in press). Distribution of shrimp and fish associated with the mangrove forest of Mai Po Marshes Nature Reserve, Hong Kong. In Lee, S.J. ed: Asia-Pacific Symposium on Mangrove Ecosystems Workshop (in press)

Viney, C. and K. Phillips. 1988. Birds of Hong Kong and South China. Government Publication Centre, Hong Kong.

Viney, C., K. Phillips, and Lam C.Y. 1994. Birds of Hong Kong and South China. Government Publications Centre, Hong Kong.

Wei, W.Y., Zhang, G.X. and Du, W.C. 1995. A study on water pollution in the Zhujiang Estuary. In Wong *et al.* eds: Environmental Research in Pearl River and Coastal Areas. Guangdong Higher Education Press.

World Wide Fund for Nature Hong Kong (WWF) 1993. Possible impacts of the Shenzhen River Training Project on the Internationally Important Deep Bay Wetland. The World Wild Fund for Nature, Hong Kong.

Wong, F. K. O. 1991. Habitat utilization by Little Egrets breeding at Mai Po egretry. Hong Kong Bird Report 1990:185-190.

Wilson, K. 1995. Hong Kong Dragonflies. Urban Council, Hong Kong.

Yates, M.G., *et al.* 1993. Sediment characteristics, invertebrate densities and Shorebird densities on the inner banks of the Wash. Journal of Applied Ecology, 30: 599-614.

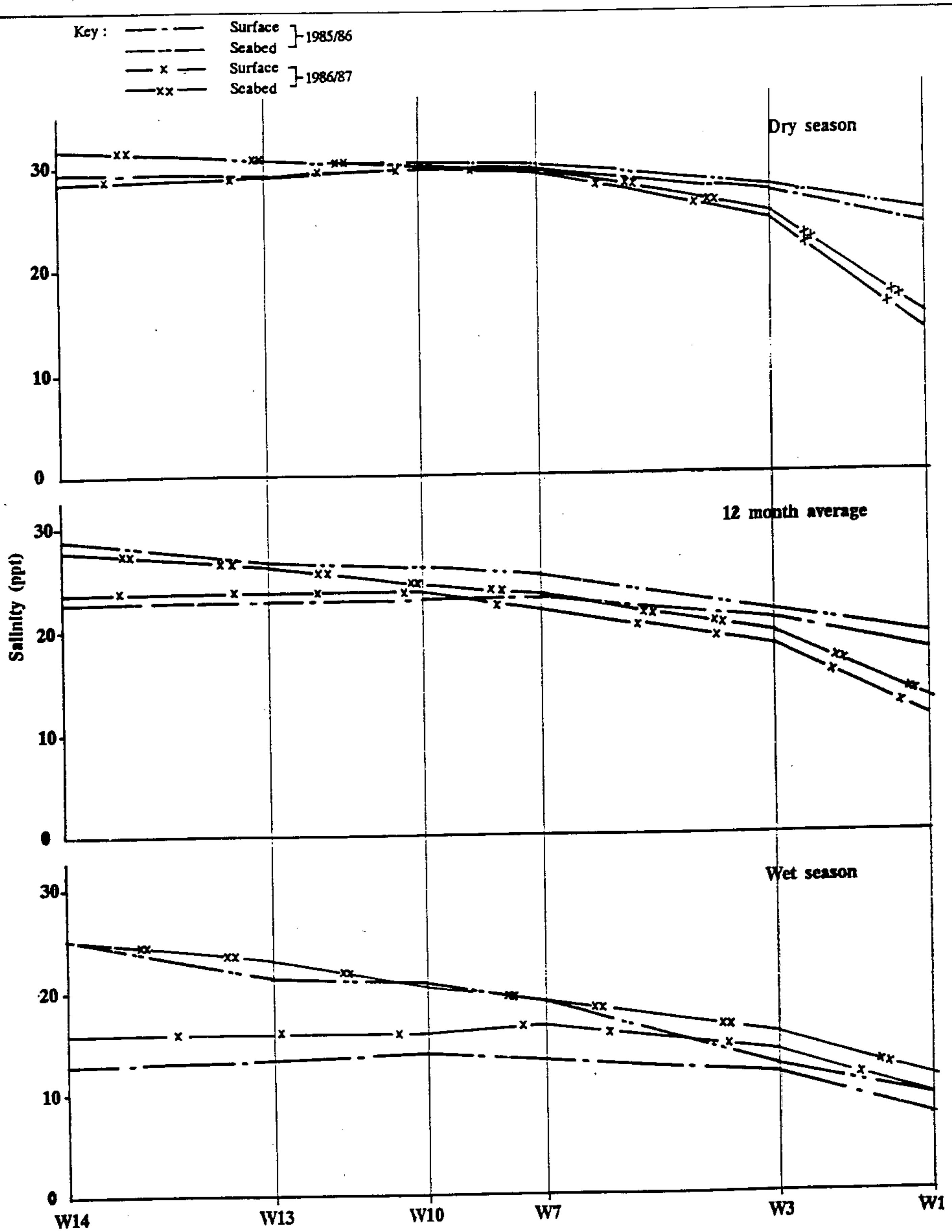
Young, L. and D.S. Melville, 1993. Conservation of the Deep Bay Environment. Pages 211-231 in B. Morton (ed), The Marine Biology of the South China Sea. Proceedings of the First International Conference on the Marine Biology of Hong Kong and the South China Sea. Hong Kong University Press.

Young, L. and Melville, D.S. 1995. Environmental research at the WWF Hong Kong Mai Po Marshes Nature Reserve. In Wong *et al.* eds: Environmental Research in Pearl River and Coastal Areas. Guangdong Higher Education Press.

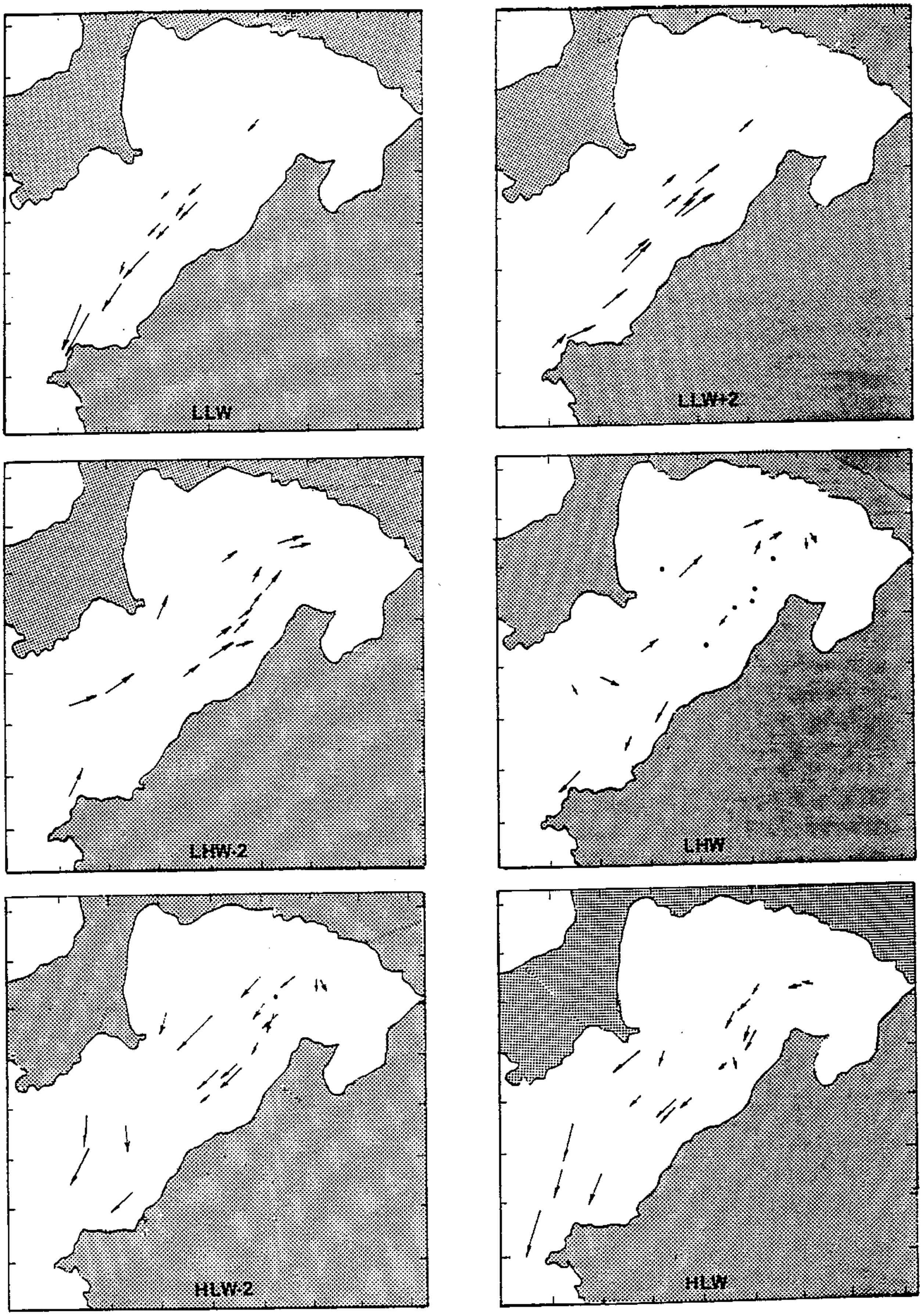
Young, L. 1993. The ecology of Hong Kong Ardeidae (Aves) with special reference of the Chinese Pond Heron at the Mai Po Marshes nature Reserve. Unpublished PhD. thesis, University of Hong Kong, Hong Kong.

Young, L. 1994. Mai Po News. Porcupine! 11.

Young, L. 1995. The biological importance of Deep Bay and the Mai Po Marshes. Pages 16-26 in Chiu S. T. (editor). Wetlands - Deep Bay and the Mai Po Marshes.

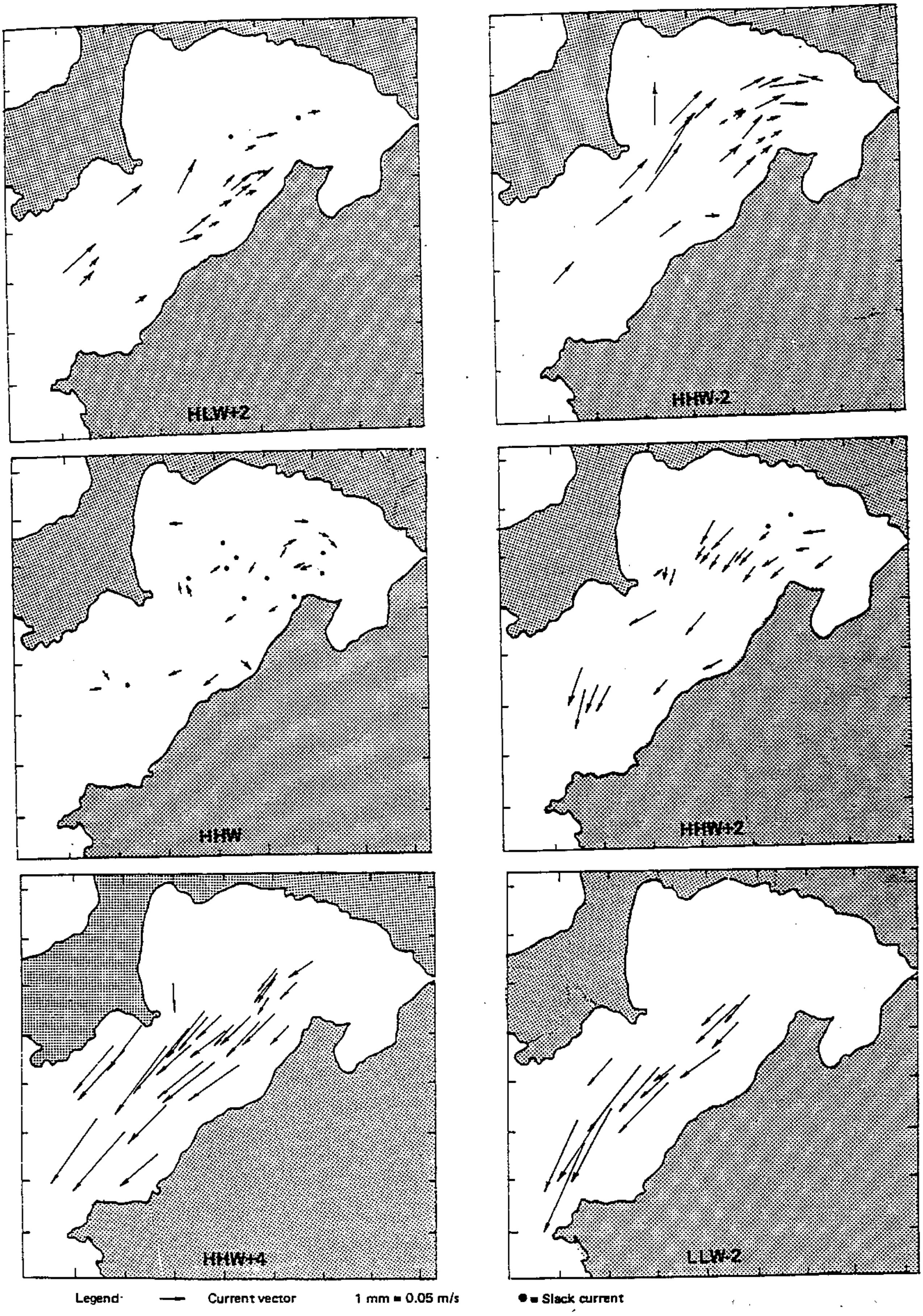


TIN SHUI WAI DEVELOPMENT AGREEMENT NO. CE 10/95 ENGINEERING INVESTIGATIONS FOR DEVELOPMENT OF AREAS 3, 30 & 31 OF THE DEVELOPMENT ZONE AND THE RESERVE ZONE	Title : AVERAGE SALINITY OVER DEEP BAY SHENZHEN RIVER TO URMSTON ROAD (BINNIE & PARTNERS (HK), 1987)	Figure No. E1.1	Revision 0
BINNIE CONSULTANTS LIMITED 賓尼工程顧問有限公司 ENGINEERS AND SCIENTISTS 賓尼		Reference No. BINNIE (HK) 1987	File Name -
		Prepared WPC	Checked WYC
		Date FEB 96	Scale -



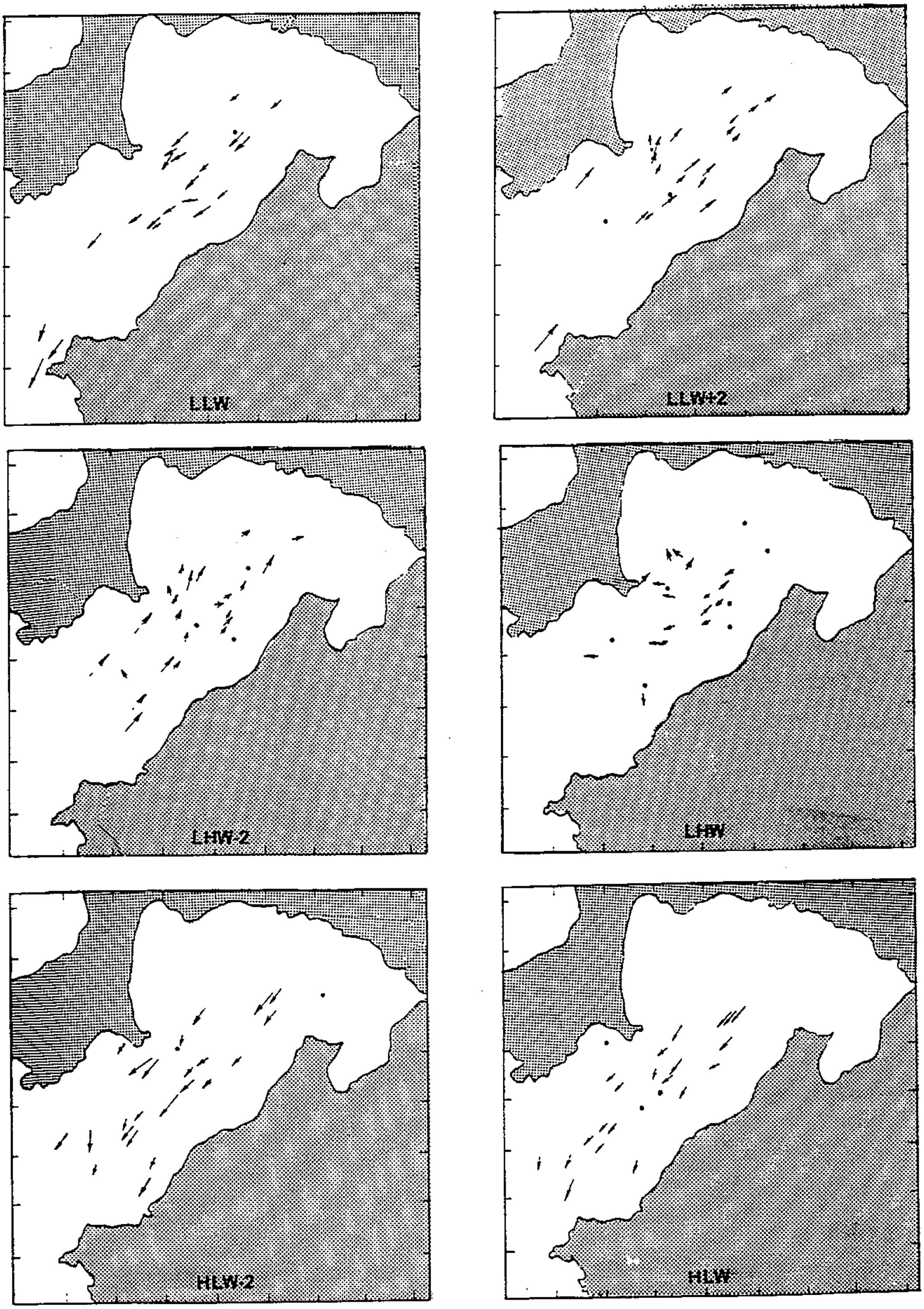
Legend: —— Current vector 1 mm = 0.05 m/s ● = Slack current

TIN SHUI WAI DEVELOPMENT AGREEMENT NO. CE 10/95 ENGINEERING INVESTIGATIONS FOR DEVELOPMENT OF AREAS 3, 30 & 31 OF THE DEVELOPMENT ZONE AND THE RESERVE ZONE	Title : DEEP BAY - SPRING TIDE CURRENT VECTORS (BINNIE & PARTNERS (HK) AND SHANKLAND COX, 1985)	Figure No. **E1.2a**	Revision 0
BINNIE CONSULTANTS LIMITED 賓尼工程顧問有限公司 賓尼 ENGINEERS AND SCIENTISTS		Reference No. BINNIE (HK) AND SHANKLAND COX 1987	File Name -
		Prepared WPC	Checked WYC
		Date FEB 96	Scale -



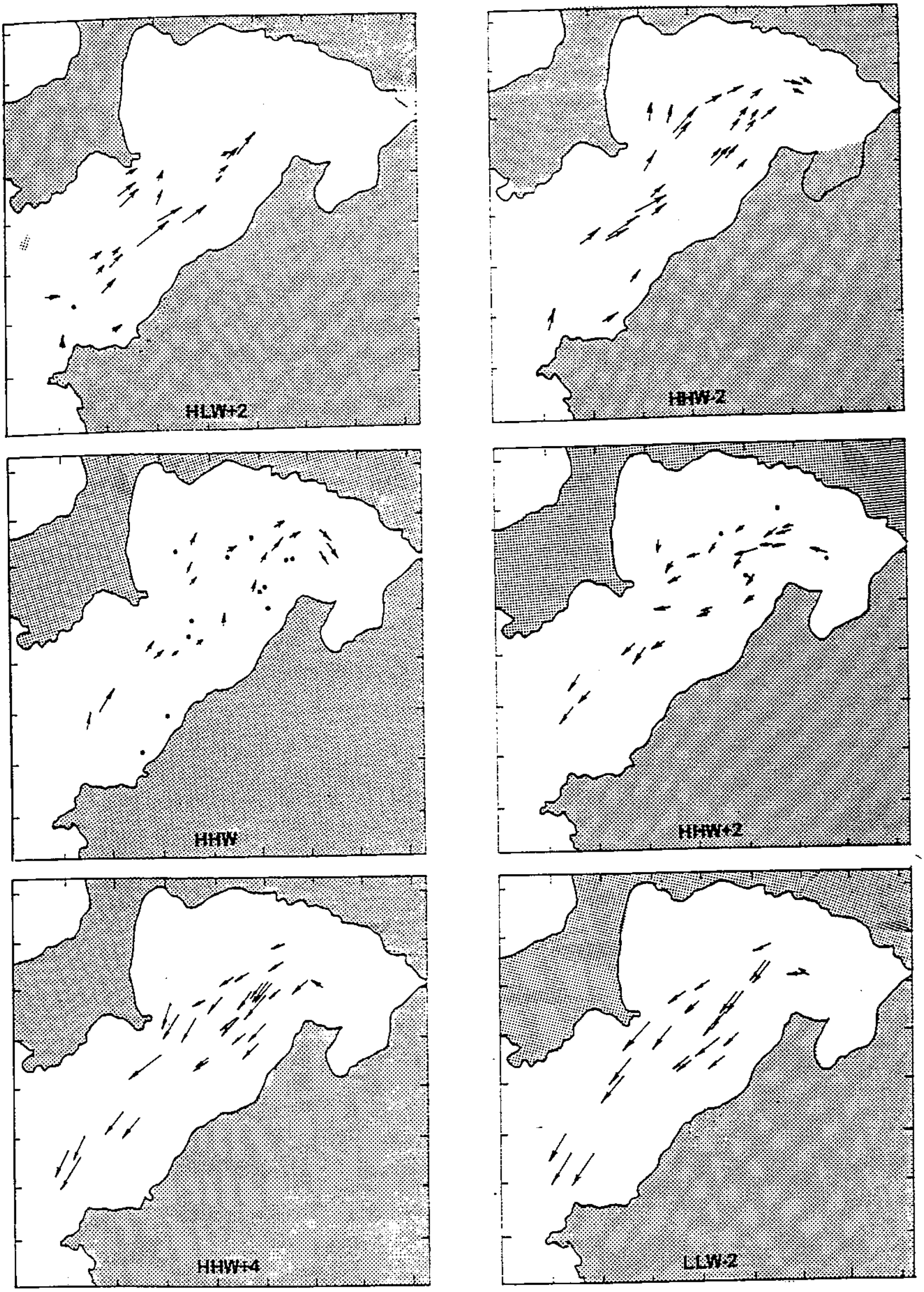
Legend: → Current vector 1 mm = 0.05 m/s • = Slack current

TIN SHUI WAI DEVELOPMENT AGREEMENT NO. CE 10/95 ENGINEERING INVESTIGATIONS FOR DEVELOPMENT OF AREAS 3, 30 & 31 OF THE DEVELOPMENT ZONE AND THE RESERVE ZONE	Title : DEEP BAY - SPRING TIDE CURRENT VECTORS (BINNIE & PARTNERS (HK) AND SHANKLAND COX, 1985)	Figure No. E1.2b	Revision 0
		Reference No. BINNIE (HK) AND SHANKLAND COX 1987	File Name -
BINNIE CONSULTANTS LIMITED 賓尼工程顧問有限公司 賓尼 ENGINEERS AND SCIENTISTS		Prepared WPC	Checked WYC
		Date FEB 96	Scale -



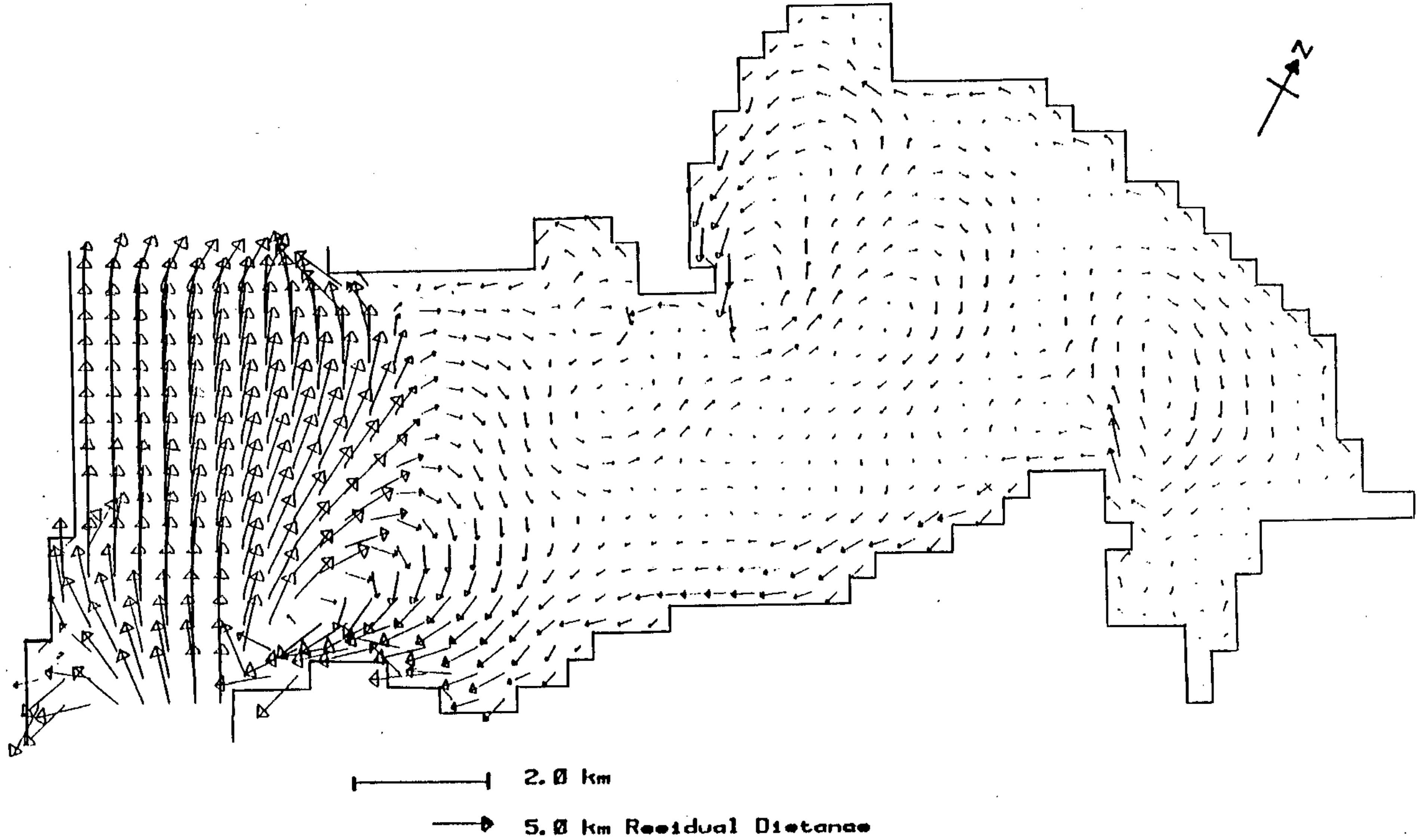
Legend: —— Current vector 1 mm = 0.05 m/s • = Slack current

TIN SHUI WAI DEVELOPMENT AGREEMENT NO. CE 10/95 ENGINEERING INVESTIGATIONS FOR DEVELOPMENT OF AREAS 3, 30 & 31 OF THE DEVELOPMENT ZONE AND THE RESERVE ZONE	Title : DEEP BAY - NEAP TIDE CURRENT VECTORS (BINNIE & PARTNERS (HK) AND SHANKLAND COX, 1985)	Figure No. **E1.3a**	Revision 0
		Reference No. BINNIE (HK) AND SHANKLAND COX 1987	File Name -
BINNIE CONSULTANTS LIMITED 賓尼工程顧問有限公司 賓尼 ENGINEERS AND SCIENTISTS		Prepared WPC	Checked WYC
		Date FEB 96	Scale -

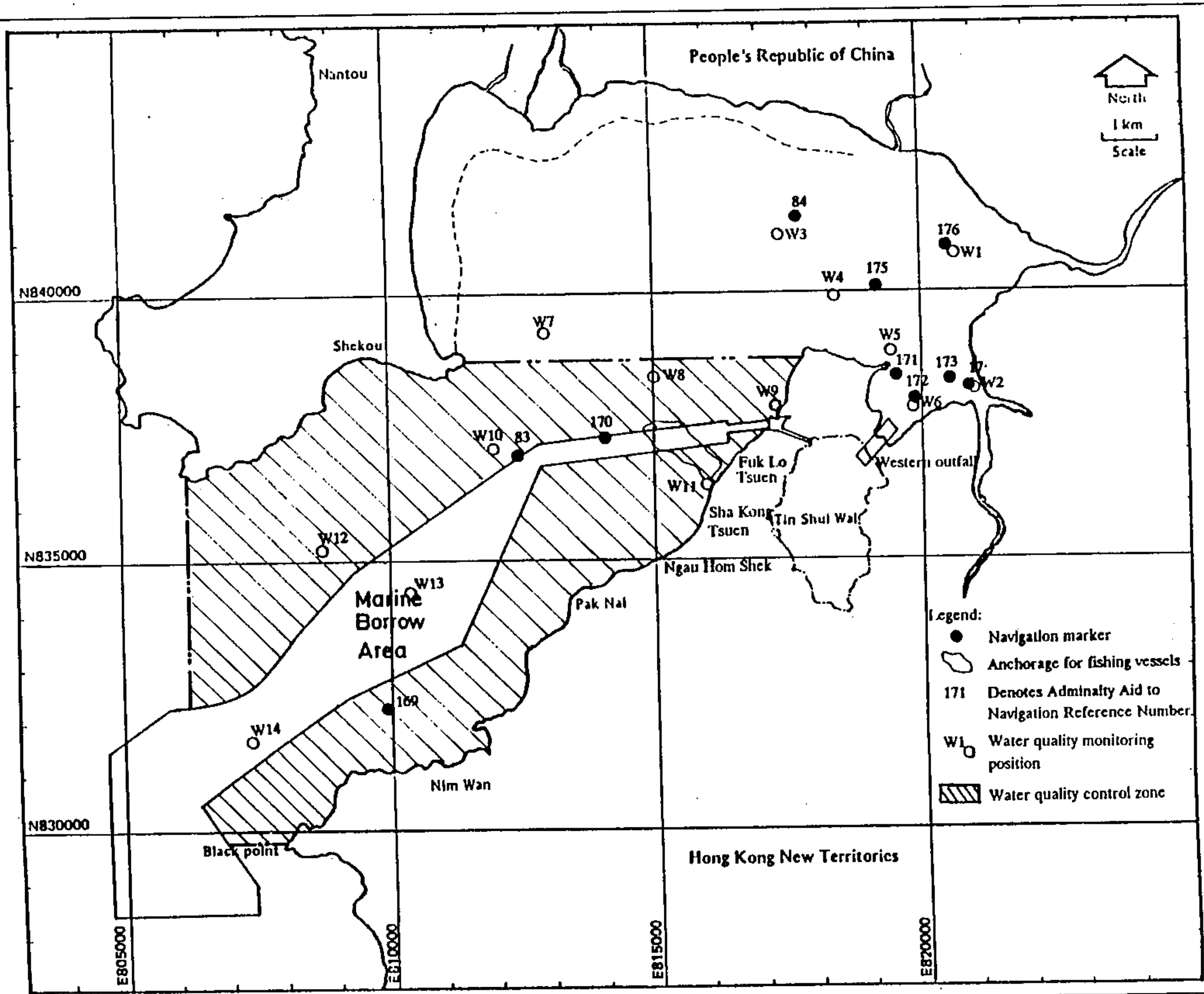


Legend: ⟶ Current vector   1 mm = 0.05 m/s   • = Slack current

TIN SHUI WAI DEVELOPMENT AGREEMENT NO. CE 10/95 ENGINEERING INVESTIGATIONS FOR DEVELOPMENT OF AREAS 3, 30 & 31 OF THE DEVELOPMENT ZONE AND THE RESERVE ZONE	Title : DEEP BAY - NEAP TIDE CURRENT VECTORS (BINNIE & PARTNERS (HK) AND SHANKLAND COX, 1985)	Figure No. E1.3b	Revision 0
		Reference No. BINNIE (HK) AND SHANKLAND COX 1987	File Name -
BINNIE CONSULTANTS LIMITED 賓尼 賓尼工程顧問有限公司 ENGINEERS AND SCIENTISTS		Prepared WPC	Checked WYC
		Date FEB 96	Scale -



TIN SHUI WAI DEVELOPMENT AGREEMENT NO. CE 10/95 ENGINEERING INVESTIGATIONS FOR DEVELOPMENT OF AREAS 3, 30 & 31 OF THE DEVELOPMENT ZONE AND THE RESERVE ZONE	Title : SPRING TIDE RESIDUAL CURRENT PATTERN (BINNIE & PARTNERS (HK), 1986)	Figure No. **E1.4**	Revision 0
		Reference No. BINNIE (HK) 1986	File Name -
		Prepared WPC	Checked WYC
BINNIE CONSULTANTS LIMITED 賓尼工程顧問有限公司 賓尼		Date FEB 96	Scale -



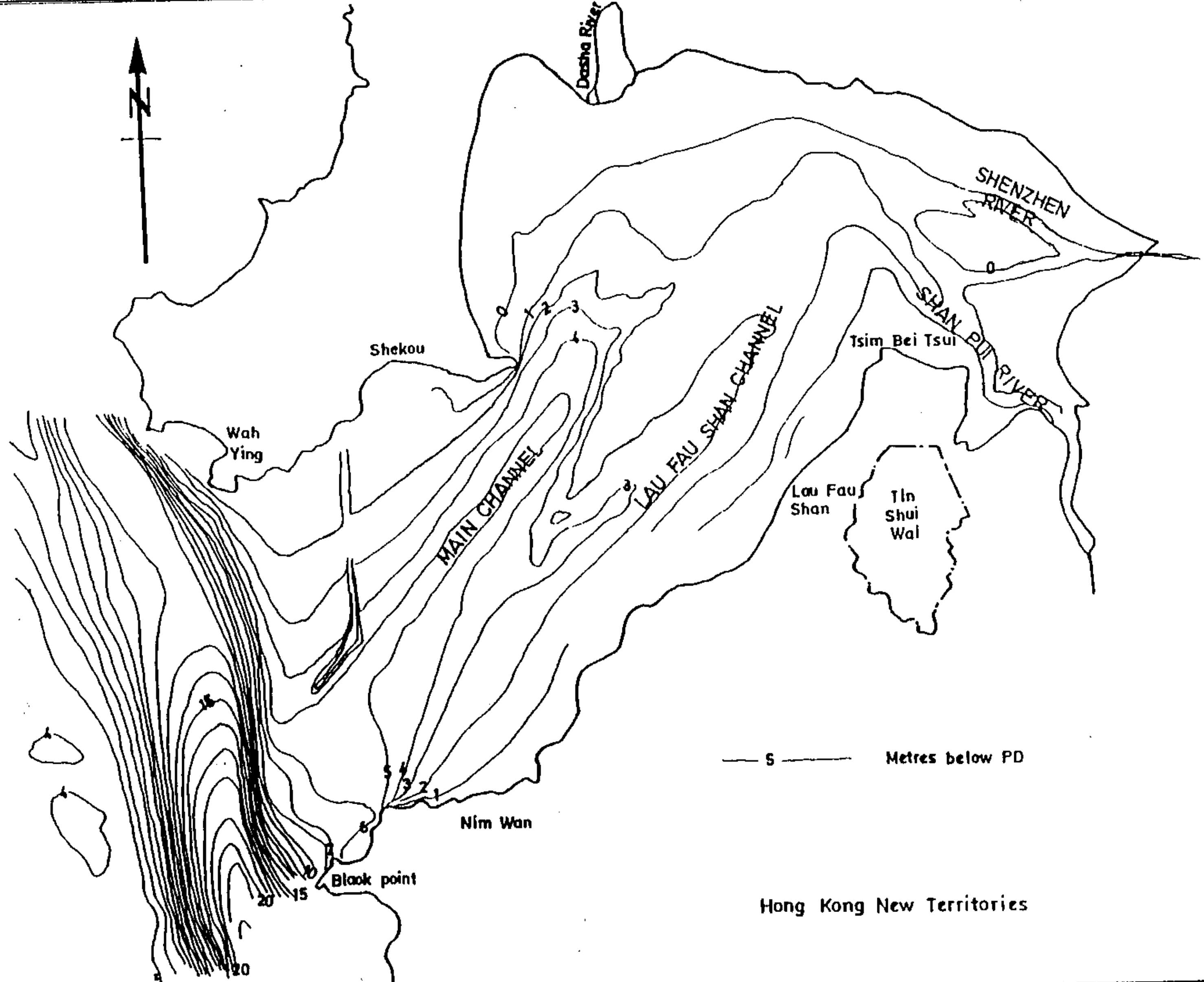
TIN SHUI WAI DEVELOPMENT
AGREEMENT NO. CE 10/95
ENGINEERING INVESTIGATIONS FOR DEVELOPMENT OF AREAS 3, 30 & 31 OF THE DEVELOPMENT ZONE AND THE RESERVE ZONE

BINNIE CONSULTANTS LIMITED 賓尼工程顧問有限公司

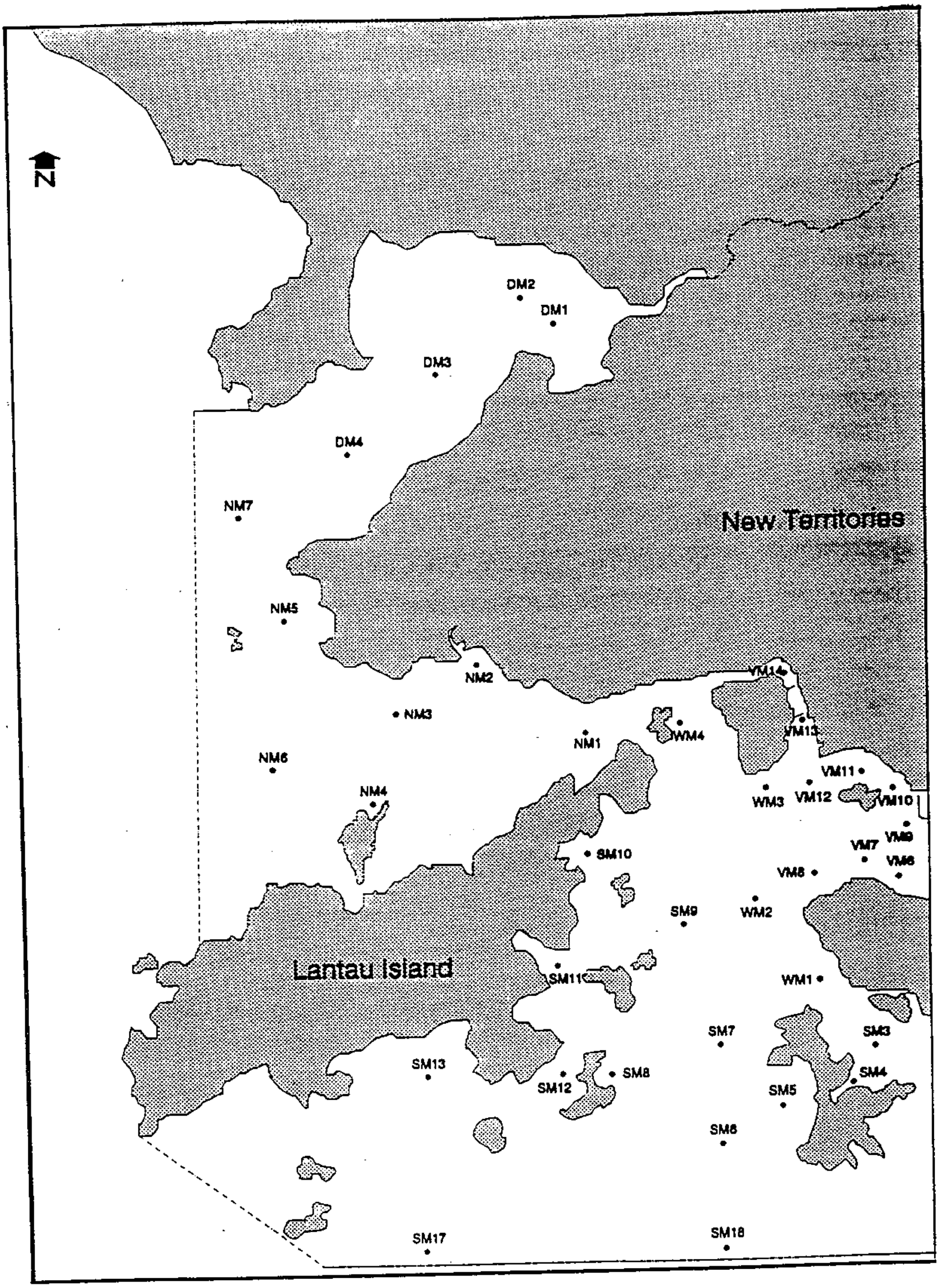
Title :

LOCATIONS OF WATER QUALITY MONITORING POSITIONS (BINNIE & PARTNERS (HK), 1987)

Figure No E1.6	Revision 0
Reference No. BINNIE (HK) 1987	File Name -
Prepared WPC	Checked WYC
Date FEB 96	Scale -



TIN SHUI WAI DEVELOPMENT AGREEMENT NO. CE 10/95 ENGINEERING INVESTIGATIONS FOR DEVELOPMENT OF AREAS 3, 30 & 31 OF THE DEVELOPMENT ZONE AND THE RESERVE ZONE	Title : BATHYMETRIC MAP OF DEEP BAY (BINNIE & PARTNERS (HK), 1986)	Figure No E1.5	Revision 0
BINNIE CONSULTANTS LIMITED 賓尼工程顧問有限公司 賓尼 ENGINEERS AND SCIENTISTS		Reference No. BINNIE (HK) 1986	File Name -
		Prepared WPC	Checked WYC
		Date FEB 96	Scale -



TIN SHUI WAI DEVELOPMENT AGREEMENT NO. CE 10/95

ENGINEERING INVESTIGATIONS FOR DEVELOPMENT OF AREAS 3, 30 & 31 OF THE DEVELOPMENT ZONE AND THE RESERVE ZONE

BINNIE CONSULTANTS LIMITED 賓尼工程顧問有限公司 賓尼

ENGINEERS AND SCIENTISTS

Title :

WATER QUALITY SAMPLING LOCATIONS
(EPD, 1994)

Figure No. E1.7	Revision 0
Reference No. EPD 1994	File Name -
Prepared WPC	Checked WYC
Date FEB 96	Scale -

Appendix E2

Rapid Ecological Assessment

APPENDIX E2 RAPID ECOLOGICAL ASSESSMENT

E2.1 As part of the Environmental Review for the Tin Shui Wai Project, a Rapid Ecological Assessment (REA) was carried out during the week of 11 December 1995 by the EIA Ecological Team. A representative of the Worldwide Fund for Nature - Hong Kong participated as an observer. The purpose of the REA was:

(a) to describe the existing ecological value of the RZ, especially Areas 102, 109, and 117;
(b) to identify key environmental issues; and
(c) to propose measures to minimize environmental impacts as appropriate.

E2.2 The REA included one full day during which the complete Ecology Team surveyed the RZ and surrounding areas. During and after the survey, Key Issues were discussed with respect to each subarea. The issues reported here are organized by area, in and around the RZ.

E2.3 The RZ is a man-made platform and can be divided into 3 ecologically different areas: the first being the former western river channel running through the west of the RZ (Areas 101, 105, 106, 110, 111); the second a sandy soil with poor ecological value which includes most of the RZ; and thirdly Areas 109b, parts of 117 and a slice of Area 104 - the ETC. The WTC is not directly impacted by the Site Formation Works.

E2.4 The area surrounding the RZ comprises fishponds, mangroves, and extensive intertidal mudflats that serve the Ramsar site in its role in supporting waterfowl. Intertidal infauna is of ecological importance as food for migrating and resident waterbirds, as well as an integral component of the foodweb operating in Inner Deep Bay. Adjoining *fung shui* woodlands north of the RZ have supported egretries. The areas around the RZ therefore have considerable ecological importance.

Results of the Rapid Ecological Assessment

E2.5 Most of the area within the RZ is a terrestrial habitat recently formed by filling in fishponds with clean quartz sand of marine origin. Most of the plant species occurring on this land are pioneer species including grasses and exotic weeds (opportunistic species). The vegetation cover on the whole is sparse and poor in diversity on the filled areas, and is dominated by several grasses such as *Brachiaria mutica*, *Rhynchelytrum repens*, *Cynodon dactylon*, *Neyraudia reynaudiana*, *Panicum maximum*, and composites such as *Conyza* sp. and *Eriogeron*.

E2.6 In wet, marshy areas such as the incompletely filled former river channel in Areas 101, 105, 106, 110, 111 and the partially filled fishponds in Area 118, the reedgrass *Phragmites* sp. is commonly found, together with other grasses such as *B. mutica* and *Pennisetum purpureum*. The latter area is of more ecological value due to it being adjacent to the existing buffer zones. The noxious exotic weedy vine *Mikania micrantha* is also commonly found growing on other plants in the relatively moist areas of the RZ as well as the surrounding area. Insects including dragonflies and chironomid midges may breed in these marshy areas.

E2.7 The western channel and the eastern drainages in Area 118 (the mangrove edge), however, have considerable existing ecological value in terms of brackish and freshwater wetland habitat, including mangroves which provide roosting and nesting places for regionally important herons and egrets, potential shelter and food for rare and endangered mammals, and intertidal mudflats which support invertebrates used as food by migratory waterbirds including some globally endangered species.

Eastern Drainages in Area 118

E2.8 A part of Area 118 lies to the north of the spillway/dam (outfall structure). Its position adjacent to the Ramsar site and partially within the Deep Bay Buffer Zones makes it a relatively undisturbed remote location. The section of Area 118 next to Area 114 is part of the man-made platform.

E2.9 A mangrove community typical of this part of Deep Bay lines the banks of the channels, and the trees are low in stature and shrubby in appearance, especially when *Aegiceras corniculatum* is the pioneering species. There are, however, stands of mangroves probably dominated by *Kandelia candel* which achieve an estimated height of between 6-7m. There are more than eight individuals of the relatively rare mangrove species *Bruguiera gymnorrhiza* along the drainages. There are no land-ward mangrove or mangrove associated species such as *Lumnitzera racemosa*, *Exocaria agallocha*, or *Heritiera littoralis* in Area 118.

E2.10 On the western side of the eastern drainages, 5-10m from the track parallel to the channels, there is a long strip of marshy area covered by reedgrass (*Phragmites*) and a marshy fern *Cyclorus interruptus*. Both of these species are not rare in Hong Kong nor the South China region, but their distribution is limited to marshy areas only, which are becoming less common.

E2.11 Roosting birds including the regionally important species Little Egret and Chinese Pond Heron were observed in the tall mangrove stand during previous field visits. Herons and egrets were seen using the channels, partly-filled fishponds, and mangroves as feeding and roosting sites during the REA.

E2.12 Partially infilled fishponds provide marshy areas important for birds and dragonflies. The filled area has been planted with both exotic and native species by TDD about 5 years ago, with tree maintenance handed over to AFD. Only the exotic trees planted, including *Eucalyptus* spp., *Melaleuca quinquenervia*, and *Acacia auriculiformis*, had survived at the time of the REA. AFD will maintain these plantations for 9 years.

E2.13 One unidentified mammal and a possible abandoned burrow entrance that would be suitable for otter were sighted in Area 118.

Area 102

E2.14 The sandy soil found in Area 102 is representative of the majority of the RZ, namely Areas 103, 104, 107, 108, 109a, 112, 113, 115, 116 and 114, These areas are covered with the grass dominated by *Rhynchelytrum repens* and the composite weed *Conzya* sp. The overall vegetation cover is not dense and the above ground biomass is low suggesting that the area has been burnt in the recent past (and probably regularly). Area 109a is also dominated by grasses such as *R. repens*, *Brachiaria mutica*, *Neyraudia reyaudiana*, *Cynodon dactylon*, *Cyperus sp.*, *Sesbania sp. (Papilionaceae)* and *Panicum maximum*. No other plants of botanical interest or conservation value are recorded in these areas.

E2.15 The loss of habitat in these areas does not pose any serious threat to rare or endangered mammals or birds.

Areas 109b, 117 and the edge of 104: The Eastern Temporary Channel

E2.16 Area 109b is dominated by grasses such as *R. repens*, *Brachiaria mutica*, *Neyraudia reynaudiana*, and *Panicum maximum*. No other plants of botanical interest of conservation value are recorded in this area.

E2.17 Mammal evidence gathered during the REA included small diameter burrows observed in Area 117 (and although not observed most likely to be in 109b and the edge of 104 - equally marshy areas), probably caused by small burrowing rodents and insectivores (mice and shrews). The loss of the habitat in Areas 104, 109b and 117b does not pose any serious threat to rare and endangered mammals or birds, although it does provide ideal habitat life for a variety of species.

E2.18 Area 117 contains a fresh water marshy area above a spillway/dam - the outfall structure in Area 118. The area south and west of this marshy area is already filled. The banks of the marshy area are dominated by the reedgrass *Phragmites*, with the grasses *B. mutica* and *N. reynaudiana* present. The upper portion of the freshwater body is covered with the exotic weedy herb *Eichhornia crassipes* (Water Hyacinth) and there is an area of open water downstream of the Water Hyacinth extending to the spillway dam. *Phragmites* has a distribution limited to low-lying wetland areas which are diminishing in the area, but no other plant in Area 117 is of major botanical interest or special conservation value. This freshwater marshy area is a habitat for species such as dragonflies and a feeding area for birds.

Western Drainage Channel and Western Temporary Channel

E2.19 The WDC is a man-made structure that is concrete lined to a inflatable dam just south of the RZ boundary. The WTC banks are armoured with rip rap blocks.

E2.20 Mangrove (*Kandelia candel* and *Acanthus ilicifolia*) as well as mangrove-associated species (*Hibiscus tiliaceus*) are becoming established on the soft-sediment banks. The width of this mangrove belt increases downstream along the channel and attains about 40 m near the entry point of the WTC in Deep Bay.

E2.21 For this Study, the term 'wading birds' is defined to include shorebirds, storks, egrets, herons, and Blackfaced Spoonbills, as well as grebes, ducks and pelicans which are not strictly wading birds, but utilize the same estuarine habitat, and forage or roost side by side with the wading birds.

E2.22 During the REA, waterbirds increased in total number, diversity and density with proximity to the Inner Deep Bay intertidal mangrove and mudflat. No waterbirds were observed above the fabridam. At any one time, 10-30 egrets and herons were observed down stream of the dam, with rafts of dabbling ducks joining the avifauna further downstream, then waders foraging along the edge of the muddy banks. Thousands of birds, including gulls, waders, egrets, herons, ducks, and cormorants were seen on the intertidal mudflats in front of the channel mouth.

E2.23 Many birds present along the WTC were foraging. Core samples collected approximately 250m downstream from the fabridam contained no macrofauna when the samples were sieved. Lee (1995) reported the presence of only small-bodied and abundant oligochaetes in the Shan Pui River, another soft-sediment channel approximately 3km to the east of this site. The intertidal mud below the dam appears anoxic and is covered with blue-green algae whose respiration requirements at night would consume oxygen.

E2.24 During the REA, fiddler crabs (*Uca* spp.) were observed along the banks of the WTC and the adjacent Deep Bay mudflats from the security bridge crossing the mouth of the WTC. These crabs were not observed in the soft sediment just below the fabridam.

E2.25 During the field survey around the areas of the WTC, mammal burrows and droppings of unknown species were recorded.

E2.26 In addition to the specific area-based surveys, the REA also considered habitat types. Comments on these are given below.

<u>Fishponds</u>

E2.27 Many fishponds exist around the RZ and DZ. Two abandoned ponds lie within Areas 122-123. Actively managed ponds are in the area adjacent to the WTC. These would be important foraging sites for egrets and herons breeding in the nearby egretry. Active fishponds are known to provide essential food resources for resident egrets and herons, as well as contributing food to migratory waterbirds, particularly when drained down in winter.

<u>Agricultural Land</u>

E2.28 Most of the agricultural fields in the area outside the RZ and adjacent to the WTC have been turned into open storage areas for containers. Other fields are abandoned and are being colonized by weedy herbs and shrubs. These abandoned fields are of ecological interest as long as they are not filled with concrete or solid waste in that they may provide food and habitat to insects and birds.

Appendix E3

Ecological Impact Assessment Methods

E2.29 Small patches of lowland woods are found in areas between the fish ponds and hillslopes of Lau Fau Shan and Tsim Bei Tsui. The natural or semi-natural woodlands comprise mostly native tree species. However, due to their small size, proximity to human settlement, and past history of human activity, it is unlikely that these wooded areas are supporting any mammals apart from rodents. This will be checked during the Habitat Analysis, and followed up during the 12-month Eco-EIA. These wooded areas may be used by woodland birds. The Tsim Bei Tsui egretry - currently abandoned - is comprised of such woodland.

Woodland Plantation

E2.30 Patches of exotic trees are found along a belt west of the WTC. These trees are burnt frequently by brushfires. Additional plantation woodlands dominated by exotic tree species are present in Area 118.

Mangrove

E2.31 Mangroves are found on the banks of both the eastern and western drainages fringing the RZ and form the high intertidal zone where the drainage channels open into Deep Bay. The mangrove community seems to be one typical of this part of Deep Bay. The assemblage is dominated by *Acanthus ilicifolius*, *Aegiceras corniculatum*, and *Kandelia candel*, with occasional individuals of *Avicennia marina*. The creepers *Derris trifoliata* and *Mikania guacha* are common on the canopies of the mangroves in the drier sections of the mangrove belt.

E2.32 The Tsim Bei Tsui egrety population has changed location several times in recent years and in May 1995 was located in the mangrove forest fringing Deep Bay. Mangroves provide valuable foraging and roosting sites for crakes and rails, kingfishers, and some shorebirds such as Whimbrel and Redshank are seen foraging among mangrove trees at the edge of the forest and can be heard calling from within.

E2.33 Mangrove islands form the entry point of the WTC into Deep Bay. The mudflat-fringed islands seem to be favoured by many species of waterbirds as a roosting and foraging site. More than 300 Little Egrets were observed together on mangrove islands at the WTC entrance to the intertidal mudflats during the REA.

E2.34 Starlings and wagtails formed large nighttime roosts of hundreds of individuals in the mangroves and fringing fishpond bund habitat in the Inner Deep Bay area in recent years. In autumn, these species fly in one direction in late afternoon, almost certainly towards a roost, but its location had not been determined at the end of the REA.

E2.35 The mangrove is a likely habitat for the rare mammals otter and crab-eating Mongoose, as otter spraint has been collected on the floating boardwalk through the mangrove at Mai Po Marshes Nature Reserve.

Intertidal Mudflat

E2.36 As noted previously, the intertidal mudflats are the key foraging habitat for the wading birds that are the reason for the Ramsar designation of the area. During the REA, the mudflats were observed to be occupied by thousands of birds of many different species. Because the infaunal community is well known, no additional samples were taken from the mudflats. Thousands of both the mudskipper fish and two species of fiddler crab were observed on the mudflats during the REA.

Reference

Lee, S.Y. 1995. Macrobenthic community structure of a polluted tidal river in Deep Bay, Hong Kong. Pages 43-51 in Proceeding of The 2nd International Conference of the Marine Biology of the South China Sea.

APPENDIX E3 ECOLOGICAL IMPACT ASSESSMENT METHODS

Introduction

E3.1 As part of Agreement No. CE 10/95, (Tin Shui Wai Development, Engineering Investigations for the Development of Areas 3, 30 and 31 of the DZ and the RZ), Binnie Consultants Limited has been assigned to carry out an EIA. An important component of the EIA is a 12-month Eco-IA in a Study Area that includes much of Inner Deep Bay and the surrounding coast.

E3.2 The Eco-IA began with a Rapid Ecological Assessment and habitat mapping exercise in December 1995. Subsequently, the Eco-IA has been designed to include baseline surveys of the most valuable ecological communities in the vicinity of the site. These are mangroves, terrestrial wetlands, intertidal mudflat infauna and epifauna, sub-tidal seabed fauna, birds and mammals.

E3.3 Deep Bay and the surrounding coastline is an ecosystem with many natural features of high ecological value. It contains a high proportion of the wildlife recorded in southeastern China including a number of rare and endangered species. Government has recognized the high conservation value of Deep Bay for many years and designated the Inner Deep Bay SSSI in 1976. Subsequently, Government supported the Worldwide Fund for Nature-Hong Kong's management of the core area Mai Po Marshes Nature Reserve since 1983. Inner Deep Bay is internationally famous as a migratory bird feeding ground, and many other types of birds use the area year around. In recognition of this, in September 1995, Government designated Inner Deep Bay as a Ramsar site of international importance especially for waterbirds.

E3.4 The Ecological Impact Assessment (Eco-IA) design included seven components:

- Habitat Mapping — simple mapping procedure, no additional details
- Intertidal Infauna — This Appendix
- Intertidal Epifauna — This Appendix
- Waterbirds — This Appendix
- Mangrove — This Appendix
- Mammals — This Appendix
- Subtidal Seabed — This Appendix

In addition to forming the basis for ecological impact assessment, the results will form the baseline for the Environmental Monitoring and Audit (EM&A) programme. Where results of early studies indicated that further detailed work was desirable to enhance assessment, those studies have also been included:

- Terrestrial Birds — Appendix E4
- Amphibians — Appendix E4
- Fish — Appendix E4
- Insects — Appendix E4

E3.5 Since field work started in December 1995, the field work and analysis plans have been further defined. The details of the protocols for the seven initial components of the Eco-IA are described in this appendix. Each component includes the following sections: Introduction; Purpose; Methods; Analysis; and Related Communities. Additional study methods are included with results in Appendix E4.

E3.6 The Introduction explains why each particular component of the ecosystem was chosen for the Eco-IA. The Purpose sets out the goals for the Eco-IA. The Methods section details the field methods, data analysis and interpretation. The section on Related Communities indicates how the information gained from monitoring each community relates or is linked to the results from monitoring other communities.

E3.7 Since the habitat mapping protocol is a simple mapping procedure, no additional details have been included here.

The Methodology of the Eco-IA

Ecological Parameters Measured

E3.8 Twenty-seven indicators were chosen for the 12-month ecological surveys as indicators of potential impacts (Table E3.1). Seven studies were initially designed for the ecological impact assessment of the project. The project could impact waterbirds, intertidal benthic infauna (worms, clams, and snails living in the mud that provide food for waterbirds), epifauna (crabs and mudskippers living on the mud surface that similarly serve as food for birds), mangroves, the terrestrial habitat, the subtidal seabed, and the rare and endangered mammals present in the area.

Table E3.1
Measurable Ecological Parameters

Impact study	Ecological parameters to measure
waterbirds	presence/absence of rare or endangered species
	density and feeding behaviour
	prey choice and intake rate
infauna	density, biomass, average size
epifauna	density
mangroves	density
	dbh (diameter at breast height), basal area, biomass
	rare species
	subjective measure of health: leaf condition, success of dropper recruitment
mammals	identities
	locations
	relative abundance
habitat mapping	dominant species
	area of habitats
seabed ecology	depositional layer thickness
	sediment particle size
	prism penetration depth
	surface roughness
	mud clasts
	apparent redox depth
	sedimentary methane
	infauna successional stage
	organism-sediment index

Intertidal Infauna Eco-IA Work Plan for Intertidal Infauna

Introduction

E3.9 The benthic infauna contribute to the overall biodiversity in the bay, they are the primary consumers in the food web and serve as important food for waterbirds. Data on infauna abundance and biomass will be gathered. Biomass and energy content are the parameters important to birds. Information on abundance is useful to detect natural changes due to seasonal spawning and recruitment events, enhancing the overall ecological knowledge against which any impact of the project can be detected.

E3.10 Infauna are slow moving and have short reproductive cycles (few in Deep Bay have a lifespan of more than a year), as a result they are especially sensitive to environmental disturbance and change.

E3.11 The Intertidal Fauna Study is one component of the overall Eco-IA. The sites chosen for this infauna monitoring correspond to the sites selected for the monitoring of epifauna, waterbird use of Deep Bay, mangrove habitat, water and sediment quality. Considering these sites together, changes detected by any one monitoring study can be checked against the others to evaluate the extent of changes on other components of the ecosystem.

Purpose

E3.12 We will assess the natural variation in abundance and biomass of intertidal benthic macrofauna against which effects of the Project can be detected during the subsequent EM&A period.

Methods

General

E3.13 In order to provide data of intertidal infauna for the Eco-IA, it will be monitored three times during the Eco-IA at four-month intervals.

E3.14 After reviewing the available information on Deep Bay infauna, we have selected three taxa for monitoring; the polychaete worms *Dendronereis pinnaticirrus, Neanthes glandicincta*, and all members of the capitellid family.

E3.15 *D. pinnaticirrus* are an important food source harvested by most types of birds foraging on the mudflat (McChesney 1996), they have low sample variance and hence are appropriate to monitor. Capitellid polychaetes are particularly sensitive to disturbance (Pearson and Rosenberg, 1978; Rhodes and Germano, 1986). *N. glandicincta* is a large worm, and may also be sensitive to pollution (McChesney 1996). A high abundance of capitellid polychaetes is an accepted indicator of organic pollution (Pearson and Rosenberg, 1978), and capitellids are early recolonizers after physical disturbance (Rhoads and Germano, 1986). Increases in the abundance of capitellids could indicate physical or organic disturbance at the site.

Monitoring Sites

E3.16 A beyond-BACI design requires a minimum of three sites; two references and one potential impact site. We will establish a potential impact site on the mudflat at the mouth of the drainage channel, and two sites farther away will act as the references. One reference site will be located adjacent to Mai Po, corresponding to sites monitored earlier (McChesney, 1996). This gives a historical time series of data to enhance interpretations. The second reference site will be located on the mudflats north of Tsim Bei Tsui (Figure E3.1).

Field Methods

E3.17 Hand cores are a rapid method of sampling mud infauna. PVC cores are 10 cm in diameter and 20 cm long. Samples will be sieved through a 500 μm screen. Benthos remaining on the mesh will be fixed in 10% borax-buffered formalin stained with $0.1 g.L^{-1}$ rose bengal.

E3.18 In the laboratory, the remaining mud shall be washed across a 250 μm screen, and rose-bengal stained benthos shall be separated from any remaining sediment, and preserved in 70% ethanol pending further analyses.

E3.19 To estimate the sample size needed to detect a potential future impact on the infauna abundance, we have used a previous study as a pilot, and statistical power analyses (McChesney, 1996). To detect roughly a 50-100% difference in abundance, the power test indicates that at least fourteen cores would be needed at each of the three sites. This sampling effort will yield a power of 80% or greater.

E3.20 Specifically, for *D. pinnaticirrus,* the minimum detectable difference at a power of >80% is 6.1-6.8 individuals (a 34-38% change in the mean value of the pilot study) with an effort of 13 samples in each area. For capitellids, 13 samples in each area is predicted to allow detection of a difference of 39-43 individuals (a 92-102% change in the mean value from the pilot study). For *N. glandicincta*, the minimum detectable difference is 12.3 individuals (a 63% reduction in the mean value from mean value in the pilot study).

Laboratory Methods

E3.21 Abundance shall be counted for entire individuals and for fragments with heads. Fragments without heads should not be counted, but fragments of the three target worm species need to be included with entire individuals and heads for biomass determination.

E3.22 Wet-weight biomass for these three taxa and total biomass of the sample shall be determined to 4 decimal places by air-drying the benthos on paper towelling for ten to fifteen minutes prior to weighing.

E3.23 Average body size for these three benthic groups at each site shall be determined. The slope of the linear regression of abundance versus biomass in each of the cores at each station will be used to estimate average body size.

E3.24 After biomass is determined, other benthos present in the samples will be archived in 70% ethanol for a period of one year, in case any taxonomic, or other questions arise.

Analyses

E3.25 Our analytical goal is to use parametric ANalysis Of VAriance (ANOVA) in a "beyond" Before-After Control-Impact (BACI)-type comparison (Underwood 1992) to investigate temporal-spatial interactions attributable to impact. Both the abundance of the three target taxa and biomass can be tested.

E3.26 Slopes of average body size curves can be compared using methods of Zar (1984) to investigate any changes in average body size.

E3.27 In addition to the parametric tests, non-parametric and multivariate statistical comparisons may be used e.g. non-metric MDS (Warwick and Clarke 1991).

Related Communities

E3.28 The condition of the benthic infauna is relevant to the health of the birds, and possibly mammals, that may feed on them. During the baseline monitoring, any changes in the infauna will be communicated to all members of the Ecology Team so that follow-on effects in these other communities can be watched for.

References

McChesney, Stephen. 1996. *Intertidal benthic community of the Mai Po mudflat with special reference to predation by migratory waders.* M. Phil. thesis, University of Hong Kong, Hong Kong.

Pearson, T.H., and R. Rosenberg (1978) Macrobenthic succession in relation to organic enrichment and pollution of the marine environment. *Oceanography and Marine Biology An Annual Review* 16: 229-311.

Rhoads, D.C. and J.D. Germano (1986) Interpreting long-term changes in benthic community structure: a new protocol. *Hydrobiologia* 142: 291-308.

Underwood, A.J. (1992) Beyond BACI: the detection of environmental impacts on populations in the real, but variable, world. *Journal of Experimental Marine Biology and Ecology* 161: 145-178.

Warwick, R.M. and K.R. Clarke 1991. A comparison of some methods for analysing changes in benthic community structure. *Journal of the Marine Biological Association of the United Kingdom* 71: 225-244.

Zar, J.H. 1984. *Biostatistical Analysis.* Prentice-Hall, New Jersey, USA.

Intertidal Epifauna Eco-IA Work Plan

Introduction

E3.29 On Deep Bay mudflats, fiddler crabs (*Uca*) and mud skippers are two important macro-epifauna in terms of number and biomass (Chan, 1989 and Choi, 1991). Potentially, they can enhance the decomposition and cycling of organic carbon in the mudflat ecosystem. The presence of burrows, faecal pellets, burrowing and feeding activities may increase carbon and nutrient flow (Montague, 1980).

E3.30 Fiddler crabs (*Uca*) are quite tolerant of organic pollution in Deep Bay (Lee, 1995). Mud skippers are likely to be more sensitive to organic loading than *Uca*. Because these two species are common, and their ecology is relatively well-known, they should prove useful indicators of potential impacts on the mudflats which are essential to the health of birdlife.

Purpose

E3.31 The objective of the epifaunal survey is to provide data of abundance to assess the ecological impact of the project and provide a baseline so that any potential impacts during the construction period can be detected by the future EM&A programme.

Methods

Study Sites

E3.32 As required by the BACI design, there will be two reference sites and one potential impact site. The potential-impact site will be located on the mudflat at the mouth of the western drainage channel where impacts are most likely. The two reference sites will be located at Tsim Bei Tsui pier and in front of the bird-hide at Mai Po Nature Reserve (Figure E3.1). The latter two sites are considered to be far enough away to be unaffected by changes due to the development.

E3.33 The intertidal faunal study is one component of the overall Ecological Study Programme of the EIA. The sites chosen for the epifauna monitoring correspond to the sites selected for the monitoring of waterbird use of Deep Bay, mangrove habitat, water and sediment quality. Considering these sites together, changes detected by any one study can be checked against the others to evaluate the extent of changes on other components of the ecosystem.

Field Methods

E3.34 The taxa of intertidal epifauna to be monitored, will be sampled four times during the Project.

E3.35 Marked quadrats will be used at each of the three sites. For mud skippers and fiddler crabs, five permanent 25 (5x5) m^2 and 1 m^2 quadrats will be laid on the mud flat respectively where a representative population of the animal is present. During low tide, the observer will be required to stay motionless some distance away from the monitoring site and wait for the fish to appear. If mudskippers retreat due to disturbance, counts will cease for 5 minutes to allow fish to return to the surface.

E3.36 All animals within the quadrats will be counted, using a telescope, and recorded.

E3.37 Since both mud skippers and fiddler crabs tend to be inactive when temperature falls below 20°C (remaining in their burrows), all field surveys will be conducted at a temperature >20°C to ensure that the numbers of organisms recorded are representative (Chan, 1989 and Choi 1991). During each survey, mud surface and air temperatures and information on weather conditions will be recorded.

E3.38 For each complete survey, the organisms within each quadrat will be counted, three times at 30 minute intervals, on the same day so that a mean abundance can be calculated.

E38.1 Fiddler crab survey is included in the intertidal epifauna Eco-IA because they co-exist with the mudskippers on the mud flat. It is therefore cost effective to conduct the fiddler crab survey along with the mud skipper survey.

Analyses

E3.39 For the Ecological Assessment study, the only comparisons of interest will be among the three stations. Standard parametric ANOVA will be used for this comparison.

E3.40 In order to prepare for the EM&A, the design will follow the 'beyond-BACI' protocol (Underwood, 1992), so that parametric two-way ANOVA can be used to detect impacts on the benthic organisms outside of the normal seasonal variation in populations.

E3.41 In addition to ANOVA, non-parametric ANOVA and multivariate techniques such as multidimensional scaling can be used to detect differences between the impact area and reference sites.

Related Communities

E3.42 The density of the epifaunal community in Inner Deep Bay is closely related to the health of wading birds, and possibly mammals, as it is likely that the young are a food source. There will be close interaction among team members to ensure that changes in epifaunal mudflat communities are communicated to all team members and can be taken into account.

References

Chan K.Y. Phoebe (1989) *The Ecology of Mudskippers (Pisces: Periophthalmidae) at the Mai Po Marshes Nature Reserve, Hong Kong*. Unpublished M. Phil thesis, University of Hong Kong.

Choi, K.C. (1991) *The Ecology of Fiddler Crabs (Crustacea: Ocypodidae) at the Mai Po Marshes Nature Reserve*, Hong Kong. Unpublished M. Phil thesis, University of Hong Kong.

Montague, C.L. (1980) A natural history of temperate western Atlantic fiddler crabs (genus Uca) with reference to their impact on the salt marsh. *Contributions in Marine Science*, 23:25-55.

Lee, S.Y. (1995) *Macro benthic community structure of a polluted tidal river in Deep Bay, Hong Kong*. In Proceeding Marine Biology of the South China Sea, Guangzhou 1993. World Publishing Corporation, Beijing. pp. 43-51.

Underwood, A.J. (1992) Beyond BACI: the detection of environmental impacts on populations in the real, but variable world. *Journal of Experimental Marine Biology and Ecology* 161:145;178.

Waterbirds Eco-IA Work Plan

Introduction

E3.43 Given the high conservation value of Inner Deep Bay due in part to its status as an essential resource for wading birds, it is critical that development be completed without significant impacts on waterbirds. Most of the Inner Deep Bay Ramsar site is included within the Eco-IA Study Area, and the mudflats used as wading bird feeding grounds are adjacent to and directly downstream of the Tin Shui Wai infrastructure development. High numbers of waterbirds (sensu Bhushan *et al.* 1993) including grebes, pelicans, egrets, ibises, waders, spoonbills, cormorants, ducks, gulls, terns, and mergansers use this site to forage for food in every season, with highest densities in January and February (Wong 1991, Peking University 1995). Direct effects of the development on wading birds e.g. pollution are considered unlikely, however, indirect effects due to possible changes in sedimentation and water flow of drainage channels could occur.

Purpose

E3.44 Three objectives of the Eco-IA waterbird survey are: 1) to assess the ecological impact of the project by recording the present abundance and feeding regime of the waterbirds feeding on the mudflats in the vicinity of the drainage channel; 2) to census rare and endangered species of waterbirds; and 3) to establish a baseline that can be used during the EM&A period.

Methods

Monitoring Sites

E3.45 We have chosen three intertidal areas to monitor, two reference areas and the potentially impacted mudflat at the mouth of the drainage channels. This will enable us to use the "beyond-BACI" type design (Underwood 1992) to have a chance of distinguishing impacts at the channel mouth from natural variation during EM&A. The two reference sites are located at the mudflat adjacent to the floating hide at WWF-HK Mai Po Marshes Nature Reserve, and the mudflat north of the Tsim Bei Tsui Police post (Figure E3.1). These sites were chosen to be far enough away from the development to be unaffected by any works-related impacts.

E3.46 The best location to record observations for the potentially impacted site at the channel mouth is the observation tower, or alternatively from the bridge. Observations for the Tsim Bei Tsui site will be obtained from the hilltop above the police post, and/or from the Tsim Bei Tsui jetty. Observations at the Mai Po mudflat will be carried out from the WWF-HK floating boardwalk hide.

E3.47 A methodology has been developed and tested by McChesney (1996) to monitor waterbird population use of the Deep Bay habitat. We will use these methods assess two aspects of waterbirds adjacent to the Tin Shui Wai infrastructure development: a census of rare, endangered, and regionally important species, and the use of the Deep Bay habitat for feeding.

E3.48 We have chosen a single species, Little Egret (*Egretta garzetta*) to assess bird utilization of the Deep Bay habitat because this species is a relatively large bird that is easy to identify, and its feeding behaviour can be discerned from long distances. Its diet is known to include the invertebrates and mudskippers that are important members of the mudflat community and which will be monitored as part of the Intertidal Epifauna component of the Eco-IA. The Little Egret breeds in Deep Bay and accounts for between 0.4 and 10% of the entire S. China population (Young 1995). This species has been studied previously in Deep Bay (e.g. Wong 1991, Britan 1992, Cornish 1995 and in press) and in other locations.

E3.49 Measuring changes in waterbird utilization of a habitat after the works begin at the development will depend on establishing an adequate baseline. We plan to use a "beyond BACI" design (Underwood 1992) that in the future, will allow us to assess anthropogenic impacts through the use of parametric ANOVA.

General

E3.50 Fieldwork is scheduled in January, April, July, and October 1996 to provide data spanning the wet and dry seasons in Hong Kong. The April and October periods are transitional between the wet and dry seasons.

E3.51 Large quadrats approximately 250 m on a side will be established at each of three areas. Quadrat edges will be marked with bamboo stakes placed at about 10 m intervals so that at least two stakes can be seen in the field of view using a 20X telescope.

Monitoring Methodology

E3.52 The fieldwork will consist of three tasks: censusing rare, endangered and regionally important species; recording the proportion of waterbirds that are feeding within quadrats; and assessing the diet of the target species, the Little Egret. All birds visible in the monitoring areas will be scanned with binoculars and telescopes to check for rare and endangered species. We will count the total number of waterbirds feeding within quadrats. The number of prey of each type (e.g. worms, crabs, mudskippers) of the Little Egret on the mudflat will be recorded to assess its diet.

E3.53 Fieldwork will require a two-person monitoring team to efficiently complete the tasks.

Task 1. Rare/Regionally Important Bird Census in Monitoring Areas

E3.54 Using binoculars and a telescope, the team will scan all waterbirds, including Little Egret, visible from the observation point (both inside and outside the quadrats). Numbers of rare and endangered, and regionally important bird species should be recorded from each of the three intertidal areas.

E3.55 The rare and endangered, and regionally important species are defined and listed in Table 6.10 of the Environmental Review, and included here as Table E3.2.

Task 2. Habitat Utilization by waterbirds: Density and Activity

E3.56 We will count and identify all waterbirds within quadrats in order to estimate the food removal rate. The quadrats adjacent to Mai Po and Tsim Bei Tsui will be marked with stakes at ten-metre intervals; the channel mouth site is defined by the edges of intertidal channels and the mangrove.

E3.57 Activity scans record the proportion of birds engaged in various activities, such as standing, foraging, feeding and preening. We will use a telescope with a 20-60x zoom to identify each bird and note its behaviour in the quadrats. Data will be recorded on Form I (Table E3.3). One team member will dictate observations to the other team member. Data recorded include species identification and behaviour.

E3.58 Weather conditions can have a strong influence on bird behaviour. Temperature, wind conditions (direction and the description "strong", "light", or "calm") and estimated percentage of cloud cover and precipitation (mist, rain) will be recorded. Horizontal visibility (e.g. fog) will be estimated. We will record complete weather information and prey availability on Form I.

Task 3. Focused Observations on Target Species, Little Egret

E3.59 The feeding rate of the Little Egret will be defined by counting the number of prey eaten. Behaviour will be recorded for 10 minutes using a telescope, and the number of strikes and picks, proportion of successful strikes and picks, and the identification of the prey captured will be recorded on Form II (Table E3.4). We define strikes as sudden head movements by a Little Egret that attempts to capture prey, usually highly mobile fish or other swimming prey. Picks are head movements where the tip of the bill makes contact with the mud surface, and can result in the capture of less mobile prey, such as worms.

The number of attempts, the proportion of successful and unsuccessful attempts, and the identity of prey will be recorded by observation to assess the utilization by waterbirds of their habitat.

E3.60 One team member will watch the subject bird with a telescope and dictate the behaviour to the second team member who will time the duration and record feeding behaviour on Form II (included in Table E3.4). A checklist of additional weather and available prey information is printed on Form II to ensure all relevant information is recorded.

Sequence of Tasks

E3.61 Feeding activity varies with time of day and state of tide. To make the results comparable, the observation period should be standardised a far as possible. Feeding is most intense during the time that the tide is rising or falling across the mudflat. During this time, an activity scan (Task 2) should be immediately followed by a focused observation (Task 3), and the activity scan/focused observation pair repeated. Counts (Task 1) should be made at least once at the beginning and end of the flood/ebb period.

E3.62 During high tide, waterbirds move off the flooded mudflat and roost in shallow water in drained fishponds or *gei wais*, in the mangroves trees, or, in the case of breeding egrets and herons, at their nesting sites. During high-tide, these roosts will be checked for presence of rare and endangered species in the Project area and its surroundings.

Analysis

E3.63 Predation rates for Little Egrets will be determined by multiplying the percentage of egrets foraging by the observed intake rates. Estimates will be summed as a function of time or tide to provide an estimate of total food harvested.

E3.64 For the Eco-IA, the only comparisons of interest will be between the two reference and one impact site. During the EM&A for the construction phase of the project, the goal will be to use parametric ANOVA in a "beyond-BACI" type design (Underwood 1992) to investigate temporal-spatial interactions attributable to impact. The design requires at least two reference sites to compare with a putatively impacted site. Data are collected at all sites both before and after the impact. Significant interactions in temporal/spatial measurements between impact and control sites can indicate anthropogenic impact.

E3.65 In addition to ANOVA, non-parametric ANOVA and multivariate techniques such as multidimensional scaling and analysis of similarity can be used to detect differences between the impact area and reference sites.

Related Communities

E3.66 The density and behaviour of the wading bird communities in Inner Deep Bay are closely related to the health of the food resources available as well as habitat available for roosting. There will be close interaction among team members to ensure that changes in mangrove, bird, or intertidal mudflat communities are communicated and can be taken into account.

References

Bhushan, Bharat, Graham Fry, Akira Hibi, Taej Mundkur, Dewi M. Prawiradilaga, Koichiro Sonobe, and Shunji Usui. 1993. *A Field Guide to the Waterbirds of Asia.* Wild Bird Society of Japan, Tokyo.

Britton, Adam R.C. 1992. Feeding behaviour of the Little Egret at Mai Po, Hong Kong. *Hong Kong Bird Report* 1992: 176-184.

Cornish, A. 1995. Focus on fishponds. *Porcupine!* 13.

McChesney, Stephen. 1996. *Intertidal benthic community of the Mai Po mudflat with special reference to predation by migratory waders.* M. Phil. thesis, University of Hong Kong, Hong Kong.

Peking University. 1995. Environmental Impact Assessment Study on Shenzhen River Regulation Project. Final EIA Study Report. 3 Volumes. Shenzhen River Regulation Office of Municipal Government.

Wong, F.K.O. 1991. Habitat utilization by Little Egrets breeding at Mai Po egretry. *Hong Kong Bird Report* 1990: 185-190.

Underwood, A.J. 1992. Beyond BACI: the detection of environmental impacts on populations in a real, but variable, world. *J. Exp. Mar. Biol. Ecol.* 161:145-178.

Young, L. 1995. Focus on fishponds. *Porcupine!* 13.

Table E3.2
Bird Species of Special Conservation Importance in Mai Po and Deep Bay

Common name	Scientific name	Endangered/ threatened	Represents significant % of regional/global populations
Asiatic Dowitcher	*Limnodromus semipalmatus*	*	
Cormorant	*Phalacrocorax carbo*		*
Curlew Sandpiper	*Calidris ferruginea*		*
Dalmatian Pelican	*Peleconus crispus*	*	
Greater Sand-plover	*Charadrius lescchenaultii*		*
Imperial Eagle	*Aquila heliaca*	*	
Lesser Sand-plover	*Charadrius mongolus*		*
Lesser Spoonbill (Black-faced)	*Platalea minor*	*	*
Little Egret	*Egretta garzetta*		*
Marsh Sandpiper	*Tringa stagnatilis*		*
Nordmann's Greenshank	*Tringa guttifer*	*	
Oriental White Stork	*Ciconia ciconia*	*	
Relict Gull	*Larus relictus*	*	
Saunder's Gull	*Larus saundersi*	*	
Spoon-billed Sandpiper	*Eurynorhynchus pygmaeus*	*	
Swinhoe's Egret	*Egretta eulophotes*	*	

Table E3.3
ECOLOGICAL MONITORING: FORM I

ACTIVITY SCAN
LOCATION:
DATE:
TIME:
TIDE: distance of flock from tide, rising or falling
TEMPERATURE WIND CLOUD COVER
Epibenthos

species								
forage								
preen								
sleep								
walk								
stand								

Table E3.4
ECOLOGICAL MONITORING: FORM II

Continuous Observation Record
Species: juvenile or adult?
Location:
Date:
Time:
Tide: (distance of bird from strand; rising or falling)
TEMPERATURE WIND CLOUD COVER
Epibenthos

secs 5	10	15	20	25	30	35	40	45	50	55	60

Table E3.4 continued
Summary

	number	successful	prey items
pics			
jabs			
probes			
strike			

Total time:
Foraging + Walking:

codes:

W walking	s strike
Fo Foraging	st standing
p pick	Pr preening
Fl flying	Sl sleeping

circle successful strikes and write prey taken

Tin Shui Wai Infrastructure Development - Mangrove Eco-IA Work Plan

Introduction

E3.67 One of the most important ecological features of Inner Deep Bay is the mangrove forest. Deep Bay supports one of the largest stands of mangroves in China. Of the 330 ha of mangrove forest remaining around Deep Bay, Mai Po contains approximately 40% (Fan 1993, Li and Lee, in prep.). Mangroves are important because they create habitat, breeding sites, and feeding grounds for a large number of terrestrial and aquatic species.

Purpose

E3.68 The purpose of the Eco-IA mangrove survey is to characterize the coverage, diversity and condition of the mangroves in the vicinity of the Tin Shui Wai development, and to choose monitoring sites that can be used during the EM&A period.

Methods

Mangrove Assessment Methodology

E3.69 A survey of the mangrove assemblages at 3 locations was conducted so as to provide baseline data for the assessment of potential impacts of the Tin Shui Wai development on the intertidal mangroves on the southern shores of Deep Bay. The study sites were selected in order to give a spatial gradient of effect size, should any impact result from the development. The three sites are: a control site at the western boundary of Deep Bay (Tsim Bei Tsui), an impact site near the eastern discharge channel in Tin Shui Wai and a second eastern control site at Mai Po (Figure E.4.1, Table E.4.12). These survey sites will be able to provide the basis for spatial comparison for the detection of impact. Repeated measurements at the same sites after the development project will allow temporal comparisons be made for impact detection. Combined spatial and temporal comparison will therefore allow a Before-After Control-Impact (BACI) study be made.

Methodology

Mangrove forest structure

E3.70 The line transect method (English et al. 1994) was used for determining mangrove forest structure. Although more time consuming than the plotless methods, this method gives accurate measurements of parameters such as tree density and basal area.

E3.71 A total of six rectangular plots varying from 100 to 400 m^2 in area were surveyed. The size of the plots varied according to tree density, with smaller plots at locations with high tree density. In all cases, between 200-400 trees were measured in each plot, giving a reasonable sample size for the determination of forest structure (English et al. 1994 recommended a minimum of 40-100 trees per plot). The number of plots was two, one and three at Tsim Bei Tsui, Tin Shui Wai eastern channel and Mai Po respectively. The locations of the plots were determined by a hand held GPS. The size and location of the six study plots are detailed in Table E.4.12. Apart from the Tsim Bei Tsui site, all the plots were located at considerable distances from forest edges so as to avoid effects of edge on forest structure.

E3.72 The four sides of a plot were demarcated with the help of a handheld compass. The corners of the plots were marked by colour ribbons for easy future location. Plots at Tsim Bei Tsui were of the same tidal position while 2 plots in the high intertidal and 1 in the low intertidal were surveyed at Mai Po. The girth at breast height (gbh, measured at 1.4 m aboveground) of all trees in the plot was measured using a flexible fibre glass tape. If the trunk branched before breast height, the girth of all stems was measured treating them as separate trees. The girth was measured just below the forking point if branching occurred at about breast height. The identity of all trees was noted. In addition to adult trees, all seedlings (current year newly established individuals) and saplings (young trees at >1 year but with tree height less than 1.5 m) were identified and counted. The low growth form of *Acanthus ilicifolius* made girth measurement impossible and only the area coverage was measured. Only the live individuals of the trees were counted and measured.

E3.73 The general condition of the mangroves was also noted using indicators of tree health such as the presence of propagules, leaf colour and condition.

Data analysis

E3.74 The following parameters are calculated using the field data in order to characterise the mangrove forest at the three sites:

Stem density

$$\text{Density} = \frac{\text{Number of stems in plot}}{\text{Area of plot}} \quad (\text{in stems m}^{-2})$$

Basal area (BA)

$$\text{BA} = \frac{(\text{gbh})^2}{4\pi} \quad (\text{in cm}^2)$$

Stand Basal Area

E3.75 The total BA for all species is the sum of BAs of all trees in the plot (=Σ BA). The stand basal area can then be calculated:

$$\text{Stand basal area} = \frac{\Sigma\ \text{BA}}{\text{Area of the plot}} \quad (\text{in cm}^2\ \text{m}^{-2})$$

E4.76 The importance of the contribution of each of the component species to the stand are evaluated using the parameters of relative density and relative dominance in terms of basal area:

$$\text{Relative density} = \frac{\text{Number of individuals of one species}}{\text{Total number of individuals from all species}} \times 100 \quad \text{(in \%)}$$

$$\text{Relative dominance} = \frac{\text{Total basal area of species}}{\text{Basal area of all species}} \times 100 \quad \text{(in \%)}$$

E3.77 Since the plots are of different sizes, relative frequency of the species is not calculated. The importance value (Curtis 1959) of any species is then taken as the sum of its relative density and relative dominance values.

<u>Species Diversity</u>

E3.78 The species richness (total number of species present) and species diversity (*H*) of the plot are also calculated, where

$$H = -\Sigma\ (N_i/N)\ \log\ (N_i/N)$$

with N_i = importance value of species i and
N = sum of importance values for all species

Related Communities

E3.79 The condition of the mangrove forest is relevant to the health of the birds and mammals that may feed or reside there, as well as the intertidal infaunal and epifaunal communities. During the Eco-IA, any changes in the mangrove forest will be communicated to all members of the Ecology Team so that follow-on effects in other communities can be observed.

References

Curtis, J.T. 1959. *The Vegetation of Wisconsin. An Ordination of Plant Communities.* University of Wisconsin Press, Madison.

English, S., Wilkinson, C. and Baker V. 1994. *Survey manual for tropical marine resources.* Australian Institute of Marine Science, Townsville, Queensland, Australia.

Fan, H.Q. (1993) Necessity of establishing China Mangrove Research Centre and its task. *Journal of the Guangxi Academy of Sciences.* 9(2) 122-129.

Li, M.S. and S.Y. Lee (In prep.) *Mangroves of China: A Review.*

Mammal Study (Eco-IA Work Plan)

Introduction

E3.80 Young and Melville (1995) summarized the conservation value of the Mai Po Marshes and reported that a high proportion of the many groups of wildlife found in Hong Kong can be found in Mai Po. The mammal fauna in Mai Po included some very rare species. For example, the otter was considered extinct in Hong Kong until rediscovered in 1990 at Deep Bay. The otter and the crab-eating Mongoose are apparently restricted to the Deep Bay wetland areas within Hong Kong. The fishponds also provide habitat for the Leopard Cat and Seven-banded Civet. Due to its close proximity to Tin Shui Wai, it is assumed that fauna recorded in Mai Po area could be present at Tin Shui Wai and could be affected indirectly by the development.

Purpose

E3.81 The objectives of the Mammal Study are to characterise the mammal populations in the area surrounding the Tin Shui Wai development, and if possible, to describe their numbers and locations. This information can be used in the future to avoid unnecessary impacts arising from the implementation of the development project.

E3.82 Within the study area, a total of six rare mammal species have been sighted from Mai Po and Tsim Bei Tsui as shown in Table E3.5. (Porcupine! vol 1-13; Marshall, 1967; Hill and Phillipps, 1981).

Table E3.5
Mammals recorded in the vicinity of Tin Shui Wai

Mai Po		Size range		
Species	Common name	Head & body (mm)	tail (mm)	weight (kg)
Mus carolo	Ryukyu Mouse			
Herpestes javanicus	Javan Mongoose			
Viverricula indica	Small Indian Civet	521-648	330-427	2.15-3.5
Felis bengalis	Leopard Cat	445-660	220-315	1.75-3.1
Lutra lutra chinensis	Chinese Otter	495-800	243-480	2.5-8.5
Tsim Bei Tsui		Size range		
Species	Common name	Head & body (mm)	tail (mm)	weight (kg)
Herpestes urva	Crab-eating Mongoose	405-840	220-336	1.15-2.25
Herpestes javanicus	Javan Mongoose			

Methods

Study Sites

E3.83 The Mammal Study is one component of the overall Ecological Study Programme of the EIA. The sites chosen for the study include three reference and three potential impact areas (Figure E3.1). The impact sites will be located outside the perimeter of the Project area where impacts are most likely, while the reference sites have been chosen based on distance beyond the expected zone of impacts. In practice, these study sites will not be point locations but are centres of a series of trap sites.

E3.84 It has been shown that exploitation of different habitats by different mammal species is common due to the animal's specialization and adaptation (Delany, 1982). Selection of the study sites was based on information gathered by the habitat analysis so that each major habitat will be surveyed for mammals. The six sites include a wide range of habitats including scrubland, woodland, fishpond, mudflat and mangrove.

Methodology

E3.85 We have reviewed the methods currently used in Hong Kong for mammal studies with Dr Gary Ades of Kadoorie Agricultural Research Centre, Graham Reels of University of Hong Kong Department of Ecology, Dr Lew Young of World Wide Fund for Nature and staff of the Agriculture and Fisheries Department. Three non-injurious methods have been used successfully in Hong Kong: trapping, paw print and scat identification. We propose to use these methods in combination to ensure the best chance of characterising mammal populations.

Trapping

E3.86 Given the relative rarity of the animals, non-destructive trapping has been chosen as one of three suitable methods. Since the animals caught will depend on the trap size, it is necessary to select target species in order to determine which size traps to use.

E3.87 Wire cage-type live traps (Tomahawk Co., USA) have been chosen because they do not injure the animals, but are effective. By selecting two trap sizes (26"x9"x9") and (32"x10"x12"), five of the six species known to occur in the area can be targeted. The Ryukyu Mouse will be excluded because of its small size.

E3.88 The trapping will be carried out two times for 10 days, at six-month intervals. At each tentative study area, one trap of each size will be placed in shaded/hidden places, and if possible, chained to a tree to prevent vandalism. Multiple baits such as dead quail, crab, fish or meat, etc will be used and traps will be set in the evening. All traps will be checked the following morning. Animals caught will be identified, photographed, weighed and sexed. Any distinguishing marks will be noted so that recapture rates can be assessed. Animals will be released. On subsequent days, the traps will be moved to new locations in the vicinity of the six study locations, so that a large area is covered.

ii) & iii) Paw print and scat studies

E3.89 At each study site, a 30 minutes walk of the area will be conducted. Any paw print and scat will be recorded and collected, respectively. Identification of the species in relation to the paw print will be made on site whereas identification in relation to scat will be made in the laboratory.

E3.90 In addition, researchers will interview the local villagers that are encountered during the study to determine what mammals, if any, have been observed by them in the area.

Analysis

E3.91 Due the rarity of the target species, the data are unlikely to be sufficient to allow statistical analysis. The emphasis of the analysis will be on relating the location of animals to the habitat found there. If sufficient data are available, this process can be carried out using the GIS to analyse the relationship between the habitat map and the mammal occurrence maps. The results of this analysis should be useful in showing where mammal clusters are located and what habitat they are dependent upon. This information can, in turn, be used to indicate where extra care may be needed to avoid impacts on mammals.

Related Communities

E3.92 The condition of the mammals could be affected by changes in the health of intertidal infaunal and epifaunal communities where they may feed, and in terrestrial plant communities. During the Eco-IA, any changes in these other communities will be communicated to all members of the Ecology Team so that potential follow-on effects on the mammal can be watched for.

References

G. Ades and G.T. Reels (1992-1995) *Porcupine*. No. 1-13.

M.J. Delany (1982). *The Ecology of Small Mammals, Studies in Biology*, No. 51. Edward Arnold Ltd, London.

P. Marshall (1967) *Wild Mammals of Hong Kong*. Hong Kong University Press.

D.S. Hill and K. Phillips (1981) *Hong Kong Animals.* Government Printer, Hang Kong.

L. Young and D.S. Melville (1995) *Environmental research at the WWF Hang Kong Mai Po Marshes Nature Reserve.* In Wong *et al.* eds; Environmental Research in Pearl River and Coastal Areas. Guangdong Higher Education Press.

Subtidal Seabed Fauna Baseline Monitoring Methods

Introduction

E3.93 The methods employed in the April 1996 REMOTS® survey of Inner Deep Bay (Tin Sui Wai Infrastructure Development - Subtidal Seabed Fauna Baseline Monitoring) were the same as those employed in all previous Hong Kong REMOTS® surveys (e.g., SAIC 1994a and b). A complete description of these methods and procedures is provided below.

Field Methods and QA/QC Procedures

E3.94 The following technical description and QA/QC procedure for sediment-profile imaging and analysis is a formal and standardized technique called REMOTS® (Remote Ecological Monitoring Of The Seafloor; Rhoads and Germano 1982; 1986). The method of acquiring REMOTS® data and its subsequent analysis, interpretation, and synthesis is described together with QA/QC procedures for each of these steps. This mapping technique and QA/QC plan has evolved over the past 15 years as a result of the survey experience of SAIC scientists.

E3.95 The REMOTS® field QA/QC procedures are follows: At the beginning of each survey day, the time on the data logger mounted on the REMOTS® camera is synchronized with the internal clock on the computerized navigation system used to locate sampling sites during the survey. Each REMOTS® station replicate is identified by the time recorded on the film and on disk along with vessel position. Even though multiple replicate images are taken at each location, each image is assigned a unique sample number in the precision navigation data file.

E3.96 Redundant sample logs are kept by the field crew. Test shots are fired on deck at the beginning and end of each roll of film to verify that all internal electronic systems are working to design specifications. Spare cameras and charged batteries are carried in the field at all times to ensure uninterrupted sample acquisition. After retrieval of the camera at each station, the frame counter is checked to make sure that replicate images had been taken at each location. In addition, a prism penetration depth indicator on the camera frame is checked to see that the optical prism had actually penetrated the bottom to a sufficient depth to acquire a profile image. If images are missed (frame counter indicator) or the penetration depth is insufficient (penetration indicator), weights are removed or added, or the camera chassis "stops" are adjusted, and additional replicates are taken. Changes in prism weights and stop positions are noted in the log for each replicate image. Exposed film is developed at the end of every survey day to verify successful data acquisition; strict controls are maintained for development temperatures, times, and chemicals to ensure consistent density on the film emulsion so as to minimize interpretive error by the computer image analysis system. The film is then visually inspected under magnification. Any images that are of insufficient quality for image analysis are noted, and, if possible, the appropriate stations are reoccupied on subsequent survey days.

E3.97 Thorough measurements of all physical parameters and some biological parameters are subsequently taken directly from the color film positives using a video digitizer and computer image analysis system. The actual film slides are used for analysis instead of positive prints in order to avoid changes in image density that can accompany the printing of a positive image. The full color image analysis system can discriminate up to 16.7 million different shades of color, so subtle features can be accurately digitized and measured. Proprietary SAIC software allows the measurement and storage of data on 21 different variables for each REMOTS® image obtained. All data stored on disks are printed out on data sheets for editing by the principal investigator and as a hard-copy backup; a separate data sheet is generated for each REMOTS® image. All data sheets are edited and verified by a senior-level scientist before being approved for final data synthesis, statistical analyses, and interpretation. Automatic disk storage of all parameters measured allows data from any variables of interest to be compiled, sorted, displayed graphically, contoured, or compared statistically. In addition, the integration of the REMOTS® analysis software with GIS software allows any REMOTS® measurement to be plotted (and contoured if desired) on a base map of the survey area.

Measurement of REMOTS® Parameters

Depositional layer thickness

E3.98 Because of the camera's unique design, REMOTS® has proven invaluable in detecting depositional and dredged material layers ranging from 20 cm (the height of the REMOTS® optical window) to 1 mm in thickness. During image analysis, the thickness of the deposited sedimentary layers is determined by measuring the linear distance between the pre- and post-deposition sediment water interface. Recently deposited material is usually evident because of its unique optical reflectance, texture, fabric, and/or color relative to the underlying material representing the predisposal surface. Also, in most cases, the point of contact between the two layers, and a textural change in sediment composition in the new layer, are clearly visible, facilitating measurement of the thickness of the newly deposited layer.

Sediment type determination

E3.99 The sediment grain size major mode and range are visually estimated from the images by overlaying a grain size comparator which is at the same scale. This comparator was prepared by photographing a series of Udden-Wentworth size classes (equal to or less than coarse silt up to granule and larger sizes) through the REMOTS® camera. Seven grain size classes are on this comparator: ≥ 4 phi, 4-3 phi, 3-2 phi, 2-1 phi, 1-0 phi, 0-(-1) phi, < -1 phi. The lower limit of optical resolution of the photographic system is about 62 microns, allowing recognition of grain sizes equal to or greater than coarse silt. The accuracy of this method has been documented by comparing our REMOTS® estimates with grain size statistics determined from laboratory sieve analyses. The REMOTS® analysis is most accurate when the major mode is distinctly different from the minor modes (i.e., the sediments are well sorted). If the major and subordinant modes are in adjacent size classes, the accuracy of the estimate decreases slightly.

Prism penetration depth

E3.100 The REMOTS® prism penetration depth is determined by measuring both the largest and smallest linear distance between the sediment-water interface and the bottom of the film frame. The REMOTS® analysis software automatically averages these maximum and minimum values to determine the average penetration depth. All three values (maximum, minimum, and average penetration depth) are included on the data sheets. Prism penetration is potentially a noteworthy parameter; if the position of the stop collars and number of weights used in the camera are held constant throughout a survey, the camera functions as a static-load penetrometer. Changes in camera prism weight and stop positions are sometimes necessary to obtain acceptable data. In these cases, interpretation of penetration values considers the change in weight and/or stop positions. Comparative penetration values from sites of similar grain size give an indication of relative sediment water content and sedimentation rate. Highly bioturbated sediments and rapidly accumulating sediments tend to have the highest water contents and greatest prism penetration depths.

Small-scale surface boundary roughness

E3.101 Surface boundary roughness is determined by measuring the vertical distance (parallel to the film border) between the highest and lowest points of the sediment-water interface. In addition, the origin of this small-scale topographic relief is indicated when it is evident (physical or biogenic). Boundary roughness is only accurately measured when the camera is level. In sandy sediments, boundary roughness can be a measure of sand wave height. On silt-clay bottoms, boundary roughness values often reflect biogenic features such as fecal mounds or surface burrows.

Mud clasts

E3.102 When fine-grained, cohesive sediments are disturbed, either by physical bottom scour, faunal activity (e.g., decapod foraging), dredging, or deposition of cohesive muds from scows, intact clumps of sediment are often scattered about the seafloor. These mud clasts can be seen at the sediment-water interface in REMOTS® images. During analysis, the number of clasts is counted, the diameter of a typical population of clasts is measured, and the oxidation state is assessed. Depending on their place of origin and the depth of disturbance of the sediment column, mud clasts can be reduced or oxidized (in REMOTS® images, the oxidation state is apparent from their reflectance value; see section on apparent redox potential discontinuity depth below). Also, once at the sediment-water interface, these sediment clumps are subject to bottom-water oxygen levels and bottom currents. Based on laboratory microcosm observations of reduced sediments placed within an aerobic environment, oxidation of reduced surface layers by diffusion alone is quite rapid, occurring within 6-12 hours (Germano 1983). Consequently, the detection of reduced mud clasts in an obviously aerobic setting suggests a recent origin. The size and shape of mud clasts, e.g., angular versus rounded, is also considered. Mud clasts may be moved about and broken-up by bottom currents and/or animals (macro- or meiofauna; Germano 1983). Over time, fresh large angular clasts become smaller and rounded. Overall, the abundance, distribution, oxidation state, and angularity of mud clasts are used to make inferences about the recent pattern of seafloor disturbance in an area.

Apparent redox potential discontinuity (RPD) depth

E3.103 Aerobic near-surface marine sediments typically have higher reflectance values relative to underlying hypoxic or anoxic sediments. Surface sands washed free of mud also have higher optical reflectance than underlying muddy sands. These differences in optical reflectance are readily apparent in REMOTS® images; the oxidized surface sediment contains particles coated with ferric hydroxide (an olive or tan color when associated with particles), while reduced and muddy sediments below this oxygenated layer are darker, generally grey to black. The boundary between the colored ferric hydroxide surface sediment and underlying grey to black sediment is called the apparent redox potential discontinuity (abbreviated as the RPD).

E3.104 The relationship between the thickness of the high reflectance layer and the presence or absence of free molecular oxygen in the associated pore waters must be made with caution. The actual RPD is the boundary (or horizon) which separates the positive Eh region of the sediment column from the underlying negative Eh region. The exact location of this Eh=0 potential can only be determined accurately with microelectrodes; hence, the relationship between the change in optical reflectance, as imaged with the REMOTS® camera, and the actual RPD can only be determined by making the appropriate *in situ* Eh measurements. For this reason, we describe the optical reflectance boundary, as imaged, as the apparent RPD, and it is mapped as a mean value. In general, the depth of the actual Eh=0 horizon will be either equal or slightly shallower than the depth of the optical reflectance boundary. This is because bioturbating organisms can mix ferric hydroxide-coated particles downward into the bottom below the Eh=0 horizon. As a result, the apparent mean RPD depth can be used as an estimate of the depth of pore water exchange, usually through pore water irrigation (bioturbation).

E3.105 Measurable changes in the apparent RPD depth using the REMOTS® optical technique can be detected over periods of one or two months. In sediment-profile surveys of ocean dredged material disposal sites sampled seasonally or on an annual basis throughout North America's northeastern (New England) region, SAIC repeatedly has documented a drastic reduction in apparent RPD depths immediately after dredged material disposal, followed by a progressive postdisposal apparent RPD deepening (barring further physical disturbance). Consequently, time series RPD measurements can be a critical diagnostic element in monitoring the degree of recolonization in an area by the ambient benthos.

E3.106 The depth of the mean apparent RPD also can be affected by local erosion. The peaks of disposal mounds commonly are scoured by divergent flow over the mound. This can result in washing away of fines, development of shell or gravel lag deposits, and very thin apparent RPD depths. During storm periods, erosion may completely remove any evidence of the apparent RPD (Fredette et al. 1988).

E3.107 Depositional events can also affect the thickness of the RPD. A bottom area receiving dredged material in the form of oxidized mud clasts will have an apparent RPD greater than, or equal to, the clast layer. Another important characteristic of the apparent RPD is the contrast in reflectance values at this boundary. This contrast is related to the interactions among the degree of organic loading, bioturbational activity in the sediment, and the levels of bottom-water dissolved oxygen in an area. High inputs of labile organic material increase sediment oxygen demand and, subsequently, sulfate reduction rates (and the abundance of sulfide end-products). This results in more highly reduced (lower-reflectance) sediments at depth and higher RPD contrasts. In a region of generally low RPD contrasts, images with high RPD contrasts indicate localized sites of relatively high past inputs of organic-rich material (e.g., organic or phytoplankton detritus, dredged material, sewage sludge, etc.).

Sedimentary methane

E3.108 At extreme levels of organic loading, pore water sulfate is depleted, and methanogenesis occurs. The process of methanogenesis is detected by the appearance of methane bubbles in the sediment column. These gas-filled voids are readily discernable in REMOTS® images because of their irregular, generally circular aspect and glassy texture (due to the reflection of the strobe off the gas). If present, the number and total areal coverage of all methane bubbles are measured.

Infaunal successional stage

E3.109 The mapping of successional stages is possible with REMOTS® technology and is based on the theory that organism-sediment interactions follow a predictable sequence after a major seafloor perturbation. This theory states that primary succession results in "the predictable appearance of macrobenthic invertebrates belonging to specific functional types following a benthic disturbance. These invertebrates interact with sediment in specific ways. Because functional types are the biological units of interest..., our definition does not demand a sequential appearance of particular invertebrate species or genera" (Rhoads and Boyer 1982). This theory is formally developed in Rhoads and Germano (1982) and Rhoads and Boyer (1982), with a brief overview presented in the paragraph below.

E3.110 After an initial disturbance to an area of bottom, the first invertebrate community that appears within days after the disturbance are dense assemblages of tiny, tube-dwelling marine polychaetes that reach population levels of 10^4 - 10^6 individuals m^2. These animals feed at or near the sediment-water interface and have the effect of physically stabilizing the sediment by the production of a mucous "glue" used to build their tubes. We note that some dredged material clast layers contain Stage I tubes still attached to individual clasts. These transported individuals are considered as part of the in-situ fauna in our assignment of successional stages. If there is no repeated disturbances, these initial tube-dwelling, suspension and surface deposit-feeders are followed by burrowing, head-down deposit feeders that rework the sediment deeper and deeper over time and mix oxygen from the overlying water into the sediment. The animals in these later-appearing communities are larger, attain lower overall population densities (10^1 - 10^2 individuals m^2) and can rework the sediments to depths of 3 - 20 cm or more. These animals "loosen" the sedimentary fabric, increase the sediment water content (thereby lowering sediment shear strength), and mix oxygen into the sedimentary column to the depth of the burrowing activity. This phenomenon of mixing the sediment fabric by the reworking activities of burrowing invertebrates is called bioturbation. The continuum of change in animal communities after a disturbance (primary succession) has been divided arbitrarily into three stages: Stage I is the initial community of tiny, dense polychaete communities, Stage II is the start of the transition to head-down, burrowing deposit feeders, and Stage III is the mature equilibrium community of deep-dwelling, head-down deposit feeders.

E3.111 Infaunal successional stages or seres are recognized in REMOTS® images by the presence of dense assemblages of near-surface polychaetes (Stage I) and/or the presence of subsurface feeding voids produced by head-down deposit feeders (Stage III); both types of assemblages may be present in the same image. Stage II, or transitional sere assemblages, are not yet known for the Hong Kong area. In temperate mid-latitudes, these often tend to be amphipods or shallow-dwelling bivalves. Recognition of Stage II seres for the Hong Kong area will require additional mapping experience over a longer period of time with associated ground-truth verification; however, some initial predictions about assigning local taxa to this soft-bottom successional paradigm can be made. A review of Hong Kong benthic literature has identified candidate species that may be tentatively categorized within this successional paradigm. For example, Thompson and Shin (1983) show that the most severely polluted areas within Victoria Harbor and approach channels have station/species dominance clusters (VH4 and VH3 as labelled in Thompson and Shin 1983) that may represent a Stage I assemblage (*Thalassodrilides gurwitschi*, *Capitella capitata*, *Minuspio cirrifera*, *Tharyx* sp., and *Aglaophamus* sp., *Hippolytid* sp. and *Alpheus* sp.). Studies in Tolo Harbor also show that fouling communities consisting of barnacles, tunicates, and bryozoans are well developed in stressed environments (Wu 1982). In profile images where bits of shell or rock are visible, these kinds of epifauna may be recognized.

E3.112 Clusters VH2 and VH1, as defined for Victoria Harbor (Thompson and Shin 1983) include species that are candidates for Stage II colonizers such as *Tapes philippinarum*, *Melita* sp., and *Notomastus latericeus*. Benthic studies along a pollution gradient in Tolo Harbor and Mirs Bay show some of the same species found in Victoria Harbor with the addition of the amphipod *Ampelsica* sp. and several bivalve species belonging to the family Tellinidae (Shin 1983 and 1986). In temperate nearshore benthic environments, *Ampelisca* and tellins are known to be part of a Stage II assemblage.

E3.113 Stage III candidates are more difficult to identify from the existing literature. Hutchings and Wells (1992) note that two species of polychaete worms belonging to the family Maldanidae are present in Hoi Ha Wan. Another head-down feeding polychaete family Pectinaridae (*Amphictene* sp.) has been reported in grab samples from Lamma Channel and the deep-dwelling sipunculid *Golfingia* is present south of Ninepins (Binnie Consultants 1994). In temperate latitudes these taxa are important components of Stage III equilibrium assemblages. Other Hong Kong candidates for Stage III species include infaunal ophiuroids (e.g., *Amphiura*; Binnie 1994) and the holothurian *Protankyra* (Shin 1986).

E3.114 A major difference noted between the density of infaunal benthos in Hong Kong waters and those of temperate latitudes (particularly Stage I species belonging to the polychaete families Spionidae and Capitellidae) is that the densities of the Hong Kong assemblages appear to be much lower. This may be related to the lower carrying capacity of tropical waters relative to nutrient-rich temperate environments and/or instability of the surface sediments due to frequent physical disturbance, such as that which results from passage of typhoons or strong northeast monsoons. This density factor must be kept in mind while interpreting successional status in Hong Kong sediment-profile images.

Organism-Sediment Index

E3.115 The Organism-Sediment Index (OSI) is a summary mapping statistic which is calculated on the basis of four independently measured REMOTS® parameters: mean apparent RPD depth, presence of methane gas, low/no oxygen at the sediment-water interface, and successional status. Table E3.6 shows how these parameters are summed to derive the OSI.

Table E3.6
Calculation of the REMOTS® Organism-Sediment Index Value

A. CHOOSE ONE VALUE:

Mean RPD Depth	Index Value
0.00 cm	0
> 0 - 0.75 cm	1
0.76 - 1.50 cm	2
1.51 - 2.25 cm	3
2.26 - 3.00 cm	4
3.01 - 3.75 cm	5
> 3.75 cm	6

B. CHOOSE ONE VALUE:

Successional Stage	Index Value
Azoic	-4
Stage I	1
Stage I → II	2
Stage II	3
Stage II → III	4
Stage III	5
Stage I on III	5
Stage II on III	5

C. CHOOSE ONE OR BOTH IF APPROPRIATE:

Chemical Parameters	Index Value
Methane Present	-2
No/Low Dissolved Oxygen**	-4

The **REMOTS® ORGANISM-SEDIMENT INDEX** is equal to the total of the above subset indices (A+B+C). It has a **RANGE** of -10 to +11.

** Note: This is not based on a Winkler or polarigraphic electrode measurement. It is based on the imaged evidence of reduced, low-reflectance (i.e., high oxygen demand) sediment at the sediment-water interface.

E3.116 The highest possible OSI value is +11 which reflects a mature benthic community in relatively undisturbed conditions (generally a good yardstick for high benthic habitat quality): deeply oxidized sediment with a low inventory of anaerobic metabolites and low sediment oxygen demand, populated by a climax (Stage III) community. The lowest OSI value is -10 indicating that the sediment has a high inventory of anaerobic metabolites, has a high oxygen demand, and is azoic. In our mapping experience with this parameter over the past 15 years, we have found that OSI values of 6 or less indicate that the benthic habitat has experienced physical disturbance, eutrophication, or excessive, bioavailable contamination in the recent past.

Mapping and Interpretation of REMOTS® Data

E3.117 The integration of text files from a computerized navigation system with REMOTS® and GIS software allows the production of maps showing the areal distribution of each of the above REMOTS® parameters. Data from follow-up surveys can then be entered into the GIS system and overlaid and subtracted to look at changes in the system over time.

E3.118 By comparing the REMOTS® images with Udden-Wentworth sediment standards photographed through the REMOTS® optical system, it is possible to estimate accurately the grain size major mode and range. Also, near-surface stratigraphy such as sand-over-mud or mud-over-sand can be mapped. This information can provide information as to transport directions when mapped on a local scale near facies boundaries. The surface boundary roughness (i.e., sediment surface relief) measured over a horizontal distance of 15 cm can typically range from 0.02 to 3.8 cm and may be related to either physical structures (ripples, rip-up structures, mud clasts), or biogenic features (burrow openings, fecal mounds, foraging depressions). Biogenic roughness typically changes seasonally and is related to the interaction of bottom turbulence and bioturbational activities.

E3.119 The depth of the camera's penetration into the bottom reflects the bearing capacity and shear strength of local sediments. Over-consolidated or relic sediments and shell-bearing sands resist camera penetration. Highly bioturbated, sulfitic, or methanogenic muds are the least consolidated, and deep penetration is typical. Seasonal changes in camera prism penetration are typically observed at the same station related to the control of sediment geotechnical properties by bioturbation (Rhoads and Boyer 1982). The effect of water temperature on bioturbation rates appears to be important in controlling both biogenic surface relief and prism penetration depth (Rhoads and Germano 1982).

E3.120 The depth of the apparent RPD in the bottom is an important time-integrator of dissolved oxygen conditions within sediment pore waters. The surface layer of most of the aerobic seafloor has high optical reflectance because the grains are coated with ferric hydroxide, and the associated pore waters are relatively free of sulfides. In the absence of bioturbating organisms, this high-reflectance layer (in muds) will typically be 1-3 mm thick (Rhoads 1974). This depth is related to the rate of supply of molecular oxygen (by diffusion) into the bottom, and the consumption of that oxygen by the sediment and associated microflora. In sediments which have very high sediment oxygen demand (SOD), a high-reflectance layer may be absent even when the overlying water column is aerobic.

E3.121 The apparent mean RPD depth can be used as an estimate of the depth of pore water exchange, usually through pore water irrigation (bioturbation). In the presence of bioturbating macrofauna, the thickness of the high-reflectance layer may be several centimeters. Biogenic particle mixing depths can be estimated by measuring the maximum and minimum depths of imaged feeding voids in the sediment column. This parameter represents the particle mixing depths of head-down feeders (mainly polychaetes).

E3.122 The depression of the apparent RPD within the sediment is relatively slow in organic-rich muds (on the order of 200 to 300 micrometers per day); therefore this parameter has a long time constant (Germano and Rhoads 1984). The rebound in the apparent RPD is also slow (Germano 1983). Measurable changes in the apparent RPD depth using the REMOTS® optical technique can be detected over periods of one or two months. This parameter is best used to document changes (or gradients) which develop over a seasonal or annual cycle related to water temperature effects on bioturbation rates, seasonal hypoxia, sediment oxygen demand, and infaunal recruitment.

E3.123 By combining these measured REMOTS® parameters with, for example, precision bathymetric survey results and comparing successive surveys, it is possible not only to detect the thickness and areal extent of dredged material deposits along with assessing the effectiveness of capping operations, but also to identify near-bottom kinetic gradients, areas of erosion or deposition, and disturbance gradients in the biological communities. In addition, the rate of benthic recolonization, ecosystem recovery, and depth of bioturbation can be assessed.

Using REMOTS® Data to Assess Benthic Health

E3.124 While various measurements of water quality are often used to assess regional ecological health (e.g., dissolved oxygen, various contaminant or nutrient levels), interpretation is difficult because of the transient nature of water column phenomena. Measurement of a particular level of any water column variable represents an instantaneous "snapshot" that will change within minutes after the measurement is taken. Very often by the time an adverse signal in the water column is persistent (e.g., low dissolved oxygen levels), the system has degraded to the point where resource managers can do little but map the areal extent of the phenomenon while gaining a minimal understanding of factors contributing to the overall degradation.

E3.125 The seafloor, on the other hand, is a long-term time integrator of sediment and overlying water quality; levels of any variable measured are the result of physical, chemical, or biological interactions on time scales much longer than those present in a rapidly moving fluid. The seafloor, therefore, is an excellent predictor of environmental health, both in terms of historical impacts and as an indicator of future trends for any particular variable. Physical measurements made with the REMOTS® system from profile images provide background information about gradients in physical disturbance (e.g., dredging, disposal, or storm erosion) from maps of sediment grain size, boundary roughness, fabrics, and structures. The level of organic matter in the sediment (an important indicator of the relative value of the sediment as a carbon source for both bacteria and infaunal deposit feeders) and sediment oxygen demand can be inferred from the optical reflectance of the sediment column and the depth of the apparent RPD. Sediment oxygen demand is an important measure of ecological health; oxygen can be depleted quickly in sediment by the accumulation of organic matter and bacterial respiration, both of which place an oxygen demand on the interstitial water, thereby competing with animals for a potentially limiting oxygen resource (Kennish 1986).

E3.126 The distribution of successional stages in the context of the mapped disturbance gradients described above is one of the most sensitive indicators of the ecological health of the seafloor (Rhoads and Germano 1986). The presence of equilibrium Stage III equilibrium taxa (mapped from subsurface feeding voids as observed in profile images) can be a good indication of high benthic habitat stability and relative "health". A Stage III assemblage indicates that the sediment surrounding these organisms has not been disturbed severely in the recent past and that the inventory of bioavailable contaminants is relatively low. These inferences are based on past work primarily in temperate latitudes showing that Stage III species are relatively intolerant to sediment disturbance, organic enrichment, and sediment contamination. Stage III species expend metabolic energy on sediment bioturbation (both particle advection and pore water irrigation) to control sediment properties including pore water profiles of sulfate, nitrate, and the redox potential discontinuity in the sedimentary matrix near their burrows or tubes (Aller in press; Rice and Rhoads 1989). This bioturbation results in an enhanced rate of decomposition of polymerized organic matter by stimulating microbial decomposition ("microbial gardening"). Because of their stability, benthic assemblages of this structure are also called climax or equilibrium seres.

E3.127 The metabolic energy expended in bioturbation is rewarded by creating a sedimentary environment where refractory organic matter is converted to usable food. Stage III bioturbation has been likened to processes used in tertiary sewage treatment plants to accelerate organic decomposition, such as stirring and aeration (these can be interpreted as a form of human bioturbation). Physical disturbance, contaminant loading, and/or overenrichment result in habitat destruction leading to local extinction of the climax sere. Loss of Stage III species results in the loss of sediment stirring and aeration (tertiary treatment analogy) and may be followed by a build-up of organic matter (eutrophication) of the sediment. A classic example of this process in the Hong Kong region can be seen at some stations of the Fairway Channel transect (see SAIC 1994a). Because Stage III species tend to have relatively conservative rates of recruitment and intrinsic population increase as well as slow ontogenetic growth rates, they may not reappear for several years once they are excluded from an area.

E3.128 The October 1993 survey (SAIC 1994a) showed evidence of widespread reworking of bottom sediments by typhoon generated waves on the shelf surrounding Hong Kong. These same sediments showed evidence of Stage III seres. This appears to be an anomaly relative to the preceding discussion linking physical habitat stability and Stage III equilibrium seres. In a shelf environment experiencing wave reworking of the bottom on a time-scale ≤ 1 year, it is possible that a non-equilibrium suite of very mobile head-down feeding species may occupy this deep infaunal niche, for example, the ophiuroid genus *Amphiura* and the infaunal holothurian *Protankyra bidentata*. Both *Amphiura* and *Protankyra* are part of a Stage III assemblage described from the East China Sea shelf off the Changjiang delta platform (Rhoads et al. 1985).

E3.129 The presence of Stage I seres (in the absence of Stage III seres) can indicate that the bottom is in an advanced state of organic enrichment or has received high contaminant loading. Unlike Stage III communities, Stage I seres have a relatively high tolerance for organic enrichment and contaminants. These opportunistic species have high rates or recruitment, high ontogenetic growth rates, and live and feed near the sediment-water interface, typically in high densities. Often, Stage I seres co-occur with Stage III seres in marginally enriched areas. In this case, Stage I seres feed on labile organic detritus settling onto the sediment surface while the subsurface Stage III seres tend to specialize on the more refractory buried organic reservoir of detritus.

E3.130 The presence of Stage II seres is a transitional stage indicating a community "in recovery" following a disturbance. It provides a preliminary indication of the time constant for the frequency of disturbance once the successional sequence for a particular region is documented. At the present time, the makeup and dynamics of Stage II communities for Hong Kong regional waters are unknown; these can be determined after either seasonal mapping occurs over a longer period of time or a time series of REMOTS® monitoring is planned after an initial disturbance has taken place in a known area in order to monitor the full successional sequence from start to finish.

E3.131 A review of tropical and subtropical benthic literature indicates that in high depositional areas off of major river mouths and in lagoonal soft sediments frequently scoured by waves and currents, the full range of Stage I, II, and III seres may not be realized. In these situations, the benthic assemblage may not progress beyond a pioneering sere (Alongi and Christoffersen 1992; Alongi et al. 1992; Aller in press). These chronic disturbance assemblages tend to be dominated by pioneering species and large organisms are conspicuously absent. Periodic anoxia can also retrograde succession, resulting in a narrow range of succession (e.g. Wu 1982; Hutchings and Wells 1992).

E3.132 The end-member successional seres (Stage I and Stage III) also have dramatically different effects on sediment geotechnical properties (Rhoads and Boyer 1982). With their high population densities and feeding efforts limited at or near the sediment-water interface, Stage I communities tend to physically bind fine-grained sediments, making them less susceptible to resuspension and transport. Just as a thick cover of grass will prevent erosion on a terrestrial hillside, so too will these dense assemblages of tiny polychaetes serve to stabilize the sediment surface. Conversely, Stage III taxa increase the sediment water-content and lower its shear strength through their deep burrowing and pumping activities, rendering the bottom more susceptible to erosion and resuspension. In shallow areas of fine-grained sediments that are susceptible to storm-induced or wave orbital energy, it is quite possible for Stage III taxa to be carried along in the water column in suspension with fluid muds. When redeposition occurs, these Stage III taxa can become quickly re-established in an otherwise physically disturbed surface sedimentary fabric.

References

Aller, J. In press. The distribution and seasonal characteristics of benthic communities on the Amazon Shelf as indicators of physical processes: *Continental Shelf Research.*

Alongi, D.M., P. Christoffersen, F. Tirendi, and A.I. Robertson. 1992. The influence of freshwater and material export on sedimentary facies and benthic processes within the Fly Delta and adjacent Gulf of Papua (Papua, New Guinea): *Continental Shelf Research*, 12, 287-326.

Alongi, D.M. and P. Christoffersen. 1992. Benthic infauna and organism-sediment relations in a shallow, tropical coastal area: influence of outwelled mangrove detritus and physical disturbance: *Mar. Ecol. Prog. Series*, 81, 229-245.

Binnie Consultants Ltd. 1994. Fill management study - phase IV, investigation and development of marine borrow areas: south of Ninepins, Environmental Impact Assessment Key Issue Study, Benthic Grab Survey Draft Report.

Fredette, T.J., W.F. Bohlen, D.C. Rhoads, and R. W. Morton. 1988. Erosion and resuspension effects of Hurricane Gloria at Long Island Sound dredged material disposal sites. Proceedings of the COE Seminar on "Water Quality '88", February Meeting, Charleston, South Carolina. U.S. Army Corps of Engineers, Hydraulic Engineering Center, Davis, CA.

Germano, J.D. 1983. Infaunal succession in Long Island Sound: animal-sediment interactions and the effects of predation: PhD. dissertation, Yale University, New Haven, Ct., 206 pages.

Germano, J.D. and D.C. Rhoads. 1984. REMOTS® sediment profiling at the Field Verification Program (FVP) Disposal Site: Dredging'84: Proceedings of the Conference, ASCE/Nov. 14-16, Clearwater, Fla., pp. 536-544.

Hutchings, P.A. and F.E. Wells. 1992. An analysis of the marine invertebrate community at Hoi Ha Wan, Hong Kong. In: The marine flora and fauna of Hong Kong and Southern China III: Proceedings of the Fourth International Marine Biological Workshop (B. Morton, ed.) Hong Kong Univ. Press, 851-864.

Kennish, M.J. 1986. Ecology of estuaries. Volume I. Physical and Chemical Aspects. CRC Press, Boca Raton, FL.

Rhoads, D.C. 1974. Organism-sediment relations on the muddy seafloor: *Oceanogr. Mar. Biol. Ann. Rev.*, v. 12, pp. 263-300.

Rhoads, D.C. and J.D. Germano. 1982. Characterization of benthic processes using sediment profile imaging: an efficient method of Remote Ecological Monitoring Of The Seafloor (REMOTS™ System): *Mar. Ecol. Prog. Ser.*, v. 8, pp. 115-128.

Rhoads, D.C. and L.F. Boyer. 1982. The effects of marine benthos on physical properties of sediments. In: Animal-sediment relations (P.L. McCall and M.J.S. Tevesz, eds.), Plenum Press, New York, pp. 3-52.

Rhoads, D.C., D. F. Boesch, T. Zhican, X. Fengshan, H. Liqiang, and K.J. Nilsen. 1985. Macrobenthos and sedimentary facies on the Changjiang delta platform and adjacent continental shelf, East china Sea: *Continental Shelf Research*, 4, 189-213.

Rhoads, D.C. and J.D. Germano. 1986. Interpreting long-term changes in benthic community structure: a new protocol: *Hydrobiologia*, v. 142, pp. 291-308.

Rice, D.L. and D.C. Rhoads. 1989. Early diagenesis of organic matter and the nutritional value of sediment. In: Ecology of marine deposit feeders (G. Lopez, G. Tagon, and J. Levinton, eds.), Lecture Notes on Coastal and Estuarine Studies, v. 31, Springer-Verlag, New York, pp. 59-97.

SAIC. 1994a. REMOTS Survey of Soft-bottom Environments in Coastal Waters of Hong Kong, October 5-13, 1993. SAIC Report No. 304. Submitted to Hong Kong Civil Engineering Department, Geotechnical Engineering Office, 34 p.

SAIC. 1994b. REMOTS Survey of Soft-bottom Environments in Coastal Waters of Hong Kong, May 5 - June 6, 1994: Baseline Conditions in Eastern Waters and the Fury Rocks Area. SAIC Report No. 315. Draft submitted to Hong Kong Civil Engineering Department, Geotechnical Engineering Office.

Shin, P.K.S. 1983. A trawl survey of the subtidal mollusca of Tolo Harbor and Mirs Bay, Hong Kong. In: Proceedings of the Second International workshop on the Malacofauna of Hong Kong and southern China (B. Morton and D. Dudgeon, eds.), Hong Kong Univ. Press, 339-447.

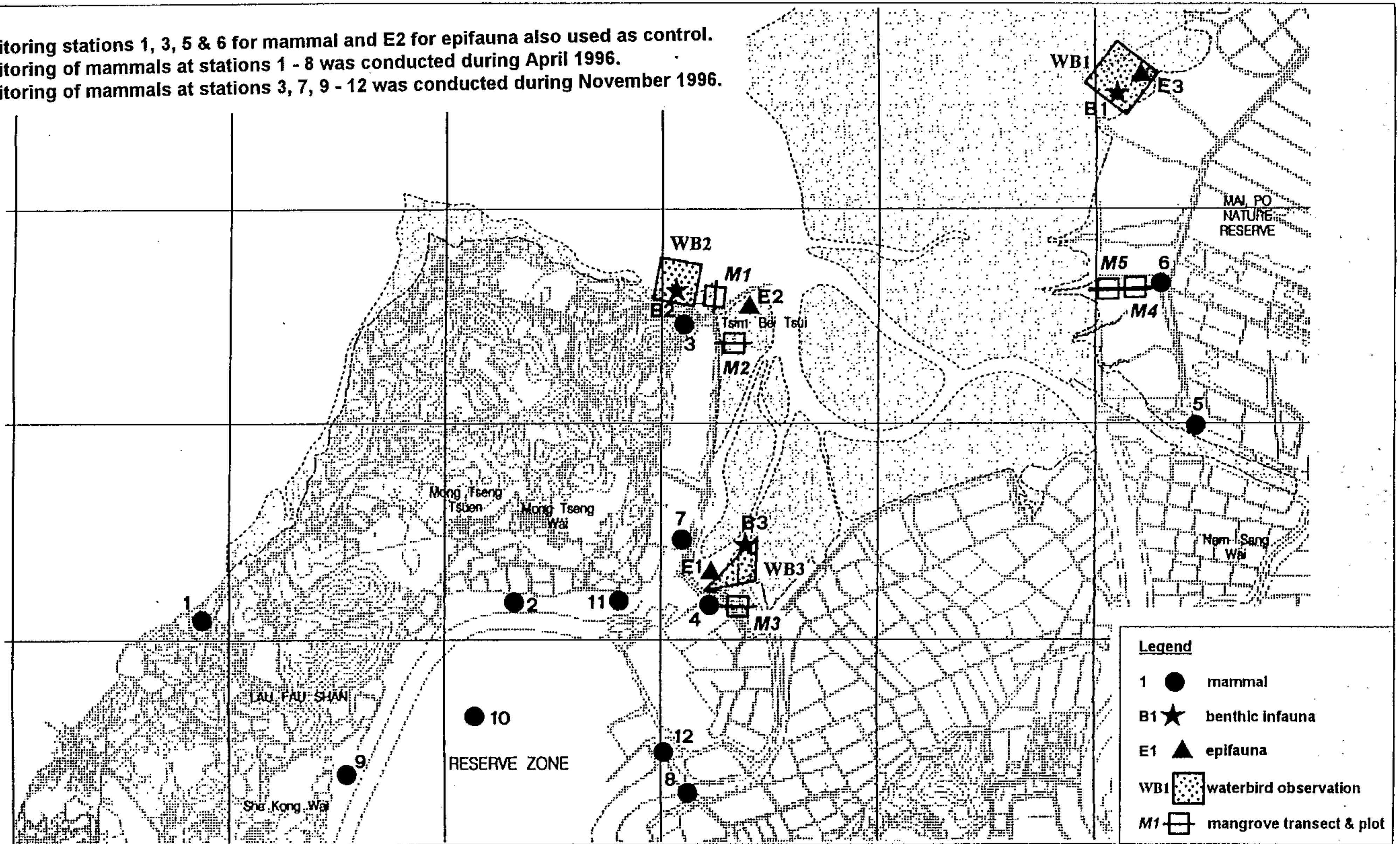
Shin, P.K.S. 1986. Benthic invertebrate communities in Tolo Harbor and Mirs Bay: a review: The Marine Flora and Fauna of Hong Kong and Southern China: Proceedings of the Second International Marine Biological Workshop (B. Morton, ed.), Hong Kong Univ. Press. 883-898.

Thompson, G.B. and P.K.S. Shin. 1983. Sewage pollution and the infaunal benthos of Victoria Harbour, Hong Kong: *J. Exp. Mar. Biol. Ecol.*, 67, 279-299.

Wu, R.S.S. 1982. Periodic defaunation and recovery in a subtropical epibenthic community, in relation to organic pollution: *J. Exp. Mar. Biol. Ecol.*, 64, 253-269.

Young, L. (1995a). *The biological importance of Deep Bay and the Mai Po Marshes.* Pages 16-26 in Chin S.T. editor. Wetlands in Deep Bay and the Mai Po Marshes. Institute of Biology, Hong Kong.

Note :
(1) Monitoring stations 1, 3, 5 & 6 for mammal and E2 for epifauna also used as control.
(2) Monitoring of mammals at stations 1 - 8 was conducted during April 1996.
(3) Monitoring of mammals at stations 3, 7, 9 - 12 was conducted during November 1996.



TIN SHUI WAI DEVELOPMENT AGREEMENT NO. CE 10/95 ENGINEERING INVESTIGATIONS FOR DEVELOPMENT OF AREAS 3, 30 & 31 OF THE DEVELOPMENT ZONE AND THE RESERVE ZONE	Title : ECOLOGICAL IMPACT ASSESSMENT MONITORING SITES
BINNIE CONSULTANTS LIMITED 賓尼工程顧問有限公司 ENGINEERS AND SCIENTISTS 賓尼	

Figure No. E3.1	Revision 0
Reference No. -	File Name -
Prepared MC	Checked SMc
Date NOV 96	Scale 1 : 25000

Appendix E4

Results of Ecological Impact Assessment Studies

APPENDIX E4 RESULTS OF ECOLOGICAL IMPACT ASSESSMENT STUDIES

Introduction

E4.1 This appendix presents the results of the 12 month Eco-IA. Statistical analyses are included here, and assessment was presented in Section 9.

E4.2 Eleven studies have been divided into studies of the terrestrial habitats and studies of the estuarine habitats.

Terrestrial Studies
- Habitat Mapping
- Mammals
- Terrestrial Birds on the Reserve Zone
- Amphibians
- Fish
- Odonates

Estuarine Studies
- Waterbirds
- Infauna
- Epifauna
- Mangrove Survey
- Seabed

Habitat Map

E4.3 The detailed habitat maps were given in Section 9 (Figures 9.3 and 9.4) and show the extent of the habitats present and their boundaries. This information will form the basis for assessing the ecological impact of the project as well as provide a baseline against which to determine impact during EM&A.

E4.4 Eight different habitats were designated during the REA in December and in the air photo interpretation of the RZ and the surrounding area. The habitat designations were bare land, woodland, fish pond, *gei wai*, mangrove, farm, grassland, and grassland with bare patches. Buildings, roads and footpaths were also distinguished.

E4.5 During the first detailed habitat mapping in April 1996, field work confirmed the location of the boundaries, and the woodland, grassland, and farmland habitats were further subdivided. For example, woodland was distinguishable as native woodland, orchard, or plantation, and grassland was distinguished as abandoned and active agricultural fields.

E4.6 The second round of detailed habitat mapping was carried out on 1 and 29 September and 10 October 1996 by Dr Lawrence Chau, Kadoorie farm and Botanical Garden. The results are described in the following sections.

Vegetation and Plant Species

E4.7 No major changes have been observed in the vegetation cover on the study area since the last survey in April 1996. However, thicker growth of grasses and sedges, and more dense groves of shrubs in some places were detected in this survey which represented the end of the wet season, notably the following features:

a) A more extensive area of the legume *Sesbania (S. cochinchinensis)* was found on the Northern side of the RZ.

b) One colony of sedge, *Scirpus subulatus* was found on the northern end of the Old Western River Channel. This species is not included in the latest Checklist of Hong Kong Plants (AFD, 1993) although it is also found in several similar habitats in the Territory (per. comm. with Julia Shaw, Dept. of Ecology and Biodiversity, HKU).

c) The commoner sedges found in marshy patches along the eastern channel are *Cyperus polystachyos* and *Fimbristylis ferruginea.*

d) The Grassland/Bare area adjacent to the AFD plantation trial in the SE of the Tin Shui Wai bund channel were densely covered with the dominant grass *Brachiaria mutica* and a prostrate grass *Paspalum distichum.*

e) Within the AFD plantation areas in the NE of the Tin Shui Wai bund channel, another colony of *Pragmites australis* was found, indicating that this area is relatively wet, at least during the wet season.

f) To the north of the stockpile by the ETC, there was an area of a red-stemmed herb of the Amaranthaceae. However it is neither of the known native species and is most likely an exotic species introduced by hydro-seeding.

Specific Sites

E4.8 Along the Old Western River there was no change in vegetation cover, except for one new sedge recorded above. In the ETC and the abandoned ponds on the West Bank, there was no change in vegetation cover since the last survey.

E4.9 Government plantations exist on Areas 119, 123 and 118.

E4.10 On Area 119 was a narrow strip of exotic tree plantation. The understorey is not well endowed, but contains grasses and herbs including *Cynodon dactylon*, *Rhynchelytrum repens*, *Brachiaria mutica*, *Eleusine indica*, *Eragrostris sp.*, *Digitaria sanquinalis*, and the composite weed *Mikania micrantha*, and shrubs such as *Sesabania cochinchinensis* and *Phyllanthus cochinchinensis*.

E4.11 On Area 123 the vegetation was similar to Area 119 with some additional herbs and shrubs such as *Cassia mucronata*, *Cassia mimosoides*, *Alysicarpus vaginalis*.

E4.12 The ground cover in the plantation in Area 118 is much thicker and denser than that in Area 119. More species of native or exotic herbs and shrubs were found there. The plantations in this area can be divided into 2 groups, one in the south (as described in d) above) and the others in the north (as mentioned in e) above). In addition, in the northern plots, the grass *Panicum maximum* is quite common in the understorey. *Brachiaria mutica* is also common in the more open areas (e.g. near the edge of the plots). Seedling of several native species of trees (*Ficus microcarpa*, *Ficus superba*, *Litsea glutinosa*) and shrubs (*Rhaphidepis indica*) and some exotics (*Melia azaderach*, *Leucaena leucocephala*, *Tamarix chinensis*). The invasion of native and naturalized exotic species into this plantation is most likely a result of seed dispersal by birds and other animals. It also indicates the possibility of enriching this recently filled area by planting more native species in the adjacent area in the near future.

Assessment

E4.13 Natural habitats have a higher priority for conservation than man-made habitats. Among the sites highlighted (i.e. Old Western River, ETC, abandoned ponds and government plantations), only the Old Western River is natural habitat while all others are artificial or highly altered by man. Unfortunately, the present "Old Western River" has already been cut off and only a small section is left. The special plant species occurring over there include *Pragmites australis* and *Scirpus subulatus*. They also occur in similar habitats in the Territory and therefore the concern is more for habitat loss rather than for the loss of a particular species. One remedial action is habitat compensation, by creating or preserving on area of similar habitat in other places to compensate for the loss of the Old Western River bed.

E4.14 The ETC has already been severely disturbed, but there is good potential for preserving a river/pond habitat for RZ.

E4.15 The abandoned ponds on the West bank are of little value from a botanical view point (although they might be valuable for animal conservation) since these ponds were created and maintained for fish culturing. They do not harbour any rare plants at present. However, these ponds may have a potential for growing aquatic plants as a site for conservation and perhaps education.

E4.16 All the trees grown in the government plantation trial plots are exotic trees and therefore of little ecological value from a botanical view point. However, the trees now attain a height of about 5-8 m and form a good canopy which may provide roosting sites for birds. As mentioned in E4.12 above, evidence of seed dispersal by birds shows that this area may (at least to a certain extent) be of value for animal conservation.

Mammals

E4.17 The first mammal trapping survey was carried out between 30th April and 11th May 1996 using a total of eight sites (Figure E.4.1). The types of habitats of these sites included woodland, fishpond, grassland, scrubland and mangrove. At each site, two traps of different sizes (26"x9"x9" and 32"x10"x12") were deployed. In order to ensure that the baits used for the study fell into the food category of the target animals, a variety of food items was used and this included meat (fish and chicken), seafood (crab), bread and fruit (banana).

E4.18 During the survey, traps were set in hidden places to avoid vandalism (Plate E4.1). Traps were set in late afternoon and checked the following morning. Trapped animals were then put in canvas bag, their body size measured and weighed, and released afterwards (Plates E4.2 to E4.4).

E4.19 The first survey resulted in the capture of five Javan Mongooses (*Herpestes javanicus*) and one puppy from four of the eight sites (Table E.4.1a). All five trapped Javan Mongooses were adults: four males and one female. Details of the animals suggest that the four male Mongooses were different individuals (Table E.4.2a). Traps from three other sites also showed signs of animal visit (Table E.4.1a). For example, food items were found missing or moved outside the traps. Vandalism of traps was experienced.

E4.20 The second mammal trapping survey was carried out between 5th - 16th November 1996. As no mammals were captured during the first survey in the Mai Po area, it was decided that the traps originally set in the Nature Reserve should be relocated to the RZ. The range of habitats of the six sites selected for the second survey were similar to those of the first (see Figure E3.1). Trapping methods (size of traps, types of bait and handling procedures) replicated those of the first survey.

E4.21 The second mammal survey resulted in the capture of three Javan Mongooses (*H. javanicus*), one Greater bandicoot rat (*Bandicota indica*) and a feral domestic cat. The Mongooses comprised two female adults and one individual (sex not identified) multilated by other animals - possibly by the feral dog population in the trapping site vicinity. Details of the second survey are given in Tables E4.1b and E4.2b.

Table E.4.1a
Results of First Round of Mammal Surveys of the Study Area

Site / Habitat / Trap size	Site No. 1 woodland		Site No. 2 fishpond/grass land		Site No. 3 woodland		Site No. 4 mangrove		Site No. 5 mangrove		Site No. 6 mangrove		Site No. 7 mangrove		Site No. 8 scrub	
	S	L	S	L	S	L	S	L	S	L	S	L	S	L	S	L
30-Apr-96													-	-	-	-
1-May-96													-	-	-	-
2-May-96			1 (dog)				5						-	-	-	-
3-May-96					4,5		4	5					-	-	-	-
4-May-96	4				5		4	2			2		-	-	-	-
7-May-96					5		-	-	-	-	2,1 (crab)	2,5				
8-May-96	5			1	5		-	-	-	-						
9-May-96		5,6			5		-	-	-	-		5	1,3,8		1	
10-May-96		5		1			-	-	-	-	1 (bird)	2	-			7
11-May-96					1		-	-	-	-			-			-

Note: Trap size: S = (26" x 9" x 9"); L = (32" x 10" x 12")

1 Trap with Javan Mongoose (unless noted otherwise)
2 Cage partially submerged in water
3 Cage vandalised
4 Cage door closed but with no animal
5 Some food items were missing; some with evidence of being eaten
6 Some food items were moved outside the trap
7 Cage was stolen
8 Animal was found dead, appeared to be attacked by dog (with tooth mark on body)
\- Trap site not used

Table E.4.1b
Results of Second Round of Mammal Surveys of the Study Area

Site Habitat Trap size	Site No. 3 woodland		Site No. 7 fishpond/grass land		Site No. 9 woodland		Site No. 10 mangrove		Site No. 11 mangrove		Site No. 12 mangrove	
	S	L	S	L	S	L	S	L	S	L	S	L
5-Nov-96					5, 4	6	4, 5					
6-Nov-96	1 (cat)								1 (bird)			
7-Nov-96					4, 5		1 (rat)					
8-Nov-96	6				4, 5			1			4	
9-Nov-96			4		4			4				
12-Nov-96	4		4									5
13-Nov-96			1		4, 5, 9	9		4				5
14-Nov-96	4		4	5	1 (bird)	9, 5	4, 5					5
15-Nov-96			4	5	4, 5		5	1, 8, 9				5
16-Nov-96	4		5	5	5		4, 5	-				5

Note: Trap size: S = (26" x 9" x 9"); L = (32" x 10" x 12")
1 Trap with Javan Mongoose (unless noted otherwise)
2 Cage partially submerged in water
3 Cage vandalised
4 Cage door closed but with no animal
5 Some food items were missing; some with evidence of being eaten
6 Some food items were moved outside the trap
7 Cage was stolen
8 Animal was found dead, appeared to be attacked by dog (with tooth mark on body)
9 Trap disturbed
\- Trap site not used

Table E.4.2a
Morphometric record of Javan Mongooses trapped in First Round of Mammal Surveys

Date	Body length (cm)	Tail length (cm)	Body weight (kg)	Sex	Remarks
8-May-96	30	29	n/a*	M	light brown fur mixed with black, yellow hairs
9-May-96	34	58	1.04	F	adult; teeth worn out, incisor dull
9-May-96	31	26	1.0	M	quite worn out teeth
10-May-96	32	30	0.8	M	young adult with very good teeth
11-May-96	34	30	0.95	M	young adult with very good teeth

* animal escaped and body weight not available (n/a).

Table E.4.2b
Morphometric record of Javan Mongooses trapped in Second Round of Mammal Surveys

Date	Body length (cm)	Tail length (cm)	Body weight (kg)	Sex	Remarks
8-Nov-96	26	20	0.75	F	young adult with clean teeth
13-Nov-96	29	28	0.75	F	young adult with clean teeth
15-Nov-96	n/a	n/a	n/a	n/a	dead animal, ripped in half

Table E.4.3
Reported Mammal records in Inner Deep Bay area

Month		Area sighted	Leopard Cat *(Felis bengalensis)*	Small Indian Civet (7-banded) *(Viverricula indica)*	Chinese Otter *(Lutra lutra chinensis)*	Javan Mongoose *(Herpestes javanicus)*	Crab-eating Mongoose *(Herpestes urva)*
92	Sep/Oct	Mai Po (footpath to EC; back of EC)				1+1	
	Sep/Oct	Mai Po (AFD Post)	1				
	Sep/Oct	Mai Po (Gei Wai #18)		dead			
	Dec	Tsim Bei Tsui (border fence)					1
93	Feb	Tsim Bei Tsui				1	
	Mar	Tin Shui Wai (Tin Shui)			1		
	Mar	Mai Po (back of EC)	dead, female				
	Mar	Mai Po (behind Waterfowl Collection)				dead	
	Apr	Tsim Bei Tsui (Mong Tseng)					1
	Apr	Tsim Bei Tsui				2	
	Apr	Tsim Bei Tsui fence				road kill	
	Apr	Tsim Bei Tsui fence				1	
	Jun	Mai Po (Peter Scott Study Centre)		1			
	Sep	Mai Po (footpath)	1				
94	Jun	Mai Po (EC)		dead			
	Jul	Mai Po (Gei Wai #7)			1		
	Jul	Mai Po (boardwalk)			spraints		
	Aug	Mai Po (AFD Warden Post footpath)		1			
95	Jan	Tsim Bei Tsui (Police Post)	1				
	Apr/May	Tsim Bei Tsui (border fence)				2	
	May	Mai Po (Gei Wai #10)			dead		
	Oct	Tsim Bei Tsui Pier				1	

EC: Education Centre
(Source: Porcupine! vol. 1 to vol. 13)

E4.22 Although the only wild animal captured during the survey was Javan Mongoose (*Herpestes javanicus*), it should be noted that four other larger mammals are recorded in the study area namely the small Indian Civet (*Viverricula indica*) and the Chinese Otter (*Lutra lutra chinensis*) in Mai Po, and the Crab-eating Mongoose (*Herpestes urva*) and the Leopard Cat (*Felis bengalensis*) in Tsim Bei Tsui (see Literature Review, Table E1.7 and Table E4.3).

E4.23 According to consultation with villagers, the Javan Mongoose (*Herpestes javanicus*) is considered to be quite common around Tsim Bei Tsui and adjacent areas with sightings of the animals on regular basis. Consultation also reveals that the Javan Mongoose was also common within the area before pond filling took place. The animals are now believed to occupy adjacent areas. Based on the results of the present survey and interviews with local villagers, the Javan Mongoose (*Herpestes javanicus*) is a common animal within the study area.

E4.24 The second mammal survey will be conducted in November 1996.

Terrestrial Birds on the Reserve Zone

Introduction

E4.25 In addition to information presented in Section 9 regarding the use of the Reserve Zone by breeding birds, bird traverses were completed across the RZ to sample the variety and distribution of birds.Traverses were completed both during the spring and autumn migrations. Autumn data were collected in September and October. Bird survey results along the WTC and ETC were reported for the spring migration period in the Territory Land Drainage and Flood Control Strategy Study - Phase III (Acer 1996). Traverses were also undertaken during December 1996.

E4.26 Birds utilizing the intertidal mudflats, including resident herons and egrets, and migratory shorebirds, ducks, gulls, are reported in the following section on waterbirds.

Methods

E4.27 The traverses consisted of five legs (Figure E.4.2), surveyed by walking during afternoons and evenings. Leg L1 was designed to sample birds associated with the Old West River channel, now filled with *Phragmites* reeds. The bed of the WTC is not visible along this leg of the traverse. Legs L2 and L3 crossed the interior of the landbank. Leg L4 sampled birds along the ETC and the freshwater wetland areas along the Tin Shui Wai bund. The bed of the intertidal channel was not visible along this leg. Leg L5 crossed the interior of the landbank. The surveys along the WDC were designed to sample birds particularly using the intertidal habitat. While the traverse route along the eastern drainages (Acer 1996) is imprecisely known, the route is dominated by freshwater fishponds and a narrow, mangrove-fringed channel.

E4.28 Birds were identified and numbers recorded along each traverse leg. Identification was aided with 8x40 binoculars. Birds were also identified and counted along two transects during the sedimentation study cited above (Acer 1996), along both the East and West channels.

E4.29 Multivariate statistical techniques were applied to the data to determine if there were differences in the bird community on different parts of the landbank. Three areas were of interest: 1) the interior of the created sandy landbank, hydroseeded with grasses and herbs, crossed by traverse legs L2, L3, and L5; 2) the intertidal wetland areas along the WDC; and 3) the freshwater wetlands along traverse legs L1, L4 and the ETC.

E4.30 Multivariate methods included non-metric multidimensional scaling ordination (MDS: Kruskal and Wish 1978) and tests of significance (ANOSIM: Clarke 1988, Clarke and Green 1993). MDS ordination creates a plot showing the samples that are similar to one another closer together, while samples that are very different lie further apart. Any apparent differences between samples from different areas can be tested for statistical significance using analysis of similarity (ANOSIM).

Results

E4.31 Over sixty bird species were recorded during surveys in March, September-October and December on and immediately adjacent to the Reserve Zone (Table E.4.4).

E4.32 The MDS ordination for the 1st two sampling occasions suggested that the three groups of interest were distinctive such that there was no interspersion of samples from different areas. The three areas tended to have samples more similar to each other than to other areas. This is reflected in the groupings drawn on the MDS ordination plot (Figure E.4.3). High variability in the interior land-bank bird communities (the right-hand group samples) is apparent, and is due to the L3 traverses containing just a single bird, while many more birds were seen along legs L2 and L5.

E4.33 The ANOSIM confirmed that there were significant differences among these areas in terms of their bird communities (R=0.244, p=0.04). Pairwise comparisons suggested that the freshwater wetland assemblages (center group on the MDS plot) were significantly different from both other groups ($p<0.05$), but that the intertidal bird assemblage was not significantly different from the interior landbank community ($p>0.05$).

E4.34 However the addition of December data led to a much higher stress value of 0.23 compared to the earlier value of 0.08 and the MDS plotting no longer gave good representation of the bird communities. With the December data, the ordination continues to show the estuarine traverses (WDC and L4) distinct from the landbank traverses.

Discussion

E4.35 It is not surprising that the bird communities should tend to be different from one another: Different habitat types (comprising freshwater wetland, hydroseeded grassland, and intertidal mud in this comparison) support different animal communities. The lack of a significant difference between the intertidal bird assemblage and the landbank birds may be due to the low sample size for the intertidal community (n=2) and the high variability shown by the broad dispersion of samples in the landbank community (Figure E.4.3).

Table E.4.4 Results of Bird Surveys. Location and time of surveys are coded for each column.
Location codes: WTC (Western Temporary Channel); L1-L5 (legs of traverse shown on Figure E.4.2.); ETC (Eastern Temporary Channel).
Time codes are: Mar (March 1996), Sep (September 1996), Oct (October 1996), Dec (December 1996).
March Surveys are from Acer (1996).

	WTC Mar	ETC Mar	L1 Oct	L2 Oct	L3 Oct	L4 Oct	WTC Oct	L1 Sep	L2 Sep	L3 Sep	L4 Sep	L5 Sep	L1 Dec	L2 Dec	L3 Dec	L4 Dec	L5 Dec	WTC Dec
Little Grebe	0	0	0	0	0	2	0	0	0	0	0	0	2	0	0	2	0	0
Cormorant	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	54
Grey Heron	5	1	0	0	0	9	70	1	0	0	7	0	0	0	0	56	0	154
Great Egret	2	1	0	0	0	6	50	0	0	0	2	0	4	0	0	5	0	21
Little Egret	51	0	15	0	0	32	400	4	0	0	4	0	0	0	0	2	0	14
Egret sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	14
Chinese Pond Heron	6	2	0	0	0	4	5	1	0	0	2	0	0	0	0	4	0	3
Black-crowned Night Heron	0	0	0	0	0	0	0	0	0	0	6	0	0	0	0	1	0	0
Wigeon	35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	67
Green-winged Teal	400	0	0	0	0	0	80	0	0	0	0	0	0	0	0	63	0	180
Northern Pintail	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Black-eared Kite	2	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	4
Hobby	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
Kestrel	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
Marsh Harrier	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Japanese Sparrowhawk	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Japanese Quail	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
Quail sp	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
Rail sp.	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
White-breasted Waterhen	5	3	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1
Coot	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table E.4.4 (cont'd)

	WTC Mar	ETC Mar	L1 Oct	L2 Oct	L3 Oct	L4 Oct	WTC Oct	L1 Sep	L2 Sep	L3 Sep	L4 Sep	L5 Sep	L1 Dec	L2 Dec	L3 Dec	L4 Dec	L5 Dec	WTC Dec
Moorhen	2	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
Wader sp.	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0
Little Ringed Plover	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Common Snipe	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Tringa sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6
Common Redshank	25	0	0	0	0	1	20	0	0	0	0	0	0	0	0	0	0	0
Common Greenshank	0	0	0	0	0	0	12	0	0	0	0	0	0	0	0	0	0	0
Common Sandpiper	3	0	0	0	0	2	4	0	0	0	0	0	0	0	0	0	0	2
Green Sandpiper	2	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0
Rufous Turtle-dove	0	0	1	1	0	0	0	1	0	0	0	0	0	0	0	0	0	1
Spotted Dove	2	3	0	0	0	0	1	0	0	0	4	0	0	0	0	0	0	0
Greater Coucal	1	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	1
Koel	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
White-breasted Kingfisher	0	0	0	0	0	1	1	0	0	0	1	0	0	0	0	1	0	0
Common Kingfisher	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	2	0	0
Barn Swallow	6	0	7	4	0	10	0	6	0	0	10	9	0	0	0	0	0	0
Oriental Skylark	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0
Tree Sparrow	6	0	1	0	0	12	23	0	0	0	0	0	0	0	0	0	1	0
Pipits and Wagtails UNID	0	0	5	11	0	3	3	1	1	0	0	1	0	2	0	1	0	3
Richard's Pipit	3	2	7	1	0	0	1	1	0	0	0	0	3	1	0	1	0	2
Grey Wagtail	1	0	6	0	0	4	2	1	0	0	1	0	1	0	0	0	0	0
White Wagtail	1	0	0	0	0	0	1	1	0	0	0	0	3	1	0	0	0	2
Black-faced Laughing Thrush	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table E.4.4 (cont'd)

	WTC Mar	ETC Mar	L1 Oct	L2 Oct	L3 Oct	L4 Oct	WTC Oct	L1 Sep	L2 Sep	L3 Sep	L4 Sep	L5 Sep	L1 Dec	L2 Dec	L3 Dec	L4 Dec	L5 Dec	WTC Dec
Black-winged Cuckoo Shrike	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
Crested Bulbul	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	21	0	0
Chinese Bulbul	1	23	31	0	0	0	5	10	7	0	1	0	7	0	0	9	0	2
Red-vented Bulbul	0	0	0	0	0	0	7	0	0	0	0	0	0	0	0	1	0	0
Thrush sp.	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
Siberian Stonechat	0	1	6	1	0	5	5	3	2	0	0	1	2	1	0	2	0	3
Cisticola & Prinia UNID	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	0	0
Fantail Warbler	1	5	0	0	0	0	0	2	4	1	2	2	0	0	0	0	0	0
Plain Prinia	8	15	3	2	0	1	0	2	1	0	1	0	0	4	0	7	0	1
Yellow-bellied Prinia	4	21	2	0	1	5	2	3	1	0	4	0	3	0	0	4	0	5
Old World Warblers UNID	0	1	0	2	0	1	0	1	0	0	2	1	1	0	0	0	0	0
Chinese Bush Warbler	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
Oriental Reed Warbler	0	0	2	0	0	1	2	4	3	0	5	0	0	0	0	0	0	0
Dusky Warbler	1	0	2	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0
Rufous-backed Shrike	0	1	1	0	0	2	0	0	0	0	2	0	0	1	0	1	0	0
Black Drongo	0	2	0	0	0	0	0	1	1	0	5	0	2	0	0	0	0	0
Hair-crested Drongo	0	0	2	0	0	0	1	0	1	0	1	0	0	0	0	0	0	0
Magpie	1	0	0	0	0	2	0	0	0	0	0	0	0	0	0	1	0	2
Magpie Robin	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
Jungle Crow	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Collared Crow	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Black-necked Starling	6	2	21	18	0	0	7	9	2	0	4	3	6	0	0	1	0	4
Crested Myna	29	0	31	4	0	0	8	14	15	0	0	0	11	3	0	0	0	6

Table E.4.4 (cont'd)

	WTC Mar	ETC Mar	L1 Oct	L2 Oct	L3 Oct	L4 Oct	WTC Oct	L1 Sep	L2 Sep	L3 Sep	L4 Sep	L5 Sep	L1 Dec	L2 Dec	L3 Dec	L4 Dec	L5 Dec	WTC Dec
Masked Bunting	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6
Common Shelduck	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6
Spotbill duck	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6
Duck sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	378
Northern Shoveler	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4
Avocet	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	39
House Swift	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	50	0	0
Total Abundance	627	91	145	44	1	105	720	68	40	1	67	19	48	13	0	244	2	992
Total number of species	30	19	19	9	1	21	32	21	13	1	22	8	15	7	0	25	2	31

E4.36 The importance of these differences can be seen in the number of birds and the variety of species in the three areas (Table E.4.4). The greatest species richness (>30) and highest abundance (>627) occurred on the intertidal mud. The lowest species richness (<13) and lowest abundance of birds (<44) was recorded on the hydroseeded landbank. Freshwater wetland areas held intermediate values, with species richness >14 and abundance >47.

E4.37 The results of this survey illustrate the reasoning behind placing most ecological assessment and monitoring resources in the wetland areas that are more extensive adjacent to the Reserve Zone. It also illustrates that freshwater wetland habitat present on the Reserve Zone has a good variety and abundance of birds.

Amphibians

E4.38 The importance of wetland areas on the Reserve Zone to amphibians was investigated. The breeding of several common frog species occurs in spring, and many frogs and toads breed throughout the year, remaining active in temperature above 13° C (Karsen *et al.* 1986). Sites that are wet for only part of the year (vernal wetlands) may be particularly valuable for amphibian breeding, because they lack the alien fishes that predate upon tadpoles (Ashworth *et al.* 1993).

E4.39 The amphibian surveys were scheduled to investigate amphibian distribution during the time of year when vernal wetlands were present.

E4.40 Amphibians were identified when encountered along traverses adjacent to the wetland areas on the Reserve Zone, i.e. the Old Western River and the ETC (see Figure E.4.2). Traverses were completed on the 13th and 19th of September. Rain puddles were present both evenings, and rain fell on both days.

E4.41 Most frogs were identified after individuals heard calling were located. Toads were usually seen hopping.

E4.42 Six distinct types of amphibian, all being frogs and toads, were located during the evening surveys of the Reserve Zone (Table E.4.5). Five species were identified, and the sixth type of frog may have been a juvenile or sexual dimorphic type.

Table E.4.5
Amphibians Recorded on the Reserve Zone

Asiatic Common Toad	*Bufo melanostictus*
Marbled Pygmy Frog	*Microhyala pulchra*
Brown Tree Frog	*Polypedates leucomystax*
Gunther's Frog	*Rana guentheri*
Paddy Frog	*R. limnocharis*

E4.43 The Asiatic Common Toad was widespread across the Reserve Zone, and seen during the day as well as after dark, on the hydroseeded grassland, as well as on cycle paths and footpaths. Individuals of Marbled Pygmy Frog were along the edges of rain water puddles or water-filled vehicle tracks. These occurred in numbers varying from four to a dozen or more around each puddle, judging from the number of calls. A single individual of Brown Tree Frog was perched on a road barrier above the ETC, and a single individual Gunther's Frog was recorded on a footpath underneath the Tin Wah road bridge across the WTC. A single paddy frog was recorded from a rainwater-filled tyre rut adjacent to the ETC outfall.

E4.44 The usage of ephemeral wetlands by amphibians on the Reserve Zone was confirmed by these surveys. When not breeding, these amphibians disperse. It is likely that by providing areas for ephemeral wetlands in the Ecological Park - Conservation Area, these species will continue breeding in this area.

Fish

E4.45 The fish resources in the Reserve Zone waterbodies were investigated during the Eco-IA. The 1380 ha of managed fishponds in the Northwest New Territories produce Chinese carps (Cyprinidae), talapia (Cichlidae), and mullet (Mugilidae) in polyculture systems, and snakehead (Ophiocephalidae) and catfish (Clariidae, Siluridae) (Man and Hodgkiss, 1981, Wilson 1995). Waterbodies on the Reserve Zone consist of impounded rainwater (the ETC and the Old West River) that now resemble fishponds, abandoned fishponds, and the tidal WTC.

E4.46 Gill nets were used at two locations to sample the fish. One net was placed across the WTC just upstream of the security bund bridge, and the other was drawn through the ETC (see Figure E4.2). The gill net across the WTC was placed on a rising tide and left in place through high water and part the following ebb tide. Gill net sampling was done in April, and observations regarding fish were also collected during the other terrestrial surveys.

E4.47 Gill netting recovered just four Talapia (*Sarotherodon mossambicus*) from the ETC, and no fish were recovered from the gill net across the WTC. People have been seen gill netting in the ETC at other times during this Eco-IA. One dead Talapia was noted along the dense-reedy edge of the Old Western River where the individual was presumably stranded as rainwater levels subsided. People fishing in the abandoned fishponds of Area 122 had caught a snakehead (*Ophiocephalus maculatus*).

E4.48 Fish were present in the standing waterbodies on the Reserve Zone. Abundances were not considered high and the variety of fish was restricted to a single species where fish were present. The presence of fish in the permanent water bodies correlates with a lack of amphibians being recorded from permanent pools. The lack of fish in the WTC gill net may be due to relatively poor water quality there. Poor water quality is evidenced by the dominance of capitellid polychaetes in the WTC sediments adjacent to the gill net site, and the black, anoxic methane or hydrogen-sulfide bearing sediments recorded in the REMOTS survey of the sediments, within about 1000 - 1500 m north of the gill net site.

Odonates

E4.49 A site walkover was completed with local dragonfly expert Keith Wilson (author of Hong Kong Dragonflies) to evaluate the site for the presence of two endangered species of Odonate (dragonflies and damselflies), *Mortonagrion hirosei* and *Orthretum poecilops* (Groombridge 1993). These are present in Hong Kong. They are endangered because their ranges are limited by fragmentation, and declining habitat. *M. hirosei* was the 12th most common aerial insect collected in malaise traps in reedbeds at Mai Po Marshes Nature Reserve (Reels 1994) and is confined to dense stands of *Phragmites* reed beds at Luk Keng (Wilson 1995). *O. poecilops* is present at Nam Cheng (NE New Territories) where a fresh water stream discharges into a mangrove. Very similar habitat occurs in the Reserve Zone where the eastern temporary channel discharges fresh water into a mangrove.

E4.50 Neither species was observed during an afternoon survey of the ETC and the Old West River with Keith Wilson. However, the occurrence of *Rhodothemis rufa* along the Old West River channel indicated the high quality of the reedbed there, and *Mortonagrion hirosei* should be expected to occur there (K. Wilson, pers. comm.). The reserve zone probably does not provide suitable habitat for the other endangered Odonate *O. poecilops*. The discharge of fresh water from the ETC into the mangrove zone occurs into standing water, while the habitat supporting *O. poecilops* at Nam Cheng is characterized by a freshwater stream, fed by fishpond discharge, flowing through the mangrove at low tide that is inundated at high tide.

E4.51 The 15 species noted during the survey are listed in Table E4.6.

Table E.4.6
Odonates noted during field visit with K. Wilson

Within and adjacent to ETC:
Agriocnemis pygmaea
A. femina
Ceriagrion auranticum ryukyuanum
Ischnura senegalensis
Pantala flavescens
Neurothemis tullia (paddy field indicator species)
Zyxomma petiolatum (pollution tolerant)
Freshwater marshy area in area 118:
Pantala flavescens
Brachydiplax chalybea flavovittat (fishpond species)
Orthetrum sabina (fishpond species)
Brachythemis contaminata (pollution tolerant)
Old West River Channel:
Pantala flavescens
Diplacodes trivialis
Acisoma panorpoides
Crocothemis servilia (fishpond species)
Rhodothemis rufa (indicator of good wetland quality)
Anax guttalus (fishpond species)

References

Ades, G. and Reels, G.T. 1992-1995. *Porcupine!* No. 1-13.

Ashworth, J.M., R.T. Corlett, D. Dudgeon, D.S. Melville, W.S.M. Tang. 1993. Hong Kong flora and fauna: computing conservation. Worldwide Fund for Nature Hong Kong, Hong Kong.

Clarke, K.R. 1988. Detecting change in benthic community structure. Proceedings XIVth International Biometric Conference, Namur: Invited Papers. Societe Adolphe Quetelet, Gembloux, Belgium.

Clarke, K.R. and Green, R.H. 1998. Statistical design and analysis for a 'biological effects' study. Marine Ecology Progress Series 46: 213-226.

Clarke, K.R. 1993. Non-parametric multivariate analyses of changes in community structure. Australian Journal of Ecology 18: 117-143.

Groombridge, B. (editor). 1993. 1994 IUCN Red List of Threatened Animals. IUCN, Gland, Switzerland and Cambridge, U.K.

Karsen, S.J. Lau, M.W.N. and Bogadek, A. 1986. Hong Kong amphibian & reptiles, Urban Council, Hong Kong.

Kruskal, J.B. and Wish, M. 1978. Multidimensional scaling. Sage Publications, Beverley Hills, California.

Man, S.H. and Hodgkiss, I.J. 1981. Hong Kong Freshwater Fishes, Urban Council, Hong Kong.

Reels, G. 1994. Management strategies for the reed *Phragmites australis* (Cav.) Steud. at Mai Po Marshes Nature Reserve, Hong Kong, with observations on the associated insect fauna. Unpublished M. Phil. thesis, University of Hong Kong.

Wilson, K. 1995. Hong Kong Dragonflies. Urban Council, Hong Kong.

Waterbirds

Introduction and summary of methods

E4.52 Inner Deep Bay is known to provide suitable habitat for 27 globally threatened or near threatened bird species (Melville 1995), and 5 species are regularly present in abundances greater than 1% of their population throughout the world, to qualify Inner Deep Bay as a Ramsar site. The Tin Shui Wai site adjoins the Ramsar site, so that the use of the Tin Shui Wai site or its immediate vicinity by rare and endangered birds is relevant to the ecological impact assessment of the Project.

E4.53 In addition, quantification of habitat use by waterbirds is important to assess the value of habitats to them. In order to attempt to adequately quantify waterbird use of the estuarine habitat with limited resources, a target species was necessary. The density, intensity of foraging, prey choice, and intake rate of Little Egret were selected to quantify the usage of the intertidal area by waterbirds. Data were recorded within quadrats at three places: the WTC mouth, and at two control sites, one at Mai Po, and one at Tsim Bei Tsui (see Figure E.4.1). Data were recorded during regular data collection surveys in January, April, July and October. In addition, some observations were collected in September when the opportunity arose. Details of the methods are in Appendix E3.

E4.54 Presence/absence data for rare and endangered species were taken largely from anecdotal and as-yet unconfirmed reports from the Hong Kong Bird Watching Society bird hotline. Many of these reports will have been submitted by the observer to the HKBWS, and the details of the sightings will be assessed by experts for acceptability as a confirmed sighting. Other sightings were taken from the newsletter of the HKBWS.

E4.55 Quantitative data are presented graphically in Figure E4.4, with the data for each site plotted in each survey time. This presentation allows for a visual assessment of important differences between sites at different times, and inspection for interactions in data between survey time and location. Non-parametric Kruskal-Wallis analyses of variance were calculated to test for significant differences among areas at each survey, because data transformation could not always satisfy the assumptions of parametric statistics. Two-way ANOVA were calculated to judge statistical significance of interactions, but the conclusions of the statistical tests should be viewed together with the graphs, because the data do not comply with the assumptions for parametric statistics.

Rare and Endangered Species Present

E4.56 The ICBP/Birdlife International criteria classifications are being applied to determine the status of individual bird species in Hong Kong (Collar *et al.* 1994). The categories are critical, endangered, vulnerable, and near-threatened. A list of the waterfowl species for which Deep Bay is important was compiled by Young and Melville (1995) (Table E.1.1).

E4.57 The rare and endangered species observed during the study period are tabulated in Table E.4.7, and described in the following paragraphs.

Table E.4.7
Unconfirmed Reports of Threatened or Near-threatened Bird Species and Abundance near Tin Shui Wai Study Area (Sources: Lewthwaite (1995, 1996a, 1996b), and HKBWS bird watcher's hotline)

Date	Location	Species	Abundance	Status
29-Sep-95	Mai Po	Black-faced Spoonbill (immature)	3	C
7-Oct-95	Mai Po	Black-faced Spoonbill	50	C
12-Oct-95	Mai Po	Black-faced Spoonbill	62	C
21-Oct-95	Tsim Bei Tsui	Black-faced Spoonbill	5	C
28-Oct-95	Tsim Bei Tsui	Black-faced Spoonbill	17	C
31-Oct-95	Mai Po	Black-faced Spoonbill	99	C
2-Apr-96	Mai Po	Black-faced Spoonbill	41	C
17-Apr-96	Deep Bay mudflats	Black-faced Spoonbill	41	C
16-May-96	Mai Po	Black-faced Spoonbill	14	C
8-Jun-96	Mai Po (scrape)	Black-faced Spoonbill	1	C
3-Oct-96	Mai Po	Black-faced Spoonbill	1	C
3-Oct-96	Mai Po	Black-faced Spoonbill		C
14-Dec-96	Mai Po	Black-faced Spoonbill	123	C
9-Dec-95	Tsim Bei Tsui	Oriental Stork	1	E
21-Jan-96	Tsim Bei Tsui	Baikal Teal (drake)	1	E
22-Jan-96	Mai Po (boardwalk)	Baikal Teal (female)	1	E
29-Feb-96	Tsim Bei Tsui	Baikal Teal	1	E
2-Apr-96	Mai Po (boardwalk)	Chinese Egret	1	E
20-Apr-96	Tsim Bei Tsui	Chinese Egret	1	E
24-Apr-96	Mai Po	Chinese Egret	1	E
25-Apr-96	Mai Po	Chinese Egret	1	E
16-May-96	Mai Po	Nordmann's Greenshank	11	E
18-May-96	Mai Po	Chinese Egret	1	E
22-May-96	Mai Po (scrape)	Nordmann's Greenshank		E
25-May-96	Mai Po	Nordmann's Greenshank	2	E
27-May-96	Mai Po (scrape)	Chinese Egret	1	E
8-Jun-96	Mai Po (scrape)	Nordmann's Greenshank	1	E
21-Sep-95	Mai Po (boardwalk)	Asian Dowitcher	1	N
24-Sep-95	Mai Po (boardwalk)	Asian Dowitcher	1	N
24-Oct-95	Tsim Bei Tsui	Black-headed Ibis	1	N
28-Oct-95	Tsim Bei Tsui	Black-headed Ibis	1	N
12-Nov-95	Tsim Bei Tsui	Black-headed Ibis	1	N
22-Apr-96	Mai Po	Asian Dowitcher	70	N
23-Apr-96	Mai Po (boardwalk)	Asian Dowitcher	142	N
5-May-96	Mai Po (boardwalk)	Asian Dowitcher	3	N
16-May-96	Mai Po	Asian Dowitcher	11	N
25-May-96	Mai Po	Asian Dowitcher	7	N
8-Jun-96	Mai Po (scrape)	Asian Dowitcher	2	N
4-May-96	Mai Po	Asian Dowitcher	3	N
10-Aug-96	Mai Po	Asian Dowitcher	1	N
6-Oct-96	Tsim Bei Tsui	Chestnut-cheeked Starling	3	N
7-Oct-96	Tsim Bei Tsui	Chestnut-cheeked Starling	8	N

Table E.4.7 (cont'd)

Date	Location	Species	Abundance	Status
4-Nov-95	Lut Chau	Imperial Eagle	1	V
4-Nov-95	Lut Chau	Spotted Eagle	1	V
18-Nov-95	Mai Po	Imperial Eagle	3	V
9-Dec-95	Tsim Bei Tsui	Dalmatian Pelican	4	V
17-Dec-95	Tsim Bei Tsui	Dalmatian Pelican	8	V
6-Jan-96	Deep Bay	Dalmatian Pelican	20	V
13-Jan-96	Ma Tso Lung	Baer's Pochard	1	V
5-Apr-96	Lim Barn Tsuen	Japanese Yellow Bunting	6	V
5-Apr-96	Mai Po	Japanese Yellow Bunting	2	V
6-Apr-96	Mai Po	Spoon-billed Sandpiper	1	V
6-Apr-96	Mai Po (boardwalk)	Spoon-billed Sandpiper	3	V
20-Apr-96	Mai Po (casurinas)	Japanese Yellow Bunting	1	V
21-Apr-96	Mai Po	Spoon-billed Sandpiper	1	V
22-Apr-96	Mai Po	Spoon-billed Sandpiper	1	V
24-Apr-96	Mai Po	Spoon-billed Sandpiper	3	V
4-May-96	Mai Po	Spoon-billed Sandpiper	1	V
5-May-96	Mai Po (boardwalk)	Spoon-billed Sandpiper		V
21-May-96	Mai Po	Spoon-billed Sandpiper	3	V
22-May-96	Mai Po (scrape)	Spoon-billed Sandpiper	3	V

Status codes: C = critically endangered; E = endangered; V = vulnerable; N = near-threatened
Status defined in IUCN Red Data Book (Collar *et al* 1994), Melville (1995).

Critically Endangered Species

E4.58 The most critically threatened species for which Deep Bay is important is the Black-faced Spoonbill (*Platalea minor*). Inner Deep Bay hosts 25% of the world's population, mostly as winter visitors, although three juveniles probably spent the summer at Mai Po in 1995 (Lewthwaite 1995). During the 1995 migration cycle, Black-faced Spoonbills began returning to spend the winter in August 1995. About 40 individuals using the intertidal mudflats were observed during fieldwork in April 1996 (Table E.4.7). Up to around 130 have been reported at Mai Po in December 1996.

Endangered Species

E4.59 Deep Bay is important for four species of waterbirds classified as "endangered": Chinese Egret (*Egretta eulohotes*), Oriental Stork (*Ciconia boyciana*), Spotted Greenshank (*Tringa guttifer*), and Saunder's Gull (*Larus saundersi*). Chinese Egret is seen occasionally around the Deep Bay wetlands. A Chinese Egret was reported in breeding plumage at Mai Po in July 1995, which was the first mid-summer sighting of this species since a pair bred at Starling Inlet in 1982 (Lewthwaite 1995). In April, 1996, the species was recorded at Tsim Bei Tsui, the individual reported at Mai Po was observed during field work for this EIA. A single individual of the endangered species Oriental Stork arrived in December 1995 and was recorded at Tsim Bei Tsui and Mai Po during the winter of 1995-1996. Spotted Greenshanks were recorded by the HKBWS on the mudflats and *gei* *wais*/fishponds throughout northbound migration (February - April 1996) (Table E.4.7). Saunder's Gulls were present on the mudflat during the winter 1996 (January-February), and Deep Bay hosts more than 5% of the world's population in winter (Young and Melville 1995).

Vulnerable Species

E4.60 Vulnerable bird species listed by Collar *et al.* (1994) for which Deep Bay is important include Dalmatian Pelican (*Pelicanus crispus*), Baer's Pochard (*Aythya baeri*), Imperial Eagle (*Aquila heliaca*) and Spoon-billed Sandpiper (*Eurynorhynchus pygmaeus*). Dalmatian Pelicans arrived for the winter in December 1995. In January 1996, 23 were counted in Deep Bay, the highest count since 1989 (Lewthwaite 1996). The pelicans departed in February or March. Baer's Pochard was recorded on the fishponds at Ma Tso Lung in January 1996, the first sighting since 1992 (Lewthwaite 1996). Imperial Eagles were recorded at Lut Chau, Ma Tso Lung, and Mai Po in November 1995, as is usual during late autumn. A juvenile Spoonbilled Sandpiper was present at Mai Po in August 1995, two months earlier than the normal southbound passage for this species (Lewthwaite 1995). Individual or small groups of Spoonbill Sandpipers have been recorded at Mai Po and the Deep Bay mudflats during northbound migration 1996 (Table E.4.7).

Near-threatened Species

E4.61 The fourth classification given by Collar *et al.* (1994) is near-threatened species. Of the birds in this category, Deep Bay provides important habitat for Asian Dowitcher (*Limnodromus semipalmatus*) and Relict Gull (*Larus relictus*). Asian Dowitchers have been recorded at Mai Po in small groups or individuals in August, September, and October 1995 (Lewthwaite 1995). Larger flocks of Asian Dowitchers normally utilize the Deep Bay wetlands for their northbound migration, and flocks of up to 142 individuals were recorded in April 1996 on the Mai Po mudflats (Table E.4.7). The Relict Gull is rare (Bhushan *et al.* 1993).

Table E.4.8
Unconfirmed Reports of Rare or Unusual Birds in the Tin Shui Wai Study Area, Oct-95 to Jun-96. (Sources: Lewthwaite (1995, 1996a, 1996b) and reports from HKBWS bird watcher's hotline)

Date	Location	Species	Abundance
21-Oct-95	Tin Shui Wai	Black-naped Monarch	1
28-Oct-95	Tin Shui Wai	Citrine Wagtail (female adult)	1
14-Oct-95	Tin Shui Wai	Pallas's Grasshopper Warbler	4
1-Nov-95	Tin Shui Wai	Wryneck	1
13-Oct-95	Tin Shui Wai (reclamation)	Black Baza	7
14-Oct-95	Tin Shui Wai (reclamation)	Hobby	5
3-Oct-95	Tin Shui Wai (reclamation)	Sooty Tern	1
15-Sep-96	Tin Shui Wai (reclamation)	Banded Rail	1
15-Sep-96	Tin Shui Wai (reclamation)	Button Quail sp.	1
15-Sep-96	Tin Shui Wai (reclamation)	Pallas' Grasshopper Warbler	7
15-Sep-96	Tin Shui Wai (reclamation)	Oriental Reed Warbler	31
15-Sep-96	Tin Shui Wai (reclamation)	Fantail Warbler	60
22-Sep-96	Tin Shui Wai (reclamation)	Button Quail sp.	2
14-Oct-95	Tsim Bei Tsui	Blue-tailed Bee-eater	6
15-Oct-95	Tsim Bei Tsui	Blue-tailed Bee-eater	4
3-Oct-95	Tsim Bei Tsui	Blue-tailed Bee-eater	1
20-Sep-95	Tsim Bei Tsui	Chinese Starling	25
5-Nov-95	Tsim Bei Tsui	Common Starling	1
20-Sep-95	Tsim Bei Tsui	Forest Wagtail	1
21-Jan-96	Tsim Bei Tsui	Long-billed Dowitcher	1
31-Mar-96	Tsim Bei Tsui	Red-breasted Merganser (male)	1
14-Apr-96	Tsim Bei Tsui	Red-necked Phalarope	135
31-Dec-95	Tsim Bei Tsui	Scaup	13
4-Feb-96	Tsim Bei Tsui	Tufted Duck	387
31-Dec-95	Tsim Bei Tsui	Tufted Duck	291
30-Sep-95	Tsim Bei Tsui	Wryneck	1
12-Nov-95	Tsim Bei Tsui	Yellow-browed Bunting	1
3-Mar-96	Tsim Bei Tsui	Great Crested Grebes	255
12-May-96	Tsim Bei Tsui	Pechora Pipit	3
9-Dec-95	Tsim Bei Tsui (paddy/ north)	Tufted Duck	251
28-Oct-95	Tsim Bei Tsui (pier)	Black-necked Grebe	1
12-Mar-96	Lut Chau	Asian House Martin	100
12-Mar-96	Lut Chau	Barn Swallow	1400
27-Oct-95	Lut Chau	Black-headed Bunting (female immature)	1
12-May-96	Lut Chau	Cinnamon Bittern	
12-Mar-96	Lut Chau	Citrine Wagtail	1
6-Jan-96	Lut Chau	Citrine Wagtail (adult female)	1
27-Oct-95	Lut Chau	Citrine Wagtail (adult female)	1
28-Oct-95	Lut Chau	Citrine Wagtail (female adult)	1
12-Mar-96	Lut Chau	Common Reed Bunting	2
12-Mar-96	Lut Chau	Common Rosefinch	1
12-Mar-96	Lut Chau	Pacific Swift	100
12-Mar-96	Lut Chau	Penduline Tit	25
19-Sep-95	Lut Chau	White-throated Needletail	1
19-Sep-95	Lut Chau	Wryneck	1

Table E.4.8 (cont'd)

Date	Location	Species	Abundance
18-Oct-95	Lut Chau	Yellow-legged Buttonquail	1
19-Sep-95	Lut Chau	Chestnut Bittern	1
29-Feb-96	Lau Fau Shan	Chinese Grosbeak	6
28-Apr-96	Lim Barn Tseun	Blue-tailed Bee-eater	
28-Apr-96	Lim Barn Tseun	Pechora Pipit	
1-Feb-96	Lim Barn Tsuen	Buff-bellied Pipit	3
13-Mar-96	Lim Barn Tsuen	Buff-bellied Pipit	1
11-Mar-96	Lim Barn Tsuen	Common Reed Bunting	4
27-Sep-95	Lim Barn Tsuen	Great Reed Warbler	80
19-Feb-96	Lim Barn Tsuen	Oriental Pratincole	2
20-Nov-95	Lim Barn Tsuen	Pallas's Reed Bunting	1
22-Mar-96	Lim Barn Tsuen	Ruddy Crake	1
4-Apr-96	Mai Po	"Type 1" swiftlet (Himalayan Swiftlet)	2
1-Apr-96	Mai Po	"Type 1" swiftlet (Himalayan Swiftlet)	1
3-Apr-96	Mai Po	"Type 1" swiftlet (Himalayan Swiftlet)	1
21-Sep-95	Mai Po	Asian House Martin	12
26-Sep-95	Mai Po	Asian House Martin	10
22-Sep-95	Mai Po	Barred Buttonquail	1
7-Oct-95	Mai Po	Besra	3
12-Sep-95	Mai Po	Besra	1
3-Sep-95	Mai Po	Black Bittern	1
20-Sep-95	Mai Po	Black Bittern	1
6-Nov-95	Mai Po	Black-headed Bunting	1
7-Nov-95	Mai Po	Black-headed Bunting	1
8-Nov-95	Mai Po	Black-headed Bunting	1
9-Nov-95	Mai Po	Black-headed Bunting	1
15-Oct-95	Mai Po	Blue-tailed Bee-eater	15
11-Sep-95	Mai Po	Blyth's Pipit	1
24-Sep-95	Mai Po	Brown Flycatcher	15
22-Oct-95	Mai Po	Chinese Goshawk (immature)	1
3-Apr-96	Mai Po	Common Swift	1
28-Dec-95	Mai Po	Great Black-headed Gulls	1
24-Sep-95	Mai Po	Great Reed Warbler	80
18-Sep-95	Mai Po	Great Reed Warbler	60
19-Sep-95	Mai Po	Grey-faced Buzzard	1
21-Sep-95	Mai Po	Grey-streaked Flycatcher	1
22-Oct-95	Mai Po	Japanese Paradise Flycatcher	1
8-Oct-95	Mai Po	Japanese Sparrowhawk	1
18-Sep-95	Mai Po	Manchurian Reed Warbler	1
19-Sep-95	Mai Po	Manchurian Reed Warbler	1
20-Sep-95	Mai Po	Manchurian Reed Warbler	1
24-Sep-95	Mai Po	Middendorff's Grasshopper Warbler	1
7-Oct-95	Mai Po	Middendorff's Grasshopper Warbler	1
11-Nov-95	Mai Po	Northern Skylark	2
13-Feb-96	Mai Po	Paddyfield Warbler	1
8-Nov-95	Mai Po	Pallas's Reed Bunting	1
9-Oct-95	Mai Po	Pechora Pipit	1
7-Oct-95	Mai Po	Pied Harrier	1

Table E.4.8 (cont'd)

Date	Location	Species	Abundance
18-May-96	Mai Po	Ruff (male breeding plumage)	
3-Jan-96	Mai Po	Rufous Turtle Dove	809
28-Dec-95	Mai Po	Slaty-backed Gull	1
1-Dec-95	Mai Po	Styan's Grasshopper Warbler	1
17-Sep-95	Mai Po	Thick-billed Warbler	1
24-Sep-95	Mai Po	Thick-billed Warbler	1
25-Oct-95	Mai Po	Thick-billed Warbler	1
3-Mar-96	Mai Po	Thick-billed Warbler	1
25-Apr-96	Mai Po	UNID bee-eaters	7
30-Sep-95	Mai Po	Watercock	1
2-Apr-96	Mai Po	Asian House Martin	150
10-Apr-96	Mai Po	Baillon's Crake	1
28-Apr-96	Mai Po	Baillon's Crake	1
18-Feb-96	Mai Po	Barn Swallow	1
18-Sep-95	Mai Po	Black Baza	7
3-Mar-96	Mai Po	Common Reed Bunting	1
18-Feb-96	Mai Po	Common Reed Bunting	2
20-Apr-96	Mai Po	Little Stint	1
22-Apr-96	Mai Po	Little Whimbrel	2
15-Apr-96	Mai Po	Pectoral Sandpiper	1
2-Apr-96	Mai Po	Ruddy Sparrow	1
12-Nov-95	Mai Po	Scaup (immature male)	1
25-Feb-96	Mai Po	Styan's Grasshopper Warbler	1
8-Apr-96	Mai Po	Water Rail	1
2-Apr-96	Mai Po	White-vented Needletail	50
13-May-96	Mai Po	Black Bittern	1
16-May-96	Mai Po	Reef Egret	1
16-May-96	Mai Po	Ruff	1
16-May-96	Mai Po	Nordmann's Greenshank	11
17-May-96	Mai Po	Ruff	1
18-May-96	Mai Po	Ruff	1
22-May-96	Mai Po	Baillon's Crake	1
25-May-96	Mai Po	Watercock	1
26-May-96	Mai Po	Watercock	1
8-Jun-96	Mai Po	Yellow Wagtail	1
28-Jul-96	Mai Po	Hoopoe	1
Aug-96	Mai Po	Asian Paradise Flycatcher	3
31-Aug-96	Mai Po	Yellow-rumped Flycatcher	2
10-Aug-96	Mai Po	Ruff	2
17-Aug-96	Mai Po	Red-necked Strint w/ red leg flag	1
13-Sep96	Mai Po	Great Knot	76
14-Sep-96	Mai Po	Ruff	2
8-Oct-95	Mai Po (boardwalk)	American Golden Plover	1
6-Feb-96	Mai Po (boardwalk)	Black-tailed Gull	2
24-Mar-96	Mai Po (boardwalk)	Glaucous-winged Gull	1
6-Feb-96	Mai Po (boardwalk)	Great Black-headed Gull	1
6-Feb-96	Mai Po (boardwalk)	Herring 'mongolicus' Gull	1
7-Feb-96	Mai Po (boardwalk)	Herring 'mongolicus' Gull	1

Table E.4.8 (cont'd)

Date	Location	Species	Abundance
7-Oct-95	Mai Po (boardwalk)	Jack Snipe	1
22-Nov-95	Mai Po (boardwalk)	Long-billed Dowitcher	2
9-Mar-96	Mai Po (boardwalk)	Long-billed Dowitcher	1
2-Apr-96	Mai Po (boardwalk)	Long-billed Dowitcher	1
18-Feb-96	Mai Po (boardwalk)	Oriental Pratincole	1
9-Apr-96	Mai Po (boardwalk)	Slavonian Grebe (summer plumage)	1
2-Mar-96	Mai Po (boardwalk)	Styan's Grasshopper Warbler	1
4-Apr-96	Mai Po (casurinas)	Yellow-browed Bunting (male)	1
27-Sep-95	Mai Po (reclamation)	Pechora Pipit	1
8-Jun-96	Mai Po (scrape)	Nordmann's Greenshank	1
11-Feb-96	Mai Po (Waterfowl Collection)	Common Pochard	11
21-Feb-96	Mai Po (Waterfowl Collection)	Northern Sparrowhawk (female)	1
13-May-96	reedbed-Mai Po carpark	Black Bittern	
1-Sep-96	Mai Po	Black Bittern	1
7-Sep-96	Mai Po	Thick-billed Warbler	1
15-Sep-96	Tin Shui Wai RZ	Palla's Grasshopper Warbler	7
15-Sep-96	Tin Shui Wai RZ	Swinhoe's Snipe	8
15-Sep-96	Tin Shui Wai RZ	Pintail Snipe	7
15-Sep-96	Tin Shui Wai RZ	Buttonquail	1
15-Sep-96	Tin Shui Wai RZ	Fantail Warblers	60
15-Sep-96	Tin Shui Wai RZ	Great Reed Warblers	31
20-Sep-96	Mai Po	Yellow-rumped Flycatchers	
20-Sep-96	Mai Po	Grey-streaked Flycatchers	
20-Sep-96	Mai Po	Sooty Flycatchers	
20-Sep-96	Mai Po	Asian Brown Flycatchers	
20-Sep-96	Mai Po	Asian Paradise Flycatchers	
22-Sep-96	Mong Tseng	Hobby	1
22-Sep-96	Tin Shui Wai RZ	Buttonquail	2
24-Sep-96	Tin Shui Wai RZ	Buttonquail	4
27-Sep-96	Mai Po (scrape)	Garganey	715
5-Oct-96	Tsim Bei Tsui	Eurasian Sparrowhawk	1
6-Oct-96	Mai Po	Japanese Sparrowhawks	1
7-Oct-96	Tsim Bei Tsui	Japanese Sparrowhawks	1
25-Oct-96	Tsim Bei Tsui	Daurian Starling	2
27-Oct-96	Tin Shui Wai RZ	Eagle Owl	1

Others

E4.62 Deep Bay hosts more than 1% of the world's population of Black-tailed Godwit (Young & Melville 1995), regarded as a threatened species (Collar and Andrew 1988). More than 1% of the flyway population of Lesser Sandplover (*Charadrius mongolus*), Greater Sandplover (*Charadrius leschenaulti*) , Curlew Sandpiper (*Calidris ferruginea*), Broad-billed Sandpiper (*Limnicola falcinellus*), Marsh Sandpiper (*Tringa stagnatilus*), and Greenshank (*Tringa nebularia*) are present in Deep Bay at some stage of their annual migration. While these are not currently regarded as threatened, these species depend on Deep Bay for their continued security.

E4.63 Greenshank have been recorded from WTC sites (Table E.4.4). In winter, the WTC hosts large concentrations of waterbirds (Peking University 1994) as confirmed by the December traverse.

E4.64 Breeding Savannah Nightjar (*Caprimulgus affinis*) has been recorded on the Tin Shui Wai RZ during WWF-HK's Big Bird Race in April 1996. Oriental Skylark (*Alauda gulgula aevensis*) and Little Ringed Plover (*Charadrius dubius*) have also bred on the RZ (BCL 1996).

E4.65 The occurrences of notable unusual species or abundances recorded in the Tin Shui Wai Eco-IA study area are included in Table E.4.8.

E4.66 No individuals of rare or endangered bird species were recorded on the RZ site. Critically-endangered Black-faced Spoonbills were recorded from the mudflats northwest of Tsim Bei Tsui in an area remote from the likely project impact sites. Endangered Baikal Teal, Oriental White Stork, and Chinese Egret, and near-threatened Black Ibis were recorded from the area immediately downstream of the WDC at Tsim Bei Tsui. The vulnerable species Dalmatian Pelican, Chestnut-cheeked Starling and Silky Starling were similarly recorded from Tsim Bei Tsui.

E4.67 While none of the other bird species listed as endangered or threatened (Table E.1.1) have been recorded on the RZ , the RZ currently has suitable habitat for most or all of them and any could be recorded there. It is clear, however, that these species are not regularly using the RZ.

Density and Activity of Little Egret

E4.68 The results of the waterbird studies in all surveys show that the Western Temporary Channel mouth site tends to have dense concentrations of Little Egret. The WTC mouth held the highest measured densities in January, July and October, and second highest densities in April, when Little Egret density was lowest at the Mai Po site. The WTC tends to have high concentrations of waterbirds, especially ducks (Peking University 1995, Acer 1996).

E4.69 The foraging intensity as measured by the percent of individuals foraging in flocks was generally low at the WTC site, in the first half of the year rising in the latter part of the year, and the intake rates measured there have been in the middle of the range in all four surveys.

Density

E4.70 Density was highest at the WTC site in January ($0.0031 \cdot m^{-2}$), significantly higher than the Mai Po or Tsim Bei Tsui sites ($H=20.3$, $p<0.00005$, Kruskal-Wallis ANOVA). In May, highest densities were measured at the Tsim Bei Tsui site but the differences among sites were not significantly different. In July, densities were much higher at the WTC site and the Tsim Bei Tsui site (749 ± 646, and 673 ± 546 ($x10^{-6}$) $\cdot$ m^{-2}) than at Mai Po (95 ± 78 ($x10^{-6}$) $\cdot$ m^{-2}).

E4.71 Densities at all three locations showed increases through time with the exception of the WTC site in January (Figure E.4.4). While there were no significant differences among survey dates in the density of Little Egrets (F=1.3, p=0.28, two-way ANOVA, untransformed data), there were significant differences in density between places for data pooled from different months (F=5.6, p=0.00, two-way ANOVA, untransformed data). There was also significant interaction between survey time and place (F=2.6, p=0.02, two-way ANOVA, untransformed data), which means that differences among survey sites changed at the different survey times. The differences were not consistent, and sites with high density during one survey had low density during other surveys.

Foraging Intensity

E4.72 The mean percentage of foraging Little Egrets in flocks showed the greatest difference among areas during the January survey, with 98% of birds in flocks foraging at TBT, 68% foraging at Mai Po, and 19% foraging at the WTC (Figure E.4.4). In April, Mai Po showed the highest foraging intensity (88%), and the WTC the lowest again (40%). In July, the percentage foraging in all areas converged, and feeding intensity varied between 51 and 54%. In October at Mai Po, the percentage was 43%, at Tsim Bei Tsui 8% and WTC 38%.

E4.73 There was strongly significant difference in foraging intensity among survey times (F=0.9, p=0.0002, two-way ANOVA, data arcsin transformed), but strongly significant differences among areas (F=6.1, p<0.003, two-way ANOVA, data arcsin transformed). There was an interaction between place and month in the foraging percentage data (F=5.4, p<0.0001, two-way ANOVA, data arcsin transformed). In July, foraging proportion decreased at Mai Po and TBT, while it increased at the WTC.

Intake Rate

E4.74 The highest intake rate and the greatest variability was recorded on birds feeding at the Tsim Bei Tsui site in July. They captured prey at a rate of $0.12 \cdot s^{-1}$ versus a rate of $<0.04 \cdot s^{-1}$ at the WTC and at Mai Po.

E4.75 There appear to be small differences in the intake rate data among various sites on different survey dates. The differences are of insufficient magnitude to show significant interaction (F=1.1, p=0.35, two-way ANOVA, untransformed data).

Diet

E4.76 Identified prey in January was dominated by worms, with mudskippers providing a minor component. Most items in the diets were unidentified, and diets were likely composed entirely of worms. This pattern continued throughout the year.

Infauna

Introduction and Methods

E4.77 The infauna of Inner Deep Bay provides an essential food resource for the migratory waterbirds that migrate through or spend the winter in Deep Bay. Two lines of evidence, predator exclusion cages and balancing theoretical consumption demand by waterfowl with benthic production, have suggested that the food resources at Mai Po were being heavily exploited in 1994 (Peking University 1995, McChesney 1996). This predicted that waterbird numbers could not substantially increase because food resources were limiting. The apparent decline of food resources noted by WWF-HK staff this summer-autumn (1996), and seen by comparing benthic infauna abundances during this survey to previous surveys (Peking University 1995, McChesney 1996) suggests that overwintering bird numbers will be lower this coming winter than in previous years.

E4.78 For this Eco-IA, density, biomass, and mean body size were recorded for four species of benthic infauna. The survey was designed to achieve two purposes: first, to assess the ecological value of the WTC mouth, which would most likely be the site impacted by the Project due to its proximity, and second, to establish natural variation through time at more than one control location. This fulfills the requirements of a "beyond BACI" design (Underwood 1992), which may allow the cause of any changes measured at the WTC mouth site during or after the Project to be attributed either to the Project or to natural variation on a wider scale.

E4.79 Without sites for comparison with the putative impact site, any changes at the WTC mouth site cannot be interpreted. For example, decreases in abundance at the WTC mouth site could reflect regional changes and not an impact of the Project. Alternatively, a real impact of the Project would go undetected if reference sites were not compared. Comparisons between a single reference site and a putatively impacted site must always be confounded, because two sites may differ purely by chance. It is necessary to have more than one reference site in order to measure confidence regarding whether or not an impact site differs from the control area.

E4.80 For the infaunal study, data were recorded from core samples collected from three locations, each location within the quadrats established to record bird behaviour. One site was located at the WTC mouth, another at Mai Po, and the third at Tsim Bei Tsui (see Figure E.4.1). Benthic infaunal surveys were completed in February, June and November. Details of the methods are presented in Appendix E.3.

E4.81 As for the waterbird data, benthic infauna data are presented graphically, with the data for each site plotted in each survey time. A visual assessment of important differences between sites at different times, and inspection for interactions, can be made. Non-parametric Kruskal-Wallis analysis of variance calculated to assess the differences among areas at each survey, because data transformation could not always satisfy the assumptions of parametric statistics.

Results

E4.82 The results (in terms of biomass and abundance, see Figures 9.6 and 9.7) of the benthic infaunal studies show that food resources for migratory and resident waterbirds had been present across all three monitoring areas. However, these Figures illustrate the diminution of the food supply at all three monitoring stations towards the year end. The importance of the WTC site (adjacent to the RZ) is illustrated by the relatively high biomass at the site (highest biomass recorded during the study was at this site in June (1.6 g (wet) • $core^{-1}$), and the second highest biomass during the February survey (1.0 g (wet) • $core^{-1}$). Capitellid polychaetes are the numerically dominant species for the WTC mouth food resource, and that indicates the site's vulnerability to increasing organic loading. Capitellid polychaetes are tolerant of organic pollution and are taken to be pollution indicator species (Pearson and Rosenberg 1978). Infaunal assemblages in highly polluted areas are dominated by opportunistic species, such as capitellids at the WTC site in February, June and November (Figure 9.10). If pollution levels continue to increase, the entire benthic infaunal assemblage is vulnerable to collapse.

E4.83 In terms of bird food, biomass of the infauna is the most relevant component (Piersma *et al.* 1993).

<u>Biomass</u>

E4.84 The WTC site and the Mai Po site had the highest biomass in June and February, respectively (Figure 9.6), and the biomass was dominated by different species (Table E.4.9). The WTC biomass was dominated by sabellid polychaetes, while the Mai Po site contains the highest biomass of *Dendronereis* polychaetes and other nereids.

E4.85 Sabellid polychaetes at the WTC form the largest biomass class recorded during the first two surveys, ranging between 0.8 and 1.3 g (wet) • $core^{-1}$. The two nereid polychaete groups (*Dendronereis* sp. and other nereids) comprise the next highest biomass classes, present at Mai Po in February (0.7 and 0.6 g (wet) • $core^{-1}$). The high numerical densities of capitellid polychaetes at the WTC site in June comprise the next highest biomass component, at 0.2 g (wet) • $core^{-1}$.

E4.86 There were significant differences in biomass of the monitored polychaetes among locations in each survey. The two nereid polychaete groups differed significantly among the three locations in each survey month (Figures E.4.5b and E.4.6b) ($p<0.01$, Kruskal-Wallis ANOVA). In February, Mai Po held the highest biomass of both nereid groups, and in June the WTC held the greatest biomass of the two groups, but at a biomass less than 20% of the January Mai Po peak (Table E.4.9). Sabellid and capitellid biomass was significantly higher at the WTC location than the other two sites in the first two months ($p<0.0005$, Kruskal-Wallis ANOVA) (Figures E.4.7b and E.4.8b), with the June sabellid biomass at the WTC being the highest recorded. In November ,biomass at all three sites was low with WTC still having a higher biomass than the other two sites.

Average Size

E4.87 Large prey is important for large birds and those birds with a pecking/picking feeding style, capturing individual prey. Smaller prey may be suitable for birds that feed with a dabbling style, engulfing mouthfuls of sediment and straining out the benthos. Thus the distribution of prey of various sizes is important in assessing the value of each location.

E4.88 The two groups of nereid polychaetes tend to have the largest average body size, ranging between 5 and 95 mg (wet) per individual (Table E.4.9). Sabellids are intermediate, ranging between 0.06 and 39 mg. The capitellids are small-bodied, ranging between 0.2 and 2.4 mg per individual.

Density of Prey (Abundance)

E4.89 At the WTC site, sabellid and capitellid polychaetes were most abundant, comprised the greatest biomass in each survey, and were of moderately large body size, suitable for large birds (Table E.4.9). They are tube-dwelling, sedentary, filter-feeding polychaetes. Their diameter is only ever exposed to bird predators making them a difficult target. Sabellids may be more vulnerable to harvesting by dabbling birds, but may be able to escape predation by retreating to depth.

Table E.4.9
Polychaete Component Breakdown at the Three Study Sites

Parameter(s)		Site	Feb-96	Jun-96	Nov-96
Polychaete Component Breakdown (per unit core)					
Dendrenereis sp.	Density (N±SD)	MP	8.00±4.28	0.63±0.68	0.36±0.93
		TBT	0.14±0.36	0.05±0.22	0.07±0.27
		WTC	1.07±1.69	0.35±0.59	0.71±0.83
	Biomass [g (wet weight)±SD]	MP	0.675±0.433	0.013±0.024	0.020±0.064
		TBT	0.013±0.046	0.003±0.014	0.006±0.023
		WTC	0.020±0.035	0.029±0.069	0.011±0.013
	Average Size [g (wet weight) per individual]	MP	82.9E-3	18.3E-3	43.6E-3
		TBT	94.5E-3	64.7E-3	87.3E-3
		WTC	10.1E-3	93.1E-3	12.0E-3
Nereidae	Density (N±SD)	MP	10.07±5.81	7.16±5.19	1.07±1.38
		TBT	2.14±1.35	2.15±1.42	0.43±0.65
		WTC	4.07±2.87	4.40±3.33	9.50±6.07
	Biomass [g (wet weight)±SD]	MP	0.550±0.373	0.080±0.067	0.021±0.052
		TBT	0.085±0.075	0.022±0.031	0.006±0.009
		WTC	0.145±0.103	0.106±0.109	0.065±0.054
	Average Size [g (wet weight) per individual]	MP	34.5E-3	9.3E-3	5.0E-3
		TBT	28.7E-3	15.0E-3	5.2E-3
		WTC	10.8E-3	26.4E-3	5.9E-3
Sabellidae	Density (N±SD)	MP	1.43±1.95	0.37±0.76	5.71±8.26
		TBT	12.71±8.51	8.00±4.03	0.79±0.89
		WTC	32.43±15.89	36.60±27.62	6.29±3.20
	Biomass [g (wet weight)±SD]	MP	0.009±0.019	0.004±0.015	0.010±0.020
		TBT	0.231±0.150	0.228±0.145	0.000±0.00
		WTC	0.841±0.342	1.276±1.127	0.155±0.124
	Average Size [g (wet weight) per individual]	MP	7.9E-3	16.3E-3	508.0E-6
		TBT	122.4E-3	22.4E-3	61.4E-6
		WTC	18.5E-3	38.7E-3	19.3E-3
Capitellidae	Density (N±SD)	MP	7.00±13.36	5.84±8.56	3.43±0.73
		TBT	11.07±19.39	0.40±0.50	1.00±1.24
		WTC	73.36±22.01	134.0±37.9	52.50±2.18
	Biomass [g (wet weight)±SD]	MP	0.003±0.006	0.002±0.003	0.001±0.000
		TBT	0.002±0.004	0.001±0.001	0.000±0.000
		WTC	0.035±0.021	0.229±0.155	0.062±0.014
	Average Size [g (wet weight) per individual]	MP	460.1E-6	308.5E-6	346.2E-6
		TBT	205.3E-6	1.3E-3	375.0E-6
		WTC	343.0E-6	1.4E-3	2.4E-3

E4.90 The two types of nereid polychaetes were most abundant at the Mai Po site (Table E.4.9). In February, the combined biomass of both nereids at Mai Po exceeded the biomass of sabellids at the WTC mouth, and were the largest bodied prey. These nereid polychaetes are mobile omnivores that retreat into unlined burrows. They are vulnerable to bird predators when moving along the surface, and then their length is exposed making then easy prey to capture.

E4.91 The component species in the benthic assemblage at each site changed in abundance, between sampling times. The nereids *Dendronereis* and Nereidae sp. were more abundant at Mai Po than at Tsim Bei Tsui or the WTC in February (Figure E.4.5a) ($p<0.0005$, Kruskal-Wallis ANOVA), and the Tsim Bei Tsui site held fewer individuals of both nereids than the other two sites in June (Figure E.4.5a) ($p<0.005$, Kruskal-Wallis ANOVA). Sabellid and capitellid polychaetes were significantly more abundant at the WDC compared to the other two sites in all months (Figures E.4.7a and E.4.8a) ($p<0.0005$, Kruskal-Wallis ANOVA).

E4.92 *Dendronereis* abundance showed a significant time-location interaction, with the abundance at Mai Po declining more strongly between February and June than the decline at the other survey sites (Figure E.4.5a). There were no such interactions among areas and surveys for the Nereidae sp. data (Figure E.4.6a). Abundances were highest at Mai Po and lowest at Tsim Bei Tsui in both surveys. Sabellid and capitellid abundances were consistently highest at WTC. The significant interaction between location and survey time for capitellid abundance (Figure E.4.8a) is likely to be a seasonal response to increasing disturbance at the WTC mouth site in summer, due to higher temperatures decreasing DO.

E4.93 The total density of the four target species of benthos was consistently highest at the WTC (110.9 • $core^{-1}$, 175.4 • $core^{-1}$ and 17.3 • $core^{-1}$ in February, June and November respectively) compared to the two control sites (2.6 - 26.5 • $core^{-1}$ at Mai Po, and 0.57 - 26.1 • $core^{-1}$ at TBT).

Epifauna

E4.94 Surveys have been completed in April, June, and September. Crab abundance data were collected during the mudskipper epifauna surveys as there was very little additional effort required.

Fiddler Crab

E4.95 A total of 588, 720 and 24 fiddler crabs (*Uca* spp) were recorded from quadrats at Tsim Bei Tsui (control site), Western Temporary Channel (impact site) and Mai Po (control site) respectively, during three surveys between April and late September 1996. Due to sampling methods, no attempts were made to collect the crabs and identify the composition of species within the population recorded. According to Bones (1983) and Choi (1991), the species composition around Mai Po and its adjacent areas include five species: *Uca vocans borealis, Uca chlorophthalmus, Uca lactea lactea, Uca arcuata* and *Uca acuta acuta.* It is therefore reasonable to assume that the crabs recorded in the study contain the above mentioned species.

E4.96 Density of fiddler crabs fluctuated between 1.5-7.3 crabs.m^{-2} in Tsim Bei Tsui, 2.4-7.3 crabs.m^{-2} in WTC and 0.2-1.6 crabs.m^{-2} in Mai Po (Figure E.4.9, Table E.4.10). In general, the density of fiddler crabs in Mai Po is significantly lower ($P<0.05$) than those from the other two sites during the three survey. The crab density recorded in Mai Po was consistently lowest, and there was no significant difference in density at Mai Po among the surveys ($P<0.116$). The crab densities at Tsim Bei Tsui and WTC, however, differed markedly. At Tsim Bei Tsui, the density increased significantly ($P<0.013$) between April and June, but showed the reverse trend ($P<0.003$) in September. At WTC, the density decreased significantly ($P<0.000$) between April and June, and remained relatively the same in September.

Mudskippers

E4.97 A total of 2285, 1634 and 419 mudskippers were recorded in quadrats from Tsim Bei Tsui (control site), WTC (impact site) and Mai Po (control site) respectively, during the three surveys between April and late September 1996. Similar to fiddler crabs, no attempts were made to identify species composition. According to Chan (1990), there are three species of mudskippers in Hong Kong: *Periophthalmus cantonensis, Boleophthalmus pectinirostris* and *Scartelaos viridis* and their distribution is generally limited to Mai Po and Tsim Bei Tsui areas.

E4.98 Density of mudskippers fluctuated between 1.5-2.7 fish.m^{-2} in Tsim Bei Tsui, 0.9-2.5 fish.m^{-2} in WTC and 0.3-0.5 fish.m^{-2} in Mai Po (Figure E.4.9, Table E.4.11). Similar to fiddler crabs, the density of mudskippers in Mai Po was consistently significantly lower ($P<0.05$) than at the other two sites during all three surveys. At Tsim Bei Tsui and WTC, the mudskippers increased significantly ($P<0.05$) between June and September. This is probably attributed to the migration of the animals to the more open areas (where quadrats were set) during the reproductive season between March - August (Chan 1990).

Conclusions

E4.99 The density of epifauna is consistently low at the Mai Po survey site compared to the WTC mouth and the Tsim Bei Tsui site. The Tsim Bei Tsui site consistently held the highest densities of mudskippers. The WTC mouth had higher densities of *Uca* spp. crabs in April and September.

E4.100 Despite problems interpreting the causes for reduced densities for the two types of epifauna, both types are low at Mai Po. Compared to previous studies, mudskipper density at Mai Po has fallen. Mudskipper density ranged between 0.3 - 0.5 fish.m^{-2} in this study, and between 0.2 - 5.0 fish.m^{-2} in 1988-89 (Chan 1990). The same decreasing trend in Mai Po is also observed for the density of fiddler crabs. In the present study, density was lower (0.2-1.6 crabs.m^{-2}) than a previous study (5-15 crabs.m^{-2}, Choi 1991). Although some of the difference may be attributable to different sampling methods, communication with Mai Po Nature Reserve confirmed that the density of crabs on the mud flat in Mai Po is exceptionally low this year.

Table E.4.10 Results of Three Fiddler Crab Surveys of the Study Area

Site Quadrat Size Replicates	Apr-96									Jun-96									late Sep-96								
	Control Sites						Impact Site			Control Sites						Impact Site			Control Sites						Impact Site		
	Mai Po 5 x 5 m^2			T.B.T. 1 m^2			Western Channel 1 m^2			Mai Po 5 x 5 m^2			T.B.T. 1 m^2			Western Channel 1 m^2			Mai Po 5 x 5 m^2			T.B.T. 1 m^2			Western Channel 1 m^2		
	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
Quadrat No.																											
1	0	1	0	0	2	5	10	7	15	2	0	2	1	5	3	4	6	6	0	0	2	1	3	0	1	0	0
2	0	0	0	2	4	5	12	11	12	4	2	0	12	3	5	4	5	2	0	0	0	2	0	3	1	0	0
3	0	1	0	10	1	5	13	11	9	0	0	2	14	7	8	5	4	1	0	0	0	1	2	0	1	4	1
4	0	2	1	5	6	3	17	15	11	2	0	0	10	11	4	1	6	2	0	0	0	0	3	3	2	0	0
5	1	1	0	0	10	2	5	7	6	0	1	0	5	4	5	2	1	3	0	0	0	0	4	1	3	2	3
6				5	5	2	2	3	4				7	4	7	2	4	2				0	0	1	4	3	0
7				0	4	6	6	8	5				4	3	3	3	3	5				5	3	2	1	1	4
8				1	0	4	6	3	1				8	5	5	2	1	4				2	1	0	1	1	1
9				0	4	3	4	6	7				4	3	6	2	5	2				3	2	4	1	7	9
10				2	0	1	3	4	4				6	6	4	3	2	0				1	3	4	7	1	3
11				2	2	4	4	1	3				9	3	5	3	6	3							4	0	3
12				1	3	3	13	15	12				6	5	3	5	9	7							6	5	5
13				2	3	3	9	9	8				6	5	4	8	3	2							3	4	0
14				4	4	4	15	7	8				4	4	4	1	5	2							7	8	3
15				4	2	2	2	4	7				8	5	3	3	2	3							1	4	3
16				3	4	3	6	10	8				4	8	7	0	2	0							4	3	4
17				2	0	3	6	4	5				17	11	4	0	0	5									
18				0	4	5	5	3	4				17	11	4	0	0	5									
19				1	0	3	2	4	3				7	17	5	2	3	1									
20				0	4	5	5	3	2				7	3	5	1	3	2									
Total	1	5	1	44	62	71	145	135	134	8	3	4	145	119	93	53	72	52	0	0	2	15	21	18	47	43	39
Mean	0.20	1.00	0.20	2.20	3.10	3.55	7.25	6.75	6.70	1.60	0.60	0.80	7.25	5.95	4.65	2.65	3.60	2.60	0.00	0.00	0.40	1.50	2.10	1.80	2.94	2.69	2.44
S.D.	0.45	0.71	0.45	2.48	2.43	1.32	4.58	4.04	3.73	1.67	0.89	1.10	3.75	3.50	1.46	1.90	2.19	1.96	0.00	0.00	0.89	1.58	1.37	1.62	2.21	2.52	2.45
Overall Mean		0.47			2.95			6.90			1.00			5.95			2.95			0.13			1.80			2.69	
Overall S.D.		0.64			2.18			4.07			1.25			3.21			2.04			0.52			1.49			2.35	
Stand.* Overall Mean		0.02			2.95			6.90			0.04			5.95			2.95			0.01			1.80			2.69	
Stand.* Overall S.E.**		0.01			0.28			0.52			0.01			0.41			0.26			0.01			0.27			0.34	

* The quadrat size was standardized to 1 m^2.
** Standard Error was used to take account of different quadrat number.

Not all quadrat sampled at Sep-96 as some marking disappeared.

Table E.4.11 Results of Three Mudskipper Surveys of the Study Area

Site Quadrat Size Replicates	Apr-96									Jun-96									Sep-96								
	Control Sites						Impact Site			Control Sites						Impact Site			Control Sites						Impact Site		
	Mai Po 5 x 5 m^2			T.B.T. 5 x 5 m^2			Western Channel 5 x 5 m^2			Mai Po 5 x 5 m^2			T.B.T. 5 x 5 m^2			Western Channel 1 m^2			Mai Po 5 x 5 m^2			T.B.T. 1 m^2			Western Channel 1 m^2		
	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
Quadrat No.																											
1	10	14	10	56	54	56	41	38	58	5	5	10	44	46	49	17	12	18	12	9	6	54	31	34	40	57	58
2	5	4	9	45	47	42	38	39	43	12	6	5	53	38	51	21	21	22	11	8	8	35	62	53	48	52	46
3	11	15	13	53	58	45	42	41	39	9	6	5	34	36	39	28	26	28	15	12	6	60	84	87	29	54	56
4	15	13	7	43	33	56	28	32	26	5	8	9	45	42	24	22	29	16	10	12	8	70	81	82	35	77	56
5	14	14	12	59	42	39	21	26	18	8	9	8	40	29	38	26	23	27	12	8	6	65	70	81	46	66	48
Total	55	60	51	256	234	238	170	176	184	39	34	37	216	191	201	114	111	111	60	49	34	284	328	337	198	306	264
Mean (m^{-2})	0.44	0.48	0.41	2.05	1.87	1.90	1.36	1.41	1.47	0.31	0.27	0.30	1.73	1.53	1.61	0.91	0.89	0.89	0.48	0.39	0.28	2.27	2.62	2.70	1.58	2.45	2.11
S.D.	0.16	0.18	0.10	0.28	0.40	0.32	0.37	0.25	0.62	0.12	0.07	0.09	0.28	0.26	0.43	0.17	0.26	0.21	0.07	0.08	0.04	0.54	0.85	0.92	0.31	0.41	0.22
Overall Mean (m^{-2})	0.44			1.94			1.41			0.29			1.62			0.90			0.38			2.53			2.05		
Overall S.D.	0.14			0.32			0.41			0.09			0.32			0.20			0.11			0.75			0.48		

E4.101 It has been demonstrated that fiddler crabs are not good indicators for assessing pollution levels (Lee 1995) because of their behaviour. *Uca* sp. forage on the mudflat surface at low tide, and burrow at high tide, which isolates them from the polluted water. The results of the benthic infauna studies for this Eco-IA suggest that the WTC mouth is the most polluted, supporting the highest densities of capitellid polychaetes. *Uca* spp. crabs are most dense at this location in two of the three surveys, consistent with the Shan Pui River results (Lee 1995).

E4.102 It has been demonstrated that pollution stress may not have direct undesirable impacts on adult animals, but the sublethal effect of the same pollutants can be harmful to juvenile recruitment (Choi 1991 and Lee 1995).

Mangrove Forest Structure at the three sites

E4.103 The mangrove assemblage at the three sites are typical of the Deep Bay area, with dominance by *Kandelia candel* (Family Rhizophoraceae), *Aegiceras corniculatum* (F. Aegicerataceae) and *Avicennia marina* (F. Avicenniaceae). Differences in the composition of the assemblages at the three sites are the result of alteration of the relative importance of these three dominant species. *Kandelia candel* was by far the most important species, was present at all the sites and often the species dominant both in terms of density and basal area. The occurrence of *Aegiceras corniculatum* was patchy, but can attain considerably high local stem densities where present, e.g. at 1.02 stems m^{-2} at the MPL site (Table E.4.15). *Avicennia marina* was not well represented in the present survey, partly because of its low abundance at most of the sites, e.g. TBT, MPH and TSW, and also partly due to the prostrate habit making survey measurements extremely difficult. *Bruguiera gymnorrhiza* (F. Rhizophoraceae) has been considered as a rare species in local mangals (Peking University 1995). This species was only recorded from the high intertidal sites at Mai Po (MPH1 and MPH2; Tables E.4.13 and E.4.14), and only at low densities when present (between 0.045 to 0.065 stems m^{-2}).

E4.104 A site walk-over survey also located individuals of *B. gymnorrhiza* in Area 118 near the edges of the drainage channels.

Table E.4.12
Summary of the plot information and values of the parameters characterising the mangrove assemblage at the 6 survey locations. Key to study locations: MP H - Mai Po high intertidal; MP L - Mai Po low intertidal; TSW - Tin Shui Wai east channel; TBT - Tsim Bei Tsui. Species codes: KC - *Kandelia candel*; BG - *Bruguiera gymnorrhiza*; AC - *Aegiceras corniculatum*; AI - *Acanthus ilicifolius*; AM - *Avicennia marina*. N.D.: No data

Parameters	MP H1	MP H2	MP L	TSW	TBT 1	TBT 2
Location	114°01'45" 22°29'13"	114°01'44" 22°29'11"	114°01'38" 22°29'8"	114°00'34" 22°28'32"	114°00'52" 22°29'17"	114°00'54" 22°29'24"
Density (stems m^{-2})	0.643	0.536	1.826	2.37	1.69	4.05
Stand BA (cm^2 m^{-2})	31.89	64.53	25.96	26.08	16.73	28.11
H	0.1899	0.1491	0.3392	0.3842	0.3207	0.0897
Size of plot (m^2)	400	400	264	207	225	100
No. of stems	257	214	482	699	380	386
Density of seedlings (no. m^{-2})	KC:0.108 BG:0.010	KC:0.045 BG:0.023	KC:0.023 AC:0.284	N.D.	KC:0.773 AC:0.013	KC:0.06 AC:0.180
Species recorded	KC,BG,DT AI	KC,BG,DT	KC,AC, AMAI	KC,AC,DT	KC,AM,AC	KC,AC,AI

E4.105 In addition to the four mangrove tree species, the climber *Derris trifoliata* (F. Papilionaceae) and the herb *Acanthus ilicifolius* (F. Acanthaceae) have also been commonly recorded at the study sites. The occurrence of these two species seems to be associated with particular physical conditions: *Derris* was absent at sites where tidal inundation was significant, e.g. station MPL, or where mangrove stem density was high enough to cause severe shading of the understorey, e.g. TBT2 (Table E.4.12). The distribution of *Acanthus* was erratic and was common only in mangrove plots with a more open understorey stratum, e.g. the MPH stations. The mangrove fern *Acrostichum aureum* known to occur in the Deep Bay area was not recorded in the present survey at the three study sites.

E4.106 The mangrove assemblage of the individual plots is described below.

Mai Po High Intertidal (Plots MPH1 and MPH2)

E4.107 These plots are located in the southern quarter of the intertidal mangrove forest at Mai Po, just seaward to *gei wai* no. 19 of the reserve. The *K. candel* at this site are amongst the tallest in Hong Kong, attaining a height of >7 m. By noting the height of the mark left by the water line on the tree trunks during the previous high tide (=89.5 cm), the tidal elevation of the MPH1 and MPH2 plots are estimated to be at +1.61 and 1.67 m above Chart Datum respectively. The forest at these plots have an open understorey but *Acanthus ilicifolius* occurs at high densities in patches.

E4.108 While the plots were dominated by *K. candel* both in terms of numbers and basal area, *Bruguiera gymnorrhiza,* which is considered to be a relatively rare species in Hong Kong, was present in considerable abundance (Table E.4.13). These individuals of *B. gymnorrhiza* grow to a height of ≤5 m. The condition of these trees was considered unsatisfactory, as no propagules could be found on the trees despite the fact that the survey was conducted at a time when viviparous droppers were expected to be present. There was also only a small number (a total of 4 in the whole plot) of live seedlings of *B. gymnorrhiza* on the forest floor.

Table E.4.13

The composition of Plot One at the high intertidal of the Mai Po site (MPH1). *Acanthus ilicifolius* occurred as a dense understorey species, occupying an area of 76.6 m^2 in the plot (19.2% of plot area) but the number of stems was not counted. Gbh values in all tables are mean±1 S.D.

Species	Density (no. m^{-2})	Mean gbh (cm)	Relative density (%)	Relative dominance (%)	Importance value
Kandelia candel	0.523	29.2±8.5	81.3	95.6	176.9
Bruguiera gymnorrhiza	0.065	12.9±6.5	10.1	2.8	12.9
Derris trifoliata	0.055	10.5±1.8	8.6	1.6	10.2

E4.109 Plot Two at the Mai Po high intertidal was structurally similar to Plot One at the same site. Based on the height of the tidal markings on the tree trunks, Plot Two was estimated to be located at 6.5 cm lower in the tidal gradient and about 100 m away from Plot One. The plot was again dominated by *K. candel* both in terms of basal area and density, with only minor occurrences of *B. gymnorrhiza* and *D. trifoliata*. Individuals of *K. candel* again attained a height of 7-8 m. The open understorey, tall tree height and minor occurrences of *D. trifoliata* suggest that the plot is a healthy mature *K. candel* community. This is further supported by the occurrence of some individuals of *K. candel* with gbh >50 cm and a mean of 29.6±9.0 cm (S.D.) for the plot, which is the highest amongst all the plots surveyed (Table E.4.14). *B. gymnorrhiza* was present at low density and again no developing propagules could be found on the trees, which grew to about 4-5 m in height.

Table E.4.14
The composition of Plot Two at the high intertidal of the Mai Po mangrove (MPH2)

Species	Density (no. m^{-2})	Mean gbh (cm)	Relative density (%)	Relative dominance (%)	Importance value
Kandelia candel	0.453	29.6±9.0	84.6	98.8	183.4
Derris trifoliata	0.038	11.2±5.9	7.0	0.74	7.74
Bruguiera gymnorrhiza	0.045	12.7±4.9	8.4	0.45	8.85

The Mai Po low intertidal plot (MPL)

E4.110 This plot occurs at the seaward edge of the *Avicennia marina* belt, where the mud is fluid and soft. The tidal height was estimated to be at +1.49 m above Chart Datum. This plot has a significantly higher tree density but lower total basal area compared with the high intertidal plots (Table E.4.15). This high stem density is probably a result of the high abundance of *Aegiceras corniculatum* which have a significantly lower mean gbh compared to *K. candel*.There was also a high density of *K. candel* at this site, the trees were also significantly smaller in size compared with their counterparts in the high intertidal plots (mean values at 18.0 and ≈29 cm respectively). This difference is more likely a result of the younger age of the stand rather than difference in growth condition. The occurrence of *Avicennia marina* reflects the more seaward position of the plot. The more equitable distribution of both relative density and basal area contribution by the two dominant species resulted in the high diversity index (H = 0.3392; Table E.4.12).'

Table E.4.15
The stand characteristics of the mangrove assemblage of the plot in the Mai Po low intertidal forest (MPL plot). Note the high stem density of *Aegiceras corniculatum*

Species	Density (no. m^{-2})	Mean gbh (cm)	Relative density (%)	Relative dominance (%)	Importance value
Kandelia candel	0.765	18.0±5.7	41.9	81.1	123.0
Agiceras corniculatum	1.015	7.3±4.1	55.6	15.7	71.3
Acanthus ilicifolius	0.023	4.8±0.7	1.2	0.2	1.4
Avicennia marina	0.023	18.9±9.0	1.2	3.0	4.2

The Tin Shui Wai Eastern Channel Site (TSW)

E4.111 The TSW plot is located on the northern bank of the Tin Shui Wai Eastern Channel, near its discharge point into Deep Bay. Tidal position as estimated from the water mark left on tree trunks indicate a height of +1.56 m above Chart Datum. The plot was dominated by *K.candel* in terms of basal area, as the gbh of this species was significantly greater than those of the other two species (Table E.4.16).

E4.112 This site differs from the other sites that *D. trifoliata* actually was the numerical dominant species in the plot, with a high density of 1.09 stems m^{-2}, exceeding that of *K. candel*. This high density of *Derris* is indicative of significant stress on *K. candel*. This phenomenon is usually found at sites which have either become too infrequently inundated by tides or have been significantly physically disturbed/stressed to allow a proliferation of the climber. Since the plot actually occurs at a lower tidal position than the high intertidal sites at Mai Po (MPH1 and MPH2), reduced tidal inundation is probably not a primary factor causing the infestation of *Derris*. The impact of frequent inundation by polluted river water draining down the Tin Shui Wai channel is a possible cause but the exact contribution has to be more carefully assessed.

E4.113 Another observation made related to the general condition of the mangrove assemblage at this site is the fact that most of the *Aegiceras corniculatum* individuals were dead in the plot. Those that were still alive had a very low leaf area index, usually with only a small number of green leaves on the barren branches. Whereas shading by the tall *K. candel* is a common cause of reduced vigor of the understorey *Aegiceras corniculatum* in local mature mangrove forests, the leaf area index at this plot was significantly lower than that expected even in strongly shaded sites, e.g. the MPL plot. Probably the combined effect of shade and some other stressors, e.g. anoxic water, have resulted in the poor growth of this species at this site. Shading is probably one important factor as smaller individuals of the same species occurring just outside the plot, where adult *K. candel* were absent, seemed not to suffer the same degree of reduction in vigor.

Table E.4.16
The stand characteristics of the mangrove assemblage in the Tin Shui Wai eastern channel plot. Note the high density of *Derris trifoliata* in the plot

Species	Density (no. m^{-2})	Mean gbh (cm)	Relative density (%)	Relative dominance (%)	Importance value
Kandelia candel	0.95	16.3±5.3	40.0	84.4	124.4
Aegiceras corniculatum	0.33	7.5±2.8	14.0	6.6	20.6
Derris trifoliata	1.09	5.0±1.4	45.9	9.1	55

Tsim Bei Tsui Sites (TBT1 and TBT2)

E4.114 These sites are located on the two sides of the Tsim Bei Tsui pier, to the west of the Tin Shui Wai development site. Despite their proximity to each other, the sites have significantly different mangrove stand structure. The width of the mangrove belt at these sites are narrow, with only about >25 m of forest. The western site (TBT1) has a structure similar to other forests in the mid-intertidal in Deep Bay.All the common species are represented. The forest was dominated by *K. candel*, attaining a considerable density (1.16 stems m^{-2}) and a height of about 4.5 m on average. *Aegiceras corniculatum* is also present at high density (0.49 stems m^{-2}) whereas the occurrence of *A. marina* was only sparse (0.04 stems m^{-2}, Table E.4.17).

Table E.4.17
The structural characteristics of the mangrove assemblage in the TBT1 plot

Species	Density (no. m^{-2})	Mean gbh (cm)	Relative density (%)	Relative dominance (%)	Importance value
Kandelia candel	1.16	28.9±10.2	68.4	65.2	133.6
Aegiceras corniculatum	0.49	10.7±5.6	29.2	30.8	60
Avicennia marina	0.04	15.9±6.2	2.4	3.8	6.2

E4.115 The structure of the plot on the eastern side of the Tsim Bei Tsui pier was distinctly different from the western plot. This plot is overwhelmingly dominated by *K. candel*, as is reflected by the low diversity value (Table E.4.12) and the extreme importance value of this species (Table E.4.18). The density of *K. candel* approached 4 stems m^{-2} and is highest amongst all the plots surveyed in this study (Table E.4.12). Probably related to the high stem density, the individuals of *K. candel* showed little branching but each supported only a small canopy. The trees also have a small mean girth (mean = 9.5±2.7 cm, Table E.4.18). The canopy of the forest is closed and resulted in strong shading, which may explain the lack of seedlings or the low abundance of understorey species (*A. corniculatum* and *A. ilicifolius*) in the plot. Trees of *K. candel* grew to about 4.5 m in height in the plot.

E4.116 The extreme high density and dominance of *K. candel* may be explicable by the location of the stand.The presence of the pier on the western side of the plot may encourage the accumulation of propagules. *K.candel,* being the dominant species in Deep Bay (the co-dominant *A. marina* seems to have generally low reproductive success due to intense herbivory during the reproductive season, see Anderson and Lee, 1995), may easily outcompete the more slow-growing *A. corniculatum* to result in a dense and almost monospecific stand.

Table E.4.18
The structural characteristics of the mangrove assemblage in the plot on the eastern side of the Tsim Bei Tsui pier (TBT2). Note the extremely high density of *K. candel* in the plot

Species	Density (no. m^{-2})	Mean gbh (cm)	Relative density (%)	Relative dominance (%)	Importance value
Kandelia candel	3.77	9.5±2.7	93.1	96.8	189.9
Aegiceras corniculatum	0.27	6.2±1.6	6.7	3.1	9.8
Acanthus ilicifolius	0.01	N.D.	0.3	0.05	0.35

Other mangroves in the general study area

E4.117 Mangroves can be found on the bank of most tidally influenced drainage channels in the vicinity of the development site. The composition and structure of these mangrove patches are similar to those typical of other tidal channels, e.g. Shan Pui River, entering into Deep Bay. A mixture of *K. candel*, *A. corniculatum*, *A. ilicifolius* domiantes and occassionally, *B. gymnorrhiza, A. marina* and the mangrove fern *Acrostichum aureum* are occasionally present . Tree height on these banks is usually <4 m but density of stems is high.

E4.118 Mangroves also occur on mud islands lying at the confluence of the drainage channels leading from Tin Shui Wai. These mangrove patches have not been surveyed in the present study but it is expected to have a structure similar to those of their counterparts on the banks of the channels and at the TSW plot.

E4.119 Some mature stands of mangroves dominated by *K. candel* (height at ≈ 5 m) are present in the development site close to the discharge point of the eastern channel. The detailed structure of these patches has not been studied. A rapid assessment revealed that there are considerable numbers of *B. gymnorrhiza* in these patches, especially near to their edges adjoining the drainage channels. These trees are used by some birds, e.g. the Little and Great Egrets, as a roosting site.

E4.120 The tidal ponds located to the north of the Tin Shui Wai site and to the west of the border fence road near Tsim Bei Tsui also house significant areas of mangroves. These mangroves only seem to have developed within these ponds in recent years and have a low average tree height. Due to the restricted water exchange, these ponds and mangroves seem to be much favoured by waterfowl for roosting and as a feeding site. Although lying outside the boundary of the present project, these ponds can be utilised as alternative wildlife habitats in inner Deep Bay.

Potential Impact of the Project on the Mangroves in Southern Deep Bay

E4.121 The location of the survey plots in the present study will enable impacts generated by the Tin Shui Wai development project to be picked up and contrasted at the three sites. Any impact generated will most likely be strongest on the site at the discharge point of the Tin Shui Wai Eastern Channel. This is because the proximity of this site to the construction site and the dependence of the mangroves on a hydrological regime largely dominated by the water in the Eastern Channel would make them highly susceptible to any alteration of water quality or drainage pattern. Tidal flow patterns have been described that are both clockwise and anti-clockwise. If tidal flow is anti-clockwise, the flow pattern of water in Deep Bay (Peking University 1995) will probably cause a larger impact to be felt at the Mai Po sites compared to the Tsim Bei Tsui site, as the flow pattern would make sites at Mai Po equivalent to a "down stream" location to the source of impact. The actual magnitude of impact at the Mai Po sites is, however, dependent on the resultant effects of the Tin Shui Wai development and other concurrent projects with potential influence, e.g. the Kam Tin-Yuen Long main drainage project and the Shenzhen River Training Project are expected to have some impact on the Mai Po mangroves. The Tsim Bei Tsui sites, due to their more distant location from these confounding impact sources, can therefore serve as the second control sites for assessing the impacts of the Tin Shui Wai development.

E4.122 Since the mangrove sites will remain under general inundation by water in Deep Bay upon completion of the project, it is expected that they will not suffer from drastic impacts generated by the sites. The most likely impacts that may be generated by the site during and after completion of the project include changes in inundation and sedimentation regime, increased human disturbance and changes in pollution loading.

Alteration of the hydrological regime

E4.123 Mangroves, as with other wetland communities, are strongly affected by the hydrological regime (Seneca et al. 1985; Olff et al. 1988; Mitsch and Gosselink 1994). This may result in indirect or cascading effects on the macroinvertebrate and bird community (e.g. Neckles et al. 1990; Batzer et al. 1993; Leschisin et al. 1992). Alteration of the existing drainage system will result in changes of the inundation pattern as well as the quality and quantity of water in contact with the mangroves. Given the likely high level of organic and other pollutants accumulated in the mud of the drainage channels, any stagnant areas created as a result of alteration of flow could have strong impacts on the mangroves.

E4.124 Most wetland soils typically have low oxygen availability. The plant community benefits from "subsidy" from tides, which bring in nutrients, propagules as well as aeration of the substratum and alleviate oxygen stress (Howes and Goehringer 1994). Stagnant conditions in eutrophic sediments will pose serious problems to macrophytic hydrophytes such as mangroves, as most of them will face problems in oxygenating the underground tissues. Diversion of water supply may expose the roots to higher oxygen availability but will also prove detrimental to mangroves which are dependent on periodic inundation for maintenance of their competitive advantage over land or more terrestrial plants such as *Derris* or *Macaranga*. Consequently, if the mangroves around the Tin Shui Wai development site (e.g. the mature *K. candel* stand with individuals of *Bruguiera* in zone 118 near the eastern channel) are to be preserved, suitable measures would have to be taken to ensure their continual inundation by tidal water with considerable flow.

E4.125 Work on the Western Temporary Channel, e.g. lining of the channel bank, may also have profound effect on the mangrove community in the vicinity. Whereas lining may improve maintenance of the channel and increase flow into Deep Bay, increased sediment and pollutant transport may also result in the receiving areas including mangroves. When happening gradually, increased sedimentation may aid mangrove colonisation by providing new substrata at the right tidal elevation for propagule establishment. This, if continued on a prolonged scale, will decrease the area of the intertidal mudflat in inner Deep Bay capable of supporting bird life. As a matter of fact, the mangroves at Mai Po have been estimated to be progressing seaward at a rate of about 7.6 m yr^{-1} (Duke and Khan in press). Accelerated seaward progression is anticipated arising from the Shenzhen River Training Project. Although the potential contribution of sediment load from this project is likely small compared with the background level set by the Pearl River input or the extra supply arising from the Shenzhen River project, the implication of any alteration of the drainage channels for the mangroves should, however, be noted. Sudden increases in sedimentation (unlikely to be important in the present project) could suffocate the mangrove fauna and stress the mangroves.

Increased human disturbance

E4.126 The project will inevitably result in increased human disturbance. This factor is expected to be important only to the mangroves located within the project site but outside the Mai Po Marshes Nature Reserve or frontier closed area boundary, as those mangroves are currently fairly adequately protected by limiting access. The mangroves which are more likely to be affected by this threat include the patches of *K. candel* near the Eastern Channel and those associated with the tidal ponds towards Tsim Bei Tsui. As stated above, both habitats, especially the tidal pond mangroves, seem to be used by birds and possibly other wildlife for refuge and feeding. Increased and improved human access to the sites will compromise their existing value. In view of their larger areas and more diverse landscape, the ponds near Tsim Bei Tsui should be better managed/protected in parallel to the Tin Shui Wai development, through, for example, controlled access. The Eastern Channel patches are home to a considerable number of the locally rare *Bruguiera gymnorrhiza*. Although more individuals of the same species have been recorded from the Mai Po site (MPH1 and MPH2), these individuals of *Bruguiera* may still deserve conservation. The fate of these trees and others in the eastern channel area will depend on the preferred engineering option for the eastern channel. In view of the local rarity of *Bruguiera* and the value of the *Kandelia* stands to birds, consideration should be given towards the conservation of these mangroves.

Pollution

E4.127 The development will be provided with suitable sewerage and sewage treatment facilities. The problem of pollution is then expected to be primarily due to the transportation of pollutants accumulated in the bottom sediment of the drainage channels rather than large volumes of new pollutant generated by the development itself. The actual transportation pattern of pollutants along the drainage channels will depend on the engineering work but is expected to be able to ameliorate the present hypertrophic situation in the long term.

Seabed

Introduction

E4.128 As part of Agreement No. CE 10/95, (Tin Shui Wai Development, Engineering Investigations for the Development of Areas 3, 30 and 31 of the Development Zone and the Reserve Zone), Binnie Consultants Limited has been assigned to carry out an Environmental Impact Assessment (EIA). An important component of the EIA is a 12-month Ecological Impact Assessment (Eco-IA) in a Study Area that includes much of Inner Deep Bay and the surrounding coast, an ecosystem with many natural features of high ecological value.

E4.129 One potential impact of the Tin Shui Wai Infrastructure Development is on communities of benthic organisms inhabiting the subtidal area of Inner Deep Bay, including the channels between mudflats which provide a connection between Inner Deep Bay and the development site. Direct effects of the development on subtidal benthic communities are considered unlikely, however, indirect effects due to potential changes in sedimentation and the water flow of drainage channels could occur.

E4.130 A REMOTS seabed-profiling survey of the subtidal environment of Inner Deep Bay was performed on 23 April 1996. The objective of the survey was to characterize the baseline biological and physical condition of the seabed which may be affected by impacts associated with the Tin Shui Wai Development. The REMOTS seabed profiling technique was used to measure key indicators of seabed ecological condition and assess the overall health of the benthic habitat.

Methods

E4.131 The REMOTS seabed profiling camera obtains high-resolution photographs of the seabed surface in cross-section (upper 15 to 20 cm). A suite of standard physical and biological measurements is obtained from each image, allowing an assessment to be made of overall benthic habitat quality. A complete description of methods for REMOTS field operations, computer image analysis and interpretation, and associated QA/QC is provided in Appendix E4a.

E4.132 Up to three replicate REMOTS images were obtained at each of fifteen (15) stations located near Tsim Bei Tsui in Inner Deep Bay (Figure E4.10). The position of each station was determined by taking line-of-sight compass bearings on prominent local landmarks. The field work occurred during a high tide, and the survey vessel attempted to get as close to the mouth of the Western Temporary Channel as possible, until it became too shallow to proceed.

Results and Discussion

E4.133 The REMOTS image analysis data are presented in Table E4.19. The REMOTS images show that sediments in the study area are predominantly fine-grained (i.e., silt-clay with grain size major mode of >4 phi, Figure E4.11). Sand-over-mud stratigraphy was seen at station 1 (Figure E4.11 and Plate E4.7).

Table E4.19 REMOTS IMAGE ANALYSIS DATA - INNER DEEP BAY REMOTS SURVEY 23/4/96

STAT	REPL	DATE	TIME	AYST	SS	GSMM	MDCNT	MDAVG	PENMEAN	RPDMEAN	METCNT	METMEAN	LODO	OSI	CMNT
1	A	23/4/96	11:10	RV	0	4 to 3	0	0	5	1	0	0	N	-8	none
1	B	23/4/96	11:11	RV	1	>4-3	0	0	9	1.5	0	0	N	3	s/m,red sed @ depth
1	C	23/4/96	11:13	RV	0	>4-3	4	0	9	0	0	0	Y	-8	s/m, red sed > p
2	A	23/4/96	11:27	RV	1	>4	0	0	11	0.2	0	0	N	2	thin surf ox lyr, surf tubes, worms@depth
2	B	23/4/96	11:28	RV	1	>4	0	0	10	0.1	0	0	N	2	thin surf ox lyr, surf tubes
2	C	23/4/96	11:29	RV	1	>4	0	0	12	0.2	0	0	N	2	thin surf ox lyr, worms@depth
3	A	23/4/96	11:37	RV	ind	ind	ind	ind	ind	ind	ind	ind	ind	ind	pull out = smear
3	B	23/4/96	11:37	RV	ind	ind	ind	ind	ind	ind	ind	ind	ind	ind	pull out = smear
4	A	23/4/96	11:45	RV	0	>4	0	0	22	1	15	5	Y	-8	thin RPD, bubbles, O.P.
5	A	23/4/96	12:54	RV	0	>4	0	0	22	0	>20	7	Y	-10	no RPD, bubbles, O.P.
5	B	23/4/96	12:55	RV	0	>4	0	0	22	0	>20	7	Y	-10	no RPD, bubbles, O.P.
5	C	23/4/96	12:56	RV	0	>4	0	0	18	0	20	5	Y	-10	no RPD, bubbles
6	A	23/4/96	1:02	RV	0	>4-3	0	0	7	0	0	0	Y	-8	no RPD, sandy mud
6	B	23/4/96	1:02	RV	1	>4	1	1	12	0.1	0	0	Y	-2	surf tubes
6	C	23/4/96	1:03	RV	0	>4	0	0	8	0	0	0	Y	-8	slight pull away
7	A	23/4/96	1:08	RV	0	>4	1	1	16	0	15	10	Y	-10	no RPD, bubbles
8	A	23/4/96	1:13	RV	0	>4	0	0	7	0	0	0	Y	-8	high SOD
8	B	23/4/96	1:13	RV	0	>4	0	0	17	0	12	7	Y	-10	no RPD, bubbles
8	C	23/4/96	1:14	RV	0	>4	0	0	22	0	20	6	Y	-10	no RPD, bubbles, dep lyr=10 cm thick
8	D	23/4/96	1:14	RV	ind	ind	ind	ind	ind	ind	ind	ind	ind	ind	pull out = smear
9	A	23/4/96	1:19	RV	0	>4	0	0	4	0	0	0	Y	-8	U.P.
9	B	23/4/96	1:20	RV	ind	ind	ind	ind	ind	ind	ind	ind	ind	ind	pull out = smear
10	A	23/4/96	1:25	RV	0	>4	0	0	12	0	0	0	Y	-8	none
10	B	23/4/96	1:26	RV	0	>4	0	0	12	0	0	0	Y	-8	smearing
11	A	23/4/96	1:30	RV	0	>4	0	0	15	0	8	6	Y	-10	high SOD, dep lyr = 8 cm thick
11	B	23/4/96	1:30	RV	ind	ind	ind	ind	ind	ind	ind	ind	ind	ind	pull out = smear
11	C	23/4/96	1:31	RV	0	>4	0	0	16	0	20	3	Y	-10	dep lyr = 8 cm thick
12	A	23/4/96	2:15	RV	1	>4	0	0	11	1	0	0	N	3	thin RPD, 1 worm@depth
12	B	23/4/96	2:16	RV	1	>4	0	0	10	0	0	0	Y	-3	1 surf tube + 1 worm@depth
12	C	23/4/96	2:16	RV	1	>4	20	0.5	11.0	1	0	0	N	3	thin RPD, worm@depth
13	A	23/4/96	2:20	RV	ind	>4	0	0	22	ind	0	0	ind	ind	O.P.
13	B	23/4/96	2:20	RV	ind	ind	ind	ind	ind	ind	ind	ind	ind	ind	pull out = smear
13	C	23/4/96	2:21	RV	0	>4	0	0	10	ind	0	0	ind	-4	pull out
14	A	23/4/96	2:26	RV	0	>4	0	0	17	0	0	0	Y	-8	no RPD, sulfur bacteria?
14	B	23/4/96	2:27	RV	0	>4	5	1	12	0	0	0	Y	-8	no RPD
14	C	23/4/96	2:28	RV	0	>4	3	1	8	0.1	0	0	Y	-7	sulfur bacteria?
15	A	23/4/96	2:31	RV	0	>4	3	1	17	0	0	0	Y	-8	high SOD, dep lyr=7 cm thick
15	B	23/4/96	2:32	RV	ind	ind	ind	ind	ind	ind	ind	ind	ind	ind	pull out = smear
15	C	23/4/96	2:33	RV	ind	ind	ind	ind	ind	ind	ind	ind	ind	ind	pull out = smear
15	D	23/4/96	2:37	RV	0	>4	ind	ind	22	ind	0	0	ind	-4	O.P.

E4.134 The sediments at all stations were extremely dark (black to dark grey). The black appearance is indicative of anoxic (no or low dissolved oxygen) conditions, and, in many images, the redox layer was either very thin or non-existent (Plate E4.5 and Figure E4.12). The average depth of the redox potential discontinuity (RPD) measured in the REMOTS images ranged from 0 to 0.8 cm (Figure E4.12). The zero values all occurred at stations south of the Tsim Bei Tsui marine police pier. At the stations located farther out in Inner Deep Bay (stations 1, 2, 4, 11, 12 and 14), there was a very thin layer of oxidized surface sediment (Plate E4.5).

E4.135 It is inferred that the study area is subject to high rates of organic loading, resulting in sediments which are extremely anoxic, sulfitic and probably have high sediment oxygen demand (SOD). At several stations, gas bubbles were visible in the REMOTS images (Plate E4.6 and Figure E4.13), indicating the active production of methane (CH_4) and/or hydrogen sulfide (H_2S) within the sediment column. At stations 8, 9 and 11, there was a depositional layer having a thickness of about 8 cm at the sediment surface, possibly due to settling out of fine-grained suspended sediment from the water column (Plate E4.7). The sediments in this area are clearly subject to excessive organic enrichment, probably due to high inputs of sewage waste from livestock from nearby pig farms.

E4.136 Despite the unfavorable sediment conditions, there was evidence of living organisms in some of the REMOTS images. This evidence was in two forms: 1.) tubes of polychaete/oligochaete worms were visible at the sediment surface (Plates E4.5 and E4.8), and 2.) the organisms themselves were visible down within the sediment (Plates E4.5 and E4.8). These features were observed in images from stations 1, 2, 6, and 12 (Figure 4.15). At all other stations, there was no visible evidence of macrofauna in the REMOTS images (Figure E4.14).

E4.137 The organisms visible in the REMOTS images are probably spionid or capitellid polychaetes, or oligochaetes. These are all well-known opportunistic taxa (i.e., REMOTS "Stage I" as mapped in Figure E4.14) able to persist in highly-stressed environments, particularly in areas like Inner Deep Bay where there is excessive organic enrichment. The results of a previous subtidal survey in a nearby area (Shan Pui River) are in agreement with the present results in showing extremely low species diversity and animal density, abiotic sediments at many stations, and oligochaetes as the sole abundant taxon (Lee 1993).

E4.138 The REMOTS Organism Sediment Index (OSI) is a summary value which provides an overall indication of sediment habitat quality. The highest value of +11 indicates healthy, oxidized seabed characterized by a deep RPD and numerous subsurface deposit-feeding infaunal organisms. At the other extreme, a REMOTS OSI of -10 indicates very degraded sediment conditions in which an oxidized surface layer is absent (zero RPD depth), with high apparent oxygen demand (low dissolved oxygen), methane gas being produced at depth, and no visible signs of macrofaunal life (refer to Appendix A for a more thorough discussion of how REMOTS OSI values are derived).

E4.139 The average REMOTS OSI values ranged from -10 to 2 at the Inner Deep Bay stations (Figure E4.15). These are very low values which reflect the highly-degraded nature of these subtidal sediments, most likely due to excessive sewage inputs. The very lowest OSI values are consistently found at the stations south of the Tsim Bei Tsui pier.

Slightly higher OSI values at the Inner Deep Bay stations reflect the fact that there was some limited oxygenation of the seabed surface in this area (shallow RPD's) as opposed to the highly anoxic sediments south of Tsim Bei Tsui, which lacked any apparent oxygenation (zero RPD's and methane gas production).

Conclusions

E4.140 1) Surface sediments in the study area consist mainly of black, extremely anoxic mud, with methane/hydrogen sulfide gas being produced in some places. These conditions are indicative of high rates of organic loading, probably due to high inputs of livestock wastes in this area. Such conditions are generally unfavorable to the establishment of a diverse and abundant benthic community.

2) There was no visible evidence of macrofaunal organisms in many of the REMOTS images obtained in the study area. This is evidence of an extremely impoverished benthic community.

3 Surface tubes and subsurface worms observed in REMOTS images from a limited number of stations are hypothesized to be either spionid or capitellid polychaetes, or oligochaetes. All of these taxa are known to be highly tolerant to organic over-enrichment of sediments.

4) In terms of benthic habitat quality, the subtidal sediments in the study area are extremely degraded.

References

Anderson, C. and Lee, S.Y. 1995. Defoliation of the mangrove *Avicennia marina* in Hong Kong: cause and consequence. *Biotropica* 27:218-228.

Batzer, D.P., McGee, M., Resh, V.H. and Smith, R.R. 1993. Characteristics of invertebrates consumed by mallards and prey response to wetland flooding schedules. *Wetlands* 13:41-49.

Bhushan, B., Fry, G., Hibi, A., Mundkur, T., Prawiradilaga, D.M., Sonobe, K.and Usui, S. 1993. *A Field Guide to the Waterbirds of Asia.* Wild Bird Society of Japan, Tokyo.

Binnie Consultants Ltd., 1996. Tin Shui Wai Development - Environmental Impact Assessment, Final Environmental Review.

Bones, L.A. 1983. The behaviour and ecology of the Hong Kong fiddler crabs with special reference to *Uca lactea* and *Uca vocans.* Ph.D thesis, University of Hong Kong.

Chan, K.Y. 1990. *The ecology of mudskippers (Pisces: Periophthalmidae) in the Mai Po Marshes Nature Reserve, Hong Kong.* M.Phil thesis, University of Hong Kong.

Choi, K.C. 1991. *The ecology of fiddler crabs (Crustacea: Ocypodidae) at the Mai Po Marshes Nature Reserve Hong Kong.* M.Phil thesis, University of Hong Kong.

Collar, N.J, Crosby, M.J., and Stattersfield, A.J. 1994. *Birds to Watch 2. Birdlife Conservation Series No. 4*. Birdlife International, Cambridge.

Collar, N.J. and Andrew, P. 1988. *Birds to Watch. The ICBP World Checklist of Threatened Birds*. ICBP, Cambridge.

Duke, N.C. and Khan, A. in press. Structure and composition of the seaward mangrove forest at the Mai Po Marshes Nature Reserve, Hong Kong. In *Proceedings of the International Workshop on the Mangrove Ecosystem of Deep Bay and the Mai Po Marshes, Hong Kong*. (ed. Lee, S.Y.).

Green, R.H. 1979. *Sampling design and statistical methods for environmental biologists*. John Wiley and Sons, New York.

Howes, B.L. and Goehringer, D.D. 1994. Porewater drainage and dissolved organic carbon and nutrient losses through the intertidal creekbanks of a New England salt marsh. *Marine Ecology Progress Series* 114:289-301.

Lee, S.Y. 1995. Macrobenthic community structure of a polluted tidal river in Deep bay, Hong Kong. Pages 43-51 in B.S. Morton, Xu, G., Zou, R., Pau, J. and Cai, G., editors. *The Marine Biology of the South China Sea*, World Publishing Beijing.

Leschisin, D.A., Williams, G.L. and Weller, M.W. 1992. Factors affecting waterfowl use of constructed wetlands in northwestern Minnesota. *Wetlands* 12:178-183.

Lewthwaite, R. 1995. The Hong Kong Bird Watching Society Bulletin 158.

Lewthwaite, R. 1996a. The Hong Kong Bird Watching Society Bulletin 159.

Lewthwaite, R. 1996b. The Hong Kong Bird Watching Society Bulletin 160.

McChesney, S. 1996. *Benthic Infauna of the Deep Bay mudflats with special reference to usage by migratory waterbirds*. Unpublished M.Phil Thesis, Hong Kong University.

Melville, D. 1995. The Hong Kong Bird Watching Society Bulletin 158.

Mitsch, W.J. and Gosselink, J.G. 1994. *Wetlands*. Van Nostrand Reinhold, New York.

Neckles, H.A., Murkin, H.R. and Cooper, J.A. 1990. Influences of seasonal flooding on macroinvertebrate abundance in wetlands habitats. *Freshwater Biology* 23:311-322.

Olff, H., Bakker, J.P. and Fresco, L.F.M. 1988. The effect of fluctuations in tidal inundation frequency on a salt-marsh vegetation. *Vegetation* 78:13-19.

Seneca, E.D., Broome, S.W. and Woodhouse, W.W. Jr. 1985. The influence of duration-of-inundation on development of a man-initiated *Spartina alterniflora* Loisel. marsh in North Carolina. *Journal of Experimental Marine Biology and Ecology* 94:259-268.

Underwood, A.J. 1992. Beyond BACI: the detection of environmental impacts on populations in the real, but variable, world. *J.Exp. Mar. Biol. Ecol.,* 161: 145-178.

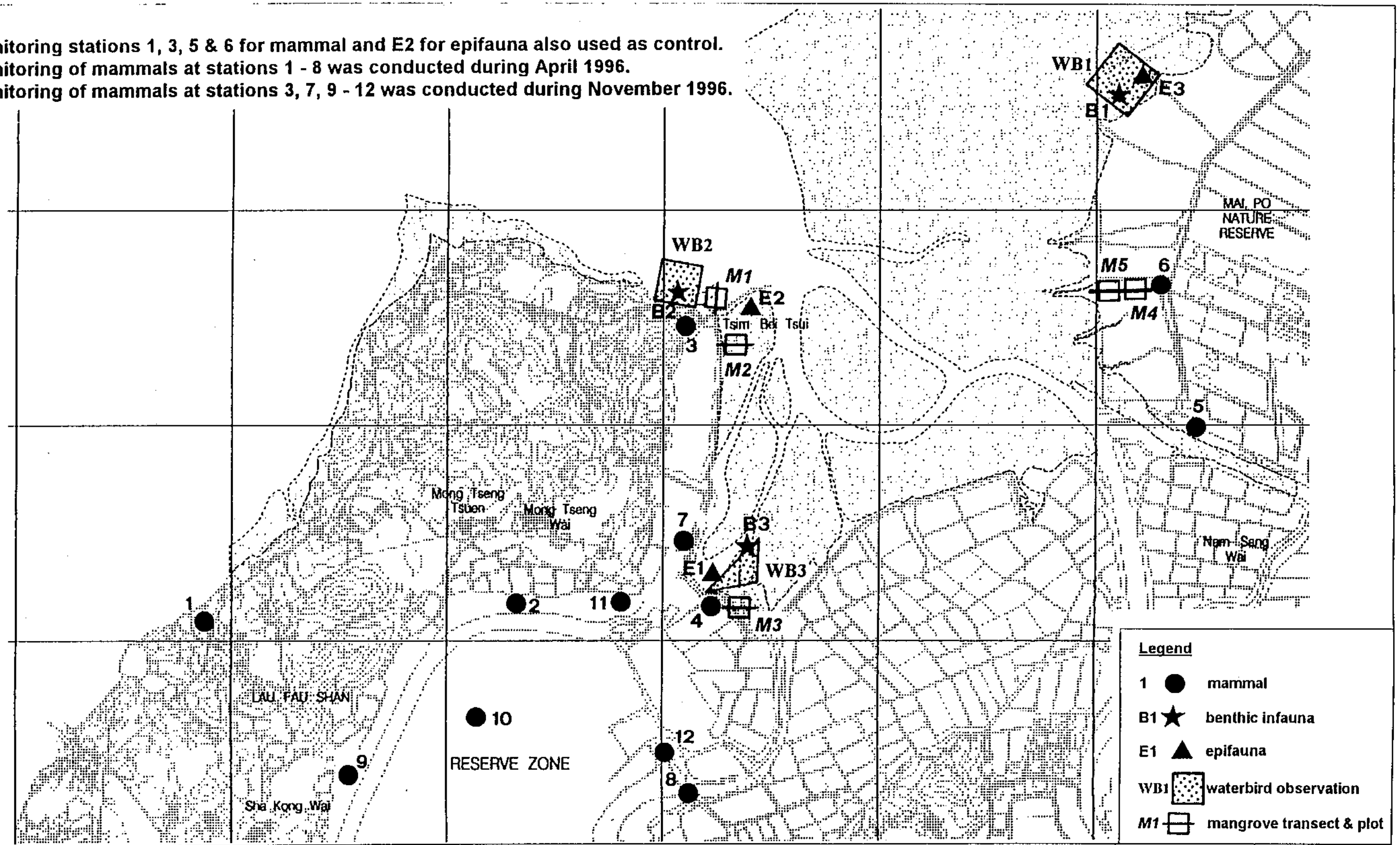
Watkins, D. 1993. *A national plan for shorebird conservation in Australia.* RAOU Research Report No. 90. Royal Australasian Ornithological Union and Worldwide Fund for Nature, Melbourne.

Young, L. 1995a. *The biological importance of Deep Bay and the Mai Po Marshes.* Pages 16-26 in Chin S.T. editor. Wetlands in Deep Bay and the Mai Po Marshes. Institute of Biology, Hong Kong.

Young, L. 1995b. Focus on Fishponds. The heron and egret perspective. *Porcupine!* 13.

Young, L. and Melville, D.S. (1995). *Environmental research at the WWF Hong Kong Mai Po Marshes Nature Reserve.* In Wong *et al.* (eds.): Environmental Research in Pearl River and Coastal Areas. Guangdong Higher Education Press.

Note :
(1) Monitoring stations 1, 3, 5 & 6 for mammal and E2 for epifauna also used as control.
(2) Monitoring of mammals at stations 1 - 8 was conducted during April 1996.
(3) Monitoring of mammals at stations 3, 7, 9 - 12 was conducted during November 1996.



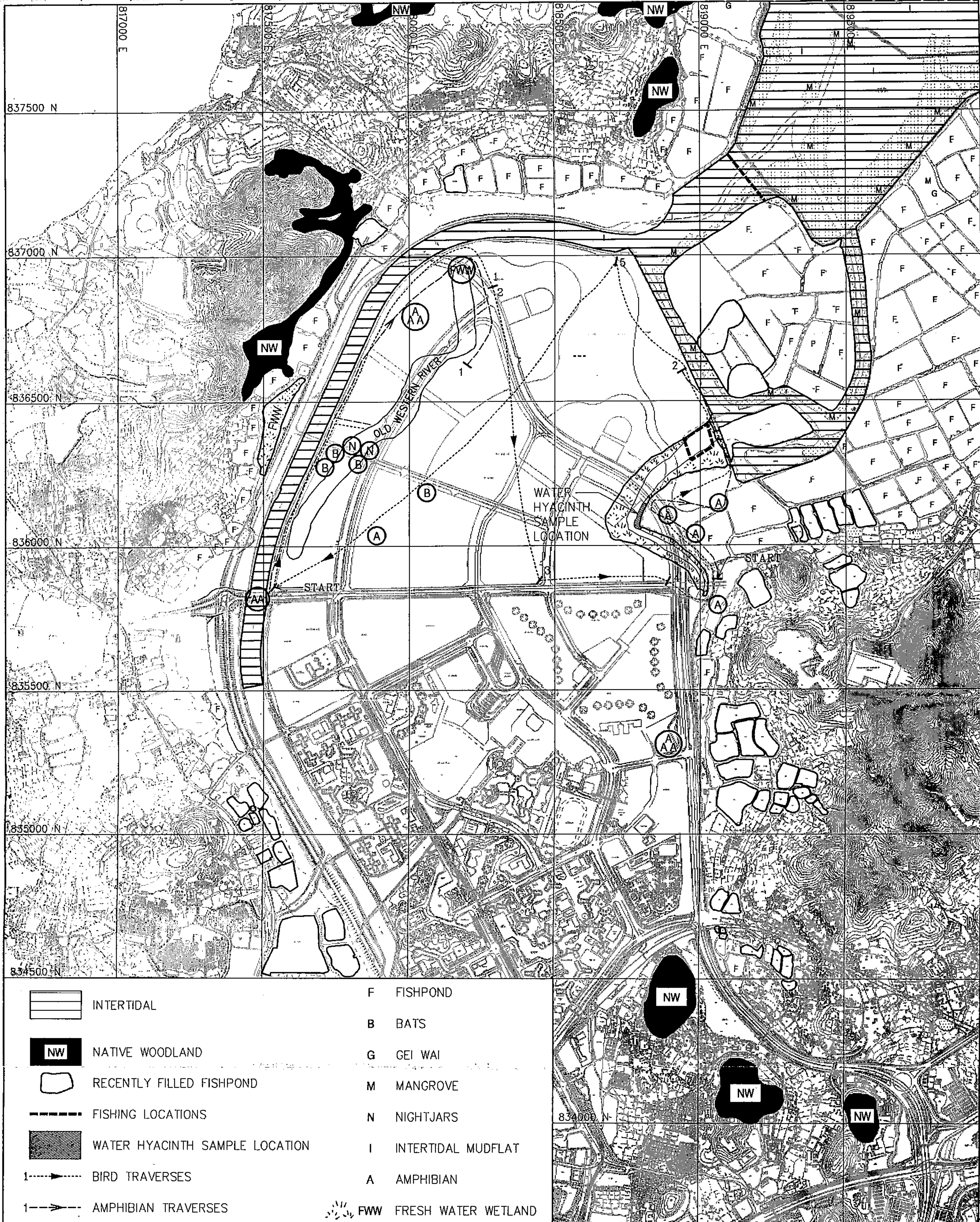
TIN SHUI WAI DEVELOPMENT
AGREEMENT NO. CE 10/95
ENGINEERING INVESTIGATIONS FOR DEVELOPMENT OF AREAS 3, 30 & 31 OF THE DEVELOPMENT ZONE AND THE RESERVE ZONE

BINNIE CONSULTANTS LIMITED
賓尼工程顧問有限公司
ENGINEERS AND SCIENTISTS
賓尼

Title :

LOCATIONS OF ECOLOGICAL MONITORING STATIONS

Figure No. E4.1	Revision 0
Reference No. -	File Name -
Prepared MC	Checked SMc
Date NOV 96	Scale 1 : 25000



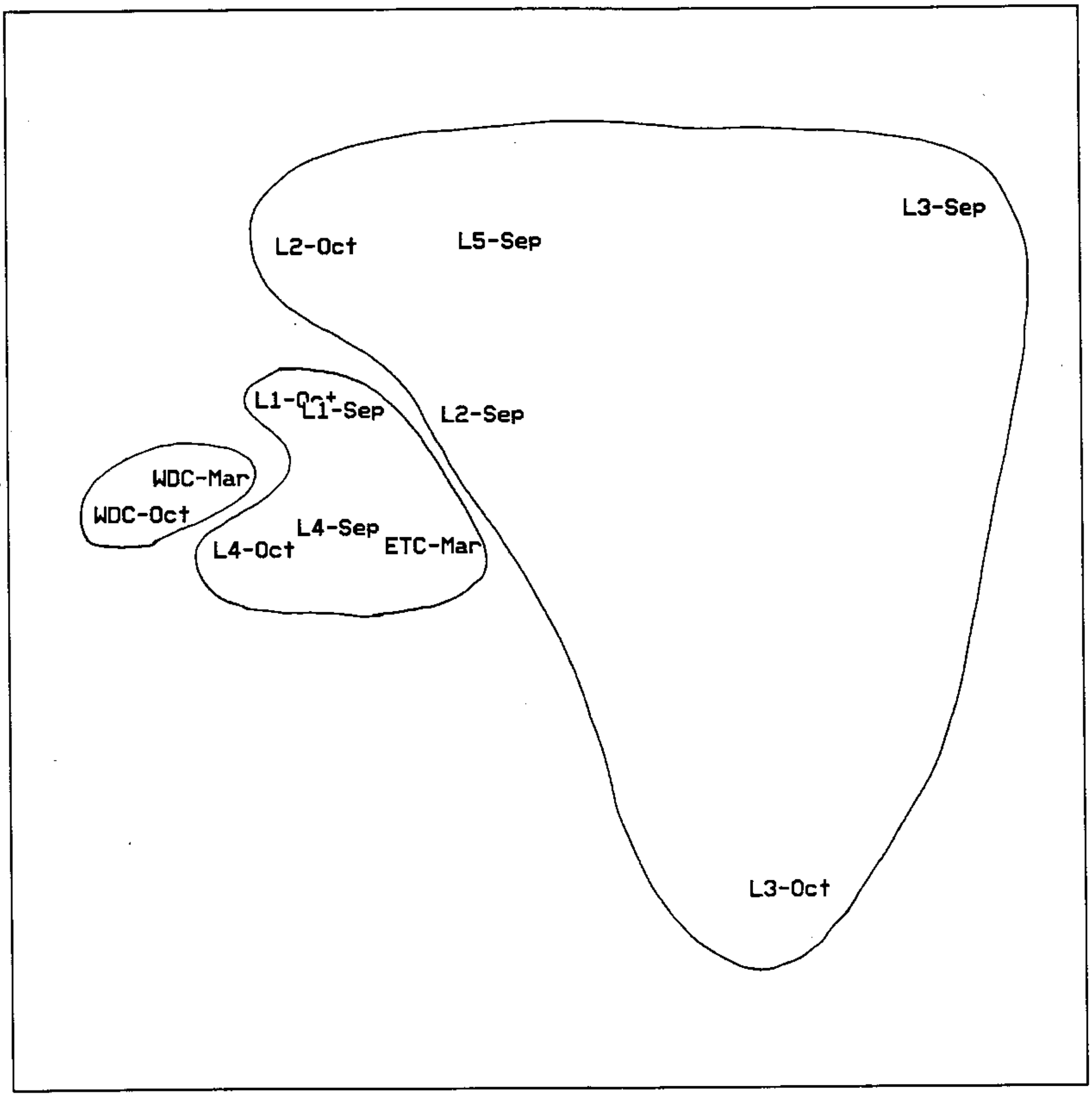
TIN SHUI WAI DEVELOPMENT AGREEMENT NO. CE 10/95
ENGINEERING INVESTIGATIONS FOR DEVELOPMENT OF AREAS 3, 30 & 31 OF THE DEVELOPMENT ZONE AND THE RESERVE ZONE

BINNIE CONSULTANTS LIMITED 賓尼工程顧問有限公司 ENGINEERS AND SCIENTISTS 賓尼

Title :

RESERVE ZONE ECOLOGICAL RESOURCES ON-SITE STUDIES

Figure No. E4.2	Revision 1
Reference TSW-BASE	File Name 01380018.C09
Prepared AMP	Checked SMC
Date OCT. 96	Scale N.T.S.



Stress = 0.08

TIN SHUI WAI DEVELOPMENT AGREEMENT NO. CE 10/95 ENGINEERING INVESTIGATIONS FOR DEVELOPMENT OF AREAS 3, 30 & 31 OF THE DEVELOPMENT ZONE AND THE RESERVE ZONE	Title : BIRD COMMUNITIES ON-SITE : MDS ORDINATION	Figure No. E4.3	Revision 0
		Reference No. -	File Name -
BINNIE CONSULTANTS LIMITED 賓尼工程顧問有限公司 ENGINEERS AND SCIENTISTS 賓尼		Prepared HYH	Checked SMc
		Date NOV 96	Scale NTS

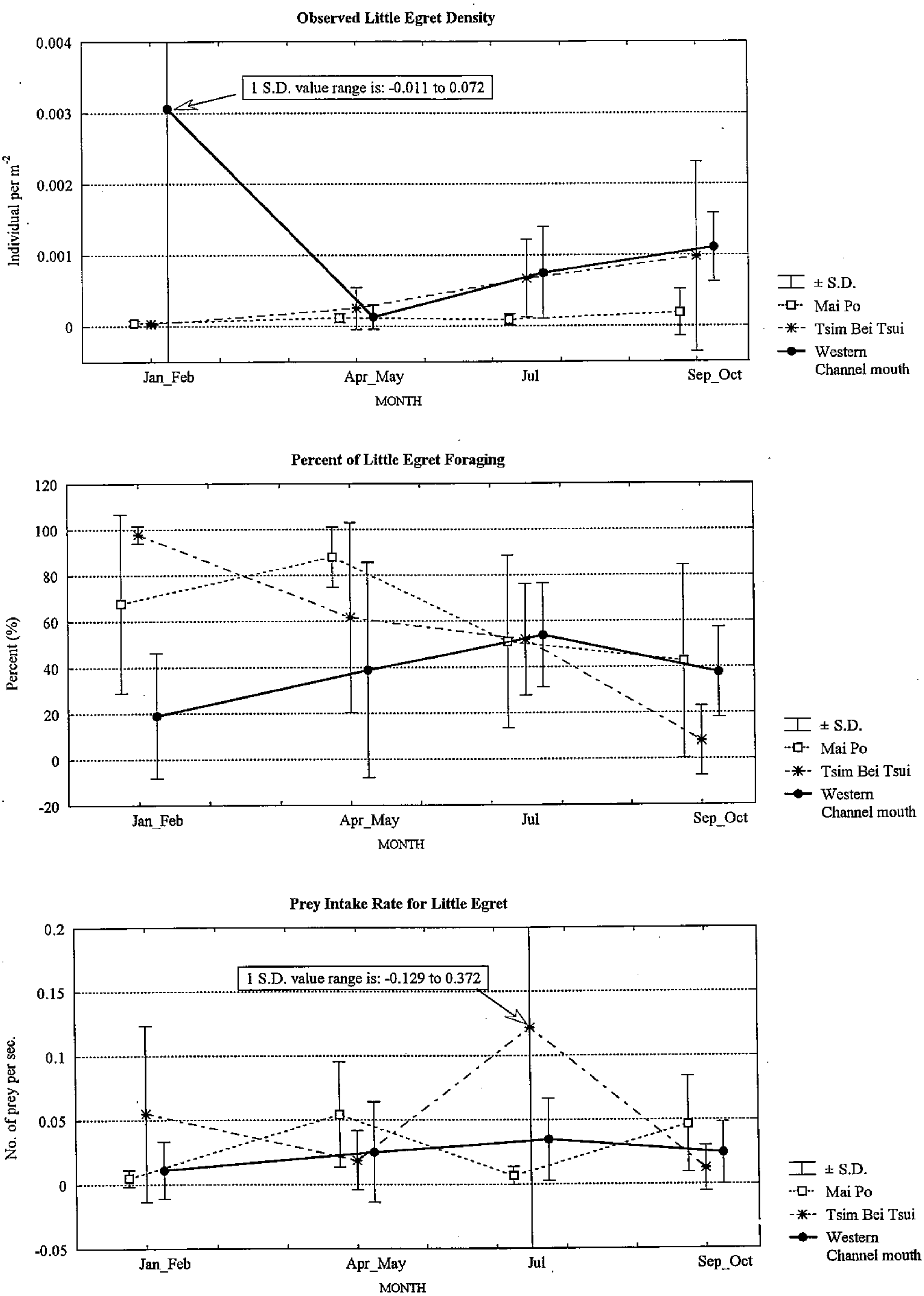


Figure E4.4 Little Egret Density, Activity and Intake Rate at the Three Study Sites

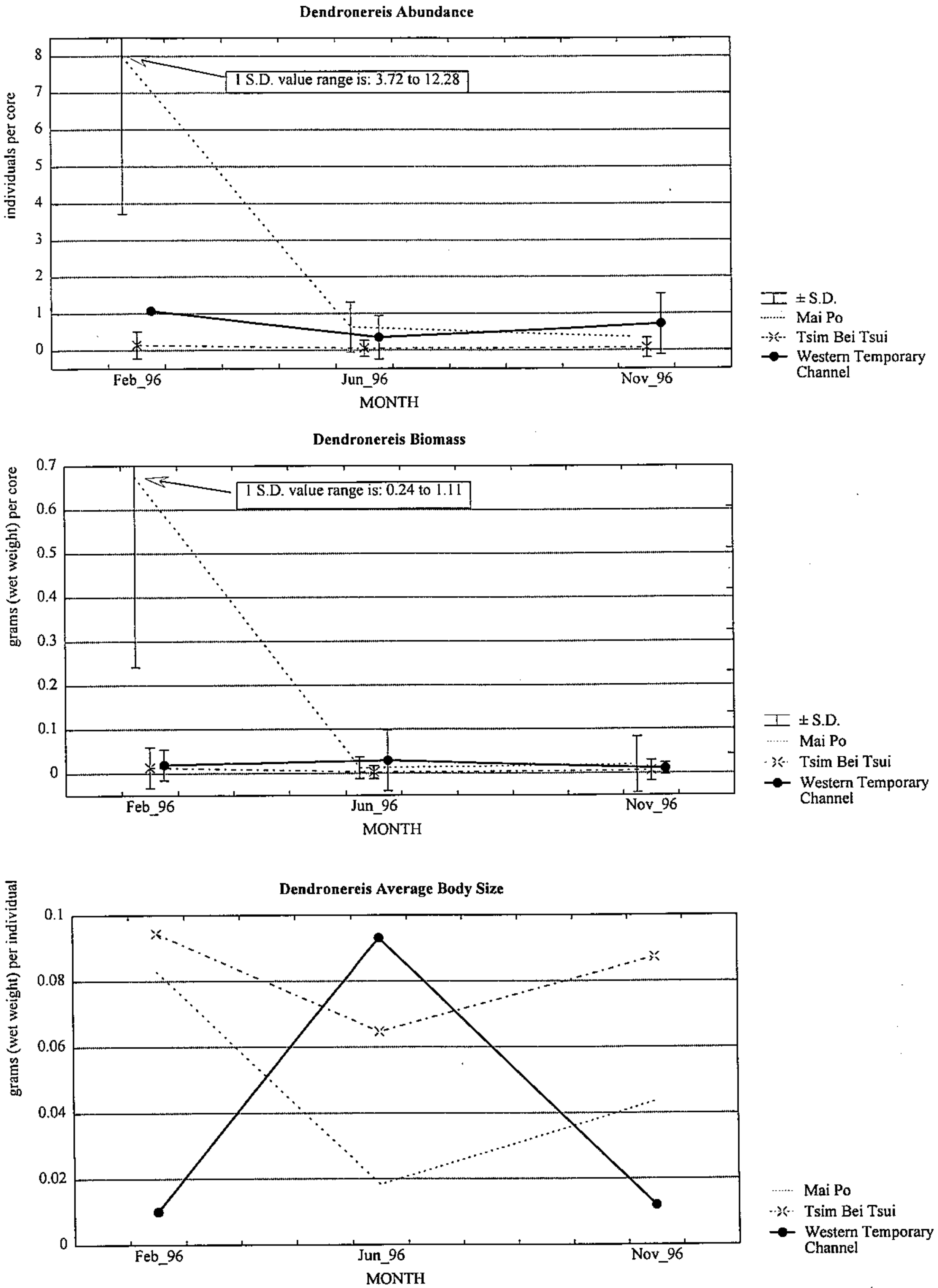


Figure E4.5 Dendronereis Abundance, Biomass and Average Body Size at the Three Study Sites

Remark: Samples were taken within 3 consecutive days of the sampling month

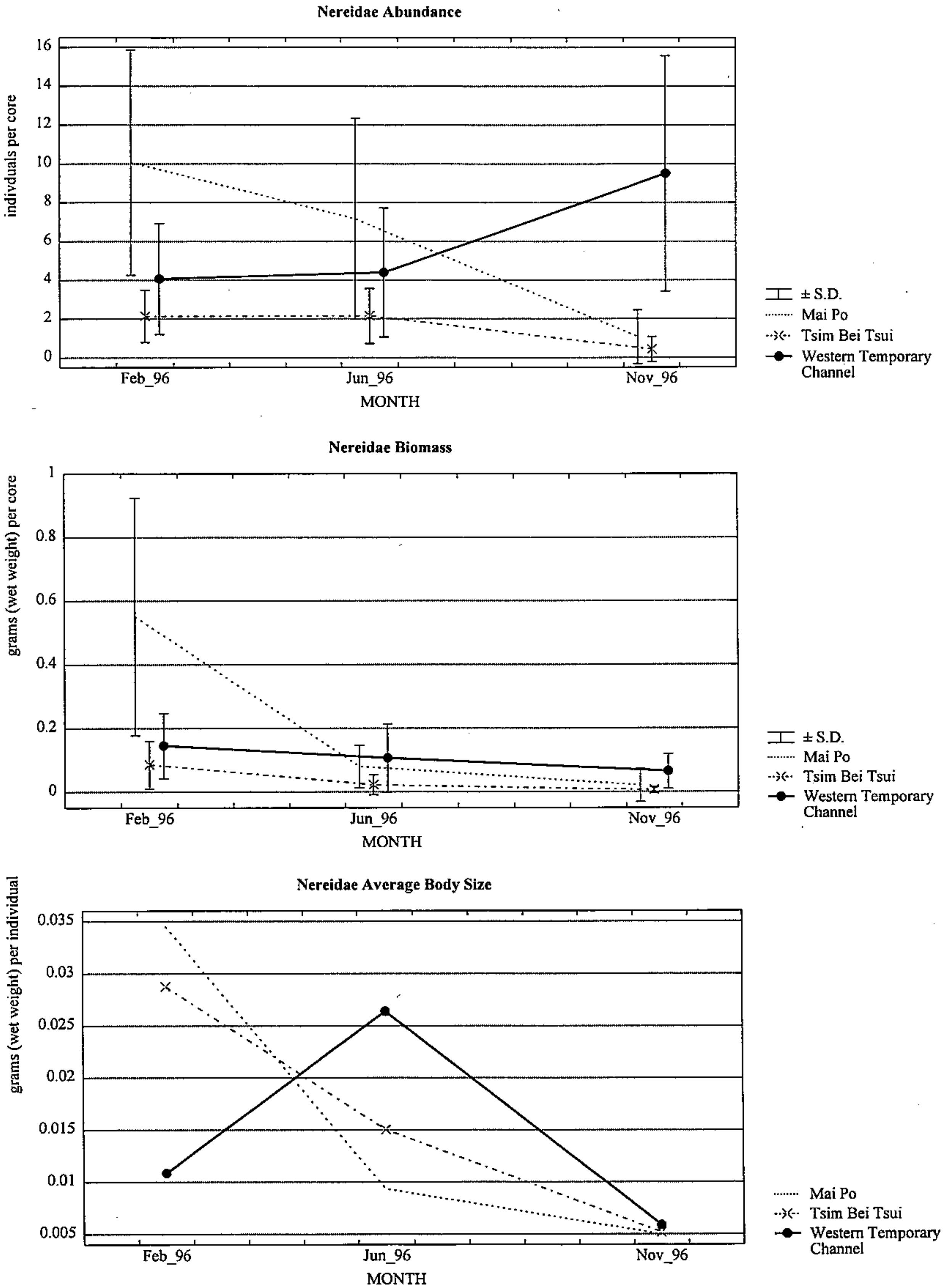


Figure E4.6 Nereidae Abundance, Biomass and Average Body Size at the Three Study Sites

Remark: Samples were taken within 3 consecutive days of the sampling month

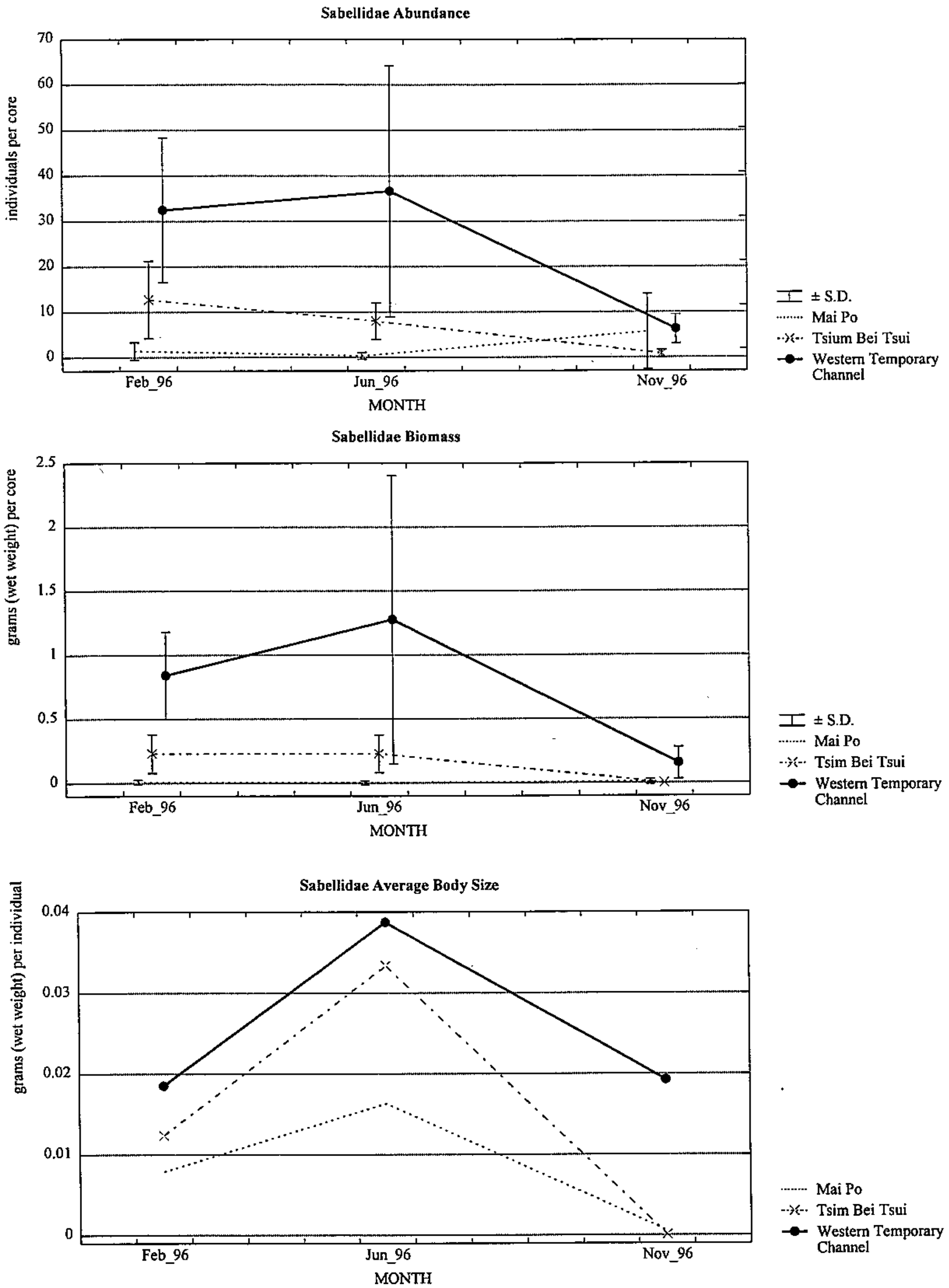


Figure E4.7 Sabellidae Abundance, Biomass and Average Body Size at the Three Study Sites

Remark: Samples were taken within 3 consecutive days of the sampling month

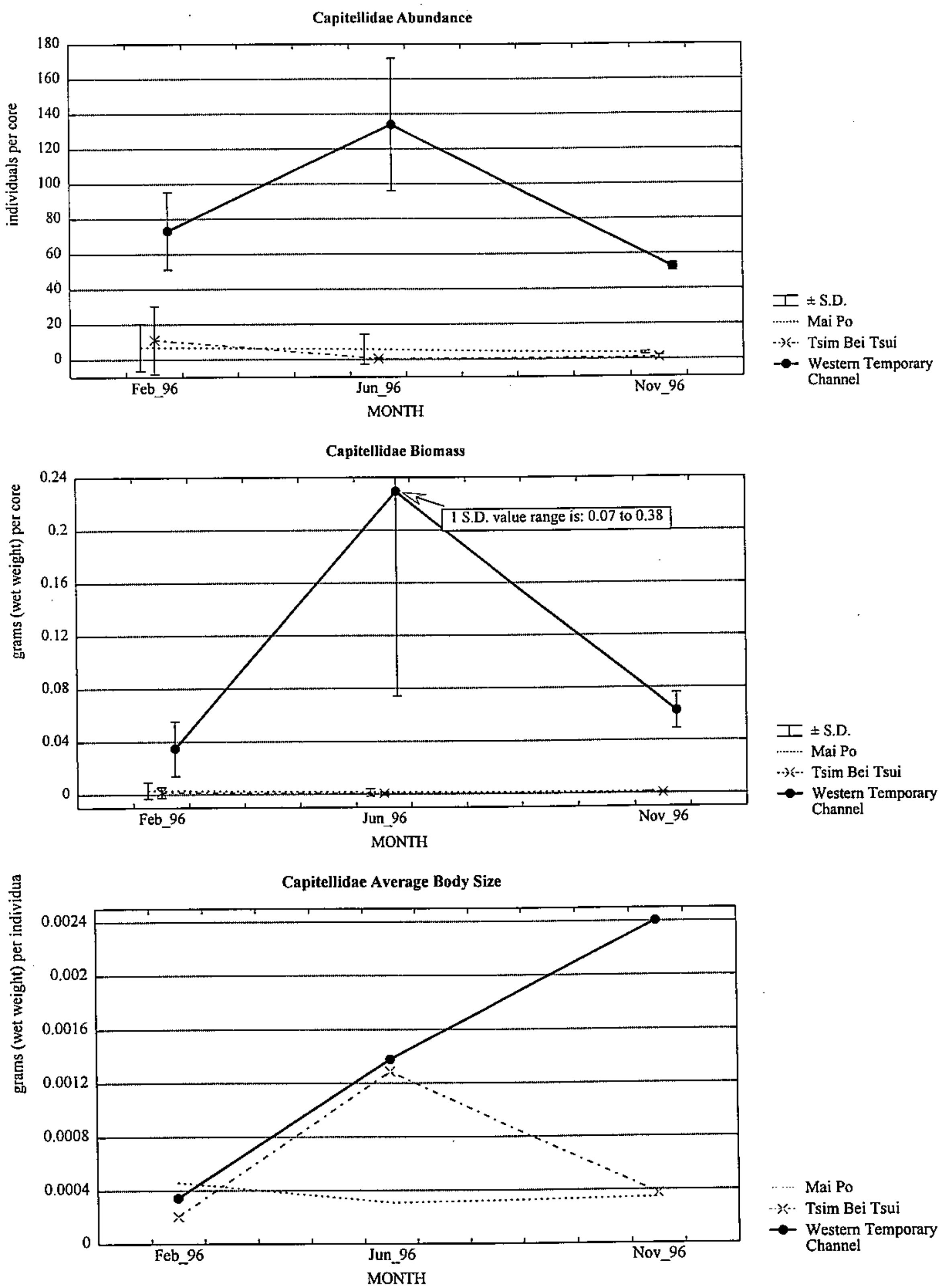
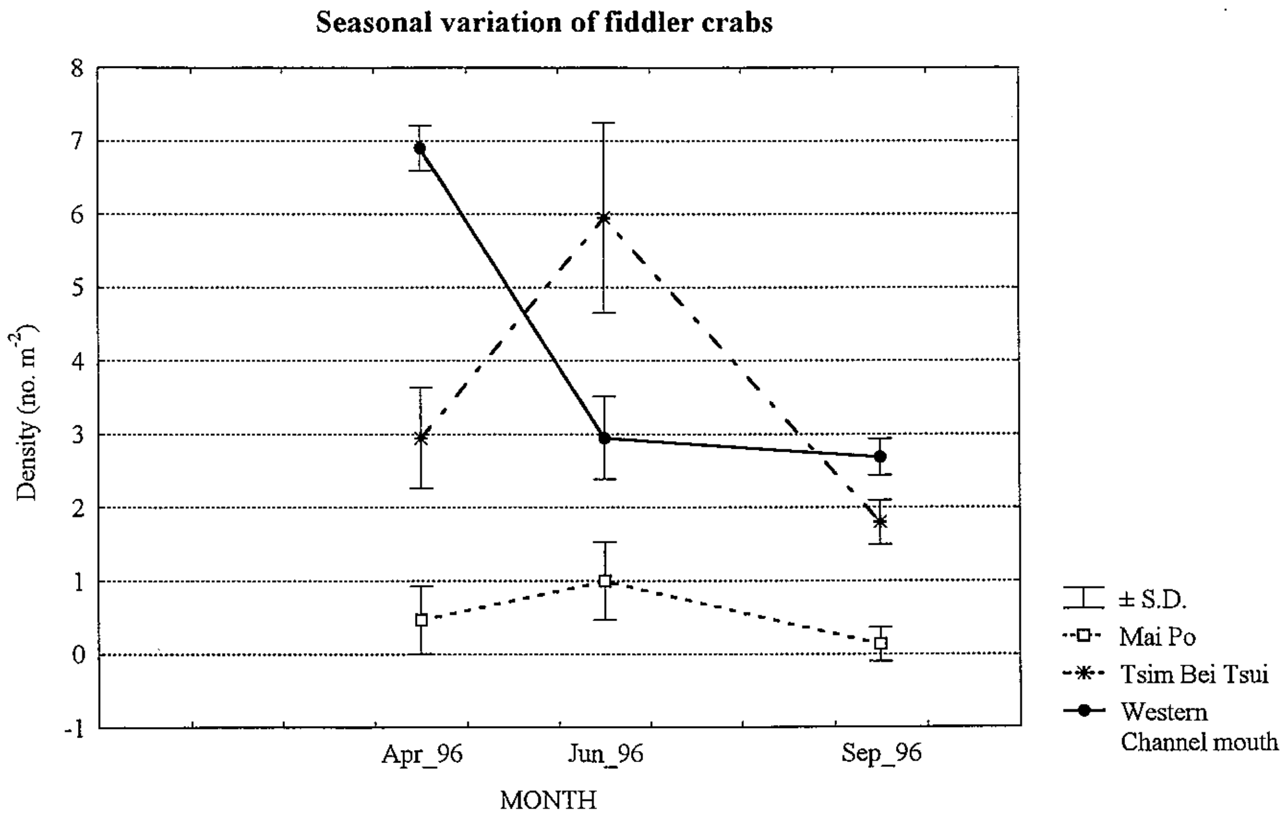


Figure E4.8 Capitellidae Abundance, Biomass and Average Body Size at the Three Study Sites

Remark: Samples were taken within 3 consecutive days of the sampling month



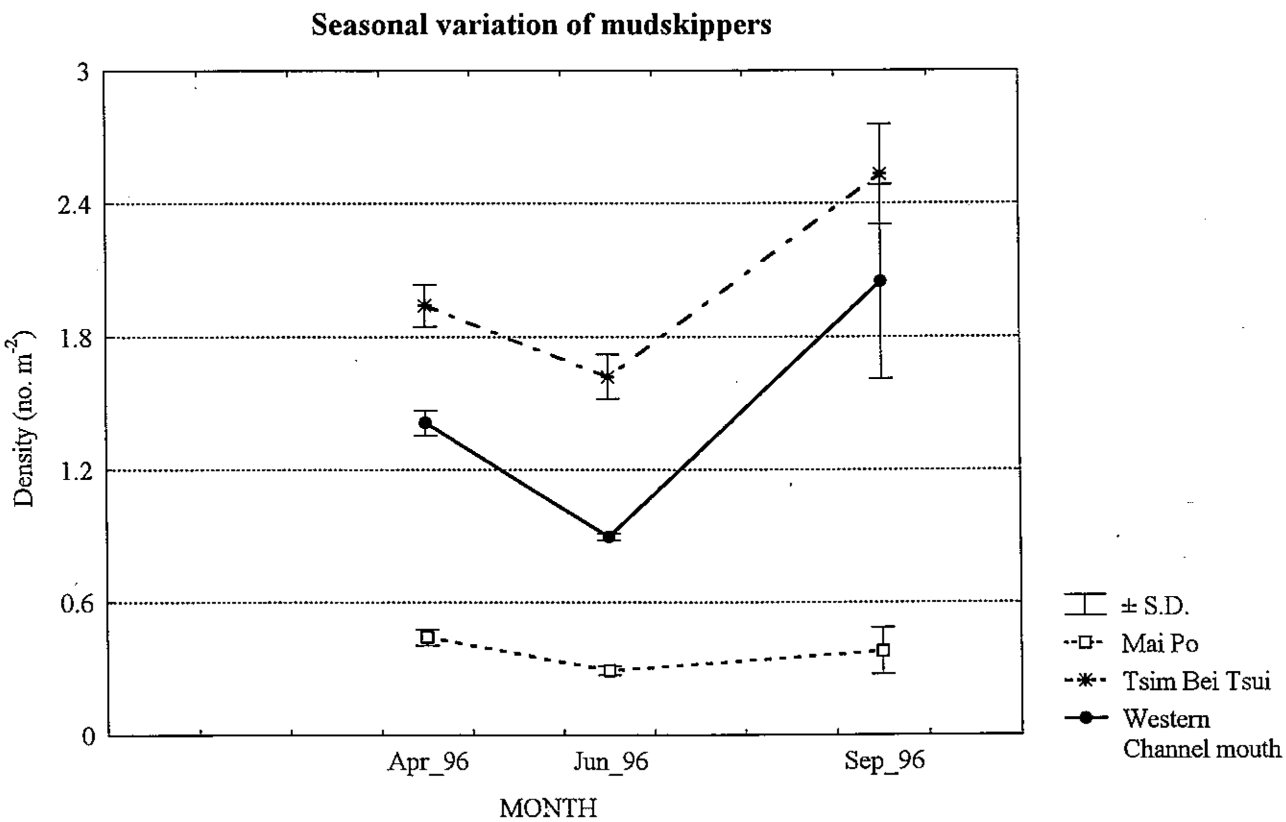
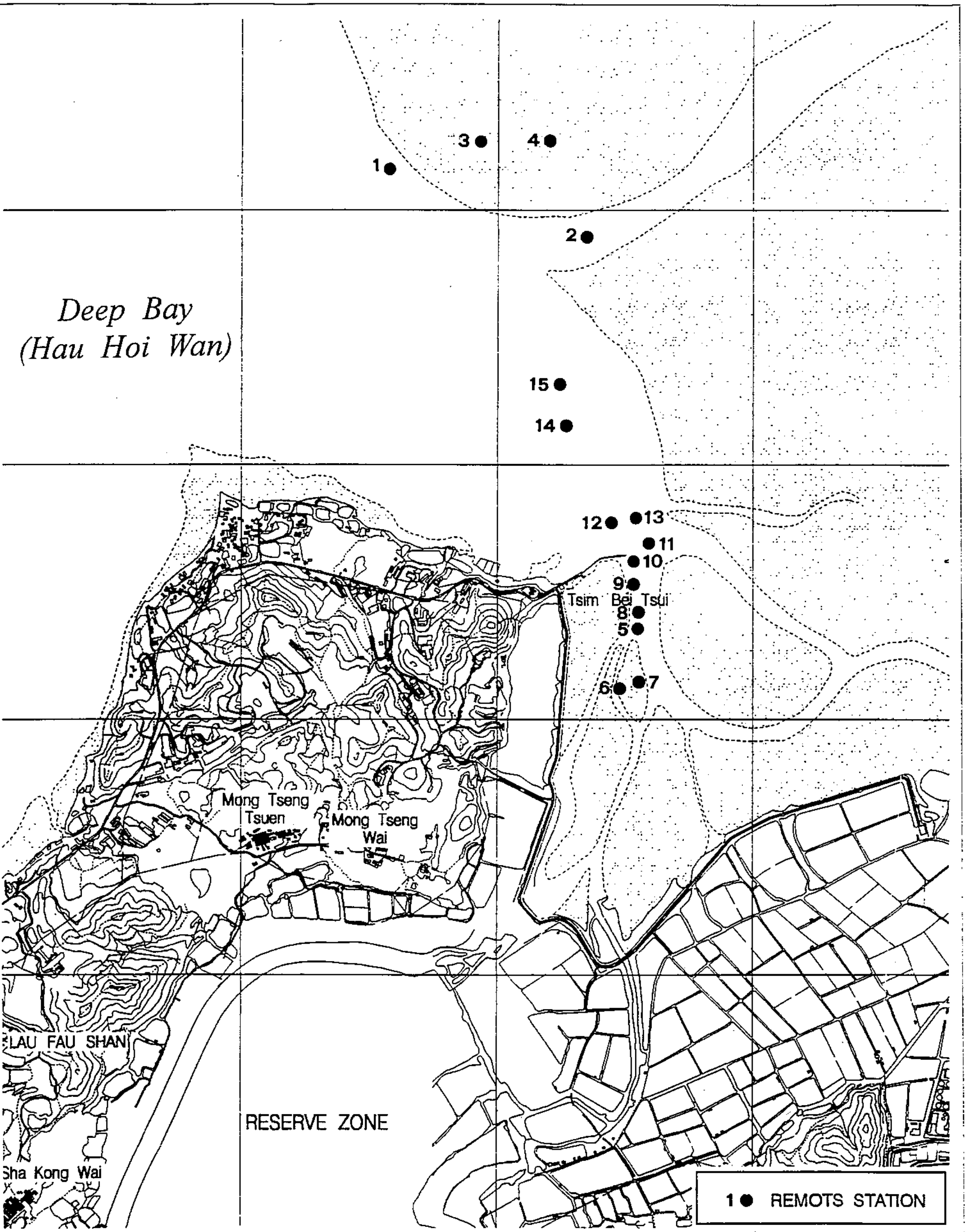


Figure E4.9 Seasonal Variation in Density of Fiddler Crabs and Mudskippers at the Three Study Sites

Remark: Sampling was taken within 3 consecutive days of the sampling month



TIN SHUI WAI DEVELOPMENT AGREEMENT NO. CE 10/95

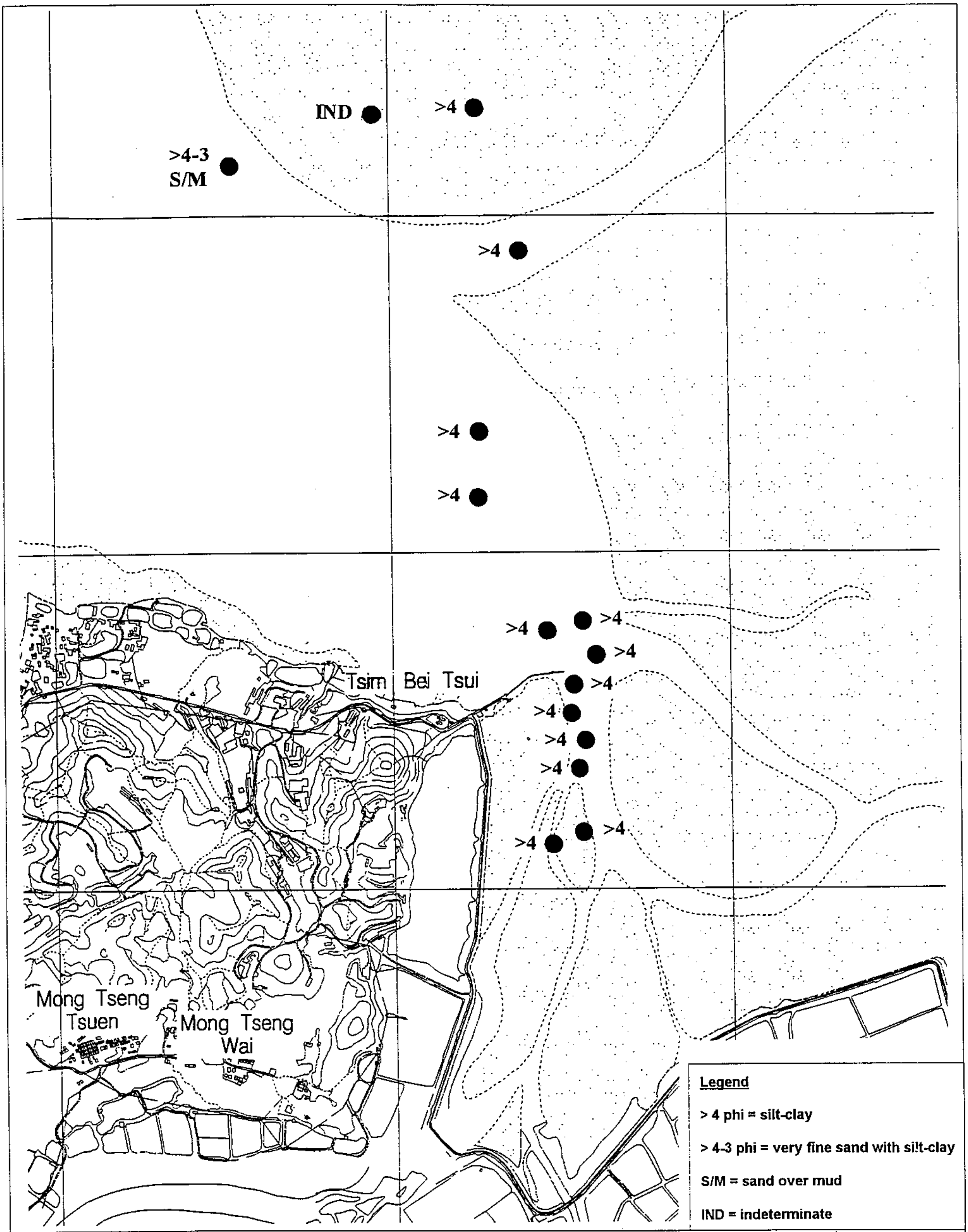
ENGINEERING INVESTIGATIONS FOR DEVELOPMENT OF AREAS 3, 30 & 31 OF THE DEVELOPMENT ZONE AND THE RESERVE ZONE

BINNIE CONSULTANTS LIMITED
賓尼工程顧問有限公司
ENGINEERS AND SCIENTISTS
賓尼

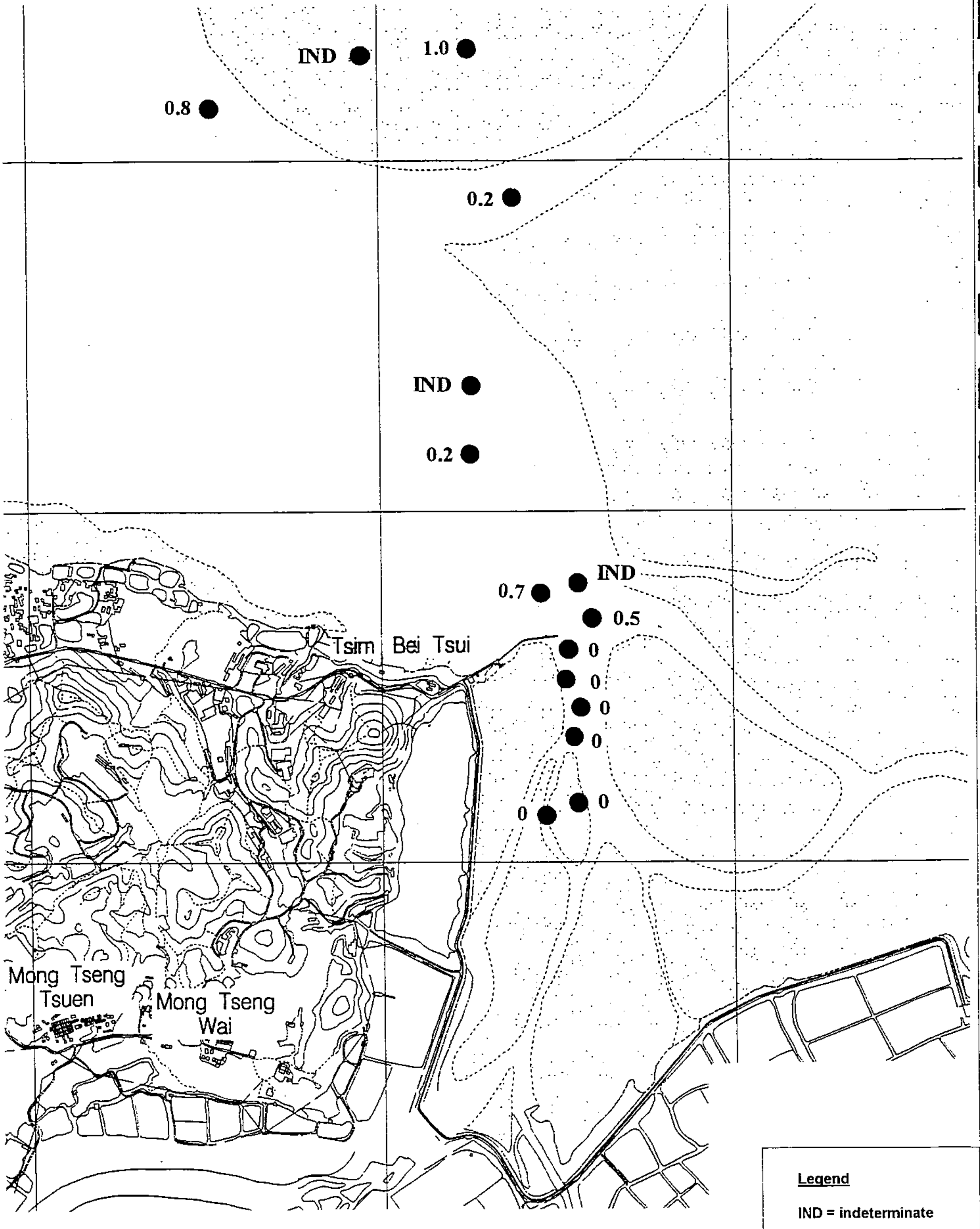
Title :

STATION LOCATIONS FOR THE INNER DEEP BAY REMOTS SURVEY

Figure No. E4.10	Revision 0
Reference No. -	File Name -
Prepared MC	Checked SMC
Date OCT 96	Scale 1 : 20000



TIN SHUI WAI DEVELOPMENT AGREEMENT NO. CE 10/95 ENGINEERING INVESTIGATIONS FOR DEVELOPMENT OF AREAS 3, 30 & 31 OF THE DEVELOPMENT ZONE AND THE RESERVE ZONE	Title : GRAIN SIZE MAJOR MODE, IN PHI UNITS, AT THE INNER DEEP BAY REMOTS STATIONS	Figure No. E4.11	Revision 0
		Reference No. -	File Name -
BINNIE CONSULTANTS LIMITED 賓尼工程顧問有限公司 ENGINEERS AND SCIENTISTS 賓尼		Prepared MC	Checked SMc
		Date NOV 96	Scale N.T.S.



TIN SHUI WAI DEVELOPMENT AGREEMENT NO. CE 10/95

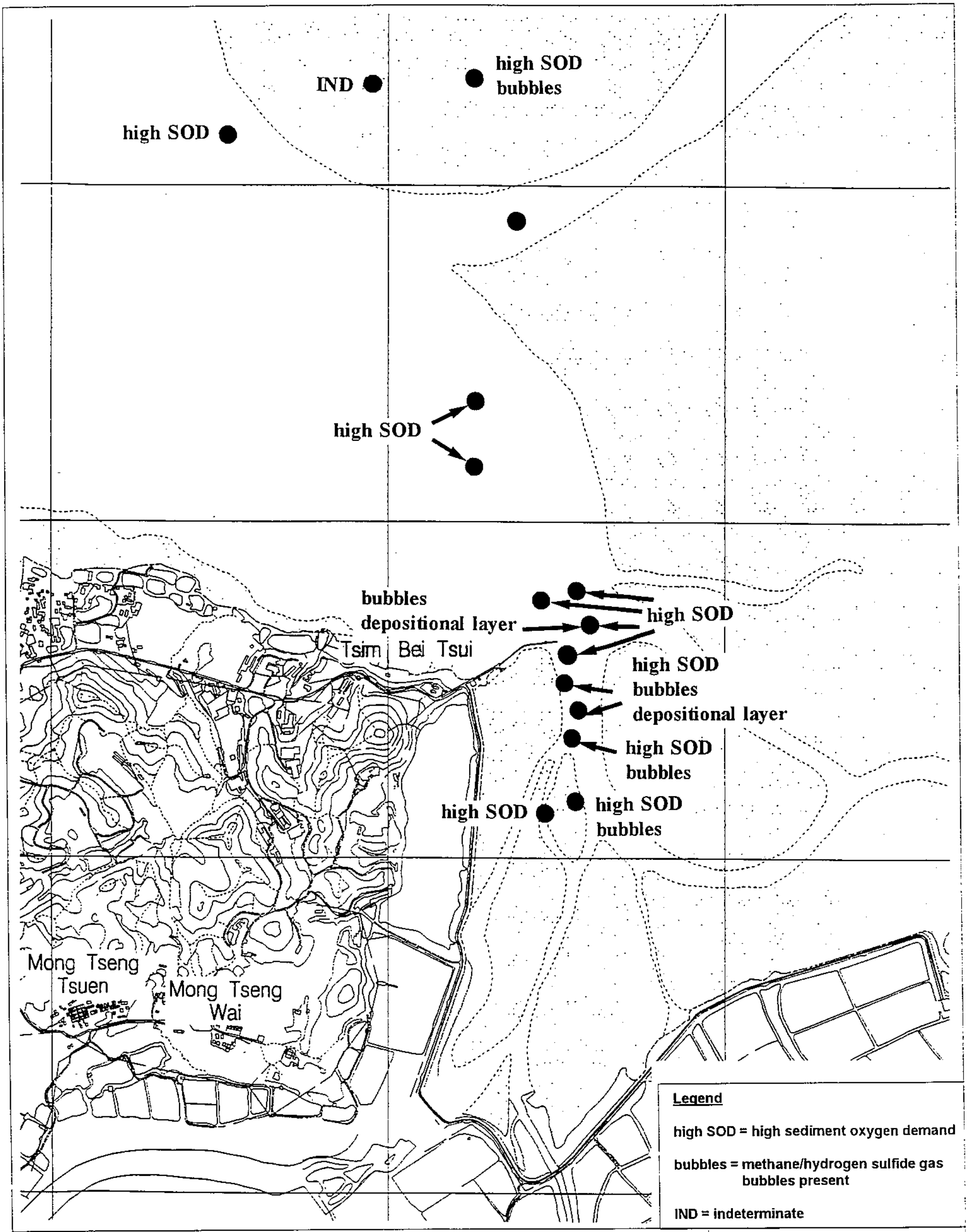
ENGINEERING INVESTIGATIONS FOR DEVELOPMENT OF AREAS 3, 30 & 31 OF THE DEVELOPMENT ZONE AND THE RESERVE ZONE

BINNIE CONSULTANTS LIMITED 賓尼工程顧問有限公司 ENGINEERS AND SCIENTISTS 賓尼

Title :

AVERAGE REDOX-POTENTIAL DISCONTINUITY (RPD) DEPTH, IN CENTIMETERS, AT INNER DEEP BAY REMOTS STATIONS

Figure No.	Revision
E4.12	0
Reference No. -	File Name -
Prepared MC	Checked SMc
Date NOV 96	Scale N.T.S.



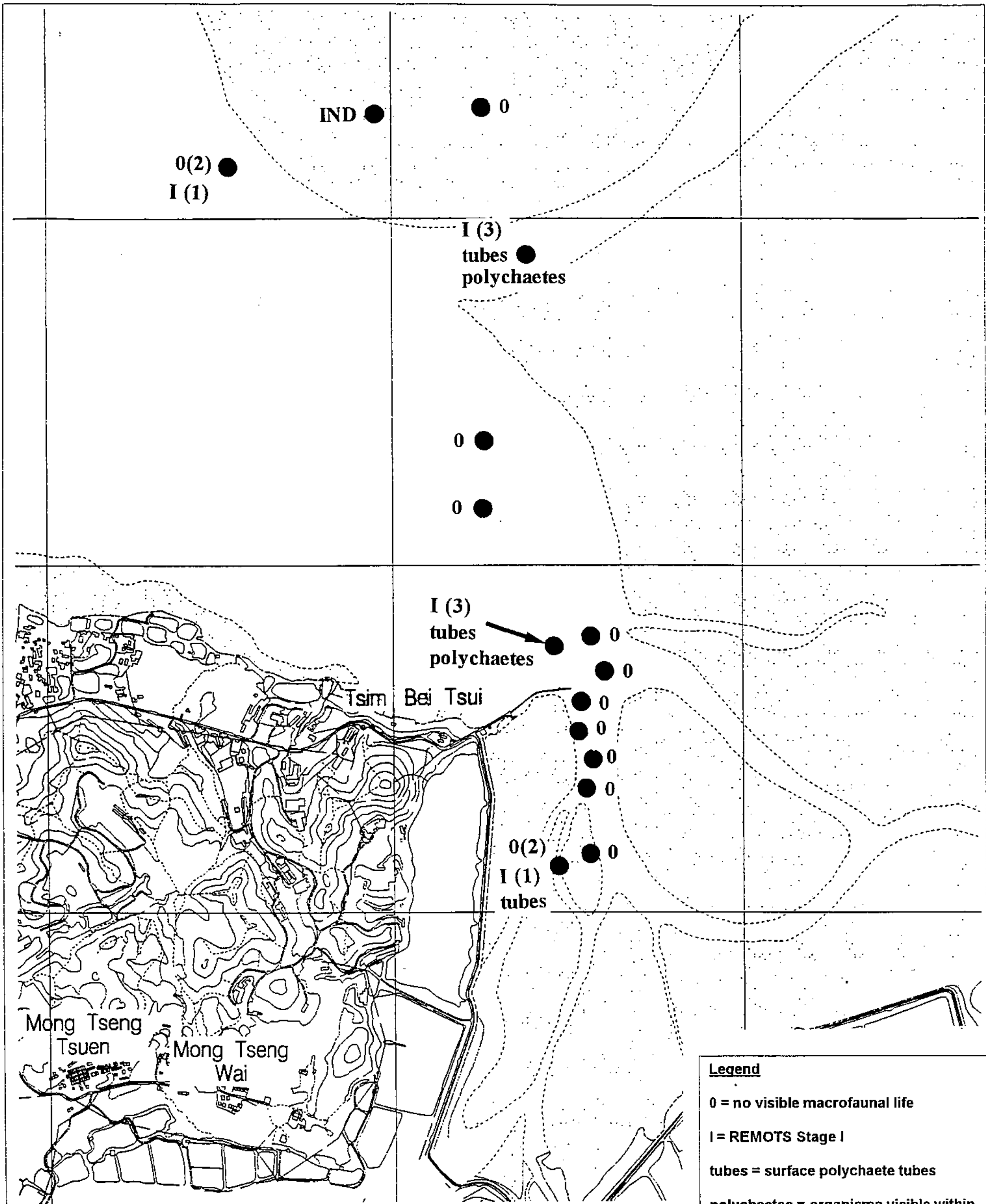
TIN SHUI WAI DEVELOPMENT
AGREEMENT NO. CE 10/95
ENGINEERING INVESTIGATIONS FOR DEVELOPMENT OF AREAS 3, 30 & 31 OF THE DEVELOPMENT ZONE AND THE RESERVE ZONE

BINNIE CONSULTANTS LIMITED
賓尼工程顧問有限公司
ENGINEERS AND SCIENTISTS
賓尼

Title :

KEY SEDIMENT CHARACTERISTICS AT THE INNER DEEP BAY REMOTS STATIONS

Figure No. E4.13	Revision 0
Reference No. -	File Name -
Prepared MC	Checked SMc
Date NOV 96	Scale N.T.S.



Legend

0 = no visible macrofaunal life

I = REMOTS Stage I

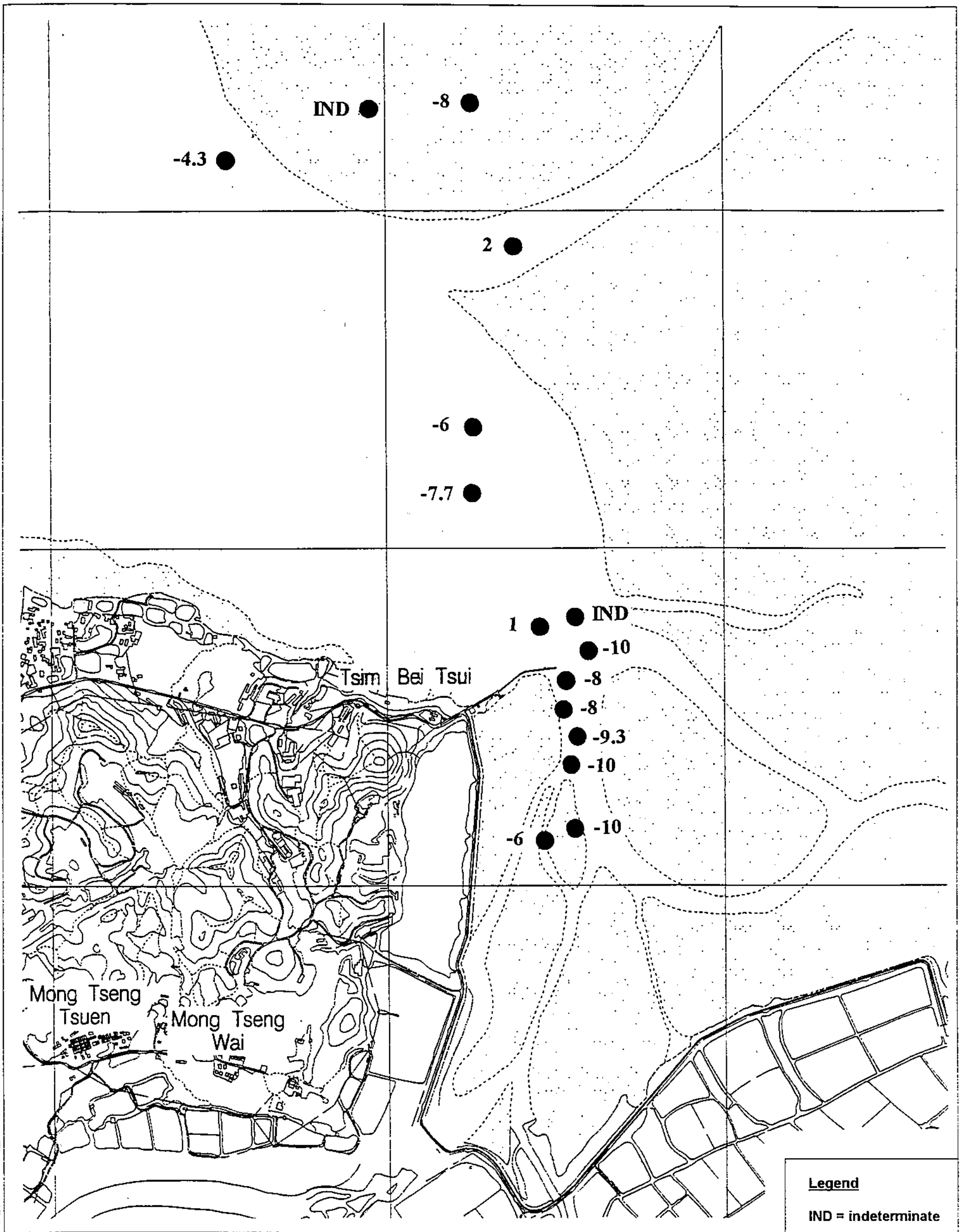
tubes = surface polychaete tubes

polychaetes = organisms visible within the sediment

IND = indeterminate

Note : The number of replicate REMOTS images showing a particular successional stage designation at each station is indicated in parenthesis.

TIN SHUI WAI DEVELOPMENT AGREEMENT NO. CE 10/95 ENGINEERING INVESTIGATIONS FOR DEVELOPMENT OF AREAS 3, 30 & 31 OF THE DEVELOPMENT ZONE AND THE RESERVE ZONE	Title : REMOTS SUCCESSIONAL STAGE DESIGNATIONS AT INNER DEEP BAY STATIONS	Figure No. E4.14	Revision 0
		Reference No. -	File Name -
BINNIE CONSULTANTS LIMITED 賓尼工程顧問有限公司 ENGINEERS AND SCIENTISTS		Prepared MC	Checked SMc
		Date NOV 96	Scale N.T.S.



TIN SHUI WAI DEVELOPMENT
AGREEMENT NO. CE 10/95

ENGINEERING INVESTIGATIONS FOR DEVELOPMENT OF AREAS 3, 30 & 31 OF THE DEVELOPMENT ZONE AND THE RESERVE ZONE

BINNIE CONSULTANTS LIMITED
賓尼工程顧問有限公司
ENGINEERS AND SCIENTISTS
賓尼

Title :

AVERAGE REMOTS ORGANISMS-SEDIMENT INDEX (OSI) VALUES AT INNER DEEP BAY STATIONS

Figure No. E4.15	Revision 0
Reference No. -	File Name -
Prepared MC	Checked SMc
Date NOV 96	Scale N.T.S.

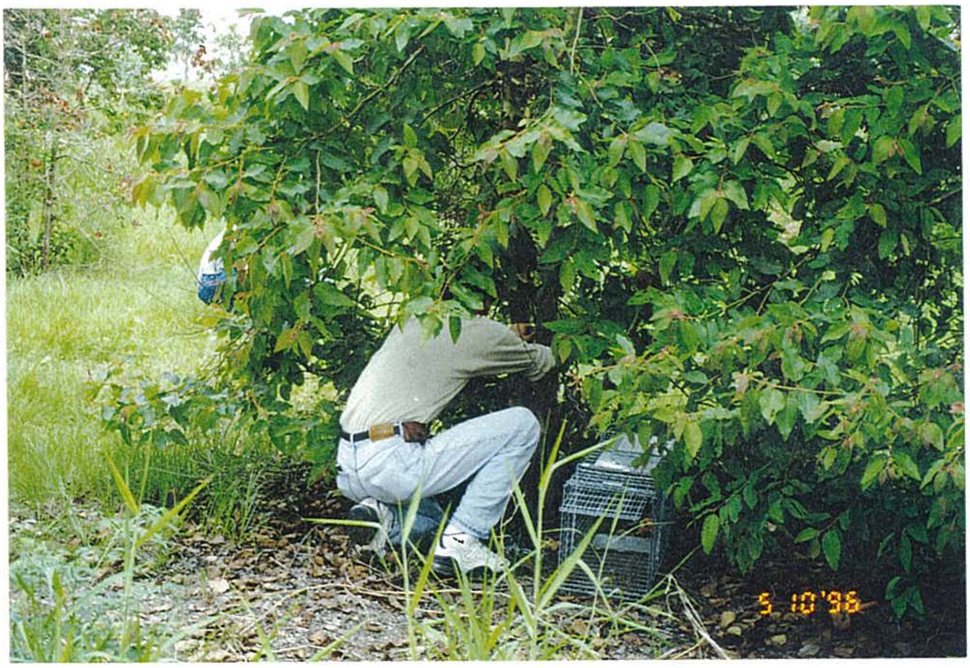


Plate E.4.1 Setting up mammal traps. Traps are set up under shade to reduce dehydration stress in trapped animals.

Plate E.4.2 The Javan Mongoose (*Herpestes javanicus*) standing on the trigger paddle.

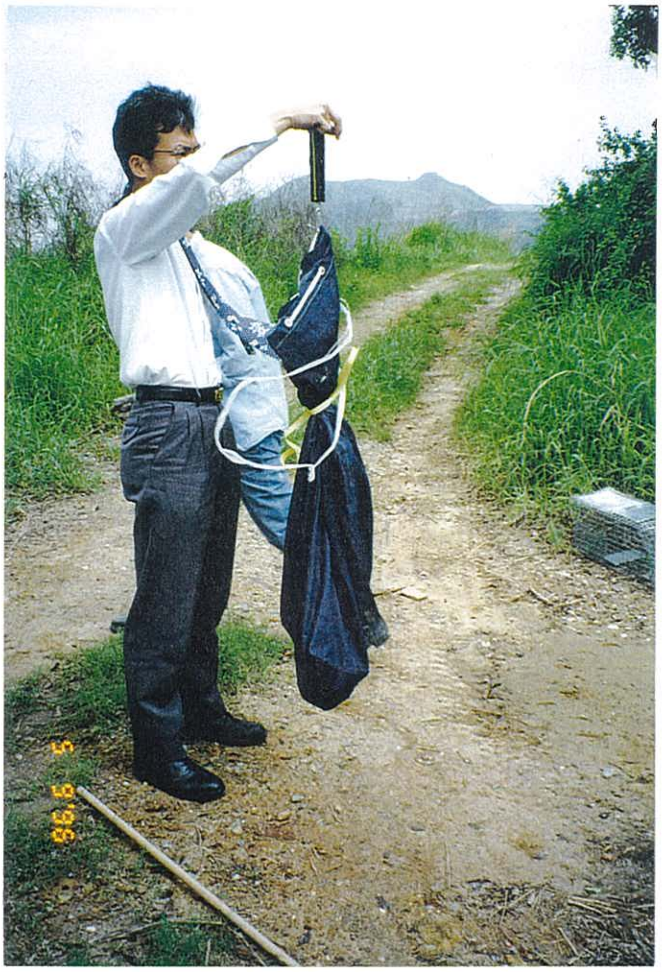


Plate E.4.3 Measuring and weighing of the mongoose.

Plate E.4.4 Releasing of mongoose after measurement (arrow).

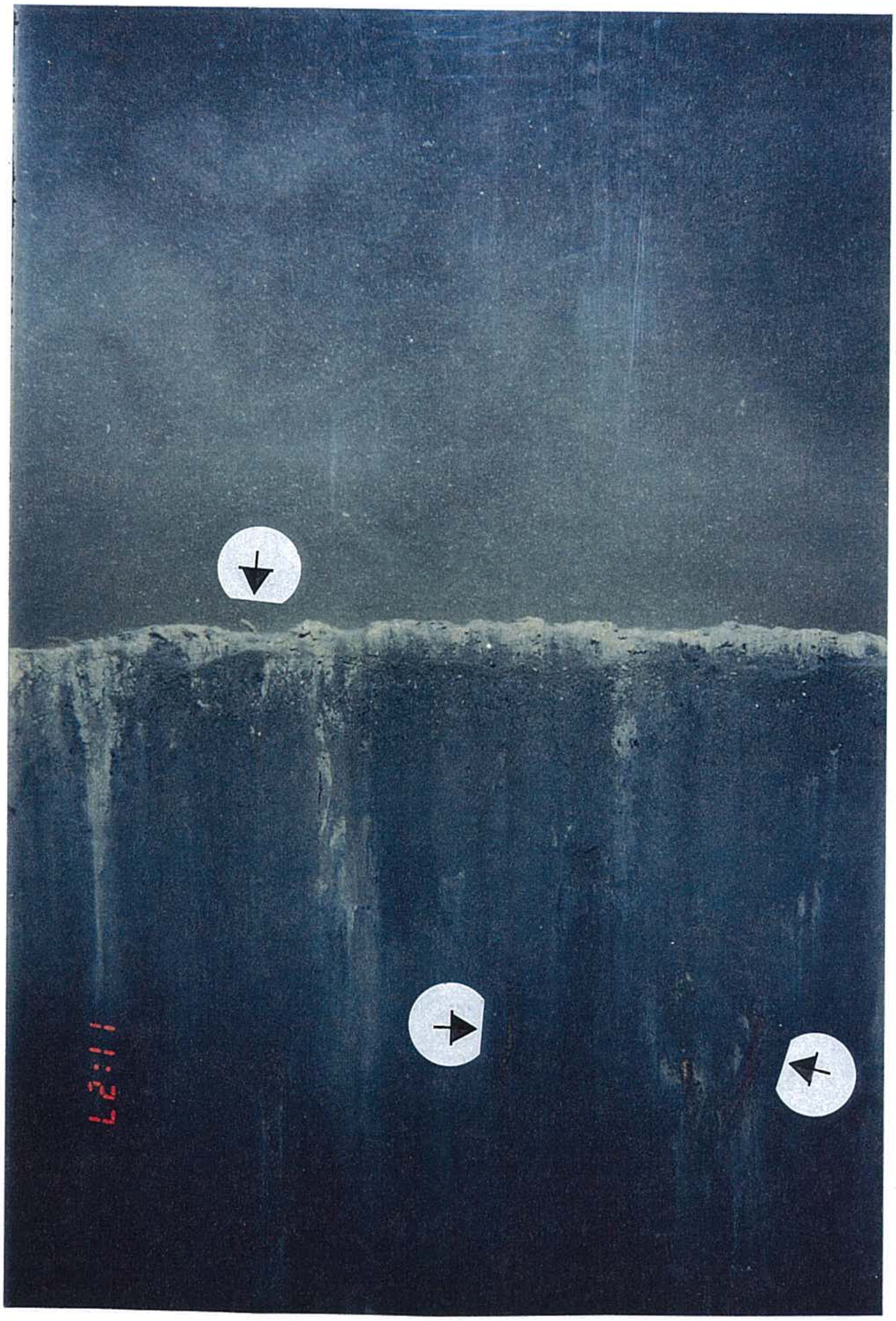


Plate E.4.5 REMOTS image from station 2 showing black, fine-grained sediment. A very thin (< 0.5 cm) layer of light-colored oxidized sediment occurs at the sediment-water interface. A polychaete tube is visible at the sediment surface (arrow), and several worms are visible at depth within the sediment (arrows). Scale: image width is 15 cm.

Plate E.4.6 REMOTS image from station 8 showing very black, anoxic sediment and numerous gas bubbles (arrow) within the sedimentary matrix. Scale: image width is 15 cm.

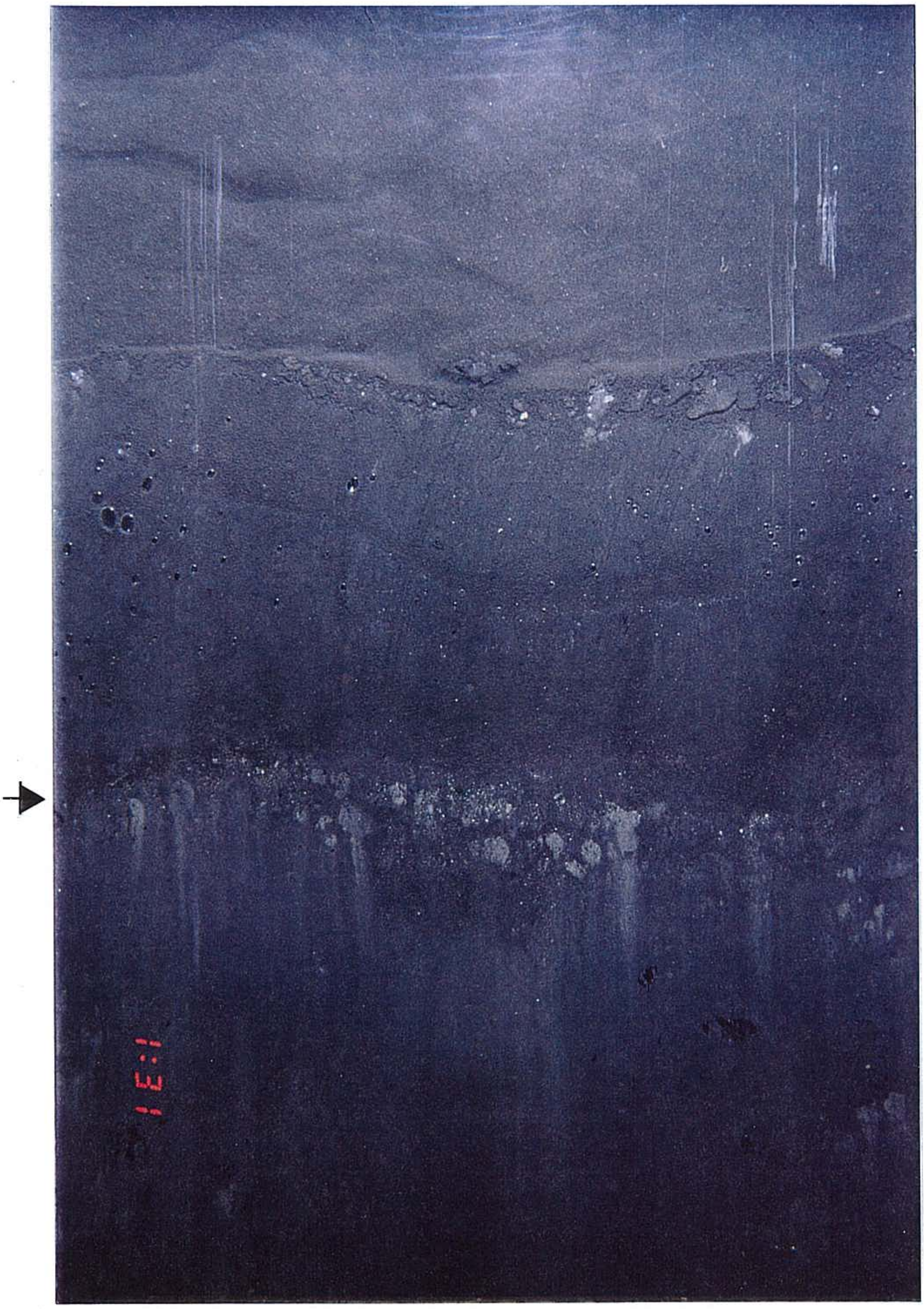


Plate E.4.7 REMOTS image from station 11 showing a surface depositional layer containing numerous small gas bubbles. An arrow marks the point of contact between the depositional layer and the previous sediment-water interface. Scale: image width is 15 cm.

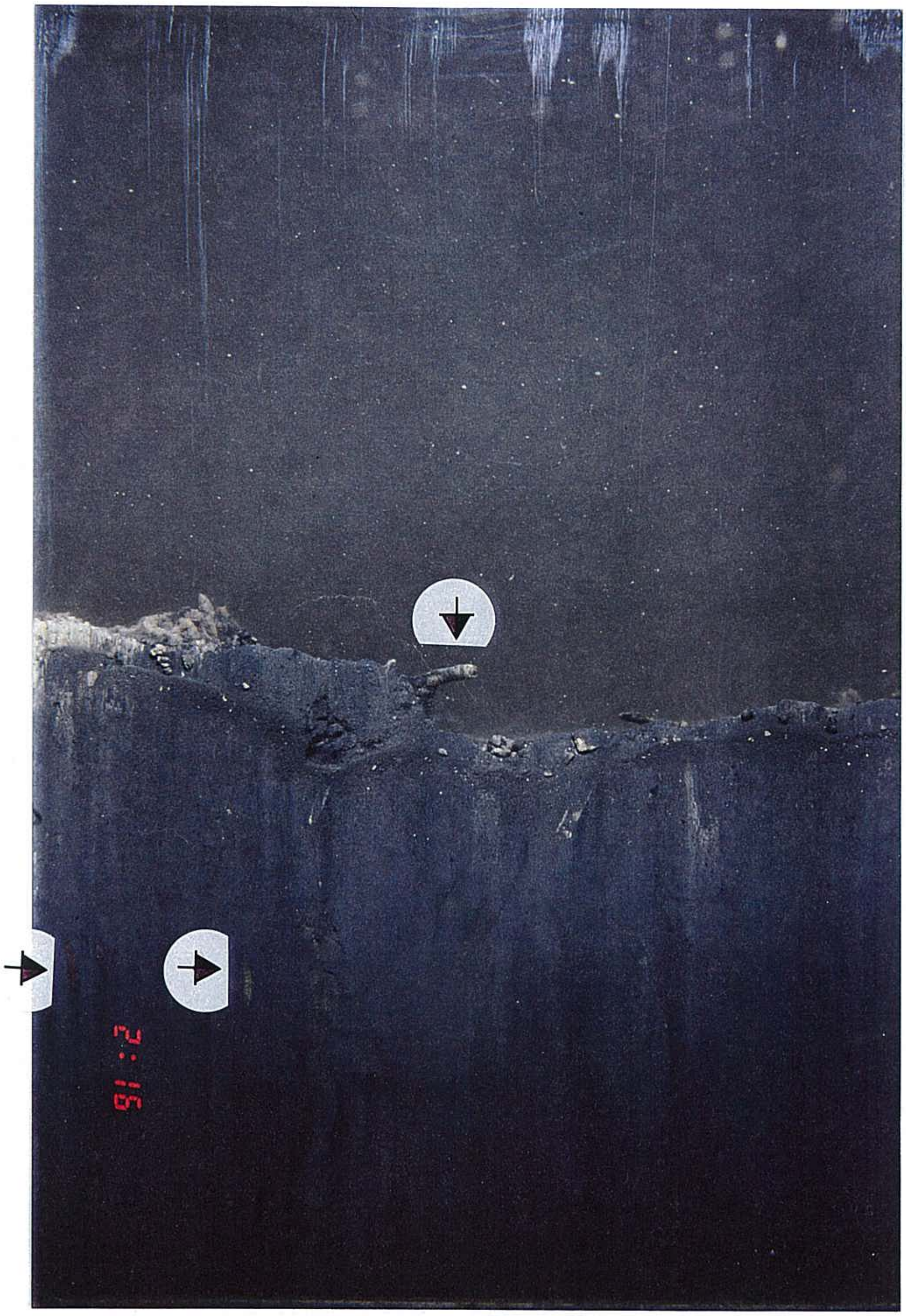


Plate E.4.8 REMOTS image from station 12 showing a polychaete tube at the sediment surface (top arrow) and worms visible within the sediment (arrows). Scale: image width is 15 cm.