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1 February 2017

Ms. Sharon Chung
Clerk to the Panel on Development
Legislative Council
Legislative Council Complex
1 Legislative Council Road
Central
Hong Kong

Dear Ms. Chung,

Panel on Development
Meeting on 16 December 2016
<u>Reports on Studies Related to the Work of the Proposed "Sustainable Lantau Office"</u>

In our reply letter dated 29 December 2016, we mentioned that the Highways Department was still working on the Final Report for the "Green Island Link Preliminary Feasibility Study". The related preparation work has been completed and the Final Report (English version only) is now enclosed for Members' reference.

Since the Study has been completed for more than 20 years, most of the contents of the report (including the planning and other assumptions) may no longer be applicable and thus can only be used for reference. Moreover, the cost estimates of the project mentioned in the Study are subject to amendments due to changes in various factors, including design amendment, revised implementation programme, fluctuation of construction price levels, etc. Therefore, the latest cost estimates of the project may be substantially higher or lower than their corresponding estimates given in the Study report.

Yours faithfully,

(Original Signed)

(Alan C W Wong)
for Secretary of Development

PSN 18090

HIGHWAYS DEPARTMENT - WESTERN HARBOUR LINK OFFICE

GREEN ISLAND LINK

PRELIMINARY FEASIBILITY STUDY

FINAL REPORT

FEBRUARY 1992

Volume 1: ENGINEERING FEASIBILITY

PAPM
CONSULTANTS

A joint venture of
PYPUN-HOWARD HUMPHREYS LIMITED
OVE ARUP & PARTNERS HONG KONG LIMITED
PARSONS BRINCKERHOFF (ASIA) LIMITED
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GREEN ISLAND LINK PRELIMINARY FEASIBILITY STUDY

FINAL REPORT

VOLUME 1 - ENGINEERING FEASIBILITY

CONTENTS

SUMMARY

1 INTRODUCTION

1.1 The purpose of this Preliminary Feasibility Study is to demonstrate the engineering feasibility and environmental acceptability of the proposed Green Island Link immersed tube road tunnel (in both dual 2-lane and dual 3-lane configurations) and its connections to the road systems on Lantau and Hong Kong Islands; to identify land and marine requirements for the project, including acceptable limits on dredging west of Green island; and to prepare outline designs and phased programmes for a 2004 opening date.

1.2 The Study commenced in May 1991, and tabled a Preliminary Environmental Assessment (PEPA) Paper in June 1991. The Study reported in August 1991 on conceptual designs for alternative alignments of the Link. Since August 1991, the Study has been engaged in development of outline designs for the chosen alternatives, and in demonstration of the environmental acceptability of these outline designs.

1.3 The Green Island Link Preliminary Feasibility Study assumes that the Green Island Reclamation, as envisaged in the Green Island Reclamation Feasibility Study, will go ahead as planned. An alternative arrangement of the Green Island landfall of the Link may be more appropriate if the reclamation is changed or is not required.

1.4 The Causeway connection to the Lantau Port Peninsula assumes a layout of the peninsula as envisaged by the Port and Airport Development Strategy, with the peninsula having reached Siu Kau Yi Chau by 2001. In the event that the Port Peninsula Development Study changes these assumptions, appropriate modification to Green Island Link may be required.

2 TRAFFIC

2.1 Strategic and sub-regional traffic models developed for 2011 provided traffic forecasts from which design figures for both dual 2-lane and dual 3-lane tunnel configurations operating at capacity were derived.

2.2 2011 peak hour demand flows were found to be reasonably close to the capacity of a dual 2-lane tunnel. 2011 tunnel demand flows were therefore factored to reach tunnel capacity, while background traffic was held at 2011 levels.

2.3 For the dual 3-lane case, differential growth factors were applied to tunnel and background demand flows to allow for the predicted four-five year period beyond 2011 it would take for a dual 3-lane tunnel to reach capacity.

3 CONCEPTUAL DESIGNS

3.1 From all alignment and design possibilities, a range of conceptual designs was developed, with due reference to the criteria of the PEPA Paper, for both dual 2-lane and dual 3-lane tunnels and for road connections on Lantau and Hong Kong Island. The feasibility and environmental acceptability of all these conceptual designs was established in broad terms. The feasibility of a dual 3-lane Green Island Link was found to depend on an increase in the capacity of the road network on the north coast of Hong Kong Island. How such increased capacity could be provided (in the form of a "Central By-Pass") has been considered.

3.2 Conceptual designs so identified were assessed comparatively against evaluative criteria which include environmental, highway, tunnel, geotechnical, land use, tunnel operation, marine and hydraulic, and cost standards.

3.3 Two options were selected for outline design: a conceptual design for a dual 2-lane tunnel from north of Green Island to the centre of Kau Yi Chau, which implied razing of the latter; and a conceptual design for a dual 3-lane tunnel design north of Green Island to north of Kau Yi Chau, which allows retention of the latter. The two selected do not represent a preferred choice for the particular tunnel configuration. The dual 2-lane configuration could equally follow the route of the dual 3-lane presented or vice versa. Final choice will also take into account the conclusions of the Lantau Port Peninsula Development Study.

4 OUTLINE DESIGN

Highway Design

4.1 Slip roads and link roads on approaches to the Link have been designed to a 70 km/h design speed. Tunnel vertical alignment was found to be controlled by the marine clearance required in the East Lamma Channel, carriageway levels falling from 5.5mPD at the portal to -36mPD in mid-channel. Gradients have been selected to avoid climbing lanes within the immersed tube tunnel, with 4% gradients and climbing lanes within cut and cover lengths only. A design speed of 85 km/h has been referred to for the tunnel section.

4.2 On Hong Kong Island, grade separated slip roads provide all movement connections between GIL and Route 7 at an interchange in the south east corner of Green Island Reclamation. All necessary road connections as envisaged by the Green Island Reclamation Feasibility Study have also been preserved. The interchange allows for a "Central By-Pass" in the case of a dual 3-lane GIL.

4.3 A toll plaza is allowed for at the western landfall, and the landfall is linked to the Port Peninsula development by a causeway.

Structures

4.4 Outline designs have been produced for both steel shell and concrete immersed tube units for a dual 2-lane tunnel, but for a dual 3-lane tunnel, an outline design has been produced only in concrete. It has thus been found feasible to design the immersed tube sections to meet all relevant criteria and to accommodate the necessary ventilation ducts.

4.5 In-situ construction in the dry in open excavation is envisaged for approach tunnels. Ventilation buildings will either be integral with the tunnel approaches, or will be independent structures floated into position above the immersed tube tunnel or approaches. The main administration building will be near the toll plaza on either Kau Yi Chau or reclamation. The outline design of the Port Peninsula Causeway is for construction on reclamation.

Tunnel Services

4.6 Outline designs have been produced for ventilation, power supply, lighting, drainage, fire protection, traffic control, building services, and cross adits.

4.7 Haze criteria have been found to govern ventilation design, and the system identified will both satisfy standards put forward by the consultants and meet EPD requirements. A semi-transverse ventilation system is proposed, with 3km between ventilation buildings. Duct size may be varied along the tunnel length and has been determined so as to limit air velocity in the duct.

Marine & Navigation Considerations

4.8 Total vessel movement through the tunnel site in 2001-3 has been estimated, and possible arrangements for marine traffic during construction of the Link have been identified on the basis that the width of the main part of the waterway occupied by construction plant will not be allowed to exceed about 700m, and on the basis that by 2001, VTC will have moved towards control of individual vessels along the lines of air traffic control.

Geotechnical and Marine Site Considerations

4.9 Outline design work has been based upon the considerable amount of geotechnical information assembled and supplemented by sampling and testing carried out during the course of the Study. The geological succession consists of marine deposits overlying alluvium and decomposed granite and granite bedrock.

4.10 Hydraulic studies indicate that upon completion of the causeway and Port Peninsula, extensive scour will occur across the route of the Link, with increases in ultimate water depth of 10 - 18m. This will have the effect of developing deep scour holes to the north and south of the tunnel route, the depth of scour being broadly limited to the top of the alluvium layer. Scour protection for the tunnel itself has been designed, and 250mm rocks and coarse 25mm gravel with a thickness of 1-1.5m are proposed. Rates of erosion of the seabed north and south of the tunnel are expected to be low, and bed level changes, and the need for dumping of additional armour, will be easily monitored.

4.11 On the approaches to Green Island and Kau Yi Chau, it is proposed that marine deposits be removed both from under the immersed tube tunnel and from under the cut and cover tunnel lengths.

4.12 The extent of the South Tsing Yi Borrow Area potentially sterilized by the GIL has been identified. Only a small proportion of the sand resource in BP4, the southern-most borrow-pit, is affected.

4.13 One of the designed alignments implies razing of Kau Yi Chau. This could be carried out in two phases, one for soil, the other for rock. Soil material excavated is expected to be suitable for general fill. Rock would be suitable for rock fill, although in some areas rock of larger size suitable for armour protection could be expected.

4.14 The total quantity of excavated material for disposal for the dual 2-lane configuration would be about 8.5M m^3, about 85% being (uncontaminated) marine mud. The quantity of excavated material for disposal for the dual 3-lane configuration is about 10.8M m3. Disposal sites would be subject to the requirements of the Fill Management Committee. About 12M m^3 of fill for the dual 2-lane tunnel, and about 17M m^3 for the dual 3-lane tunnel, would be required. Kau Yi Chau, if razed, would generate approximately 7.3M m^3 of fill.

5 CONSTRUCTION METHODOLOGY

5.1 North Green Island, Kau Yi Chau Landfall, Siu Kau Yi Chau, and the Port Peninsula itself, all constitute potentially suitable sites for a casting basin for concrete immersed tube units. Various areas have been identified as suitable for storing completed units.

5.2 Dredging to a maximum depth of about 42m will be required. Trailer suction hopper dredgers can possibly be modified for use at these depths, but final trimming by grab dredgers is likely to be required.

5.3 On the assumption that no breakwater to the west of Lamma Island is in place when the tunnel is being constructed, preliminary analysis indicates that wave heights from the south and southwest will exceed 1m about 6% of the time. 2-3 weeks of difficult conditions can thus be expected in any one year, with the worst conditions unlikely to persist for more than one week at any one time.

5.4 The tunnel site lies across a zone of current movement where surface water velocities of up to 1m/sec may occur, and the line of the tunnel lies almost perpendicular to flow. Sinking operations must therefore take place within slack-current "windows".

6 TUNNEL OPERATION

6.1 It is expected that by 2004, autotoll collection facilities will be feasible, and outline design of the toll plaza has assumed such facilities will be provided for GIL.

6.2 It is considered prudent to design traffic control and surveillance facilities to allow for tidal flow. Consideration has been given in outline design to measures related to entrapment of overheight and overweight vehicles, and to safety procedures in the event of fire, explosion and/or breakdown.

7 IMPLEMENTATION, CONSTRUCTION PROGRAMME AND COSTS

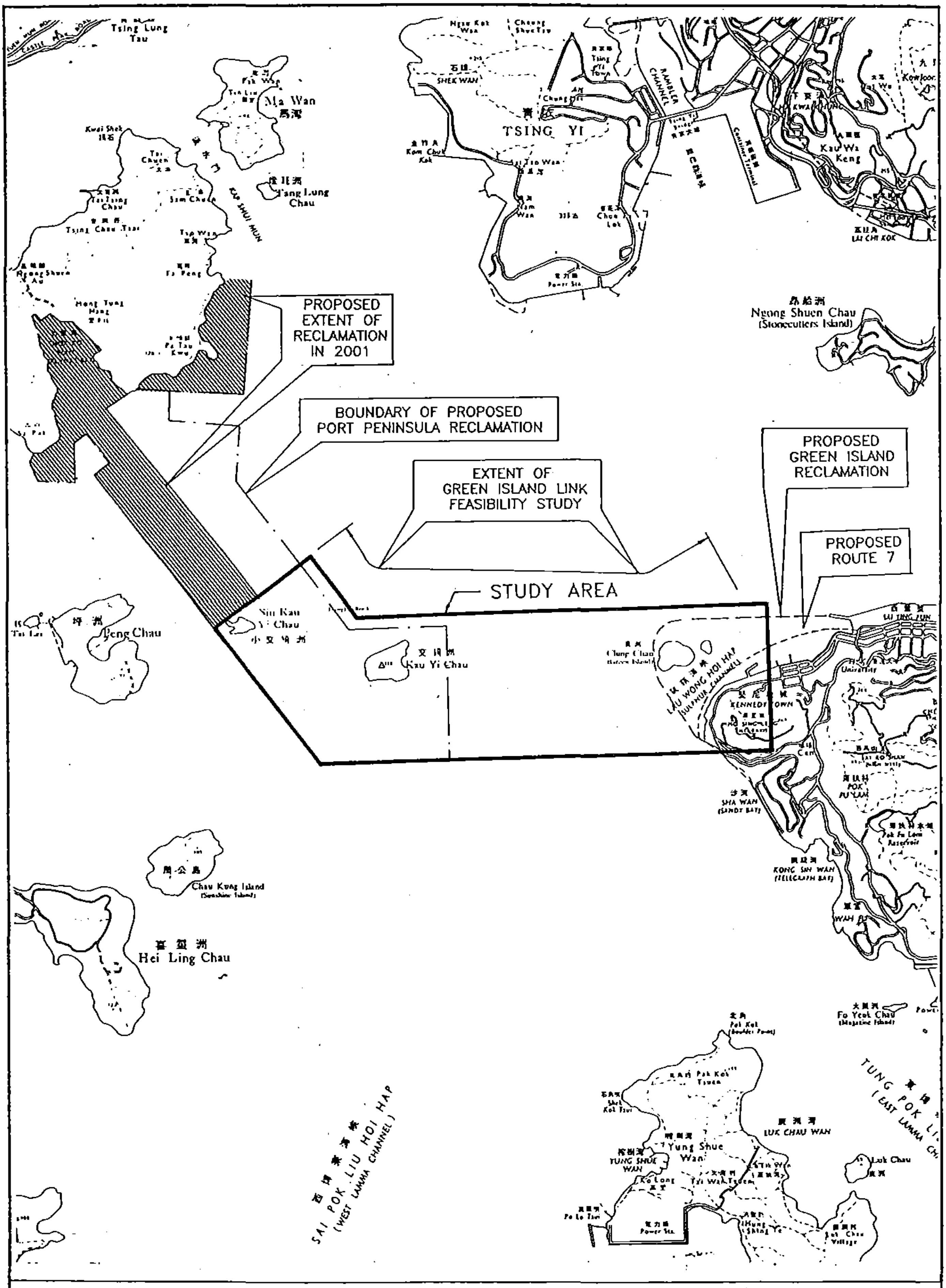
7.1 Construction programmes have been prepared for each type of tunnel aimed at completion of the GIL by 2004. It has been established that the programme for construction of Green Island Reclamation identified by the Green Island Reclamation Feasibility Study (GIRFS) team in response to their Study Brief is compatible with completion of the Link by 2004. It has further been established that a latest possible start date for construction of the reclamation of 1997, 18 months later than the GIRFS start date, will meet the programme requirement for a dual 3-lane concrete GIL tunnel (the option with the longest programme duration).

7.2 The cost of a dual 3-lane tunnel is estimated to be HK$12 billion, and of a dual 2-lane tunnel HK$9.6 billion at the valuation date of fourth quarter 1991.

E ENVIRONMENTAL ASSESSMENT

E.1 The Environmental work of the Study commenced with the production in June 1991 of a Preliminary Environmental Assessment (PEPA) Paper. This Paper reviewed the pre-existing situation, identified the main environmental issues, and set out guidelines for reference by the Study Team in the identification, development, and choice between, conceptual schemes. Thereafter, environmental input to the Study continued through outline design, and as designs developed, so environmental impact and mitigatory measures were both identified, and are reported in Volume 4 of this Report in the form of a Preliminary Environmental Assessment.

E.2 Chapter 8 of Volume 4 is in the form of a summary "Statement of Environmental Impact" of the Green Island Link.



GREEN ISLAND LINK PRELIMINARY FEASIBILITY STUDY

HIGHWAYS DEPARTMENT	KEY PLAN	PAPM CONSULTANTS

CHAPTER 1

1 INTRODUCTION

1.1 STUDY BACKGROUND

1.1.1 On 11 October 1989, the Government announced its intention to proceed with the construction of a replacement airport at Chek Lap Kok with a target opening date in early 1997. The associated port development, as proposed in the Port and Airport Development Strategy Study, will be concentrated mostly in the Western Harbour. Initially, this will consist of construction of Container Terminals 8 and 9 at Stonecutters Islands and Tsing Yi respectively. Subsequent port development will be arranged along a proposed peninsula reclamation from south east of Tsing Chau Tsai to Kau Yi Chau.

1.1.2 Road access to the Port Peninsula development from Kwai Chung will be provided initially via Tsing Yi and the proposed Lantau Fixed Crossing. The Port and Airport Development Strategy Consultants in their Draft Final Report of July 1989 forecast that by about 2004, the increase in port and airport traffic would necessitate the provision of an additional road access from Hong Kong Island via Green Island known as the Green Island Link.

1.1.3 The Civil Engineering Department, assisted by the Territory Development Department, commenced a planning and engineering study, The Lantau Port Peninsula Development Study, on 12 August 1991 to determine the type, layout and timing of the proposed developments on North Lantau, including the Port Development. The scale and viability of this development is contingent upon the feasibility of the Green Island Link.

1.1.4 The Metroplan Final Technical Report on Transport forecast traffic flows using the Link of 150,000 pcu/day in about 2011 with maximal development on Lantau suggesting that the Green Island Link may have to be of dual 3-lane capacity to meet ultimate traffic demand.

1.1.5 The Study was therefore formulated to establish the engineering feasibility and environmental acceptability of this link. The Study commenced on 30 April 1991. The Study is a preliminary feasibility exercise, to be followed later in the decade by a full Feasibility Study.

1.2 STUDY OBJECTIVES

1.2.1 The primary objectives of the Study are stated in the Study Brief (Appendix B) as follows:

- to establish the feasibility and alignment of the immersed tube road tunnel and the road connections to the existing and planned road systems on Lantau and Hong Kong Islands for both dual 2-lane and dual 3-lane options;
- to prepare outline designs for the immersed tube tunnel including cross sections and spatial requirements for both dual 2-lane and dual 3-lane options;
- to identify acceptable limits and restraints on the proposed dredging west of Green Island;
- to identify the locations for disposal of marine mud and of sources of backfill;
- to advise the preliminary site investigation requirements necessary to assist the study;
- to identify the land and marine requirements for the Green Island Link project;
- to prepare outline designs of approach ramps, slip roads, temporary and permanent connecting roads and interchanges, and conceptual designs for the ventilation system, toll plaza, administration building, control areas and workshops;
- to determine the phasing and programming requirements, for the planned Western Harbour and Port Peninsula Developments and the Green Island Reclamation, necessary to permit the Green Island Link to be opened to traffic in 2004; and
- to demonstrate the environmental acceptability of the Green Island Link.

1.3 STUDY STRUCTURE

1.3.1 The principal objectives of the Study as outlined above are to enable Government to obtain confirmation of the engineering feasibility and environmental acceptability of constructing an immersed tube road tunnel from the proposed Green Island Reclamation to a landfall at Kau Yi Chau.

1.3.2 The approach to the Study has incorporated two main phases of work. The first phase from May 1991 to August 1991 established and developed conceptual designs for alternative alignments. These alternatives were then evaluated to determine two options, one each for dual 2-lane and dual 3-lane configurations, to be carried forward to outline design in the second phase of the Study.

1.3.3 Phase 2 of the Study from September 1991 to December 1991 further developed the two configurations on the chosen alignments to outline design level which included further consideration of:

- highway layout, alignment and interchange form;
- outline geotechnical design;
- outline structural design of immersed tube, cut and cover tunnel and open ramp cross-sections;
- conceptual design of ventilation, power, lighting and drainage;
- conceptual design of toll plaza, ancillary buildings, tunnel operation, traffic surveillance and control;

- design for mitigation of marine impacts including hydraulic modelling of scour effects and definition of impact on marine sand source; and
- preliminary environmental assessment of impacts both during construction and of the permanent works.

1.3.4 During the Study a number of Reports, Working Papers and Technical Notes have presented results and interim conclusions to the Steering Group and Working Groups. A schedule of all such papers is shown in Table 1.1.

TABLE 1.1 SCHEDULE OF PAPERS

No	Description	Date of Issue
	Reports	
R1	Inception Report	May 1991
R2	Draft Final Report	Dec 1991
	Working Papers	
WP1	Draft Design Standards Memorandum	June 1991
WP2	Preliminary Environmental Planning Assessment	June 1991
WP3	Limits and Restraints on Proposed Dredging and Impact on Marine Sand Source West of Green Island	Sept 1991
WP4	Conceptual Designs	Aug 1991
	Technical Notes	
TN1	Tunnel Ventilation - Air Quality Standards	July 1991
TN2	Derivation of Traffic Design Figures	Aug 1991
TN3	Speed and Vertical Alignment	Nov 1991
TN4	The Impact of Auto-Tolling on Toll Plaza Sizing	Nov 1991

1.4 LOCATION AND STUDY LIMITS

1.4.1 The Study boundaries for the Green Island Link are shown in the Brief in Appendix B. The western limit for the Study is located at Siu Kau Yi Chau to coincide with the boundary of the Lantau Port Peninsula in the year 2001 as envisaged by the Port and Airport Development Strategy (PADS). The eastern limit for the Study is Route 7 on the Green Island Reclamation which is assumed to be in place or under construction by 2001.

1.4.2 The northern and southern boundaries, as shown in Appendix B, were adequate to allow consideration of alignment possibilities between landfalls north and south of Green Island and a realistic range of alternative landfalls on the Lantau Port Peninsula envisaged by PADS.

1.5 PROJECT DESCRIPTION

1.5.1 The Green Island Link Preliminary Feasibility Study has examined the engineering feasibility and environmental acceptability of an immersed tube road crossing from the proposed Green Island Reclamation to Kau Yi Chau.

1.5.2 Conceptual designs for both dual 2-lane and dual 3-lane tunnel configurations were considered within the Study for a number of alternative alignments. From these, two were selected, one each for dual 2-lane and dual 3-lane, for further consideration to outline design and are shown in Figure 1.1. The two selected do not represent a preferred choice for the particular tunnel configuration. The dual 2-lane configuration could equally follow the route of the dual 3-lane presented or vice versa. Final choice will take into account also the conclusions of the Lantau Port Peninsula Development Study (see 1.5.12 below)

1.5.3 The dual 2-lane configuration identified in this report consists of a 3km long immersed tube which interfaces with cut and cover tunnels at either end. At the Green Island approaches, an approach tunnel of about 250m length is required for the roadway to rise up to ground level. The Green Island Reclamation Feasibility Study (GIRFS) proposed that the tunnel portal be located east of the landfall location in order to reduce severance, provide environmental mitigation and maximise land area; and accordingly this Study has located the tunnel portal as recommended by GIRFS. This necessitates a significant additional length of cut and cover tunnel. The position of the western landfall of the dual 2-lane tunnel necessitates the razing of Kau Yi Chau. This provides fill for the project, a construction platform adjacent to the landfall site and reduces the extent of reclamation and dredging with a corresponding reduction in water quality impact during construction.

1.5.4 This Report also presents a dual 3-lane configuration which has a similar landfall arrangement at Green Island Reclamation, but an alternative alignment which provides a western landfall to the north of Kau Yi Chau. The length of the immersed tube tunnel between interfaces with cut and cover approaches is 3070m. The western landfall for this configuration does not require the razing of Kau Yi Chau but necessitates a greater extent of reclamation than would be necessary for the option through the island.

1.5.5 The toll plaza and administration building containing the control centre, workshop and stores would be sited at Kau Yi Chau making partial use of the razed island for the dual 2-lane option or sited totally on reclamation for the dual 3-lane configuration. Remote end facilities would be provided at Green Island Reclamation comprising suitable accommodation for several recovery vehicles and associated staff together with a secondary control centre.

1.5.6 A causeway links the western landfall, in either location, to the extent of the Lantau Port Peninsula in 2004. The best indication, at present, of the likely extent of the Lantau Port Peninsula in 2004 is the 2001 layout indicated in the Brief. The construction form of this causeway has been selected to maintain maximum flexibility for the future land use planning on the Lantau Port Peninsula and to allow reclamation adjacent to the causeway when the Port Reclamation is extended.

1.5.7 Road connection at the east end of the Green Island Link comprise a full grade separated all movement interchange with Route 7, and connection to a "Central Bypass" in the case of the dual 3-lane Green Island Link. The interchange also provides for a connection to the Kennedy Town Public Cargo Working Area.

1.5.8 Both preferred alignments for the Green Island Link impact on the South Tsing Yi borrow area. The extent of the borrow area potentially sterilized represents only a small proportion of the sand source in BP4, the southern most borrow pit.

1.5.9 The Green Island landfall, approach roads and interchange with Route 7 lie wholly within the new reclamation proposed by the Green Island Reclamation Feasibility Study. Recommendations concerning phasing and form of the reclamation necessary for construction of the Green Island Link are contained within this Report.

1.5.10 An item of particular importance to the planning of the Link will be the future of Kau Yi Chau Island. i.e. whether the Island is preserved as a landscape feature, or whether it is razed. One of the two outline design alignments assumes the razing of Kau Yi Chau for the significant benefits it provides for the Green Island Link. The future of Kau Yi Chau and the incorporation of the Green Island Link within the Port Peninsula land use will be a matter for recommendation by the Lantau Port Peninsula Development Study.

1.5.11 The Lantau Port Peninsula Development Study (LPPDS) commenced in August 1991, some three and a half months after the commencement of this (GIL) Study, and liaison has been maintained with the LPPDS team during the months of concurrency of the Studies.

1.5.12 Although the final outline for continuance through to completion of the LPPDS will not be chosen until after completion of this (GIL) Study, the range of conceptual outlines for development of the Port Peninsula has now been identified by the LPPDS team. The range under current consideration includes conceptual outlines with landfalls located to the south of Kau Yi Chau as well as with landfalls located centrally and to the north of the island. However, the range is compatible with the provision of the Green Island Link within the Corridor examined in this (GIL) Study, and the results of this (GIL) Study thus provide a satisfactory basis for future development of a preliminary design for the Link compatible with the final LPPDS landfall location wherever this is chosen to be on the Peninsula.

1.6 SCOPE AND FORM OF THIS REPORT

1.6.1 This Report is the Final Report of the Green Island Link Preliminary Feasibility Study. It contains proposals for the form and alignment of the Green Island Link at outline design level. It also describes the impact of these proposals. It is presented in four volumes:

- Volume 1, Engineering Feasibility (this volume), describes the proposed alignment and form for both dual 2-lane and dual 3-lane configurations of the Link and sets out the traffic, highway, geotechnical, structural, construction and operational issues addressed;
- Volume 2, Drawings, is complementary to Volume 1 and contains engineering drawings showing the layout, alignment and form of the Link;
- Volume 3, Site Investigation, describes the details and results of land and marine based site investigations undertaken for this Study; and
- Volume 4 Preliminary Environmental Assessment, describes the probable effects of the Link on the environment during construction and operation, and the monitoring and mitigation measures which should be implemented to minimise these effects.

1.7 FORM OF THIS VOLUME

1.7.1 Chapter 2, following this introduction, describes the methodology and input assumptions to achieve the traffic forecasts used for the outline design of the alignment and interchange form.

1.7.2 Chapter 3 describes the corridor alignments considered, the development of conceptual designs and the evaluation and selection of outline schemes.

1.7.3 Chapters 4, 5 and 6 describe the engineering design considerations of the highway, structure and tunnel service elements of the Link.

1.7.4 Chapters 7 and 8 describe the external restraints and influences of the marine, geotechnical and hydrological considerations.

1.7.5 Chapter 9 describes the construction methods which may be used for the Green Island Link.

1.7.6 Chapter 10 summarises the principal requirements for the tunnel operations.

1.7.7 Chapter 11 describes the requirements for implementation and construction of the project including programme and cost estimates.

1.7.8 Appendix A contains the Design Standards Memorandum, which sets out standards and guidelines for the development of the detailed design. It was originally issued in draft form as Working Paper WP1, and is now presented in revised form to reflect the design development undertaken in the Study.

1.7.9 Appendix B contains the Study Brief for reference.

1.7.10 Appendix C contains the comments received on the Draft Final Report circulated in December 1991 and PAPM's responses to those comments.

2 TRAFFIC STUDIES

2.1 GENERAL

2.1.1 This Chapter describes the methodology adopted for the production of traffic design figures and the traffic assessment for the Study.

2.1.2 The Study has prepared outline designs for both dual 2-lane and dual 3-lane options which include an interchange on Hong Kong Island and a landfall at Lantau Port Peninsula. Design figures for the Green Island Link options operating at capacity, rather than the usual 5 yearly demand forecasts, have been prepared for input to the engineering and environmental impact studies. It has been assumed for both dual 2-lane and dual 3-lane options that climbing lanes will be provided where gradients require.

2.1.3 To ensure consistency between various ongoing Government studies, vehicle and person trip matrices were provided by Transport Department for the design year 2011. The trip data was produced by Transport Department in October 1990 and the forecasts are derived from land use planning data supplied by Planning Department in July 1990.

2.2 MODELLING METHODOLOGY

2.2.1 The traffic model was developed in the Study to provide information to assist in the resolution of two main issues:

- interchange arrangements (ramp configuration and sizing) assuming either a dual-2 or dual-3 lane tunnel running at capacity; and
- broad assessment of the adjacent network to identify capacity constraints (if any) on the dual-2 or dual-3 lane tunnels running at capacity.

2.2.2 A two stage modelling process was adopted:

- a strategic model - to define the main movements likely to use the Green Island Link, and to determine the relative balance between the Link and the Lantau Fixed Crossing; and
- a sub-regional model - which is a more detailed sub-set of the strategic model, used for analysis of the broad network effects.

2.2.3 The main features of the strategic and sub-regional models are summarised below.

Strategic Model

2.2.4 The Strategic Network Assignment Model divides the Territory into 272 internal zones and 4 cross border zones. The 264 zones of the Government's model have been split into 276 zones to give more details within the future reclamation areas such as Green Island, West Kowloon, Kai Tak and Kowloon Bay. These traffic zones are shown in Figures 2.1 to 2.3 for Hong Kong Island, Kowloon and the New Territories respectively.

2.2.5 To move from the Strategic Model down to the Sub-Regional Model (SRM), a cordon is constructed around the SRM boundary. The flows crossing these corridor points are then fixed and become the boundary conditions for the SRM. In this way, the major corridor flows remain compatible between the two models.

Sub-Regional Model

2.2.6 The more detailed level of the hierarchical assignment modelling procedure is the SRM. This model covers the whole of Hong Kong Island with flows through the Cross Harbour Tunnel, the Eastern Harbour Tunnel, the Western Harbour Tunnel and the Green Island Link.

2.2.7 The SRM has been created by taking the Green Island Area Model from the Green Island Reclamation Study and extending it eastwards to cover the whole of the Hong Kong Island.

2.2.8 The SRM covers 57 CTS-2 traffic zones. The zones closest to the entrance to the Green Island Link, i.e. Green Island Reclamation, Kennedy Town, Shek Tong Shui, Sai Ying Pun and Pokfulam, have been sub-divided into smaller zones to enable the traffic movements around the eastern portal of the Green Island Link to be modelled in more detail.

2.3 INPUT ASSUMPTIONS

2.3.1 The main input assumptions made in the preparation of the trip matrices supplied by Transport Department are summarised below. These were extracted from a letter from the Territory Transport Planning Division (ref TTS 171/200/9). Full details are given in Technical Note No.2 : Derivation of Traffic Design Figure, circulated in August 1991.

Economic Growth

2.3.2 The projections on Gross Domestic Product (GDP) between 1990 and 2000 were provided by Census and Statistics Department in September 1989. They were subsequently updated by Economic Services Branch in February 1990 for the period between 1990 and 1996. The GDP growth assumptions are shown in Table 2.1

TABLE 2.1 LONG TERM GROSS DOMESTIC PRODUCT (GDP) PROJECTIONS

Period	Annual Growth Rate (%)
1991 - 1994	5.5
1995 - 1996	6.0
1997 - 2001	5.5
2002 - 2006	5.1
2007 - 2011	4.8

Note: Annual growth rates for the period 2007-2011 are assumed to be lower than those in 2002-2006 by 0.3 percentage point.

Planning Data

2.3.3 Land use data for 2011 were provided by the Planning Department from the Metroplan Study. Population and employment levels are forecast to drop along the existing north shore of the Island, whilst a rise is predicted in the South Island and on the new reclamation areas. In Kowloon, although additional population and employment have been allocated to new reclamation areas, the overall population and employment are expected to decrease. The older New Towns, Tsuen Wan and Sha Tin, which have already reached maturity are expected to remain stable or even decrease in population (in the case of Tsuen Wan). The other New Towns will gradually develop as planned, resulting in an overall population increase in the New Territories.

2.3.4 The planning data have been summarised to 28 sectors as shown in Table 2.2. The geographic definition of the sectors is shown in Figures 2.4 to 2.6.

2.3.5 A transport infrastructure development programme for the period up to 2011 has been developed by Transport Department for use in transport projects. In line with this programme the following highway and rail networks were adopted for producing the travel forecasts.

2.3.6 The 1996 highway network is assumed to comprise the existing network plus the following major routes:

- New Territories Circular Road improvements (Mai Po to Au Tau, & widening to dual 3-lane under Phase VI);
- Yuen Long - Tuen Mun eastern corridor and Yuen Long west link;
- Kwai Chung Road improvements;
- Route 3 (Western Harbour Crossing);
- Route 3 (West Kowloon Expressway);
- Route 3 (CRA1);
- Lung Cheung Road and Ching Cheung Road improvements (Lai Chi Kok Park to Lion Rock Tunnel);

- Lantau Fixed Crossing;
- North Lantau Expressway;
- West Kowloon Corridor - Yau Ma Tei Section;
- Yuen Long Southern Bypass;
- Route 7 (Sai Ying Pun to Kennedy Town) (including Belcher's Bay Link);
- Tin Shui Wai west access;
- Texaco Road improvements - Phases 1 and 2;
- Route 5 extension from Shek Wai Kok to Chai Wan Kok; and
- Tin Shui Wai east access and Long Ping estate link.

2.3.7 The 2001 highway network consists of the 1996 network plus:

- North Tsing Yi Coastal Road;
- Route 3 (Country Park); and
- Hung Hom Bypass and Princess Margaret Road Link.

2.3.8 The 2006 highway network is the 2001 network plus:

- Island Eastern Corridor Link (Causeway Bay to Wan Chai)
- Central & Wan Chai Bypass
- Route 16 between West Kowloon and Sha Tin
- Central Kowloon Route
- Route 7 (Kennedy Town to Aberdeen)
- Green Island Link

2.3.9 The 2011 highway network is the 2006 network plus:

- Route 3 (CRA4)
- Ma Wan - Sham Tseng Link
- Kai Tak Connector (between Kai Tak and Kwun Tong)
- Boundary Street Flyover (West)

2.3.10 The 1996 and 2001 rail network includes the existing rail system plus the Airport Railway, the North West Railway Regional Link of the LRT, which includes the Tin Shui Wai Link (Stage 1), the Tuen Mun North East Link and North-west Railway Regional Links: Tin Shui Wai Link (Stages 2 & 3), Pier Head-Yau Oi, and Yau Oi-Sham Shing. The MTR extensions to both Tseung Kwan O and the North West New Territories are included in the 2006 rail network. The 2011 rail network includes the MTR urban rail line through Central Kowloon, extended to Tai Wai via Diamond Hill.

TABLE 2.2 PLANNING DATA FOR 1986 AND 2011

SECTOR	1986 POP	2011 POP	1986 EMP	2011 EMP
1 Western	176542	162250	67649	70856
2 Central & Sheung Wan	82498	87730	194113	223399
3 Wanchai & Causeway Bay	224572	193030	157457	212672
4 Eastern	475274	506350	146333	195159
5 Southern	248624	284610	77278	99228
6 Green Island Reclamation	0	113960	0	28512
7 Central & Wanchai Reclamation	0	14550	0	62820
HONG KONG ISLAND SUB-TOTAL	1207510	1362480	642830	892646
8 Tsim Sha Tsui	46206	47160	104655	124396
9 Yau Ma Tei	122457	62690	80816	66287
10 Mong Kok	200985	128100	123505	86030
11 North West Kowloon (Sham Shui Po)	328604	242440	213778	133397
12 Hung Hom & Ho Man Tin	352454	311020	151851	93503
13 Kowloon Tong	143651	87290	27377	28280
14 North East Kowloon (Wong Tai Sin)	515670	411190	154060	108404
15 East Kowloon (Kwun Tong)	666180	516650	309040	316901
16 West Kowloon Reclamation	0	82380	0	55875
17 Kai Tak & Kowloon Bay Reclamation	215	262520	18603	109857
KOWLOON SUB-TOTAL	2376422	2151440	1183685	1122930
18 Tsuen Wan & Kwai Chung	576540	449330	304879	306091
19 Tsing YI & Container Port	74810	155830	40763	122538
20 Tuen Mun	286460	436480	124583	155952
21 Yuen Long & Tin Shui Wai (& Kam Tin)	243287	361110	86090	109235
22 Sheung Shui & Fanling	105177	196350	38992	61933
23 Tai Po	156551	286130	58023	75021
24 Sha Tin	366354	438270	166519	111562
25 Ma On Shan	169	179000	13	32502
26 Junk Bay and South East N.T.	45825	367780	19346	110263
NEW TERRITORIES (excl Islands) SUB-TOTAL	1855173	2870280	839208	1085097
27 Lantau	45617	220740	5406	141188
28 Other Islands	2998	22200	3186	5222
ISLANDS SUB-TOTAL	48615	242940	8592	146410
TERRITORY WIDE TOTAL	5487720	6627140	2674315	3247083

Source: 1986 - Second Comprehensive Transport Study
2011 - Planning Department Transport Infrastructure

Legend: POP - Population
EMP - Employment

Traffic Restraint

2.3.11 Similar vehicle restraint assumptions as for the Port and Airport Development Strategy (PADS) have been adopted for producing the travel forecasts. The assumptions are:

- the number of cars have been assumed to grow at 5% per year;

- a 15% reduction has been applied to 2006 and 2011 car trips obtained through the 5% annual growth rate in the number of cars;
- non-port goods vehicle trips for 2006 and 2011 have been reduced by 25% compared with the number obtained by assuming a growth rate proportional to the GDP increase;
- port trips for 2006 and 2011 have been reduced by 15% compared with total trips generated by various port facilities including container ports, multi-purpose terminals and public cargo working areas based on the tonnage throughput; and
- it has been assumed that the airport railway will carry 55% of all airport passengers.

Toll Levels

2.3.12 The toll charges for the road tunnels and crossings which were assumed as inputs to the transport model are shown in Table 2.3.

2.3.13 Not only is the Green Island Link (GIL) the direct route to Lantau Island, but also in terms of tolls, travel between Lantau and Hong Kong Islands will be very much cheaper by the GIL. Travel between Lantau Island and West/Central Kowloon will be cheaper via the Lantau Fixed Crossing (LCF) ($30) than via the GIL and Western Harbour Crossing or Cross Harbour Tunnel ($20+$20 = $40). Travel between East Kowloon and Lantau Island will cost the same via LFC ($30) or via GIL and Eastern Harbour Crossing ($20+$10 = $30). Thus traffic between Lantau Island and East Kowloon, in toll terms, will have an equal choice, and will choose their route on a travel time and distance basis.

TABLE 2.3 ROAD TUNNEL TOLL CHARGES

Road Tunnel/Crossing	Toll Charges HK$ (1990 Prices)
Lantau Fixed Crossing	30
Green Island Link	20
Ma Wan - Sham Tseng Link	20
Cross Harbour Tunnel	20
Western Harbour Crossing	20
Eastern Harbour Crossing	10

Note: The above toll charges are for private cars. Tolls for other vehicles will be at the same ratio to those of private cars as at present for similar facilities.

Airport Related Travel

2.3.14 The forecast of airport related trips was produced from a sub-model developed by PADS. The total number of trips generated, however, was a function of the number of terminating air passengers which was taken from the Alternative Replacement Airport Sites Study. The distribution of the air passenger related trips was correlated with the total number of hotel rooms and households with high income level on a zonal basis.

Port

2.3.15 The forecasts of the total trip ends by goods vehicle type using each type of port facility, including container ports, multi-purpose terminals and public cargo working areas, were based on the Territory's tonnage throughput of cargoes.

2.4 TRAFFIC FORECASTS

2.4.1 To ensure that the approach ramps, interchange and connecting roads do not pose a constraint on the ultimate tunnel capacity, it was necessary to examine both dual 2-lane and dual 3-lane configurations operating at capacity. Figures for alternative alignment options were investigated to enable comparison between these alignments in the first phase of the Study.

2.4.2 Discussions were held with Transport Department and a methodology agreed for producing the dual-2 lane and dual-3 lane traffic forecasts.

2.4.3 The 2011 forecasts do not produce traffic levels which are equivalent to either a dual-2 or dual-3 lane tunnel operating at capacity. Traffic forecasts were therefore required for an unknown year beyond 2011 when the tunnel would be at capacity.

Dual 2 Lane Tunnel

2.4.4 The 2011 peak hour demand traffic flows through the links were reasonably close to a dual 2 lane tunnel capacity. It was agreed, for this case, that the tunnel demand flows would be factored to capacity, while background traffic on the surrounding network would be held at 2011 levels. This was considered a justifiable simplification for the purpose of this preliminary feasibility study.

Dual 3 Lane Tunnel

2.4.5 Because of the disparity between the 2011 demand traffic flows and the flow required to fill a dual 3 lane tunnel, it was agreed that an alternative methodology should be adopted in this case. Likely growth rates through the tunnel were examined and compared with likely growth rates on the Hong Kong Island network. Differential growth factors were applied to produce traffic forecasts which represented some year in the future, beyond 2011, when the tunnel would be at capacity. The details of the factors applied are given below.

2.5 TRAFFIC FLOWS FOR DESIGN

Dual 2 lane Capacity Tunnel

2.5.1 The 2011 traffic flows were examined with a dual 2 lane tunnel. Green Island Link flows through the alternative conceptual alignment options are not significantly different. The peak hour 2011 demand flows for the GIL and all the cross harbour tunnels are given in Table 2.4

TABLE 2.4 PEAK HOUR DEMAND FLOWS THROUGH THE GIL AND HARBOUR CROSSINGS - 2011 DUAL 2 GIL (PCUS PER HOUR)

Direction	WHC	CHT	EHC	GIL
AM Peak				
Away from Hong Kong	5400	3500	4000	3500
Towards Hong Kong	6800	4700	4000	3500
PM Peak				
Away from Hong Kong	5800	4200	4300	3000
Towards Hong Kong	4700	3500	3600	3300

Note: WHC - Western Harbour Crossing; EHC - Eastern Harbour Crossing; CHT - Cross Harbour Tunnel; GIL - Green Island Link

2.5.2 The highest flows, in the AM peak, represent 83% of the capacity in both the eastbound and the westbound directions. To produce dual 2 flows for a tunnel operating at capacity, the dual 2 flows were factored pro-rata by 1.2 in both directions. These figures represent only 2 years growth at 9% per annum, thus a simple pro-rata was sufficient for interchange design. No changes were made to the base flows on the other routes, other than to add the additional tunnel traffic. Traffic distribution pattern to and from the tunnel was maintained. The peak hour flows for a full dual 2 lane GIL and the corresponding flows on the other cross harbour tunnels are given in Table 2.5. These flows represent demand flows, and it can be seen that the Western Harbour Crossing and the Cross Harbour Tunnel are overloaded in the morning peak towards Hong Kong.

2.5.3 The analysis has incorporated a restraint on the Western Harbour Crossing flow (from 6,900 pcus to 6,500 pcus) and on the Cross Harbour Tunnel flow (from 4,700 pcus to 4,200 pcus) to reflect the maximum possible peak hour flow through the tunnels. The difference between demand and restrained flows indicated in Table 2.5 shows that there would be peak hour queuing on the Kowloon side in the morning peak.

TABLE 2.5 PEAK HOUR DESIGN FLOWS THROUGH GIL AND HARBOUR CROSSINGS FULL DUAL 2 CASE (PCUS PER HOUR)

Direction	WHC	CHT	EHC	GIL
<u>AM Peak Hour Demand Flow 2011 (plus)</u>				
Away from Hong Kong	5600	3500	4100	4200
Towards Hong Kong	6900	4700	4200	4200
<u>AM Peak Hour Flow but Cross Harbour Restrained 2011 (plus) Design Flow</u>				
Away from Hong Kong	5600	3500	4100	4200
Towards Hong Kong	6500	4200	4200	4200

Note: WHC - Western Harbour Crossing; EHC - Eastern Harbour Crossing; CHT - Cross Harbour Tunnel; GIL - Green Island Link

Dual 3 Lane Capacity Tunnel

2.5.4 In 2011 a dual 3 lane tunnel will not be operating at capacity. It is forecast to attract under 10% more traffic than a dual 2-lane tunnel. The peak hour flows for the GIL and the cross harbour tunnels are shown in Table 2.6. Note, that again these are demand flows, and so some of the tunnels are overloaded.

TABLE 2.6 PEAK HOUR DEMAND FLOW THROUGH THE GIL AND HARBOUR CROSSINGS DUAL 3 CASE (PCUS PER HOUR)

Direction	WHC	CHT	EHC	GIL
<u>AM Peak</u>				
Away from Hong Kong	5700	3500	4100	3700
Towards the Island	6800	4700	4100	3700
<u>PM Peak</u>				
Away from the Island	5800	4200	4300	3100
Towards the Island	4700	3600	3700	3500

Note: WHC - Western Harbour Crossing; EHC - Eastern Harbour Crossing; CHT - Cross Harbour Tunnel; GIL - Green Island Link

2.5.5 Demand for additional capacity on the Green Island Link will be driven by two factors:

- capacity constraints on the Lantau Fixed Crossing and Ma Wan to Sham Tseng bridge, which are expected to have reached capacity in the peaks by 2011; and
- demands from Lantau traffic using Green Island Link and a harbour crossing to reach Kowloon Peninsula and South East New Territories, which is anticipated will be the major part of growth in demand for Lantau - Kowloon traffic, not Lantau - Hong Kong Island traffic.

2.5.6 The 2011 AM peak hour Green Island Link flows required factoring by 1.76 in both directions to reach the level at which a dual 3 lane tunnel was at capacity.

2.5.7 Traffic through the link was forecast to grow by an average of 9% per annum between 2006 and 2011. The growth of traffic on Lantau, however, averaged 10.5% and port growth was higher than this, averaging 13% per annum. The growth through the Green Island Link beyond 2011 was assumed to be 13% per annum. This was in line with an assumption that general traffic growth on Lantau Island would be reducing beyond 2011 as the New Towns reached maturity, and the port growth would probably slow into the future. This was balanced by the fact that the Lantau Fixed Crossing had reached capacity, thus most of the growth from the port must use the Green Island Link.

2.5.8 At an assumed annual growth rate of 13% it would take between 4 and 5 years for the dual 3 lane tunnel to reach capacity. An analysis of traffic growth for Hong Kong Island revealed that general growth will average about 3% per annum between 2006 and 2011. Thus the equivalent growth factor for Hong Kong Island traffic was 1.16 (assuming 5 years' growth). The above factors were applied on a zonal and cordon point basis.

2.5.9 The resulting design forecasts for each of the 4 cross harbour tunnels are presented in Table 2.7. It can be seen that the demands generated by the assumed 13% and 3% growth factors (for the Green Island Link and Hong Kong Island respectively) will overload the Western Harbour Crossing, the Cross Harbour Tunnel and the Eastern Harbour Crossing.

2.5.10 To overcome this, restrained forecasts have also been produced. Restraint has been applied to the tunnels so that they do not exceed capacity, the resulting design flows are shown in Table 2.7.

TABLE 2.7 PEAK HOUR DESIGN FLOW THROUGH GIL AND CROSS HARBOUR TUNNELS FULL DUAL 3 CASE (PCUS PER HOUR)

Direction	WHC	CHT	EHC	GIL
AM Peak Hour Demand Flow 2011 (plus)				
Away from Hong Kong	6700	4100	4700	6500
Towards Hong Kong	7900	5500	4800	6500
AM Peak Hour Flow but Cross Harbour Restrained 2011 (plus) Design Flow				
Away from Hong Kong	6500	4200	4200	6500
Towards Hong Kong	6500	4200	4200	6500

Note: WHC - Western Harbour Crossing; CHT - Cross Harbour Tunnel; EHC - Eastern Harbour Crossing; GIL - Green Island Link

Vehicle Mix

2.5.11 The vehicle mix is summarised in Table 2.8. This is a direct output of the CTS2 model boundary conditions which gives a 40% private vehicle, 60% goods vehicle split. The volumes are split into sub-categories based on an analysis of the current split at the CHT, EHC, Lung Cheung Road, and Kwai Chung Road within those categories. The goods vehicle flows using the GIL are expected to be dominated by port traffic and air cargo related. Lung Cheung Road and Kwai Chung Road carry largely port and industry related traffic. Based on the analysis the goods vehicles have been split into light, medium and heavy, as shown.

2.5.12 The statistics of current vehicle registration in Hong Kong by engines types, as shown in Table 2.8, are supplied by Transport Department. Based on the traffic mix shown in Table 2.9, it can be estimated that the split of petrol and diesel engines of vehicles using the GIL is as follows:

Petrol Engines:	32%
Diesel Engines:	68%

TABLE 2.8 CURRENT VEHICLE REGISTRATION BY ENGINE TYPES

Class	Total Registration	Petrol(%)	Diesel(%)	Electric(%)	Others(%)
Motor-cycle/ Motor-tricycle	22,336	22,334 (99.99)	2 (0.01)	-	-
Private Car	228,731	224,015 (97.94)	4,671 (2.04)	1 (0.00)	44 (0.02)
Taxi	17,520	4 (0.02)	17,516 (99.98)	-	-
Private/Public Bus	8,090	-	8,090 (100.00)	-	-
Private/Public Light Bus	6,903	80 (1.16)	6,823 (98.84)	-	-
Light Goods Vehicle	103,103	20,016 (19.41)	83,072 (80.57)	6 (0.01)	9 (0.01)
Medium Goods Vehicle	29,055	9 (0.03)	29,039 (99.94)	2 (0.01)	5 (0.02)
Heavy Goods Vehicle	851	-	850 (99.88)	-	1 (0.12)
Special Purpose Vehicle	253	14 (5.53)	178 (70.36)	36 (14.23)	25 (9.88)

TABLE 2.9 VEHICLE MIX BREAKDOWN

Vehicle Type	% of total
Car	25%
Motor Cycles	2%
Taxis	10%
Total Private Vehicles	**37%**
Light Goods	29.5%
Medium Goods	20%
Heavy Goods	11%
Total Goods Vehicles	**60.5%**
Single Deck Bus	0.5%
Double Deck Bus	2.0%
Total Buses	**2.5%**

Directional Split

2.5.13 The design figures, shown in Table 2.10, indicate the following splits for the AM Peak Hour in pcus.

2.5.14 The majority of traffic is eastbound along Route 7, this requires 2 lanes in simple capacity terms for the dual 2-lane option and 3-lanes for the dual 3-lane option. The requirement for the southbound traffic along Route 7 is a single lane in both the dual 2 and dual 3 option. The traffic to the ground level network also requires only a single lane in both options.

TABLE 2.10 AM PEAK HOUR DIRECTIONAL SPLIT (PCU PER HOUR)

	Dual 2-lane		Dual 3-lane	
	To GIL	From GIL	To GIL	From GIL
Route 7 Central	3400	2900	5100	4100
Route 7 South Island	500	500	900	900
Ground Level	300	800	500	1500
Total	4200	4200	6500	6500

2.5.15 The present design figures are based on current Government forecasts. Major changes in development levels at Lantau and Hong Kong Islands could affect the directional split at the Green Island landfall.

2.5.16 The sub-regional traffic model has been used to produce the dual 2 and dual 3 traffic from these 2011+ traffic forecasts. The resulting traffic flows for the dual 2-lane Link at the Green Island interchange, including lane provisions, are given in Figure 2.7.

2.5.17 The dual 3-lane tunnel running at capacity would overload the section of Route 7 between the interchange and the Hill Road Flyover. Alternative methods of overcoming this capacity constraint were therefore examined and are discussed further in Chapter 3. The resulting traffic flows at the Green Island interchange including lane provisions are given in Figure 2.8 for the dual 3-lane Link.

CHAPTER 3

3 CONCEPTUAL DESIGN

3.1 GENERAL

3.1.1 The first phase of the Study established a realistic range of alignment and design possibilities for a proposed Green Island Link immersed tunnel, including road connections with the existing and planned road systems on Lantau and Hong Kong Islands. These were developed into conceptual designs for both dual 2-lane and dual 3-lane configurations, then evaluated under all relevant headings.

3.1.2 The evaluation of the conceptual design alternatives to select one scheme for each of the dual 2-lane and dual 3-lane configurations for outline design, considered various basic criteria. These included highway, tunnel, geotechnical, environmental, land use, tunnel operation, marine and hydraulic, and cost.

3.1.3 This Chapter describes the selection of corridor alignments and then outlines under the various topic headings the conceptual design alternatives considered. It concludes with a summary of the evaluation used to enable recommendation of two alignments for carrying forward to outline design. A full description of the first phase of the Study was contained in Working Paper No.4 Conceptual Designs.

3.2 CORRIDOR ALIGNMENT

3.2.1 The Study boundary defined in the brief allows a number of alignment opportunities for both dual 2-lane and dual 3-lane configurations. A range of alignment corridors was considered between the Green Island Reclamation and the expected extent of the Lantau Port Peninsula.

3.2.2 To the east, landfall locations north and south of Green Island were chosen to concur as far as possible with those considered by the Green Island Reclamation Feasibility Study. At the western end of the tunnel, landfalls north and south of Kau Yi Chau were considered, together with a central option which would require the island to be razed. A total of six feasible alignments were identified and are shown in Figure 3.1. For each alignment a dual 2-lane and dual 3-lane conceptual design was developed.

3.2.3 Where possible, alignments for the immersed tube tunnel sections were kept straight for ease of construction, or where this proved impracticable, large radius curves were used.

3.2.4 A road connection is required from the Kau Yi Chau landfall to the western limit of the Study Area at Siu Kau Yi Chau. This location is the expected boundary of the Lantau Port Peninsula at the time that Green Island Link is required. Realistic alignments were produced to enable consideration of the feasible causeway alternatives.

3.3 HIGHWAY

Green Island Interchange

3.3.1 Interchange forms for the landfall options north and south of Green Island were designed to accommodate the expected peak hour flows corresponding to full tunnel capacity for dual 2-lane and dual 3-lane configurations in order to avoid capacity constraints on the Link. The four conceptual interchange forms are shown in Figure 3.2.

3.3.2 In the case of dual 3 configuration the full tunnel flow, when combined with the expected flows on Route 7, resulted in flows exceeding road capacity on the Route 7 corridor eastbound from the interchange to Hill Road flyover, and east to Rumsey Street flyover. To avoid this capacity constraint an additional two lanes in each direction are required for the Route 7 corridor.

3.3.3 Alternative ways of providing two additional lanes of capacity for the existing Route 7 corridor were explored. On-line widening of the existing corridor would be restrained by the many constraints to the elevated and ground level roads, among them Hill Road flyover, Western Harbour Crossing interchange and Rumsey Street flyover. Provision of an additional two lanes off-line was explored and possible alternatives produced. Whilst these are constrained by existing land uses, it is believed that an off-line option may provide the best solution to this problem. One feasible alignment for this "Central Bypass", is shown in Figure 3.3.

3.3.4 This "Central Bypass" would take traffic from Green Island Link and Route 7 eastbound, and pass over the Spine Road as an elevated carriageway in a similar manner to the elevated structure on Connaught Road. Heading east, it would pass over the Western Harbour Crossing approach ramps before following the north shore of the present Public Cargo Working Area (PCWA) at Sai Ying Pun, which would need to be reprovisioned, thereby avoiding the proposed waterfront park. The route would then cross the site of the Macau Ferry Terminal, which would have to be relocated as envisaged by PADS or adapted possibly by the addition of a further section into the harbour. This would require Government's approval after identification of a suitable site and construction of a replacement facility.

3.3.5 The Bypass is assumed to terminate at the proposed Central and Wanchai Reclamation with a connection to the main trunk road tunnel. Such a connection would affect the current proposals for the trunk road layout through the Central and Wanchai Reclamation and will require further study to investigate its feasibility and desirability, which is outside the scope of this Study. This bypass represents a radical solution to the problem of catering for a dual 3-lane GIL and the shortfall in existing road capacity, and has been considered only in sufficient detail to confirm the basis upon which a dual 3-lane option could be considered viable. It may be that further detailed consideration would identify alternative options.

3.3.6 The northern dual 2-lane and dual 3-lane options comprise a cut and cover tunnel and approach road along the north and east sides of the Green Island Reclamation, with an interchange in the south-east corner. Grade separated slip roads provide all movement connections between the Green Island Link and Route 7. Slip roads are provided on the tunnel approach roads to allow direct access to and from the PCWA. The interchange also included a connection from Kennedy Town to the PCWA and a ground level link between the primary distributor on Green Island Reclamation with the Belcher Bay Link which is located beneath the elevated Route 7.

3.3.7 The northern dual 3-lane option considered differs from the dual 2-lane option in the requirement for the connection to the Central Bypass described above. A number of options were considered for the interchange between the Green Island Link, Route 7 and the Central Bypass. The preferred arrangement involved re-aligning Route 7 at the interchange to connect to the Central Bypass. This permitted simple connections to be made from the Link to both the Central Bypass and the original Route 7 corridor. Connections between Route 7 from the south and the original Route 7 corridor would be gained via the primary distributor on Green Island Reclamation.

3.3.8 The southern dual 2-lane and dual 3-lane options considered comprise a cut-and-cover tunnel approach to the south of Green Island, with a portal directly beneath the elevated Route 7. The interchange consisted of direct ramp connections between the Green Island Link and Route 7 to the east, and 180° loop roads passing beneath Route 7 for traffic to and from Route 7 south. The ground level road junction in the south-east corner of Green Island Reclamation was simplified as a result, linking the primary distributor road to the Belcher Bay Link beneath the elevated Route 7, and providing a connection from Kennedy Town to the PCWA area.

3.3.9 The southern dual 3-lane option differs from the dual 2-lane option in that the portal was moved eastwards relocating the interchange to a similar position to the northern dual 3-lane option. Connections to the Central Bypass were provided from the interchange loop roads, so allowing links from both the GIL and Route 7 onto the Bypass. As the Route 7 alignment remained unchanged, through traffic on the Route 7 corridor could be maintained. The two local roads between Kennedy Town and the Green Island Reclamation would need to be depressed below reclamation level in order to pass beneath the interchange overhead, resulting in three levels of structures.

Kau Yi Chau

3.3.10 Alignments were considered both north and south of Kau Yi Chau, with two additional alignments considered through the island itself. The four landfall options were considered for dual 2-lane and dual 3-lane tunnel configurations.

3.3.11 A road connection on a causeway will be required from the Kau Yi Chau landfall to the boundary of the Lantau Port Peninsula. The causeway road was assumed at conceptual design stage to be a dual 3-lane highway as required by the Brief. The difference between alternative tunnel landfall arrangements is in the length of the causeway and the extent of reclamation required for the approach tunnel and toll plaza.

3.3.12 In passing to the south of Kau Yi Chau, the southern landfall option would require the longest length of causeway to reach the end of the Lantau Port Peninsula at the western limit of the Study. The tunnel portal and toll plaza would be built on reclamation formed to the south of Kau Yi Chau.

3.3.13 The northern landfall option was considered to offer the shortest and most direct route in terms of the overall alignment between Green Island and the western limit. For this alignment the whole of the north landfall, the portal and toll plaza would be constructed on reclamation.

3.3.14 The Kau Yi Chau landfall option was considered attractive as it would have advantages in construction terms, and would clearly reduce the length of causeway and the amount of reclamation required.

3.4 TUNNEL

3.4.1 Six feasible tunnel alignments for both dual 2-lane and dual 3-lane tunnel sections were identified as described in Section 3.2.1 and shown on Figure 3.1.

3.4.2 The main aspect of the vertical profiles was the steep gradients necessary to reach the reclamation levels at either landfall from the tunnel low-point dictated by marine clearance requirements. Climbing lanes were incorporated in the vertical profiles based on preliminary capacity analysis. The conceptual vertical designs sought to avoid climbing lanes within the immersed tube sections.

3.4.3 Whilst it is technically feasible to construct immersed tube units to accommodate a climbing lane into the dual 2-lane tunnel, preliminary investigations indicated that it would not be feasible to accommodate a climbing lane into the dual 3-lane immersed tube units.

3.4.4 There was considered to be little significant difference between the six tunnel routes in terms of structural design, vertical profile and related highway standards.

3.5 GEOTECHNICS

3.5.1 The geological succession was found to be relatively consistent within the Green Island Link corridor. Variations in depths of the various layers were identified. However, the overall impact of the geology on the alternative conceptual alignments was found to be essentially the same.

3.5.2 The marine deposits, which overlay the alluvium, are predominantly clay and silt, with sand layers to the north of the GIL corridor. In the vicinity of Kau Yi Chau, the former dumping ground will contain a variety of materials. The alluvium is somewhat variable, consisting of interbedded layers of silt, clay, sand and gravels, but predominantly granular materials which will provide a good foundation for the tunnel. The geotechnical aspects are described in more detail in Chapter 8.

3.5.3 The northern alignments were considered to have a greater potential impact on the marine sand source to the west of Green Island, known as the South Tsing Yi borrow area. It was concluded at the conceptual design stage that the potential loss of sand source associated with the northern alignments was not a significant disadvantage because of the marginal nature of the resource affected and the potential impact of scour at the tunnel location. This aspect is dealt with in more detail in Chapter 8.

3.5.4 Alignments passing through Kau Yi Chau resulted in a significant, 800 metres reduction in length of seawall as well as reduced quantities of reclamation. It was considered that to raze the island would be to form land which is compatible with the usage set out in the PADS Study. Additionally Kau Yi Chau could provide much of the fill materials required for the project at less cost than importing the material from elsewhere. The island, once razed would form an excellent construction platform for construction activities associated with the Green Island Link.

3.6 ENVIRONMENT

Green Island Landfall

3.6.1 The northern tunnel alignment ventilation building, located approximately 50m from the reclaimed coastline, is in the vicinity of private (R1) housing. However, the emissions from a ventilation building located on the western shore line will have good natural dispersion due to the prevailing easterly winds.

3.6.2 The ventilation building for a southern tunnel alignment would also be located approximately 50m from the reclaimed coastline within an area designated as private (R1) housing. Comments made above would also apply to this location. The natural dispersion due to the prevailing easterly winds would differ from that of the northern option due to the greater influence of the nearby terrain. For winds in other than the prevailing easterly direction, greater impact on the proposed reclamation would be likely than for the northern location.

3.6.3 In order to reduce severance, provide environmental mitigation and maximize land area, Green Island Reclamation Feasibility Study proposed additional cut-and-cover tunnel for the northern alignment, moving the portal considerably further eastwards than needed for the Link. This arrangement was maintained in this Study. Similar measures could only be incorporated for the southern alignment to a very limited extent. The highway at the northern tunnel portal would emerge into an area dominated by mixed land use including government, institutional, commercial and residential within the immediate vicinity. There are two potential portal locations for the south alignment. Both are located in areas earmarked for residential development and hence noise and air contaminants emitted from the southern tunnel portal would also have the potential for impact on a significant number of sensitive receivers.

3.6.4 The interchanges proposed for the southern alignment were complicated and take up significant land areas, exposing a greater area to high traffic flows and associated noise and air contaminants than for the northern interchange. The proposed southern portals were both located close to existing Kennedy Town developments and close to the steep landform. Both factors would impede the dispersive capacity of the atmosphere to some extent and reduce air quality.

Kau Yi Chau Landfall

3.6.5 Environmental impact of the ventilation building, toll plaza and portal were considered broadly similar for all alignments and could be mitigated by careful planning of the development.

3.6.6 It was considered probable that the retention of Kau Yi Chau as a "wild life haven" would be impractical; existing bird species of interest were expected to desert the site once the shores of the island are disturbed by this Project or by the Lantau Port Peninsula. Hence the razing or flattening of the island to accommodate tunnel landfall facilities was not expected to be environmentally unacceptable.

3.6.7 The extent of earthmoving necessary to accommodate each of the three selected landfall options would determine the extent of noise and vibration, and of air contaminants released during preparatory construction stages. However, the remote nature of the landfall would generally make any adverse impact negligible. Of the options, the central option may result in the greatest potential for noise and dust emissions.

3.6.8 In terms of adequate dispersion of pollutants, the potential dispersion capacity was broadly considered similar for each option should Kau Yi Chau be razed. However, if the island were to remain, the landform may serve to shelter a southern portal arrangement under some wind conditions and hence hinder dispersion of air pollutants.

3.7 LAND USE

3.7.1 The Green Island Reclamation Feasibility Study (GIRFS) established a clear preference, from the Green Island Reclamation point of view, for a northern Green Island Link landfall. This solution was considered to have land use and severance advantages both within the reclamation and between Kennedy Town and the reclamation. Now nearing completion, GIRFS has produced a Recommended Outline Development Plan based on the northern landfall. This recommendation has not yet been formally adopted by Government.

3.7.2 Although GIRFS only considered a dual 2-lane Green Island Link, many of the issues would be the same for a dual 3-lane configuration. It was established that the land requirements for the northern landfall and interchange would be less than that for a southern alignment.

3.7.3 At Kau Yi Chau both north and central landfalls would require the northern extent of the proposed Port Peninsula to be constructed up to 500m further north than shown in the PADS plans which assume a southern landfall for the Link. This would be in order to maintain the container terminal clearance. The effect of this on planning for the Lantau Port Peninsula would appear to be minimal. Assuming that the peninsula is eventually to be developed to its full potential, the loss of quay length would need to be compensated by additional facilities. It was assumed that this could be arranged without difficulty. The southern landfall option followed the alignment proposed in PADS, and therefore did not require any change to the PADS Lantau Port Peninsula layout.

3.8 TUNNEL OPERATION

3.8.1 Consideration was given to accommodating the toll plaza area at either the east or west end of the tunnel. In the absence of information from the Lantau Port Peninsula Study, it was assumed that the land use on the proposed Port Peninsula would be predominantly industrial. This would more easily accommodate the toll plaza than the Green Island Reclamation which includes a mix of residential, government, institutional and community land uses.

3.8.2 The provision of a toll plaza on Green Island for the northern landfall alignments would be at the expense of development land and increased environmental impact on the surrounding area. The southern landfall alignments do not readily allow for a practicable toll plaza location. For these reasons it was not considered desirable to locate the toll plaza on Green Island.

3.8.3 Locations were considered for the toll plaza at Kau Yi Chau either on the extent of the Port Peninsula completed at the time of construction, or adjacent to the portal on reclamation or land formed for the Green Island Link.

3.8.4 For operational reasons it would be advantageous for the toll plaza area functions and facilities to be located together, and adjacent to the tunnel portal. If the toll plaza were sited on the then existent Lantau Port Peninsula northwest of Siu Kau Yi Chau it would adversely affect the land use at this location and would not be in the best position for efficient use of the highway link after final reclamation for the Lantau Port Peninsula. Subsequent re-positioning of the toll plaza area would be disruptive and costly.

3.8.5 The siting of the toll plaza area adjacent to the tunnel portal at Kau Yi Chau could be provided either by additional reclamation or on the razed island itself. Either of these sites could be provided quite economically, as the principal cost element in reclamation is seawall provision and widening any reclamation is relatively inexpensive. By siting the toll plaza adjacent to the portal the highway link from the portal to Lantau could then be used by local traffic by provision of an interchange immediately to the west of the toll plaza following reclamation of the full Lantau Port Peninsula. In conclusion it was considered that the toll plaza area is best sited adjacent to the Kau Yi Chau landfall.

3.9 MARINE AND HYDRAULIC

3.9.1 The marine fairways and navigation clearances were advised by Marine Department, and are shown in relation to the proposed alignments in Figure 3.1. Marine and hydraulic considerations assumed that the Western Harbour Breakwater is in place prior to construction of Green Island Link.

3.9.2 There are no buoys laid in the vicinity of any of the conceptual alignments that were considered, but the area is used for anchorage. There is a naval anchorage indicated on the chart to the east of Kau Yi Chau which could be affected, and the area is also used for anchorage by other vessels. Such anchoring as is now permitted just to the west of the fairway would be prohibited upon establishment of the proposed West Lamma Channel to the Lantau Port Peninsula. The additional loss of potential anchorages due to Green Island Link would be minimal, and was not sensitive to the horizontal alignment.

3.9.3 The existence of a causeway or structure between Kau Yi Chau and the end of the Lantau Port Peninsula represents an increased risk of grounding by vessels during a storm. All of the alignments were considered similar in this respect because they presented the same projected area to the northeast and to the south, which are the directions from which vessels might be expected to drift in a storm.

3.9.4 The type of damage which might occur to the Green Island Link depends on the type of vessel, the nature of the collision, and the type of structure adopted. It is self-evident that damage will be greater for a viaduct than for a causeway, greater for larger vessels, and, in general, greater for the case where vessels at full steam go off-course than for vessels drifting in a storm. The reclamation to the east of Kau Yi Chau is therefore at greater risk than the part to the west as it is highly unlikely that ocean-going vessels would ever be steaming at speed to the west of Kau Yi Chau. The possibility of vessel collision with the reclamations for landfalls and ventilation buildings is discussed further in Chapter 7.

3.9.5 Previous WAHMO model simulations of tidal flows following reclamation for the Lantau Port Peninsula, carried out under PADS and Metroplan, were examined. Preliminary assessment of bed stability established that increased water velocities between Green Island and Kau Yi Chau would produce potential deep scour of the marine deposits in the vicinity of the Green Island Link corridor. The effect on all the alignments is similar and was not a factor in the choice between options. The further examination of the likely scour is considered in Chapter 8.

3.10 EVALUATION

3.10.1 The evaluation procedure assessed each of the conceptual design alternatives against basic criteria. The criteria consist of both quantifiable and non-quantifiable factors and therefore overall evaluation was by relative assessment which was of necessity subjective. Ratings proposed for each criterion lie in the range "A" (very good) to "D" (poor).

3.10.2 The elements considered in the evaluation were:

- highway;
- tunnel;
- geotechnical;
- environment and land use;
- tunnel operation;
- marine and hydraulic; and
- cost.

In the following paragraphs criteria applicable to each of these elements are compared for the conceptual alignments and the ratings assigned are summarised in Table 3.1

Highway

3.10.3 All alignment options are similar in highway provision at the Kau Yi Chau landfall and causeway connection to the Lantau Port Peninsula. The Green Island northern landfall options are better overall in terms of traffic routing and connection to Route 7, the local road network, including retention of links between Green Island Reclamation; and Kennedy Town. However, the dual 3-lane northern option provides no direct connection between Route 7 west of the interchange and the old Route 7 corridor to the east. The southern landfall options provide good connection to Route 7 east.

3.10.4 The Green Island northern landfall options provide higher geometric standards and relatively simple layouts. Both northern options require offside diverging and merging of minor traffic flows to Route 7 west. However, the southern landfall options involve greater traffic weaving for this traffic and more complex layouts.

3.10.5 The close proximity of the southern portals to Route 7 at Green Island will require more complex construction techniques than the northern options. Both dual 3-lane alignments at Green Island allow for phased construction of the Central Bypass link. The southern option will require initial construction of a greater part of the full provision but will be easier to connect to the Central Bypass at a later date.

Tunnel

3.10.6 All alignments have negligible influence over both the type of immersed tube tunnel and the ventilation requirements.

Geotechnical

3.10.7 The southern landfall alignments at Kau Yi Chau require less reclamation for the portal works than the northern landfall alignments. Both require more than the central landfall which uses Kau Yi Chau itself thereby requiring less reclamation and also providing a construction platform and source of fill and rock armour for the project.

Land Use

3.10.8 The impact on future land use of the Kau Yi Chau landfall, portal and toll plaza is roughly the same for each alignment. The impact on planned land use and severance at Green Island for dual 2-lane northern alignments is less than the southern alignments as defined by Green Island Reclamation Feasibility Study. This is also true for the dual 3-lane alignments.

Environment

3.10.9 Visual impact is likely to be similar for all schemes with the exception of those passing through Kau Yi Chau. Ecologically the alignments that pass through Kau Yi Chau which require it to be razed have a more adverse impact on the ecology. However, whether this is less than when the final Lantau Port Peninsula is in place is questionable, particularly if Kau Yi Chau would anyway be razed as part of the Lantau Port Peninsula.

3.10.10 Air quality impact and noise impact on existing sensitive receivers in Kennedy Town will be greater for the southern landfall alignments at Green Island.

3.10.11 During construction the alignments have generally the same impact on water quality. The alignments which go through Kau Yi Chau, require less reclamation and hence less dredging thereby reducing water quality impact. During operation all alignments have a similar impact.

Tunnel Operation

3.10.12 Provision of remote end operation facilities for overheight vehicles, official vehicle turnarounds and emergency vehicles can be provided at Green Island landfall. It is harder to provide these facilities at the southern landfall on Green Island, than for the northern landfall for both tunnel configurations.

Marine and Hydraulic

3.10.13 The eventual extent of the Lantau Port Peninsula will affect the water velocities between Green Island and Kau Yi Chau resulting in scour in this area. All of the alignments will require equal protection. The landfalls at, and to the north of Kau Yi Chau would require modification to the PADS outline of the Lantau Port Peninsula to maintain clearances for port development. The northern alignments may provide marginally greater risk of vessel collision by reason of the closer proximity to the shipping channel. These northerly alignments are less of a restriction to the marine channels during construction phases.

Cost

3.10.14 Total construction costs of the project were calculated from unit rates developed from similar projects, equated to a base year 1991, for the purposes of a comparative evaluation. These indicated that costs for the conceptual alignments varied by only 6%.

3.11 RANKING

3.11.1 The summary of ratings for each alignment against each of the seven evaluation criteria is given in Table 3.1.

TABLE 3.1 EVALUATION - SUMMARY

Criteria	Alignment options											
	Dual 2-lane						Dual 3-lane					
	N-N	N-C	N-S	S-S	S-C	S-N	N-N	N-C	N-S	S-S	S-C	S-N
Highway	B	B	B	C	C	C	C	B	C	C	C	C
Tunnel	B	B	B	B	B	B	B	B	B	B	B	B
Geotechnical	C	B	C	C	B	C	C	B	C	C	B	C
Environment and Land Use	B	B	B	C	C	C	B	C	B	C	C	C
Tunnel Operation	B	B	B	C	C	C	B	B	B	D	D	D
Marine and Hydraulic	C	C	C	C	C	C	C	C	C	C	C	C
Cost	C	B	D	B	A	D	B	A	C	B	B	D
Ranking	2	1	4	5	2	6	2	1	2	5	4	6

Conclusions

3.11.2 On Green Island Reclamation the northern landfall alignments generally ranked higher than the southern landfall options on all criteria but cost, where there was a very slight disadvantage. The interchange connection with Route 7 and the local road network at Green Island was considered better in terms of traffic routing and higher geometric standards for the northern alignments. Air quality and noise impact on existing sensitive receivers in Kennedy Town was less for the northern alignments. The southern alignments had greater land use implications and severance between the Green Island reclamation and Kennedy Town.

3.11.3 Environmentally the options which implied the razing of Kau Yi Chau scored lower in visual and ecological impact terms than options which retained the island. An environmental advantage for the routes through Kau Yi Chau is the potentially less adverse impact on water quality during construction as a result of the reduced dredging and reclamation requirement.

3.11.4 The analysis of the relative ranking of the various options was conducted on the assumption, stated in the Brief, that Green Island Reclamation will be in place or under construction by 2001. It was also, of necessity, conducted without reference to the merits/demerits of the razing of Kau Yi Chau from the perspective of the Lantau Port Peninsula Development. On this basis, the recommendation of Working Paper No.4 was that both configurations should follow the same N-C alignment.

3.11.5 It was concluded subsequently that a greater range of design output would be obtained if the dual 3-lane configuration was taken to outline design stage as a N-N alignment, north of Green Island and Kau Yi Chau. This has the advantage of maintaining greater flexibility by producing a range of designs which may readily be adopted to encompass possible variations to the basic assumptions of the Brief. An instruction to proceed with the outline design on the basis of a dual 2-lane N-C alignment and a dual 3-lane N-N alignment was given by the GE/WHL subsequent to the Steering Group Meeting which considered Working Paper No.4.

CHAPTER 4

4 HIGHWAY DESIGN

4.1 GENERAL

4.1.1 The two alignments selected for development to outline design, as identified in Chapter 3, are as follows:

- dual 2-lane (N-C) - from a landfall north of Green Island to a landfall through the centre of Kau Yi Chau; and
- dual 3-lane (N-N) - from a landfall north of Green Island to a landfall north of Kau Yi Chau.

4.1.2 This Chapter describes the development of the highway design of these two configurations to outline design of the approach ramps, slip roads, temporary and permanent connection roads and interchanges. General alignment criteria are described followed by specific highway design considerations for the two landfalls and the tunnel.

4.2 HORIZONTAL ALIGNMENTS

4.2.1 The outline highway designs for a dual 2-lane N-C alignment and a dual 3-lane N-N alignment are shown in Figures 4.1 and 4.2 respectively. Each layout including the Green Island interchange is designed for the tunnel operating at capacity for the respective configuration. The highway designs for the tunnel alignment approach ramps, slip roads, connecting roads and interchanges comply with the design criteria specified in the Design Memorandum (included in Appendix A).

4.2.2 Highway cross sections use minimum desirable dimensions within the tunnel and on approach ramps. Highway sections on slip roads, interchanges and connecting roads use desirable carriageway widths. Typical highway cross-sections are shown in Figure 4.3.

4.2.3 Horizontal alignment of the immersed tube tunnel is designed to be predominantly straight for ease of construction and maximum economy. Where landfall constraints have necessitated curves, these are accommodated principally within the cut-and-cover sections. Radii greater than R7 (table 3.3.3.1 TPDM) are used to avoid the need for transitions within the immersed tube and to maintain desirable sight distances without the need for widening of the tunnel section.

4.2.4 The link roads and slip roads on Green Island Reclamation are designed to meet the requirements of a 70km/h design speed. The tunnel and Kau Yi Chau approach causeway have higher geometric standards and have thus been designed to at least meet the requirements of a trunk road with a design speed of 85km/h.

4.2.5 The higher geometric standard of the predominantly straight tunnel section could be utilized to provide a high speed limit within the tunnel and thereby reduce total journey time. A very high speed limit of 100km/h or higher can present transitional problems and drivers may not slow down for the connecting link roads. A speed limit within the tunnel of 80km/h could be considered.

4.2.6 A speed limit on the link roads on Green Island Reclamation which reflects the lower design speed of 70km/h is considered appropriate. Prominent signing of a change to this lower speed will provide advance warning for road users of the radii to be negotiated on the links. This would be particularly important after a long section of straight tunnel.

4.2.7 Direction signs and warning signs both within the tunnel and on the approaches have been considered as part of the conceptual highway design development. Allowance has been made both in the tunnel headroom and the tunnel approach designs for signage requirements.

4.3 VERTICAL ALIGNMENTS

4.3.1 Vertical profiles have been influenced by a number of factors including marine clearance, geology, highway design parameters immersed tube tunnel considerations and tunnel headroom requirements.

4.3.2 The length and depth of the Green Island Link will be greater than that of other tunnels in Hong Kong. The tunnel is over 4 km long and carriageway level falls from a portal level of 5.5 mPD to a minimum level of approximately -36 MPD. This latter level is dictated by the marine clearance requirements within the limits of the East Lamma Channel, as defined in the Design Standards Memorandum. In addition to providing clearance for existing vessels using the channel it is necessary to provide clearance for the much larger coal carriers envisaged for the proposed new power station at Black Point. As a result the tunnel protection profile must be no higher than -25.15 MPD under the channel, which is generally lower than the existing sea bed.

4.3.3 The tunnel protection profile will lie above the existing seabed where the tunnel approaches the new seawalls at both the Green Island Reclamation, and at Kau Yi Chau. This is because the protection normally provided by placing the tunnel below the existing seabed can only be provided if the tunnel is below the predicted scoured bed profile. This would result in a very deep tunnel. A clear water depth of 5.15m at the seawalls has been agreed with Marine Department as sufficient for shipping and navigation requirements, and the vertical alignment is designed to accommodate this requirement.

4.3.4 Upgrades can be expected to have an effect on the operational speed of goods vehicles and hence possibly on tunnel traffic capacity. The significant percentage of heavy goods vehicles forecast to use the Green Island Link coupled with the length of the upgrades has necessitated consideration of these capacity effects to prevent the climbing sections of the tunnel becoming a capacity restraint on the Link.

4.3.5 Two methods of analysis of the capacity constraint of long gradients have been developed for this Study. One analysis is based on the US Highway Capacity Manual and the other on a speed analysis. The former allowed modelling of capacity constraints and requirements for climbing lanes, whilst the latter enabled comparison and optimisation of vertical profiles by considering the effects of gradient and length of upgrade on heavy goods vehicle speeds. This analysis has enabled an optimisation of the vertical profiles for the tunnel alignments which have minimised the requirement for climbing lanes. In particular the analysis has indicated that whilst there is likely to be some loss of capacity on the underwater upgrades, where it is expected that climbing lanes are technically or economically undesirable, this loss of capacity can be shown to be minimal where heavy goods vehicle speeds can be maintained above 60 km/h. This is achieved by careful optimisation of the lengths and gradients of the upgrades.

4.3.6 A climbing lane throughout the whole of the Green Island approach tunnel has been avoided by easing the gradient in the cut-and-cover section of the tunnel and providing a minimal length of 4% upgrade. The short length of climbing lane thus necessary will also serve to assist traffic to distribute to the various destinations at this location.

4.3.7 At the Kau Yi Chau end of the tunnel the depth and length of the approach tunnel has been minimised by using a 4% gradient. It has also been possible to restrict the climbing lane requirement to within the cut and cover section of the tunnel and the approach ramps.

4.4 GREEN ISLAND APPROACH

4.4.1 The evaluation of Green Island landfall options, as described in Working Paper No.4 and summarized in Chapter 3, led to the selection of a landfall to the north of Green Island for both dual 2-lane and dual 3-lane configurations. This option allows better connections between the tunnel, Route 7 and the local road network in terms of geometry and traffic routing.

4.4.2 Figure 4.4 shows the northern dual 2-lane option which is the preferred option identified by the Green Island Reclamation Feasibility Study. It comprises a cut and cover tunnel and approach roads along the north and east sides of the Green Island Reclamation, with an interchange in the south-east corner. Grade separated slip roads provide all movement connections between the GIL and Route 7. The interchange also includes a connection from Kennedy Town to the Public Cargo Working Area and a ground level link between the primary distributor on Green Island Reclamation and the Belcher Bay Link which is located beneath the elevated Route 7. Slip roads are provided on the tunnel approach roads to allow direct access to and from the Public Cargo Working Area.

4.4.3 The dual 3-lane option shown in Figure 4.5 has a similar conceptual layout to the dual 2-lane option; the main difference being the requirement of the Central Bypass. It is apparent that a dual 3-lane configuration of tunnel running full would, when combined with expected flows on Route 7, exceed the road capacity currently planned for Route 7 corridor eastbound from Hill Road flyover. The Central Bypass described in Chapter 3 represents a feasible option for the provision of this additional road capacity, however, it may affect existing or planned land use. Land uses affected include the tram depot; the Sai Ying Pun Public Cargo Working Area; the existing Macau Ferry Terminal; the proposed Western Parkland; and the west end of the Central Reclamation. A number of options have been considered for the interchange between the GIL, Route 7 and the Central Bypass. The preferred arrangement involves re-aligning Route 7 at the interchange to connect to the Central Bypass. Connections between Route 7 from the south and the original Route 7 corridor east of Green Island will be gained via the primary distributor which connects to Route 7 at the roundabout junction in the south west corner of Green Island Reclamation.

4.4.4 An alternative layout to the preferred dual 3-lane option has been considered which retains Route 7 on its original line and which connects the GIL directly to the Central Bypass. However, this arrangement does not easily allow Route 7 eastbound traffic onto the Central Bypass.

4.4.5 The link roads at the Green Island interchange have been designed to a 70km/h design speed. Generally a desirable minimum standard has been maintained with the exception of the slip roads from Route 7 (south) to GIL and from GIL to Route 7 (east). These have been designed to an R2 standard (between normal and absolute minimum, Table 3.3.3.1 TPDM) in order to minimise land-take. This concurs with the recommendations in the Route 7 Alignment Report of the Green Island Reclamation Feasibility Study. Stopping sight distances will be kept above desirable minimum values through the interchange. This will be achieved by a combination of careful location of critical columns and adjustment of bridge spans as required.

4.4.6 The dual 2-lane and dual 3-lane interchange lane provisions correspond to the traffic design flows described in Chapter 2 and shown on Figures 2.7 and 2.8.

4.4.7 The Green Island approach tunnel will have different signage requirements for entry and exit traffic. Westbound traffic would have no directional signage requirements and therefore the standard 300mm additional headroom above the standard structural gauge is sufficient. Eastbound traffic would on emerging from the tunnel have several destination choices within short succession. Ideally each choice should be between two options and choices should be separated from one another as far as possible. Direction signs within the tunnel would give advance notice and coupled with the addition of a climbing lane would facilitate lane choice by the time motorists emerge from the tunnel. Within this section, the tunnel height would be raised to at least 1m above the structural gauge to accommodate the directional and variable message signs. These signs would indicate the lanes to be used for each of the various destinations.

4.4.8 The most critical area of choice for vehicles for both dual 2-lane and dual 3-lane alternatives is immediately on exiting the approach tunnel when traffic will leave left for the port area and leave right for Route 7 (South). Since the space between the two diverging points would be insufficient to provide the correct signs and diverging lanes for the second divergence, it is considered that the road should be widened immediately on leaving the tunnel. This will provide dedicated single lanes on the left and the right for the diverging traffic, whilst retaining the full number of lanes as in the tunnel for the main through traffic to Route 7 and Central Bypass, where appropriate. An overhead gantry sign visible from the tunnel exit would indicate the lane to be occupied for each destination.

4.5 IMMERSED TUNNEL ALIGNMENT

4.5.1 For the two alignments chosen for development to outline design, vertical profiles of the immersed tube tunnel have been derived using the criteria described previously. For the dual 2-lane immersed tube, two construction methods are considered, concrete unit and steel shell. The dual 3-lane immersed tube is considered only as a concrete unit as discussed in Chapter 5. Three profiles have therefore been produced as shown on Figures 4.6, 4.7 and 4.8:

- Route N-C: dual 2-lane option (concrete)
- Route N-C: dual 2-lane option (steel)
- Route N-N: dual 3-lane option (concrete)

4.5.2 The profiles are designed to avoid climbing lanes within the immersed tube and the radii of vertical curves are chosen to minimize the increase in height of tubes. Where possible, the vertical intersection points should be located at the joints between the tubes. In order to avoid deep cut and cover sections behind the sea walls, the profiles are kept as high as possible consistent with marine clearance requirements described previously.

4.5.3 Indicative road levels along each vertical profile have been calculated using tunnel headroom requirements. A standard structural gauge allowance of 5.0m has been provided as described in Chapter 5, together with depths of tunnel roof structure depending on the construction type. An additional dredging tolerance of 1.0m has been allowed for between the marine clearance level and the top of tunnel protection level.

4.5.4 Within the immersed tube, additional headroom above the structural gauge will be required for lighting and signage purposes. An extra 300mm is allowed for this purpose, which is sufficient for the signing provision necessary.

4.6 KAU YI CHAU APPROACH

4.6.1 From the evaluation of landfall options at Kau Yi Chau, two configurations have been chosen:

- Through Kau Yi Chau island, if it were to be razed (Route N-C, dual 2-lane configuration).
- North of Kau Yi Chau (Route N-N, dual 3-lane configuration).

The two landfall layout options are shown on Figures 4.9 and 4.10.

4.6.2 The two landfall options are similar except that the central option on Kau Yi Chau island would have a reduced length of causeway and would require less reclamation.

4.6.3 The causeway linking the portal at Kau Yi Chau to the assumed limits of the Lantau Port Peninsula in 2004, adjacent to Siu Kau Yi Chau, would be either dual 2-lane or dual 3-lane to match the tunnel configuration. Whilst it would be feasible to provide a dual 3-lane causeway to a dual 2-lane tunnel there is considered to be little merit in constructing a wider causeway than is necessary. This would be particularly true if an elevated structure were to be substituted for a reclamation form of causeway. It may be that subsequently an interchange would be provided adjacent to the toll plaza to provide access to the eastern end of the Lantau Port Peninsula which may require that the road is dual 3-lane. It is considered that any widening or re-aligning might be more economically provided at this time when adjacent reclamation would be available. Thus the causeway has been identified as dual 2-lane for a dual 2-lane tunnel and dual 3-lane for a dual 3-lane tunnel.

4.6.4 For both landfall options, the toll plaza will be located close to the Kau Yi Chau tunnel portal as described in Chapter 3. For the northern landfall option, the start of the toll plaza taper occurs at the tunnel portal. For the central option the taper starts at the edge of the original island so that the plaza is situated entirely on the island platform. This has the advantage that the toll plaza and buildings will be founded on rock but will result in a longer turn around road over the tunnel portal. The overall increase in road length, however, is minimal because an access road will be required from the control centre to the ventilation building. In both cases, vertical curves are envisaged through the toll plaza to reach the required level of +5.5mPD with shallow gradients for vehicles queuing at the toll booths. Further description of the toll plaza facilities and toll lane provision is given in Chapter 10.

4.6.5 At the Kau Yi Chau approach the sign requirement would be different for eastbound and westbound traffic. For the eastbound traffic no requirement for additional signage has been identified. For traffic proceeding west, the initial Link will have no interchange close to the tunnel exit. There would therefore be no initial requirement for extra height to accommodate directional signing in the cut-and-cover section of tunnel. A requirement for such may, however, emerge from the Lantau Port Peninsula Development Study.

CHAPTER 5

5 STRUCTURES

5.1 GENERAL

5.1.1 The size of the immersed tube tunnel, the approach tunnels and the ventilation buildings is a function of the internal space requirements which are in turn governed by the following dominant factors:

- structure gauge for vehicular clearance;
- space above structure gauge for signage and lighting;
- space for services and utilities;
- ventilation ducts; and
- electrical and mechanical plant.

5.1.2 The structural gauge allowance of 5.0m has been provided in accordance with the Design Standards Memorandum. Above the structure gauge, space is provided for lane signals, direction signs and lighting. In most areas of the tunnel a vertical allowance of 300mm is sufficient for this purpose, but an allowance of 1000mm is required at the direction sign locations near the exit portals.

5.1.3 Ventilation ducts are provided to deliver fresh air to the air grilles along the tunnel, and these can also, in times of emergency, be used for smoke extraction. The size of the ventilation ducts is governed by the total fresh air requirements, which are described in Chapter 6, and in accordance with the design standards to be adopted.

5.1.4 Within the ventilation duct, services and utilities will be installed. Some of these will be located in sand filled trenches on the floor of the concrete immersed tube whereas other services will be wall mounted. For the steel shell tunnel, services will be located in the overhead air duct or behind wall panels.

5.2 IMMERSED TUBE

5.2.1 The immersed tube tunnel will be about 3km long between the ventilation buildings and will be built in a similar manner to other underwater immersed tube tunnels worldwide.

5.2.2 There are two general forms of immersed tube in common use, referred to as "steel shell unit" and "concrete unit" types. The two forms are distinguished primarily by methods of construction, which are further described in Chapter 9. The choice between the two forms is influenced by a number of factors which include, the contractor's expertise and the programme requirements both of which can effect the project cost.

Concrete Units

5.2.3 Preliminary designs have been developed for the dual 2-lane and dual 3-lane tunnel units. Due to the required water depth above the tunnel, the forces acting on the tunnel are greater than normally occur on tunnel units of this nature.

5.2.4 The dual 2-lane tunnel, with a roadway box of 9.45m width can be constructed in reinforced concrete as shown in Figure 5.1.

5.2.5 The dual 3-lane tunnel, with a roadway box of width of 12.70m can also be constructed of reinforced concrete to the section shown at Fig 5.2. However, due to the larger spans of the roof and base slabs, the quantity of reinforcement is high. Consideration should be given during the detailed feasibility stage to the use of prestressed concrete, or the use of voided slabs.

5.2.6 As the requirements for air supply will vary along the tunnel length, the width of the outer air ducts can be varied. Provision of such variation in width will not add undue difficulty to the construction of the tunnel units.

Steel Shell Units

5.2.7 The dual 2-lane tunnel can be constructed as either a flat-bottom binocular section, as shown in Figure 5.3 or as a full binocular section. The use of the full binocular has some advantages in that it provides space for additional air ducts and in that having a circular hull it more efficiently resists hydrostatic pressure.

5.2.8 Requirements for air supply and exhaust vary along the length of the tunnel, not least due to variations of gradient. In order to provide air duct sizes to match requirements, the overall radius of the tunnel section may be varied, although the actual traffic duct can remain visually the same size for the user. It would be preferable to locate changes in radius away from the tunnel tube joints.

5.2.9 As far as is known no dual 3-lane steel shell units have yet been constructed. In order to utilise the circular form dual 3-lane steel shell units would have a very tall section, and this tends to make them uneconomical. Accordingly no designs have been prepared for this configuration. However, during the detailed feasibility study, further work may be able to demonstrate that an elliptical shaped unit is practical although this shape has not previously been used in an immersed tube tunnel.

Joints

5.2.10 The joints between immersed tube units will act both to ensure a watertight joint between the units and to provide a structural shear connection in horizontal and vertical directions. It is now general practice to arrange for the joint between units to maintain flexibility in the permanent situation, and techniques to achieve this are well established for both concrete and steel shell type units.

Seabed Armouring

5.2.11 The underwater section of the tunnel will be covered by an armoured protection layer about 2m thick as shown as Figure 5.4. This layer serves to protect the tunnel from damage in the event of a ship sinking, and also serves, in the areas adjacent to the tunnel, to maintain the stability of the seabed and thus avoid erosion of the softer material adjacent to the tunnel.

5.2.12 A detailed discussion on the possibilities of seabed erosion is included at Chapter 8 and this concludes that an armour layer constructed of 250mm size rocks about 1.5m thick should be sufficient.

Settlement

5.2.13 Immersed tube tunnels are not generally very susceptible to settlement as the effective load on the foundations is low. However, in the zones adjacent to and under the seawalls the foundation load is much higher and it is considered necessary to remove the softer marine deposits. This matter is addressed in more detail in Chapter 8.

5.3 APPROACH TUNNELS AND RAMPS

5.3.1 The landfalls at Kau Yi Chau and at Green Island Reclamation will be in new reclamation which can be expected to have a high permeability, although the form of the reclamation has not yet been determined.

5.3.2 As the landfall structures will be constructed in new reclamation there will be a high potential for settlement and the options are either to design the structure to resist the settlement, thus resulting in high foundation loading, or to allow the structure to settle with the landfill.

5.3.3 Various different construction techniques have been considered, and the application of these to the Kau Yi Chau and Green Island Reclamation landfalls is described in more detail in Chapter 9.

5.3.4 The principal factors which affect the design are ease of construction, cost, and construction programme, and it has been concluded that an in situ construction in the dry in open excavation will provide the simplest solution. This will be achieved by installation of a hydraulic cut off wall and dewatering equipment further described in Chapter 9.

5.3.5 The approach tunnels will have a ventilation duct in the roof as this reduces the construction cost. The duct may be formed by use of a false ceiling constructed of precast concrete slabs.

5.3.6 The open approach ramps will be as shown in Figure 5.5 and these require a thick base slab to overcome hydrostatic uplift pressure.

5.3.7 If a casting basin for concrete units were to be provided in the area of the Green Island approaches, then the approach tunnel could be constructed within the casting basin excavation.

5.4 VENTILATION BUILDINGS

5.4.1 The design and operation of the ventilation system is described in Chapter 6, and requires a ventilation building near each of the landfalls. The primary function of these buildings is to supply and extract air from the road tunnels and to house the associated fans, plenums, ducts, power supplies and control equipment.

5.4.2 The ventilation buildings at each landfall contain all the fans required for fresh air delivery and exhaust, and must be sized accordingly. They also contain the associated power supply and control equipment and these require space for installation. Above ground the intakes should be sized and located to ensure that no recirculation occurs between exhaust and intake locations.

5.4.3 The two buildings will occupy conspicuous positions on the waterfront, and they should be designed to make them as interesting and acceptable as possible whilst at the same time ensuring that they are functional and meet the necessary environmental criteria.

5.4.4 The building structure occupies a space above the tunnel, and can be constructed either integral with the approach tunnel structure, or as an independent caisson structure to be floated into position on top of either the approach tunnel or the immersed tube.

5.4.5 Access for vehicles will be required for general maintenance and for plant replacement, and an access road should be provided to each building.

5.5 IMMERSED/APPROACH TUNNEL INTERFACES

5.5.1 The form of interface between the immersed tunnel, the approach tunnels and the ventilation building is dependent on the sequence and method of construction. Consequently there are a number of possible interface options:

- construct both ventilation buildings first, lay tubes outwards from these buildings and complete the immersed tunnel with a special joint;
- construct one ventilation building first and lay all the immersed tubes outwards from the side and backfill over the top of the final unit. Construct the second ventilation building against the exposed immersed tunnel end;
- lay the immersed tunnel units, with or without a special joint, and backfill over the top of the final units. Construct the ventilation buildings against the exposed immersed tunnel ends;
- portions of the approach tunnels could also be constructed as immersed tunnel units with a different configuration to that of the cross channel section, the ventilation building being either precast and floated in over the top, or constructed on the top in the dry.

5.5.2 For the purposes of costing and programming within this Study, the general approach adopted has been the conventional one of laying immersed tube units outwards from an existing approach tunnel interface. This not only has the advantage of gaining early "drive in" access to the unit but enables approach tunnel works to proceed on both sides in parallel which gives early access for Electrical & Mechanical installation.

5.5.3 The adopted approach requires the construction of a special underwater joint since it is not possible to joint the final unit hydrostatically at both ends. There are established techniques for construction of this type of final joint.

5.6 ADMINISTRATION AND ANCILLARY BUILDINGS

5.6.1 The administration and control building should be situated near the toll plaza, and will contain office accommodation for tunnel staff, messing and locker facilities for operating staff, cash handling facilities and also houses the Central Control Room. The building should be airconditioned and noise protected and can be integral with stores, workshop and garage facilities if required.

5.6.2 A perimeter road provides access to the building, as well as to the workshops, garages and weighbridge. Restricted access to the local road system for use by tunnel staff should also be provided.

5.6.3 The building will be of three or four storeys height with a gross floor area of about 3-4000m^2, and will accommodate the facilities shown in Table 5.4.

TABLE 5.4 ADMINISTRATION BUILDING

Floor	Use
Third Floor	Administration and management
Second Floor	Tunnel control room and offices
First Floor	Staff facilities, canteen etc.
Ground Floor	Workshops, stores and cash handling

5.6.4 A Control Point will be required near the Green Island portal, and this will incorporate minimum Closed Circuit Television and sign control equipment interlocked to the Central Control Room. It should have air conditioning and toilet facilities but should otherwise not be elaborate.

5.6.5 Pumphouses will be installed at or near each portal, as well as at the lowest point of the tunnel. The portal pumphouse will have large sumps in order to prevent flooding under extreme conditions, whereas the nadir sump will be designed to accommodate flow from wash water and fire hydrants.

5.6.6 At each portal there is a pumphouse structure with drainage sump, which will contain the interceptor drainage pumps, petrol/oil interceptors and the appropriate control gear. The pumphouse structure can most conveniently be located at one side of the approach ramp, with the sumps beneath the roadway.

5.7 GREEN ISLAND LINK INTERCHANGE/ROUTE 7

5.7.1 The Green Island Reclamation Feasibility Study recommended in the Major Road Layout Report that the majority of Route 7 through Green Island Reclamation be constructed as elevated structure. This allowed for the Green Island Link interchange slip roads and the primary distributor to pass onto the reclamation without restricting ground level links between Kennedy Town and the reclamation.

5.7.2 It was recommended that, in order to maintain continuity, the same shape and form be used for the Route 7 structure, as was used for Rumsey Street flyover. This consists of a continuous post tensioned multicellular concrete deck supported on single central columns. It is recommended that the same form is adopted for the Green Island Link slip roads. The side cantilevers of the deck would be shorter than those of Route 7, and the flares on the supporting columns would be less pronounced but based on the same shape as those supporting Route 7. The adoption of a structural form different from that of Route 7 would lack continuity and compatibility resulting in an undesirable aesthetic appearance.

5.7.3 The location of structures necessary for the interchange are shown on Figures 5.6, and 5.7 for dual 2-lane and dual 3-lane configurations respectively. The form of structure is also indicated.

5.7.4 The spans would vary depending on location but would be generally between 30 and 40 metres. The columns would be supported on pile caps on groups of end bearing large diameter bored piles or driven tubular piles. The use of piles would obviate the need to remove the marine deposits, would allow early commencement of foundations after completion of reclamation and reduce structural movement during settlement of the reclamation. Careful selection and placement of material would be needed during reclamation to minimise piling obstruction and prevent lateral movement problems.

5.7.5 By using a continuously pre-stressed box construction, expansion joints are only required typically every four spans. This would result in improved road riding quality, reduced road traffic noise and reduced maintenance as compared to alternative structural forms such as pre-cast beam decks.

5.7.6 Wherever possible the link roads should be constructed on earthworks to minimise costs and to assist the development of earth moulding and landscaping to provide environmental benefits. However, settlements may result unless ground improvement measures are undertaken.

5.8 CAUSEWAY

5.8.1 A causeway is required to link the portal at Kau Yi Chau to the end of the Lantau Port Peninsula adjacent to Siu Kau Yi Chau. Various forms of causeway construction have been investigated including an elevated viaduct structure and several forms of reclamation causeway.

5.8.2 An elevated structure consisting of a simply supported deck on discrete marine pile supports would not restrict the flow of water from the western harbour. Whilst local currents would almost certainly alter the seabed profile adjacent to the supports, the scour identified between Kau Yi Chau and Green Island (see Chapter 8) would be avoided until after the full extent of the Lantau Port Peninsula is constructed.

5.8.3 Costs for a structure are likely to be very much higher than any alternative if vessel collision protection in the form of rock berms or piled dolphins are provided. An alternative to this protection would be for the two carriageways to be constructed independently and spaced to allow accidental demolition of one structure should a vessel impact, without affecting the second. Access to the tunnel could then be maintained by contraflow on the remaining carriageway, although at a reduced level of service, whilst structural repairs are effected. The risk of collision in the location exists and this course of action requires acceptance of a level of risk by Government.

5.8.4 An elevated structure would present particular construction difficulties for the reclamation for the full extent of the Port Peninsula when extended to Kau Yi Chau. Down drag caused by settlement of the reclamation and lateral forces caused by filling would restrict the speed and type of reclamation adjacent to the structural supports. It is possible that sleeves around the piles could mitigate these effects, but would be unlikely to negate them altogether.

5.8.5 The structure could be constructed at a level sufficient to provide traffic gauge clearance between the reclamation and the structure. This would reduce the construction difficulties of the future reclamation and enable connection for access across the reclamation. However, it would restrict the flexibility for future changes to the Port Peninsula land use or highway layout. A structure designed to be constructed at a lower level, which would be incorporated in the future reclamation, would also not be as flexible to such changes as a reclamation causeway.

5.8.6 The construction of a reclamation type causeway would consist of two seawalls protecting a narrow strip of reclamation on which the highway would be constructed. Various forms of construction of this causeway have been investigated and are further described in Chapter 8.

5.8.7 The prevailing currents are not expected to affect the feasibility of constructing the reclamation. However, it should be noted that as reclamation for the Lantau Port Peninsula and Green Island Link causeway proceed, the significant increase in currents will affect the phasing of the works. The most significant implication of accommodating the subsequent construction of the Lantau Port Peninsula is the need to extend the dredging for the north-south wall for the immersed tube landfall so that no future dredging or filling works will affect the existing structures.

5.8.8 Given the limitations on subsequent filling operations for the elevated structure option, together with the cost disadvantage of providing vessel collision protection or accepting the associated risk, the reclamation type causeway has been taken to outline design level. It is not the intention of this Study to rule out an elevated structure which may have advantages if the extent of the Lantau Port Peninsula is modified by subsequent decisions. However, in the context of the Brief it is felt that the reclamation option has several advantages including cost, resistance to vessel impact and flexibility for future adjacent reclamation.

CHAPTER 6

6 TUNNEL SERVICES

6.1 VENTILATION

Objectives

6.1.1 The purpose of tunnel ventilation is to maintain the air quality at an acceptable level. The tunnel is ventilated by supplying fresh air, by mechanical or other means, thus causing dilution of any pollutants present, and maintaining the concentration of pollutants at a level no worse than the design level at any time. The vitiated air is expelled at the tunnel portals and the ventilation buildings.

6.1.2 The mechanical ventilation system for the tunnels shall be designed to:

- maintain the concentration of vehicle emitted pollutants such as carbon monoxide (CO) and nitrogen oxides (NO_x) at or below acceptable levels;
- maintain visibility within the tunnel by preventing the accumulation of vehicle emitted pollutants that contribute to haze;
- control the spread of smoke when a fire occurs in the tunnel;
- minimize the impact of noise due to the ventilation system, both inside the tunnel and outside; and
- minimize the impact of airborne pollutants, particularly from the portals and the ventilation buildings.

Methodology

6.1.3 In order to standardize the calculation methods used worldwide, the Permanent International Association of Road Congresses (PIARC) has issued recommendations for ventilation design. The latest relevant publication used for outline design of the tunnel ventilation for this Study is titled "Technical Committee Report NO.5" (PIARC 1987). The methodology of PIARC has also been applied to recent tunnel projects in Hong Kong. An updated Report (PIARC 1991) was issued after completion of the design of the ventilation system.

6.1.4 The airflow requirements are derived from traffic mix, weight, percentage of petrol and diesel engine vehicles, basic emission factors, vehicle speeds, conversion rate (NO to NO_2) and pollution concentration limits.

6.1.5 The air quality within the tunnel should be such as to ensure that an acceptable environment can be maintained for tunnel users. Acceptable criteria must be determined taking into account both the duration and frequency of use by any specific user.

6.1.6 The required air quality within the tunnel was discussed in Technical Paper No.1 (Tunnel Ventilation-Air Quality Standards), and this, together with subsequent discussions with the Environmental Protection Department (EPD) have led to the recommended air quality standards according to PIARC 1987, and the air quality standards required by EPD shown in Table 6.1.

TABLE 6.1 AIR QUALITY STANDARDS FOR TUNNEL VENTILATION

Pollutant		Permissible Concentration	
		Recommended (PIARC 1987)	EPD Requirements
Carbon Monoxide (CO)		150 ppm	125 ppm
Nitric Oxide (NO)		25 ppm	7.5 to 15 ppm
Nitrogen Dioxide (NO_2)		5 ppm (15 min.) 3 ppm (1 hour)	1.5 ppm (15 min.) 1.5 ppm (1 hour)
Haze	Through traffic	$0.005\ m^{-1}$	
	Stationary to slow moving traffic	$0.009 m^{-1}$	

Note: The volumetric conversion rate of NO to NO_2 is taken as 15%.

6.1.7 EPD have advised that they require maximum permissible concentrations of CO, NO and NO_2 of 125ppm, 15ppm and 1.5ppm respectively. The ventilation system proposed for the tunnel will satisfy both the recommended criteria and EPD requirements, as in most cases the airflow requirements for control of visibility obscuration by haze will be a governing factor in the design.

Emission Factors

6.1.8 The basic emission factors of the vehicle fleet using the Green Island Link at the earliest in 2004, have been agreed with EPD to be Standard B of the year 2000. Table 6.2 shows the appropriate figures derived from PIARC 1987.

6.1.9 The airflow requirements and duct sizes for the ventilation system are shown in Figure 6.1 for dual 2 and dual 3 tunnels.

TABLE 6.2 BASIC EMISSION FACTORS

Vehicles:	Standards B
Opening Year:	2004
Design Year:	2004, but emissions for year 2000(1)
CO:	$0.3m^3$/hr-vehicle
NO:	$0.03m^3$/hr-vehicle for passenger cars and taxi $0.025m^3$/hr-tonne for goods vehicles and buses
Smoke:	$13m^2$/hr-tonne for diesel vehicles

Note: (1) PIARC (1987) recommendations do not cover the period after year 2000, but it is probable that the next Technical Committee Report (1991) will do so.

Fire Emergency System

6.1.10 In the event of a fire in the tunnel, it is essential that the ventilation system can operate in such a manner as to control the spread of smoke. The situation that could generate the largest fire is probably that of a large petrol tanker which has overturned, but in Hong Kong it is normal practice to ban such dangerous goods vehicles from using road tunnels. Such a fire could have a heat release rate of 100MW.

6.1.11 Apart from the above, the next worst design fire would be that of a large goods vehicle on fire and this could generate a heat release rate of 20MW, which could be handled.

6.1.12 Accordingly, the ventilation system should be capable of controlling a 100MW when operating in the normal uni-directional mode, as this will allow for future flexibility in tunnel operations. When the tunnel is operating in bi-directional mode, high risk dangerous goods vehicles should not be allowed in the tunnel, and a design fire of 50MW is considered appropriate.

Conceptual Design of System

6.1.13 There are two basic schemes of road tunnel ventilation, namely, longitudinal and transverse. A longitudinal system uses jet fans to activate a longitudinal airflow along the tunnel to dilute the pollutants. Transverse ventilation systems require one or two ventilation ducts running continuous along the tunnel to provide a transverse air exchange so as to dilute the pollutants. A transverse ventilation system can be semi-transverse (with one supply duct), partial-transverse and fully-transverse (one supply and one exhaust duct). Ventilation buildings are also required to house the ventilation fans for the transverse systems.

6.1.14 The longitudinal and transverse ventilation systems can both be operated to handle smoke generated from a fire inside the tunnel, and either of two basic methods can be used to achieve this function.

6.1.15 The non back layering method requires that a longitudinal flow of air is generated in the tunnel in the direction of traffic flow, such that a smoke free zone is maintained upstream of the fire. The minimum critical air velocity required to prevent back-layering of smoke from the design fire is a function of the gradient and length of the tunnel and will be of the order of 3m/s for the Link.

6.1.16 The alternative method of handling smoke is to extract the smoke from the tunnel directly into the ventilation ducts and this can be achieved by extracting the smoke into overhead ducts, or through high level openings into side ventilation ducts.

6.1.17 For the design of the ventilation system, when operating in the smoke extract emergency mode, PIARC (1987) recommends a volumetric extraction rate of 80 to 160 m^3/s. km. lane for a 100MW fire inside a tunnel. However, prior to 1982, ASHRAE recommended an extraction rate of 155 m^3/s. km. lane without reference to any specific fire load and this recommendation has not been revised since that date. Accordingly the ventilation system for the Green Island Link tunnel is designed to provide an extraction rate of 80 m^3/s. km. lane for both the dual 2-lane and dual 3-lane tunnels. This will require review in the event that large dangerous goods vehicles are allowed in the tunnel.

6.1.18 For the Green Island Link, the length of the tunnel is too great for the use of a longitudinal ventilation system, which is normally only used for shorter tunnels.

6.1.19 A fully transverse ventilation system cannot be justified in terms of cost, as it requires a much greater size of ventilation ducts.

6.1.20 The semi-transverse ventilation system will provide adequate ventilation and fire security, whilst maintaining reasonable economy in duct sizes and ventilation equipment, and accordingly should be used for this project.

Outline Design

6.1.21 As described in 6.1.20 above, the ventilation system of Green Island Link will be semi-transverse with exhaust points at the two ventilation buildings. Supply air fans will deliver air into the tunnel via a supply air duct, as shown in the schematic arrangement of the ventilation system in Figure 6.1. Exhaust air fans are provided at the ventilation building to extract air directly from the traffic box so as to keep the longitudinal air velocity in the traffic duct to below the desirable limit of 8m/s.

6.1.22 The ventilation fans will be arranged in multiple fan groups with the quantity of air supplied or extracted being controlled by the number of operating fans and positions of dampers. The arrangement will be such that no fan groups will be totally inoperable even with a defective fan. Spare fans will be provided in both ventilation buildings for rapid replacement of defective units or those requiring maintenance.

6.1.23 With the fan capacities indicated in Figure 6.1, the control of smoke from the design fire can be achieved with either of the modes described above, the system having the capacity to generate sufficient air velocity to avoid smoke back layering, or, in the extract mode, to achieve the required smoke extraction rate.

6.1.24 As continuous testing programmes are continuously in progress by various authorities, the parameters to be used for the design of the smoke extract system should be further reviewed during the full feasibility study to be carried out later in the decade.

6.1.25 The ventilation system will be controlled from a control location, with input parameters obtained from environmental sensors within the tunnel, and these will enable control of pollutant concentrations to the required limits.

6.1.26 The ventilation system will be designed to incorporate silencers so that the noise level within the tunnel will not exceed 85dB(A). Externally at the ventilation buildings, silencers will be used to limit the fan noise to meet the external environmental conditions as required by the Noise Control Ordinance.

Size of Ducts

6.1.27 The size of the ventilation ducts has been determined to limit the air velocity within the duct to 16m/s. This velocity is considered suitable for ventilation duct of about 1.5km long between the ventilation building and the bulk head near the mid point of the immersed tube. The duct sizes have been incorporated in the various tunnel sections and types for dual 2 and dual 3 tunnel boxes.

6.2 ELECTRICAL POWER SUPPLY SYSTEM

6.2.1 An initial estimate of the maximum electrical demand of the Green Island Link is 10.5MVA and 14.0MVA for the dual 2-lane and dual 3-lane configurations respectively.

6.2.2 Assuming two independent sources of power supply at 11kV will be available, one from China Light and Power Company Limited (CLP) and the other from the Hong Kong Electric Company Limited (HEC), the conceptual design of the power supply system is outlined in the following paragraphs. The description applies to both dual 2-lane and dual 3-lane configurations.

6.2.3 Four 11kV in-feeds from the power companies will be required, two from HEC and two from CLP. The capacity of each in-feed required is 7.0MVA to allow for redundancy in the power supply capacity.

6.2.4 For security reasons, electrical interconnection will be provided among the four in-feeds from the power companies to provide back-up of power supply. In addition, interlock will be provided to safeguard against parallel operation of the power supply sources. The interconnection and interlock will be implemented within the internal 11kV power supply network of the tunnels.

6.2.5 Four load centres will be provided, two at the ventilation buildings and two at the tunnel portals. The load centres at the ventilation buildings will serve primarily the tunnel ventilation fans, tunnel interior zone lighting and the mid-tunnel sump pumps. The load centres at the tunnel portals will serve primarily the reinforcement lighting of the tunnel lighting system, portal sump pumps, and E & M services at portal buildings and external roadway.

6.3 LIGHTING SYSTEM

6.3.1 The conceptual design presented in this report is based on the Publication CIE88 issued by the International Commission on Illumination in 1990. The recommended lighting system should be determined on the basis of:

- length of tunnel;
- visibility of tunnel when viewed from stopping distance in front of tunnel;
- extent of daylight penetration;
- wall reflectance; and
- traffic flow.

6.3.2 The following data have been adopted for the conceptual design:

- a design speed of 85km/h for uni-directional and bi-directional traffic of the Green Island Link tunnels, based on the data presented in Working Paper No.4. The corresponding stopping distance is assumed to be 90m.
- a traffic flow of greater than 1,000 vehicles/per hour for both dual 2-lane and dual 3-lane configurations, based on the data presented in Working Paper No.4.
- assumed values of access zone luminance, based on Table 5.1 of CIE88, with the figures corresponding to the highest percentage of sky in the 20 degrees field of view being adopted result in an access zone luminance at the portals of 5000 cd/m^2.

6.3.3 Based on the data presented in the preceding paragraph, outline calculations have been carried out to determine the luminance diagrams of the tunnel lighting system. This is illustrated in Figure 6.2, for a design speed of 85km/h. This diagram applies to both dual 2-lane and dual 3-lane configurations.

6.3.4 The tunnel should have white or light coloured reflective walls. This will have merit in reducing electrical requirements for a given illumination level. Additionally this may help traffic safety by allowing drivers to be able to see the brake lights of several vehicles in front.

6.3.5 Due to the east-west orientation of the tunnel alignment, tunnel users may, when emerging from the tunnel, be facing directly towards the rising or setting sun. In order to compensate for this, the exit zone lighting may be boosted to reduce the contrast in lighting levels. As reinforcement lighting is provided at each end of each tube to cater for bi-directional traffic, this increased lighting requirement is therefore available.

Lighting for External Roadway

6.3.6 The design average illuminance is recommended to be 50 lux with a uniformity of 0.4 at road level to provide adequate illumination for tunnel surveillance by Closed Circuit Television (CCTV) at night.

Lighting for Toll Plaza

6.3.7 The covered toll plaza is recommended to be illuminated to an average illuminance level of 200 lux at road level to satisfy the visual task required by toll collection activities.

6.4 DRAINAGE SYSTEM

Outline Drainage Design

6.4.1 Drainage systems will be provided to cover the tunnel, ancillary buildings and approach roads to prevent flooding due to storm water, seepage, spillage, washing operation to tunnel and discharge from hydrant/hose reel systems.

6.4.2 Storm water falling on portal catchment areas will be collected by transverse gratings located immediately inside the portals. The collected water will be fed to the petrol interceptor and sump underneath the road surface inside the tunnel. Dewatering pumps will be provided in duplicate to discharge the water via drainage manholes at grade.

6.4.3 A mid-tunnel sump will be provided to collect the seepage water from tunnel structure, storm water spilled over the portal gratings, water from washing operation or discharge from fire hydrants. Foul water inside the tunnel will be collected into a continuous enclosed channel through the discrete gratings laid on one side of the carriageway. An enclosed drainage channel is desirable to reduce the chance of fire propagation from burning of petroleum spills by vehicles. All water will be collected in the mid-tunnel sump where a petrol interceptor will be incorporated. Foul water will be discharged to the portal sump at Kau Yi Chau.

6.4.4 The total capacity or the mid-tunnel sump pumps will be able to cope with the maximum inflow of 4000 litres per minute from the fire hydrants. Sizing of the petrol interceptor will be based on the tunnel seepage rate, water discharged during tunnel cleansing and rain water carried over into the tunnel. Water discharge from tunnel hydrants or from overturned vehicles are considered emergency situations and are not taken into account in determining the size of the interceptor.

6.4.5 The petrol interceptors will contain compartments such that the escape of petrol and oil can be contained. The interceptors will be designed to have a retention time of twenty minutes based on average inflow.

6.5 FIRE PROTECTION SYSTEM

6.5.1 The fire protection provision for the Green Island Link will comprise two parts, namely the fire alarm system and fire fighting system. The fire alarm system will serve to provide a fast and accurate report to the Fire Services Communication Centre (FSCC) and to the tunnel operators once a fire is detected. The fire fighting system will enable the tunnel operators, patrons and the Fire Services personnel to control the fire once it has started. Fire alarm call points and fire fighting equipment will be housed in niches provided along the carriageway.

6.5.2 The fire protection system will work in coordination with the traffic control and surveillance system and tunnel ventilation system so that the tunnel operators and FSD personnel can tackle the fire more efficiently to minimize casualties and damage to property.

Fire Alarm System

6.5.3 A Central Command Centre (CCC) will be provided in the Administration Building. The CCC will receive fire alarms from the tunnel and all ancillary buildings. A direct link will be provided to relay the alarm message from the tunnel immediately to FSCC. Each of the ancillary buildings will also be connected to FSCC via a direct link for report of fire alarms.

6.5.4 Fire alarm from the tunnel will be given out via the actuation of any break glass units which will be provided along the carriageway. In addition, the CCC will receive warning message if any of the following happens:

- use of emergency telephone;
- opening of cross-passage doors; and
- opening of hose reel cabinet.

The CCC attendant will then confirm the fire through the use of CCTV and incident detection system of the traffic control and surveillance system. If a fire is recognized, the CCC attendant will then report to FSCC and take appropriate actions.

Fire Fighting System

6.5.5 Hose reels will be provided for use by tunnel operators and patrons. The hose reel system will be fed by two pump/tank systems, one at each ventilation building. Fire services inlets will be provided such that water supply can be maintained after the water tanks have been emptied.

6.5.6 Fire hydrants will be provided for use by Fire Services at regular spacing of 100m along the carriageways. The fire hydrants system will be directly fed by two separate connections from city water mains located at the two ventilation buildings. Such arrangement will eliminate the need for pump/tank systems while ensuring unrestricted water supply to the hydrant system.

6.5.7 Portable fire extinguishers will be provided for use by tunnel operator and patrons. They will be housed in niches on the side walls of the carriageways.

6.6 TRAFFIC CONTROL SYSTEM

6.6.1 A central computer system consisting of dual central processing units will be required. The adoption of a hot standby computer configuration will provide a high degree of system availability. The duty and standby computer systems should be identical and each system capable of handling both the on-line and off-line system. In order to maximise the operational flexibility, duty/standby system changeover should be included with both automatic and manual features. The schematic system is depicted as shown in Figure 6.3 which shows the dedicated communication path between the central computer and field equipment. The traffic central computer should have the capabilities of performing a complete system safety check before any traffic plan change.

Tunnel Closure Facilities

6.6.2 Information in relation to "tunnel open" or "tunnel closed" should be clearly conveyed to the tunnel users. Variable message signs or equivalent facilities must be provided to all access points leading to the tunnel. They are normally in form of graphics approved by local authority and are located in strategic positions easily visible by the tunnel users day and night.

6.6.3 Signs and barriers will be provided at the last point of no return. These facilities are best provided at the point where overheight vehicles are diverted from the tunnel.

6.6.4 Comprehensive tunnel closure strategies in form of pre-planned software routines will provide traffic control for the following conditions:

- grave emergency which requires the closure of both tubes of the tunnel;
- major incident which requires the closure of one tube of the tunnel; and
- minor incident which requires the closure of one lane.

Overheight Detection and Control

6.6.5 At each approach to the tunnel there has to be automatic detection and signing to divert overheight vehicles. The detection facilities should use duplicate light beams or similar equipment with supplementary induction loops or other vehicle detectors to avoid false alarms. Immediately following the detectors there should be variable message signs to indicate to the overheight vehicle that it must divert. Upon actuation of the overheight vehicle system, a buzzer should be sounded inside the control point kiosk to alert the field attendant who can intercept the offending vehicle.

6.6.6 In order to further intercept overheight vehicles, consideration should be given to the installation of a physical barrier. This should be a strong structure, accurately set to a height intermediate between that for overheight vehicle detection and the actual tunnel ceiling; the siting of this structure should take into account the likelihood of parts of an overheight vehicle or its load becoming displaced and landing on the roadway.

Emergency, Maintenance and Tidal Flow

6.6.7 During peak hour periods of unbalanced traffic conditions, the tunnel supervisor should have the option of implementing tidal flow. To maintain traffic control during this situation, control facilities including overhead gantry-mounted signals, secret signs, traffic signals, wig-wag ambers, barriers and pavement lights will be required.

6.6.8 Traffic signals will be provided at all crossovers between the two directions of travel. In particular they should be provided at the maintenance crossovers (close to the portals) and at the tidal flow crossovers. Conventional three-aspect traffic signals may be used, so as to provide a warning amber signal. However, the signals will normally be set by manual intervention through the control system. For advance information, variable message signs should be provided and activated whenever a non-standard arrangement is in operation.

6.6.9 Traffic signals are effective in controlling the traffic and should have the capability of being remotely controlled by the traffic control computer. The state of the traffic signals should be scanned periodically and sent back to the traffic control computer for close system monitor.

Lane Usage

6.6.10 Close to and within each tunnel tube there will be signals to control lane usage with the tunnel. These are usually in the form of small red, amber and green overhead signals. Amber is used to indicate the imminence of red, or the presence of congestion or other difficulties ahead.

6.6.11 Correct and appropriate green signal interlocks should be considered to ensure no unsafe condition exists during the implementation of lane-used signal plan.

Radio Communication

6.6.12 The re-broadcasting of all current popular radio programmes, and the retransmittal of future two-way communications systems including Radio Data Systems, will enable tunnel announcements to be made by intercepting these channels to advise motorists of the correct behaviour in emergencies. Information should similarly be provided on signs, some of which will be fixed e.g. indicating emergency points, and others variable e.g. indicating the need to switch off engines.

Emergency Services Radio Facility

6.6.13 The emergency services radio facility will allow both Fire Services Department (FSD) and Royal Hong Kong Police (RHKP) to use their existing vehicle mounted radio equipment to maintain communication with their respective control centres.

Emergency Telephones

6.6.14 A highly reliable emergency telephone system will be provided at 100 metre intervals. The telephones will be in pairs immediately opposite one another. Presence of the caller or lifting of the handset should automatically establish connection with the control room and inform the control staff which telephone is in operation. This should not prevent any other emergency telephone simultaneously being in operation. There should be a ring-back facility for control room staff to summon attendance at any tunnel telephone.

Closed Circuit Television

6.6.15 Closed Circuit Television (CCTV) cameras will be spaced at approximately 200 metres throughout the tunnel. Cameras should normally face in the direction of traffic flow so as to avoid headlight glare and fouling of the lens with traffic dirt but should also have the facility for 180° pan.

6.6.16 Outdoor cameras should have appropriate remote controls operated from the central control room. Control facilities such as pan, tilt and zooming should be provided for those cameras situated outside the tunnel.

Radar

6.6.17 A radar system linked to the CCTV and associated recording equipment should be installed to detect and record vehicles which exceed the speed limits.

6.7 BUILDING SERVICES

6.7.1 There will be ancillary buildings such as control centres, ventilation buildings and toll booths in which electrical and mechanical equipment are housed and operation staff will station therein to provide the necessary support for roadway operations. Building services systems will be provided to ensure reliable functioning of equipment and to maintain a safe and comfortable environment for the operation staff.

Fire Services Systems

6.7.2 In general, automatic fire detection systems will be provided to cover all plant rooms, computer-based equipment rooms, control rooms and toilets. Office areas, workshops, stores and general areas will be protected by automatic fire sprinklers. The computer-based equipment rooms and control rooms will be protected by automatic gas flooding system. The extinguishing agent of the flooding system will be confirmed with the Fire Services Department (FSD). Fire extinguishers will be provided in the areas not covered by fire detection system. All buildings will be provided with hydrant/hose systems in accordance with FSD regulations. A direct link will be provided to connect the fire alarm panel of each building to FSCC. An alarm message will also be transmitted to the CCC of Green Island Link.

Ventilation and Air-Conditioning

6.7.3 Plant rooms will be provided with mechanical ventilation system which will be actuated by temperature control. Computer-based equipment rooms and manned areas will be air-conditioned to render environments of suitable temperature and humidity for proper functioning of equipment and for the comfort of operation staff.

Plumbing and Drainage

6.7.4 The plumbing system will comprise the supply of cold and hot potable water and flush water to various buildings. In general, cold water will be supplied to the kitchen, toilets, shower rooms and probably workshops. Hot water will be required in kitchens and shower rooms.

6.7.5 Waste water from various buildings will be discharged to government sewers while the storm water from the buildings will be drained to the government storm water drainage system or directly to the sea.

6.7.6 Petrol/oil interceptors and silt traps will be provided as appropriate for trapping oil or diesel spillage collected from the all waste water and storm water drainage systems.

6.8 CROSS ADITS AND NICHES WITHIN THE TUNNEL

6.8.1 Cross adits linking the two tubes shall be provided to allow people to evacuate from one tube to the other in case of fire occurring inside the tunnel. The cross adits shall be placed at a spacing of 100m. This is in line with the current recommendation of FSD. These cross adits should generally only be operated under the control of tunnel staff, and should be fitted with remote monitoring devices to ensure that they are normally closed.

6.8.2 As described in sections 6.5, fire fighting equipment shall be provided inside the tunnel for use by the tunnel patrons, tunnel operation staff and FSD personnel to cope with incidents inside the tunnels. This equipment will comprise breakglass units, emergency telephones, portable fire extinguishers, fire hydrants, and hose reels. Emergency power socket outlets will also be provided for use by FSD personnel.

6.8.3 The equipment will be housed inside niches along both sides of the tunnel tubes. Figure 6.4 indicates the typical arrangement of the niches and cross-adits.

CHAPTER 7

7 MARINE AND NAVIGATION CONSIDERATIONS

7.1 GENERAL

7.1.1 The Green Island Link will be constructed across the Lamma Channel at a time when marine traffic densities are anticipated to be around 2½ times those of today (Port Development Strategy Review: April 1991), and at a time when the Sulphur Channel will have been closed to shipping. As a result more vessels will be making the sharp turn from the north of Green Island across the tunnel site.

7.1.2 For these reasons, marine and navigation considerations have been regarded as an important aspect of this Study.

7.2 MARINE TRAFFIC

7.2.1 Records kept by Marine Department of Hong Kong VTC surveillance radar permit identification of tracked vessels and their routes across the study area. The vessel tracks have been extracted from available data and plotted on Figure 7.1 for a typical 24 hour period.

7.2.2 Each line represents the route of one vessel either inbound or outbound, and this clearly shows the separated lanes of the East Lamma Channel, the confluence of tracks at a number of locations, and the location of anchorages utilised.

7.2.3 The radar records do not identify the large number of small vessels such as ferries, fishing boats, tugs, pleasure craft and barges that use the waterway, and the quantities of these vessels has been determined from examination of other records.

7.2.4 The tunnel site is, for ocean-going traffic, the busiest part of Hong Kong's waters. The East Lamma Channel and the proposed West Lamma Channel which will serve new port facilities on Lantau Island, are expected to carry around 80% of overseas port traffic. The potential for diverting traffic to other approaches is limited: the Eastern Approach via Lei Yue Mun is too shallow for many container ships, and other routes are too shallow for even mid-sized cargo vessels. The likelihood of closure of the waterway by a sinking near the tunnel site is considered negligible since the width of the waterway is several times the length of the largest vessels. The worst conceivable scenario is that tunnel laying operations and a sunken ship would together block about 600m of the width of over 2km. If traffic densities were considered too high in such a case, tunnel construction would have to be suspended while the vessel was raised.

7.2.5 Most ocean-going ships entering the port via the East Lamma Channel proceed northwards to Ma Wan or to the container terminals. The remainder either: turn into the Sulphur Channel towards buoys in the southern part of the Harbour; turn to the north of Green Island towards the northern part of the Harbour; or turn west to anchorages in the Western Harbour. Many ships proceeding towards anchorages start their turning manoeuvre opposite Green Island.

7.2.6 In future, with the Sulphur Channel closed by the Green Island Reclamation, more traffic will be making the 120° turn around the north of Green Island. Turning vessels require a wider channel than for those proceeding straight ahead.

7.2.7 Vessels leaving the port do so by the same route as the above. General rules for navigation require vessel to pass "port to port" so that the vessel tracks for departing vessel are generally to the west of those arriving. To the south of the tunnel site there is a traffic separation scheme which in general requires vessels to adhere to one-way routing and local, "inshore" vessels to generally keep clear of the designated traffic lanes.

7.2.8 Vessels turning from the proposed dredged channel to the north of Green Island into the East Lamma Channel must therefore cross the path of incoming traffic, and may not have a clear view of such traffic until they have cleared the western tip of the reclamation. If they, at the same time, have to avoid a fixed obstruction in the channel, the chances of an incident are increased.

7.2.9 Another factor tending to increase the potential for conflict is the presence of a pilot station nearby. Although the charted boarding point for pilots is some 2km to the south, it is understood pilots are often taken on or leave vessels closer to Green Island. To take on a pilot a vessel slows leading to reduced headways between vessels and a correspondingly increased density of traffic.

7.2.10 Whereas ocean-going traffic proceeds generally north-south past the site, local traffic moves mainly northeast-southwest. Most of the traffic is high speed ferries serving Macau, but slower passenger and vehicular ferries serve Lantau, Lamma, Cheung Chau and Peng Chau. None of these routes is likely to be replaced by road links in the foreseeable future.

7.2.11 The estimated average number of movements of ocean-going vessels past Green Island is presently 85 per day. Daily peaks are believed to occur of perhaps twice the average rate. Public transport schedules list 390 ferry movements per weekday including outlying island ferries, with fewer at weekends, and again a daily peak of about double the average rate is evident during rush hours. Marine Department's estimate of Hong Kong-Macau cargo traffic is about 130 movements per day. Daily peaking of these vessels are expected to be less than for ferries, and a 50% increase is assumed.

7.2.12 The survey data available for inshore traffic moving between the Harbour, Lamma Island and Aberdeen indicates that a daily total of 500 movements should be assumed for ferries, pleasure craft, fishing vessels lighters and other small craft.

7.2.13 As noted above, during the next decade ocean-going vessel calls are expected to more than double. Some vessels, under the proposals in the PADS study, would proceed to berths to the west of Kau Yi Chau. If account is also taken of seasonal peaking, which increases the throughput of the port around August by about 25% over the annual average, the number of ocean-going vessels passing the site during construction could be 200 per day or up to 17 per hour (say 8 in each direction). These would be split between the East and West Lamma Channels. Perhaps 70% might use the Eastern channel and 30% the Western. The Marine Department has expressed concern that the estimated volume of traffic coupled with the construction work due to be carried out could cause congestion. It is considered that these difficulties can be overcome, however, it is essential that detailed planning of the construction operations is fully examined at the full feasibility stage of this project.

7.2.14 The increase in local traffic is more difficult to predict. New ferry piers at the Central and Wanchai Reclamation are being planned, but whilst the number to be allocated to outlying island services has not yet been determined, Marine Department advise that the number of outlying island ferry routes will be maintained. Growth patterns in Macau-bound passenger traffic are also difficult to predict with the changing political situation. It is however, reasonable to expect growth in both passenger numbers and the size of vessels on all ferry routes. An increase in the number of vessels of 50% over today's traffic is plausible and is adopted for the purposes of this study. Cargo vessels on the Hong Kong-Macau route are assumed to increase by the same percentage. It is assumed there are generally no seasonal variations in this traffic, but the peak in Macau Ferry movements for three weeks around Chinese New Year should be noted.

7.2.15 Total estimated vessel movements through the tunnel site are summarized in Table 7.1 for the design years of 2001-3.

TABLE 7.1 ESTIMATED NUMBER OF VESSELS PASSING THE TUNNEL SITE IN THE CONSTRUCTION PERIOD 2001 - 2003

Vessel Type	General Direction	Max. Daily Average (No.)	Peak Hourly (No./hr)	Notes
Ocean-going	N - S	200	17	70% to East Lamma Channel
Ferries	SW - NE	585	50	Mostly fast craft
Others	SW - NE	195	12	Macau barge traffic
	N - S	750	48	Harbour-Aberdeen
Total		1355	103	

7.2.16 These figures may be compared with the survey of vessel movements for the Western Harbour Crossing Study which recorded 3000 movements across the waters between the Macau Ferry Terminal and the Ocean Terminal in 14 hours, suggesting a daily total of about 3300 movements. Whereas the total traffic density is much less at the present site, the number of ocean-going vessels is over ten times that expected at the WHC, and the average vessel size will be larger.

7.2.17 Prior to construction it will be necessary to define the mitigation measures which would have to be applied to the construction method and sequence, and to the control of shipping in order to provide acceptable conditions for each. These measures may include any or all of those described briefly in the following sections. The measures to be implemented will depend on the stage of construction, for example more attention will need to be paid to construction of the parts of the tunnel in the busiest parts of the water than to parts in less well-trafficked areas.

7.3 THE CONSTRUCTION OPERATION

7.3.1 For the purposes of this Study, it is assumed that both the East Lamma Channel and West Lamma Channel will be in use when the tunnel is constructed. It is understood, however, that this may not be the case because the East Lamma Channel may not have reached capacity by 2001. Present indications are that the West Lamma Channel will be required at about the same time that the tunnel is being built. This suggests not only that the total navigation width between Green Island and Kau Yi Chau is more than adequate for the shipping anticipated at that time, but also that the absolute maximum blockage of the waterway which might be tolerated is total closure of one or other of these two channels to ocean going shipping. Thus the width of the main part of the waterway occupied by construction plant should not be allowed to exceed about 700m (the width of the non-anchorage area indicated on the chart). A marine works area of 400m length along the centre line of the tunnel is sufficient within which to carry out bed laying, unit laying and backfilling operations, and a series of such areas, overlapping by 100m, are indicated on Figure 7.2 for illustration of possible construction sequences.

7.3.2 It is considered that any one of these works areas may be occupied at any time with acceptable impact on the anticipated marine traffic and with acceptable risk to both marine traffic and the tunnel laying equipment. Quantification of possible delays and risks to shipping will require better estimates of the timing of tunnel construction and growth in marine traffic than are available at present.

7.3.3 The measures that need to be considered for application to the tunnel laying operations to minimize their impact and risk, include dredging with manoeuvrable high capacity plant; operating at night; and sequencing the work so as not to require excessive numbers of changes to navigation routes.

7.3.4 Ideally, any dredging carried out by grab dredgers in the busy part of the waterway should be done within the proposed marine works areas, just prior to tunnel laying, in order to minimize the number of times vessels using the existing channels need to be diverted. Consideration will need to be given to scheduling the more delicate operations, such as laying tunnel units at night, when the density of traffic is relatively low. Such timing would minimize any problems caused by the wash of ocean-going ships, and in general sea conditions tend to be calmer at night.

7.3.5 If the tunnel is to be constructed from either end with a closure somewhere within the channel, it would make sense from the point of view of minimizing disturbance to traffic to make the closure away from the existing channels and traffic routes. This means the final joint would also be in shallower water which is otherwise desirable. It would be best to make the closure to the west end to avoid the more heavily trafficked East Lamma Channel and the busy water just to the west of Green Island.

7.3.6 Finally, it will be less confusing for all concerned if the number of fairway diversions is kept to a minimum. This requirement conflicts with the requirement to keep the works area relatively short but the works area size suggested above seems a reasonable compromise. Certainly, if at all possible, the works should be arranged so that all operations can be carried out within each works area on a single possession. Otherwise separate series of possessions would be required for dredging, bed laying, unit laying and backfilling.

7.4 MARINE TRAFFIC CONTROL MEASURES

7.4.1 Management of marine traffic can reduce the potential conflict between vessels and construction operations. At present, traffic control is limited, with the Marine Department's Vessel Traffic Centre (VTC) acting in a monitoring role only. In time, it is anticipated that the VTC will need to move towards more active traffic management more along the lines of air traffic control, particularly control of the timing and routing of vessels into and out of the port to smooth out the peaks in traffic densities. By 2001, traffic densities will be such that such management will be highly desirable, if not essential, and the following paragraphs assume that such control can be applied to individual vessels as the need arises.

7.4.2 The various measures which are available to control traffic patterns include those which are desirable in any case, such as relocation of the pilot boarding station, encouraging Macau traffic to use the Ma Wan Channel or Kap Shui Mun, and encouraging more use of Lei Yue Mun, and more radical measures such as compulsory diversion to other routes, and reorganisation of traffic between the East and West Lamma Channels. The relative merits in terms of safety should be examined further at feasibility stage.

7.4.3 There is a pilot boarding station just to the south of the site. It is understood that relocation of the station to south of Lamma Island is under consideration. This is highly desirable to avoid congestion in the area near Green Island and to provide better control over vessels. The programme for relocation may be linked to the date of opening of the West Lamma Channel. It is suggested that this relocation should be prior to 2001.

7.4.4 Macau ferries may use the route which passes the site or may go north of Lantau via the Ma Wan Channel or Kap Shui Mun. The northern route is already used in bad weather as it is more sheltered. However, with the phasing out of the smaller hydrofoils the route is not so popular since the present vessels can withstand rougher seas and the southern route is shorter. The ferries may pass the site at speeds of 30-40 knots, travelling at right angles to the main channels. A reduction in the number of ferries passing the site could have a significant effect on safety so diversion to the northern route is desirable. In any case, if any ferries are to be passing the site, ferry masters will need to be kept informed of tunnel laying operation, particularly if floating-in is done at night. There would be only limited benefit to diverting Macau traffic north of Kau Yi Chau. Although this would reduce conflicts between ferries and the tunnel, a channel would need to be dredged, and this is unlikely to be cost-effective.

7.4.5 If the programme for the Green Island Reclamation permits, consideration could be given to keeping the Sulphur Channel open preferably until the last possible moment or at least while the eastern part of the tunnel is being constructed. If this were possible, at least the small vessels (up to 500 per day) moving between the Harbour and the Aberdeen area could do so clear of the tunnel construction and clear of the marine shipping channels. Preferably, some of the larger ships going to buoys should also be able to continue to use this route. Otherwise, at certain stages of construction it is considered necessary to encourage or even compel vessels to approach the harbour mooring buoys from the Northern Fairway or Lei Yue Mun, rather than turning round Green Island to use the Southern Fairway. Harbour moorings west of Green Island may need to be removed when work takes place in areas 5, 6 and 7 on Figure 7.2.

7.4.6 Three levels of control may be exercised by the Marine Department:

- one in which it is left to pilots and masters as to which route to take depending on the prevailing traffic and tidal conditions;
- the second in which the VTC advises those vessels with which it can communicate allowable routes on a case-by-case basis; and
- the third in which all vessels of certain classes are required to avoid certain routes.

7.4.7 At other times in the construction sequence, one or other of the East and West Lamma Channels will be substantially blocked by a working area. Consideration will then need to be given to operating one of the channels, or perhaps both, as one-way only. Certainly, there is more flexibility if the West Lamma Channel is open before these critical stages are reached. Possible arrangements for traffic are discussed below.

7.5 CONSTRUCTION SEQUENCE

7.5.1 Indicative arrangements for construction are shown in Figure 7.2. Each working area is given a number, not necessarily indicating the order of construction. Tentative traffic arrangements for each works area are discussed below.

Working Area 1

7.5.2 On possession of Working Area 1, at the far west of the immersed tube, marine traffic may continue substantially as normal. The working area is outside the designated channels. No special arrangement are envisaged for aids to navigation.

Working Area 2

7.5.3 Working Area 2 extends across part of the West Lamma Channel, but there is not enough room between the area and the proposed reclamation to route ocean-going traffic through the gap. The West Lamma Channel would be moved eastwards about 300m and this would require some dredging if the West Lamma Channel were formed on the alignment proposed by PADS. Because of the reduced navigation width, consideration should be given to operating the West Lamma Channel as one-way only, by requiring outbound vessels to give priority to inbound vessels at the tunnel position. If traffic levels were so high that delays to outbound vessels became unacceptable, then a possibility is to require outbound vessels to cross to the East Lamma Channel north of the site.

Working Area 3

7.5.4 Working Area 3 takes up the eastern part of the West Lamma Channel. There would be sufficient width of water between the working area and the reclamation for vessels to pass through, but there would be sufficient depth over only about 300m width. This is adequate for one-way traffic and a traffic scheme similar to that for Working Area 2 could operate in the West Lamma Channel.

Working Area 4

7.5.5 This Working Area is between the two channels, intruding about 200m into each. There is adequate navigation width available for both channels by moving each away from the centre of the waterway. Mooring buoys A43 and A49 may need to be downgraded or their use suspended on moving the East Lamma Channel eastwards. On the proposed vertical alignment for the tunnel, the East Lamma Channel could be moved up to 300m eastwards whilst maintaining a depth of 15m, which is adequate for all but the largest bulk carriers.

Working Area 5

7.5.6 In this phase, it is recommended that only inbound vessels using the East Lamma Channel and outbound vessels from the Southern Fairway pass to the east of the Working Area. The width of water available to the west of the Working Area is around 800m, which is adequate, with temporary buoyage, for three vessel routes: inbound and outbound via the West Lamma Channel and outbound via the East Lamma Channel. However consideration should also be given to operating the West Lamma Channel for inbound vessels only, outbound vessels from the Lantau Port crossing and merging with East Lamma Channel traffic just north of the tunnel.

Working Area 6

7.5.7 In this phase, marine traffic conditions are at their worst. There is only 300m of water of sufficient depth to the east of the Working Area for inbound vessels using the East Lamma Channel. This may not be adequate for the level of traffic expected. It is recommended that only traffic proceeding straight ahead towards the Ma Wan Channel, Tsing Yi, Kwai Chung or the more northerly buoys be permitted through the gap. Other ocean-going traffic should use other routes, in order to avoid turning in the tunnel area.

7.5.8 The water to the west of the Working Area could be used in two different ways. In the first scenario, the East and West Lamma Channels would operate as they do now, with three lanes of traffic in opposing directions. An alternative is to designate the entire East Lamma Channel for inbound traffic and the West Channel for outbound. Although this would give more room for inbound traffic going to Ma Wan and the Harbour, it would require vessels bound for Lantau Port to cross the main stream of outbound vessels. It would also require adjustment of the Traffic Separation Scheme for which the International Maritime Organization requires at least four month's notice and may lead to potential confusion for unpiloted craft. This alternative may not be worth pursuing unless it can be shown to be clearly safer than the first option.

Working Area 7

7.5.9 This Working Area is substantially clear of the designated channel so that vessels using the Lantau Port, Ma Wan Channel, Tsing Yi, Kwai Chung and the northern part of the Harbour are largely unaffected. Vessels intending to turn into or out of the Southern Fairway would however be severely affected. Inbound turns for vessels drawing more than 7 metres could not easily be made between the working area and the Green Island Reclamation because of the restricted depth of water, and outbound turns would need to go to the west of the Working Area, crossing the tracks of the majority of inbound vessels at exactly the location where there is no room for such vessels to take avoiding action. Restriction of such turning movements for certain classes of vessel would be essential. Alternative routes via the northern Fairway and Lei Yue Mun are available.

Working Area 8

7.5.10 The effect of this area is similar to that of Working Area 7 except that turns from the Southern Fairway could be permitted with little effect on safety. This phase is critical for small craft movements between the Harbour and Aberdeen, but there is little that can be done to control these craft.

Working Area 9

7.5.11 This Working Area is adjacent to the Green Island Reclamation and will affect small craft movements. Ocean-going vessels making for the Southern Fairway should be encouraged or, possibly, compelled to take other routes.

7.5.12 It may in some circumstances be desirable for more than one Working Area to be occupied at any one time. Except in the case of Working Areas 1 and 2, it is recommended that adjacent working areas are never allowed to be occupied simultaneously. It is also recommended that not more than one Working Area within the designated fairways is occupied at any time. These recommendations would not prevent works in Area 1 while working in Areas 5-9 or works in Area 2 while working in Areas 7, 8 or 9.

7.5.13 The direction of construction (west-east or east-west) will have little net effect on marine traffic. It should be noted that towards the ends of the tunnel the existing seabed may be dredged to provide extra navigation width for the larger vessels but this option is not available once tunnel units are in place. This would favour a west-east progression. On the other hand, it is felt that the final units should be placed in less heavily trafficked areas near the western end, so there is no clear choice from the point of view of impact on marine traffic.

7.6 ASSESSMENT OF MITIGATION MEASURES

7.6.1 From the above discussion it is concluded that disturbance to traffic during construction of the tunnel, although inevitable, can be made acceptable. A range of mitigation measures is available, some of which would have tangible cost implications, These are the cost associated with dredging for increased channel widths and buoyage. The difference in direct cost to the project between the various options for traffic management is not great, but each option will have a different impact in terms of delays to shipping and relative safety of shipping and construction equipment. The cost of construction may, on the other hand, be sensitive to the size of the proposed working areas and sequence of construction. If savings may be made at the expense of increased disturbance to shipping then a quantitative evaluation of the effects would be required.

7.6.2 In order to compare and contrast different proposed arrangements on a quantitative basis a mathematical model of marine traffic is required. The model would be used to establish firstly the likely marine traffic conditions in the absence of a tunnel, that is, how much vessels' desired routes and speeds are likely to be affected by other vessels in the area. Then by defining various obstructions, rules for navigation and restrictions on certain types of vessel, increased delays to vessels, or increased risks may be identified and comparisons made between different scenarios for both the permanent works and the construction sequence.

7.6.3 Such models are available and are presently being applied in other studies for the Western Harbour. It is understood that probable traffic conditions will have been established in those studies by about March 1992 which is therefore the earliest time that the effects of the tunnel construction could be examined. Work using these mathematical models could be commissioned thereafter.

7.7 VESSEL TRAFFIC CONTROL SYSTEM

7.7.1 The present Vessel Traffic Control (VTC) System operates with radar transmitters and reflectors mounted at various locations throughout Hong Kong. It is understood to be the intention of Marine Department to expand the system by the addition of a radar transmitter on Kau Yi Chau by the end of 1993, and this will enable a greater degree of detection of traffic in the Western Harbour.

7.7.2 If, as noted in this report, the island of Kau Yi Chau is removed, then it will be necessary to find another suitable location for the proposed installation.

CHAPTER 8

8 GEOTECHNICAL AND MARINE BED CONDITIONS

8.1 REGIONAL GEOLOGY

8.1.1 The Green Island Link (GIL) corridor traverses an area where the geological succession is typical of offshore conditions in Hong Kong. The geological succession consists of marine deposits overlying alluvium and decomposed granite (soil) and granite bedrock.

8.1.2 The marine deposits are predominantly very soft to firm clay and silt. Marine sand deposits have been identified on the northern side of the GIL corridor within the Lamma Channel. Around the former dumping ground areas to the north of Kau Yi Chau the top layer of the marine deposits is expected to contain construction debris and other waste materials.

8.1.3 The alluvium consists of interbedded layers of silt/clay, sand and gravel deposits. Both the thickness and base level of the alluvium varies along the alignments of the proposed submerged link. However, around Kau Yi Chau and in the area of proposed reclamation on the southern edge of the Lantau Port Peninsula the level at the top of the alluvium is reasonably uniform at -28mPD. The alluvium is thought to be part of the Chek Lap Kok Formation, and of Pleistocene Age. As a result the alluvium would be a relatively stiff material and would probably be over consolidated. Within the Green Island Link Corridor, the existing borehole information described in Section 8.2 indicates that the alluvium is predominantly a granular material comprising mostly silty gravelly sand.

8.1.4 The mantle of decomposed granite soil (CDG) also varies in thickness along the proposed alignments. In general rockhead is at between -40mPD and -75mPD, although borehole (BH15) south of Kau Yi Chau did not reach rockhead at a level of -71mPD. The CDG underlying the sediments is characteristically a very stiff material being the in situ weathering product of the granite bedrock.

8.1.5 The East Lamma Channel is inferred to follow the alignment of the fault system which is orthogonal to the Tolo Channel/Lai Chi Kok lineament shown on the 1:20000 Geological Series published by the GEO. The assessment of the recent activity of the fault is discussed in Section 8.5.

8.2 EXISTING SITE INVESTIGATION INFORMATION

8.2.1 The geotechnical conditions along the proposed alignments have been examined by studying the following existing data:

- Marine Source of Fill Study, 1988 - Lamma Channels;
- Port and Airport Development Strategy, 1988 - Western Harbour, particularly Kau Yi Chau and Siu Kau Yi Chau;
- Green Island Reclamation Feasibility Study, 1989 - Green Island;
- Study of Harbour Reclamation and Urban Growth, 1983 - Green Island;
- Route 7 Study, Kennedy Town to Aberdeen, 1982 - Green Island;
- A Study of Gas in Marine Sediments in Hong Kong - Geotechnical Report - NGI, August 1990;
- The Search for Evidence of Neotectonic Movement along Faults and Variations in Bedrock Character using Continuous Reflection Profiles in Hong Kong Waters - Evans, 1990;
- Hong Kong Geological Survey Memoir No. 2; and
- HKGS 1:20,000 Scale Map - Sheets 10 and 11.

8.2.2 The marine geophysical information and site investigation information which have been obtained are listed in Tables 8.1 and 8.2 respectively. The locations of the existing site investigation are shown in Figure 8.1. Figures 8.3 and 8.4 show the interpreted geological profiles along alignments N-C and N-N respectively.

8.2.3 The existing information available at the commencement of the Study was considered to be sufficiently comprehensive for this preliminary feasibility study with the following two exceptions. At the start of the Study there was no information on the chemical properties of the marine deposits as an indication of contamination or any subsurface information of Kau Yi Chau Island. Therefore limited additional site investigations were carried out to obtain information in these two areas.

8.3 SCOPE OF SITE INVESTIGATIONS

Marine Drop Cores

8.3.1 In order to determine chemical and particle size characteristics of the surface, testing on a number of dropcore samples along the proposed route was carried out. The location of the dropcore samples is also shown in Figure 8.1. The purpose of this testing was to assess if there was any contamination of the marine deposits which may need to be dredged and disposed of. The samples were tested for different metals as indicators of the extent of heavy metal contamination and the results indicated that all the samples tested can be considered as uncontaminated. Details of the test results and their interpretation are given in Volume 3 of this Report.

Site Investigation of Kau Yi Chau

8.3.2 A preliminary site investigation was undertaken of Kau Yi Chau which consisted of field mapping, 4 boreholes drilled 10 metres into rock and 3 kilometres of geophysical survey. The extent of the investigation is illustrated in Figure 8.2. The investigation was aimed at obtaining sufficient subsurface information to enable preliminary costing to be done of the earthworks associated with alternative route alignments.

TABLE 8.1 EXISTING MARINE GEOPHYSICAL SURVEY INFORMATION

GIU No./Works Order No.		Project
GIU 11755-17756	PW/7/2/20.4	Stage 1 Geophysics, Marine Source of Fill Study, September 1988
GIU 11228-11230	PW/7/2/20.13 PW/7/2/20.16	Stage 2 Geophysics, Marine Source of Fill Study, September 1988
GIU 12368-12369	N/A	Port & Airport Development Strategy Study, December 1988
N/A	PW/7/2/20.24	Green Island Reclamation Feasibility Study, 1989
GIU 5453-5455	N/A	Study of Harbour Reclamation and Urban Growth, June 1983

8.3.3 Preliminary results of the investigation indicate that the island is covered by varying depths of colluvium and in situ weathered soil. Their total thickness appears to vary to a maximum of 15 to 20 metres. Underlying the soil overburden is generally a moderately jointed intrusive rock of granitic origin. The joints are closely to moderately spaced in the south part of the island, while in the north they are moderately to widely spaced.

TABLE 8.2 EXISTING SITE INVESTIGATION INFORMATION

GIU No./Works Order No.		Project
GIU 11097 GIU 10501	PW/7/2/14./40 PW/7/2/21.20	Marine Site Investigation, Marine Source of Fill Study, 1987/1988
GIU 11099 GIU 11098 GIU 11112 GIU 10502-10503	PW/6/3/24.97 PW/6/3/24.99 PW/6/3/24.135 PW/7/2/14.40	Laboratory testing, Marine Source of Fill Study, 1988
GIU 12370-12377	N/A	Marine Site Investigation Reports, Port & Airport Development Strategy Study, July 1988 to October 1988
N/A	PW/7/2/21.33	Marine Site Investigation Green Island Reclamation Feasibility Study, 1989
N/A	PW/6/3/24.183	Laboratory testing, Green Island Reclamation Feasibility Study, 1989
GIU 5453-5455	N/A	Study of Harbour Reclamation and Urban Growth, June 1983
N/A	N/A	Route 7 Study Kennedy Town to Aberdeen, 1982

8.4 GREEN ISLAND APPROACH

8.4.1 The Green Island portal and approach tunnel are located within the Green Island reclamation which, in accordance with the Brief, is assumed to be in place or under construction when the Green Island Link is constructed.

8.4.2 The Green Island Reclamation Feasibility Study (GIRFS) has proposed that the marine deposits be left under the reclamation and wick drains installed to reduce long term settlements to acceptable levels. It is proposed in both GIRFS and this study that for the construction of the cut-and-cover tunnel section all marine deposits should be removed from under the tunnel. This work would have to be carried out as part of the Green Island Reclamation Works and will result in an additional depth of dredge of approximately 5 metres.

8.4.3 The foundations for the highway structures associated with the interchange will have to be designed to allow for the long term settlements of the reclamation. It is likely that deep, piled foundations would be required such as large diameter bored piles or driven tubular piles. The piles would need to be founded on rock at a depth of up to 65m as purely end bearing or in the weathered rock as a combination of side friction and end bearing. The negative skin friction forces caused by the long term settlements of the reclamation must be taken into account during the foundation design. Due allowances would also have to be made in the design of the superstructure for differential settlements between adjacent bridge piers.

8.5 IMMERSED TUBE

8.5.1 The geological profiles as interpreted from the existing S.I. data are shown in Figures 8.3 and 8.4 for the alternative Routes N-C and N-N respectively. It can be seen that the immersed tube tunnel will found within a sequence of recent marine deposits, pleistocene alluvium and completely decomposed granite (CDG), which are generally described in Section 8.1.

8.5.2 Unless specific S.I. data indicates otherwise, the marine deposits comprise predominantly clay and silt which are of recent origin and are normally consolidated. The marine deposits therefore exhibit low shear strength and high compressibility and are not a good foundation for engineering construction. The marine deposits are also susceptible to scour, should a change occur in the hydraulic regime at bed level.

8.5.3 The alluvium is generally considered to be over consolidated and of low compressibility. The alluvium is therefore expected to provide a firm foundation for placement of immersed tube tunnel units. The CDG underlying the alluvium is considered to be a very stiff material and is also expected to provide a firm foundation for the tunnel units.

8.5.4 The study of Gas in Marine Sediments found that negligible amounts of gas are present in the marine sediments in some areas of offshore Hong Kong. Of the two sampling locations adjacent to Green Island minor amounts of free occluded bubbles (mainly nitrogen) were found below 10.0m depth at one of the locations (GI2). The concentration of in situ methane was very low to low and does not exhibit any fire or blow out hazard to construction activities or structures built in the areas tested. The study also concluded that the presence of the gas would have little or no effect on the soil behaviour (strength and consolidation).

8.5.5 The report on evidence for neotectonic or recent movement along faults has confirmed initial verbal advice from GEO that there is no firm evidence for recent fault movements in offshore areas of Hong Kong.

8.5.6 The central 1700 to 1800m of immersed tube tunnel for each of the tunnel options described in this report, will found on alluvium or partly on CDG. The alluvium and CDG are expected to provide a firm foundation for placement of the tunnel units.

8.5.7 At each end of the immersed tube tunnel where the vertical alignment rises towards the landfalls, the foundation will comprise a variable depth of marine deposits. At the Green Island end of the tunnel, up to 15m of marine deposits will underlie the tunnel foundation level. Up to 10m of marine deposits will underlie the tunnel foundation level at the approach to Kau Yi Chau.

8.5.8 The existing S.I. indicates that the marine deposits, particularly at the approaches to Green Island Reclamation, comprise mainly marine muds and silts and the preliminary assessment of the immersed tube foundations is based on that assumption.

8.5.9 Although immersed tube tunnels have been founded in soft compressible sediments in other parts of the world, the practice in Hong Kong has been to excavate any compressible material from below the tunnel foundation level and backfill with a granular material. For the Green Island Link, excavation of marine muds and silts from below the tunnel foundation level is feasible as the dredge depths required would be no greater than for the central section of the tunnel. For this study, therefore, it is assumed that any marine deposit underlying the tunnel foundation level will be excavated and replaced with a granular fill material. A typical section through the immersed tube tunnel showing a typical dredge profile is shown in Figure 5.4.

8.5.10 The extent of over excavation of the tunnel foundation level needs to be confirmed when additional site investigation. is carried out. The assumption of complete removal of marine deposits is conservative, as any marine sand, underlying the marine clays and silts would not need to be excavated.

8.5.11 It is also assumed that the seawall at Green Island Reclamation and at the Kau Yi Chau landfall will be founded on a rockfill bund located within a dredged trench. The immersed tube tunnel section underlying the seawall, therefore, will also be founded on granular backfill material.

8.5.12 The extent of dredging for the seawalls will need to be extended at the tunnel locations to avoid undermining the seawall foundation trench should excavation for the immersed tube tunnel be carried out after the seawalls are constructed.

8.5.13 Differential settlements of the immersed tube units are normally greatest adjacent to the seawall section due to the much higher surcharge load of the seawall. Previous experience indicates however, that the potential differential settlements can be largely controlled by appropriate construction programming and/or detailing of the works.

8.6 KAU YI CHAU APPROACH AND TOLL PLAZA

Through Kau Yi Chau

8.6.1 The relatively short section of cut and cover tunnel for this option is within the possible future boundary of the Port Peninsula Reclamation. It will therefore be necessary to reclaim an approximate width of 200m for a distance of approximately 700m from Kau Yi Chau. The portal structure is sited on this reclamation while the toll plaza is situated on Kau Yi Chau where the rock will enable a simple foundation type to be adopted. This arrangement is discussed in Chapter 4 and shown in Figure 4.9.

8.6.2 The razing of Kau Yi Chau can be carried out in two phases, one for the soil and the other for the rock. The excavation of the overlying soil, consisting of approximately 1.0 million cubic metres, can be achieved by traditional earthmoving plant and equipment. The material excavated is expected to be a general fill suitable for use in either the reclamation areas or general road embankments and areas of landscaping. Approximately 6.3 million cubic metres of rock is estimated could be obtained from razing Kau Yi Chau which can be removed by blasting, the type and pattern depending on the end use of the rock. In some areas it may be possible to extract some rock suitable for inclusion in the seawalls or causeway as armour protection. In these areas the blasting would be carried out more carefully to avoid breaking the rock beyond natural joint frequencies. In the southern part of the island where the joint sets are more closely spaced, block blasting can be used to achieve a maximum daily output of suitable rock fill. This rock fill can be screened and used as general rock fill in the seawalls or as Pell Mell in the causeway.

North of Kau Yi Chau

8.6.3 The route north of Kau Yi Chau involves siting the portal structures and toll plaza on reclamation which will eventually became part of the future Port Peninsula Reclamation. As in the previous option, the short section of cut and cover tunnel will be constructed within a 200m wide band of reclamation from the edge of the proposed Port Peninsula Reclamation to Kau Yi Chau. Here the reclamation widens to join with Kau Yi Chau. This is shown in Figure 4.10.

8.6.4 A typical section through the reclamation is shown in Figure 8.5 where a conventional armoured sloping seawall has been adopted. The seawall is founded on the alluvium, the marine deposits having been removed and replaced with sand or crushed rock. The main body of the wall is constructed using marine fill and it is assumed that a general fill will be used for the reclamation over the marine deposits. This will result in generally lower allowable bearing capacities for any structures on the reclamation which may result in piled foundations being necessary. The face of the seawall is shown as being protected by layers of rock armour which are built up from the toe at a stable slope. The size and thickness of the armour rock required for protection against wave attack depends on the design incident wave height which in turn is influenced by the maximum water depth at the toe of the structure.

8.6.5 During the formation of the reclamation it will be necessary to dredge a corridor within the marine deposits in advance of the cut and cover tunnel construction.

8.6.6 The design of road structures and embankments will be affected by consolidation of the marine deposits. The design of piled foundations for any elevated structures must allow for negative skin friction and settlement of the road embankments must be anticipated. The magnitude of settlement will depend on the thickness of the marine deposits which will vary due to the variable thickness of the marine muds.

8.6.7 Minor problems could occur with the settlement of the road embankments. However from previous experience of cost comparisons between fill and structure it is clear that the use of an embankment solution is the most cost effective. To improve the foundation for the embankments and to reduce the settlements, there are various techniques which could be employed such as wick drains, preloading, chemical mixing or sand piles.

8.7 KAU YI CHAU TO PORT PENINSULA CAUSEWAY

8.7.1 The route north of Kau Yi Chau requires approximately 1.5km of causeway to be constructed while the route through Kau Yi Chau involves approximately 1.8km. For both options there is the basic choice between using a reclamation type causeway or an elevated structure. For both these alternatives due allowance must be made for the constraints imposed by the future Port Peninsula Reclamation of which the causeway will become a small part.

Causeway as Reclamation

8.7.2 Two options exist for construction of a reclamation type causeway:

- excavation of all the marine deposits to a depth of about 30 metres.
- a combination of a minimum of dredging together with wick drains to increase the strength of the marine deposits.

8.7.3 The main advantage of the second option is that there is a significant reduction in the quantity of marine deposits to be dredged and disposed of. Figure 8.6 illustrates a typical section through the causeway assuming minimum excavation of the marine deposits. Wick drains have been shown typically at 2 metre spacing although the actual spacing can be reviewed later as more information becomes available. The use of wick drains assumes that the marine deposits are not contaminated which has been indicated by the results of testing the drop core samples. The sea bed in the area of the causeway has also been the site of various types of "dumping". A geophysical investigation would highlight any extensive obstruction and the pattern of wick drains can be modified to avoid any such debris if necessary.

8.7.4 Preliminary estimates of fill quantities indicate approximately 7.5 million cubic metres of soil, rock and fill of varying types may be required for the causeway. In the context of the volumes of fill and rock required for other PADS projects it is clear that the requirements of this project are small and their provision from resources identified by the Fill Management Committee should not affect the feasibility of the project. In this context it should be noted that Kau Yi Chau could provide 7.3 million cubic metres of suitable materials.

8.7.5 The subsequent filling for the Port Peninsula Reclamation will affect the causeway by inducing settlements due to consolidation of the marine deposits. In order to minimise the effects of these settlements, the causeway can be constructed wider than is necessary for just the road. This additional width of causeway would need to be calculated based on the future reclamation and should be reviewed during the full feasibility stage. The final width of causeway can be determined at the detailed design stage when more information will be available regarding the Port Peninsula reclamation.

Causeway as an Elevated Structure

8.7.6 For any elevated structure, deep piled foundations would be required such as driven tubular piles, large diameter bored piles or barrettes. The piles would need to be founded on rock at a depth of up to 70m or would be required to act as friction piles in the weathered rock. The final choice of foundation would be made at a much later stage of the project, although a more detailed review of the options should be carried out during the full feasibility stage. Due allowance would have to be made for the likely obstructions and debris in the areas of known "dumping" which could cause difficulties for some, if not all, types of piling.

8.7.7 The superstructure could be a prestressed concrete box girder typically spanning 50 metres between supports with the cross section of the viaduct split into two separate bridges, one supporting each carriageway, with movement joints between them. This is discussed further in Chapter 5.

8.7.8 The effects of constructing the Port Peninsula Reclamation would have a significant effect on the design of the foundations and subsequently the superstructure. The piles would have to be designed for the negative skin friction caused by the reclamation and the superstructure would have to be designed for an appreciable differential settlement between adjacent supports.

8.7.9 From preliminary cost comparisons it is clear that the causeway by reclamation would be the more economic solution. It is also more appropriate since the final intention is to accommodate the causeway into the future Port Peninsula Reclamation.

8.8 SEABED STABILITY

Hydraulic Studies

8.8.1 Previous WAHMO model simulations were reviewed and a preliminary bed stability study in the vicinity of Green Island carried out (summarised in Working Paper WP3). These simulations included various Lantau Port Peninsula (LPP) layouts considered under the coarse screening exercise of the Port and Airport Development Strategy Study (PADS) and simulations of the Metroplan layout of the LPP.

8.8.2 The reclamation layouts examined produced water speeds significantly larger than those simulated for existing conditions. This indicates that erosion of the seabed would take place in the Green Island Link (GIL) corridor due to reclamation of the Lantau Port Peninsula and the preliminary bed stability study found that extensive scour of the marine clay and silt would occur in the GIL corridor to depths of about 10m to 20m.

8.8.3 To further determine hydraulic conditions two additional WAHMO model runs were carried out:

- simulation of the construction phase of the Green Island Link with the 2001 Lantau Port Peninsula layout, defined in the Brief, in place; and

- simulation of conditions following the completion of the Green Island Link and causeway for further consideration of scour.

8.8.4 The WAHMO model used a 250m grid and was considered suitable for the preliminary investigation of bed stability and expected changes in tidal flows which would follow the construction of the Port Peninsula and Green Island Reclamation. The resolution afforded by the 250m grid enabled the large scale impact of the Port related reclamations to be examined but did not allow detailed investigation of, for example, water velocities in the immediate vicinity of the reclamations as might be required for navigation and berthing studies or for investigating how local flow conditions might affect construction methods.

8.8.5 For detailed design and construction planning of placement of tunnel sections or the closure of the Sulphur Channel, it would be necessary to use the WAHMO models on a much finer grid (75m or similar) and to collect relevant local hydraulic data with which to calibrate the models. Such a detailed investigation of local flow conditions is considered appropriate for the full feasibility and detailed design stages.

8.8.6 Examination of the simulations of the partial construction of the Port Peninsula showed that while water velocities increased between the Port and Green Island, the velocities still remained within the range of values encountered at present in this part of the Harbour. In general, the area where water velocities peak between 0.6 - 0.8m/s increased in size but, within the resolution of the model, peak speeds did not exceed those currently encountered.

Scour

8.8.7 The preliminary estimates of the depth of scour along the proposed routes of the tunnel link between the Green Island Reclamation and the Port Peninsula are shown in Figure 8.7. In the model considered, assumptions include completion both of the Green Island Reclamation and of the Lantau Port Peninsula. The estimates of scour at the centre of the potential southeast and northwest scour holes were based on the assumption that the existing bed levels in the corridor area are in equilibrium with and governed by the peak ebb tidal velocities on spring tides in the dry season. Based on existing site investigation data pertaining to bed materials, it was estimated that extensive scour of the existing marine clay/silt would occur, with the depth of scour being limited by the underlying layer of alluvium lying at about -30mPD to -40mPD.

8.8.8 Further detailed hydraulic studies have indicated that the rate of erosion of the marine deposits will be fairly slow and significant scour rates will only occur when the causeway or Port Peninsula closes with Kau Yi Chau and approaches its eastward limit.

8.8.9 The progressive increase in the depth of the scour holes and decrease in the rate of erosion was estimated by fitting an exponential function satisfying the initial rate of erosion and the final depth of scour. The approximate number of years taken to reach given depths based on Figure 8.7 are shown in Table 8.3.

TABLE 8.3 SCOUR HOLE FORMATION PERIOD

Estimated periods to erode to given levels		
Level m PD	N-W hole (years)	S-E hole (years)
-20	6 - 18	-
-25	15 - 42	3 - 9
-30	28 - 82	7 - 22
-35	-	14 - 44

8.8.10 If either a reclamation type causeway is constructed or the Lantau Port Peninsula reaches its most eastward limit, before the tunnel is constructed, a single scour hole would be expected to start to form along the site of the trench for the tunnel. The act of dredging the trench for the tunnel may accelerate the rate of formation of a single scour hole by disturbing the surrounding sediments.

8.8.11 The immersed tube tunnel units will be laid on the base of a temporary trench dredged to the top of the firm alluvium. The worst case for siltation in the trench would be if the trench was started before the causeway or Lantau Port Peninsula had started to increase the tidal velocities in the gap between Green Island and Kau Yi Chau significantly. The siltation model predictions indicated a rate of deposition of about 25 kg/m^2 per month or 125 kg/m in a wet season, which is equivalent to a depth of about 0.5m. If the effect of dredging operations associated with the port works increase suspended solids concentrations 10 fold, one could expect several meters of siltation to occur in the trench in one wet or dry season. Mud would also tend to settle in a temporary gap left under the tunnel units.

Stability of Tunnel Protection

8.8.12 The top of the tunnel units will be approximately 2m below the deepest part of the navigation channel with a bed level of about -25mPD. The tunnel will be protected by a blanket of small 250mm rocks (22 kg) and coarse 25mm gravel with a thickness of between 1-1.5m. The tidal velocities predicted by the recent WAHMO model run are about 0.8-1.0m/s and will not move a 250mm rock.

8.8.13 The potential effect on the rock armour of the wash from very large ships with a small keel clearance has been investigated. The largest vessels crossing the tunnel will use East Lamma Channel and will have an underkeel clearance of about 5m.

8.8.14 If the vessel was moving at 13 kn (7 m/s) the wash from the propeller would not impact on the bed significantly. In the event of the ship manoeuvring using full thrust with little or no forward motion then greater velocities would be induced, but even in this conditions the induced velocity would not be sufficient to disturb the rock blanket.

8.8.15 The other main cause of high velocities near the bed is the displacement of water by a moving vessel with a small keel clearance compared to the draft or total depth of water. The pattern of peak velocities generated by a large coal carrier relative to the speed, shows that the maximum velocities are generated locally close to the bow or the stern of the vessel. The peak velocity ratio in the case of a large coal carrier is about 0.7 which is equivalent to a velocity of about 4.8 m/s assuming a forward speed of approximately 7 m/s (13 kn). The passage of such a vessel would cause the velocity to peak twice at an interval of about 40 seconds each time it crossed the tunnel.

8.8.16 If such a ship crossed the tunnel near lower water 50 times a year it would dislodge about one hundred 250mm (22kg) rocks from the surface of the armour blanket. The damage is likely to be concentrated in relatively narrow band near the centre line of the incoming and outgoing shipping lanes. This damage is likely to be intermittent and not very serious. The ship's wash will also tend to displace most of the finer gravel fractions from between the surface layer of rocks.

8.8.17 The erosion of soft mud deposits adjacent to the tunnel may undermine the backfill and the rock blanket at either side of the tunnel. The rate of erosion is expected to be low and of the order of 0.5m to 1m per year initially. Assuming the rock armour being used will have an angle of repose of up to 1/1, it would take 10-20 years before the impact of the scour hole approached the tunnel if the erosion process was not actually inhibited by the sloping rock covered fill.

8.8.18 The bed level changes could easily be monitored by standard bathometric surveying techniques or scour monitoring "telltales" and the need to dump any additional armour at the extremities of the rock armour layer assessed. Eventually, the scour hole and rock armour would stabilise and no further movement would occur. The proposed rock armour is expected to provide sufficient protection against any scour which could affect the tunnel for many years before remedial works would be required.

8.9 IMPACT ON MARINE SAND SOURCE WEST OF GREEN ISLAND

8.9.1 The potential impact of construction of the Green Island Link (GIL) tunnel, on the South Tsing Yi borrow area is shown in Figures 8.8 and 8.9.

8.9.2 The area either side of the tunnel in which dredging needs to be restricted, is based on the following assumptions:

- the GIL is constructed prior to dredging in the borrow area;
- the seabed has not already scoured;
- the rock protection layer overlying the immersed tube tunnel is expected to extend at least 50m either side of the tunnel centre line; and
- a long term stable slope in the alluvium is 1V:10H;

8.9.3 Monitoring of existing borrow areas in the Urmston Road area has indicated that even when subject to relatively high currents, pits formed by dredging for sand have remained stable and do not show any tendency to migrate. Based on these monitoring results, a long term slope of 1:10(H) appears a reasonable estimate.

8.9.4 The extent of the borrow area potentially sterilized due to construction of the GIL represents only a small proportion of the sand resource in BP4, the southern-most borrow pit. There will be an additional potential loss of sand resource if BP4 was extended south as indicated.

8.9.5 As outlined in Section 8.9, a preliminary assessment of the bed stability in the GIL corridor indicates that significant scour will be caused by construction of the Lantau Port Peninsula. Although, the bed stability studies are preliminary only, it appears that most of the marine clays/silts will scour due to the increased water velocities in the Green Island to Kau Yi Chau gap.

8.9.6 As the GIL tunnel is located mainly within the alluvium in the section of alignment adjacent to the borrow pit, potential bed scour is not relevant to the effect of the tunnel construction on the sand resource in the borrow pit.

8.10 DISPOSAL AND SOURCE OF EARTHWORKS MATERIALS

8.10.1 The disposal of excavated marine mud and minor amounts of alluvium and CDG would be subject to the requirements of the Fill Management Committee (FMC). The total quantity of dredged material to be disposed of for the dual 2-lane tunnel is estimated to be about 8.5 million m^3, about 85% of which would be marine mud/silt. (The quantity of dredged material is about 10.8 million m^3 for the dual 3-lane tunnel).

8.10.2 A disposal area for the excavated material from the Green Island Link construction will not be advised by FMC until the detail design stage has commenced. However, the quantity involved is relatively small and it is expected that suitable marine dumping areas could be utilised.

8.10.3 The source of fill for backfilling the immersed tube tunnel, the Kau Yi Chau reclamation and the causeway also needs to be advised by the FMC. As outlined in Section 8.7, razing of Kau Yi Chau would produce a sufficient quantity of fill material for the causeway. Alternatively, a marine source of fill would be required. Preliminary discussions with the FMC indicate that a common borrow area with the Lantau Port Peninsula Development (LPPD) could be advantageous. However, the fill requirements of the LPPD will not be known at least until the completion of the existing Study, and it is therefore too early to allocate a borrow area.

8.10.4 The total quantity of fill required for the Green Island Link would be about 12 million m^3 for the dual 2-lane N-C alignment and about 17 million m^3 for the dual 3-lane N-N alignment tunnel. If Kau Yi Chau were to be razed down to +5.5mPD, then this would generate approximately 7.3 million m^3 of the required fill material.

9 CONSTRUCTION METHODOLOGY

9.1 GENERAL

9.1.1 Construction of the Green Island Link will follow the general methodology adopted for other cross-harbour tunnels. This tunnel however is significantly longer and deeper than most, and requires construction across a relatively exposed section of water, crossing major shipping channels.

9.1.2 The landfall works at Green Island will be constructed within new reclamation, which is assumed to be in place prior to commencement of the project, whereas the landfall at Kau Yi Chau will be constructed as part of the project.

9.2 IMMERSED TUBE

9.2.1 The immersed tube tunnel may be either a dual 2-lane or dual 3-lane tunnel, and both steel shell and concrete box type units are considered to be appropriate for the dual 2-lane tunnel. For the reason described in Chapter 5, only a concrete unit is considered for the dual 3-lane tunnel.

9.2.2 The length of immersed tube tunnel between the ventilation buildings at Green Island and at Kau Yi Chau is about 3100 m, and it may additionally be suitable to use similar construction for some of the approach tunnels within the reclamation areas.

9.2.3 The principal dimensions of the tunnel cross-sections will be of the order of those indicated in Table 9.1.

9.2.4 The length of individual tunnel units is not fixed by any specific parameters, units up to 230 m long having been used on some projects, but the normal length on projects of this nature would be 100 to 150 m, and the length may be determined to suit the fabrication facilities and programme. This indicates that a total of 20 to 30 units will be required.

TABLE 9.1 APPROXIMATE DIMENSIONS OF TUNNEL UNITS

	Width, m	Height, m
Dual 2-lane Concrete	31.9	8.7
Dual 2-lane Steel	25.6	11.9
Dual 3-lane Concrete	42.3	8.9

Fabrication Techniques

9.2.5 There are two general forms of immersed tube tunnel in common use, referred to as "steel shell unit" and "concrete unit" types. The two forms are distinguished primarily by the method of construction of the units, there being no significant difference in performance between completed units. The basic forms and the various factors which may influence the choice of type are described below.

9.2.6 Whilst concrete can be formed into a variety of shapes, only rectangular concrete units are considered since they are in general use for road tunnels. They have the advantage of minimising construction depth and thus the approach gradients, and are common in Europe and Japan.

9.2.7 Steel binocular tunnels have been used extensively in the United States and for the Hong Kong Cross-Harbour Tunnel. The section can be either flat bottomed, or full binocular, this being dependant on the air duct requirements. This form of tunnel is only considered suitable for the dual 2-lane configuration, as it becomes uneconomically large for dual 3-lane tunnels.

Concrete Units

9.2.8 A concrete immersed tube tunnel is essentially a reinforced or prestressed concrete box structure, usually covered by some kind of waterproofing membrane. For ease of casting and of floating up off the casting bed, the underside waterproofing is usually a steel plate, terminating above the joint between the base slab and walls. The steel membrane can completely surround the tunnel, but a cheaper alternative is generally used around the remainder of the exterior surface.

9.2.9 The resulting massive structure is too heavy to launch and the units must therefore be constructed in a casting basin after which the basin is flooded and the units removed. Casting basins are usually built below sea level, with the dock floor level chosen to allow units to be floated out at mean tide.

Steel Units

9.2.10 A steel shell immersed tube tunnel unit consists of a reinforced concrete structural ring within a continuous steel shell plate. There are two types of steel tubes, known as the single shell and the double shell. In the case of the double shell type, the thickness of the inner shell plate is commonly 10 mm and this serves as the primary waterproofing membrane. Attached to the outside face of this shell plate are a series of plates and diaphragms which serve to stiffen the shell plate and act compositely with the structural ring concrete and the exterior ballast concrete. Steel plates 6 mm thick (form plates) are provided outside the steel shell plate to act solely as formwork for the surrounding keel and ballast concrete thus forming the double shell. In the case of a single shell tunnel unit, the steel shell is the exterior plate and the ballasting is provided by a ballast pocket on top of the unit.

9.2.11 Steel shell units are fabricated first as an independent steel structure. They are designed to be light enough and to have sufficient structural stiffness to be launched like a ship, obviating the need for the casting basin needed by concrete units. The concrete lining and any outfitting requirements are completed at fitting out berths in deeper water.

Fabrication Facilities

9.2.12 The construction of immersed tube tunnel units is a major exercise requiring substantial labour, plant and material resources over a period of 2-3 years. Bulk deliveries of aggregates, cement, steel plate and steel reinforcement may conveniently be arranged by barge; this is not only economic but avoids the environmental nuisance (dust, noise, vibration) associated with road transport. However, it is not usually practical to rely solely on marine access; delivery of other materials plant and day-to-day access by labour requires road access whenever possible.

9.2.13 If concreting is to be undertaken on site, a clean and uncontaminated water supply is essential, and is preferably to be supplied from the town main.

9.2.14 A substantial quantity of plant may be electrically powered including tower cranes, pumps and batching plant. Whilst this can be site - generated, it is clearly more convenient to use a direct utility supply.

9.2.15 The completed units must be towed to the tunnel location and a navigable route must exist or be provided. The primary navigational requirement will be water depth and dredging may be necessary to provide for completed units which may have drafts up to 9-10 m. Other navigational requirements include adverse currents (which can be avoided by restricting towing to certain states of tide) presence of other shipping (which can be controlled via Marine Department) and any restricting bends in channels which would make manoeuvring of units difficult.

9.2.16 In minimising environmental impact, factors to be considered include air and noise impacts from construction and effects on water quality of dredging, reclamation, flooding and dewatering of the casting basin and waterside construction.

Steel Shell Units

9.2.17 The fabrication of steel shell tunnel units is a two stage process. The first stage, which is done on land, involves fabrication of the steel shell. The unit is constructed on or adjacent to a slipway and is then side-or end-launched like a ship. At this stage the units will have a draft of only 2-3 m and it is not uncommon for them to be towed long distances in this condition.

9.2.18 The second stage involves placement of the main concrete keel structural lining and this is done with the unit floating in deeper water. As concrete is added to the unit, the draft increases until, when completed, it reaches its maximum draft of about 10 m.

9.2.19 The second stage concreting operations take considerably longer than the steel fabrication and for a project of this size it is estimated that 8-10 berths, each about 180 m long will be required. It is possible, however, to double-up units at the berths, thus reducing the total requirements.

9.2.20 Final outfitting of the unit, including installation of survey towers and inspection of gaskets, couplers and lowering equipment is normally undertaken at a berth close to the tunnel site.

9.2.21 The fabrication yard for the steel shells would require a land area of about 5 ha, and this would include facilities for rolling and welding of steel plates, and manipulation and yard area should allow space for simultaneous fabrication of two tunnel units, arranged in such a way as to allow alternate uses of the shipway.

9.2.22 The tunnel would be constructed as double-barrelled (binocular section) tubes, assembled from 20-30 individual single barrel tube modules.

9.2.23 The tube modules may be fabricated at this site, or may be prefabricated elsewhere in Hong Kong or at other locations. The technology of module fabrication is fairly simple and can be undertaken by most shipyards or steel fabricators.

9.2.24 The modules, completed with stiffeners and diaphragms are assumed to be assembled on platens positioned on the slipway where the external form plates of the unit would be added. When the modules are joined together, bulkheads are fabricated and attached to seal each end of the unit. Keel concrete will then be placed to add strength and rigidity and to improve metastability prior to the launching of the tube and towing to the outfitting location.

9.2.25 As each double barrelled tube is completed, it will be towed to a pier for concrete outfitting. At the outfitting site, reinforced concrete will be placed in situ in the inner shell of the tube. For speed and economy, it has been assumed that sliding steel forms will be used for the placement of the shell concrete. Concreting will have to be sequenced in stages along the longitudinal axis of the unit such that stability is maintained and construction stresses are not excessive. Structural concrete for the cap will then be placed in the dry before sinking of the unit. Following this, external tremie concrete will be placed sequentially to ballast the tube down until the required freeboard is attained. The unit will then be ready for towing to the location for placement. After the unit is attached to a lay barge, the final amount of ballast concrete will be added to provide the required negative buoyancy.

9.2.26 It is assumed that the outfitting pier would be capable of accommodating three units undergoing outfitting at the same time so as to keep pace with the tunnel placement rates and to complement the tunnel unit fabrication.

Site Requirements for Fabrication of Steel Tunnel Units

9.2.27 As the facilities for steel tunnel fabrication are relatively simple, almost any waterfront site would be suitable, subject to environmental consideration. A location on the edge of either the Green Island Reclamation or the Port Peninsula would be eminently suitable.

Site Requirements for Dry Dock Fabrication of Concrete Units

9.2.28 The requirements for fabrication of concrete tunnel units are significantly greater than for steel units, due to the longer period required for construction of individual elements. As the project will be required to complete in a reasonable period of about four years, the immersed tube tunnel units must be constructed in an expeditious manner.

9.2.29 Concrete tunnel units are massive structures and are therefore too heavy to launch in the manner of steel shells. Construction must therefore take place in a casting basin or dry dock, the floor of which is below sea level. When the units are completed the basin or dock can be flooded and the units floated and towed out.

9.2.30 It would not be economical to make the casting basin large enough to accommodate all the tunnel units required, and as the cost of the casting basin is a function of its size, it is necessary to achieve a balance between speed of construction and size of basin.

9.2.31 In order to achieve a reasonable degree of progress, it is proposed that the tunnel units are constructed in three batches over a period of 24 months (i.e. 8 months per batch), with each batch producing a total of 1200 m of tunnel. The lengths of individual units may vary, but for planning purposes we can assume either 10 units of 120 m length or eight units of 150 m length.

9.2.32 The floor area of casting basin required is of the order of 8 ha. A works area must be provided adjacent to the casting basin, and this, together with seawalls, access roads etc indicate a total site area of about 20 ha. In all cases the layout of units within the basin, and the works area, can be adjusted to suit local conditions.

9.2.33 A casting basin is a deep excavation close to the sea, and its design and construction is therefore a much more complex exercise than the simple provision of the ground level fabrication and slipway facilities that are required for steel units.

9.2.34 As it is considered unlikely that a site of the required size (20 ha) would be available already formed, it is probable that the land area must be formed, under the project, by reclamation. This will add significantly to the project cost.

9.2.35 The construction cost of a dedicated casting basin of the size required could be of the order of $250-500M (at 1990 prices), and it is apparent that this cost can be most easily mitigated by ensuring that the area so formed has a subsequent value that can be recovered (either financially or economically) from future users. The possible future uses could be either as a marine basin, casting basin for other projects, or as reclamation that will be required for other projects.

Site Investigation for Fabrication Facility

9.2.36 Before any sites can be specifically recommended, it will be necessary to confirm the ground conditions by site investigation, and this should be sufficient to determine:

- probable slope angle and stability of side slopes;
- stability of the dock floor against piping and heave;
- methods of controlling ground water flow by provision of cut-off walls, dewatering or both; and
- preliminary design and stability of the exit 'gate', to enable removal of the units, which may either be a structural unit, floated in and out, or formed by removal and replacement of a dike or bund.

Existing Shipyards and Dry Docks

9.2.37 The use of existing shipyards to construct the tubes for steel shell units obviates the need to construct the fabrication area/shipway facility. Shipyards do not necessarily welcome such work since it only utilises the steel fabrication trades and not the other shipbuilding skills they may have available. Also shipyards commit to shipbuilding work well in advance and it may be difficult for the tunnel contractor to give sufficient notice of a firm commitment. Shipyards with sufficient capacity and fabrication skills are available in Hong Kong, but the quantities required would utilise a substantial proportion of Hong Kong's total steel fabrication capacity.

9.2.38 The use of an existing dry dock or floating dock for construction of concrete tunnel units could be considered as an alternative to the use of a purpose built casting basin. However, this would impose serious programme restraints due to the number of tunnel units required, and the time required to construct each unit.

9.2.39 As with shipyards, such dry docks are usually committed to ship repair orders and would be expensive to lease. It is possible that a dry dock could be brought to Hong Kong for this project, but it cannot be recommended due to the programme restraints as described above.

Offshore Fabrication

9.2.40 For direct control of the project, it may be considered preferable to require the majority of construction to be undertaken in Hong Kong, but consideration may also be given to construction of the immersed tube tunnel units outside Hong Kong.

9.2.41 There are no major problems with transporting (by towing) the completed tunnel units over large distances (the tunnel units for the Baltimore Tunnel in USA were towed 1500 miles in open sea conditions), and construction in China or Korea could be economically undertaken.

Summary of Requirements

9.2.42 In summary, the selection and choice of sites for a tunnel unit fabrication basin requires the consideration of the following factors:

- availability over required period of use;
- navigational access;
- effects on marine traffic;
- land access;
- overall suitability for construction of steel or concrete tunnel units;
- geotechnical conditions;
- environmental impact; and
- archaeological interests.

9.2.43 An alternative to the use of a purpose built basin would be an existing dry dock, but because of the desirability of keeping towing distances short for concrete units, the dry dock would have to be in the Hong Kong area. The existing 100,000 dwt dry dock at Tsing Yi has a maximum beam of 38 m so that it would only be suitable for dual 2-lane tunnel units. As with shipyards, such dry docks are usually committed to ship repair orders well in advance and would be expensive for a proponent to lease. It is possible that a dry dock from elsewhere could be towed to Hong Kong for use on the project, but the decision to use such a facility would be for the proponent.

9.3 CASTING BASIN SITES

9.3.1 Whilst it is recognised that all future reclamation areas will need to be considered for use of this project, the detailed planning for the period immediately subsequent to GIL (i.e. 2004-2010) is sufficiently uncertain to preclude a detailed investigation at this time. It is considered however that reclamations which will be directly linked to the GIL construction should be considered in this study, and these include the following areas which are indicated on Figures 9.1 and 9.2:

- Green Island Reclamation;
- Kau Yi Chau Landfall;
- Siu Kau Yi Chau; and
- Port Peninsula.

North Green Island

9.3.2 In order to minimise land take, the casting basin would be formed on the site for the approach tunnels as shown in Figure 9.1. Use of this site would mean that the tunnel laying would progress from west to east with the last unit being laid in the entrance to the dock. Use of this site would enable construction of the approach tunnels and the ventilation building within the same excavation as the tunnel units, and these would be constructed concurrently with the last batch of tunnel units. The costs of provision of hydraulic cut-off would thus be reduced for the project as a whole.

9.3.3 A site at this location will have good access for labour, materials and services.

South Green Island

9.3.4 The site at this location will be contained within the main area of reclamation to the south of Green Island as shown in Figure 9.1 and is closer to existing residential areas than the other sites. It is known that the seawalls to the west will require deep foundations, and this indicates that provision of hydraulic cutoff may also require deep penetration. If this requirement is too onerous for sheet piles, then a grout curtain cut-off may be used, in combination with dewatering wells.

9.3.5 This site would also have good access from Hong Kong Island for labour and materials, although its environmental impact may be higher than for the north Green Island location.

Kau Yi Chau

9.3.6 As the study has recommended a route which passes through Kau Yi Chau it would be possible to modify or extend the reclamation profile to allow for a casting basin as shown in Figure 9.2. This site is unlikely to have land access from the Port Peninsula at the required time, and thus would have to rely on marine access. The site would utilise the access tunnel area in the same way as the North Green Island site, but is unlikely to be as advantageous for programme and access reasons.

Siu Kau Yi Chau

9.3.7 The current proposals for the Port Peninsula indicate that the reclamation will extend almost to Siu Kau Yi Chau by 2001, and that the Green Island Causeway will be constructed during the Green Island Link project. It appears very feasible to extend the reclamation slightly in this area, using the proposed causeway as the northern edge of the reclamation and the remains of the island as the southern edge as shown in Figure 9.2. The site should have good land access via the Port Peninsula, and it is presumed that the normal utilities and services would be available.

Port Peninsula Reclamation

9.3.8 The Lantau Port Peninsula Development Study (LPPDS) is currently in progress, but has not yet reached the stage at which it can indicate firm outlines of the peninsula at the timescale required for the Green Island Link (2001-2005). It is anticipated that various options will be presented by the consultants in early 1992, and this information may be used in conjunction with this (GIL) Study.

9.3.9 From information obtained from PADS and LPPDS, it does appear that sufficient reclamation will be in place at the required time to provide the land area (of approximately 20 ha) required for the casting basin.

9.3.10 For construction of the quays in the peninsula, consideration will be given to the use of caisson-type seawalls. Construction of these seawall caissons would be most economical if done on a large scale with large units. Large caisson units could be constructed in the casting basin in the periods before and after use by GIL thus providing further mitigation of the cost of the facility.

9.3.11 For planning purposes, Figure 9.2 has been derived from PADS, and this shows where a casting basin could be constructed at minimal cost to the GIL project by arranging that the majority of the construction cost is expended by the Port Peninsula. The cost could then be rapidly recovered by infilling the basin and using the area so formed as the next available berth(s).

9.3.12 The peninsula construction and development is expected to proceed from north to south, and the inclusion of the casing basin within one or two berth lengths should not have a significant influence on the port development or usage.

9.3.13 It is anticipated that berths would be taken over for use and development by operators who may require 2-3 berths each, and therefore use of a 1 or 2 berth space by GIL would be satisfactory.

9.3.14 Construction in this matter would mean that good road and service access would be available to the casting basin at the start of its operations, and that total costs would be kept to a minimum.

9.3.15 The disadvantages are that Government must make the facility available, with the risk that the contractor does not require it (due to use of steel shell units, or due to construction in another location), or that the use of the facility in this location will interfere in some way with the privatisation of the port development.

PADS Areas on North Lantau and at Castle Peak

9.3.16 Future reclamation projects along the North Lantau coast and near Tap Shek Kok will have a potential for use for the GIL project. A deep shipping channel already exists to the western harbour area, and although navigation through the channel north of Ma Wan is somewhat restrictive, this should not preclude use of construction sites in these areas.

Yau Ma Tei Typhoon Shelter

9.3.17 The new typhoon shelter, currently being constructed at the West Kowloon Reclamation, is planned to be reclaimed in the future. If reclamation were to be planned to commence in the period 2003-2006, then advance usage of part of the site for the tunnel unit casting basin can be considered.

Recommended Site for Casting Basin

9.3.18 For the purposes of this preliminary study, the site for the casting basin is assumed to be in the reclamation north of Green Island.

Locations for the storage of immersed tunnel units

9.3.19 As the tunnel units may be constructed in large batches (8-10 units per batch for concrete units), or in a sequence which does not permit immediate laying (steel units), it will very probably be necessary to store up to 6 units for periods up to 6 months.

9.3.20 The units will be stored in a floating condition, and the location must be chosen to satisfy the following criteria:

- adequate water depth;
- bottom suitable for anchoring ;
- sheltered location;
- away from shipping channels;
- space for swing circles; and
- maintenance accessability.

9.3.21 If individual moorings are used, then each unit would require a circular area of approximately 400m diameter. The total area required can be reduced by shackling together groups of two or three units onto a single mooring.

9.3.22 To enable the units to move safely at the mooring, a depth of 10 m of water should be available.

9.3.23 For ease of use, and to minimise towing distances, a location within reasonable distance of the casting basin and the tunnel should be sought, although this is not particularly important.

9.3.24 An initial examination indicates potentially suitable areas as described below and shown on Figure 9.3:

- Port Peninsula - East side;
- Lamma Island - Luk Chau Wan;
- Lamma Island - Tung O Wan;
- Peng Chau - South side (requires dredging);
- Tseung Kwan O - Previously used for EHC & MTR units; and
- Soko Islands - South of Siu A Chau.

9.3.25 Additionally, it may be possible to use an area adjacent to the Green Island Reclamation, but this will be dependant on the staging of the reclamation.

9.4 MARINE WORKS AND INSTALLATION METHODS

9.4.1 Immersed tube tunnels have been constructed in Hong Kong and throughout the world using a variety of construction, excavation and placement procedures. The construction of the Green Island Link will not be substantially different from sites elsewhere, although due to the location and its associated depth and exposure, the normal problems of construction will be exacerbated.

9.4.2 The main operations which will require the use of marine plant are dredging, placement of units, foundation, and backfill. The excavation depth will extend to about -40 m PD and this is towards the upper limit of the operating range of suitable dredging equipment.

Tunnel Unit Installation

9.4.3 For placing the tunnel units in position in the prepared trench, two alternative methods have generally been adopted, these requiring that the unit is lowered from the surface from either floating pontoons, or from a spud-leg barge. Where pontoons are used, these are only for the purpose of carrying the vertical loads, the horizontal loads being carried directly from the unit to the anchor system; with a spud-leg barge, horizontal forces may be applied from the barge. Due to the depth of water, it is considered that use of pontoons would be more economical.

9.4.4 If it is found that insufficient weather windows are available to suit the derived construction programme then consideration will need to be given to the use of marine plant which is less susceptible to the effects of inclement weather. This may, for instance, require semi-submersible rigs which have a minimal water-plane area, and are stabilised by tie-down anchors.

9.4.5 For construction programming purposes, it is assumed that the construction plant will be designed to accommodate the predicted weather patterns, and thus the effects of inclement weather will be no worse at this site than at any other tunnel location.

Dredging

9.4.6 Dredging of the trench will be mainly in soft marine deposits, with the lower part of the trench in the underlying alluvium. The maximum excavation depth is to about -40 mPD, corresponding to a dredging depth of about 42m, and excavation to this depth requires special consideration of the type of plant to be used.

9.4.7 Trailer suction hopper dredgers can possibly be modified for use at these depths, and whilst these continuously manoeuvrable vessels may be ideal from the point of view of marine safety, there are disadvantages to their use. In order to achieve maximum depth of excavation, large high capacity vessels would be required and these vessels could complete the dredging for the immersed tube in a matter of weeks. Although this would impose minimum disturbance to marine traffic, there would be considerable subsequent siltation of the dredge trench and therefore re-dredging required in the following years of construction.

9.4.8 If, on the other hand, the dredging were done in sections with such equipment there may be re-mobilization costs for each section. Although, it is anticipated such equipment would be available in Hong Kong, a higher unit cost for this intermittent dredging would apply than if it were done in one continuous operation. Trailer-suction dredgers are, moreover, only suitable for relatively weak soils and may not be able to cope with some conditions expected. In short, not all the dredging could be done by trailers and it is possible their use may not be economical.

9.4.9 Cutter-suction dredgers are generally not able to dredge as deep as trailers. The limit is of the order of 20-25 metres. They are suitable for harder materials, production rates are relatively high and they are not very manoeuvrable, since they are usually anchored by spuds. Cutter-suction dredgers are not, therefore, ideal for the central part of the immersed tube. Away from the main channels, in shallower water and especially where harder materials need to be dredged, cutter-suction dredgers are a viable option.

9.4.10 Even if bulk pre-dredging is carried out with more productive plant, final trimming is expected to be done with grab dredgers. These are nearly always anchored with wires to concrete sinkers or steel blade anchors. For the depth of water and the currents and waves expected, the anchors may need to be up to 150m from the centre line of the tunnel. Both positioning accuracy and impact on navigable depth should be minimized by the use of intermediate sinkers on the anchor cables. Ideally, any dredging carried out by grab dredgers in the busy part of the waterway should be done within the proposed marine works areas, just prior to tunnel laying, in order to minimize the number of times vessels using the existing channels need to be diverted.

9.4.11 For the whole of the project therefore, it appears that a combination of dredging plant will be required and mobilisation of the correct equipment will need to be predetermined by the contractor in advance of the works.

Foundation

9.4.12 For immersed tube tunnels generally, three methods of foundation construction are normally considered. These are generally described as:

- sand jetting;
- sand flow;
- screeded foundation.

9.4.13 The principal matters that may affect the choice of foundation method are that the foundation produced by the sand jetting and sand flow methods are installed after the unit is placed, whereas the screeded foundation is prepared before placing the unit, and that the sand flow method may be used from inside the tunnel unit whereas the sand jetting method requires external equipment.

9.4.14 In view of the deep water, it is considered that the sand flow method will have significant advantages over other methods, particularly if installed from inside the unit. It is recommended however that the contractor be permitted maximum flexibility in the selection and detailing of the foundation system.

Inclement Conditions

9.4.15 The location of the Green Island Link is exposed to the open seas from the south and this indicates that weather induced conditions (wind and waves) will have a much greater impact on this tunnel than on the previous cross-harbour tunnels which were placed in the relatively sheltered harbour environment. The weather conditions do vary throughout the year as can be seen from Figures 9.4 and 9.5 which indicate the weather patterns during November - April, and May - October respectively.

9.4.16 The marine operations of tunnel installation require relatively calm waters in order to obtain the necessary precision, and the exposed conditions will mean that the installation programme can be severely affected.

9.4.17 The principal effects of inclement weather will be those caused by wind, waves, and currents and the effects of these are discussed below.

Waves

9.4.18 The predominant winds are from the east and northeast. In these directions the fetch over which waves might be generated is relatively short. Although wave heights of the order of one metre could be expected quite frequently, the wave periods will be short (less than 3 seconds generally). Tunnel units of the order of 40,000 tonnes weight and their accompanying pontoons would not be significantly affected by these although spray may make working conditions difficult for some operations at times, and smaller vessels may experience some difficulties. The worst easterlies and northeasterlies occur during the winter months.

9.4.19 Exposure to the south and west is rather greater. Ocean swells with periods of over 5 seconds will affect the site from this quarter, principally during the summer months and in particular after the passage of tropical cyclones to the south of Hong Kong. The period of these swells may affect operations significantly and equipment which automatically compensates for differential movement between the floating craft and the relatively stable tunnel unit at depth may need to be considered.

9.4.20 Preliminary analysis suggests that wave heights from the south and southwest sectors will exceed 1m about 6% of the time, with typical periods of about 5 seconds, 1.5m about 3.5% of the time with 6 second period and 2m 1.5% of the time with 7 second period. These figures suggest that 2-3 weeks of difficult conditions can be expected in an average year but that the worst conditions are unlikely to persist for more than about one week on any one occasion.

9.4.21 The analysis is based on the assumption that no breakwater to the west of Lamma Island is in place when the tunnel is constructed.

Wind

9.4.22 The effect of wind is, in itself, not very severe, and short term winds of up to 10 knots should not significantly affect operations However the effect of cross-winds on vessels approaching the port is to increase the width required for safe navigation. This effect must be taken into account in devising arrangements for such traffic during the construction period.

Currents

9.4.23 The tunnel site lies across a zone of current movements where surface water velocities up to 1.0m/sec may occur, and the line of the tunnel lies almost perpendicular to the direction of flow.

9.4.24 As it will be very difficult to hold the tunnel unit with tugs against currents exceeding about 1 knot (0.5m/sec), the sinking operations must be planned to take place within slack-current "windows". These periods can be predicted and will control the installation programme.

Equipment Considerations

9.4.25 Electrical and mechanical components must be weather proof, and preferably mounted well clear of the splash zone. Winches on the lowering pontoons may be vulnerable and should be raised higher than normal, this can be achieved by using pontoons of a larger size.

9.4.26 The pontoons will be directly exposed to wave action and should be sufficiently robust to endure potentially bad weather.

9.4.27 Anchors will be required to secure the tunnel unit against lateral movement during installation. Due to the anticipated currents these will be very heavy. For ease of use, precast concrete block anchors are normally used but consideration may also be given to pile anchors and conventional ship-type steel anchors, in order to provide the greater resistance that is required.

Details at Sea Walls

9.4.28 Where the immersed tube units pass below the seawalls, the seawall profile will be similar to that in the adjacent areas. Typical construction details are shown in Figure 9.6 where the seawall is constructed before the immersed tube tunnel. Dredging for the seawall foundation trench will need to be extended as shown to avoid undermining during excavation for the tunnel.

9.4.29 Placement of the end units of the immersed tube tunnel and connection to the cut-and-cover tunnel section can be achieved in a slot excavated through the existing seawall. The placement and connection operations would be carried out underwater. Appropriate temporary excavation slopes and protection would be provided to maintain stability of the seawall and reclamation materials.

9.5 APPROACH TUNNELS AND RAMPS

9.5.1 The landfalls at Kau Yi Chau and at Green Island will be in new reclamation where there will be a significant length of cut and cover tunnel and open approach ramp, particularly at Green Island.

9.5.2 There are four basic construction methods which could be adopted for either landfall and these are briefly described below. Each construction method must take into account the high permeability expected in the newly reclaimed land even though the final form of the reclamation is not yet finalised for either landfall.

Top-Down Construction

9.5.3 This method requires the installation of diaphragm walls along both sides of the entire length of cut and cover tunnel and the deeper sections of approach ramp. Excavation can then take place between the walls installing temporary transverse props at the top as necessary. When the excavation has reached the underside of the roof slab, the latter is constructed and also acts as a transverse prop. The excavation continues, constructing each part of the tunnel section in sequence until the base slab is cast which acts as the lowest transverse prop. The diaphragm walls which support the excavation thus form part of the permanent works.

9.5.4 The diaphragm walls would have to extend below base slab level a distance sufficient to ensure lateral stability of the wall and to achieve a hydraulic cut off. The walls would extend at least into CDG, the founding level being dependent on the required load carrying capacity of the wall.

9.5.5 This construction method is well-proven and efficient although it does have a major disadvantage in that it is not possible to provide a waterproof membrane to the external faces of the walls. This could lead to a less watertight structure due to leakage by permeation through the concrete and panel joints. However with careful detailing the leakage can be controlled and collected by installing a drainage system behind the facing panels used as the inner lining to the traffic ducts.

Extended Immersed Tube Tunnel

9.5.6 Deep excavation adjacent to the sea always carries some risk associated with the difficulties of dewatering and catering for seepage forces. The effort of keeping deep excavations dry can be avoided by extending the immersed tube tunnel from its interface with the cut and cover tunnel adjacent to the seawalls, to a point further inshore.

9.5.7 The interfaces are generally located adjacent to the seawalls because this represents the point at which a steeper gradient is applied with a consequential change in cross section to permit provision of a climbing lane. The interfaces are also located adjacent to the seawalls for optimisation of the ventilation design. Immersed tube fabrication is most economical on a constant cross section, and the change in cross section may therefore be undesirable. However, it is possible to fabricate varying sizes of immersed tube units with which the immersed tunnel could be extended further inshore.

9.5.8 After completion of the tunnel in this area, the tunnel is backfilled to reclamation level. As this type of construction would probably not have foundation support (piles etc) significant settlements of the immersed tube tunnel may occur. These could have structural and geometric effects, which must be considered during the detailed design stage.

In situ Construction - Excavation Supported by Temporary Vertical Walls

9.5.9 In this method the cut and cover tunnel and deepest section of approach ramp are constructed between temporary vertical walls such as sheet piles or diaphragm walls which do not subsequently form part of the permanent works.

9.5.10 This method involves substantial temporary works together with a dewatering system such as pumping from wells in the base of the excavation. The advantage of casting the cut and cover tunnel in situ is that a waterproof membrane can be installed on all buried faces, thus minimising leakages.

9.5.11 The deepest section of cut and cover tunnel together with the ventilation shaft are constructed within a large diameter, circular cofferdam formed by driven box section piles and supported by truss-section compression rings. Again, dewatering would be necessary by pumping from wells in the base of the excavation.

In situ Construction - Open Excavation

9.5.12 The simplest and probably the most economic method of construction would be to construct the cut and cover tunnel, ventilation shaft and approach ramp within an open excavation. Figure 9.7 illustrates a stage in the construction of the ventilation building and the cut and cover tunnel section. A conventional cut slope in open excavation is used to the founding level of the cut and cover tunnel and ventilation shaft with a non-structural sheet pile wall or slurry trench wall installed at the top of the slope to act as a groundwater cut-off. This enables the construction work to take place in "dry" conditions whilst minimising the amount of de-watering of the excavation that is necessary.

9.5.13 The excavation has been assumed to be entirely within marine fill to facilitate the installation of the groundwater cut-off. The side slopes have been shown to be 1:2 although it may be necessary to introduce berms or flatter slopes to assist with stability and to facilitate the installation of well-points or deepwell dewatering.

9.5.14 The cut and cover tunnels and ramps would be cast in situ within the open excavation. Apart from a simplified method of construction, it enables the structures to be fully waterproofed and inspected.

9.5.15 The foundation of the cut and cover tunnels is expected to be on compacted general fill, replacing the marine deposits. If necessary the bearing capacity could be increased by surcharging or vibro compaction. Piled foundations are not expected to be required.

9.6 VENTILATION BUILDING

9.6.1 The ventilation buildings are situated over the top of the tunnel near each landfall. They would normally be of a width similar to the tunnel and about 15m across. Intake and exhaust chambers will extend the height to about 10-15m above ground level.

9.6.2 The ventilation buildings may be constructed in situ in the same excavation as the approach tunnels, in situ over the end of the immersed tube tunnel, or precast and floated in above the tunnel.

9.6.3 These methods all have cost and programme implications, and no specific recommendations are made. For the purpose of programme and cost derivation, it has been assumed that these buildings are constructed in situ above the approach tunnels.

9.7 KAU YI CHAU TOLL PLAZA

Control Building and Toll Plaza

9.7.1 The administration and control building, and the toll plaza will not require any special construction methods, particularly if they are located on Kau Yi Chau. The building will probably be of reinforced concrete construction, and should be programmed for construction at a relatively early part of the contract in order to have ample time for installation of control equipment.

9.8 CAUSEWAY

9.8.1 The causeway from Kau Yi Chau to the end of the Port Peninsula will be of the form shown on Figure 8.9. This requires excavation of the soft marine deposits to approximately -20m PD followed by installation of wick drains in the marine deposits to ensure early stabilisation of ground settlement.

9.8.2 The core of the causeway is formed of pell mell rubble or crushed rock placed by bottom dump barge up to approximately -3 m PD, with the remaining part placed either by grab, or by land based methods. The rock armour and underlayer would normally be placed from a barge.

9.8.3 Settlement of the marine deposits will occur after placement of fill, and although the wick drains will accelerate the settlement, construction of the permanent pavement should be delayed as long as possible.

9.8.4 The construction of the causeway will cause a significant increase in the currents in the Lamma Channel across the line of the immersed tube tunnel. The degree of change of these currents is addressed in Chapter 8 and it is considered desirable to delay completion of the causeway, in particular the construction works above the level of the surrounding seabed, until after all the immersed tube tunnel units have been installed and backfilled.

9.8.5 This will mean that all the construction works on Kau Yi Chau must be done with only marine access, and this factor has been taken into account in the construction programme and cost estimates.

CHAPTER 10

10 TUNNEL OPERATION

10.1 TUNNEL AREA

10.1.1 The formal "tunnel area" should extend far enough to cover all necessary operations. This permits the correct signs to be erected as part of the tunnel construction work, and for supplementary signs and signals to be provided as found to be necessary during operation and gives tunnel staff the authority to control traffic. Tunnel direction signs will be required up to 500m before the start of connecting links to the tunnel. For traffic leaving the tunnel, there is less justification for including the section of Route 7 and Central Bypass in the tunnel area, which could thus end immediately at the end of the connecting link. It may also be convenient for all of Route 7 between the connecting links, and part of the Central Bypass to be in the defined tunnel area.

10.2 TOLL COLLECTION SYSTEM

10.2.1 The toll collection system should be of a proven design capable of collecting tolls from vehicles with a minimum of delay caused to traffic. The system should be computer controlled in order to ensure it can fully monitor the toll collection activities. Additionally it should be capable of maintaining full records of operational statistics which may be used for planning and record purposes.

10.2.2 In addition to conventional manual toll collection various forms of automatic toll collection systems exist and are in operation worldwide, these include:

- cash payment into automatic machine;
- magnetic card read directly by machine;
- automatic tolling by remote sensing.

10.2.3 Both cash payment to machine and magnetic card systems have little advantage over the manual collection systems favoured in Hong Kong. Systems involving remote sensing of vehicle mounted devices are believed likely to be available at the time of operation of the Green Island Link in 2004. At the present time, auto-tolling systems are in full operation in Norway, Italy, France and Oklahoma (USA).

10.2.4 Two principal systems, which are already in use, involve automatic communication between the roadside control and the vehicle-mounted identification device. The simplest system involves a toll tag carried on the vehicle which contains reference to an account number which has been credited with the requisite funds. The auto-tolling system decrements the account and permits passage of the vehicle.

10.2.5 A more sophisticated alternative utilizes the tag itself to carry the record of available funds - a so called smart card. A smart card contains an integrated circuit so that the residual credit balance can be remembered by the card and is decremented for every auto-toll transaction.

10.2.6 For both systems automatic vehicle classification (AVC) is desirable to check the classification data contained on the tag or device carried on the vehicle to prevent fraudulent use. As the function of the AVC is to provide a check on the tag information, the system would not need to be totally error free.

10.2.7 For determination of the number of toll-lanes to be provided, it has been necessary to make robust assumptions on the adoption of auto-toll facilities that may be in use at opening year. Even with full auto-tolling, it is considered necessary to provide two manual toll-lanes, one in each direction, to deal with abnormal vehicles and special circumstances.

10.2.8 The capacity of a manual toll lane is assumed to be 650 pcus per hour, with no barriers being used. The capacity in vehicles per hour (vph) is a function of the pcu ratio, and normal pcu values are used for each vehicle class as it is recognised that larger vehicles take longer to pass the toll booth.

10.2.9 With auto-tolling, barriers are generally considered necessary because of the cost and difficulty of apprehending those who fail to pay the toll. This view has been supported by the views of tunnel operators. Accordingly the capacity is limited to 1000 pcus/hr/lane. In order to achieve the maximum capacity, short queues of say 4 vehicles are necessary at each booth, and if this is considered undesirable then more toll booths will be required.

10.2.10 If the tunnel toll system were incorporated into a territory-wide electronic road processing scheme, then toll enforcement would become less of an issue and a barrier free toll system could be used.

10.2.11 For outline design, the toll booths have been designed to accommodate the tunnel capacity flows of 4200 pcus/hr for dual 2-lane, and 6500 pcus/hr for the dual 3-lane tunnel. Two scenarios have been considered for auto-toll installation:

- 50% auto-tolling without lifting barriers; and
- 90% auto-tolling with lifting barriers.

10.2.12 In each case it has been assumed that there is a minimum of one manual toll lane in each direction.

10.2.13 In either of these design cases, a total of 10 toll lanes is required for the dual 2-lane tunnel, and 15 lanes for the dual 3-lane tunnel. The arrangement would be symmetrical with a number of the central booths capable of two-way operation for maximum flexibility.

10.3 TOLL PLAZA LAYOUT

10.3.1 The toll plaza layout includes full provision for the tunnel administration, main control room, parking space for visitors and recovery vehicles. There should be facilities for visitors to the administration building to return to the direction from which they came (either the Port Peninsula or through the tunnel) without paying a toll. Tunnel staff will be able to travel to and fro through the tunnel without circuitous use of ordinary roads by utilizing the separate loop system over the portal. Vehicle inspection and weighing facilities will also be provided at this location.

Toll Lanes

10.3.2 The edge toll lanes have been allocated 6m width each to accommodate special vehicles as required by Transport Department. A normal manual toll lane has been taken as 3.1m wide and the associated booth 1.5m wide. An automatic lane has been assumed to be 3.2m wide with 0.8m allowed for equipment and clearances in between the lanes.

10.3.3 The toll plaza layout shown in Figure 10.1 is for a typical dual 2-lane arrangement based on the auto-toll assumptions identified in Section 10.2.

Toll Lane Tapers

10.3.4 In order to accommodate the increase in total roadway width on the approaches to the toll plaza, a taper of 7 degrees has been assumed at each side.

Bus Interchange

10.3.5 It is recommended that a bus interchange is provided near the toll plaza, and this should be located at the landside (i.e. west) of the toll booths. Initially there may be little demand for bus services due to the isolated location and a 3m deep layby should be sufficient. As the Port Peninsula is developed, a demand may occur for a greater number of services, and at that time a larger interchange facility may be constructed, and this is shown on Figure 10.1 to indicate the land area required.

10.4 TRAFFIC CONTROL AND SURVEILLANCE

10.4.1 Traffic control facilities are essential at both ends of the tunnel as well as within the tunnel itself to ensure safe and efficient operation. Surveillance measures are a necessary requirement to restrict overheight or overweight vehicles. Other traffic control measures are required to assist drivers in normal operation and for other operational states.

10.4.2 The primary control centre in the administration building will co-ordinate the traffic control and surveillance facilities. The control centre will be located adjacent to the toll plaza at the Kau Yi Chau end of the tunnel. A secondary control centre will also be required at the Green Island landfall as described in 10.4.19. Figure 10.2 shows the proposed location of the secondary control centre and a layout of the traffic control and surveillance facilities associated with the tunnel operation which are described in more detail below.

10.4.3 In determining the tunnel operation, the following operational states should be considered:

- Normal Operation;
- Proceed with Caution Operation;
- Tidal Flow;
- Forced Lane Closure;
- Forced Tube Closure;
- Planned Lane Closure;
- Planned Tube Closure; and
- Tunnel Closure.

10.4.4 Man-computer interfaces should be user-friendly. During each signal control plan change, relevant prompts and menu should be provided to assist the tunnel supervisor to implement the signal plan change easily and safely.

Crossovers

10.4.5 The emergency/maintenance crossover should be situated as close to the portal as possible. This crossover will be in operation during routine closure of individual lanes or complete tubes for regular maintenance, usually at night when traffic flows are light and two-way operation in a single tube can be accommodated.

10.4.6 Whilst the traffic studies indicate that tidal flow will not be necessary, it is considered prudent to allow at the construction stage for its possible future implementation. A separate tidal flow crossover is required to accommodate full design flows in situations where tidal operation is planned. The maintenance crossover should not be used in this case because of the close proximity of the slip road merge/diverge points to the tunnel portal. This would not allow sufficient weaving length, for example, in the case of eastbound traffic emerging from the westbound tube and crossing the eastbound lanes to exit on the port slip road. By locating the tidal crossover adjacent to the slip roads, weaving movements will be avoided. In tidal situations, traffic entering the Kau Yi Chau portal will be directed into dedicated lanes to suit their destination at the Green Island interchange. For example, eastbound traffic in the westbound tube (as described previously) will be routed only onto the slip road towards Route 7 south, hence avoiding any weaving movements.

Overheight Vehicles

10.4.7 The operational procedure for enforcing height restrictions is critical to avoid tunnel damage. In view of the approach road layout complexity in the Green Island Reclamation, there is only very limited space for tunnel staff to apprehend overheight vehicles in the vicinity of the merge between approaches from the East, port area and Route 7 (South).

10.4.8 Figure 10.2 shows an indicative arrangement of measures to detect and intercept overheight vehicles on the approaches to the Green Island Reclamation tunnel portal. The layout is shown for the dual 2-lane configuration; the dual 3-lane is similar in terms of traffic control measures.

10.4.9 From Route 7 (either direction) and Central Bypass (for the dual 3-lane case) overheight vehicle detectors will be provided as shown in Figure 10.2. Overhead variable message signs will be provided about 150m after the detectors, to tell suspect vehicles that they are overheight and about to be diverted. In the case of an overheight vehicle coming from the East, signals on the port area slip road should simultaneously be set to red to enable the enforcement officer to walk across the merging area to be close enough to stop the overheight vehicle; simultaneously a bell should be sounded at the layby, so that the officer knows that the system has come into operation.

10.4.10 Once the vehicle has been inspected the enforcing officer may allow it to return to the traffic stream and enter the tunnel, or he may direct it across the Route 7 (South) approach to the escape route to ground level roads. Signals will be required on the Route 7 (South) approach to stop the traffic when the enforcement officer is ready to guide the overheight vehicle across.

10.4.11 To stop vehicles from Route 7 (South) a similar procedure should apply, without the complication of having to stop traffic on the Port area slip road or on Route 7 (South) itself. The offending vehicle would be taken to a layby to the left.

10.4.12 This procedure is also proposed for the dual 3-lane layout. The major difference is that traffic approaching from the east consists of the Central Bypass as well as Route 7. However, these flows merge before the overheight vehicle detector. Interception of overheight vehicles may be more difficult in the dual 3-lane case, as they must be directed across more lanes of traffic onto the escape road. In this case, patrol vehicles may be used to temporarily stop lanes of traffic to enable the enforcement officer to direct the overheight vehicle.

10.4.13 The procedures for dealing with overheight vehicles at the Kau Yi Chau end of the tunnel will be much simpler due to the proximity to the toll booths and the absence of any major junctions. Overheight vehicles will be intercepted at the toll booths and directed onto the loop road, to return from whence they came after any necessary legal actions.

Overweight Vehicles

10.4.14 Restricting overweight vehicles may be desirable to prevent damage to road surfacing but not vital for the tunnels' structural safety. It is likely that they will be dealt with by sampling, noticing particularly flagrant offenders or running periodic campaigns. In the latter case staffing would be increased as necessary. The deterrent effect of these campaigns would be the same whether a weighbridge is provided at each end of the tunnel, or at one end only. It is envisaged within this Study that all enforcement action should be taken at the toll plaza.

10.4.15 There is no fundamental requirement for weighbridges at tunnels, although TPDM design standards require them.. Their purpose is to provide part of a territory-wide weighing system to reduce highway maintenance; tunnel management also finds them convenient for demonstrating non-compliance with tunnel regulations. It is possible for all weighing to be carried at one end of the tunnel, using a single weighbridge and gaining access to it under escort by the loop road system. The cost of providing a separate weighing facility and a competent team (more than one person may be required to carry out weighing procedures) at the other landfall is thereby avoided at the expense of reduced flexibility. It is considered appropriate therefore that one weighbridge is provided at the KYC toll plaza and this may been sited in a prominent location in front of the administration building. However, the requirements for a second weighbridge should be reviewed at preliminary design stage if it can be shown that suitable facilities can also be provided at the Green Island landfall.

Heavy Goods Vehicle and Bus Restrictions

10.4.16 There is advantage in restricting these vehicles to the nearside lane(s). For heavy goods the purpose is to protect the traffic capacity of the other lanes. For buses the purpose is also to ensure that passengers from a broken-down bus do not have to alight into a traffic lane.

10.4.17 Because of the very high goods vehicle component in the traffic stream, restriction of the number of lanes allocated to them may restrict capacity and it may be necessary to allow them to use all lanes. If these restrictions are imposed, then allowing overtaking within the tunnel can ease the impact of the restrictions.

Administration Building

10.4.18 The administration and control building will be situated near the toll plaza, adjacent to the inbound lane of the tunnel approach. A layout of the building in relation to the toll plaza is shown on Figure 10.1, and this location:

- provides a good view of the toll plaza and toll booth line from the Central Control Room;
- minimises the distance from the building to toll booths for toll collection staff;
- minimises distance to transfer toll booth takings unless these are transferred by conveyor in a tunnel under the toll booths; and
- minimises the distance from the overheight vehicle detection equipment and the manned interception point (which have to be located before the toll booths).

Green Island Control Point

10.4.19 A Secondary Control Point will be provided near the Green Island portal as shown on Figure 10.2.

10.4.20 The function of this control point is to provide a manned location for control of vehicles entering from the east, and to intercept any unacceptable vehicles. Although the tunnel will be designed to be fully controlled from the CCC, some backup facilities may be provided here for emergency situations.

10.4.21 Tunnel control vehicles will normally operate only within the tunnel area, and a loop road is required to enable turn back. Recovery vehicles will be based at this location, as these could be required to deal with half of the traffic incidents within the tunnel.

10.4.22 The control room will have closed circuit television facilities duplicated from the main system to provide reasonably complete coverage of the tunnel areas. There should be parking for the staff, recovery vehicles, and impounded or restrained vehicles.

10.5 SAFETY

Fire Drills

10.5.1 A code of practice for fire drills should be established. The drills should be carefully planned, should initially be carried out in very light traffic conditions, and should eventually be carried out as realistically as possible on a regular basis. They should for example include the controlled release of smoke, and may be carried out on or near roads with normal traffic flows.

Emergency access

10.5.2 It is necessary to be able to stop traffic at the last point of no return and divert it away from the tunnel. On Green Island Reclamation the local slip roads will be useful to allow for the emergency access, once normal traffic has been stopped, perhaps from the remote end. Whether emergency vehicles enter in the affected roadway or, after stopping normal traffic, in reverse direction in the other roadway or simply in reverse in the affected roadway, must depend on the nature of the problem and whether traffic is continuing to flow at all in the affected roadway. All combinations must be possible, and can be provided by the portal area slip roads. The toll plaza provides full flexibility from the other end.

Driver behaviour

10.5.3 Kerb shyness is combatted by provision of the marginal strip and by keeping the walkways low, preferably no higher than 500mm.

10.5.4 Gradient disorientation may be combatted by painting horizontal lines on the tunnel walls. At upgrades these may be deliberately steepened or curved so as to give the impression that the upgrade is steeper or starting early. This treatment in some tunnels has been said to improve traffic capacity because drivers apply full engine power earlier. The provision of such wall markings must depend on the nature of the wall material and maintenance arrangements.

Blockages due to broken down vehicles

10.5.5 Within the tunnel broken down vehicles can be a significant problem and have been estimated to reduce capacity of some tunnels by up to 6%. The impact increases as the square of the tunnel length because of the greater probability frequency of breakdowns and because of the longer access time.

10.5.6 The impact of blockages can be reduced by allowing lane changing and overtaking in the tunnel. The benefit of this will be felt only at times of relatively light traffic.

Dangerous Goods Vehicles

10.5.7 Current legislation in Hong Kong does not generally permit passage of Dangerous Goods Vehicles (DGV) through tunnels. This is considered a sensible precaution due to the risk of damage which could occur in the event of an accident or fire, where the effects in a tunnel can be extremely serious.

10.5.8 However, with the development of the infrastructure on Lantau, a demand may arise for transport of such vehicles either through the Green Island Link or across the Lantau Fixed Crossing, these being the only vehicular routes available. A risk analysis of this matter should be carried out during the full feasibility study to determine the needs and controls that should be imposed on DGV traffic, and should also be submitted to FSD for comment.

Fire Emergency

10.5.9 The ventilation system design will have the capability to adequately control the smoke of a major fire. In these circumstances, correct operation of the system should ensure that tunnel users can escape safely without being overcome by smoke or oxygen depleted air. The installed system described in Chapter 6 is designed to satisfy this requirement.

10.5.10 Integration of the fire alarm system with the traffic control system is considered necessary, and should cause all entering traffic to be stopped before the tunnel portal in the event of a fire alarm being activated.

CHAPTER 11

11 IMPLEMENTATION, CONSTRUCTION PROGRAMME & COSTS

11.1 INTERFACE WITH OTHER PROJECTS

11.1.1 The Study Brief requires that the work of the Study proceed on the basis that the Green Island Link is to be in place by 2004; that Green Island Reclamation and Route 7 will be in place or under construction by 2001; and that a part of the Lantau Port Peninsula will be in place by 2001.

11.1.2 Phasing of the Lantau Port Peninsula is still under consideration under the Lantau Port Peninsula Development Study (LPPDS). Liaison has been maintained with the LPPDS team, although the relative timing of the two studies has meant that the work of this Green Island Link Study has had to be completed by reference to the PADS assumptions as to that extent of the Port Peninsula which will be in place by 2001.

11.1.3 The work of the Green Island Reclamation Feasibility Study (GIRFS) was, however, substantially completed before commencement of the Green Island Link Study. Liaison between the two studies has therefore made it possible to ensure compatibility between this Final Report and the Draft Final Report of GIRFS, shortly to be published. The conclusions reached as to phasing of Green Island Reclamation from the perspective of the Green Island Link Study are summarised below.

Green Island Reclamation

11.1.4 It was concluded in the GIRFS Technical Paper 5A that a phasing of the Green Island Reclamation initially advancing from north to south and from east to west would be best suited to provision of land for the Green Island Link. This conclusion is supported by the findings of this present Study.

11.1.5 Since at present no priority has been afforded the Green Island Reclamation, it has been assumed, for the purpose of preparing a programme for construction of the Link, that construction of the Reclamation should commence at the latest date which would permit completion of the Link by 2004, and that work need not be complete over the whole Reclamation area by that year.

11.1.6 The minimum land area required within the Reclamation for the Green Island Link landfall and interchange (assuming later construction of Route 7 west of the interchange) is shown on Figure 11.1. This minimum land area has been divided on Figure 11.1 into three areas to identify the different programming constraints. It must be emphasised that it is not intended that these areas should necessarily form discrete areas of reclamation.

11.1.7 The area to the north of Green Island (Phase 1c in GIRFS) is required for handover to the Green Island Link Contractor at the beginning of 2000 to accommodate the 2004 completion date for the Link. The latest date for completion of the area to the north of Belcher Bay (Phase 1b), and the northern seawall (Phase 2a), to accommodate the 2004 completion date for the Link, is 2002.

11.1.8 Liaison with the GIRFS team has established that the programme for construction of Green Island Reclamation identified in response to GIRF Study Brief will achieve these completion dates. An extract from the GIRFS Draft Final Report construction programme is shown in Schedule 11.1 at the end of this Chapter. The timing of reclamation Phase 1b has, however, been amended in this Schedule from that shown in the GIRFS Draft Final Report to show the latest possible start date compatible with completion of Green Island Link in 2004. This implies a start date of 1997, 18 months later than the GIRFS start date for Phase 1b, to meet the programme requirements for a dual 3-lane concrete GIL tunnel (the option with the longest programme duration).

11.1.9 The Phase 1b reclamation is intended under GIRFS to accommodate the reprovisioning for the Abattoir and the China Merchants Company on which final completion of the reclamation is dependent. The consequences of reprogramming Phase 1b would be delay to this reprovisioning and hence to completion of the final part of the reclamation (i.e. that part not required for GIL). Sea access to the existing waterfront would thus have to be maintained via the open channel south of Green Island until completion of the delayed reprovisioning. In addition armour protection or sacrificial fill might be required to protect the temporary southern face of the reclamation against typhoon waves.

11.1.10 It should also be noted that Belcher Bay Reclamation (Phase 1a), which will be contained within the limits of the Phase 1b reclamation, is to be constructed for completion in 1995 prior to the commencement of the area to the north. Land use allocation on Belcher Bay will thus be temporary pending completion of the Phase 1b area.

11.1.11 The area of reclamation to the north of Green Island (Phase 1c) is required for the landfall site. It can in addition provide a Green Island casting basin site as identified in Chapter 9. This has been assumed for costing and programming purposes detailed below.

Green Island Link Interchange/Route 7

11.1.12 In order to facilitate the future construction of the Green Island Link, it is recommended that provisions are made within the reclamation works for removal of marine muds under the areas of the approach roads and casting basin.

11.1.13 The phasing of the strategic highway infrastructure involving highways on Green Island Reclamation which PADS, Green Island Reclamation Feasibility Study (GIRFS) and various other studies have established as necessary are summarised in Table 11.1.

TABLE 11.1 STRATEGIC HIGHWAY INFRASTRUCTURE

Highway	Comments	Open
Belcher Bay Link	Dual 2-lane road	1995
Route 7 (Sai Ying Pun to Kennedy Town)	Dual 3-lane road	1996
Route 7 (Kennedy Town to Aberdeen)	Dual 2-lane road south of Green Island (Possible phasing within reclamation)	Pre-2006

11.1.14 The Belcher Bay Link due for completion in 1995 is on a different alignment to that considered under GIRFS and this Study. It is planned that Belcher Bay Link will be relocated to the alignment shown beneath Route 7 when the strategic road network for Green Island is constructed. The Belcher Bay Link and Route 7 (Sai Ying Pun to Kennedy Town) is assumed to be in place prior to the opening of GIL. An initial section of Route 7 (Kennedy Town to Aberdeen) will be required to connect GIL to Route 7 east of Kennedy Town. The remainder of Route 7 (Kennedy Town to Aberdeen) may be phased to suit the reclamation. Initially, traffic will gain access to and from the reclamation via the Belcher Bay Link. As reclamation development increases, Route 7 may be constructed from the interchange to the roundabout junction with the primary distributor to allow access to the western end of the reclamation. It is expected that this will not be required prior to the anticipated opening of GIL in 2004.

11.1.15 On the basis of the timing described above, road phasing plans have been developed for the Green Island interchange as shown in Figures 11.2 and 11.3 for a dual 2-lane and a dual 3-lane configuration. In each case, the sequence of construction may generally be summarised as follows:

- Green Island Reclamation required for GIL;
- Route 7 (Sai Ying Pun to Kennedy Town);
- Green Island Link;
- extend Route 7 to Green Island Interchange;
- connection of the ground level roads between Kennedy Town, the PCWA and Belcher Bay Link; and
- Route 7 (Kennedy Town to Aberdeen) to suit reclamation phasing, including slip roads. to/from GIL.

11.1.16 An additional element to the phasing of the dual 3-lane configuration is the introduction of the possible Central Bypass which is discussed in Chapter 3. It is envisaged that both the GIL and Route 7 will be constructed and operating for a number of years before the capacity of Route 7 east of the interchange is reached. Provision has therefore been made to allow the Central Bypass to be constructed at a later date when Route 7 has reached capacity and to enable the GIL to subsequently achieve full dual 3-lane capacity.

11.1.17 The phasing plan for the dual 3-lane configuration (Figure 11.3) therefore shows two stages, before and after construction of the Central Bypass. The initial stage comprises the sequence of construction similar to the dual 2-lane configuration, together with temporary connections for Route 7 east of the interchange. It is envisaged that the elevated Route 7 will end in a temporary spur as shown on the phasing plan from which the temporary connections will comprise short ramps and ground level roads within the same corridor as the final configuration. The temporary connections will then be demolished during construction of the Central Bypass.

Kau Yi Chau Reclamation

11.1.18 The Kau Yi Chau reclamation will be constructed as part of the Green Island Link project, and accordingly cannot be expected to commence before the project start date. Whilst it is accepted that work on the reclamation, including seawalls, and the bulk excavation of the island can easily by done with only marine access, work must also commence on the ventilation buildings and access tunnels, and these will be affected by the lack of land access.

Causeway to Port Peninsula

11.1.19 The construction of the causeway between Kau Yi Chau and Sui Kau Yi Chau will be relatively straight forward, and completion of the causeway is not required until fairly late in the project. In order to minimise effects on currents, the construction works above the existing seabed as assumed to take place after installation of the immersed tube tunnel units.

Port Peninsula

11.1.20 The study assumes that the Port Peninsula construction will have reached Sui Kau Yi Chau by opening date. Whilst this is reasonable assumption, there is no reason why the causeway from the Kau Yi Chau landfall could not be extended further if required. Staging at the Port Peninsula is therefore not considered critical to the tunnel construction.

Western Breakwater

11.1.21 The Western Breakwater is planned to extend in an east-west direction approximately 5km south of the tunnel location. If it is in place by the time tunnel construction commences then this may cause a reduction in wave heights, and thus improve the conditions required for tunnel installation.

11.1.22 However, as construction of the western breakwater is not yet definitely scheduled, the Green Island Link construction feasibility and programme assume that it is not in place.

11.2 TUNNEL CONSTRUCTION TYPE

11.2.1 The different types of immersed tube tunnel require different construction programmes, and it is generally considered that steel shell type tunnels can be constructed faster than concrete tunnels. This is however very dependent on the facilities and resources available.

11.3 FABRICATION FACILITIES

Steel Shell Units

11.3.1 The production rate of steel shell units is governed by the size of the facilities provided. For some steel shell tunnels, production and placement of tunnel units using two assembly lines has achieved progress at the rate of one unit every three weeks, this time being set by the rate of placement on the seabed.

11.3.2 If the rate of placement of two weeks per unit were adopted (and this is considered feasible in good weather conditions), then a further assembly line would be required to produce units at the same rate.

11.3.3 The fabrication area itself is assumed to require 5 months to prepare from the contract commencement, this period could be reduced if suitable land was made available.

Concrete Units

11.3.4 The production rate of concrete units is governed by the total cycle time per unit, and the number of units within each batch. It will be feasible to construct a basin suitable for 7-10 units, and a construction cycle time of 6-7 months is appropriate. The casting basin requires about 20 ha of land area, and can be expected to need a lead time of one year for preparation.

11.3.5 For programme purposes it has been assumed that a casting basin would be formed in the Green Island Reclamation, which would be available for use at the start of the project.

11.3.6 For the dual 2-lane tunnel, it has been assumed that the tunnel units would be constructed in three batches. For the dual 3-lane tunnel, as the units are larger, it has been assumed that the tunnel units would be constructed in four batches.

11.3.7 If a larger facility were used then some reduction in construction time may be achieved, although this would require an increase in resources.

11.4 CONSTRUCTION PROGRAMME

11.4.1 Construction programmes for each possible type of tunnel are shown at Schedules 11.1 to 11.3 at the end of this Chapter, and these indicate possible construction durations as shown in Table 11.2.

TABLE 11.2 CONSTRUCTION DURATIONS

Tunnel Type	Construction	Duration
Dual 2-lane	Concrete	4.5 years
Dual 2-lane	Steel Shell	4.0 years
Dual 3-lane	Concrete	5.2 years

11.4.2 The construction programmes shown in the schedules have been prepared to indicate an opening date of November 2004. They can be adjusted to suit available resources, but are compatible with the achieved programmes of comparable projects.

11.4.3 The Highways Department project programme is shown in Schedule 11.5 at the end of this Chapter.

11.5 COST ESTIMATES

11.5.1 Cost estimates for the project have been generated from historical data brought up to the valuation date of fourth quarter 1991 by application of the appropriate construction cost indices.

11.5.2 The capital costs do not include escalation to the expected construction start date, nor do they include any element of escalation during the construction period.

11.5.3 The capital cost estimates for each construction option are given in Table 11.3 and these costs include the following items and allowances:

- contract preliminaries + 15%;
- detail allowance + 20%; and
- design and construction contingencies + 20%.

11.5.4 The contract preliminaries represent the costs of mobilisation and demobilisation and general site-based costs.

11.5.5 The detail allowance is added to compensate for the omission of minor works and details which are not considered at this stage.

11.5.6 The design and construction contingency allows for the additional construction costs arising from:

- unforeseen changes arising during detailed design; and
- unforeseen changes or delays arising during construction.

11.5.7 A further allowance of 7% has been applied, external to the estimate, to cover costs of detailed design (3.5%), independent design check (1%) and project management (2.5%)

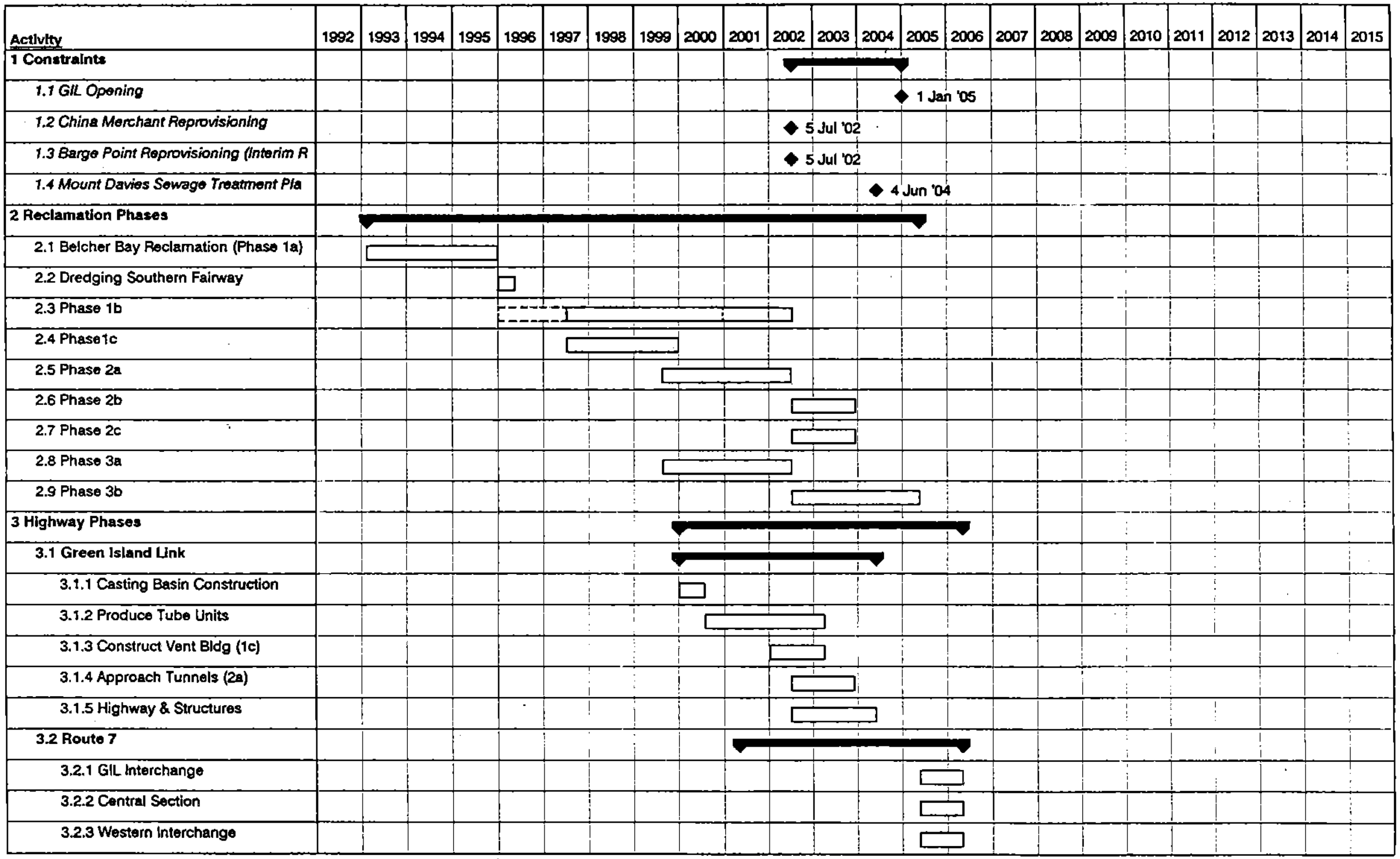
11.5.8 The capital costs include the cost of: the immersed tube tunnel; the approach tunnels; the causeway to the Lantau Port Peninsula as envisaged by PADS; reclamation for the Kau Yi Chau landfall; ventilation; lighting; drainage; control systems; toll plaza; administration building; and highways between the Study boundaries. The costs do not include reclamation at Green Island landfall, or the construction costs of Route 7 or the Central Bypass.

TABLE 11.3 CAPITAL COSTS

Description	Dual 2-lane (concrete)(1) $ millions(3)	Dual 2-lane (steel)(2) $ millions(3)	Dual 3-lane (concrete)(1) $ millions(3)
Road Pavement and Highway Structures	553	553	939
Approach Tunnels GIR	955	955	1169
Approach Tunnels KYC	570	570	665
Immersed Tube Tunnel	4,516	4,532	5,260
Reclamation - Causeway KYC	580	580	580
Reclamation - Landfall KYC	829	829	1,458
E & M - Ventilation, Lighting, Drainage, Fire	390	390	492
E & M - Control System & Toll Collect	426	426	512
Admin and Vent Buildings	197	197	210
Sub-Total	**9,016**	**9,032**	**11,285**
Design Checking and Project Management (7%)	632	633	790
Total	**9,648**	**9,665**	**12,075**

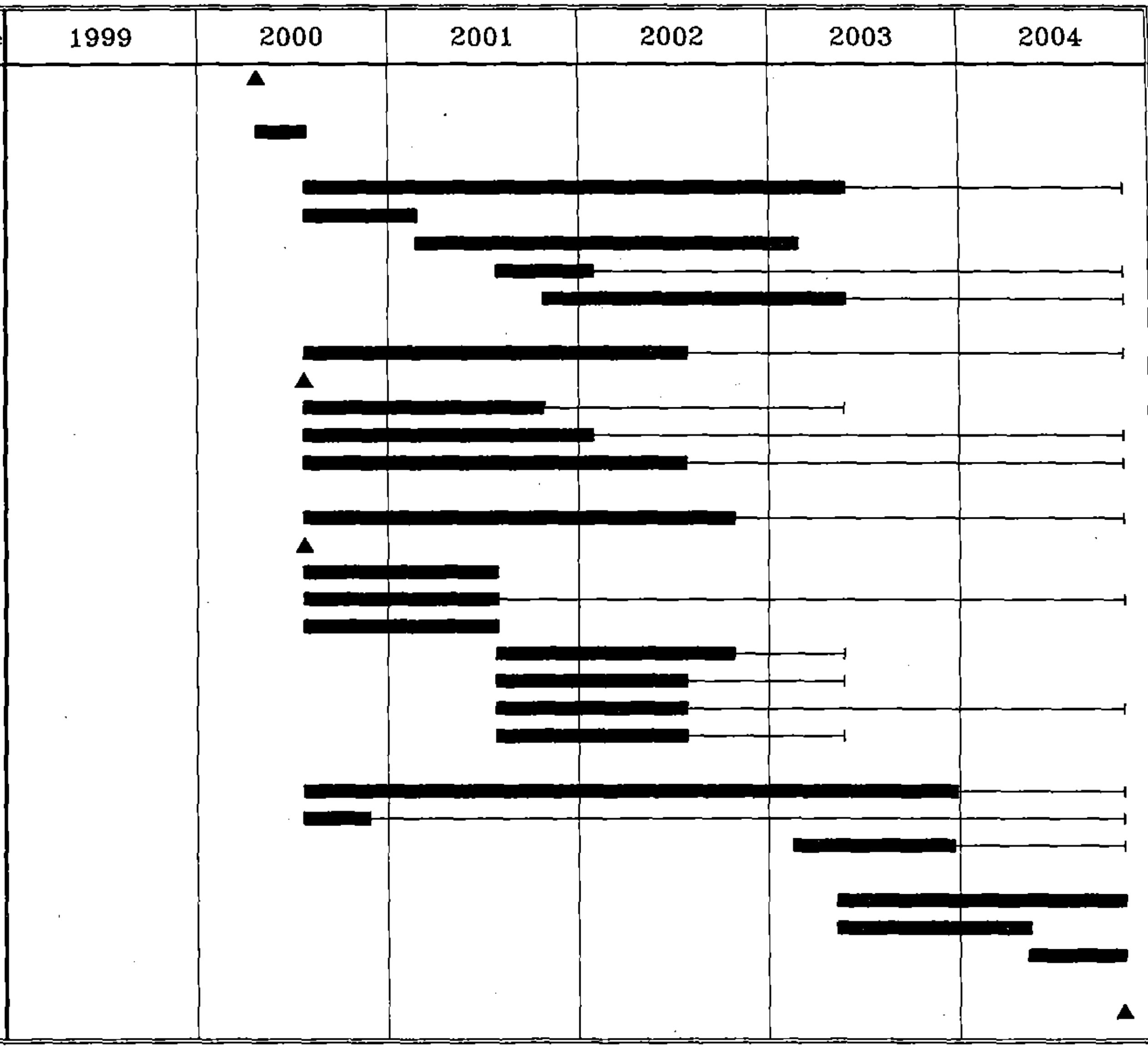
Notes:
(1) (concrete): Concrete unit immersed tube tunnel.
(2) (steel): Steel shell immersed tube tunnel.
(3) all capital costs are estimated for fourth quarter 1991.
(4) GIR - Green Island Reclamation;
KYC - Kau Yi Chau;
E&M - Electrical and Mechanical

Green Island Reclamation - Construction Programme
(Amended to show latest start for Green Island Link)



SCHEDULE 11.1

Task Name	Duration (Months)	Start Date
Contract Award	0	25-Apr-00
Site Mobilisation	3	25-Apr-00
Immersed Tube	34	24-Jul-00
Casting Basin	7	24-Jul-00
Construct Units	24	27-Feb-01
Bulk Dredging	6	28-Jul-01
Place Tunnel Units	19	26-Oct-01
Green Island Landfall	24	24-Jul-00
Reclamation Handover	0	24-Jul-00
Ventilation Building	15	24-Jul-00
Approach Tunnels	18	24-Jul-00
Highway Structures	24	24-Jul-00
Kau Yi Chau Landfall	27	24-Jul-00
Kau Yi Chau Handover	0	24-Jul-00
Bulk Excavation	12	24-Jul-00
Seawalls	12	24-Jul-00
Reclamation	12	24-Jul-00
Ventilation Building	15	28-Jul-01
Approach Tunnels	12	28-Jul-01
Toll Plaza	12	28-Jul-01
Administration Building	12	28-Jul-01
Causeway to Port Peninsula	41	24-Jul-00
Dredge & Fill to Seabed	4	24-Jul-00
Construct to +5.5mPD	10	19-Feb-03
E & M Systems	18	20-May-03
Installation	12	20-May-03
Commissioning	6	14-May-04
Start Revenue Service	0	10-Nov-04



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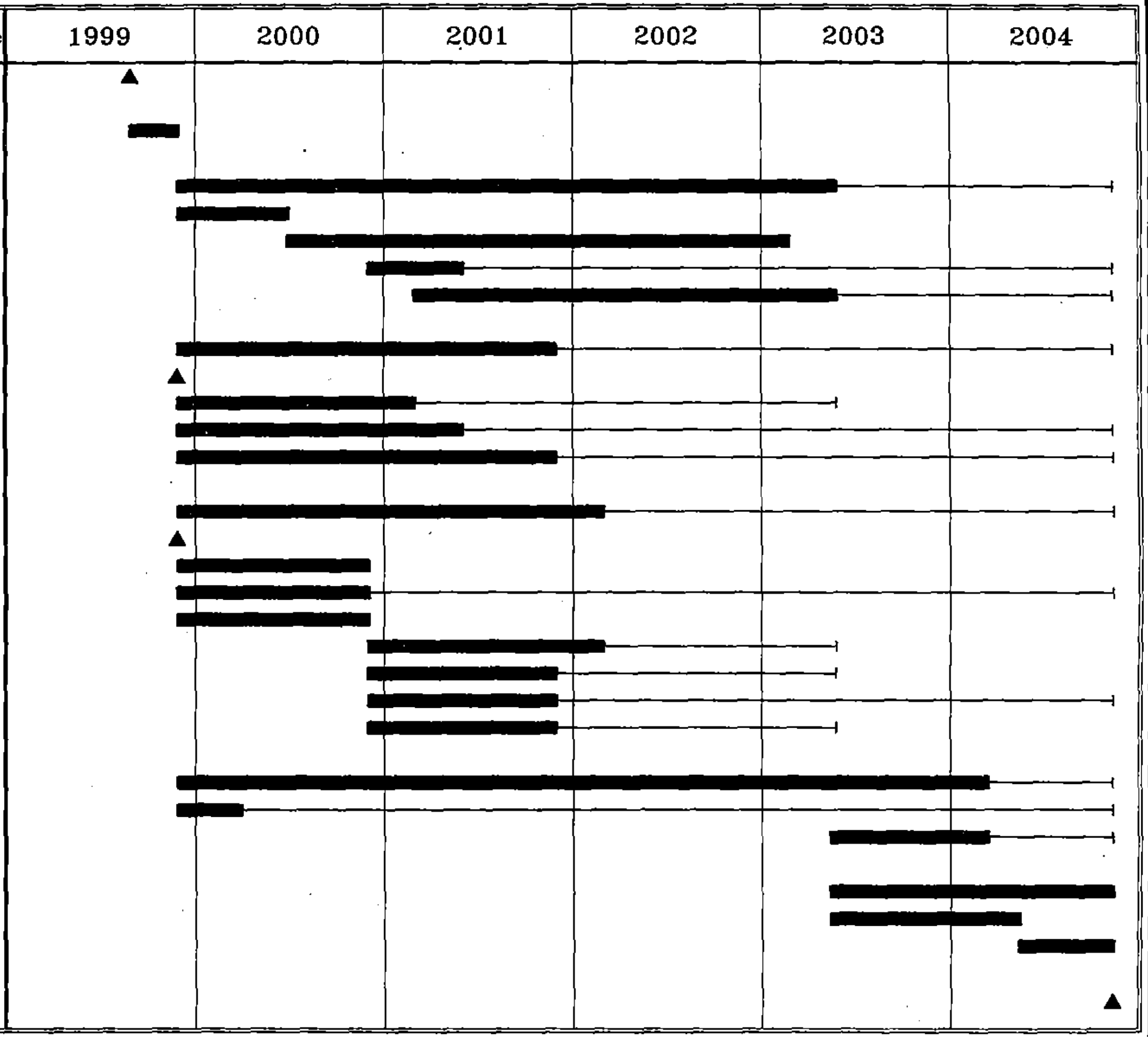
CONSTRUCTION PROGRAMME
DUAL 2-LANE CONCRETE TUNNEL

SCHEDULE 11.2

Task Name	Duration (Months)	Start Date
Contract Award	0	1-Sep-99
Site Mobilisation	3	1-Sep-99
Immersed Tube	42	30-Nov-99
Casting Basin	7	30-Nov-99
Construct Units	32	27-Jun-00
Bulk Dredging	6	2-Dec-00
Place Tunnel Units	27	2-Mar-01
Green Island Landfall	24	30-Nov-99
Reclamation Handover	0	30-Nov-99
Ventilation Building	15	30-Nov-99
Approach Tunnels	18	30-Nov-99
Highway Structures	24	30-Nov-99
Kau Yi Chau Landfall	27	30-Nov-99
Kau Yi Chau Handover	0	30-Nov-99
Bulk Excavation	12	30-Nov-99
Seawalls	12	30-Nov-99
Reclamation	12	30-Nov-99
Ventilation Building	15	2-Dec-00
Approach Tunnels	12	2-Dec-00
Toll Plaza	12	2-Dec-00
Administration Building	12	2-Dec-00
Causeway to Port Peninsula	52	30-Nov-99
Dredge & Fill to Seabed	4	30-Nov-99
Construct to +5.5mPD	10	23-May-03
E & M Systems	18	23-May-03
Installation	12	23-May-03
Commissioning	6	17-May-04
Start Revenue Service	0	13-Nov-04



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- Activity
- Float
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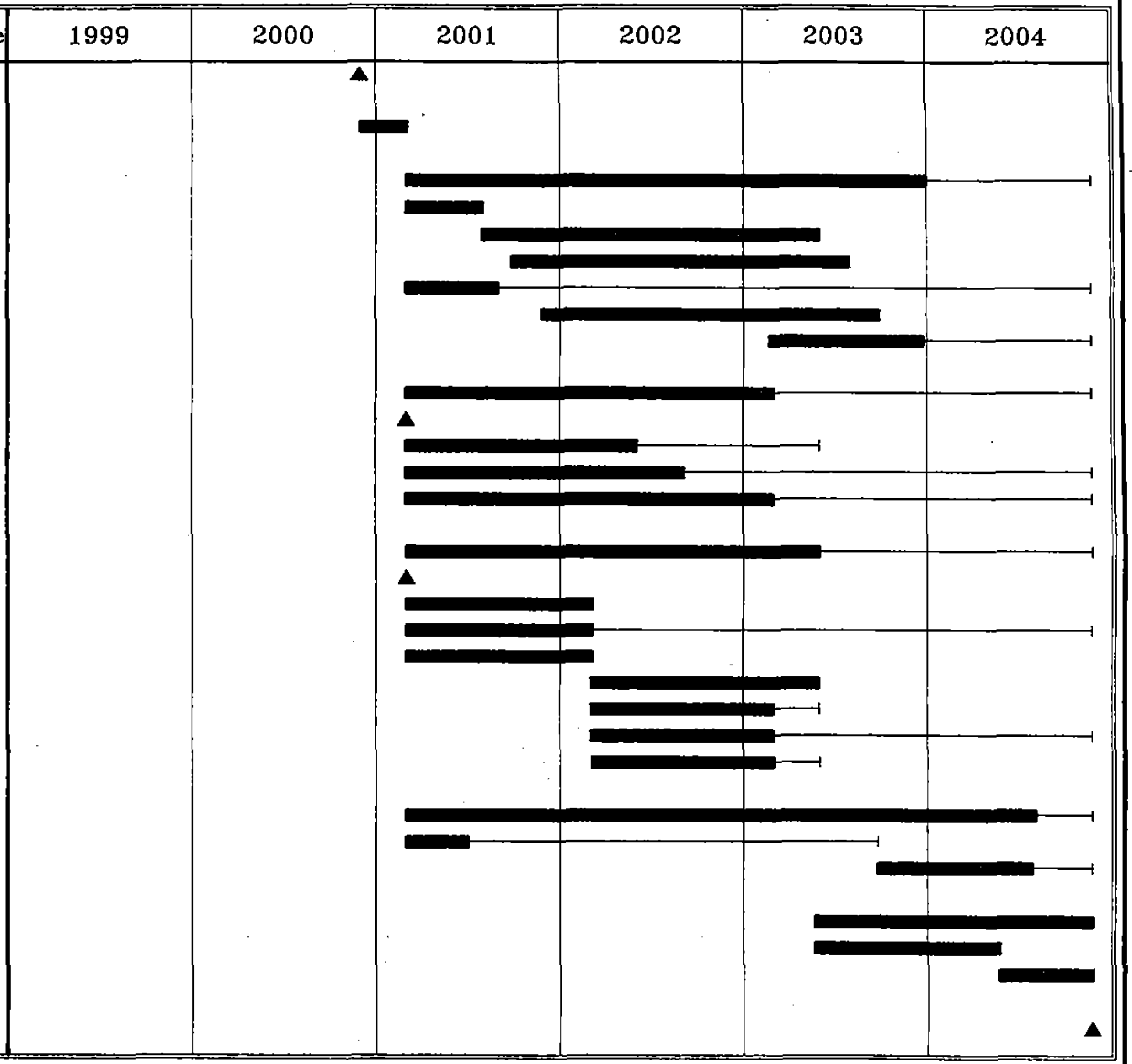
CONSTRUCTION PROGRAMME
DUAL 3-LANE CONCRETE TUNNEL

SCHEDULE 11.[illegible]

Task Name	Duration (Months)	Start Date
Contract Award	0	2-Dec-00
Site Mobilisation	3	2-Dec-00
Immersed Tube	34	2-Mar-01
Fabrication Area	5	2-Mar-01
Tunnel Fabrication	22	31-Jul-01
Tunnel Fitting Out	22	29-Sep-01
Bulk Dredging	6	2-Mar-01
Place Tunnel Units	22	28-Nov-01
Backfill	10	22-Feb-03
Green Island Landfall	24	2-Mar-01
Reclamation Handover	0	2-Mar-01
Ventilation Building	15	2-Mar-01
Approach Tunnels	18	2-Mar-01
Highway Structures	24	2-Mar-01
Kau Yi Chau Landfall	27	2-Mar-01
Kau Yi Chau Handover	0	2-Mar-01
Bulk Excavation	12	2-Mar-01
Seawalls	12	2-Mar-01
Reclamation	12	2-Mar-01
Ventilation Building	15	26-Feb-02
Approach Tunnels	12	26-Feb-02
Toll Plaza	12	26-Feb-02
Administration Building	12	26-Feb-02
Causeway to Port Peninsula	41	2-Mar-01
Dredge & Fill to Seabed	4	2-Mar-01
Construct to +5.5mPD	10	20-Sep-03
E & M Systems	18	23-May-03
Installation	12	23-May-03
Commissioning	6	17-May-04
Start Revenue Service	0	13-Nov-04



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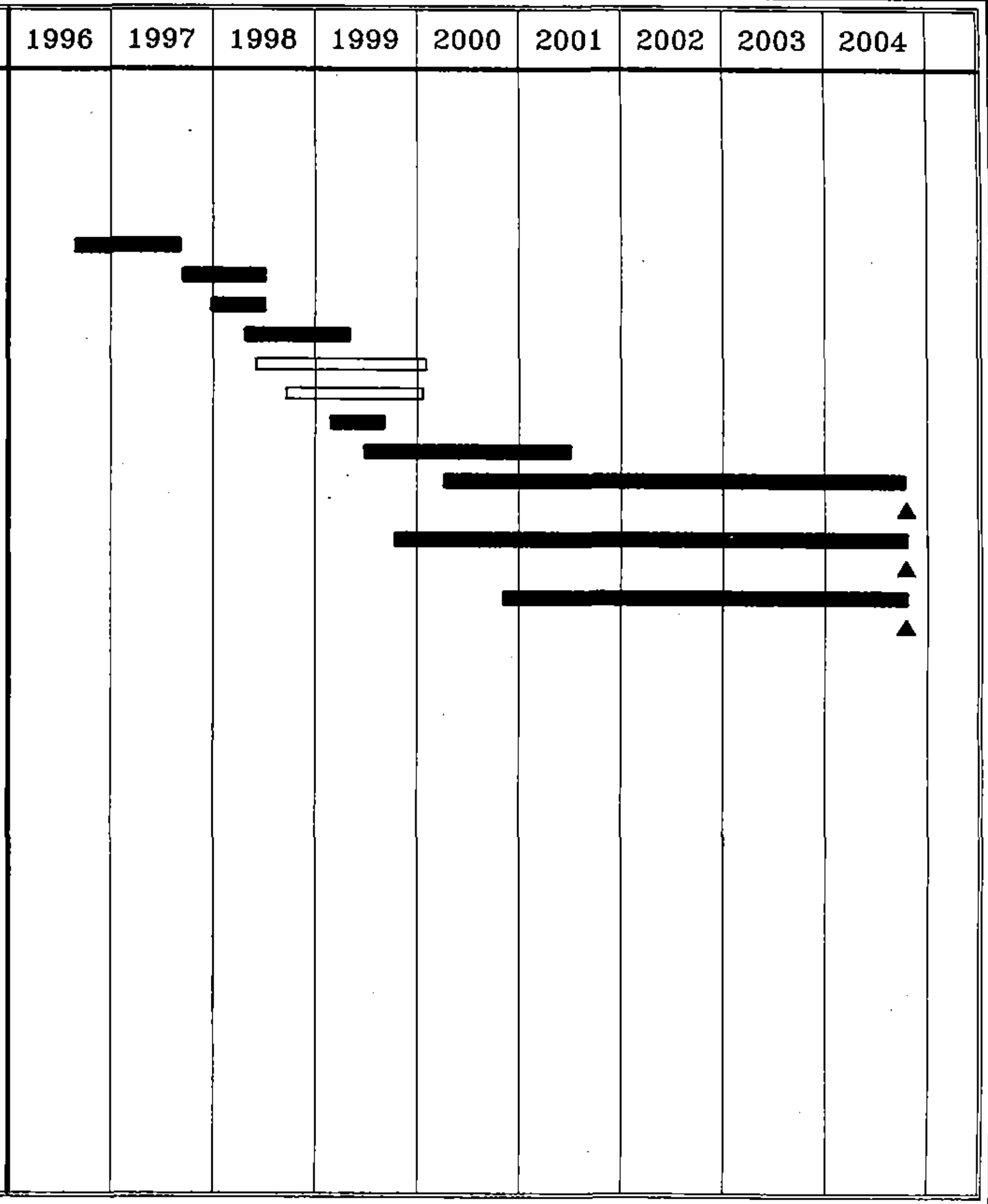
- Activity
- Float
- Milestone

CONSTRUCTION PROGRAMME

DUAL 2-LANE STEEL TUNNEL

SCHEDULE 11.4

Activity Description	Duration (Months)
Commencement of Project	0
Feasibility Study	12
Technical Bid Package	11
Project Bid Package	6
Privatisation Procedure	12
Roads Ordinance Procedure	20
FS & SB Ordinance Procedure	16
Legislation	6
Design	24
Construction Dual 2-Lane (Concrete)	56
Completion of Project Dual 2-Lane (Concrete)	0
Construction Dual 3-Lane (Concrete)	62
Completion of Project Dual 3-Lane (Concrete)	0
Construction Dual 2-Lane (Steel)	48
Completion of Project Dual 2-Lane (Steel)	0



Legend

Critical Activity

Activity

Milestone

HIGHWAYS DEPARTMENT PROJECT PROGRAMME

SCHEDULE 11.5

APPENDIX A

APPENDIX A

DESIGN STANDARDS MEMORANDUM

CONTENTS

Note: figures referred to in this appendix, and prefixed D, are included at the end of the respective Chapter.

1 INTRODUCTION

1.0.1 The purpose of this Design Memorandum for the Green Island Link is to define the overall design standards to be used for all major elements of the project, and to provide guidance to those standards.

1.0.2 A Design Manual should be prepared prior to detailed design, and should be written to suit the proposed works and methods of design. The Design Manual will be subject to the approval of Government, and this Design Memorandum may form the basis of such approval.

2 HIGHWAY ALIGNMENT

2.1 OVERALL DESIGN CRITERIA

2.1.1 The alignment shall be designed to conform with current Civil Engineering Department and Transport Department technical instructions and standards, particularly Volume V "Roads" of the Civil Engineering Department's Civil Engineering Manual and Volume 2 "Highway Design Characteristics" of the Transport Department's Transport Planning and Design Manual (TPDM).

2.1.2 The highways, interchanges, tunnel ventilation system, road signing and all other component parts of the crossing and its approaches shall accommodate traffic flows of 2000 pcu/h for each lane of the tunnel crossing without any adverse effect on the remainder of the road system. In particular the crossing and its approaches shall not normally cause traffic to back up onto Route 7.

2.1.3 Design of the exposed highway drainage shall be in accordance with Road Note 6 and Chapter 7 of Volume V of the Civil Engineering Manual. For any level or nearly level roads with a longitudinal gradient less than 0.67%, TRRL Report 602 "Drainage of Level or Nearly Level Roads" shall be used. Double gullies shall be provided at low points. Subsoil drainage will be necessary for roads on reclamation and this shall be designed in accordance with Road Note 8.

2.1.4 Tunnel portal drainage shall be designed in accordance with rainfall intensity given in Fig. 2.1.3(A) in the Civil Engineering Manual Volume VI Section 2. The design return period shall not be less than 1 in 50 years. Highway drainage within the tunnel shall be assessed after determination of maintenance, washdown, and spillage criteria. The capacity shall not be less than that required for one fire hydrant running full bore.

2.1.5 Pavement design shall be in accordance with Road Note No. 1 - "Road Pavement Design" which amplifies Chapter 7 -"Pavement Design" of the Civil Engineering Manual Vol. V.

2.1.6 The alignment shall be compatible with the requirements of the Green Island Reclamation and Lantau Port Peninsula final highway alignments and associated interchanges.

2.1.7 The vertical alignment at both landfalls shall be designed to provide a defence against flooding of the tunnel as described in Section 2.7 below.

2.1.8 All levels shall be referred to Hong Kong Principal Datum (PD).

2.1.9 The horizontal and vertical alignment parameters for design speeds of 70km/h and 85km/h are given in Tables 2.1 and 2.2.

TABLE 2.1 VERTICAL ALIGNMENT PARAMETERS

Design Speed (km/h)	70	85
Absolute minimum gradient (Except in Tunnels - refer para 2.4.4)	0.67%	0.67%
Desirable maximum gradient	4%	4%
Absolute maximum gradient	8%	8%
Vertical curve desirable min. K value		
Crest curve	19	33
Sag curve	13	18

TABLE 2.2 HORIZONTAL ALIGNMENT PARAMETERS

Design Speed (km/h)	70	85
Minimum radius (R3)	175m	250m
Desirable absolute minimum radius (R2) (see 2.5.2)	125m	
Superelevation, max.	10%	10%
Preferred edge profile variation	1%	1%
Absolute maximum edge profile variation	2%	2%
Normal minimum RL value (e = 0.30 m/sec)	25000	42000
Absolute minimum RL value (e = 0.86 m/sec)	9000	15000
Minimum stopping sight distance (SSD)	125m	165m

2.1.10 Where curves with a radius of 400m or less are used, carriageway widths should be increased in accordance with TPDM V.2.3 Table 3.4.4.1. The widening should be achieved by increasing the width at a uniform rate along the length of the transition curve on the inside of the curve.

2.1.11 In addition to meeting the defined alignment parameters, the vertical alignment shall take into account:

- Drainage requirements;
- Provision of climbing lanes; and
- Defence against flooding and inundation.

2.1.12 Bridge structures shall be designed in compliance with Civil Engineering Manual Vol. V Chapter 4. Multi-span structures shall be designed to minimize the number of bearings and movement joints. Precast beam and slab construction shall not be used on sharply curved flyover decks. All bridge and associated structures shall be subject to the approval of the Advisory Committee on the Appearance of Bridges and Associated Structures (ACABAS).

2.2 TOLL PLAZA

2.2.1 The geometric design of the Toll Plaza is not specifically covered in TPDM. However TPDM will be adopted regarding stopping sight distances and other performance criteria where appropriate.

2.2.2 Longitudinal gradients shall be 0% for a minimum distance of 20 metres on either side of the toll booths, and shall not exceed 3% within the area of expected car queuing. This arrangement reduces the risk of vehicles unexpectedly rolling forward or backward in the vicinity of the toll booths. It is desirable to locate toll booths on a crest curve in order to reduce vehicle speeds and thereby to reduce impact damage to toll booths.

2.2.3 Operational requirements are described in Section 5 of this Design Standards Memorandum.

2.3 LANTAU PORT PENINSULA APPROACHES AND CAUSEWAY

2.3.1 Alignment design shall meet at least the requirements of TPDM for a Trunk Road with a design speed of 85 km/h. Approach road grades shall not exceed 5% within 400 m of the tunnel portal and shall not exceed 4% immediately adjacent to the tunnel portal.

2.4 TUNNEL ALIGNMENT

2.4.1 The requirements of this Section apply only to the tunnel between portals.

2.4.2 The design speed for the tunnel shall be at least 85 km/h. The alignment shall at least meet trunk road standards unless stated otherwise.

2.4.3 In addition to meeting the defined alignment parameters, the vertical alignment shall take into account:
- Provision of climbing lanes;
- Optimisation of ventilation requirements;
- Drainage requirements (refer 2.4.4);
- Preferred location of vertical curves affecting the immersed tunnel shall be at joints of immersed tube units to minimise vertical height of the units;
- Marine clearances (refer 2.7);
- Additional vertical clearance above the structure gauge within the cut and cover tunnels where required to allow overhead signing within the approach tunnels; and
- Protection against scour and environmental disbenefits.

2.4.4 Drainage requirements within the tunnel are less than those for exposed roads and the TPDM minimum gradient limitation of 0.67% is therefore relaxed. Drainage gradients shall be suitable for dispersion and collection of tunnel wash water, accidental spillage etc. and this may be achieved by a suitable combination of longitudinal gradient and cross fall. True fall of the carriageway shall not be less than 1.0% at any point. Longitudinal gradients shall be sufficient to ensure that drainage after collection can flow to low point sumps.

2.4.5 The tunnel structure gauge shall not be less than that shown in Figure D 2.2 for the dual 2-lane and dual 3-lane configurations. Additional lane widths may be required on curved sections to achieve the required sight lines.

2.4.6 The structural gauge height of 5.0m is less than that recommended by TPDM, as it allows the economy of excluding the 100mm allowance for resurfacing as this is not usually provided in tunnels. This accords with the recommendations for the Western Harbour Crossing and exceeds that provided in both the Eastern Harbour Crossing and the Cross Harbour Tunnel.

2.4.7 The immersed tunnel cross-sectional configuration shall conform to one of the options below, the recommended choice being made subsequent to the Green Island Link Preliminary Feasibility Study. The arrangement of approach and other roads shall correspond to the selected option:
- Dual 2-lane tunnels, 6.75 m carriageway widths; and
- Dual 3-lane tunnels, 10.0 m carriageway widths.

2.4.8 Each tube shall be capable of operating in a bi-directional mode for emergency and maintenance purposes, with appropriate cross-over areas being provided beyond the tunnel.

2.4.9 Marginal strips 0.5 m wide and standard profile barriers shall be provided on each side of the carriageway in all cases. Walkways 0.5 m high and 0.65 m wide (minimum) shall be provided adjacent to the central wall, and an area 0.5 m high and 0.27 m wide (minimum) shall be provided adjacent to the opposite (outer) walls.

2.5 GREEN ISLAND APPROACHES AND INTERCHANGE

2.5.1 Alignment design shall meet at least the requirements of TPDM for a Trunk Road with a design speed of 70 km/h. Approach road grades shall not exceed 5% within 400 m of the tunnel portal and shall not exceed 4% immediately adjacent to the tunnel portal.

2.5.2 It has been concluded within the Green Island Reclamation Feasibility Study that R2 horizontal curves are acceptable for the slip roads between Route 7 and GIL, as shown in Table 2.2.

2.6 PROTECTION AGAINST INUNDATION

2.6.1 Protection shall be provided against inundation of the tunnel by flood water due to the combined effects of tide, surge and wave effects. The height and shape of surrounding walls and the elevation of all access roads shall be determined such that entry of water under these conditions is prevented.

2.6.2 Calculations shall be based upon a probability of the flood defence being overtopped (including wave action) 0.001 times in any one year. Levels shall be determined taking into account the foreseeable reclamations within the harbour area. Data may need to be extrapolated and may be obtained from:

- Wind Speed - CE Manual Vol VII Chapter 2.3.2; and
- Maximum Sea Level - Royal Observatory Technical Note (Local) No 35, Statistics of Extreme Sea Levels in Hong Kong, 1983.

The Royal Observatory should be consulted regarding the environmental climate in the study area.

2.6.3 Wind speed corrections and wave heights shall be calculated by rational methods such as those given in the Shore Protection Manual and the CE Manual Vol VII (Port Works).

2.6.4 In view of the 120 year design life of the structure, an allowance for a long term increase in Mean Sea Level shall be made in calculating flood heights and hydrostatic loading (refer 4.3.2). In the absence of better information, an allowance of 1 m shall be made, based on the guidance contained in Works Branch Technical Circular 6/90 (Greenhouse Effect - Allowance in Design).

2.7 MARINE CLEARANCES

2.7.1 It shall be assumed that maintenance dredging may cause marine clearance levels to vary downwards by up to 0.5 m. Allowance should also be made for siltation where this can occur. Probable shipping channels in the Western Harbour in the vicinity of the Green Island Link are shown in Figure D 2.1. The Marine Department has defined its minimum marine clearances as follows:

(a) Over the North Green Island Fairway and the West Lamma Channel charted traffic separation schemes for Macau routes, the seabed shall not be higher than -6.15 m Principal Datum (PD) [-6.0 m Chart Datum (CD)]. This level permits passage of dynamically supported Macau ferries with foils down. A request by the ferry operators to increase this clearance would raise the cost of the tunnel, and should be justified in view of the maximum draft of the vessels of only 5.3m which is required only in an emergency.

(b) Within the limits of the East Lamma Channel International Maritime Organization (IMO) charted traffic separation schemes and the prohibited anchorage area to the north of the schemes, the seabed shall not be higher than -25.15 m PD. This level permits passage of war vessels of 18 m draft, existing coal carriers of 16.5 m draft going to the Tap Shek Kok power station, and also much larger coal carriers envisaged as having drafts of about 20 m for a proposed new power station at Black Point for which minimum depths to seabed of 23.65 m will be required at low water including an allowance of 15% (3.0 m) for squat, roll, density correction and underkeel clearance, and 0.5 m for dredging tolerance in maintaining the channel.

(c) Within the limits of the proposed 328 m wide (1000 ft) West Lamma Channel charted traffic separation schemes to the Lantau Port Peninsula, the seabed shall not be higher than -17.15 m PD. The planned container terminals at the Port Peninsula may require the sea bed to be below the -14.65 m PD used for Container Terminal 8 at Stonecutters Island depending on the growth of ship size.

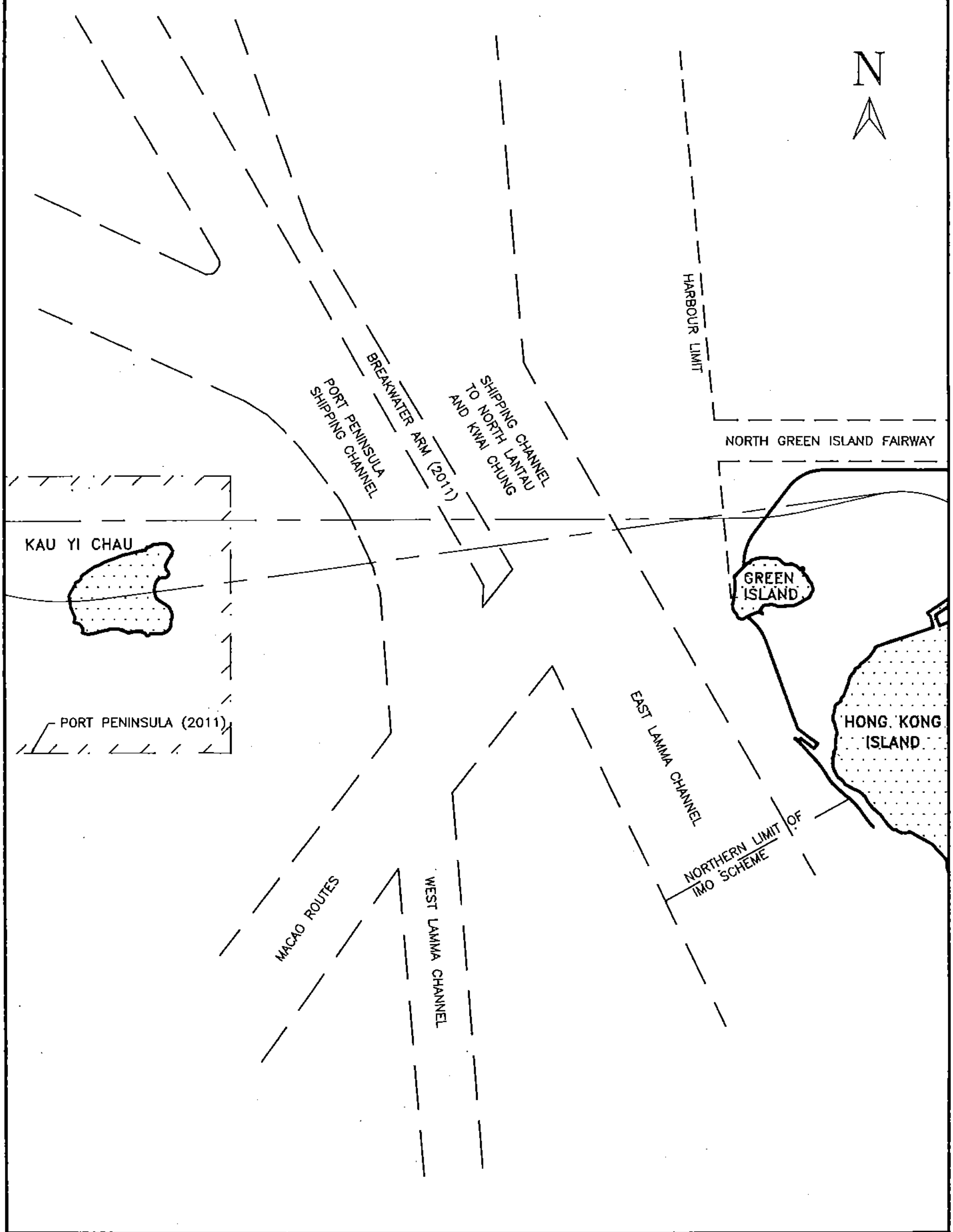
(d) Within the area of the 'OA' class anchorage and other areas which are used by naval vessels, the seabed levels shall preferably not exceed those given in Table 2.3. It is expected that the 'OA' class anchorage will be relocated elsewhere prior to construction of the Green Island Link.

TABLE 2.3 US NAVY DEEP DRAFT SHIPPING REQUIREMENTS

Location	Water Depth PD
East Lamma Channel	18.15 m
Naval Vessel Anchorage	Will not be required
North Green Island Fairway	6.15 m
OA2 & OA3	16.15 m

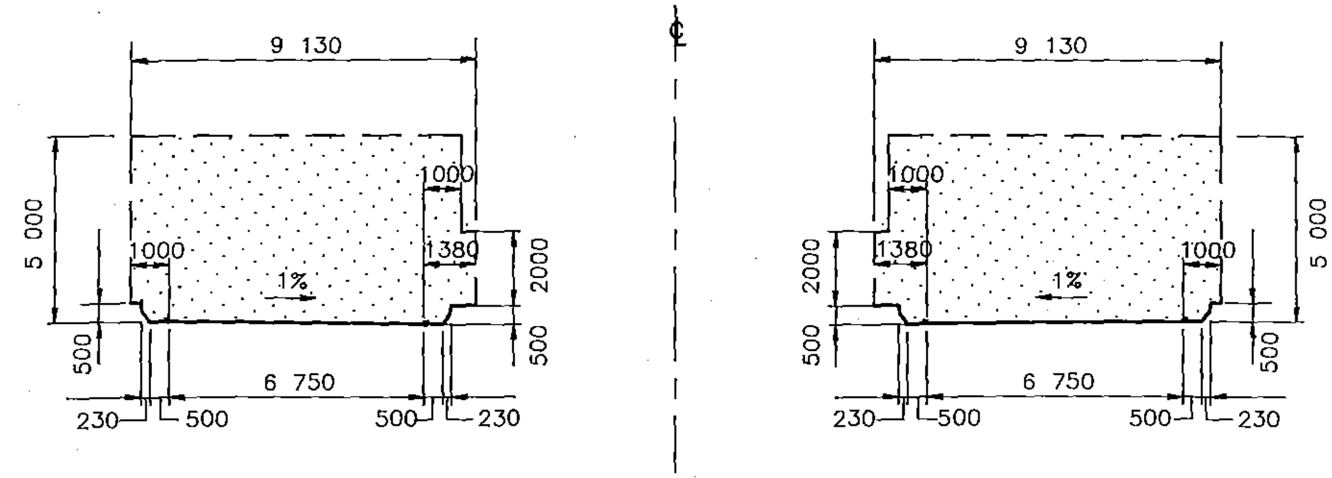
2.7.2 During construction, up to 1/3 of the width of a traffic lane of a traffic separation scheme or 1/6 of the scheme (or channel) may be temporarily closed providing the necessary Notices to Mariners have been promulgated. IMO traffic separation schemes cannot be relocated or temporarily moved. Other shipping routes may be temporarily moved providing agreement has been obtained from the Marine Department.

2.7.3 Required thicknesses of backfill/armour to be used in calculating clearance are defined in 4.8.4.

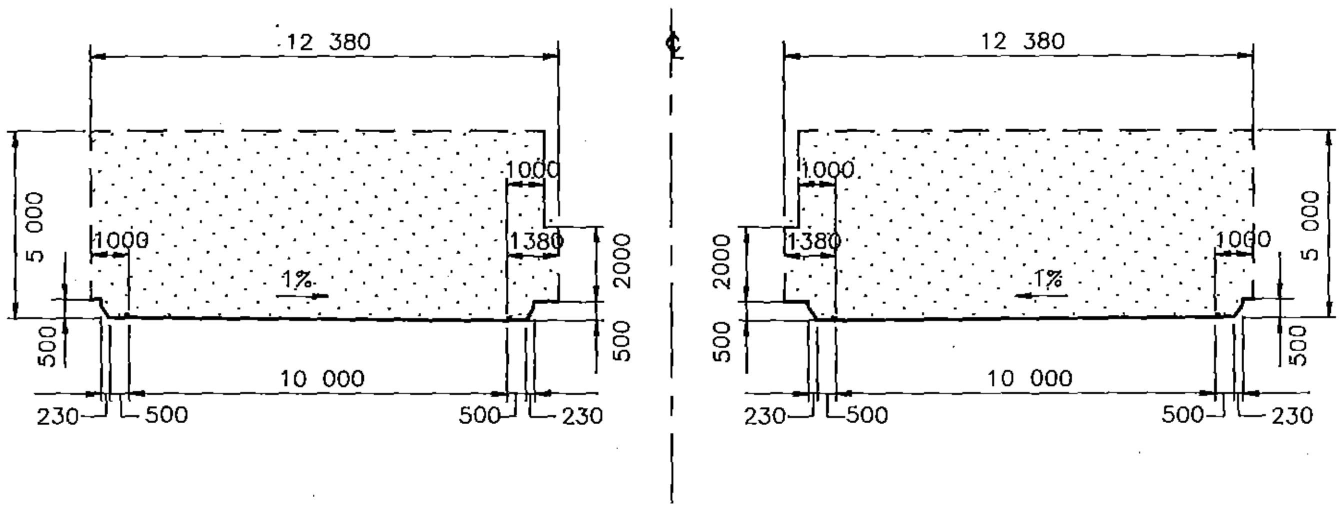


GREEN ISLAND LINK PRELIMINARY FEASIBILITY STUDY

HIGHWAYS DEPARTMENT	SHIPPING CHANNELS WESTERN HARBOUR	PAPM CONSULTANTS	FIG. D2.1



STRUCTURE GAUGE – DUAL 2 STRAIGHT SECTION



STRUCTURE GAUGE – DUAL 3 STRAIGHT SECTION

GREEN ISLAND LINK PRELIMINARY FEASIBILITY STUDY

HIGHWAYS DEPARTMENT	TUNNEL STRUCTURE GAUGE	PAPM CONSULTANTS	FIG. D2.2

3 RECLAMATION AND SEAWALLS

3.1 TEMPORARY WORKS

3.1.1 Design requirements for reclamation and seawall construction associated with fabrication facilities for immersed tunnel units or other temporary works shall be as agreed with Highways Department in consultation with the Port Development Office, Civil Engineering Department.

3.2 RECLAMATION

3.2.1 The post construction settlement of the reclamation should be determined to suit the required final land use. The settlement may be controlled or accelerated by one or a combination of the methods outlined below:

- partial or total removal of the marine deposits;
- surcharging;
- placement of wick drains through the marine deposit;
- granular columns;
- sand drains; and
- chemical treatment.

An examination of the allowable post construction settlements for different land uses and the required solutions from those above should be carried out as part of the full feasibility study.

3.3 SEAWALLS

3.3.1 The location of the sea walls shall be as shown on the outline design drawings, and on the drawings of the Green Island Reclamation Feasibility Study (GIRFS) and the Lantau Port Peninsula Development Study (LPPDS).

3.3.2 Seawalls shall conform to the following requirements:

(a) the height and shape of sea walls shall be in accordance with the recommendations of the LPPDS and GIRFS;
(b) the principles of design shall be in accordance with the Civil Engineering Manual Vol. VII Port Works and Geoguide 1, Guide to Retaining Wall Design; and
(c) a uniform ground surcharge of 11.5 kN/m^2.

3.4 CAUSEWAY

3.4.1 The Causeway consists of pell mell mounds with rock armour protection on top of the marine deposits. The marine deposits are required to be dredged to a level of approximate -20 MPD and wick drains installed to accelerate consolidation.

3.4.2 Placement of the pell mell rubble should be controlled to be compatible with the rate of consolidation and thus the rate of gain in strength of the marine deposits. At each stage of construction the causeway shall have a satisfactory factor of safety against bearing capacity or slip surface failures.

4 TUNNEL STRUCTURE DESIGN

4.1 GENERAL DESIGN ASSUMPTIONS

4.1.1 The requirements of this section shall apply as appropriate to all components of the tunnel structure including the immersed tube tunnel, approach tunnels, open ramps and ventilation building structures.

4.1.2 The design life of the tunnel shall be 120 years. The design fire resistance shall be 4 hours.

4.1.3 In sizing the cross-section of the immersed tunnel, the overall weight must be such that the section can meet requirements for floating during installation. Tolerances of ± 50 mm for highway tunnels shall be incorporated without encroaching on roadway clearances to allow for construction variations and possible misalignment of tunnel units. Allowance shall be made for the addition of more concrete or permanent ballast in order to meet requirements not to float under final conditions.

4.1.4 In selecting ventilation building locations, the ventilation buildings shall preferably be located on land behind existing seawalls or shall be protected from being hit by shipping.

4.1.5 Vessels should not be permitted to drop anchor, except in emergencies, or to be moored within the area of the Green Island Link immersed tunnel. The tunnel area is defined as that area over which tunnel protection is provided on the sea bed.

4.1.6 Pedestrian access into adjacent tubes shall be provided through cross adits at not more than about 100 m intervals for maintenance and emergency use. Vehicular cross-adits will not be provided.

4.2 APPLIED LOADS

4.2.1 Characteristic loads shall be based upon the relevant British Standards (e.g. B.S. 8110). Where structural codes do not consider the particular conditions that apply to immersed tunnels or their approaches, the following classifications shall be considered:

(a) Dead loads, to include all long term loads and mean water level (static loads).
(b) Live loads, to include creep, shrinkage, prestress, temperature, backfill (the effects of which can vary with temperature etc.), erosion of the seabed, siltation, traffic, and variations (considering appropriate static and dynamic effects), each with an annual probability of being exceeded of 0.2 or greater, of water level (including waves), current, storm loads and earthquakes.
(c) Exceptional loads, including loss of support (subsidence) below the tunnel or to one side, and storms and extreme water levels with a probability of being exceeded once during the design life (considering appropriate static and dynamic effects for each). For the immersed tube, a loss of support of not less than 10% of the length of the tunnel unit over the full width of the tunnel unit shall be considered.
(d) Extreme loads, including where appropriate: sunken or stranding ships, anchor impact, ship collision, water-filled tunnel, explosion (e.g. vehicular), fire, the design earthquake predicted for the location, and the resulting movement of soils. The design earthquake shall have a probability of being exceeded not more than once during the design life. Some of these loads may be affected by categories of dangerous goods permitted through the tunnel.
(e) Construction loads, see section 4.3.1(d).

4.2.2 Load combinations shall be selected with regard to simultaneous probability (see Table 4.1). The design earthquake may be assumed to occur without storm loads.

4.2.3 Highways shall be designed for HA loading and 45 units of HB loading.

4.2.4 The effect of an anchor impacting the tunnel structure directly or being dragged across the line of the tunnel structure shall be considered. Either the tunnel structure shall be designed to resist the full loading imposed by the design anchor, or the backfill/armour system shall be designed to mitigate the loading, in which case the tunnel structure shall be designed for the demonstrable reduced load. The design anchor shall be selected as appropriate to shipping using or expected to use the Western Harbour based on the relevant section of Lloyd's Rules.

4.2.5 The primary sunken or stranding ship design case shall be assumed to consist of a ship, the size being appropriate to those using or expected to use the Western Harbour, grounding on the tunnel at or near high tide and not being removed before the following low tide. In the absence of better information, the imposed loading shall be taken as a uniform loading of 50 Kn/m^2 (unfactored, serviceability limit state) over an area the full width of the tunnel with a length as measured on the longitudinal axis of the tunnel of 30 m. Collision impact loading shall not be considered. The loading shall not be considered at the serviceability limit state, but factored as shown in Table 4.1 as an ultimate limit state loading.

4.2.6 A secondary sunken ship design case shall be assumed to consist of a smaller vessel, such as a ferry or barge, sinking and impacting the tunnel structure with the stem or stern post in a manner similar to that of a dropped anchor.

4.3 DESIGN LOADING CONDITIONS

4.3.1 At least the following conditions shall be considered during analysis and design:

(a) Normal operating conditions, with the tunnel operation unaffected by environmental loads.
(b) Abnormal conditions, demonstrating that either a tunnel with live loads can remain operational under the after-effects of extreme or exceptional loads (but not flooded) or settlement, or that with operations ceased and closed to traffic, the tunnel can survive some loss of support beneath or to one side.
(c) Extreme actions with the tunnel closed, the abnormal conditions above combined with one of the extreme loads.
(d) Construction conditions, including temporary structures (e.g. sheet piles) and loads due to handling, transporting, and placing, combined with environmental loads appropriate to the season, duration of use, and location. Abnormal and extreme conditions may be inappropriate.

4.3.2 Allowance should be made in calculation of hydrostatic loading for a long term increase in Mean Sea Level of 1.0 m (refer 2.6.4).

4.4 METHODS OF ANALYSIS

4.4.1 Use of the design codes and documents of recommended practice listed below would be considered appropriate for structural design where these do not conflict with requirements of this Design Memorandum:

- B.S. 5337 The Structural Use of Concrete for Retaining Aqueous Liquids;
- B.S. 5400 Steel, Concrete and Composite Bridges;
- B.S. 5950 The Structural Use of Steelwork in Building;
- B.S. 8007 Design of Concrete Structures for Retaining Aqueous Liquids;
- B.S. 8110 Structural Use of Concrete; and
- CEB/FIP Model Code for Concrete Structures,
  Hong Kong Government Civil Engineering Manual,
  Geoguide 1, Guide to Retaining Wall Design.

4.4.2 Structural analysis shall include both serviceability and ultimate limit states. Serviceability analysis is not required for conditions where the tunnel is closed, as defined in 4.3.1, when some cracking and/or local repairable damage might be expected to occur; serviceability would be expected to be restored after such an event.

4.4.3 Analysis of the behaviour of structures under ultimate loads shall be investigated. Each load in a combination shall be factored. It is important in choosing appropriate factors that a consistent design code be used. Where alternate factors are given, the most adverse combinations shall be used. Material factors of $\gamma_{mc}=1.5$ for concrete and $\gamma_{ms}=1.15$ for reinforcing steel would be appropriate. For immersed tunnels, load factors (appropriate load combination multipliers) are given in Table 4.1. Effects to be examined include:

(a) Adequate safety against failure of structures and their components. Structural integrity must also be maintained against collapse so that catastrophic inundation of the tunnel does not occur.
(b) Static equilibrium of structures as a whole.
(c) Buckling.
(d) Fatigue.
(e) Ductile behaviour in the overload range. Primary members forming the tunnel, including its joints, shall be designed to be ductile.
(f) Deformations, particularly at those locations where plastic or creep deformations could transform the structure into a mechanism.

TABLE 4.1 LOAD FACTORS AND COMBINATIONS

Loading \ Design Loading Conditions (refer to 4.3.1)	(a) Normal	(b) Abnormal	(c) Extreme	(d) Construction
Dead Load and Road Ballast	1.4/0.9	1.2/0.9	1.05	1.1
Traffic Load:				
Normal	1.6/0	1.2/0	-	-
Exceptional Vehicle	1.4/0	1.2/0	-	-
Centrifugal	1.6/0	1.3/0	-	-
Braking Load:				
Normal	1.6/0	1.3/0	-	-
Exceptional Vehicle	1.4/0	1.2/0	-	-
Wind and Waves	-	1.2	1.05	1.2
Current	1.4	1.2	1.05	1.2
Water Pressure (tidal variation)	1.4/0.9	1.2/0.9	1.05	1.2
Additional Water Pressure (surge)	-	1.2/0.9	1.05	1.2
Backfill Pressure:				
Horizontal	0.9/1.6	0.9/1.4	1.05	1.3/0
Vertical	1.6/0.9	1.4/0.9	1.05	1.3/0
Creep and Shrinkage	1.3	1.3	1.05	1.1/0.9
Temperature Effects and Prestressing	1.3	1.3	1.05	-
Sunken Ship	-	1.2/0	1.05	-
Earthquake	-	1.2	1.05	-
Other Extreme Loads	-	-	1.05	-
Imposed Loads during Construction	-	-	-	1.3

4.4.4 The behaviour of structures at the serviceability limit state shall be checked for unfactored loads (see also 4.4.2). Material factors of $\gamma_{mc}=1.0$ and $\gamma_{ms}=1.0$ would be appropriate. Limit states shall include those of:

(a) Cracking.
(b) Deformation - for slender structural elements, second order deformation effects due to construction tolerances should be calculated.
(c) Vibration.
(d) Durability - including corrosion of steel and deterioration of concrete.
(e) Watertightness.

4.4.5 Where frequently reoccurring cyclic loads cause significant stresses, fatigue strength shall be considered. Detailed analyses should consider both high cycle/low amplitude and low cycle/high amplitude fatigue.

4.4.6 Structures shall be designed to accommodate expected movements due to deformation of foundations without limiting normal operations. Soil pressures shall take account of the soil surface profile as well as the geometry of the structure. Geotechnical considerations shall also include effects due to seepage, erosion, a change from drained to undrained conditions and cuts in soft clays. Differential settlements can be expected at interfaces between types of construction, at locations where subaqueous tunnels extend into the shoreline, and during construction.

4.4.7 The foundation must provide an adequate factor of safety against bearing capacity failure under the most critical combination of loads. When stability is analyzed in terms of effective stresses, the cohesive component of soil shear strength should be divided by a material factor $\gamma_c \geq 1.2$, and the frictional component should be divided by a material factor $\gamma_f \geq 1.4$. When stability is analyzed in terms of total stresses, the undrained shear strength should be divided by the factor $\gamma_c \geq 1.4$.

4.4.8 Earthquake analysis shall consider both structural and geotechnical aspects, including any possibility of liquefaction. Analysis should be directed primarily at demonstrating the ductility of the structure and the integrity of the joints under earthquake loading. The maximum ground acceleration to be assumed for derivation of earthquake loads shall be 0.07 g; it is recommended that this value should be reviewed during preliminary design.

4.5 CRACKING IN CONCRETE

4.5.1 It is important that cracking in structural concrete members is limited so that durability of the reinforcement is assured. Crack control shall be achieved by either:

(a) limiting tensile steel stresses to the values given in Table 4.2;

(b) calculating flexural crack widths at the concrete surface in accordance with the CEB/FIP Model Code for Concrete Structures. Calculated flexural crackwidths (including thermal cracks, see 4.5.5) shall not exceed 0.2 mm for reinforced concrete;

(c) any other approved rational method.

4.5.2 For prestressed concrete, no tensile stresses shall be allowed in the direction of prestress under normal loads. In the direction normal to the prestress, tensile strains at the level of the prestressing steel shall be limited so that the strains at the plane of the prestressing steel do not exceed Δ_{ps}/E_s as calculated from Table 4.2.

TABLE 4.2 LIMITING TENSILE STRESSES FOR PRESTRESS AND REINFORCING STEEL (SERVICEABILITY LIMIT STATE)

Stage	Loading	Allowable Stress	
		Δ_{ps}	f_s
Construction: Where cracking during construction would be detrimental to the completed structure	All loads on the structure during construction	130	160
Construction: Where cracking during construction is not detrimental to the completed structure	All loads on the structure during construction	130	210 or $0.6f_y$ whichever is less
Construction	All loads on the structure during transportation and construction	130	160
At final location	Loading condition (a) & (b)	75	120

f_s = maximum stress in reinforcing steel N/mm²
Δ_{ps} = stress range of prestressing steel N/mm²
For loading conditions (a), (b), (c) refer to 4.3.1

4.5.3 Where cracking and consequential hydrostatic pressure in the cracks can significantly change structural loading and behaviour, reinforcement shall be provided across the cracks in these locations, anchored in compressive zones.

4.5.4 Thin-walled sections susceptible to instability shall not be permitted to crack under working loads.

4.5.5 Differential temperature effects may lead to severe cracking in areas of structural restraint. This may include results of temperature differences across walls and slabs. Creep strain induced by temperature loadings may also be significant during the life of some members. Tensile stresses and associated crack widths in such areas shall be calculated by reference to expected thermal strains and restraint conditions. Such strains and restraints shall be justified by calculation, computer or physical modelling. Crack widths shall be limited to a maximum of 0.1 mm by minimising heat of hydration, by use of artificial cooling, or by use of reinforcement.

4.5.6 Thicknesses of concrete sections are large enough to require precautions to be taken against cracking due to heat of hydration. Measures to be considered shall include:

(a) cooling of concrete;
(b) the use of insulated forms;
(c) low water/cement ratio;
(d) partial replacement of cement using pulverized fuel ash (PFA), ground granulated blast furnace slag (GGBFS) or silica fume (microsilica) to reduce heat of hydration. This is also discussed in 4.7.4.

4.6 JOINT ANALYSIS

4.6.1 If shear strengths of the joints between immersed tube units, or between immersed tube units and cut and cover sections, are less than those of the adjacent tunnel sections, shear checks of all load conditions shall be made. Joints shall be ductile (refer to 4.4.8) in addition to accommodating longitudinal movements. Tension ties may be required to limit movement so that joints do not leak or break open. For in situ closure joints, spacers may be required to prevent the joint closing during casting.

4.6.2 Joint shear capability at end closure junctions (tunnel bulkheads) shall take into account the influence of normal forces and bending moments on the shear capacity of the section. The effects of higher or lower internal air pressure in sealed tunnel units due to variations in temperature etc. due to compression, expansion and immersion shall be considered.

4.7 DURABILITY, WATERPROOFING AND CORROSION PROTECTION

4.7.1 Cover to reinforcement and prestressing ducts shall be maintained appropriate to exposure. The presence of any waterproofing membrane shall not be considered when assessing exposure. Ventilation and traffic ducts may also be exposed to humid and salty conditions and/or wetting and drying.

4.7.2 An external waterproofing membrane shall be used but shall be discounted in assessing durability of the structure. Protection appropriate to the type of membrane against damage shall be provided. Particularly for a steel tunnel, such a membrane could be the external steel structure provided that an adequate corrosion life can be demonstrated.

4.7.3 Joints between tunnel units shall be provided both with a primary seal, generally a rubber gasket, and a secondary independent flexible seal. Each seal shall be capable of resisting the external hydrostatic pressure and shall allow for expected future movements. Protection shall be provided to the seals against damage from within the tunnel.

4.7.4 The concrete shall be designed to be of high durability, chloride free, and of low permeability. A minimum cementitious content of 350 kg/m^3 shall be used except that concrete placed by tremie methods shall have a minimum cementitious content of 400 kg/m^3. In order to reduce heat of hydration effects and permeability, consideration shall be given to the use of:

- low heat cements;
- pulverised fuel ash (PFA);
- ground granulated blast furnace slag (GGBFS); and
- silica fume (microsilica).

4.7.5 Particular attention shall be paid to curing of the concrete containing these materials. Special measures to ensure durability may be required in areas exposed to wetting and drying. The simulation of low heat characteristics utilizing cement replacement materials is recommended since this overcomes the chloride susceptibility of low heat portland cement. PFA and microsilica help to fill the interstices between the cement particles and may considerably increase durability, strength, and waterproofing. The use of at least 45% cement replacement by GGBFS has been shown to give significant improvement in chloride resistance. Sulphate resisting cements are not considered appropriate because of their low chloride resistance.

4.7.6 Exposed steelwork, whether on external or internal faces, shall be electrically isolated from steel reinforcement and prestressing steel. Expected rates of corrosion for permanent exposed and unprotected steelwork during the design life of the tunnel shall be determined and either a sacrificial thickness of metal or cathodic protection shall be provided.

4.7.7 External grounding shall be provided where significant earth leakage currents can be expected, such as in the vicinity of dc-powered transit systems, since leakage currents can be a cause of severe deterioration. Such systems may eventually exist within the zone of influence if the rail link being considered is adopted. For concrete structures, exposed steelwork and the associated anchor systems shall be electrically isolated from the primary steel reinforcement by at least 50 mm of concrete.

4.7.8 During a recent GEO study of gas in marine sediment in Hong Kong, abnormally high levels of hydrogen sulphide and methane were found in the soft marine clay. Such conditions could exist across a very large area in the Western Harbour. The need for corrosion protection of structures against such gases should be assessed.

4.8 STABILITY OF IMMERSED TUNNEL UNITS

4.8.1 In checking tunnel units for stability while floating, due attention shall be paid to effects of variations in structural dimensions including results of thermal and hydrostatic effects. Items to consider include:

- Sufficient freeboard for marine operations, so that tunnel units are relatively unaffected even when waves run over the top. A minimum freeboard of 200 mm is recommended.
- A positive buoyancy margin exceeding 1% is recommended to guard against sinking due to variations in dimensions and densities both of tunnel materials and of the surrounding water.
- Cross curves of stability shall show a factor of safety in excess of 1.4 of the area under the righting moment curve against the heeling moment curve. A positive metacentric height (static stability) exceeding 200 mm is also recommended.

4.8.2 After placing tunnel units on the seabed, a factor of safety exceeding 1.04 against flotation shall be maintained during construction, ignoring assistance from adjacent units. With the permission of the Engineer, this factor may be reduced to 1.02 for short periods.

4.8.3 Completed structures, including the immersed tunnel, shall have a factor of safety exceeding 1.2 against flotation including any backfill above the plan area, and a factor of safety never less than 1.04 against flotation when backfill, road surfacing, and all removable items are excluded. Friction effects of the backfill shall not be taken into account.

4.8.4 Backfill shall be provided around the tunnel. Armour protection may also be required. In lieu of more precise calculations, the depth to the structure below the clearance envelope required for the shipping fairways and elsewhere in the waterway shall allow for up to 1 m of over-dredge/siltation allowance (this requirement allows a safety margin to that given in 2.7.1) and a minimum of 2 m of protective backfill over the tunnel. The thickness of protective backfill may vary depending on the ability to distribute loads from sunken ships or other foreseen loads to the tunnel structure. The combined system of armour protection and backfill shall be designed to:

- ensure the availability of a minimum factor of safety of 1.2 against flotation as described in 4.8.3;
- provide protection against sinking/stranding ship and anchor hazards; and
- provide protection against scour.

4.8.5 In the absence of better information, the backfill/armour system may follow the principles shown in Figure D 4.1, consisting of :

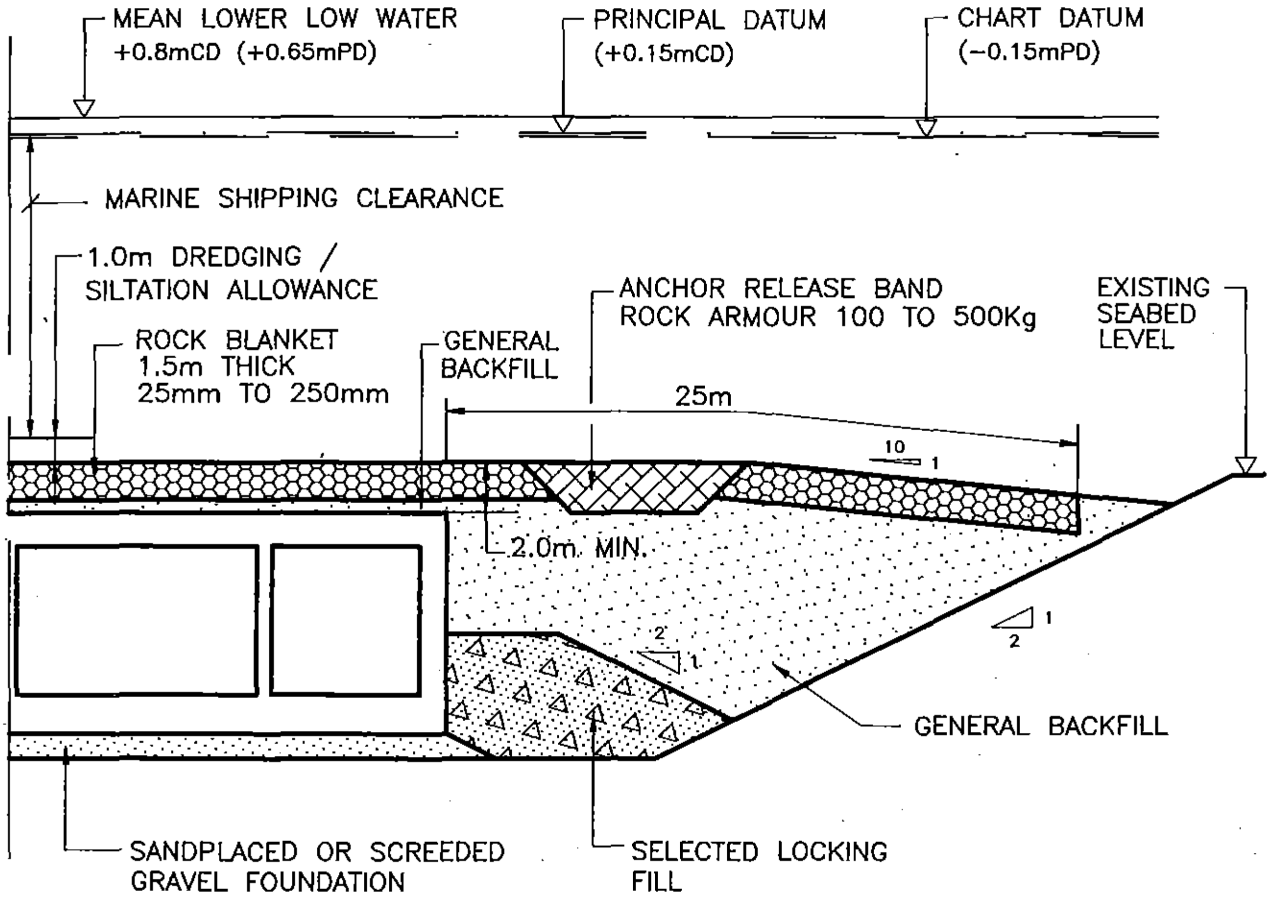
- selected locking fill to secure the units laterally;
- general backfill to the tunnel structure, also providing an impact absorbing/load spreading layer above the tunnel;
- a rock blanket generally above and adjacent to the tunnel to provide scour protection for the existing and reinstated seabed against currents and propeller wash from large ships without compromising the impact absorbing capability of the backfill; and

- rock fill anchor-release bands at either side of the tunnel which require to be designed for the design anchor.

4.9 TUNNEL FINISHES

4.9.1 Road pavement shall be selected with a view to both durability and operational characteristics including noise. Due to the difficulty of maintaining and replacing road pavements in tunnels, durability is especially important.

4.9.2 In selecting finishes for walls and ceiling, the final finish shall not permit build up of water vapour behind it. When tiles are used, care must be taken to ensure long term adherence of the tiles, particularly in ceilings. Drainage shall be provided assuming that water leakage can occur. Interior design shall be arranged for ease of cleaning by machine. Ceiling finishes shall have good acoustic absorption properties.



GREEN ISLAND LINK PRELIMINARY FEASIBILITY STUDY

HIGHWAYS DEPARTMENT	IMMERSED TUBE TUNNEL BACKFILL	PAPM CONSULTANTS	FIG. D4.1

5 TOLL PLAZA AND BUILDING DESIGN

5.1 TOLL PLAZA LAYOUT

5.1.1 The toll plaza shall satisfy all operational requirements for both traffic and toll collection.

5.1.2 The toll plaza shall have sufficient booths to allow automated collection of fees from full capacity use of the tunnel with an allowance for breakdown or malfunction of the collection booth. Sufficient booths shall be provided to permit manual collection of fees from vehicles unable to use automated collection. At least two booths, one in each direction, shall be suitable for overwidth vehicles. An adequate number of reversible lanes shall be provided to handle peak hour flows. In the event that automated collection of fees is not provided initially, provision shall be made in the design for the future installation of automated toll equipment; in the event that automated toll equipment makes it possible to reduce the number of toll booths, the design of the toll plaza shall be such that the size of the plaza can be reduced and land surrendered usefully.

5.1.3 The toll plaza shall be arranged such that all areas of the tunnel approaches shall be visible from the Command Centre. In particular, the toll booths and signs shall be arranged such that a clear overview can be obtained from the Command Centre. The layout shall enable tunnel management personnel and vehicles to have access to all areas of the approaches and the whole of the tunnel area without using adjacent public roads.

5.1.4 A toll booth canopy shall be provided to protect the booths and drivers during transactions and to carry clear and precise lane status and toll signs. Grade separated pedestrian access may be provided across the toll plaza.

5.1.5 Toll plaza lighting shall be designed to avoid any possibility of confusing either the pilots of ships using the harbour or aircraft using existing and proposed Hong Kong airports. If necessary, lamps shall be fitted with hoods to assist in this and to reduce their nighttime impact on the surrounding developments.

5.1.6 Reserved laybys shall be provided for abnormal loads or dangerous goods to pull off the approaches for inspection or to await escort. Vehicles unacceptable for tunnel transit, including overheight vehicles, must be able to turn back without impeding other traffic.

5.1.7 Public access segregated from tunnel traffic shall be provided to the tunnel administration buildings, and to any workshops and staff quarters. Parking shall be provided immediately adjacent to the administration building for:
- tunnel management staff vehicles;
- public vehicles; and
- tunnel emergency and maintenance vehicles.

5.1.8 Segregated bus stops shall be provided sufficient to cope with those bus services agreed with Public Transport Development Branch, Transport Department. All such bus stops shall be located in such a manner as to minimize interference with other traffic flow whilst maximizing accessibility for pedestrians. All pedestrian access to the bus stops shall be segregated from vehicular traffic.

5.2 BUILDING REQUIREMENTS

5.2.1 Visual aspects of the project open to public scrutiny in operational service shall be subject to the approval of the Advisory Committee on the Appearance of Bridges and Associated Structures.

5.2.2 Height restrictions, if imposed, shall not be exceeded at either landfall.

5.2.3 The administration buildings shall be designed in accordance with the requirements of the proposed management systems for the crossing and shall include at least the facilities listed below:
- a Command Centre with control and supervisory consoles, CCTV monitors and central communications; The Command Centre shall be oriented so that it can view the toll booths, tunnel portal, approach roads, and in particular the toll plaza without looking into the setting sun. Window glazing shall be arranged to minimize internal reflections;
- secure facilities for handling toll revenue;
- messing, locker, rest rooms and toilet facilities for tunnel staff;
- offices for management;
- security office and ancillary areas;
- reception and conference rooms;
- emergency first aid station;
- plant rooms for electrical and electronic installations, including computer equipment for control of traffic, surveillance, tolls, radio, ventilation, lighting, emergency telephone, and power switching;
- cash vault;
- sub-station; and
- open space for tunnel staff training.

5.2.4 Facilities available in the workshop and garage buildings shall include at least:
- store rooms for spare plant;
- store rooms for inflammable stores;

- storage for traffic control items;
- stock room for consumable items;
- workshops fully fitted for servicing and repair of tunnel vehicles and machinery;
- garages for tunnel vehicles; and
- petrol and diesel fuel supplies.

5.2.5 Access shall be provided to ventilation buildings for heavy goods delivery vehicles. Each ventilation building shall each contain at least:

- ventilation plant, inlet and outlet louvres;
- hoists and removable service floors for plant handling, transformers and switch gear;
- workshop and store rooms for the maintenance of the tunnel;
- Command Centre;
- incoming power supply equipment;
- transformers; and
- electrical distribution equipment for the tunnel lighting.

5.2.6 A secondary Command Centre is required at the end of the tunnel remote from the main Command Centre, and shall contain at least:

- Local traffic control equipment interlocked to the main Command Centre;
- Messing and toilet facilities for tunnel staff;
- Parking facilities for tunnel operating vehicles;
- Parking facilities for unacceptable vehicles; and
- Axle weighing equipment.

6 UTILITIES AND DRAINAGE

6.1 INTRODUCTION

6.1.1 This Chapter details the design requirements for the diversion of existing utilities and drainage services and the provision of new utility and drainage services to service the project.

6.1.2 Requirements for the design of additional utility supplies (if any) to be incorporated within the tunnel on behalf of any utility company shall be subject to separate agreement.

6.1.3 All diversions will be undertaken on a like for like basis, i.e. the cost of any betterment, whether to increase capacity or meet updated design standards, shall not form part of the project cost.

6.2 UTILITIES

6.2.1 For electric, telephone and gas supply utilities, the design of new utility systems, the design of diversions to existing systems and the laying of these shall be undertaken in consultation with and to the requirements of the following:

- Electricity Supply System - Hong Kong Electric Co. Ltd. and/or China Light and Power Co. Ltd.;
- Telephone System - Hong Kong Telephone Co. Ltd.; and
- Gas Supply System - Hong Kong & China Gas Co.

6.3 WATER SUPPLY

6.3.1 Water Main diversions shall be undertaken in consultation with and to the requirements of Water Supplies Department. The standards to be adopted in the design of new projects are given in Water Supplies Department Departmental Instruction No. 1309 (revised July 1985).

6.4 STORM AND FOUL DRAINAGE

Storm Drainage

6.4.1 Storm water drainage diversions shall be designed in accordance with the same standards as the existing design.

6.4.2 New storm drainage services design shall be based on Civil Engineering Manual Volume VI Chapter 2.1.

Foul Drainage

6.4.3 Foul drainage diversions shall be designed in accordance with the same standards as the existing design.

6.4.4 New foul drainage design shall be based on Civil Engineering Manual Volume VI Chapter 2.2.

7 ELECTRICAL AND MECHANICAL SERVICES

7.1 INTRODUCTION

7.1.1 The main Command Centre located in the Administration Building shall constitute the centre of operation and management. The computer control system for traffic control and surveillance should employ Open System Interconnection (OSI) in order to provide an efficient, high speed and reliable data communication highway, thus ensuring maximum flexibility of both centralized and delegated control. Localised intelligent control in traffic control booths and other designated locations to the requirements of Highways Department, including minor Command Centres shall be provided to maintain efficient tunnel operation even in the event of a fire or other abnormal situation.

7.1.2 The central computer system should consist of dual central processing units with the adoption of a hot standby computer configuration to provide a high degree of system availability. The duty and standby computer systems should be identical and each system capable of handling both the on-line and off-line system. In order to maximise the operational flexibility, duty/standby system changeover should be included with both automatic and manual features.

7.1.3 Systems shall generally be computer controlled and operated from the Command Centre. The computer shall employ real time and interactive system approaches and shall also be event-oriented with sufficient data logging facilities. Systems shall include the following:

- Traffic control systems, with signals and signing to advise tunnel users of required behaviour under any circumstances;
- Surveillance systems, including overheight and overweight vehicle detection;
- Toll collection systems;
- Emergency communication systems and facilities, including telephones, fire alarms, emergency and patrol vehicles, recovery equipment;
- Maintenance facilities;
- Ventilation systems;
- Drainage systems;
- Lighting systems;
- Power supplies and distribution systems;
- Vehicle weighing facilities; and
- Central monitoring and control systems.

...affic plans shall be accommodated for unidirectional and bi-directional ...s well as for tidal flow (if required), routine maintenance and emergency ...ngements. Safety interlocking features shall be taken into account in the ...ation of these traffic plans. The design of all electrical and mechanical systems ...these requirements into account.

7.1.5 Services and utilities within the ventilation duct shall be non-combustible, or otherwise enclosed by fire rated materials to separate them from the air stream. Essential services for emergency uses shall be temperature rated to stand hot smoke.

7.2 TRAFFIC CONTROL

7.2.1 Traffic control inside the tunnel shall be provided by lane use signals, ceiling mounted and clear of the traffic gauge within the tunnel. Lane used signals shall be monitored and controlled automatically by the computer system; initiation of the computer controlled system for a change in lane signals shall be by operator. Maximum operational flexibility shall be maintained by incorporating both remote and local manual controls in the system.

2.2 Matrix lane signals, variable message signs and speed limits shall be provided at entry and exit ramps to enable safe and efficient use of the tunnel by users. Matrix signals, "Tunnel Closed" signs and approved tunnel closed symbol signs shall be provided at strategic locations along tunnel approach areas. The use of variable message signs outside the tunnel area shall be considered.

3 Traffic control lights, signs and signals shall be provided with uninterruptible power supplies and with additional generator back-up for high system availability.

A weighbridge shall be provided at one end of the tunnel, sited in a prominent location convenient to the Administration Building, with provision for diverting offending vehicles away from the tunnel. Where the tunnel has a suspended floor to the traffic duct, has weight sensitive areas of roadway, or where required by Government, a second weighbridge at the other end of the tunnel may be installed.

SURVEILLANCE

The status of system operation and maintenance, including change of status and alarms, shall be monitored and supervised by the central computer with both event and date-time record logs.

Closed circuit television (CCTV) cameras shall be provided at regular intervals in order to ensure continuous traffic coverage of the tunnel, approach areas and toll plaza. These cameras shall be remotely controlled at the Central Command Centre and at other designated control points via monitors and control panels.

7.3.3 Incident detection loops shall be installed to detect traffic direction, slow moving vehicles and traffic congestion.

7.4 EMERGENCY COMMUNICATIONS

7.4.1 Emergency telephones with direct lines to the Central Command Centre shall be provided at regular intervals both in tunnels and in approved areas.

7.4.2 Telephones for use by police, tunnel patrols and emergency services shall be provided along the tunnel and near the cross adit doors. Similar facilities shall be provided at the toll plaza and both approaches.

7.4.3 Two emergency telephone exchange lines shall be provided at each end of the tunnel for the exclusive use of Fire Services Department (FSD) personnel.

7.4.4 Radio communication systems shall be provided for the operation and maintenance team. Both FM and AM radio re-broadcast with 'break-in' facilities at the main Command Centre shall be provided.

7.4.5 An emergency radio communication system shall be provided to enable voice communication between the main Command Centre and the respective control centre of the Royal Hong Kong Police Force.

7.4.6 An emergency radio communication system shall be provided to enable voice communication between the main Command Centre and the control centre of the Fire Services Department.

7.4.7 A public address system shall be installed at the toll plaza and at the portal areas.

7.4.8 A private wire telephone circuit shall be provided for voice communication to ensure that communications are available in case of emergency between the main Command Centre and the headquarters of Transport Department.

7.5 FIRE PROTECTION

7.5.1 A central fire alarm panel shall be provided in the main Command Centre inside the Administration Building. This panel shall receive fire alarm messages from the break glass units in the tunnels and from local fire panels provided for the various ancillary buildings. The central panel shall report any fire incident to Fire Services Department Control Centre through direct telephone links from separate buildings on different access routes to the tunnel. Tunnel fire alarm messages shall also be transmitted to control booths located at the tunnel portals. Fire alarms from buildings isolated or remote from the tunnel area shall be transmitted to Fire Services Department Control Centre through separate direct link(s) and shall be duplicated to the Tunnel Command Centre.

7.5.2 Break-glass fire alarm units shall be provided along the tunnels and connected to the central fire alarm panel (see 7.5.1).

7.5.3 A fire hydrant system shall be provided for the tunnels. The fire main shall be connected to a reliable water supply; a water tank of sufficient capacity shall if necessary be provided. Fire hydrants shall be located at a regular spacing inside each tunnel in accordance with Fire Services Department requirements. The system shall be capable of discharging water at a total rate of 4000 litres per minute based upon two hydrant outlets operating simultaneously.

7.5.4 A hose reel system shall be provided for the tunnel. Hose reels shall be located at a regular spacing inside each tunnel in accordance with Fire Services Department requirements.

7.5.5 Two sets of fire extinguishers, each consisting of 3 kg BCF, shall be provided at regular spacings on both sides of each tunnel in accordance with Fire Services Department requirements and at other locations where electrical fires could be expected.

7.5.6 Cross passages with fire-rated doors shall be provided to facilitate evacuation of people in the event of a fire or other emergency occurring inside the tunnel, at not more than 100m intervals.

7.5.7 The tunnel ventilation system shall be designed to provide a smoke free path for people to escape in the event of a fire within the tunnel.

7.5.8 An automatic foam type fire extinguishing system with manual override shall be provided for putting out fire inside the petrol interceptors at the tunnel drainage sumps.

7.5.9 All major ancillary buildings e.g. Ventilation Buildings and the Administration Building shall be equipped with fire services installations in accordance with Fire Services Department regulations and Codes of Practice. The installation shall include fire hydrants, hose reels, halon systems, fire extinguishers and automatic fire alarm systems.

7.5.10 Fire protection and fire fighting facilities shall meet the approval of the Fire Services Department and be in accordance with *Fire Protection Requirements in Road Tunnels*, issued by Fire Services Department.

7.6 LIGHTING

7.6.1 Lighting of the tunnel shall be generally in accordance with the recommendations of the International Commission on Illumination (CIE) and British Standards, with the tunnel defined as a "long tunnel". Lighting shall enable tubes to be operated in a bi-directional mode.

7.6.2 "Black hole" effects shall be minimised by using phased lighting intensities as well as threshold and transition zones to reduce lighting down to the constant illumination level used through the tunnel between the entrance zones. Lighting shall be automatically controlled via luminance sensors with manual override facilities.

7.6.3 Lighting in the tunnel shall facilitate visual guidance to drivers. To assist, the tunnel walls and the road surfaces shall be of light finish, without specular reflection and properly maintained.

7.6.4 Uninterruptible power supplies shall be connected to selected luminaries of the tunnel base lighting so that if both sources and the emergency generators fail, adequate lighting will be maintained until traffic is evacuated or dipped-headlights are brought into use.

7.6.5 The toll plaza and interchanges shall be adequately illuminated to satisfy the required visual tasks of tunnel operators, drivers and CCTV cameras.

7.6.6 Luminaries shall be energy efficient. Life cycle costing shall be used in the design and in consideration of the make and model of luminaires to be adopted.

7.7 DRAINAGE

7.7.1 A drainage system shall be provided to dispose of storm water collected within the area of the approaches.

7.7.2 The storm water drainage system shall include water pumps and a pumped sump at each tunnel portal. The capacity of the pumps and the sump shall be designed to handle extreme rainfall of all possible durations as shown under the 1 in 50 year curve of the Mean Rainfall Intensity Chart attached to Volume VI Section 2 of the Civil Engineering Manual. A standby pump shall be provided in each sump.

7.7.3 A tunnel drainage system consisting of duty pumps and a standby pump shall also be provided to handle minor leakage from the tunnel structure as well as surface water spilled over and not collected by the portal drainage system. The system shall also be capable of handling the expected discharge due to washing of the tunnel, testing and operation of fire hydrants, and spillage from vehicles. This sump shall be connected to the foul drainage system.

7.7.4 Apart from the main pumps, each sump shall be equipped with dewatering pumps to handle minor inflow. A standby dewatering pump shall also be provided in the tunnel drainage system.

7.7.5 An interceptor shall be provided at each drainage sump to trap petrol or oil entering this system. The interceptor shall be designed to a retention time of twenty minutes.

7.8 POWER SUPPLIES

7.8.1 To ensure a reliable supply, power mains shall be made available from two independent sources. The capacity of each of the sources alone shall be sufficient to maintain a full operation of the whole system. In normal operation, the load shall be shared between the supply distribution network of both sources.

7.8.2 Arrangements shall be made for power to be switched over automatically to the other supply in the event of failure in one supply. During the change over period, the supply from the remaining source shall be able to supply the minimum power required for a safe operation of the tunnel.

7.8.3 Uninterruptible power supply systems capable of maintaining supplies to vital equipment for a minimum of 30 minutes to facilitate tunnel closure and sequential shut down of plant shall be provided. An auxiliary power supply from emergency generators shall be provided within 15 seconds to ensure that the tunnel remains in operation for a minimum of six hours in the event of a failure in the power supply. The uninterruptible power supply systems shall serve:

- Command Centre equipment;
- emergency lighting;
- computer systems;
- traffic control and surveillance equipment;
- essential communication systems;
- central control and monitoring system; and
- toll collection system.

7.8.4 Cables shall be fire resistant and/or sheathed with low smoke and halogen free material where deemed necessary. Exposed cables shall be low smoke and halogen free. Supply and control cables for essential systems shall be temperature rated (250°C for one hour).

7.8.5 Unless otherwise specified herein, all electrical installations shall be designed to conform with the latest edition of the *General Specification for Electrical Installations in Government Buildings Hong Kong* as issued by the Electrical and Mechanical Services Department.

7.9 VENTILATION

7.9.1 Ventilation systems capable of adequately diluting gases and smoke from vehicle emissions shall be provided to comply with criteria for tunnel air quality acceptable to EPD. Proposed criteria are listed in Table 7.1. NO content, CO content, and visibility are to be monitored in assessing the level of ventilation required.

TABLE 7.1 CRITERIA FOR TUNNEL AIR QUALITY

Pollutant		Permissible Concentration	
		Recommended (PIARC 1987)	EPD Requirements
Carbon Monoxide (CO)		150 ppm	125 ppm
Nitric Oxide (NO)		25 ppm	7.5 to 15 ppm
Nitrogen Dioxide (NO_2)		5 ppm (15 min.) 3 ppm (1 hour)	1.5 ppm (15 min) 1.5 ppm (1 hour)
Haze	Through traffic Stationary to slow moving traffic	0.005 m^{-1} 0.009m^{-1}	
Conversion rate of NO to NO_2		0.15	0.1 to 0.2
Maximum visibility limit		0.0050m^{-1}	

7.9.2 The system shall be able to prevent propagation of smoke to passengers upstream of the place of occurrence of a major fire with a heat release rate of 100 MW. The system shall create a stream of air over the fire at a velocity higher than the critical velocity to prevent back-layering of smoke. The system should comply with the specification issued under Section J in FSD's circular letter No. 1/90.

7.9.3 In determining the ventilation requirements, the following factors shall be considered:

- maximum traffic volume;
- traffic density at standstill;
- traffic mix;
- proportion of diesel vehicles;
- emission rates of various pollutants; and
- smoke emission rate.

7.9.4 The airflow rates shall be determined according to the latest relevant PIARC Report with vehicle emission factors corresponding to Standard B in the year of tunnel opening.

7.9.5 Fans shall be controlled automatically by visibility, NO and CO sensors to maintain a safe environment. Fans shall normally be selected for maximum efficiency, but shall also be capable of running outside the normal operating range to cater for emergency operation without overloading the fan motor. The arrangements of fans and the ventilation buildings shall be such that the recirculation of vitiated air or smoke into the tunnel is minimized. Fans required to handle hot smoke shall be able to withstand 250°C for one hour.

7.9.6 Ventilation alarm and control systems shall be automatic, with visual and audio alarms at control panels. A hard-wired manual control system shall also be provided for operation in case of failure of the automatic control system.

7.9.7 Ventilation equipment shall be proven, durable and easily maintainable. It shall be accessible for maintenance, removal and replacement. The system shall be designed to take into account noise impact criteria to the surrounding areas.

7.9.8 Toll booths shall be air conditioned with fresh air duct-fed from an area away from the road system where it is less likely to be polluted by vehicle exhausts. Overpressure within the booths shall be used to prevent ingress of polluted air.

7.10 SECURITY

7.10.1 The possibility of sabotage attempts and terrorist activities shall be considered and security facilities to prevent such activities shall be provided.

7.10.2 Security cameras shall be installed at the entrance to the Administration Building, toll booths and toll accounts room in order to monitor and deter unauthorised entry.

7.10.3 Magnetic cards shall be considered to control the levels of access to the computer equipment by operators, superintendents, software engineers and maintenance personnel.

7.11 TOLL COLLECTION SYSTEM

7.11.1 A toll collection computer system with Automatic Tolling features shall be installed.

7.11.2 The toll system shall record, store and retrieve toll collection data for toll reconciliation, accounting and statistical purposes.

7.11.3 Security measures to monitor operation of the toll system, and the toll plaza generally, shall be provided. In addition to installing CCTV cameras in the toll plaza to monitor the toll collection activities, kick bar alarms shall also be provided inside toll booths.

7.11.4 Direct intercom communication shall be provided between the Central Command Centre and each of the toll booths.

7.12 CENTRAL MONITORING AND CONTROL

7.12.1 A central monitoring and control system for E & M systems shall be provided for at least the following purposes:

- Monitor the concentration of vehicular pollutants within the tunnel;
- Monitor and control the ventilation system;
- Monitor the levels of luminance of the lighting system inside the tunnel and at the portals;

- Monitor the E & M plant equipment in the ancillary building;
- Monitor the power supply system;
- Monitor the fire hydrant system; and
- Provide a central man-machine interface in order to enable effective and efficient operation by the tunnel operator.

APPENDIX B

AGREEMENT NO. CE 21/90

GREEN ISLAND LINK PRELIMINARY FEASIBILITY STUDY

BRIEF

1. Introduction

1.1 This Brief is to be read in conjunction with the Memorandum of Agreement, the General Conditions of Employment of Consultants for Feasibility Studies, any Special Conditions, the Schedule of Fees with the Schedule of General Instructions to Consultants and any other detailed instructions issued by the Director's Representative.

1.2 The Consultants are to conduct a preliminary feasibility study (the Study) to enable Government to confirm the engineering feasibility of constructing an immersed tube road tunnel from the proposed Green Island reclamation to Kau Yi Chau and a road on the proposed reclamation through the port development to join the North Lantau expressway north of Pennys Bay.

2. Study Background

2.1 On 11 October 1989, the Government announced its intention to proceed with the construction of a replacement airport at Chek Lap Kok with a target opening date in early 1997. The associated port development, as proposed in the Port and Airport Development Strategy (PADS) Study, will be concentrated mostly in the Western Harbour. Initially, this will consist of construction of Container Terminals 8 and 9 at Stonecutters Islands and Tsing Yi respectively. Subsequent port development will be arranged along a proposed peninsula reclamation from south east of Tsing Chau Tsai to Kau Yi Chau.

2.2 Road access to the port peninsula development from Kwai Chung will be provided initially via Tsing Yi and the proposed Lantau fixed crossing. The Port and Airport Development Strategy (PADS) Consultants in their Draft Final Report of July 1989 forecast that by about 2004, the increase in port and airport traffic would necessitate the provision of an additional road access from Hong Kong Island via Green Island known as the Green Island Link (GIL).

2.3 The Civil Engineering Services Department, assisted by the Territory Development Department will, in about May 1991, commence a planning and engineering study, the Port Peninsula Development Study, to determine the type, layout and timing of the proposed developments on north Lantau, including the port development. The scale and viability of this development is contingent upon the feasibility of the GIL.

2.4 A preliminary study is now required to establish the feasibility of an immersed tube tunnel in this location, and to assess the impact of the immersed tube tunnel on the area of sea bed to the northwest of Green Island from which marine sand is to be dredged for use as fill for harbour reclamations. No abstraction of sand can be undertaken in the vicinity of the crossing until the construction limits of the immersed tube are identified.

2.5 The Green Island Reclamation Feasibility Study (GIRFS) includes provision for the GIL to be completed between 2001 and 2006 and will forecast traffic flows and propose a preliminary layout for the interchange between the GIL and Route 7, based on an assumed location for the interchange.

2.6 The Metroplan Final Technical Report on Transport forecast traffic flows of 150,000 pcu/day in about 2011 with maximal development on Lantau suggesting that the GIL may have to be of dual three lane capacity to meet ultimate traffic demand.

3. Study Area

3.1 The Study Area generally will be as shown at Appendix I.

4. Study Objectives

4.1 The objectives of the Study are :-

(i) to establish the feasibility and alignment of the immersed tube road tunnel and the road connections to the existing and planned road systems on Lantau and Hong Kong Islands for both dual 2-lane and dual 3-lane options;

(ii) to prepare outline designs for the immersed tube tunnel including cross sections and spatial requirements for both dual 2-lane and dual 3-lane options;

(iii) to identify acceptable limits and restraints on the proposed dredging west of Green Island;

(iv) to identify the locations for disposal of marine mud and of sources of backfill;

(v) to advise the preliminary site investigation requirements necessary to assist the study;

(vi) to identify the land and marine requirements for the Green Island Link project;

(vii) to prepare outline designs of approach ramps, slip roads, temporary and permanent connecting roads and interchanges, and conceptual designs for the ventilation system, toll plaza, administration building, control areas and workshops.

(viii) to determine the phasing and programming requirements, for the planned Western Harbour and Port Peninsula Developments and the Green Island reclamation, necessary to permit the GIL to be opened to traffic in 2004.

(ix) to demonstrate the environmental acceptability of the Green Island Link.

4.2 General Approach to the Study

4.2.1 The Study should concentrate on proving the engineering feasibility and environmental acceptability of this link. The configuration of both dual 2-lane and dual 3-lane immersed tube tunnels shall be studied with dual 3-lane on the port peninsula.

4.2.2 The Study shall comprise two parts, namely:

(i) an Engineering Study;

(ii) a Preliminary Environmental Assessment.

4.2.3 The Engineering Study shall identify the engineering feasibility, determining optimum horizontal and vertical alignments and preparing preliminary engineering layouts for the link in sufficient detail to allow the preparation of a realistic order of cost and to determine land requirements. Since this will be the longest tunnel in the territory the ventilation problems will be significant. The immersed tube may have to incorporate a larger than normal ventilation duct and, for this reason, consideration of spatial requirements will be necessary.

4.2.4 The study will be limited to the immersed tube tunnel, the connection from the tunnel to Route 7 (on the assumption that the Green Island reclamation and Route 7 will be in place or under construction by 2001) and the connection from the tunnel to the port peninsula reclamation (as existing or assumed to exist in 2001). This latter connection may have to include for the reclamation of a causeway between the toll plaza and the completed port reclamation, since the required reclamation for port peninsula development from Siu Kau Yi Chau to Kau Yi Chau will not be completed until sometime after year 2011.

4.2.5 The Engineering Study shall also identify and provide preliminary information on potential marine impacts arising from the construction and operation of the Green Island Link, the necessary mitigation measures that may be required and any further marine study that may need to be carried out at the later feasibility and detailed design studies.

4.2.6 The Preliminary Environmental Assessment shall in identifying the engineering feasibility and determining the optimum alignment provide preliminary information on the nature and extent of potential environmental impacts arising from the construction and operation of the Green Island Link, the acceptability of environmental impacts and the necessary mitigation measures that may be required to be incorporated in the detailed design.

4.3 Extent of the Feasibility Study

4.3.1 The Engineering Study shall cover the section from Siu Kau Yi Chau (point X on the plan at Appendix I) to Route 7 on Hong Kong Island.

4.3.2 The scope of work required for the Preliminary Environmental Assessment of the project is at Appendix 2 to this Brief and shall cover the same section shown on the plan at Appendix I. WAHMO modelling, to be undertaken by Government, will also be included in the Study.

5. Study Programme

5.1 The Study should be completed within 8 months working to an agreed programme. The final report should be completed within 10 months.

5.2 The Consultants shall produce a work programme within the first month of the Study detailing the main streams of the Study, target dates for particular tasks and any decision dates which may be required for the uninterrupted continuance of the Study. Discussions will be held during this period with the Director's Representative to agree on a timetable for submission of reports and plans for each of the main elements of the Study.

6. Other Studies

6.1 The Consultants shall take into consideration the latest information from the following and any other relevant studies as may be required for the Study :-

6.1.1 Port and Airport Development Strategy (PADS) Study. The Draft Final Report was published in July 1989.

6.1.2 The Second Comprehensive Transport Study (CTS-2). The final report was published in May 1989.

6.1.3 Transport Strategy Study 2006. This is an update of CTS-2 taking account of the PADS recommendations.

6.1.4 Metroplan. A study managed by Planning Department assessing the redevelopment of the urban areas. The final Metroplan Technical Report will be published in mid-1991.

6.1.5 Western Harbour Crossing. A study managed by the Government Engineer/Western Harbour Link, Highways Department was undertaken by the Western Harbour Crossing Consultants, to investigate the feasibility of a third road crossing of the harbour. The study commenced in November 1989 and the final report was published in April 1991.

6.1.6 Green Island Reclamation Feasibility Study (GIRFS) which includes a transport study. This study is managed by the Project Manager/Urban Area, Territory Development Department and is being undertaken by Pypun-Howard Humphreys/Ove Arup Joint Venture. The draft final report is due in July 1991.

6.1.7 The Port Peninsula Development Study. This will commence in May 1991 for completion in about 16 months and will be managed by the Civil Engineering Services Department.

6.1.8 Route 7 - Sai Ying Pun to Kennedy Town. This study is managed by the Regional Highways Engineer/Hong Kong, Highways Department and is being carried out by Pypun-Howard Humphreys in association with MVA. A draft preliminary report was published in November 1988.

6.1.9 Western District Traffic Study. This is managed by the Regional Highway Engineer/Hong Kong and was carried out by Peter Y.S. Pun and Associates. The final report was published in April 1988.

6.1.10 Belcher's Bay Link Preliminary Report. This study is also managed by Regional Highway Engineer/Hong Kong and is being carried out by Peter Y.S. Pun and Associates. The study commenced in October 1988 and the preliminary report was published in December 1989.

6.1.11 Gas in Marine Sediments. A study managed by CESD was conducted by the Norwegian Geotechnical Institute in the Western Harbour area and the area near Green Island. The implications of the presence of gassy marine clays to the anticipated engineering works should be considered. The final report was published in September 1990.

7. Data to be used for this Study

7.1 The land use data used and the recommendations made in the PADS Study with regard to the layout and phasing of the Port Peninsula development should be adopted for this study.

7.2 The traffic forecasts from Green Island Reclamation Feasibility Study (GIRFS) and Lantau Port Peninsula Development Study if available, with guidance of Transport Department should be used for this Study.

8. Duties of Consultants

8.1 Within the context of the primary objectives of the Study outlined in 4.1 above, the Consultants shall carry out the following tasks:-

(a) Review strategic and other relevant studies undertaken or commissioned by Government to ensure the selected alignment, configuration, and design parameters of the proposed GIL and its approach roads are compatible with the most up to date data and recommendations;

(b) Prepare a Design Standards Memorandum stating the design criteria proposed for all aspects of the Study;

(c) Assess the impact of the immersed tube tunnel on the area of the seabed to the west of Green Island from which marine sand is to be dredged for use as fill for harbour reclamations and assess the acceptable limits and restraints on the proposed dredging;

(d) Review all available geological, hydrographical and topographical survey and site investigation data. Advise the Director's Representative of additional site investigation or surveys required to be undertaken during the Study;

(e) Advise the Director's Representative of any specialist studies or investigations necessary in order to satisfy the requirements of the study;

(f) Identify the land requirements for the project including that of suitable locations for the fabrication and storage of immersed tube (IMT) tunnel units.

(g) Establish an alignment for a proposed GIL immersed tube tunnel and road connections with the existing and planned road systems on Lantau and Hong Kong Islands. The GIL alignment and road layout shall take into consideration, inter alia, future traffic requirements, directional signage requirements, environmental considerations, marine requirements, geotechnical factors, disturbance to existing and proposed development and infrastructure, and existing and future land use.

(h) Prepare outline designs for both dual 2-lane and dual 3-lane options of the IMT tunnel including cross sections, spatial requirements, drainage, ventilation, carriageway details, spacing of cross adits and niches required for operational and emergency purposes.

(i) Prepare outline designs of the approach ramps, slip roads, temporary and permanent connecting roads and interchanges, and conceptual deigns for the ventilation system, toll plaza, administration building, control areas and workshops for both dual 2-lane and dual 3-lane options of the IMT tunnel.

9. <u>Study Output</u>

9.1 The final output of the Study shall be a Report together with an Executive Summary. The final report shall be self-contained and cover, inter alia, the following:-

(a) A summary methodology for the various parts, and the sequential development of the Study and evaluation criteria;

(b) Findings with clear interpretation of the specialist investigations;

(c) An implementation strategy of the selected alignment, including programme. The programme should take into consideration the phasing of completion of the strategic road network;

(d) Layout designs of the selected alignment and interchanges, including temporary connections;

(e) Design Memorandum stating the design criteria proposed for all aspects of the works;

(f) An environmental impact statement.

9.2 Sixty (60) copies of the final report shall be presented in separate volumes for:-

(a) Engineering feasibility, preliminary design and all relevant engineering information;

(b) Drawings;

(c) Site investigation;

(d) Preliminary Environmental Assessment.

10. <u>Director's Representative</u>

10.1 The Director's Representative as defined in the General Conditions of Employment shall be the Government Engineer/Western Harbour Link or such other person as may be authorised by the Director in writing and notified to the Consultants and all communications in connection with or arising from this Study are to be addressed to him. The Director's Representative may delegate any of the powers and functions vested in him to other officers. If the Consultants are dissatisfied with a decision or instruction of any such officer the matter shall be referred to the Director's Representative for a ruling.

11. <u>Steering Group/Working Groups</u>

11.1 A Steering Group chaired by the Director of Highways will function during the course of the Study and will meet when necessary to monitor progress, provide guidance and consider progress reports. In addition to their duties under Clause 14 of the General Conditions of Employment, the Consultants will be required to attend meetings of the Steering Group at approximately bi-monthly intervals. Attendance at Working Group meetings at approximately monthly intervals and other ad-hoc meetings will be necessary also during the Study period. Formal decisions and minutes of meetings of the Steering Group will be advised to the Consultants by the Director's Representative, who will issue to the Consultants all necessary instructions arising out of Steering Group decisions. The Consultants shall provide secretarial services as may be required by the Director's Representative.

12. <u>Progress Reports</u>

12.1 The Consultants shall submit a brief report to the Director's Representative within the first five working days of each month, giving details of progress made since the previous report together with any updates to the programme for the remainder of the project. The content and form of such reports shall be to the satisfaction of the Director's Representative.

13. Liaison with other Government Departments/Organisations

13.1 The Consultants will be expected to communicate and correspond direct with other Government departments to obtain information in connection with the project, copying such correspondence to the Director's Representative. Any problem in communication or liaison should be referred to the Director's Representative for assistance. In particular, consultation will be required with the following :-

Buildings and Lands Department
Civil Engineering Services Department
Drainage Services Department
Electrical and Mechanical Services Department
Environmental Protection Department
Fire Services Department
Marine Department
Planning Department
Transport Branch
Transport Department
Urban Area Development Office, Territory Development Department
Water Supplies Department
Works Branch
Secretary, Fill Management Committee

14. Information and Facilities to be provided by the Employer

14.1 All available data and information relevant to the Study will be provided to the Consultants. One copy of any relevant Government documents, reports, drawings, survey plans, and other background material, with the exception of items currently available from the Sales Section of the Information Services Department, will be supplied free of charge by the Director's Representative on request from the Consultants.

15. Standards and Specifications

15.1 During the course of the Study the Consultants shall adopt such technical and design standards and specifications as are in current use by the Highways and Transport Departments or, if non-existent, British Standard Codes of Practice and Specifications. Should instances arise for which suitable standards appear to require modification, the Consultants shall submit proposals on appropriate alternatives to the Director's Representative for agreement.

16. Consultant's Office and Staffing

16.1 The Consultants shall establish and maintain, for the duration of their engagement under this Agreement, an office in Hong Kong under the control of the Project Director who shall have control of the Study. He shall have sufficient authority and an adequately qualified professional technical and administrative staff of sufficient size to ensure progress to the satisfaction of the Director's Representative.

17. Specialist/Sub-consultant Services

17.1 The Consultants shall provide or arrange to provide all specialist/sub-consultant services, which may be required or directed in accordance with this Agreement or as otherwise required for the satisfactory completion of the Assignment. Except as indicated elsewhere in the Agreement no additional fees or expenses for provision of such services rendered locally or overseas will be payable by the Employer other than as provided for in the Schedule of Fees.

18. Surveys

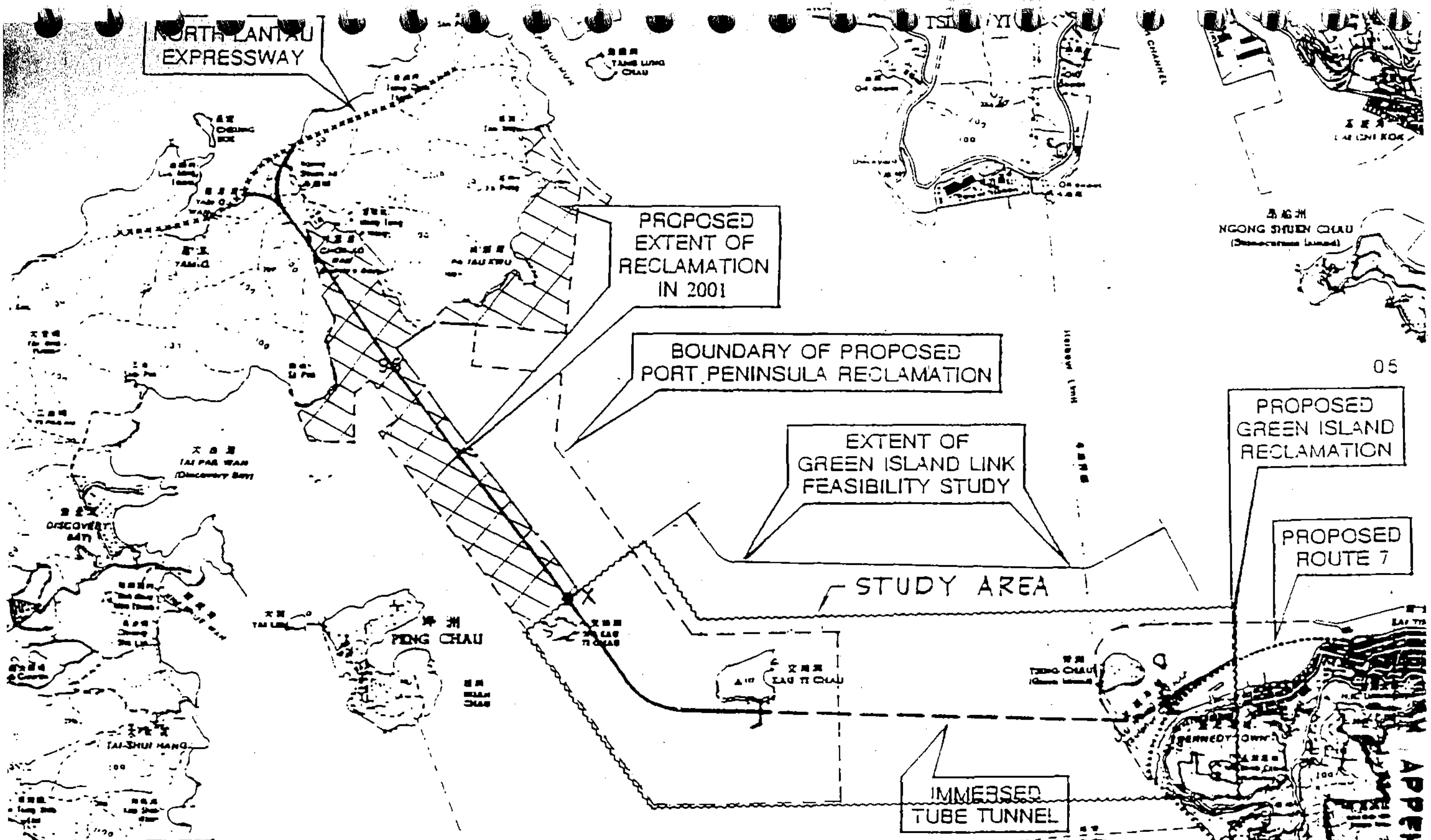
18.1 Two copies of each of any topographical maps at 1:20,000, 1:5,000 and 1:1,000 scales prepared by the Survey and Mapping Office of the Buildings and Lands Department, where available for the area covered by this Project, may be obtained free of charge on application to the Director's Representative. All field survey work required for the proper execution of the Project shall be the duty of the Consultants including geological, hydrographical and topographical surveys. A copy of filed notes, field data and resultant plans arising from these surveys shall be handed over to the Director's Representative upon completion of the Project. The accuracy as well as presentation of these surveys should be of a standard agreed by the Director's Representative.

19. Additional Work

19.1 Other items of work directly or indirectly related to the Study may be added by the Director's Representative with the agreement of the Consultants and shall form part of the overall scope of the Study and be covered by the terms of the Agreement.

* * * * *

APPENDIX



GREEN ISLAND LINK PRELIMINARY FEASIBILITY STUDY

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APPENDIX II

AGREEMENT NO. CE 21/90

GREEN ISLAND LINK PRELIMINARY FEASIBILITY STUDY

PRELIMINARY ENVIRONMENTAL ASSESSMENT

SCOPE OF WORK

1. Purpose of the Preliminary Environmental Assessment

1.1 The purpose of the assessment is to provide information on the nature and extent of potential environmental impacts associated with the proposed Green Island Link at a planning level. This information will contribute to decisions on :-

(i) the acceptability of any adverse environmental consequences that are likely to arise from the construction and operation of the new installations and related facilities; and

(ii) conditions for the preliminary design with respect to the construction and operational stages of the project.

2. Objectives of the Preliminary Environmental Assessment

2.1 The objectives of the assessment are as follows :-

(i) to describe the proposed installations and related facilities and the requirements for their development;

(ii) to identify and describe the elements of the community and environment likely to be affected by the proposed development;

(iii) to minimize pollution and nuisance arising from the development and its operation and environmental disturbance during construction and operation of the project;

(iv) to identify and evaluate at a planning level the net environmental impacts and cumulative effects with other transport modes expected to arise during the construction and operation of the development in relation to the existing and planned community and neighbouring land uses;

(v) to identify methods, measures and standards to be included in the preliminary design, which may be necessary to mitigate these impacts and reduce them to acceptable levels;

(vi) to recommend on environmental monitoring and audit requirements necessary to ensure the effectiveness of the environmental protection measures adopted;

(vii) to identify any additional studies which may be necessary to fulfil the objectives or requirements of this Preliminary Environmental Assessment.

3. Requirements of the Environmental Assessment

3.1 The assessment shall consist of:-

(i) a Preliminary Environmental Planning Assessment Working Paper which:

(a) satisfies the requirements of objectives in para. 2.1 and;

(b) provides an initial assessment and evaluation of the environmental impacts arising from the project sufficient to identify those issues which are of key concern to the project or which are likely to influence decisions on the project;

(ii) any reasonable revisions or supplements to the above as might be required to be carried out by the Director of Environmental Protection.

4. Technical Requirement of the Preliminary Environmental Assessment

The Preliminary Environmental Assessment shall include, but shall not necessarily e limited to the following tasks.

4.1 Construction Phase Assessment

4.1.1 Noise Impacts

Task 1 : Identification of Representative Sensitive Receivers

Include consideration of the planned land uses in the Study area as proposed by the GIRFS.

Task 2 : Analysis of construction Activities

Task 3 : Assessment of Construction Noise Levels

4.1.2 Air Pollution Impacts

Task 1 : Identification of Representative Sensitive Receivers

Include consideration of the planned land uses in the Study area as proposed by the GIRFS.

Task 2 : Analysis of Construction Activities

Task 3 : Air Pollution Impact Assessment

Task 4 : Proposal for Air Pollution Control Measures

4.1.3 Water Quality Impacts

Task 1 : Identification of Sensitive Receivers
From the proposed route alignment(s) identify the body(ies) which may be affected.

Task 2 : Analysis of construction Activities

Include identification of those activities likely to have an impaction the affected water body(ies).

Task 3 : Assessment of Water Pollution Problems

As far as is practical, identify interactions between sensitive receivers and construction activities. This assessment should include the impact of any proposed dredging and reclamation activities, and marine spoil (contaminated or uncontaminated mud) generation and disposal.

Task 4 : Proposals for Water Pollution Control Measures

Recommend appropriate mitigation and control measures for consideration in the preliminary design.

4.2 Operation Phase Assessment

4.2.1 Traffic Noise Impacts

Task 1 : Identification of Representative Sensitive Receivers

Task 2 : Calculation of Future Noise Levels

As far as possible calculate future road traffic noise. Calculations are to be based on traffic projections for the design years which are defined as the year 2006 and 2011.

Task 3 : Presentation of Existing Noise Levels

Task 4 : Assessment of Need for Noise Amelioration Measures

Task 5 : Proposals for Noise Amelioration Measures

As far as possible propose traffic noise amelioration measures for each situation where the predicted traffic noise level exceeds the HKPSG maxima, or appropriate criteria as advised by DEP. For planned noise sensitive developments, indications of the form of suitable measures to be incorporated in the project should be shown for further development in subsequent detailed designs.

4.2.2 Air Pollution Modelling

Task 1 : Identification of Sensitive Receivers

From a consideration of the planned land uses in the Study area as proposed by the GIRFS, identify likely sensitive receivers within 50m of the proposed project.

Task 2 : Access Air Pollution Impacts

Task 3 : Assessment of Air Pollution Impact from Tunnel Portals, Approach Roads and Ventilation System

Task 4 : Proposals for Air Pollution Amelioration Measures

4.2.3 Water Quality Impacts

Task 1 : Assessment of Water Pollution Impact

The assessment should include the modelling of the route alignment(s) for water quality impacts. Water quality modelling should be undertaken using models/techniques to be agreed with the Director of Environmental Protection.

Task 2 : Proposals for Amelioration Measures

5. Proposed Administration

5.1 The Environmental Assessment will be managed by an Environmental Working Group chaired by the Director's Representative. The Environmental Working Group shall provide advice to the Steering Group of the Study.

5.2 In accordance with LWB TC 9/88, if there is any disagreement on the findings of the Environmental Assessment or on the necessary environmental protection and pollution control measures, the issue will be referred to SPEL who will resolve the differences in consultation with the appropriate Branches and Departments.

APPENDIX C

Department	Reference	Comments	Response
Transport Branch (T Wong) (25) TRAN 4/03/89 II (91) 3 Feb 1992	Para 2.3.11	Latest forecast indicates a lower percentage of airport passengers to be carried by the Airport Railway, which corresponds to a higher figure for road-base airport related trips. As a result the dual-2 lane option may reach capacity before 2011. Traffic forecasts for the GIL may need to be reviewed at a later stage when a decision is to be made on the choice dual-2 or dual-3 option.	The latest forecast does not affect this study as our assessment assumes that GIL will operate at capacity and not based on a specific design year.
	Para 2.3.12	The toll charge assumption for Ma Wan-Sham Tseng Link (adopted by CTS-2 Update) is $25.	Noted. This change was made after our forecasts were completed.
	Para 3.3.4	A "Central Bypass" is proposed as a (perhaps the only) solution to the capacity problem for connecting roads in the dual-3 configuration of the GIL. Given that the feasibility of this Bypass will dictate the viability of the dual-3 configuration, further work needs to be done to ascertain this and its effect and implications on other planning proposals.	Agreed, but the work lies outside the scope of this study.
	Table 11.3	Is the capital cost for the Central Bypass included under Item 1 for the dual-3 lane option?	No.
Marine Department (T.H. Roberts) 29 Jan 1992	Figure 7 & Table 7.1	The vessel density shown in Figure 7.1 doesn't seem to conform with the estimated traffic volumes as shown in Table 7.1.	According to statistics available in the Macau Ferry Terminal the daily average of ferry movements for 1991 is 208. An increase of 50% as suggested in para 7.2.14 would put the figure around 310 rather than 585. Figure 7.1 shows the present situation whereas Table 7.1 is the forecast for the construction period. The figure of 390 movements in 7.2.11 includes outlying island ferries.

Department	Reference	Comments	Response
Marine Department (Cont'd)	Para 7.2.1 Line 2	Line 2 should have the word "tracked" inserted between "of" and "vessels" in the first sentence.	Agreed.
	Para 7.2.7 Line 2	Last word should be "west" and not "east".	Agreed.
	Paras 7.2.12 & 7.2.14	The estimated volume of traffic coupled with the construction work due to be carried out could cause congestion and confusion. Please note our extreme concern about this situation.	The Marine Department concern with respect of the likely congestion during construction is appreciated. Care has been taken in examining this issue, and it is considered that the difficulties can be overcome. It is essential that detailed planning of this aspect is fully examined in the next stage of the project.
	Para 7.4.1	The Consultant's report recommends more traffic management along the lines of area traffic control. It seems there is some misconception about the capability of our VTS system. The consultant should clearly understand the limitations of VTC's capacity, capability and control effectiveness vis-a-vis the high density and complexity of the heterogenous traffic in the waters of Hong Kong, particularly within the Harbour Sector. That VTS management control can be applied to individual vessels (ocean going and local craft) is almost out of the question.	The present capability of the VTS is noted. Our suggestion is that more management will be found necessary as traffic densities increase. It is believed that the technology will improve so that management becomes feasible without dramatic increases in resources. What we have in mind is control of the timing and routing of vessels' entry into or departure from the port to smooth out peaks in traffic densities and in particular to limit conflict between vessels and towed tunnel units. We believe that this is feasible although minute-by-minute control of individual vessels is accepted as impracticable.

Department	Reference	Comments	Response
Marine Department (Cont'd)	Para 7.4.2	The suggestion is made that Macau Ferry Traffic should be diverted through the Ma Wan or Kap Shui Mun Channels. This would not be a good idea as it would exacerbate existing marine traffic problems. During the year 1991 the China Trade DSC's which normally use the Ma Wan Channel, averaged 38 movements each way per day. This is forecast to rise by 8% per annum so that by the year 2001 there would be an estimated 82 movements each way per day. Add the Macau DSC traffic to this as well as all the other traffic and we would have a highly undesirable situation on our hands. It should also be noted that the diverted traffic would have an increased voyage duration of about 8% which would affect operating costs and this would need to be discussed with ferry operators.	Noted. The relative merits in terms of safety in the Ma Wan Channel and the Study Area should be examined further at feasibility stage.
	Para 7.4.3	A high priority should be given to the relocation of the pilot boarding station from its present position to a point south-east of LCS No 1 buoy. This proposal is strongly supported.	Noted.

Department	Reference	Comments	Response
Marine Department (Cont'd)	Para 7.4.5	The Sulphur Channel should be kept open for local vessels until the last possible moment. This could be achieved through careful planning of the work phases.	Noted. Whether extending the availability of the Sulphur Channel is feasible will depend on the effect on the Green Island Reclamation.
		All the harbour moorings west of Green Island may need to be removed when work takes place in areas 5, 6 and 7.	Noted. We do not foresee a need to remove mooring buoys but certain anchorage areas will need to be closed if not previously displaced by the West Lamma Channel.
		It should be noted that the number of outlying island ferry routes will be maintained regardless of the number of piers to be provisioned at Central.	Noted.
	Para 7.4.6	The second item suggests that VTC should take interactive actions to permit or not permit each vessel's plan of passage. It is presumed that this only refers to the control of ocean going vessels with which VTC has the capacity to communicate with.	Agreed.
	Appendix A Para 2.7.1. (a)	The Ferry Operators require -6.5m CD for the jetfoils with their foils down, not -6.0m CD.	The Ferry Operators request for a revised depth for jetfoils is noted. This new depth is not reflected in this report due to its late receipt. If -6.5 m CD is to be applied to any part of the tunnel the cost will increase. Ferry operators should be asked to justify their request in view of the present maximum draft of the vessels of 5.3m which is required only in emergency situations.

Department	Reference	Comments	Response
Marine Department (Cont'd)	Appendix A Para 4.1.5	The proposal to declare an anchoring prohibited zone around the area of Green Island Link immersed tunnel is not acceptable. The tunnel protection should be such that it could withstand the impact of anchors which may have to be dropped in emergency situations.	The tunnel is able to withstand the impact of anchors, however the waterproofing would be damaged by dropped or dragging anchors. There is not intended to be any restriction on the dropping of anchors in an emergency situation, only that anchoring as a matter of course would be prohibited, as is the case with other tunnels in Hong Kong. Anchoring is at present prohibited in part of this area. It would be possible to protect the tunnel from any possible anchor damage, and thereby allow unrestricted anchoring, however this would be at significant cost.
Transport Department (C.W. Kwan) (7) CT/PAD 171/200-14II 17 Feb 1992	Chapter 2 General	The Consultants should confirm whether they have taken into account the proposals of the Study of Airport-Related Activities (SARA) and the latest Port Development Programme, in the traffic assessment.	The traffic assessment is based on the data described in paragraph 2.1.3 and the traffic forecasts were obtained using the methodology agreed with TD. Subsequent changes are likely to have no significant effect on the design traffic figures which assume the tunnel will operate at capacity flow not based on a specific design year.
	Para 2.5.6	The report should address the sensitivity of the demand flows and cost effectiveness of designing the Green Island Link to a dual-3 lane configuration.	The Link is designed to cope with full capacity for either dual-2 lane or dual-3 lane configuration. The cost effectiveness or comparison between dual 2-lane or 3-lane configurations is outside the scope of the Brief for this Study.

Department	Reference	Comments	Response
Transport Department (Cont'd)	Para 2.5.14	In view of the low flows to and from Route 7 South Island and Ground Level shown in Table 2.10, it should be possible to achieve a more economical interchange design by combining the slip roads for these movements.	There is limited scope for usefully combining the slip roads to and from Route 7 South Island with those linking to the ground level roads without significantly altering the proposed interchange form which complies with the recommendations of the Green Island Reclamation Feasibility Study. Any such combination may lead to a reduction in design standards. This may be addressed at detail design stage.
	Para 4.2.5	If a speed limit of 80 km/h is adopted within the tunnel, the corresponding carriageway width should be increased from 6.75 m (Figure 4.3) to 7.3m.	Noted. The financial implications of providing an additional width of tunnel are unlikely to justify the modest increase in speed. This issue may be addressed at full feasibility stage.
	Para 4.5.2	Care is needed when choosing the radii of vertical curves as compensation is required for sag curves within the tunnel. This additional headroom should be allowed for during the design of the tunnel section without reducing the pavement thickness at the sag curves.	Agreed.
	Chapter 11 General	The Construction timing of the Green Island Link is being considered by the Lantau Port Peninsula Study, with particular reference to whether the Sham Tseng - Ma Wan link should be constructed before or after the Green Island Link.	Noted.

Department	Reference	Comments	Response
Drainage Services Department D(HK) 10/5/49 10 Feb 1992	General	It is understood that the Green Island Reclamation Feasibility Study has assessed the impact of the Green Island Link Northern Approach on the proposed foul sewerage and stormwater drainage network on the Green Island Reclamation. Presumably PAPM has checked that they are compatible with each other.	Confirmed. The outline design contained within this Study is compatible with the proposals of the Green Island Reclamation Feasibility Study.
	General	Presumably PAPM has also checked that the proposed Green Island Approach of GIL is compatible with the proposed deep sewer tunnel linking Stone Cutters Island and Mount Davies, the level of the latter, as I understand, is much deeper.	The level of the latter is considerably deeper than the whole of GIL, so compatibility is assured.
Highways Department (J. Climas) HyD T5/462TH 3 Feb 1992	Para 3.3	I refer to your above referenced memo and have only one comment on the report itself. I suggest that paragraph 3.3 of the Summary be extended to include the last two sentences of para 1.5.2 to make the alignment status clear for those who only have time to read the Summary.	Adopted.

Department	Reference	Comments	Response
Highways Department (Cont'd)		The report does however raise several questions which cannot presently be answered and raises several new issues of great consequence which require further study and policy guidance. Firstly, with regard to timing, para 11.1.3 states that, if the GIL is to be completed by 2004, reclamation of the area north of Green Island must start in 1995 and of other necessary areas by 1997. If these start dates are to be achieved it will be necessary to allocate the necessary resources in the 1992 RAS exercise and to commence design of the reclamation works within 12 months. An indication of funding requirement in the 5 year period ending March 1997 is required. If funds for the reclamation works cannot be found within this period the completion of GIL would slip to 2006 or later. Equally important, if phase I of the reclamation, as defined by GIRFS, does not start in 1997, it might not be possible to complete Route 7 to Aberdeen by 2006. This is because the reclamation for Route 7 could only commence after the abattoir and China Merchants Company are reprovisioned to the Phase I reclamation. There appears to be an urgent need for SPEL and S for T to get together and agree the implementation programmes and funding policy for GIR and GIL in the context of CTS-2 and the Territorial Development Strategy Study. S for T may wish to approach SPEL who has not received a copy of the draft Final Report.	Comment Noted.

Department	Reference	Comments	Response
Highways Department (Cont'd)		It is noted that the location of the landfall at Kau Yi Chau, and accordingly the alignment of the GIL, will be determined in the Port Peninsula Study. A subsequent detailed feasibility study of the GIL will then be required to work up construction details and costs, recurrent and operating costs and to prepare details for a BOT bid package. However, such a study probably need not commence until about 1995/96 by which time the reclamation programme and proposed tunnel configuration should have been fixed.	Comment Noted.
		It is noted that a dual 3-lane GIL necessitates the construction of a Central By-pass connecting Route 7 at GIR direct to the Central - Wan Chai By-pass. The implications of this are apparently:-	This is one option put forward to solve the traffic problem.
		(i) reduced traffic flows on Route 7 at GIR with increased traffic volumes on the reclamation primary distributor and Belcher Bay Link although this is inferred because traffic volumes on the latter roads are omitted from Figure 2.8 of the report;	Agreed.
		(ii) relocation of the Western PCWA;	Agreed.
		(iii) relocation of the Macau Ferry Terminal;	Agreed.
		(iv) redesign of the roads and building layouts at the west end of Central reclamation where tenders are about to be invited for reclamation and road construction;	Noted.

Department	Reference	Comments	Response
Highways Department (Cont'd)		(v) temporary road connections from Route 7 to Belcher Bay Link would be necessary until the Central By-pass could be constructed;	Agreed.
		(vi) possible additional traffic on the Central-Wan Chai By-pass.	Agreed.
		These apparent implications seem to require further urgent consideration before the possibility of later construction of a Central By-pass is eliminated through development on Central reclamation. If there is no Central By-pass there appears to be no point in building a dual 3-lane GIL.	The Central By-pass is proposed as an option to provide the additional road capacity needed for the Route 7 corridor east of GIL necessitated by a dual 3-lane GIL. It may be that further detailed consideration will identify alternative options.
	Para 2.5.5	Para 2.5.5 of the report suggests that the additional traffic using a dual 3-lane GIL would be travelling between Lantau and the Kowloon Peninsula and South East New Territories. 60.5% of the traffic stream is forecast to be goods vehicles suggesting that much of the additional traffic will be generated by proposed new industrial development in Kowloon Bay/Kai Tak and Tseung Kwan O. If the additional road capacity cannot be provided it may become necessary to relocate the proposed industrial development to North Lantau to eliminate the additional GV trips. It appears that this needs to be reviewed in the context of the TDS review by Planning Department.	Comments noted.

Department	Reference	Comments	Response
Civil Engineering Department (PDO) (C H Lam) (13) in L/M PD 5/3/4 II 31 Jan 1992	General	It is appreciated that the GILPFS has been undertaken in advance of the LPPDS and has to follow basically the findings of the PADS Study. As the LPPDS will provide more up-to-date information about the configuration, programme and transport requirements for the LPP, the findings of this report should be reviewed to take account of the recommendations of the LPPDS and other Studies that become available in the preliminary design stage of the GIL.	It is expected that this will be done during the Full Feasibility Study stage.
	Para 8.7.3	The effectiveness of the use of the wick drains in the reclamation for the causeway in the disused marine dumping area should be examined if the deposits consist of contaminated materials. The disused marine dumping area could also cause difficulty to the installation of the wick drains. The consultants should propose adequate measures to overcome these adverse ground conditions.	Two options are given in 8.7.2. It is expected that the effectiveness of wick drains could be examined in the light of further soils data at the time of the Full Feasibility Study. It is not currently expected that contaminants would be aggressive towards the plastics used in wick drains. At the present stage, options still exist to make construction possible. Obstructions expected have been overcome before elsewhere and it may reasonably be assumed for this study that they can be overcome again. They would not be expected to be a problem where we are proposing to dredge.
	Para 8.8.8	As significant scour will occur on both sides of the GIL upon the completion of the causeway and port peninsula, special consideration should be given to the foundation design to avoid possible progressive undermining of the tunnel due to scouring.	Agreed. The scour protection has been designed in a way that permits it to provide what is needed as stated in 8.8.17.

Department	Reference	Comments	Response
Civil Engineering Department (PDO) (Cont'd)	Para 8.8.18	The methodology for monitoring the bed level changes and assessment of the need for additional armour should be established. Also, the party responsible for scour monitoring and placement of additional armour should be identified.	Agreed. This should be determined at a later stage of the project. As stated in para 8.8.18, standard bathometric techniques could be used and are currently used for erosion/deposition studies. This work could be carried out by one or more of the tunnel operator, Marine Department or Highways Department provided appropriate financial provision is made in the BOT contract.
	Section 9.3	The latest proposals of the LPPDS indicate that none of the alternative concepts selected for further investigation envisages the reclamation to reach the Siu Kau Yi Chau by 2001. A casting yard at the Si Kau Yi Chau or the Port Peninsula may not be feasible.	This is not the only possible location given. Proposed locations should be studied further during the Full Feasibility Study. It is also possible that the Green Island Link may not be required until such time as reclamation reaches Siu Kau Yi Chau, whenever that may be, although this study Brief states that it is to be assumed that the reclamation is expected to have reached there.
	Para 11.4.1	It is noted that filling above seabed for the causeway will not commence until 2003. As most of the settlement will not occur until the filling above the seabed is placed, it is anticipated that significant settlement will occur after the GIL is commissioned in 2004. Special consideration should be given to the effect of the settlement on the pavement and installation in the causeway.	Agreed. The period of time between completion of filling and paving the road is sufficient for wick drains at normal spacing to permit consolidation to reach acceptable values at the time of paving. Some routine maintenance might possibly be required until conditions stabilize or the Port Peninsula is completed.
	A 2-5 Para 2.7.1	It would be useful to show the marine clearance requirement in a drawing. Where is Figure D2.1?	Relevant marine clearances are indicated on the vertical alignment drawings. Figure D2.1 has been renamed Figure 3.1.

Department	Reference	Comments	Response
Civil Engineering Department (GEO) (J B Massey) (51) in GCP 1/10/433-4 II 7 Feb 1992	Summary	The use of the term "marine deposits" in para 4.9 is not recommended. The term "marine mud" is preferred to clearly distinguish between marine mud and marine sand in a geotechnical context.	The term "marine deposits" has been used to refer to both "marine sand" and "marine clay" simultaneously.
		The quantity of the excavated material for disposal of the order of 10.8Mm^3 (from para 8.10.1 of the text) for the dual 3-lane tunnel option should also be stated in para 4.14.	Agreed.
		There are minor discrepancies about the estimated fill quantities from Kau Yi Chau, if razed, in para 4.14 (7Mm^3) when compared with paras 8.7.4 (7.5Mm^3) and 8.10.4 (7Mm^3) of the text.	These quantities have now been updated, based on more detailed data from the ground investigation, to 6.3Mm^3 for rock and 1.0Mm^3 for soil.
	Para 8.1.1	The use of the term "marine deposits" is not recommended, (also in sections 8.5.1 and 8.5.2).	See response to comment 2.1 above (Summary 4.9). This is consistent with usage in Marine Sources of Fill Final Report, GCO November 1988.
	Para 8.1.4	The mantle of weathered (decomposed) granite also includes highly weathered granite as well as completely weathered granite.	Noted.
	Para 8.1.5	Presumably, the report refers to the East Lamma Channel, but the inferred fault is actually orthogonal to the Tolo Channel/ Lai Chi Kok lineament. Also, the assessment of the recent activity of the fault is discussed in Paragraph 8.5.5 not 8.6.	Noted.

Department	Reference	Comments	Response
Civil Engineering Department (GEO) (Cont'd)	Para 8.5.9	The Draft Final Report assumes that the marine mud beneath the tunnel foundations is to be dredged and replaced with a granular fill. It should be noted that the capacity of dumping sites in Hong Kong waters is extremely limited. Therefore any dredging should be minimised. As stated in the report, immersed tube tunnels have been founded in soft compressible sediments elsewhere. Perhaps the possibilities of founding the tunnel on the marine mud should be seriously considered as one of the foundation options in the full feasibility stage of the project.	Agreed.
	Para 8.5.10	It would be helpful if the Consultants would outline the scope of the additional site investigation required to confirm the tunnel foundations.	This would be more beneficial at full feasibility study stage when the tunnel alignment and foundation type would be further refined.
	Para 8.5.11	The Draft Final Report assumes that the seawalls at the Green Island Reclamation and at the Kau Yi Chau landfall will be founded on a rockfill bund located within a dredged trench. This may not be appropriate without first exploring other options. Methods of seawall construction minimising dredging should be seriously considered for reasons stated in para 3.4 above. The option of combining minimum dredging and foundation treatment of installing vertical drains, such as that illustrated in Figure 8.6 for the reclaimed causeway, would be a preferred choice. The GEO has commissioned a study to investigate methods of seawall/breakwater construction on soft mud. This theme is also being actively considered for other projects such as the proposed Lamma Breakwater in the Western Harbour.	The concerns regarding excessive dredging are noted. The proposed option represents a feasible design using well established concepts for the seawall taking into account the recommendations of GIRFS and the particular problems associated with designing and constructing an immersed tube tunnel through a seawall where significant changes of load would occur along the axis of the tunnel with consequent problems associated with variation in settlement of the soft to firm founding material. It is not intended to restrict consideration of alternative options at full Feasibility Study Stage.

Department	Reference	Comments	Response
Civil Engineering Department (GEO) (cont'd)	Para 8.8.10	The report speculates the process of formation of a scour hole during the construction of an immerse tube tunnel. It would be useful if the Consultants would give some indication of the measures required to minimise the likely construction difficulties associated with scouring of the seabed.	The rate of scour is predicted to be slow, with significant scour only occurring over part of any tidal cycle when the causeway or Port Peninsula closes with Kau Yi Chau. The construction programmes have been planned to allow the completion of the causeway late in the project to minimise scour effects on construction of the immersed tube (see Para 11.1.14).
	Para 8.8.11	The term "solid alluvium" may be replaced by "firm alluvium".	Adopted.
	Para 8.10.2	Please note that the existing marine dumping grounds are not likely to be available in ten years time.	Noted.
Territory Development Department Hong Kong (UADO & SWNT DO) (H H Yeung) (14) in UAH 4/1/128 30 Jan 1992	General	a) The dual-3 option is preferred on traffic ground as it provides more reserve external capacity for Lantau Island.	For maximum capacity, a dual 3-lane option would obviously be preferred, but this would have to depend upon development of the necessary links at the Hong Kong end.
		b) Please note that the Project "Green Island Reclamation" was not included in the 5-year RAS (1991/92 to 1995/96) Programme. If the reclamation would need to commence in 1995, inclusion of the project into the Programme in the coming RAS exercise is required.	Noted. See revised Section 11.1.

Department	Reference	Comments	Response
Territory Development Department Hong Kong (UADO & SWNT DO) (cont'd)	Para 11.1.2 & 11.1.3	Please note that the Green Island Reclamation Feasibility Study Technical Paper No 5A recommended that the mooring buoys needed to be relocated in 1992 for the commencement of Phase I reclamation in 1993. Construction of the reclamation north of Green Island would need to start in early 1997 for completion of the GIL in 2004. If the Phase I reclamation could be reprogrammed to start later, as suggested in this Report, the mooring buoys would only need to be relocated in 1996 for the commencement of the reclamation north of Green Island in 1997. Therefore, please elaborate why the reclamation of the area north of Green Island would need to commence in 1995. Does it imply that this reclamation would take 4 years to complete?	Agreed. The phasing of the reclamation recommended in Green Island Reclamation Feasibility Study (GIRFS) Technical Note 5A requires a commencement date in 1992. The alternative programme investigated in this Study seeks to allow a later start date to the reclamation whilst meeting the objective of opening the Link in 2004. The alternative presented in the Draft Final Report requires that the reclamation north of Green Island commence in 1995, earlier than invisaged under GIRFS, to provide a tunnel landfall site in the absence of the Phase I reclamation. Based on the construction periods implied in GIRFS it could take up to four years for seawall construction, fill and initial settlement. The mooring buoys in this area would therefore require relocation prior to 1995, instead of 1992. It is possible to reduce the time of construction of the reclamation from that following the logic of Technical Note 5A. By mobilizing additional resources to work in areas simultaneously the construction period for the reclamation could be reduced. The areas of reclamation could additionally be handed over to the GIL contractor at an earlier stage of the primary consolidation (due to filling on the marine clay) as the settlement criteria for a works site for GIL are less onerous than for development. A later start date has been further examined in conjunction with the GIRFS team and is presented in Section 11.1.
	Volume 2 Figure 9.6	As indicated in the Plan View the "M.S.L" should not be appeared on the right hand side of Section 2-2.	This figure appears to be correct as is.

Department	Reference	Comments	Response
Highways Department (RD) (K M Ching) (21) in R933 29 Jan 1992	General	We have not comment on the captioned Report.	Noted.
Highways Department HK Region	General	I have no comments on the following volumes of the Draft Final Report: Volume 1 : Engineering Feasibility Volume 2 : Drawings Volume 4 : Preliminary Environmental Assessment.	Noted.
Building and Lands Department (A Lam) (19) in DLO/HW 152/NHRD/82 30 Jan 1992	General	I have no comments on the 3 volumes of the Draft Final Report. However, I note that there is a proposal for a Central Bypass which would require relocation of the PCWA and the Macau Ferry Terminal, GPA and D of M's comments should be obtained.	Noted.
Director of Marine (N B Smith) 39 PA/S 909/2/21 (2) 13 Feb 1992	General	Subsequent to DLO/HKW's remark about the proposed Central Bypass (their Ref: (19) in DLO/HW 152/NHRD/82 dated 30.1.92) as shown on Figure 3.3, it goes without saying that the affected Sai Ying Pun PCWA must be reprovisioned. Also any proposal to relocate the MFT would require Government's approval after identification of a suitable site and construction of a replacement facility which provides an essential service to Hong Kong and to the community. This may tie-in with PADS long-term proposals for an alternative site.	Noted.

Department	Reference	Comments	Response
Electrical & Mechanical Services Department (W K Lo) EM/PAD 30/10 29 Jan 1992	Para 6.1.3	Apart from the PIARC 1987 Technical Committee Report, the recently issued PIARC 1991 Report on Road Tunnels should also be included.	PIARC 1991 was issued recently and subsequent to completion of the design of the ventilation system. At the time when detailed design of the tunnel takes place, the then latest relevant editions of PIARC should be used.
	Para 6.1.6 & Table 6.1	The air quality standards listed in Table 6.1 are misleading. Instead the recommended Standards of EDP should be tabulated, i.e. CO 125 p.p.m NO 7.5 - 15 p.p.m NO_2 1.5 p.p.m	Values required by EPD will be incorporated into Table 6.1 alongside the recommended values as agreed at the Environmental Working Group Meeting on 14th February 1992.
	Para 6.1.8	Apart from the PAIRC 1987 report, supplementary data and alterations of emission factors given in PIARC 1991 Report should also be given.	See response to Para 6.1.3 above.
	Table 6.2	a) The design year for emissions should also be taken as 2004. The methodology given in PIARC 1991 Report (Figure 1 on page 63) for calculating the basic emission factors for a reference year can be considered.	Agreed. See response to Para 6.1.3 above. Data to 2004 was not available when the report was prepared.

Department	Reference	Comments	Response
Electrical & Mechanical Services Department (Cont'd)		b) The basic emission factor for diesel vehicles given in Table 6.2 (NO 0.025 m^3/h - tonne, Smoke 13 m^2/h - tonne) based on a linear relationship with weight is no longer as valid as according to the PIARC 1991 Report, this will overestimate the values for heavy trucks. Instead revised figures given in Table 5 (page 69 of PIARC 91) should be adopted.	See response to para 6.1.3 above.
	Para 6.1.9 & Figure 6.1	Presumably the airflow requirements shown in Figure 6.1 are derived based on PIARC 1987 report only. The Consultant should review these figures as the PIARC 1991 Report has a difference set of values for speed factors, gradient factors and altitude factors.	See Response to Para 6.1.3 above.
	Section 6.2	Requirements of Uninterruptible Power Supplies (UPS) and standby generating sets should also be included in this section.	Refer to 7.8 on page A7-5.
	Section 6.6	Public Address System for Toll Plaza and at the portal areas should be mentioned.	Refer to 7.4.7 on Page A7-2.
	Para 6.7.3	Air quality standards inside the manual toll booths as well as their associated air-conditioning system should also be addressed in this paragraph. This aspect seems to have been left out in most of the past tunnel projects.	Refer to 7.9.8 on Page A7-6.
	Table 11.3	a) Presumably item 7 has included power supplies which should also be listed out with other system.	Power supplies relevant to the listed items are provided. Power company infeeds are excluded.

Department	Reference	Comments	Response
Electrical and Mechanical Services Department (Cont'd)		b) For item 8, suggest to substitute "control system" by "Traffic Control & Surveillance System".	The headings have deliberately been kept short to keep the table to a manageable size.
		c) Capital costs for vehicles and mobile plan should also be given as they are included in other tunnel projects such as Western Harbour Crossing and Route 3 Cheung Ching Tunnel.	Deemed included. The level of detail of the estimate does not to go this accuracy in the Preliminary Feasibility Study.
	Appendix A Para 7.9.4	This sentence should be amended to read: "The airflow rates shall be determined according to the PIARC Reports 1987 and 1991 with .... ".	See response to para 6.1.3 above.
	Appendix A Para 7.9.7	To add the following clause: "Vibration and condition monitoring system shall be considered to facilitate maintenance."	This level of detail is not considered at Preliminary Feasibility Stage.
Fire Services Department (Y Cheung) (20) FSD 6/790/88 III 11 Feb 1992	Para 5.1.4	Services and utilities within the ventilation duct shall be non-combustible, or otherwise enclosed by fire rated materials to separate from the air stream. Essential services for emergency uses shall be temperature related to stand for hot smoke.	Noted. This general comment will be added as para 7.1.5 on Page A7-1. It is also referred to in 7.8.4 on Page A7-5.
	Para 5.2.3	During the structural design stage, especially for the concrete units, consideration should be given to the location of cross over facilities in twin tubes. The pedestrian cross over facilities to be provided shall be at 100 intervals.	Refer paragraph 6.8.1 to 6.8.3 and Figure 6.4 and Page A4-1 paragraph 4.1.6.

Department	Reference	Comments	Response
Fire Services Department (Cont'd)	Para 6.1.21	Recommendation from PIARC (1987) on semi-transverse smoke control system shall be followed. The system shall be capable to drive the smoke out of the tunnel tube within the length of stable spreading of 600 m.	Refer para 7.9.4 and 7.9.2 on Page A7-6.
	Para 6.2.4	The back-up of power supply to the FSI's including smoke control system shall be extended to L.V. side, i.e. operating voltage of the equipment, and shall be automatically switched over in case of failure of the duty supply source.	Refer to section 7.8 on Page A7-5.
	Appendix A Paras 6.1.21 & 7.5.7	The smoke control functions in the tunnel ventilation system shall be in accordance with the specification issued under Section J in FSD's Circular Letter No 1/90 which has been sent to you on 2.7.1991.	This will be noted in 7.9.2 on page A7-6.
	Para 10.5.1 & 10.5.2	Noted.	
	Para 10.5.8	The risk analysis shall also be submitted to FSD for comment when available.	Noted.
	Para 10.5.9 & 10.5.10	Noted.	
	Volume 2	No comment.	Noted.

Department	Reference	Comments	Response
Royal Hong Kong Police Traffic Wing (G S Bailey) (12) in CP/T/TMB 22/79 II 30 Jan 1992	Summary	I have the following comments on the DFR (Volumes 1 & 2).	
		a) I note that the two selected options do not represent a final choice, which will be subject to the conclusions of the LPPDS (para 1.5.2).	Agreed.
		b) I note that the two selected options are interchangeable (para 1.5.2).	Agreed.
		c) I note that the Central By-pass is only a requirement under a dual-3 scenario and that the eastern connection to the C&W Reclamation trunk road layout requires further study outside the scope of this study (para 3.3.5).	Agreed.
		Climbing Lanes	
	Para 3.4.3 & Fig 4.8	I note that Fig 4.8 indicates climbing lanes under a dual-3 alignment, although para 3.4.3 states they are considered not feasible.	Para 3.4.3 refers to immersed tunnel units. The climbing lanes in Figure 4.8 will be in cut-and-cover tunnels which is perfectly acceptable.

Department	Reference	Comments	Response
Royal Hong Kong Police Force Traffic Wing (Cont'd)		Toll Plaza	
	Para 3.8	a) We certainly support the view that the toll plaza is best located on the Kau Yi Chau - side together with other main facilities.	Noted.
	Para 10.2.12 & Fig 10.1	b) I note Figure 10.1 (Toll Plaza Layout D-2), it would have been useful to have a drawing also of a D-3 layout showing the 15 toll-lanes - presumably the 15 booths would be split 7/8 in favour of traffic exiting the tunnel.	The arrangement would be symmetrical with a number of the central booths capable of 2-way operation for maximum flexibility. At least one booth would be designated "spare" in case of failure of another booth.
	Chapter 5	Causeway	
		The causeway, whether elevated or not, would seem to be a highly exposed section of road, open to the elements from all sides, we would expect, therefore, that the study consider any requirement for closure or safeguarding of the route under severe weather conditions.	The causeway is a temporary condition pending completion of the Port Peninsula. Severe weather conditions other than waves should not affect the causeway more than any other section of exposed road. If waves are shown to affect the route after full design despite meeting the design criteria, further wave protection could be added. In the final instance, the highway is likely to be located centrally within the Port Peninsula. This issue should be addressed further in the full feasibility study stage when the layout and timing of the Port Peninsula is fixed.

Department	Reference	Comments	Response
Royal Hong Kong Police Force Traffic Wing (Cont'd)	Para 6.6.7 & 10.4.5	<u>Crossovers</u> I am not entirely clear on why it is considered necessary to have two separate crossovers for m/e & tidal flow (figure 2.7) and also why it is considered essential that the m/e crossover be as close as possible to the portal - this would seem to impose additional constraints on the movement of M&E vehicles due to reduced sight-lines and tighter turning radii. Judging by Fig 2.8, crossovers are only required under a dual-2 arrangement, is this correct?	The maintenance/emergency crossover is for situations which require closure of the tunnel in one direction where all traffic is diverted into the other tube and contra-flow operated. Ideally adequate lengths for merging traffic to one lane into the tunnel should be provided and this can be achieved by locating the maintenance/ emergency crossover as close as possible to the portal. The other crossover is for tidal flow operation to allow the flexibility for future implementation although the traffic forecasts suggest that it will not be necessary (see para 10.4.6). The tidal flow crossover at the recommended location can avoid the weaving problem as explained in para 10.4.6. Cross overs are also required under a dual-3 arrangement, Figure 2.8 will be amended.
	Para 6.6.14 & Appendix A.7.4.5	<u>Radio Communications</u> The facility to enable us to maintain contact with our control centres is of course essential, however I trust there is no confusion between this and the radio link between the tunnel control centre and the Police control centre, mentioned in para 7.4.5 in Appendix A. As regards this later link, we consider that a telephone link, as presently provided with existing tunnel control centres, is sufficient and in fact preferable.	Whilst the intention was to provide both links, provision of the preferred links can be resolved at the Full Feasibility Study stage.

Department	Reference	Comments	Response
Royal Hong Kong Police Force Traffic Wing (Cont'd)		<u>Tidal Flow</u> Although the inclusion of the tidal flow crossover facilities is supported, as a prudent measure, it is difficult to envisage a scenario wherein tidal flow measures facilitating westbound flow would be acceptable to Police, given its likely impact on HKI traffic - it should of course, be emphasised that such measures would require our agreement before implementation by the tunnel authority.	Provision of tidal flow should be reassessed at the full feasibility study stage. Two way flow could be necessary during maintenance of the other traffic tube.
	Para 10.4.9, 10.4.10 and 10.4.12	<u>Overheight Vehicles</u> I note 10.4.9, 10.4.10 and 10.4. 12 - certainly the inherent risks involved in stopping traffic, and the movement across traffic lanes of tunnel staff and offending vehicles, will require careful examination during the design stages.	Noted.
	Para 10.4.14 & 10.4.15	<u>Overweight Vehicle</u> I cannot agree with the statement "restriction of overweight vehicles .... is not vital for the tunnels' safety". Given the high proportion of goods vehicle traffic projected to use the link and that the greater incidence of overloading would likely occur amongst Lantau Port-bound vehicles, coupled with the exceptional length of the tunnel, we consider it advisable to include an overweight vehicle detection system and weighbridge on the Green Island side.	Structural design of the tunnels proposed would not be comprised by overweight vehicles because the applied loads act against the hydrostatic external loading and tend to produce relief. It might be desirable for these reasons to limit vehicular weight eg capacity of the road surfacing, but this is beyond the scope of this study.

Department	Reference	Comments	Response
Royal Hong Kong Police Force Traffic Wing (Cont'd)	Para 10.4.17 & 10.5.6	<u>Overtaking</u> Overtaking should not be permitted other than under exceptional circumstances where it is controlled by tunnel staff or other emergency units.	Our comments stand. It is a policy decision outside the scope of this study whether to permit overtaking or not.
Highways Department (WHL) (A K S de Mel) (38) in WHL 12/4/03 31 Jan 1992	Chapter 11	I enclose a programme for your consideration for the implementation of the GIL Project. I suggest a similar programme be included in the Final Report.	Adopted.
	Para 1.11.12	A programme should be included in the Final Report showing the proposed phasing of Green Island Reclamation for completion of GIL in 2004.	Adopted.
	Para 6.0.8	GIRFS Technical Paper No. 5A recommends that the hydraulic modelling of partial reclamation be carried forward to the Green Island Link Preliminary Feasibility Study (GILPRS) in order to:	

Department	Reference	Comments	Response
Highways Department (WHL) (Cont'd)		a) confirm that Phase I reclamation for reprovisioning the PCWA, Abattoir and China Merchants Wharf is viable, and b) test the method of closure of Sulphur Channel on which Programme Scenario one is based (Option A) i.e reclamation north of Green Island followed by construction of the North Facing Seawell.	The recommendations of this Study propose an alternative phasing of the reclamation to that contained in the GRIFS Technical Note 5A. It would commence with the area north of Green Island followed by the Phase I and the north facing seawall simultaneously. The construction of the area north of Green Island would not affect the hydraulic regime of sulphur channel. The seawall east of this to Belchers Bay would be constructed from the bottom-up. This method would avoid the constriction of flow which occurs with the GIRFS method and therefore adverse hydraulic effects are not anticipated.
	Summary Para 7.2	The base time of the estimate should be specified.	Agreed. The valuation date is fourth quarter 1991.
	Para 2.3.5	"Infrasture" should read "infrastructure"	Agreed.
	Volume 2 Figure 8.3 & 8.4	GR3, GR4 and GR11 - The type of marine deposit should be stated.	Agreed.

Department	Reference	Comments	Response
Planning Department (DPO/HK) (Y.L. So) (6) in HK-R/TT/106 10 March 1992	Para 3.3.4	In the dual-three lane scenario, it is noted that the proposed Central Bypass will affect some of the existing/ planned land use in the vicinity of the Western Reclamation which includes the tram depot, the public cargo working area and the existing Macau Ferry Terminal. Moreover, it will also have adverse visual impact on the proposed Western Parkland. This would need to be critically assessed if the proposal is to develop further. A copy of the recently circulated layout plan (L/H3B/1) for the Western Reclamation area is attached for your easy reference.	Noted.
	Para 3.6.3	The arrangement to extend the cut and cover tunnel further eastward to reduce severance and environmental impact is supported from district planning point of view.	Noted.
	Para 9.2.27 & 9.3.18	Regarding the suggestion to locating the fabrication yard and the casting basin on the Green Island Reclamation (GIR), detailed assessment of the full implication would only be possible when information on the land use, programme of development and population build-up of GIR becomes more definite. As such, I reserve my comments on the suggestion but PM/UA, who is managing the Green Island Reclamation Feasibility Study, should be informed of the possible requirement.	Agreed.
	Para 10.4.17	It appears that the suggested arrangements are not in compliance with the current practice. Surely comments from AC for T/U will be relevant.	The current practice of restricting heavy vehicles to the inside lane(s) and prohibiting overtaking within tunnels may, if applied to the GIL, restrict the capacity of the tunnel. This should be reviewed at full feasibility stage.

Department	Reference	Comments	Response
Planning Department (Cont'd)	Para 11.1.9	It is noted that the alignment of the recently gazetted Belcher Bay Link is different from the long-term alignment shown on Fig. 4.4 and 4.5. Since the subject link has been included in the strategic highway infrastructure in Table 11.1, perhaps the relationship between the two alignments, in particular whether the present alignment would need to be subsequently modified, should be clearly explained.	The strategic highway infrastructure, on and adjacent to Green Island Reclamation, has been taken to be that detailed in the Green Island Reclamation Feasibility Study (GIRFS) and PADS. The alignment of Belcher Bay Link recently gazetted is different from that detailed under GIRFS. It is planned that Belcher Bay Link will be relocated from the alignment recently gazetted, to that proposed in GIRFS, at the time of the construction of the Green Island strategic road network.
Planning Department (PADS) (W I A Rennie) PADS/C/TT 40 II 21 Feb 1992		DPO/HK will be forwarding separate comments in due course. Meantime, the following two comments from CTP/TrD and CTP/PADS are related to 'strategic issues', which, strictly speaking, are outside the Brief or Instructions given to you, but, nevertheless, need to be "aired".	Noted.

Department	Reference	Comments	Response
Planning Department (PADS) (Cont'd)		One issue concerns the Green Island Reclamation itself, which is part of the long-term Metroplan structure. However, there is going to be a lot of land available on West Kowloon Reclamation and the Kai Tak/Kowloon Bay over the next 15 years, not to mention re-development potential when the airport height restrictions are replaced. It is therefore an heroic decision to assume that the formation of Green Island Reclamation will be available for this project on the assumed schedule. Would the non-availability of the reclamation kill this transport project? Fig 11.1 illustrates what is claimed to be the minimum area of reclamation. Has the cost of this been included in the transport project cost? Has the environmental acceptability of such minimum reclamation been proven? Would the answer to these questions influence the decision on the selected alignment?	Noted. This Study has concentrated on the engineering feasibility and environmental acceptability of the Green Island Link, as proposed by PADS. The Brief assumes that the Green Island Reclamation, as envisaged by the Green Island Reclamation Feasibility Study, will be in place or under construction by 2001. Figure 11.1 shows the phasing and minimum requirements for the Green Island landfall and interchange assuming eventual construction of the whole reclamation will go ahead. An alternative arrangement for the Green Island landfall may be more appropriate if the reclamation is changed or is not required. The cost of reclamation has not been included in the capital costs identified in Chapter 11.

Department	Reference	Comments	Response
Planning Department (PADS) (Cont'd)		The second issue refers to the Central By-Pass. The methodology for forecasting possible tunnel usage in the dim future was agreed. By including Figs 2.4, 2.5 and 2.6 outlining the traffic sector boundaries, at some stage you must have been intending to give an indication of trip-end distribution, but either omitted this, or decided against it. If we are going to agree to exercise extraordinary prescience on tunnel traffic forecasts we may as well do the same for the trip-end locations and purposes. An extra couple of tables and a narrative paragraph, with suitable disclaimers, would suffice and help to establish, or otherwise, the credibility of the D2 and D3 forecasts. As things stand, the prospect of getting any new by-pass built for central is receding, regardless of any second by-pass. It is difficult to see how effective a D-2 GI Link might be, operating in conjunction with the prospective Route 3 (WHC & Expressway), the prospective Central Kowloon Route and the existing HK Island trunk road network to the east of the WHC. The distance from Kai Tak to Chek Lap Kok would be about equal maybe even shorter by GI than by the LFX. I do not expect you to do any extra work on this, but if the information is available it would be useful to include it in the DFR.	At the Strategic Network Assignment Model level, the Territory is divided into 272 internal zones and 4 cross border zones as illustrated in Figures 2.1. to 2.3. Planning data and trip ends are available for each zones. These zones are compressed into a smaller number (in this case, 28 sectors shown on Figures 2.4 to 2.6) to assist appreciation of the distribution of planning data (as demonstrated in Table 2.2, planning Data for 1986 and 2011). Trip ends can also be presented in a similar format, i.e. total origins and destinations by sector. However, the Study was required to produce traffic forecast assuming full D2 GIL and full D3 GIL. The factoring up of the GIL traffic to full capacity flows was done at the sub-regional Assignment Model level. At this level the road network had been cordoned to cover largely the Hong Kong island and Lantau Island. Other areas such as Kowloon and New Territories were treated as external zones via the cross harbour links. Therefore in the sub-regional model with GIL capacity flows, it is not possible to produce the trip end distribution based on the 28 sectors as shown in Figures 2.4. to 2.6.

Department	Reference	Comments	Response
Water Supplies Department (P.N. Cheung) WWO 3071/86 III 14 Feb 1992		I have no comment on the captioned Draft Final Report.	
		Please, however, note our Provisional Standing Orders have been re-named to Departmental Instructions. Para. 6.3.1 of Appendix A in Volume 1 of the Draft Final Report shall be rewritten to read "Water Mains diversions shall be undertaken in consultation with and to the requirements of Water Supplies Department. The standards to be adopted in the design of new projects are given in Water Supplies Department Instruction No. 1309 (Revised July 1985)."	Adopted.
Environmental Protection Department (T Tsang) 7 Feb 1992		Volume 1	
	Para 6.1.6 & 6.1.7 Table 6.1 & Appendix A (Table 7.1)	It is very ridiculous that the air quality standards required by EPD are not the Air Quality Standards for the Green Island Link tunnel ventilation system. EPD's tunnel air quality standards are derived for the protection of general public health and there doesn't appear to be any difficulty in attaining the standards (as discussed in the Technical Meeting on 18 Sept 1991). Please amend the criteria/ standards for tunnel air quality in Table 6.1 and Appendix A (Table 7.1) as follows:-	The EPD permissible concentrations will be added to Table 6.1 and Appendix A Table 7.1.

Pollutant	Permissible Concentration
Carbon Monoxide (CO)	125 ppm
Nitrogen Dioxide (NO_2)	1.5 ppm
Nitric Oxide (NO)	7.5-15 ppm *

* (based on 10-20% conversion of NO to NO_2)

Department	Reference	Comments	Response
Environmental Protection Department (Cont'd)	Para 6.1.25 & Appendix A (S.7.9.5)	As commented in previous documents, I would like to reiterate that NO_2 sensor should also be installed to control the level of ventilation required.	The wiring necessary for NO_2 sensors is included. When such a sensor becomes generally available, it may be attached.
	Para 8.3.1	The results of contaminated marine deposits sampling at Kau Yi Chau Island North do not agree with the findings as indicated in LAPH Paper No. 12 (attached for your reference). The consultants need to clarify the discrepancies between the two reports, since special precautions are required for any dredging or installation of wick drains in contaminated marine deposits/ spoil.	The LAPH paper No. 12 presents both the results of the Contaminated Spoil Management Study and the results of the testing carried out for Green Island Link (Section 5.3.3). Only a few of the sampling stations of the former Study are in the vicinity of the Link, three of which indicate generally elevated heavy metal contents indicative of Class B material. For this Study twenty samples were obtained along the line of the Link. The conclusion of this Study that all of the samples fall within the limits associated with uncontaminated soils is confirmed by the LAPH Report.

HIGHWAYS DEPARTMENT - WESTERN HARBOUR LINK OFFICE

GREEN ISLAND LINK

PRELIMINARY FEASIBILITY STUDY

FINAL REPORT

FEBRUARY 1992

Volume 2: DRAWINGS

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in association with
MVA ASIA LIMITED
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GREEN ISLAND LINK
PRELIMINARY FEASIBILITY STUDY

FINAL REPORT
FEBRUARY 1992

Volume 2: DRAWINGS

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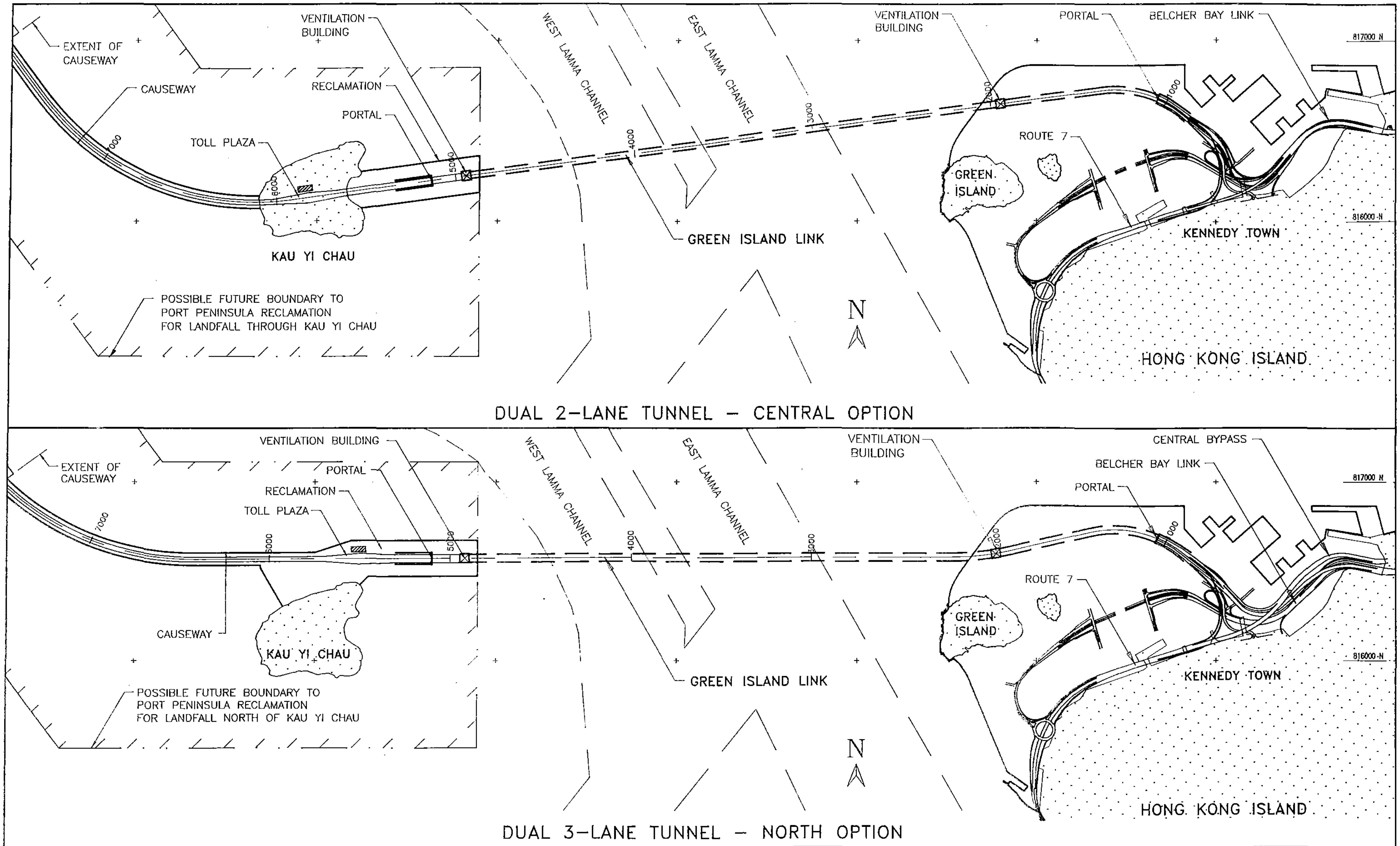

GREEN ISLAND LINK PRELIMINARY FEASIBILITY STUDY

PAPM CONSULTANTS

HIGHWAYS DEPARTMENT

OUTLINE DESIGN ALIGNMENTS

FIG. 1.1

DESIGNED	K T P	GIL/101/40
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CHECKED		
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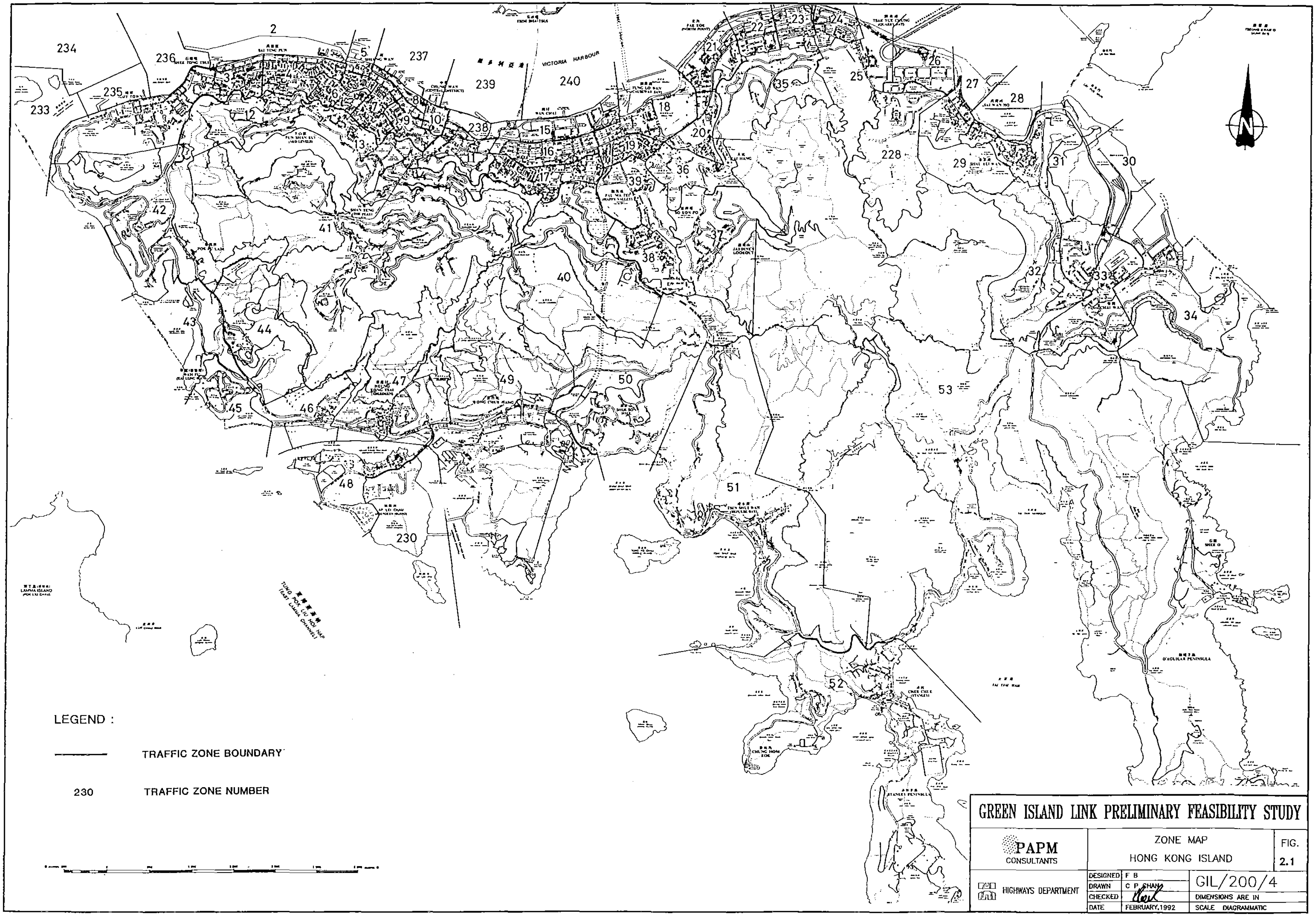
VICTORIA HARBOUR
LEGEND :
TRAFFIC ZONE BOUNDARY
230 TRAFFIC ZONE NUMBER
GREEN ISLAND LINK PRELIMINARY FEASIBILITY STUDY
PAPM CONSULTANTS
ZONE MAP
HONG KONG ISLAND
FIG. 2.1
HIGHWAYS DEPARTMENT
DESIGNED F B
DRAWN C P CHAN
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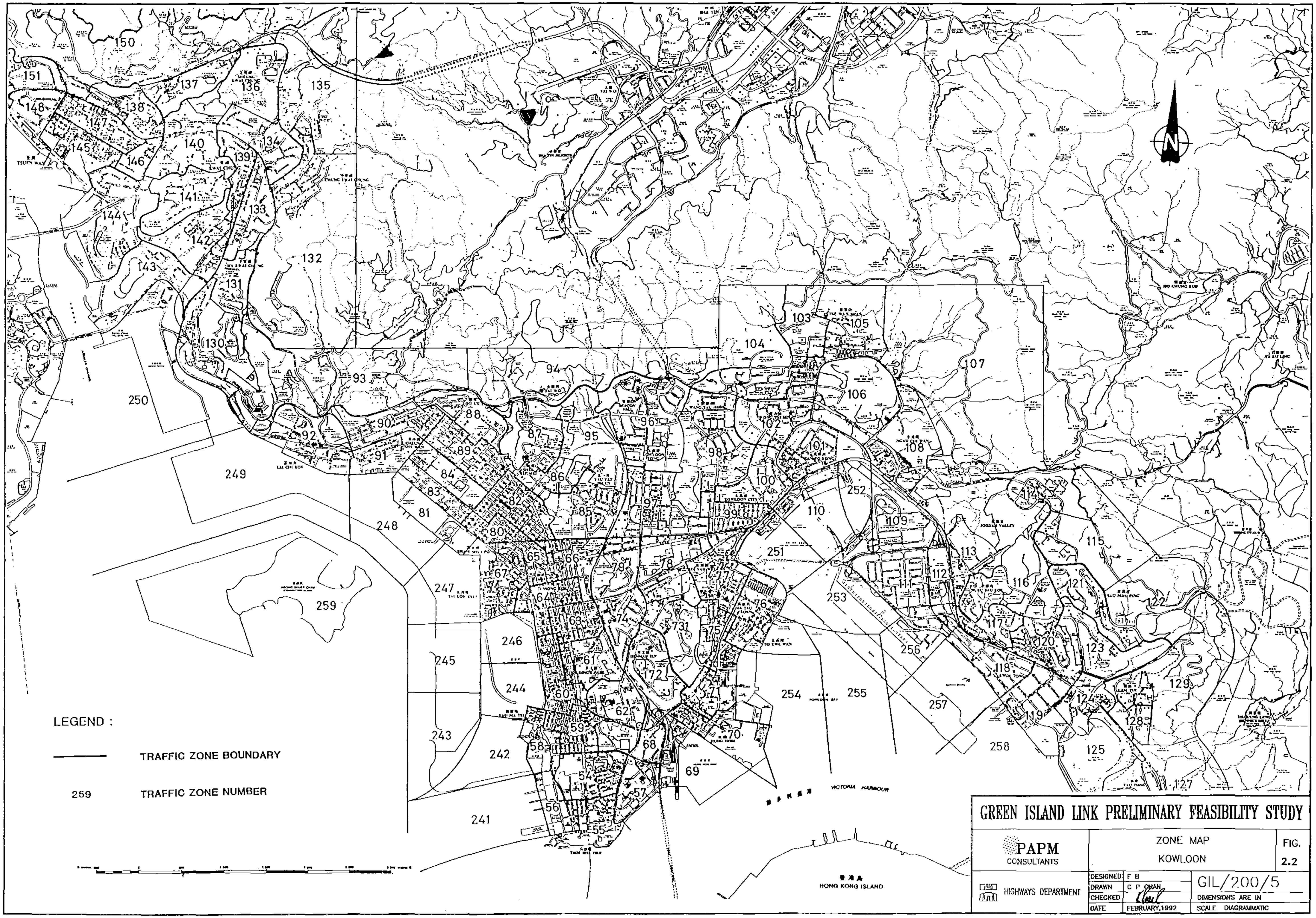
DATE FEBRUARY,1992
GIL/200/4
DIMENSIONS ARE IN
SCALE DIAGRAMMATIC



GREEN ISLAND LINK PRELIMINARY FEASIBILITY STUDY

PAPM CONSULTANTS

HIGHWAYS DEPARTMENT

ZONE MAP
KOWLOON

FIG. 2.2

DESIGNED	F B	GIL/200/5	
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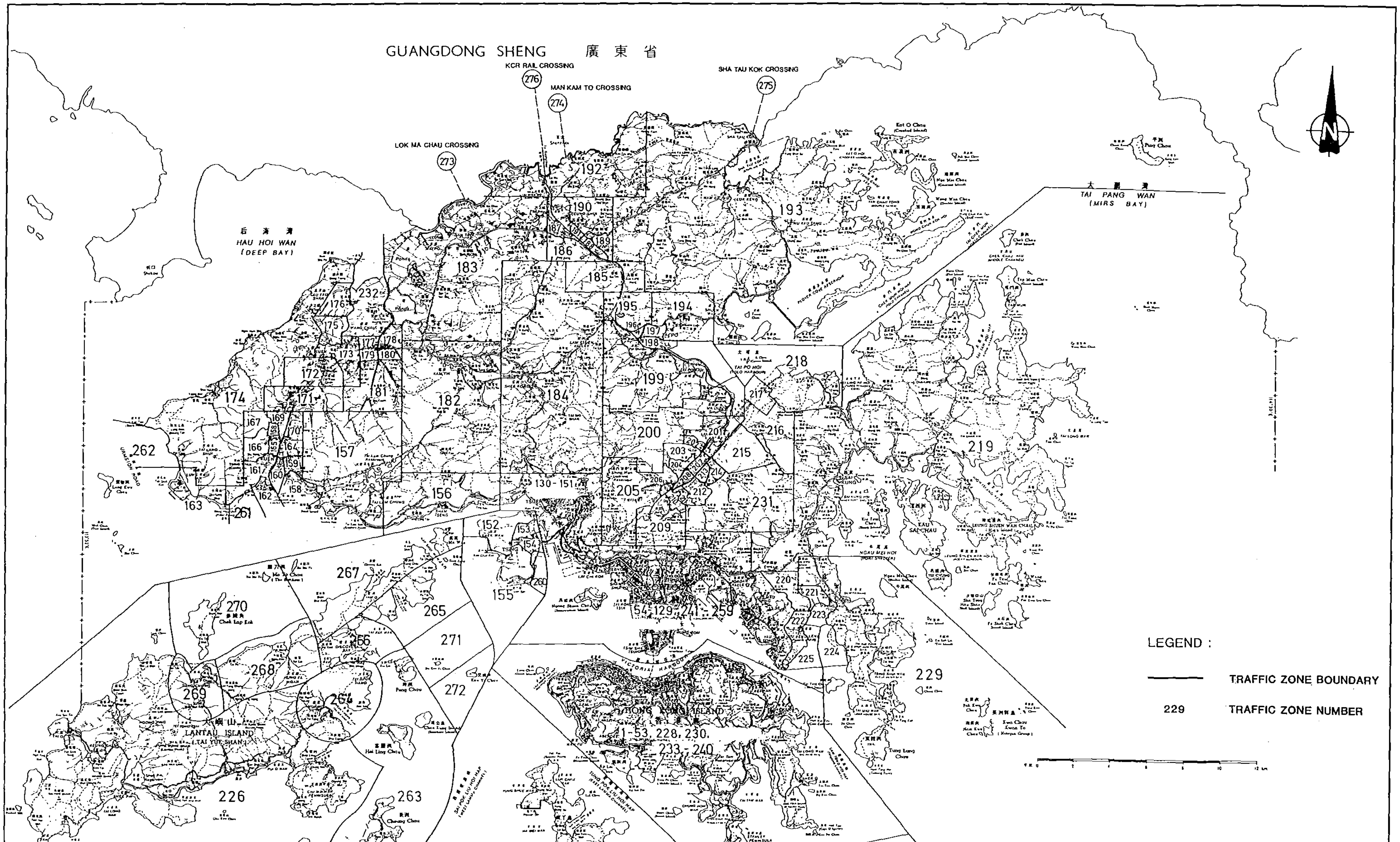
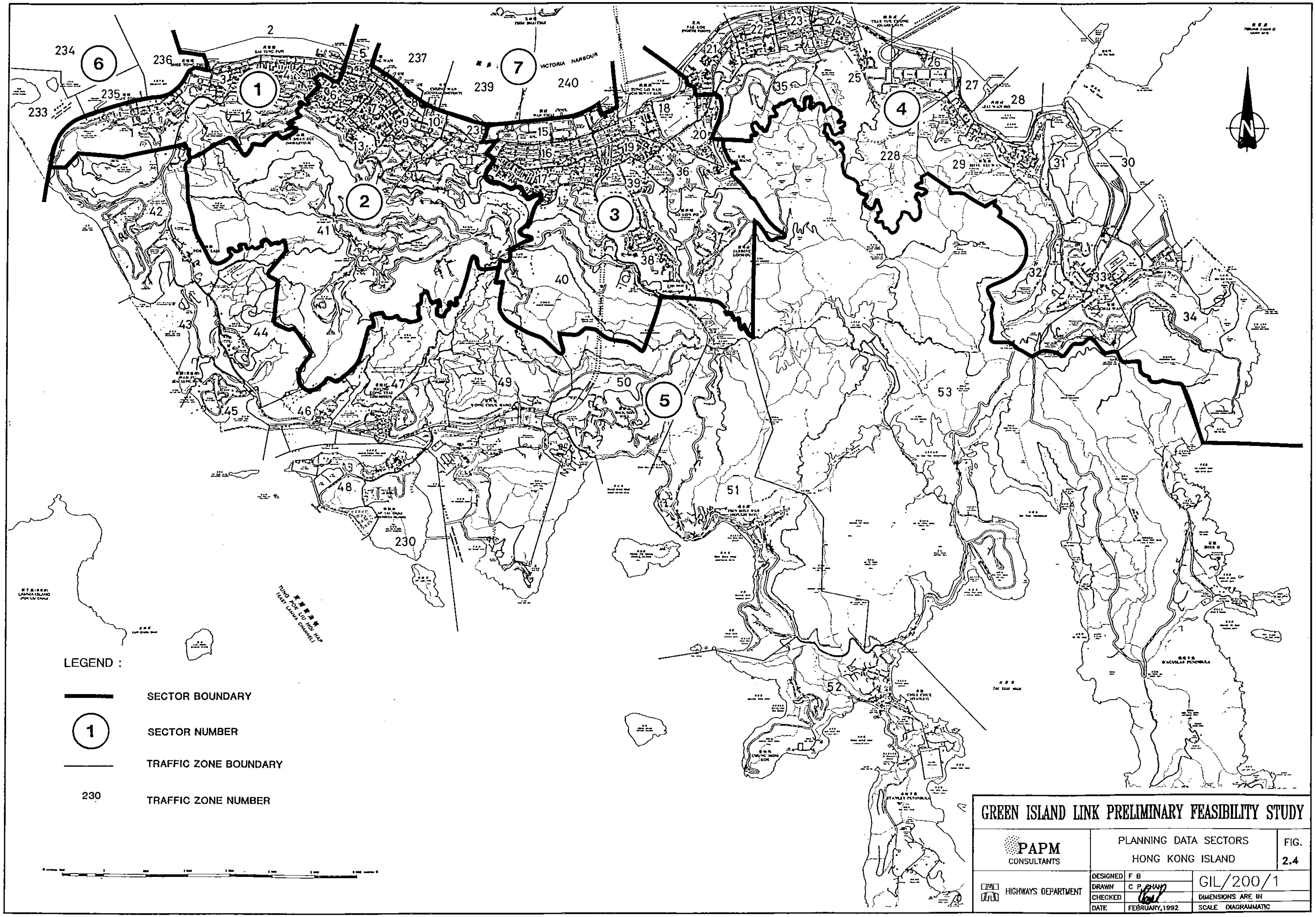
DATE	FEBRUARY,1992	SCALE DIAGRAMMATIC	



GREEN ISLAND LINK PRELIMINARY FEASIBILITY STUDY			
PAPM CONSULTANTS	ZONE MAP N.T. AND ISLANDS		FIG. 2.3
HIGHWAYS DEPARTMENT	DESIGNED: F B; DRAWN: C P CHAN; CHECKED: ; DATE: FEBRUARY,1992	GIL/200/6 DIMENSIONS ARE IN SCALE DIAGRAMMATIC	


VICTORIA HARBOUR
LEGEND :
SECTOR BOUNDARY
1
SECTOR NUMBER
TRAFFIC ZONE BOUNDARY
230
TRAFFIC ZONE NUMBER
GREEN ISLAND LINK PRELIMINARY FEASIBILITY STUDY
PAPM
CONSULTANTS
HIGHWAYS DEPARTMENT
PLANNING DATA SECTORS
HONG KONG ISLAND
FIG.
2.4
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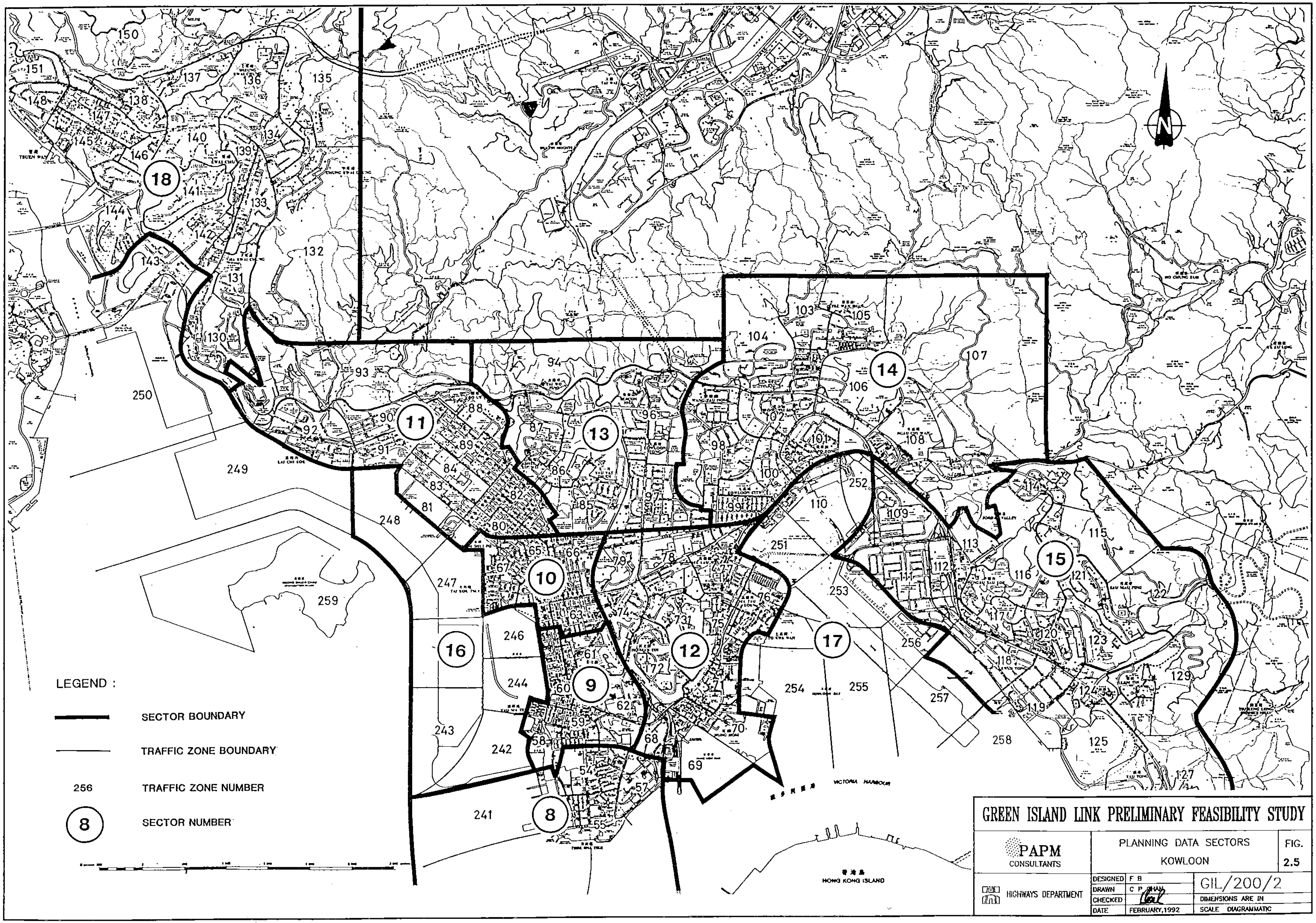
DATE FEBRUARY,1992
GIL/200/1
DIMENSIONS ARE IN
SCALE DIAGRAMMATIC


LEGEND :
SECTOR BOUNDARY
TRAFFIC ZONE BOUNDARY
256 TRAFFIC ZONE NUMBER
8 SECTOR NUMBER
VICTORIA HARBOUR
HONG KONG ISLAND
GREEN ISLAND LINK PRELIMINARY FEASIBILITY STUDY
PAPM CONSULTANTS
HIGHWAYS DEPARTMENT
PLANNING DATA SECTORS
KOWLOON
FIG. 2.5
DESIGNED F B
DRAWN C P CHAN
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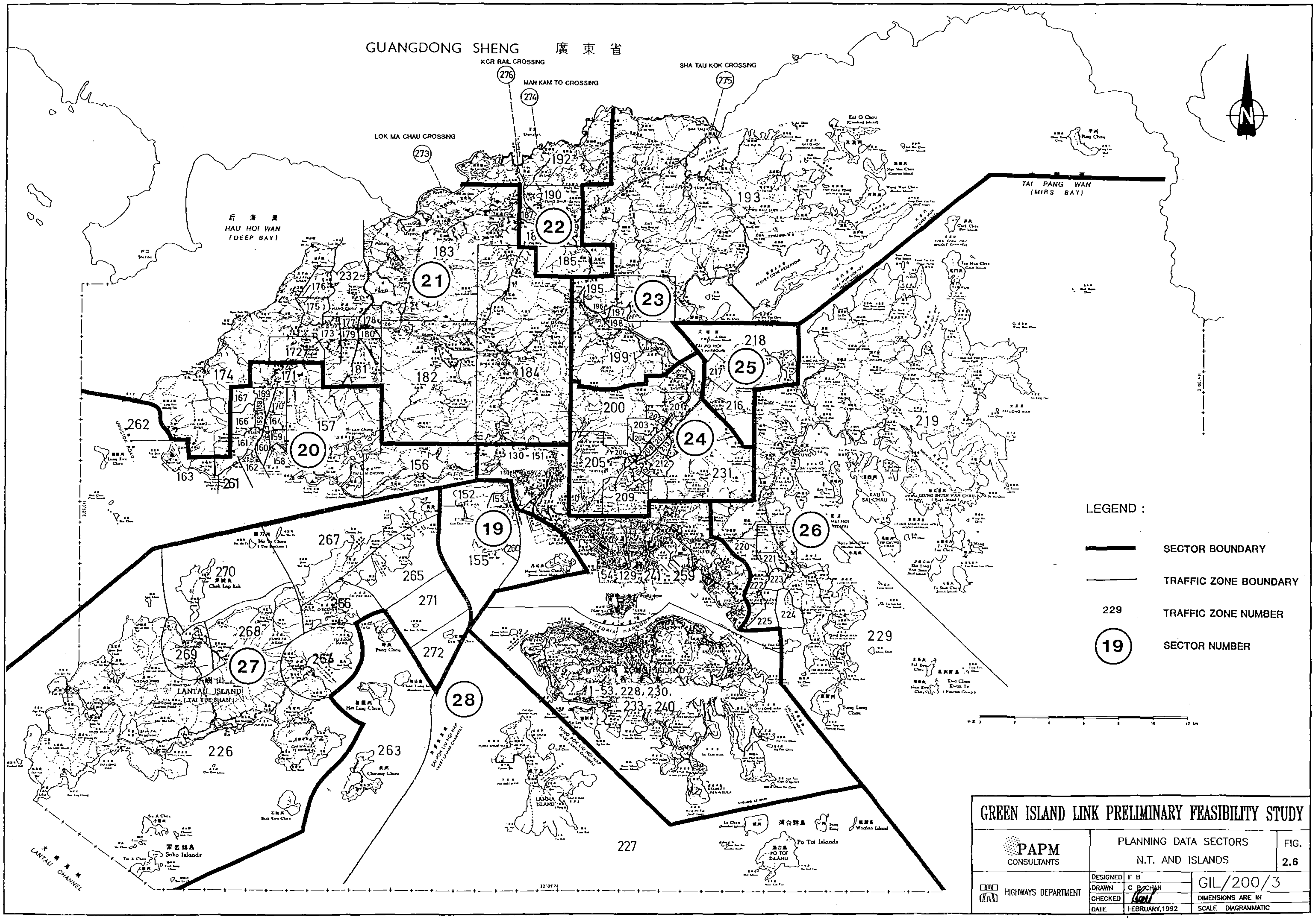
DATE FEBRUARY,1992
GIL/200/2
DIMENSIONS ARE IN
SCALE DIAGRAMMATIC



GREEN ISLAND LINK PRELIMINARY FEASIBILITY STUDY

PAPM CONSULTANTS

HIGHWAYS DEPARTMENT

PLANNING DATA SECTORS N.T. AND ISLANDS

FIG. 2.6

DESIGNED	F B	GIL/200/3
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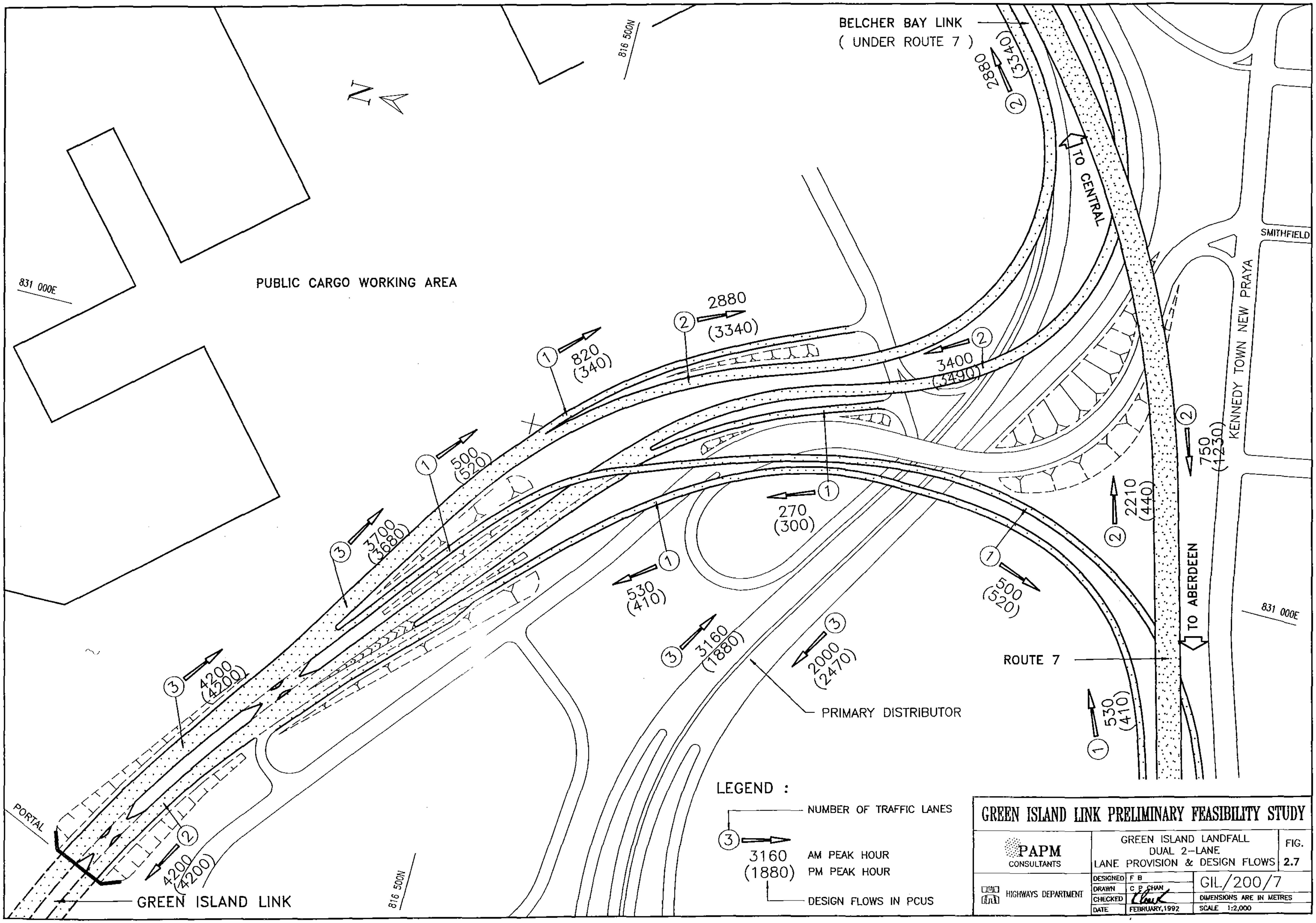
CHECKED		SCALE DIAGRAMMATIC
DATE	FEBRUARY, 1992	



GREEN ISLAND LINK PRELIMINARY FEASIBILITY STUDY

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GREEN ISLAND LANDFALL
DUAL 2-LANE
LANE PROVISION & DESIGN FLOWS

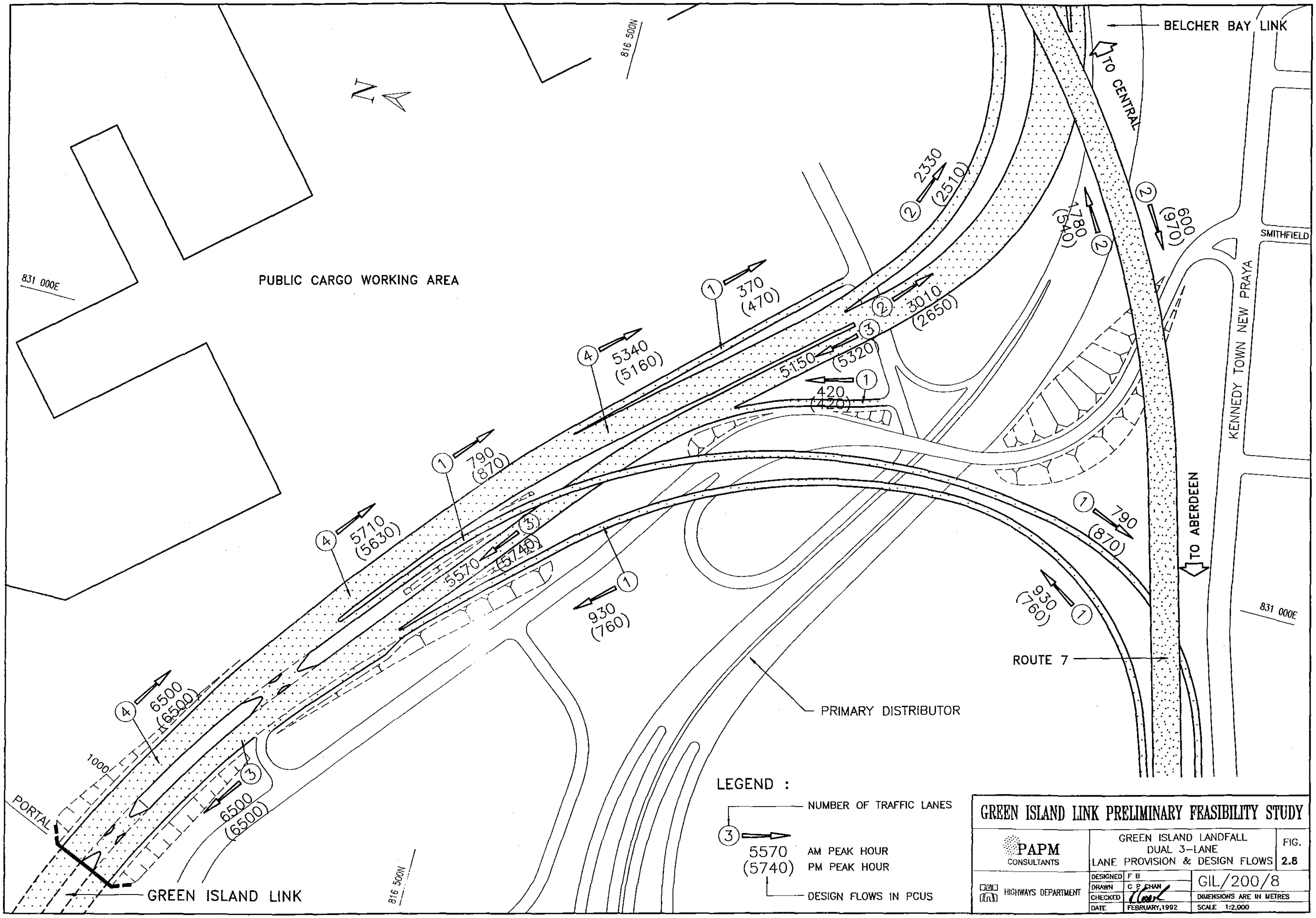
FIG. 2.7

DESIGNED	F B
DRAWN	C P CHAN
CHECKED	
DATE	FEBRUARY,1992

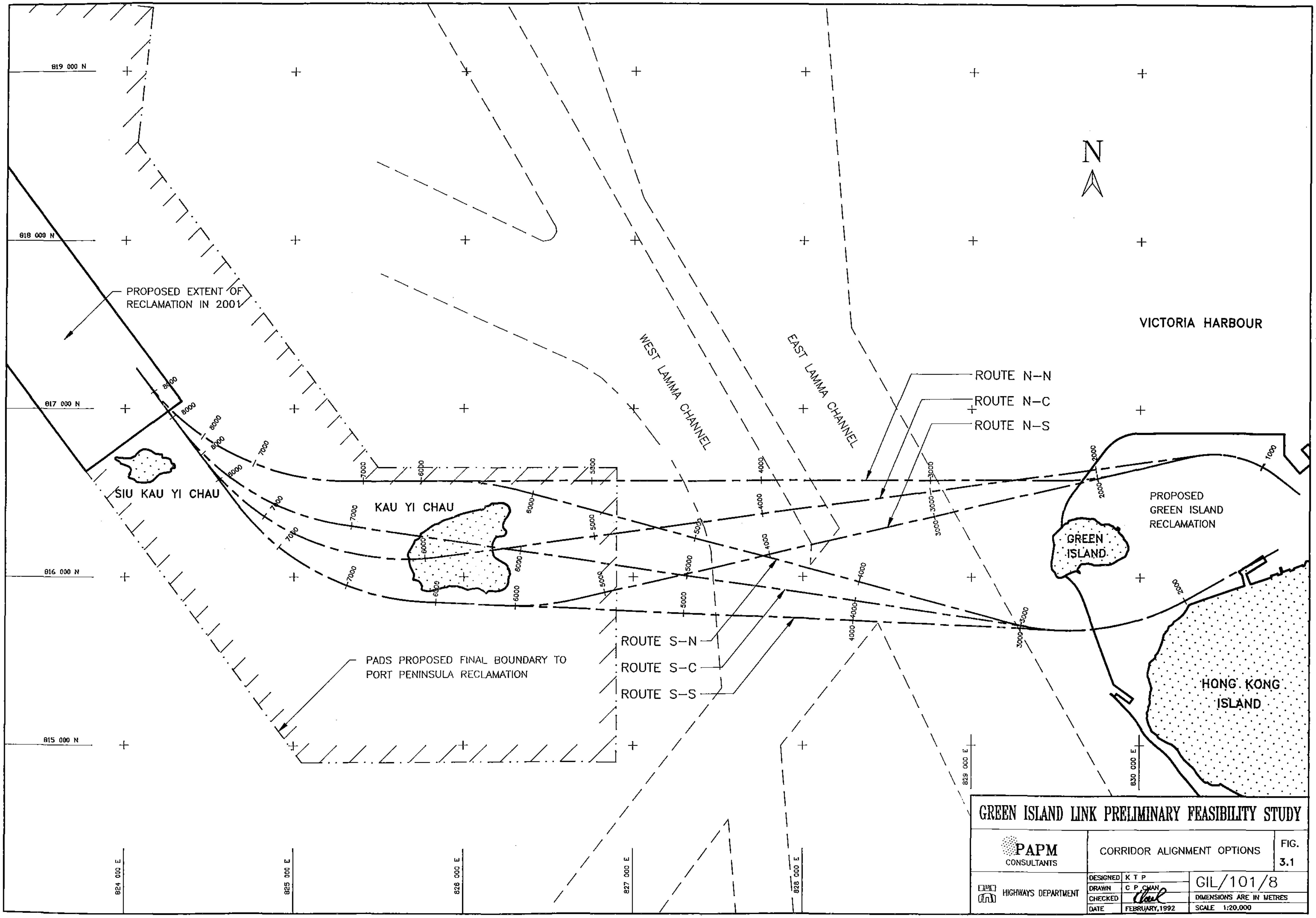
GIL/200/7

DIMENSIONS ARE IN METRES

SCALE 1:2,000



GREEN ISLAND LINK PRELIMINARY FEASIBILITY STUDY			
PAPM CONSULTANTS	GREEN ISLAND LANDFALL DUAL 3-LANE LANE PROVISION & DESIGN FLOWS		FIG. 2.8
HIGHWAYS DEPARTMENT	DESIGNED F B; DRAWN C P CHAN; CHECKED; DATE FEBRUARY,1992	GIL/200/8 DIMENSIONS ARE IN METRES SCALE 1:2,000	



GREEN ISLAND LINK PRELIMINARY FEASIBILITY STUDY

PAPM CONSULTANTS

HIGHWAYS DEPARTMENT

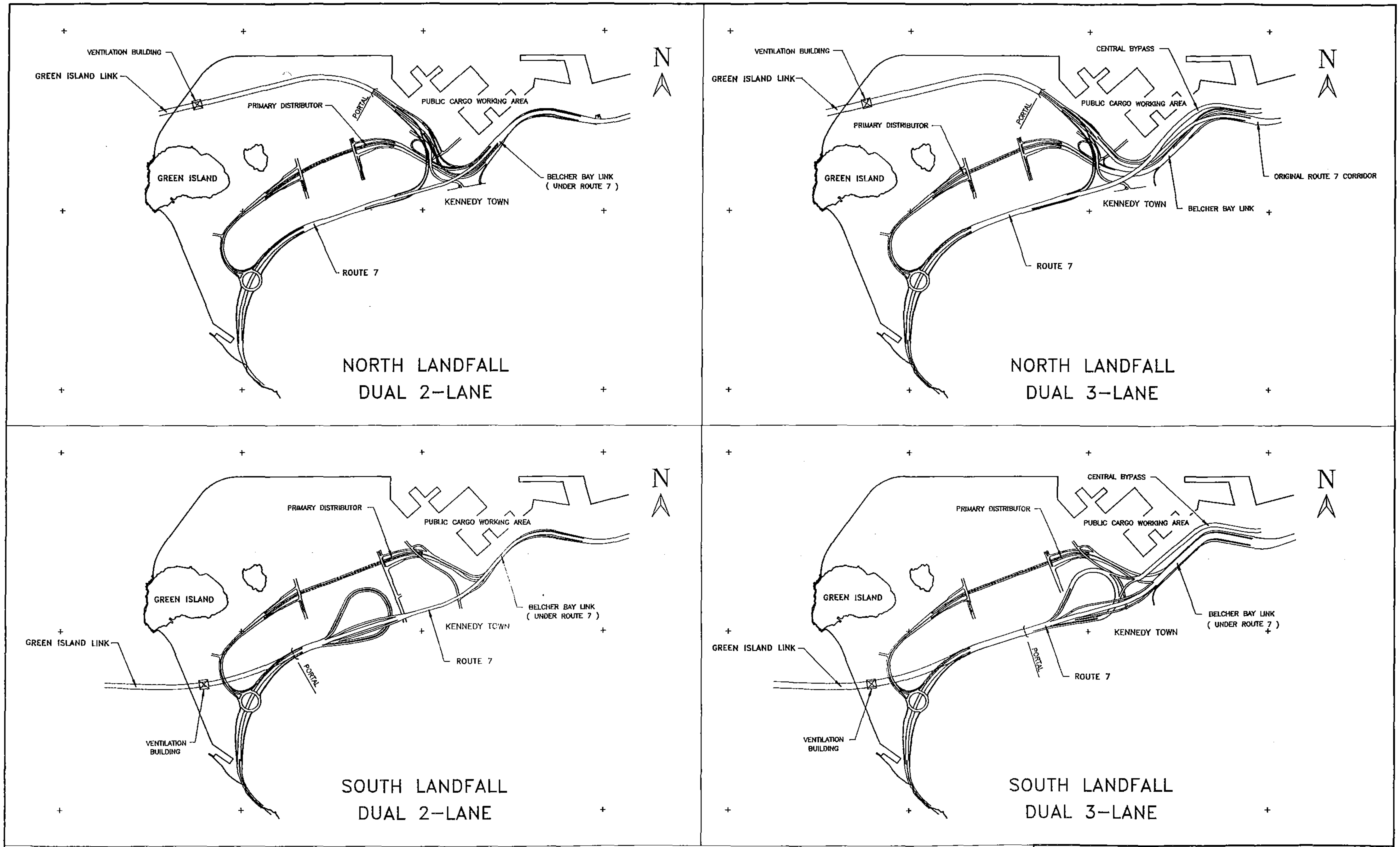
CORRIDOR ALIGNMENT OPTIONS

FIG. 3.1

DESIGNED K T P
DRAWN C P CHAN
CHECKED
DATE FEBRUARY,1992

GIL/101/8

DIMENSIONS ARE IN METRES
SCALE 1:20,000



GREEN ISLAND LINK PRELIMINARY FEASIBILITY STUDY

PAPM CONSULTANTS	GREEN ISLAND LANDFALL CONCEPTUAL OPTIONS	FIG. 3.2
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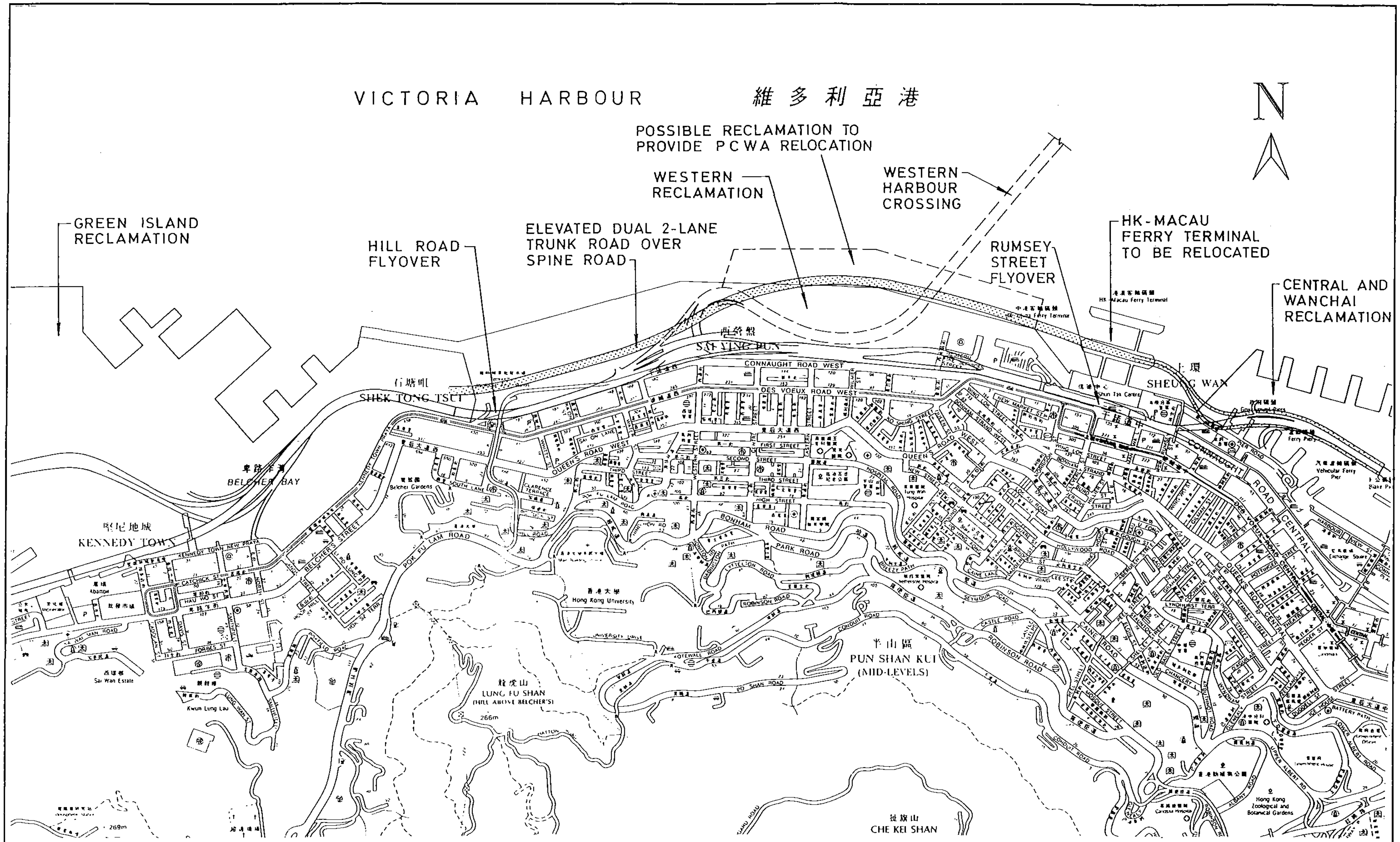
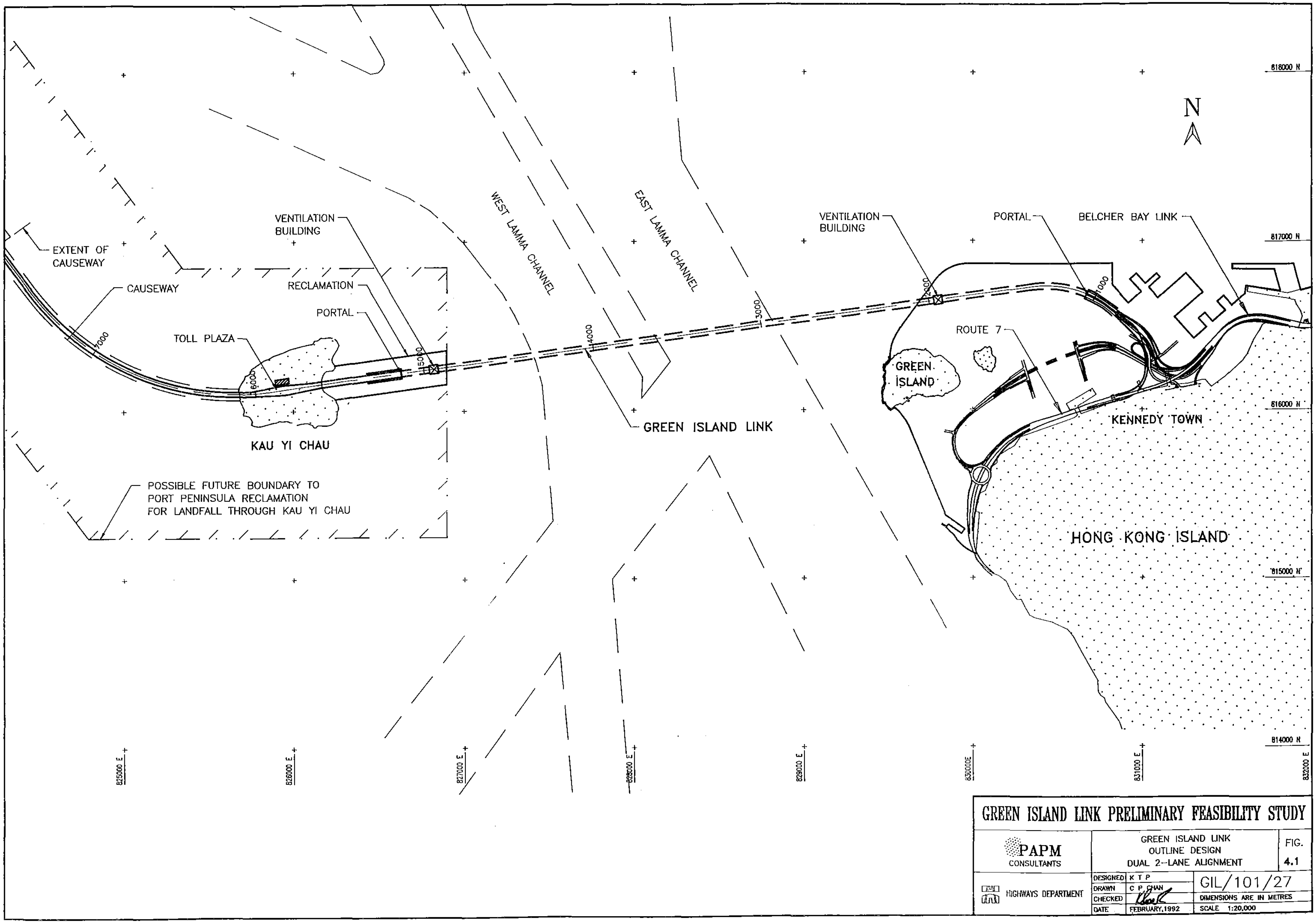


KEY :

CENTRAL BYPASS

GREEN ISLAND LINK PRELIMINARY FEASIBILITY STUDY		
PAPM CONSULTANTS	CONCEPTUAL CENTRAL BYPASS	FIG. 3.3
HIGHWAYS DEPARTMENT	DESIGNED K T P DRAWN C P SHAN CHECKED [signature] DATE FEBRUARY,1992	GIL/101/26 DIMENSIONS ARE IN METRES SCALE 1:10,000


N
818000 N
817000 N
816000 N
815000 N
814000 N
825000 E
826000 E
827000 E
828000 E
829000 E
830000E
831000 E
832000 E
EXTENT OF CAUSEWAY
CAUSEWAY
VENTILATION BUILDING
RECLAMATION
PORTAL
TOLL PLAZA
KAU YI CHAU
POSSIBLE FUTURE BOUNDARY TO PORT PENINSULA RECLAMATION FOR LANDFALL THROUGH KAU YI CHAU
WEST LAMMA CHANNEL
EAST LAMMA CHANNEL
GREEN ISLAND LINK
VENTILATION BUILDING
PORTAL
BELCHER BAY LINK
ROUTE 7
GREEN ISLAND
KENNEDY TOWN
HONG KONG ISLAND
7000
6000
5000
4000
3000
2000
1000
GREEN ISLAND LINK PRELIMINARY FEASIBILITY STUDY
PAPM CONSULTANTS
HIGHWAYS DEPARTMENT
GREEN ISLAND LINK OUTLINE DESIGN DUAL 2-LANE ALIGNMENT
FIG. 4.1
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DRAWN C P CHAN
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DATE FEBRUARY,1992
GIL/101/27
DIMENSIONS ARE IN METRES
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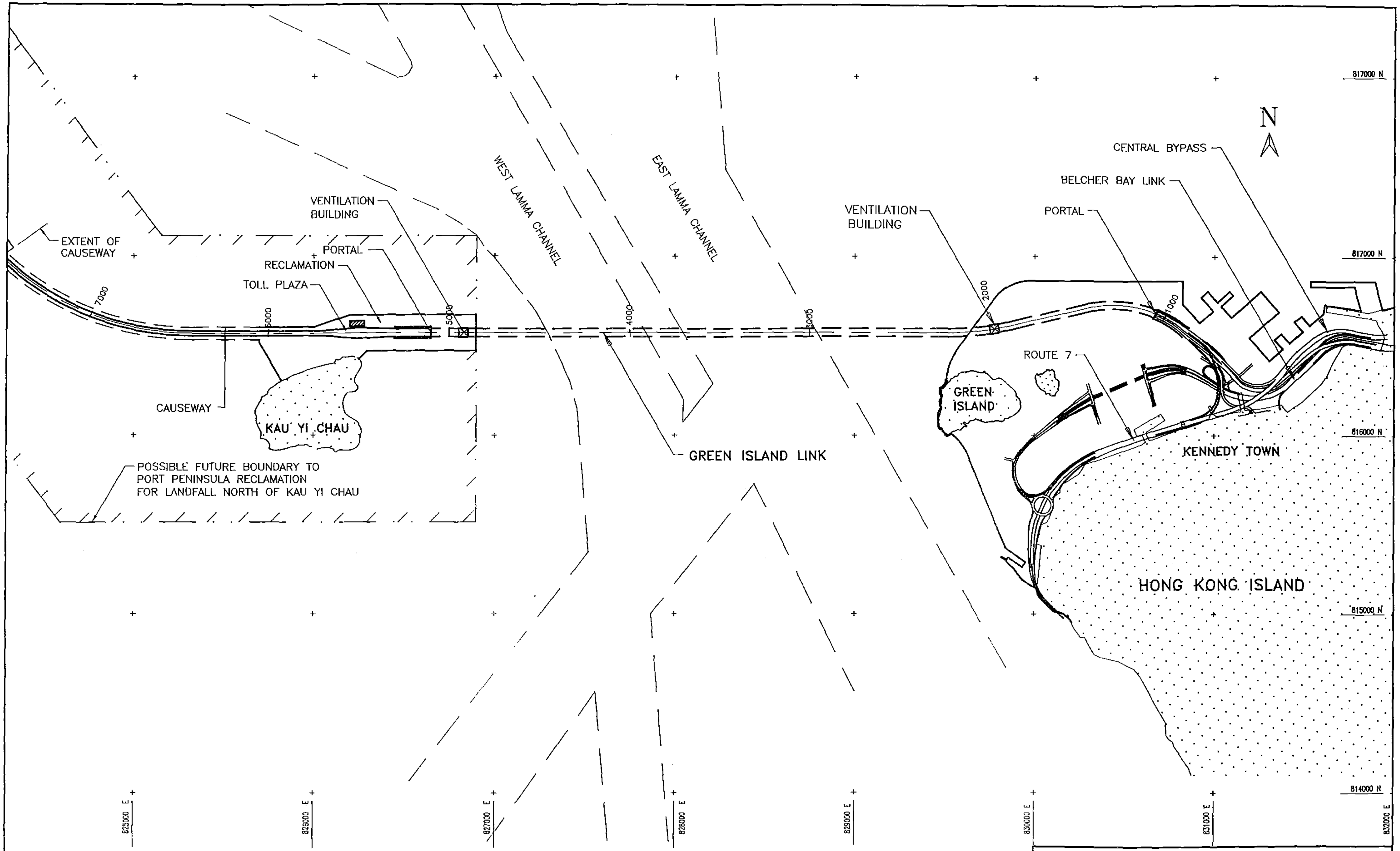

GREEN ISLAND LINK PRELIMINARY FEASIBILITY STUDY

PAPM CONSULTANTS

GREEN ISLAND LINK
OUTLINE DESIGN
DUAL 3-LANE ALIGNMENT

FIG. 4.2

HIGHWAYS DEPARTMENT

DESIGNED	K T P	GIL/101/28
DRAWN	C P CHAN	
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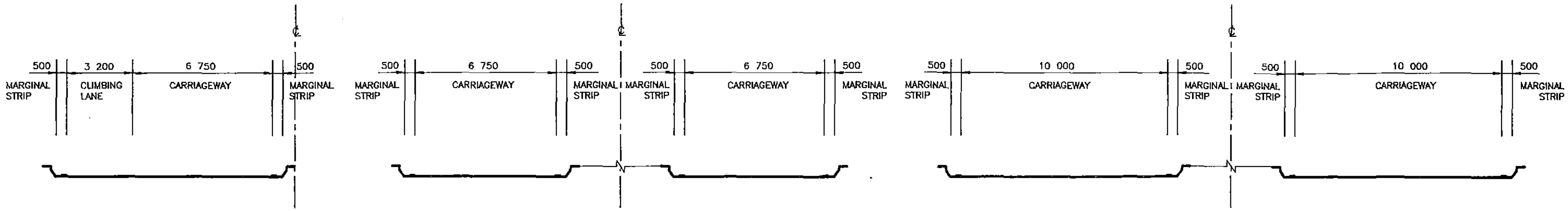
DATE	FEBRUARY, 1992	SCALE 1:20,000

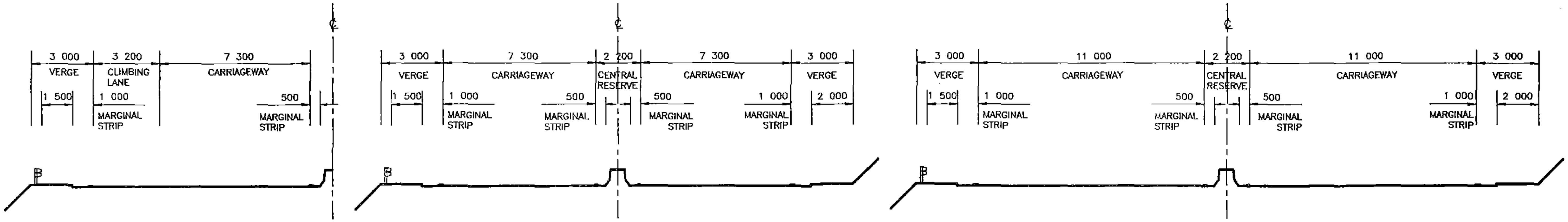


DUAL 2–LANE WITH CLIMBING LANE

DUAL 2–LANE

DUAL 3–LANE

TRUNK ROAD IN TUNNEL

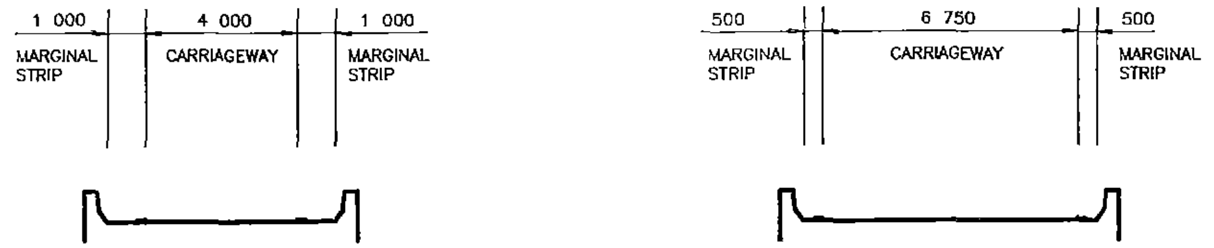


DUAL 2–LANE WITH CLIMBING LANE

DUAL 2–LANE

DUAL 3–LANE

STANDARD TRUNK ROAD

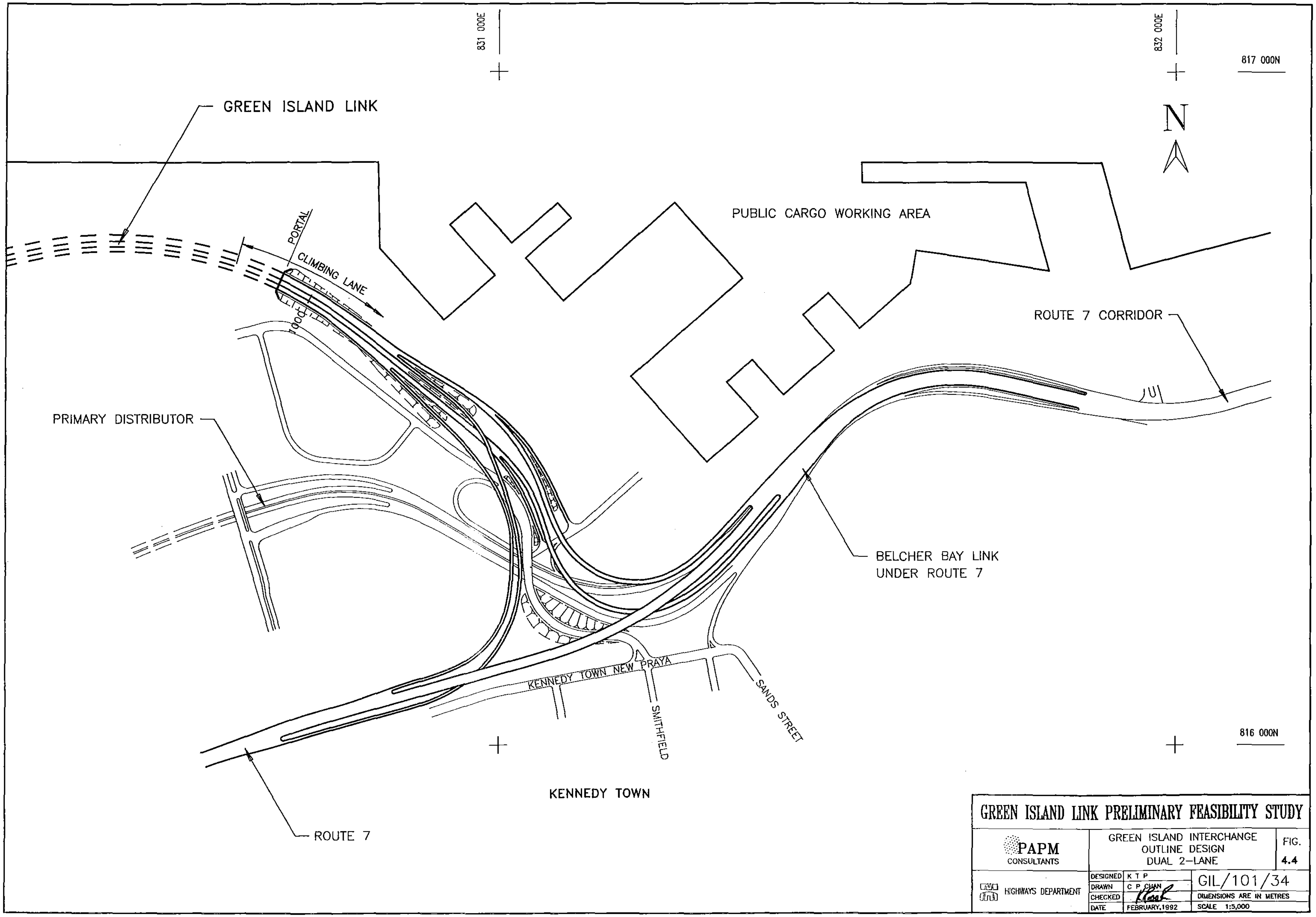


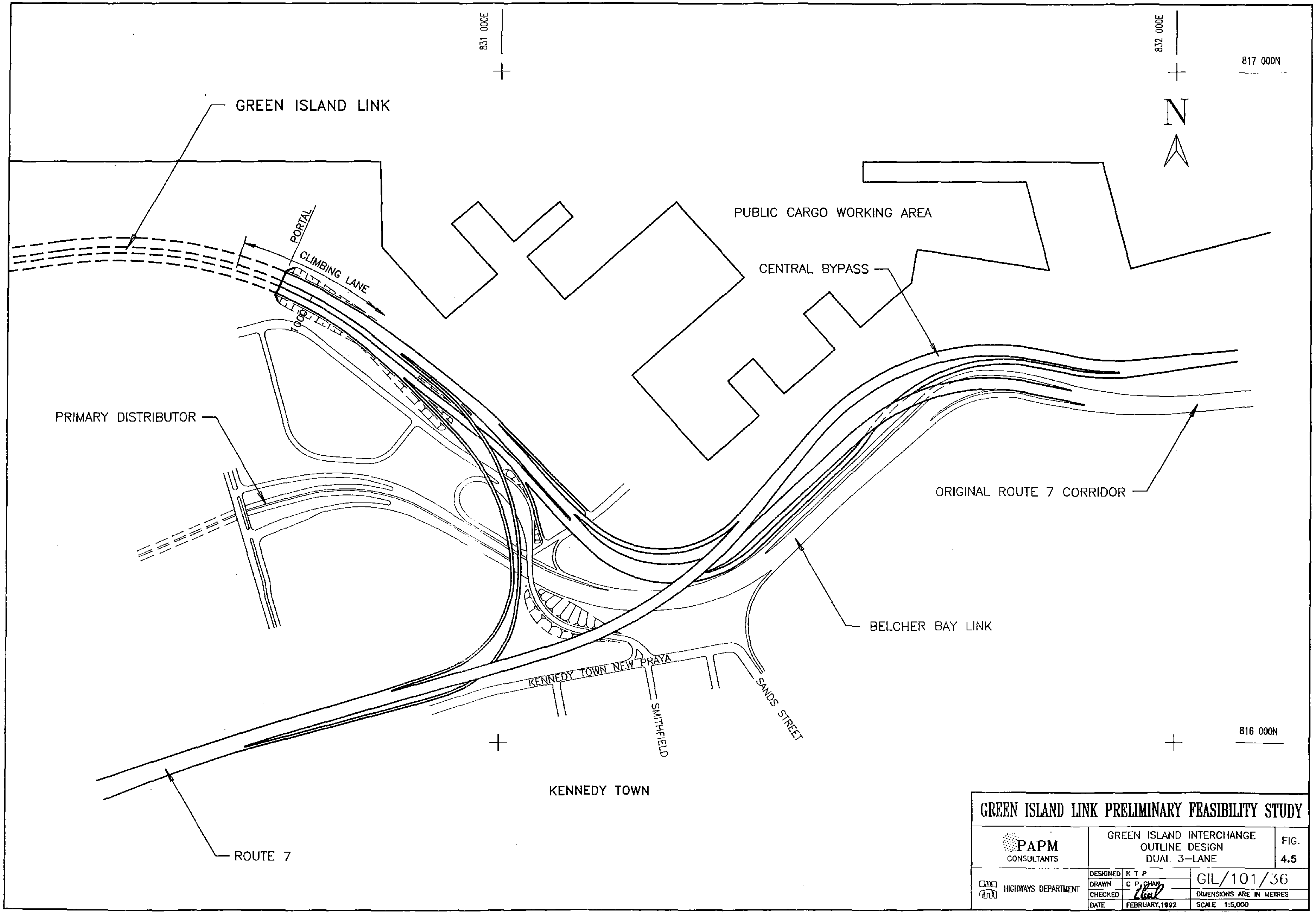
ELEVATED SINGLE CARRIAGEWAY ROAD
ONE LANE SLIP ROAD

ELEVATED SINGLE CARRIAGEWAY ROAD
TWO LANE SLIP ROAD

SLIP ROADS

GREEN ISLAND LINK PRELIMINARY FEASIBILITY STUDY		
PAPM CONSULTANTS	TYPICAL HIGHWAY CROSS SECTIONS	FIG. 4.3
HIGHWAYS DEPARTMENT	DESIGNED K T P DRAWN C P CHAN CHECKED DATE FEBRUARY.1992	GIL/100/3 DIMENSIONS ARE IN MILLIMETRES SCALE 1:200


831 000E
832 000E
817 000N
816 000N
N
GREEN ISLAND LINK
PORTAL
CLIMBING LANE
PUBLIC CARGO WORKING AREA
ROUTE 7 CORRIDOR
PRIMARY DISTRIBUTOR
BELCHER BAY LINK
UNDER ROUTE 7
KENNEDY TOWN NEW PRAYA
SMITHFIELD
SANDS STREET
KENNEDY TOWN
ROUTE 7
GREEN ISLAND LINK PRELIMINARY FEASIBILITY STUDY
PAPM
CONSULTANTS
GREEN ISLAND INTERCHANGE
OUTLINE DESIGN
DUAL 2-LANE
FIG.
4.4
HIGHWAYS DEPARTMENT
DESIGNED K T P
DRAWN C P CHAN
CHECKED
DATE FEBRUARY,1992
GIL/101/34
DIMENSIONS ARE IN METRES
SCALE 1:5,000



GREEN ISLAND LINK PRELIMINARY FEASIBILITY STUDY

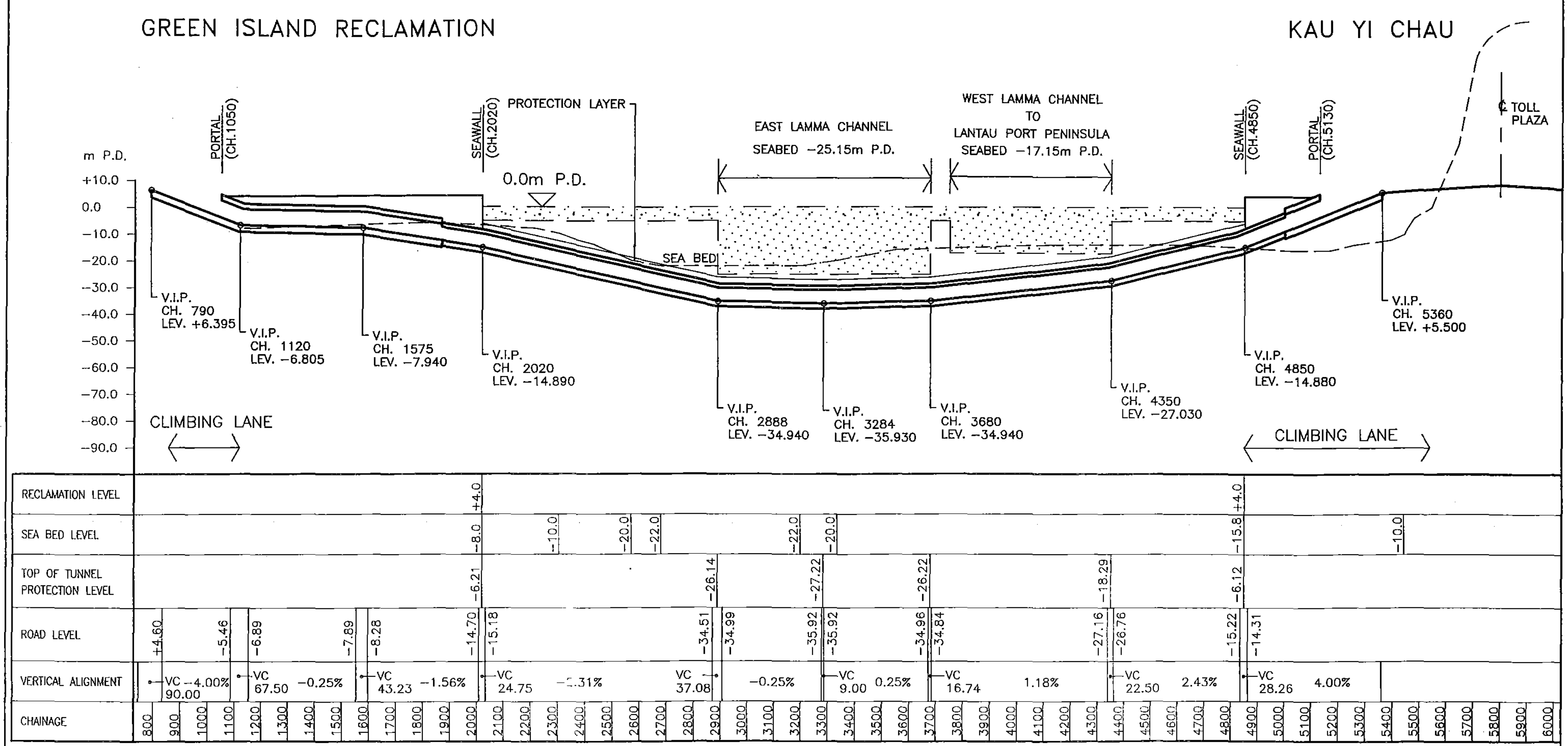
PAPM CONSULTANTS

HIGHWAYS DEPARTMENT

GREEN ISLAND INTERCHANGE
OUTLINE DESIGN
DUAL 3-LANE

FIG. 4.5

DESIGNED	K T P	GIL/101/36	
DRAWN	C P CHAN		
CHECKED	[signature]	DIMENSIONS ARE IN METRES	
DATE	FEBRUARY, 1992	SCALE 1:5,000	



GREEN ISLAND LINK PRELIMINARY FEASIBILITY STUDY

PAPM CONSULTANTS

HIGHWAYS DEPARTMENT

VERTICAL ALIGNMENT
ROUTE N-C
DUAL 2-LANE (CONCRETE)

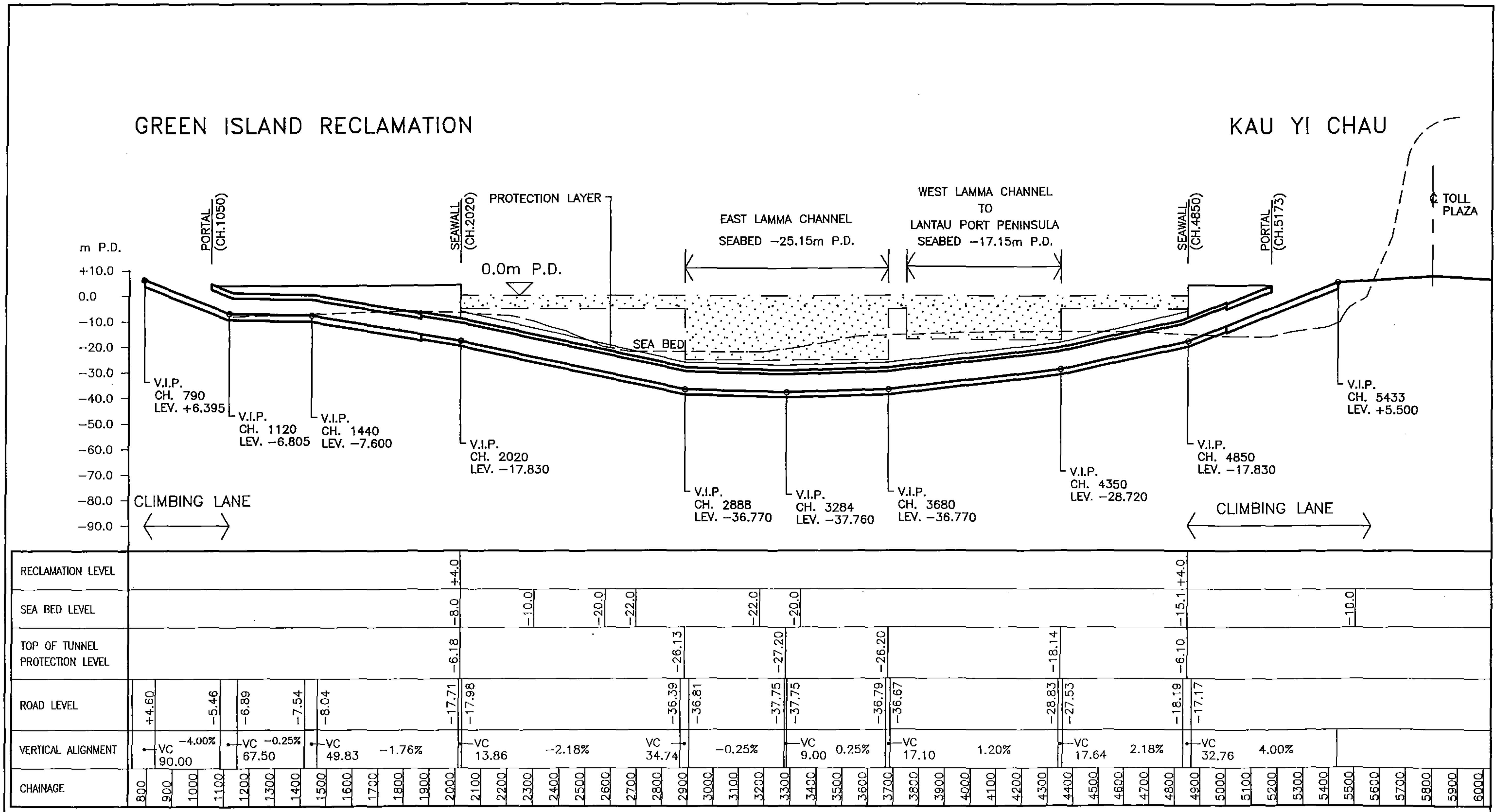
FIG. 4.6

DESIGNED	K T P
DRAWN	C P CHAN
CHECKED	[signature]
DATE	FEBRUARY,1992

GIL/101/2

DIMENSIONS ARE IN METRES

SCALE H 1:15,000 V 1:1,500



GREEN ISLAND LINK PRELIMINARY FEASIBILITY STUDY

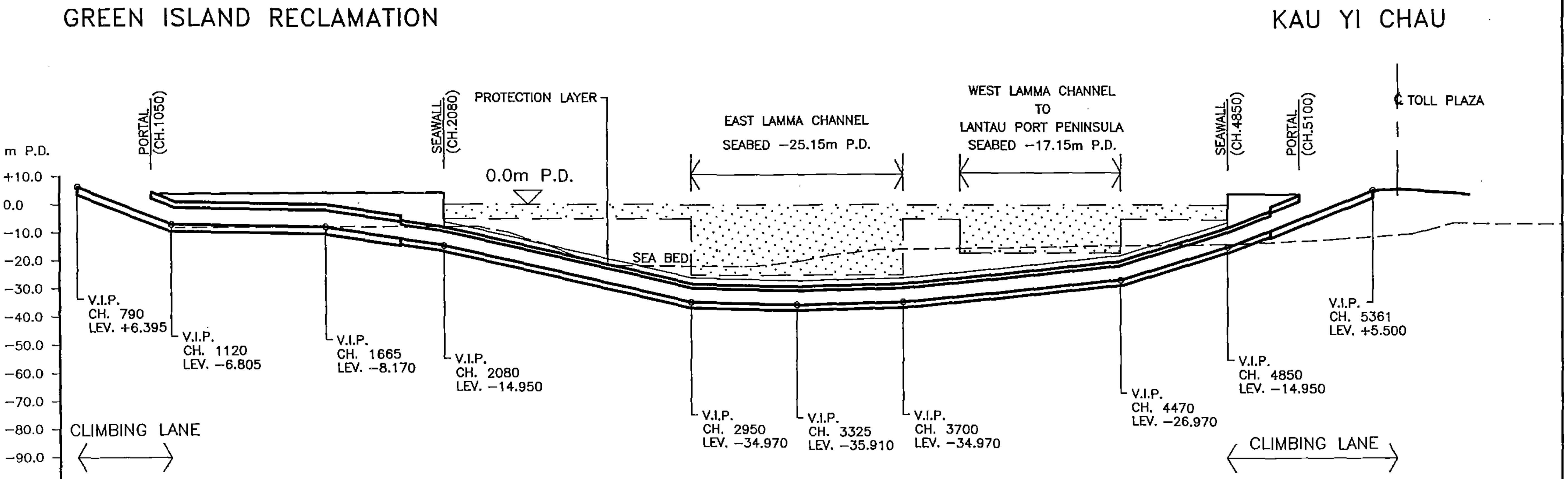
PAPM CONSULTANTS

HIGHWAYS DEPARTMENT

VERTICAL ALIGNMENT
ROUTE N–C
DUAL 2–LANE (STEEL)

FIG. 4.7

DESIGNED	K T P	GIL/101/32	
DRAWN	C P CHAN		
CHECKED	[signature]	DIMENSIONS ARE IN METRES	
DATE	FEBRUARY,1992	SCALE H 1:15,000 V 1:1,500	



RECLAMATION LEVEL: +4.0 (CH. 2080); +4.0 (CH. 4850)

SEA BED LEVEL: −8.00; −10.0; −20.0; −22.0; −22.0; −20.0; −13.85; −10.0

TOP OF TUNNEL PROTECTION LEVEL: −6.22; −26.13; −27.15; −26.21; −18.11; −6.18

ROAD LEVEL: −5.46; −6.89; −8.11; −8.54; −14.93; −15.20; −34.55; −35.01; −35.90; −35.90; −34.99; −34.90; −27.17; −26.37; −15.19; −14.65

VERTICAL ALIGNMENT: −4.00% | VC 67.50 | −0.25% | VC 45.54 | −1.63% | VC 22.11 | −2.30% | VC 36.90 | −0.25% | VC 9.00 | 0.25% | VC 14.22 | 1.04% | VC 38.16 | 3.16% | VC 15.12 | 4.00%

CHAINAGE: 800, 900, 1000, 1100, 1200, 1300, 1400, 1500, 1600, 1700, 1800, 1900, 2000, 2100, 2200, 2300, 2400, 2500, 2600, 2700, 2800, 2900, 3000, 3100, 3200, 3300, 3400, 3500, 3600, 3700, 3800, 3900, 4000, 4100, 4200, 4300, 4400, 4500, 4600, 4700, 4800, 4900, 5000, 5100, 5200, 5300, 5400, 5500, 5600, 5700, 5800, 5900, 6000

GREEN ISLAND LINK PRELIMINARY FEASIBILITY STUDY

PAPM CONSULTANTS

HIGHWAYS DEPARTMENT

VERTICAL ALIGNMENT
ROUTE N−N
DUAL 3−LANE (CONCRETE)

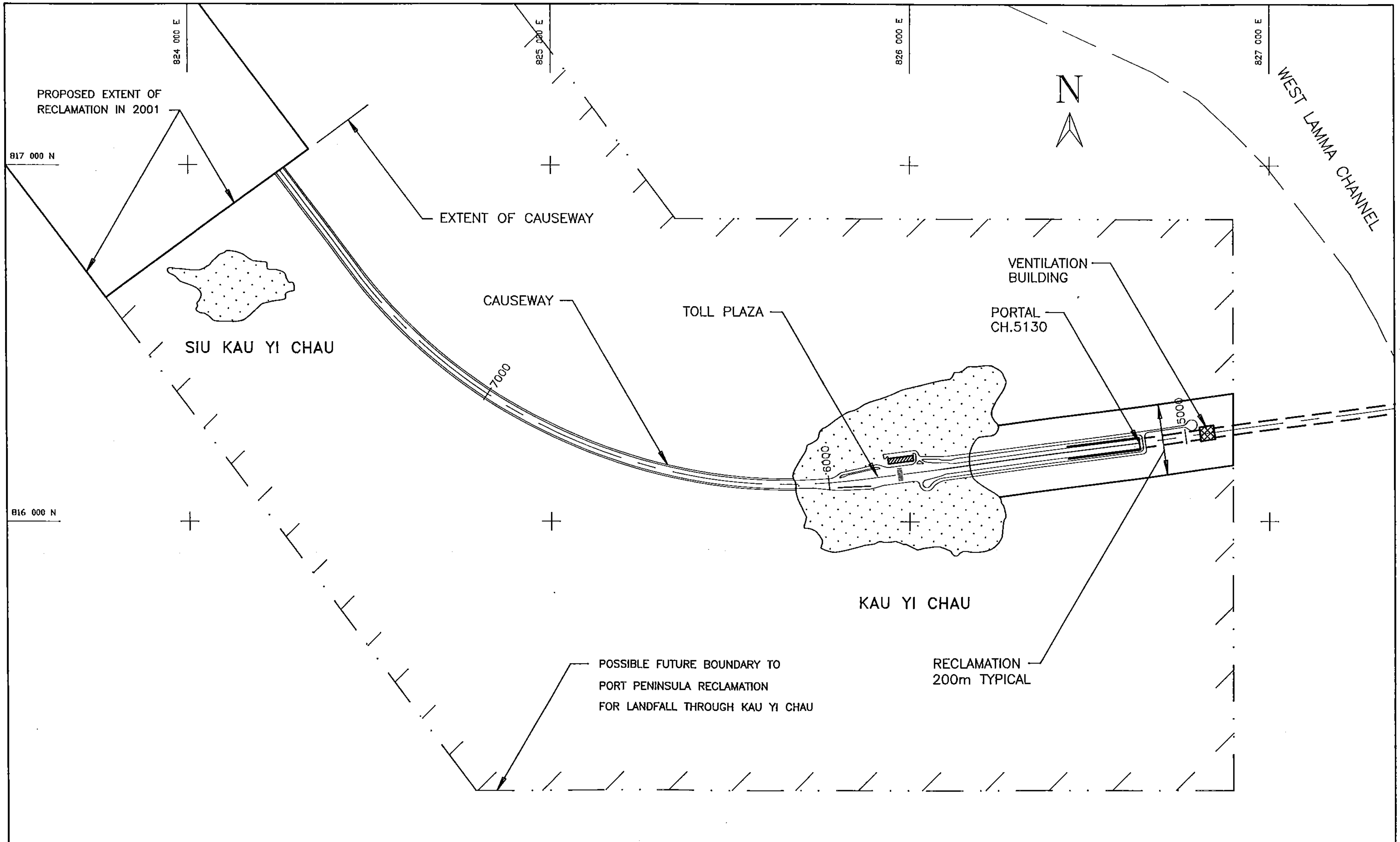
FIG. 4.8

DESIGNED	K T P
DRAWN	C P CHAN
CHECKED	[signature]
DATE	FEBRUARY,1992

GIL/101/33

DIMENSIONS ARE IN METRES

SCALE H 1:15,000 V 1:1,500



GREEN ISLAND LINK PRELIMINARY FEASIBILITY STUDY

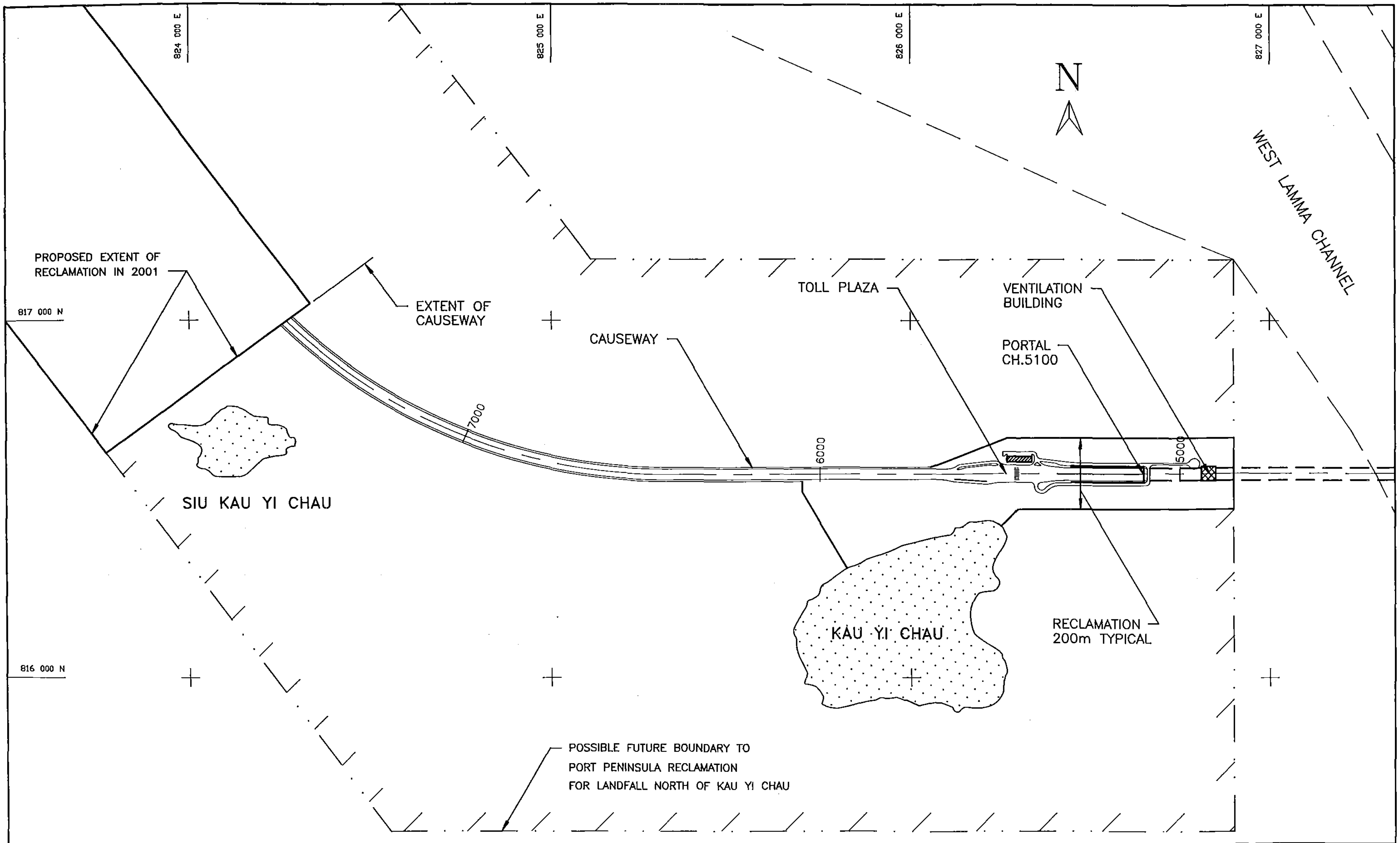
PAPM CONSULTANTS

HIGHWAYS DEPARTMENT

KAU YI CHAU LANDFALL
OUTLINE DESIGN
DUAL 2-LANE

FIG. 4.9

DESIGNED	K T P	GIL/101/18	
DRAWN	C P CHAN		
CHECKED		DIMENSIONS ARE IN METRES	
DATE	FEBRUARY, 1992	SCALE 1:10,000	



GREEN ISLAND LINK PRELIMINARY FEASIBILITY STUDY

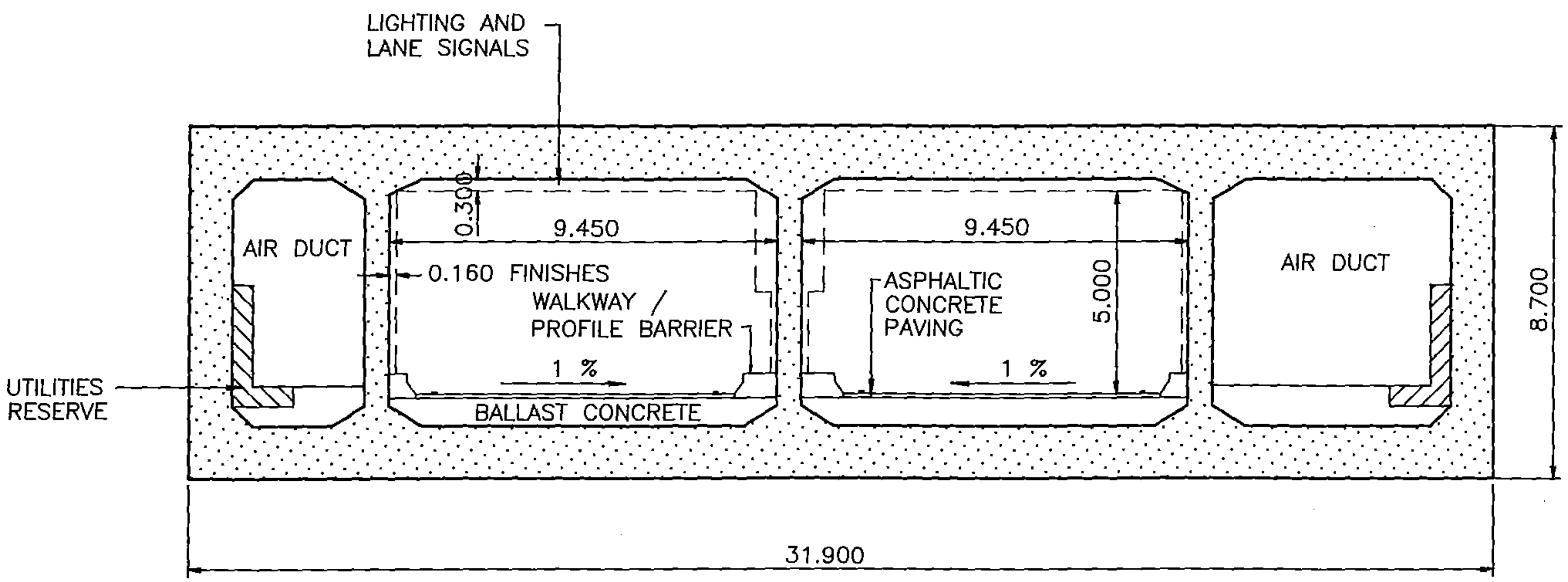
PAPM CONSULTANTS

HIGHWAYS DEPARTMENT

KAU YI CHAU LANDFALL
OUTLINE DESIGN
DUAL 3-LANE

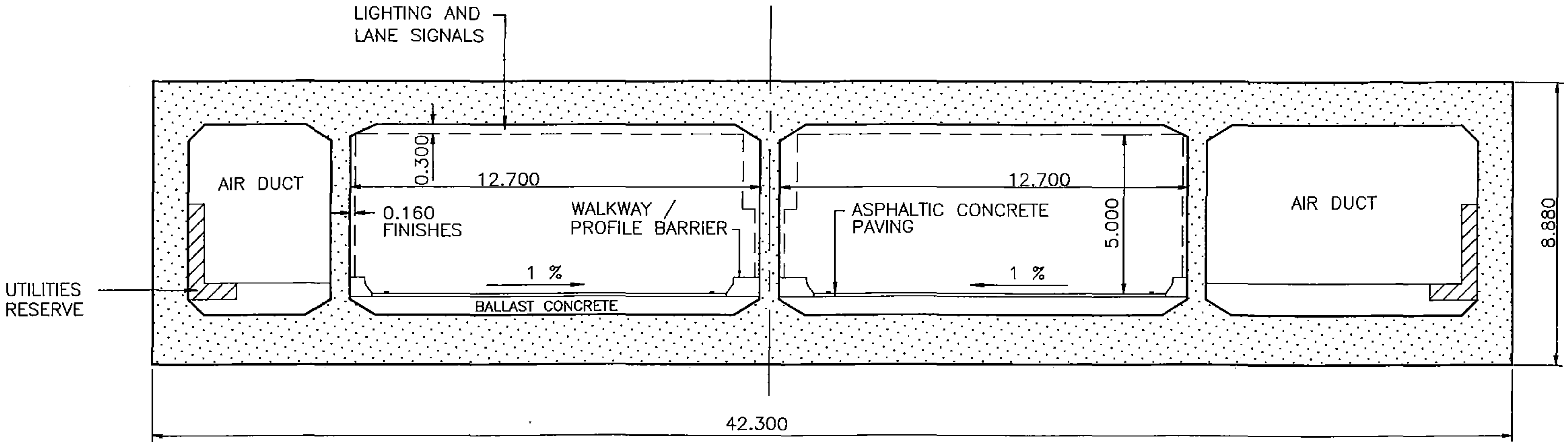
FIG. 4.10

DESIGNED	K T P	GIL/101/17	
DRAWN	C P CHAN		
CHECKED		DIMENSIONS ARE IN METRES	
DATE	FEBRUARY,1992	SCALE 1:10,000	



SECTION NEAR VENTILATION BUILDING

GREEN ISLAND LINK PRELIMINARY FEASIBILITY STUDY			
PAPM CONSULTANTS	IMMERSED TUBE TUNNEL DUAL 2-LANE (CONCRETE) TYPICAL SECTION		FIG. 5.1
HIGHWAYS DEPARTMENT	DESIGNED: C A H DRAWN: C P CHAN CHECKED: DATE: FEBRUARY, 1992	GIL/303.1/10 DIMENSIONS ARE IN METRES SCALE 1:150	



SECTION NEAR VENTILATION BUILDING

GREEN ISLAND LINK PRELIMINARY FEASIBILITY STUDY

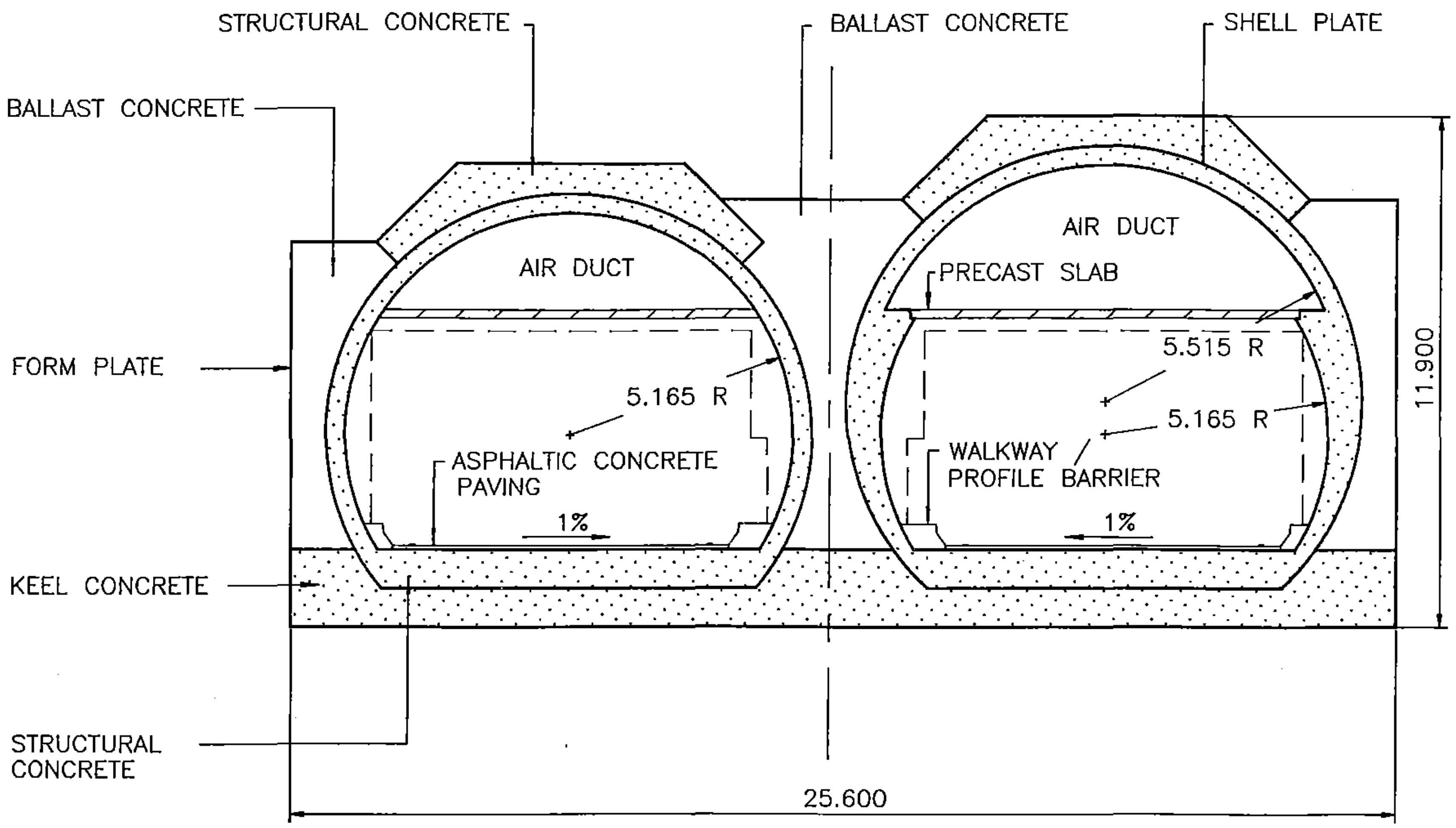
PAPM CONSULTANTS

IMMERSED TUBE TUNNEL
DUAL 3-LANE (CONCRETE)
TYPICAL SECTION

FIG. 5.2

HIGHWAYS DEPARTMENT

DESIGNED	G A H	GIL/303.1/11
DRAWN	C P CHAN	
CHECKED		DIMENSIONS ARE IN METRES
DATE	FEBRUARY,1992	SCALE 1:150



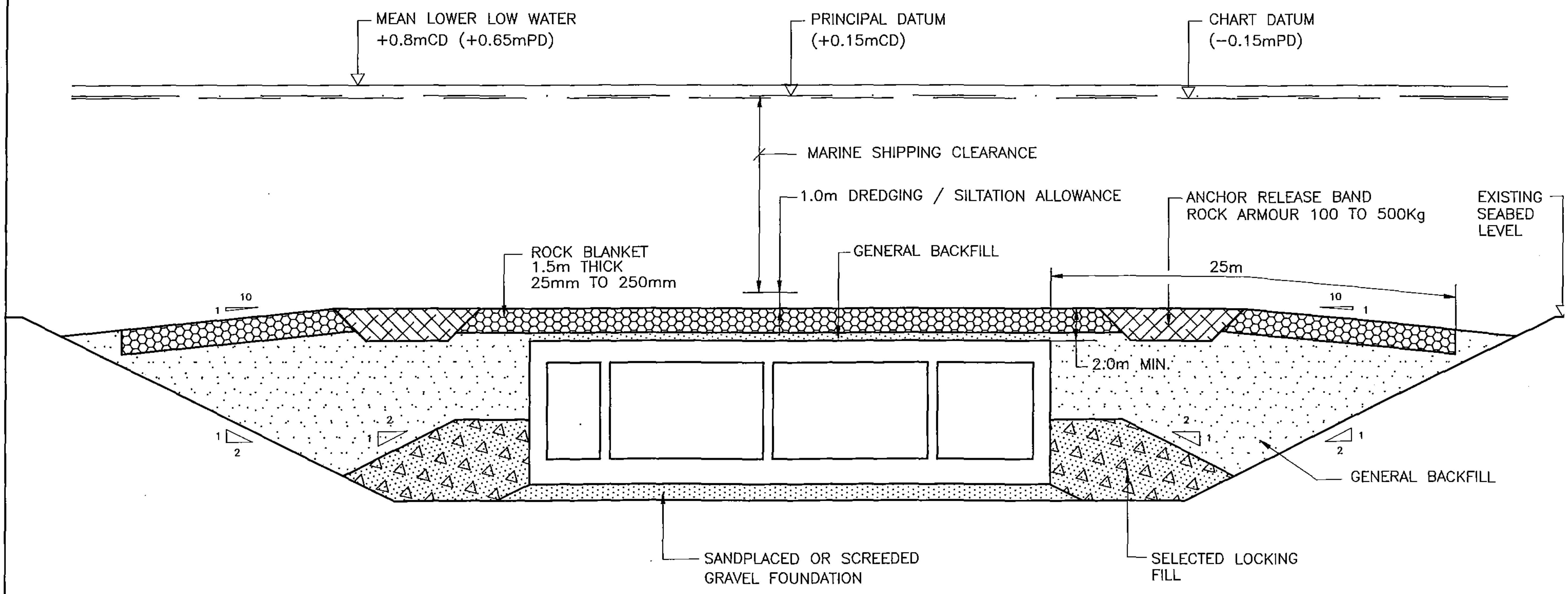
SECTION NEAR VENTILATION BUILDING

NOTE :

1. THE ASSYMETRICAL SECTION IS REQUIRED NEAR THE ENDS OF THE IMMERSED TUBE, IN ORDER TO PROVIDE ADDITIONAL AIR DUCT AREA.

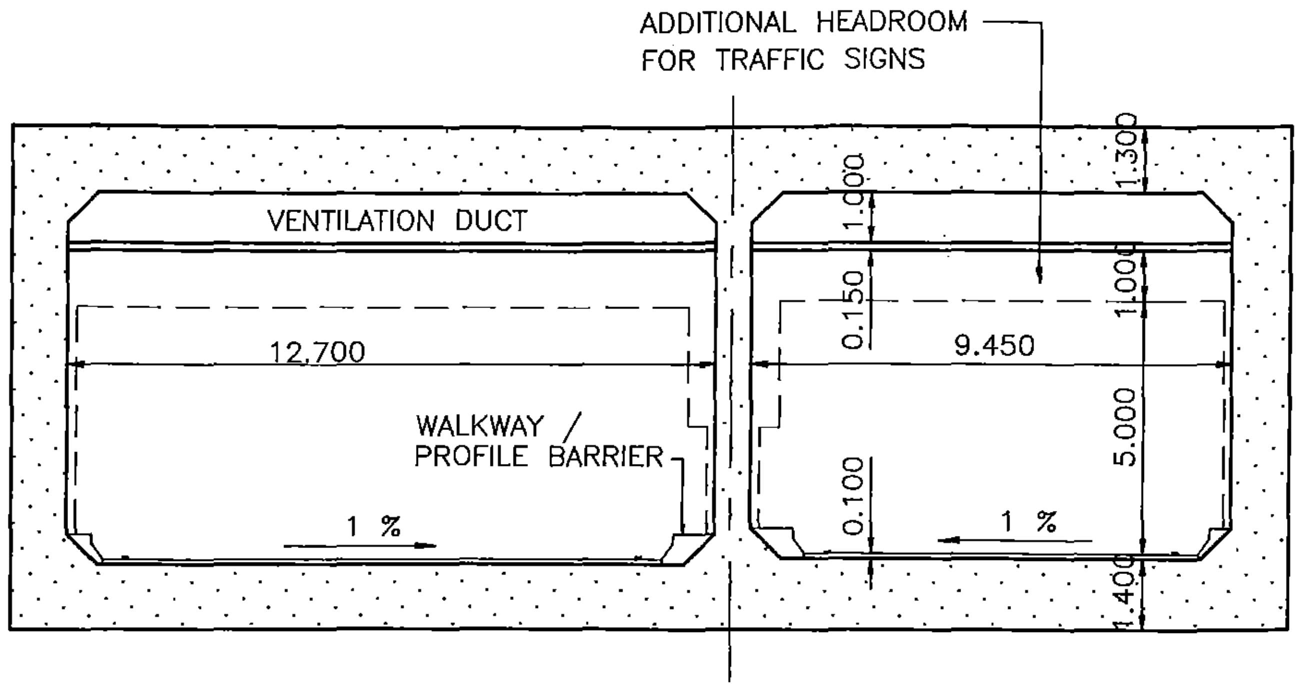
2. THE PROFILE OF THE VEHICLE DUCT WALL REMAINS CONSTANT THROUGHOUT THE TUNNEL.

GREEN ISLAND LINK PRELIMINARY FEASIBILITY STUDY				
PAPM CONSULTANTS	IMMERSED TUBE TUNNEL DUAL 2-LANE (STEEL) TYPICAL SECTION			FIG. 5.3
HIGHWAYS DEPARTMENT	DESIGNED	L C F I	GIL/303.1/8	
	DRAWN	C P CHAN		
	CHECKED	[signature]	DIMENSIONS ARE IN METRES	
	DATE	FEBRUARY,1992	SCALE 1:150	

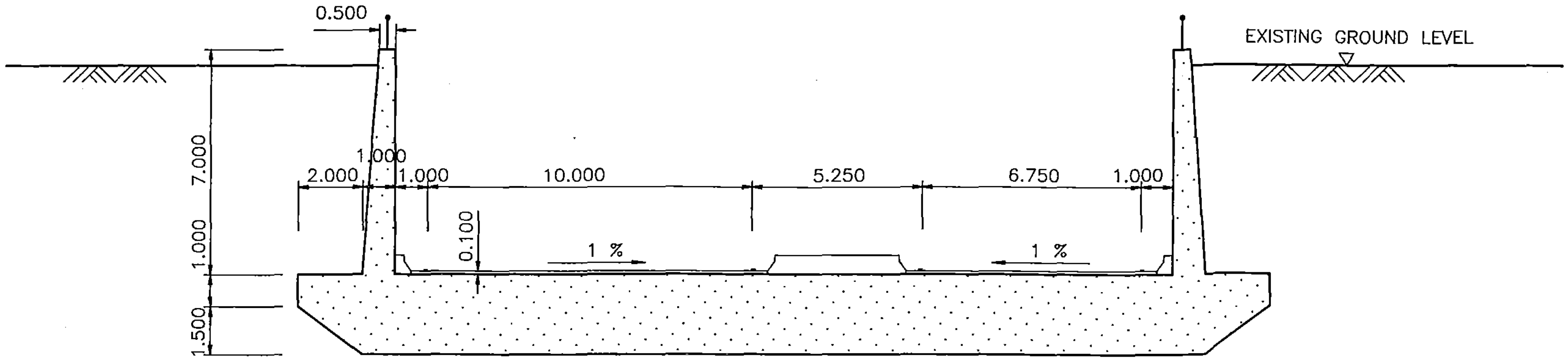


GREEN ISLAND LINK PRELIMINARY FEASIBILITY STUDY

PAPM CONSULTANTS	IMMERSED TUBE TUNNEL BACKFILL		FIG. 5.4
HIGHWAYS DEPARTMENT	DESIGNED: L C F I	GIL/303.1/2	
	DRAWN: C P CHAN	DIMENSIONS ARE IN METRES	
	CHECKED:	SCALE 1:250	
	DATE: FEBRUARY,1992		



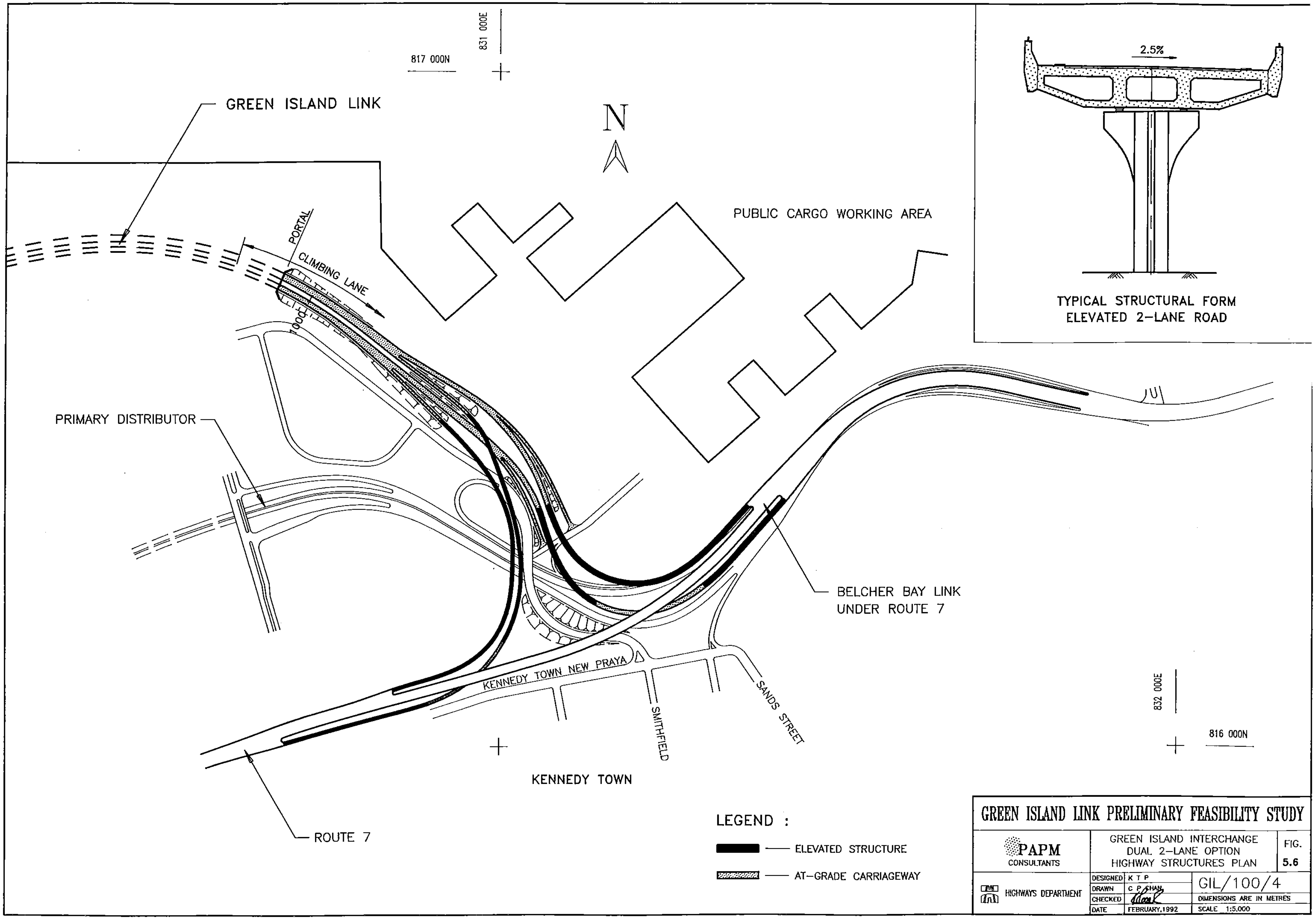
APPROACH TUNNEL WITH CLIMBING LANE



OPEN APPROACH RAMP

GREEN ISLAND LINK PRELIMINARY FEASIBILITY STUDY

PAPM CONSULTANTS	APPROACH TUNNEL AND RAMP	FIG. 5.5
HIGHWAYS DEPARTMENT	DESIGNED G A H DRAWN C P CHAN CHECKED [signature] DATE FEBRUARY, 1992	GIL/303.1/12 DIMENSIONS ARE IN METRES SCALE 1:150



GREEN ISLAND LINK PRELIMINARY FEASIBILITY STUDY

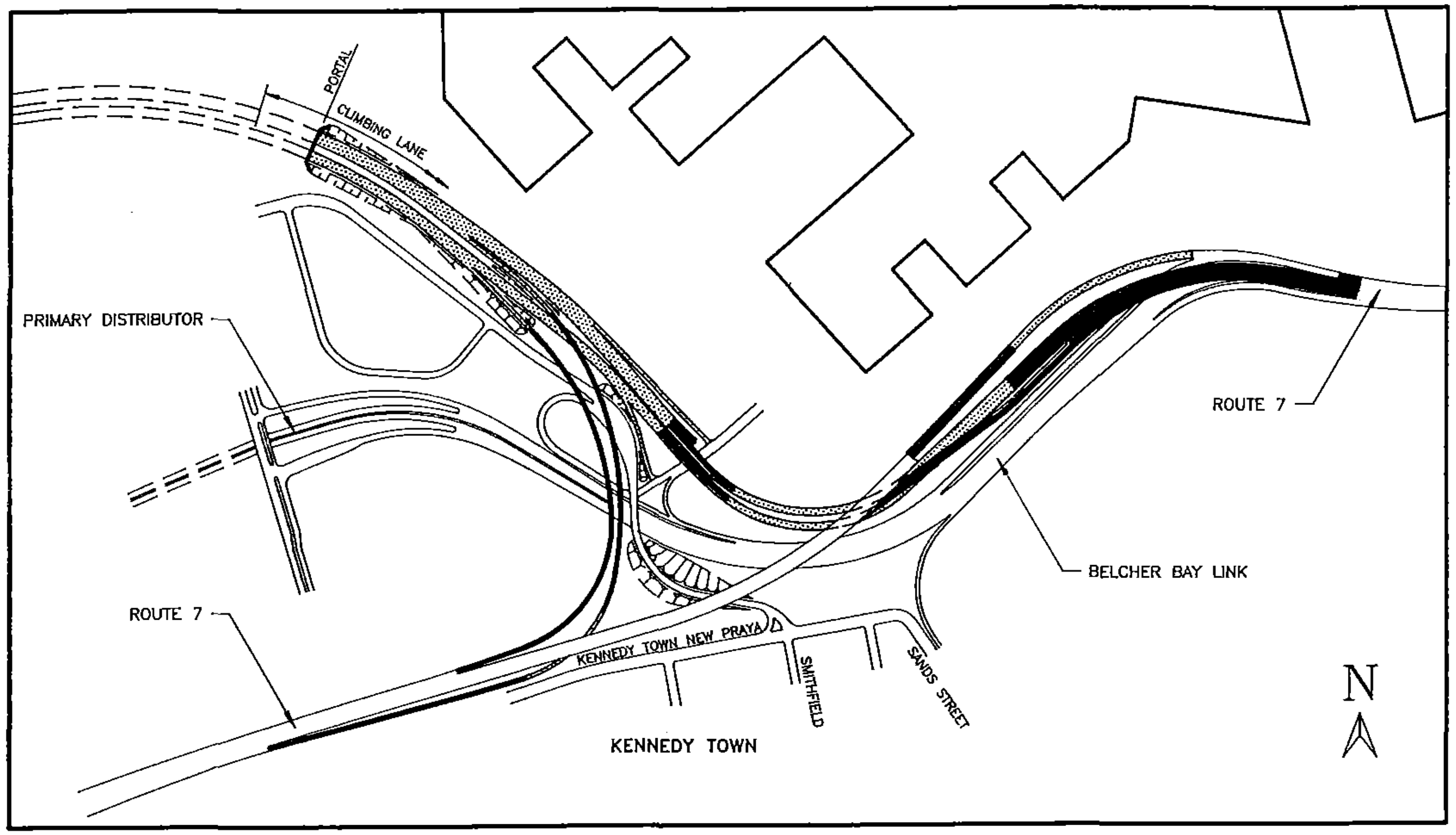
PAPM CONSULTANTS

HIGHWAYS DEPARTMENT

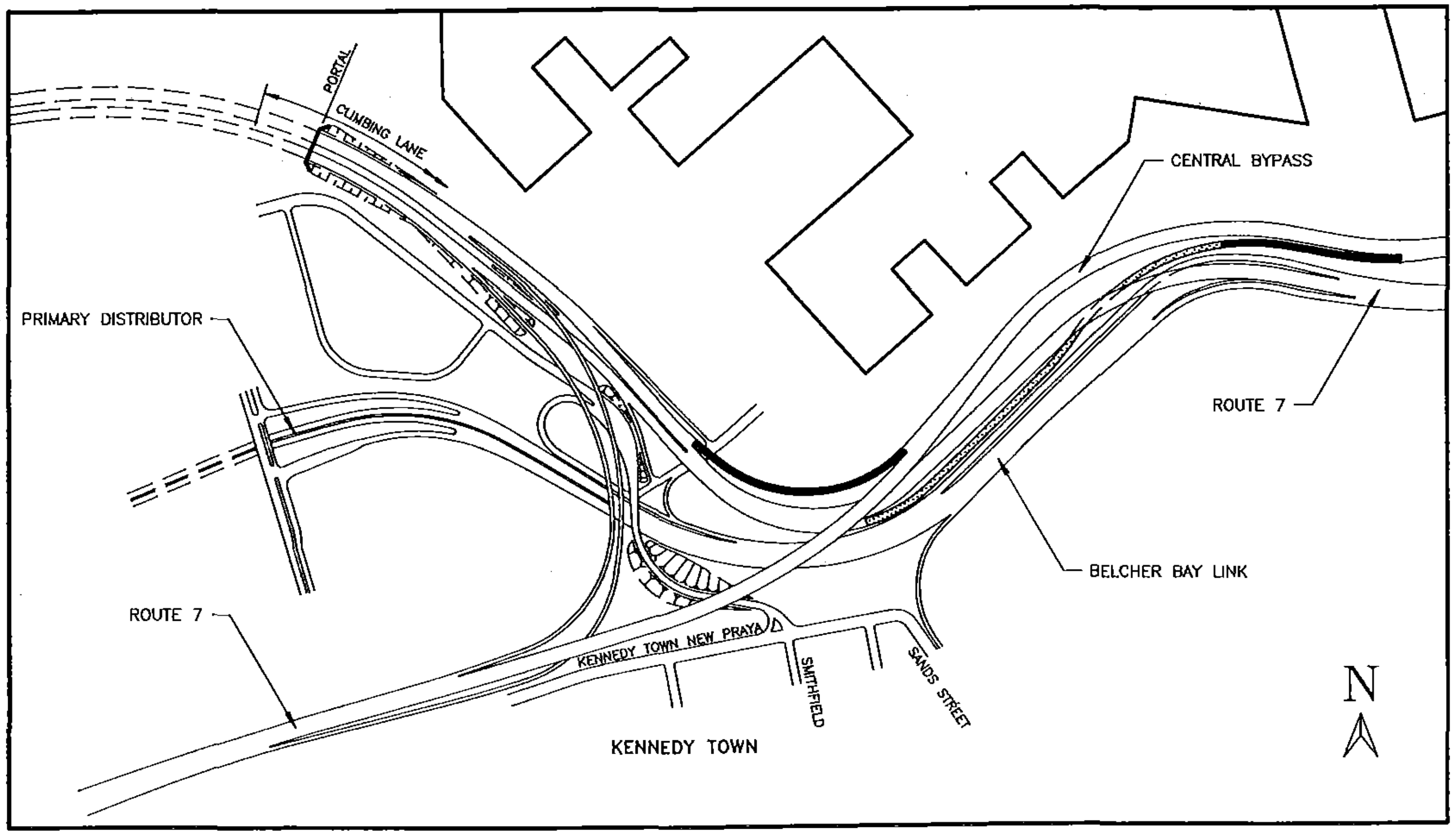
GREEN ISLAND INTERCHANGE
DUAL 2-LANE OPTION
HIGHWAY STRUCTURES PLAN

FIG. 5.6

DESIGNED	K T P	GIL/100/4	
DRAWN	C P SHAN		
CHECKED		DIMENSIONS ARE IN METRES	
DATE	FEBRUARY,1992	SCALE 1:5,000	



PHASE 1 : GREEN ISLAND LINK CONNECTION
WITH ROUTE 7 ONLY



PHASE 2 : GREEN ISLAND LINK CONNECTION
TO CENTRAL BYPASS

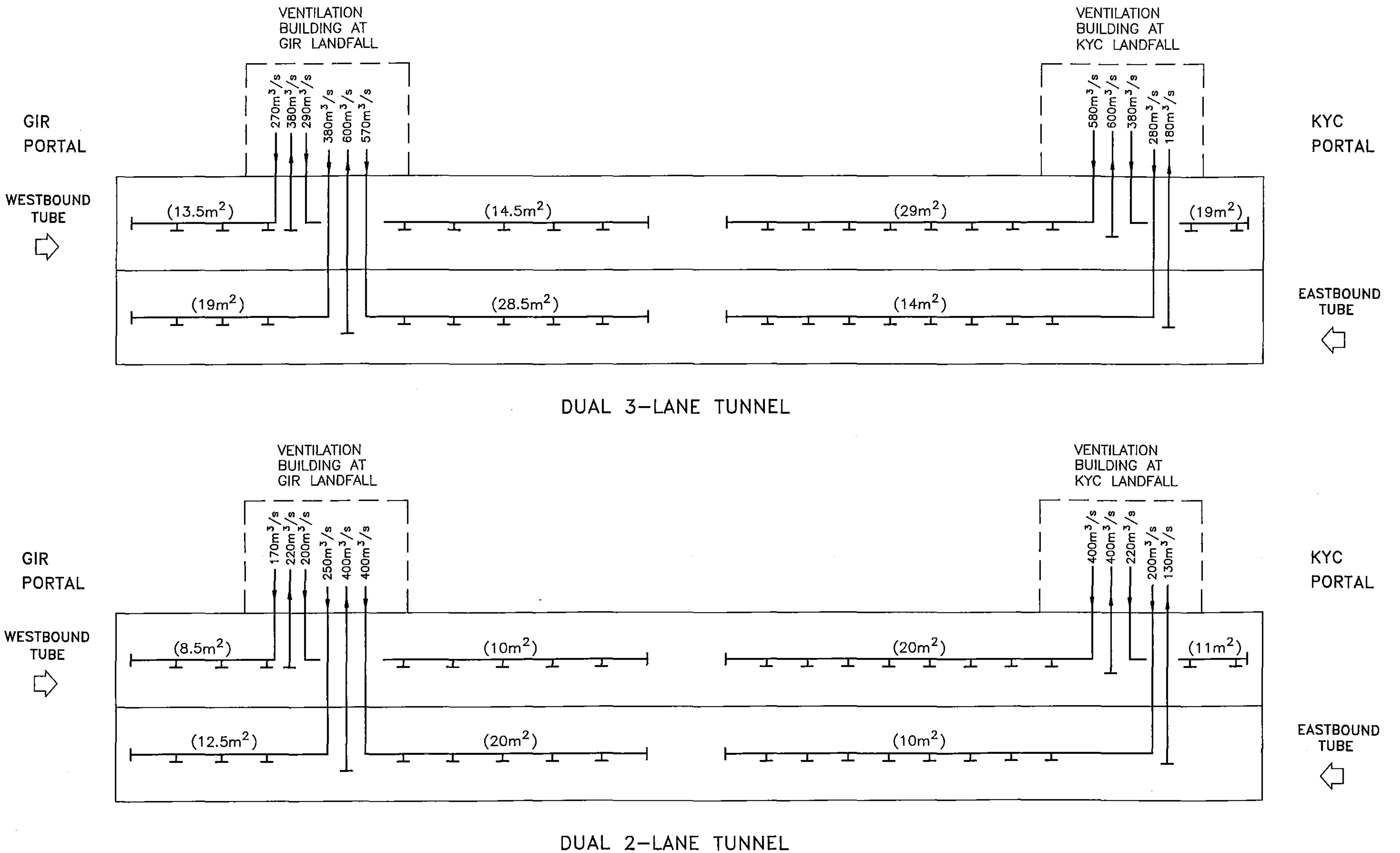
LEGEND :

— ELEVATED STRUCTURE

— AT-GRADE CARRIAGEWAY

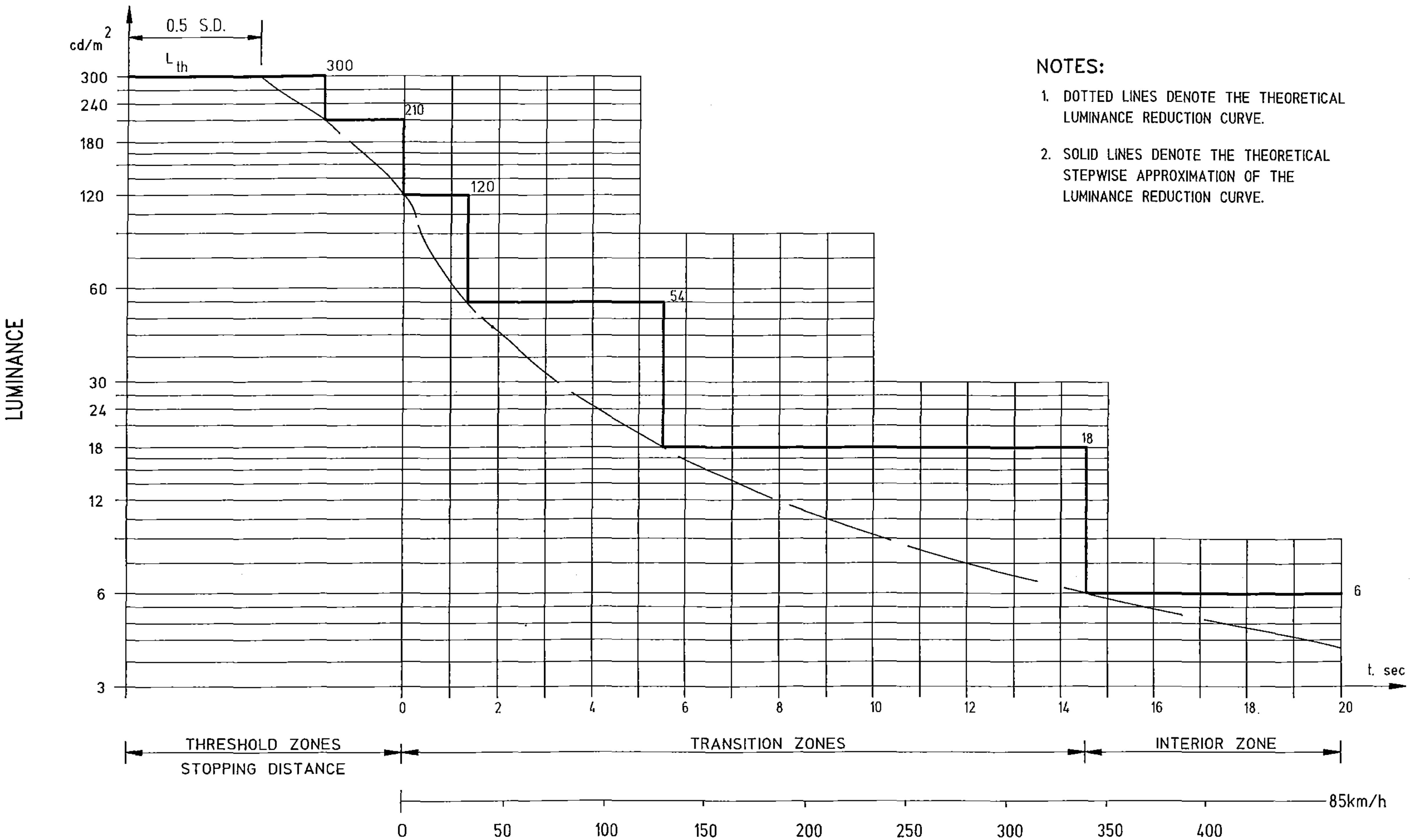
GREEN ISLAND LINK PRELIMINARY FEASIBILITY STUDY

PAPM CONSULTANTS	GREEN ISLAND INTERCHANGE DUAL 3-LANE OPTION HIGHWAY STRUCTURES PLAN	FIG. 5.7
HIGHWAYS DEPARTMENT	DESIGNED K T P DRAWN C P CHAN CHECKED [signature] DATE FEBRUARY,1992	GIL/100/5 DIMENSIONS ARE IN METRES SCALE 1:7,800 (APPROX.)



NOTE : FIGURES IN ( ) INDICATE MINIMUM SIZE OF AIR DUCT

GREEN ISLAND LINK PRELIMINARY FEASIBILITY STUDY		
PAPM CONSULTANTS	VENTILATION SCHEMATIC	FIG. 6.1
HIGHWAYS DEPARTMENT	DESIGNED L C F I; DRAWN W H WONG; CHECKED [signature]; DATE FEBRUARY, 1992	GIL/304.1/5; DIMENSIONS ARE IN; SCALE N.T.S.



NOTES:

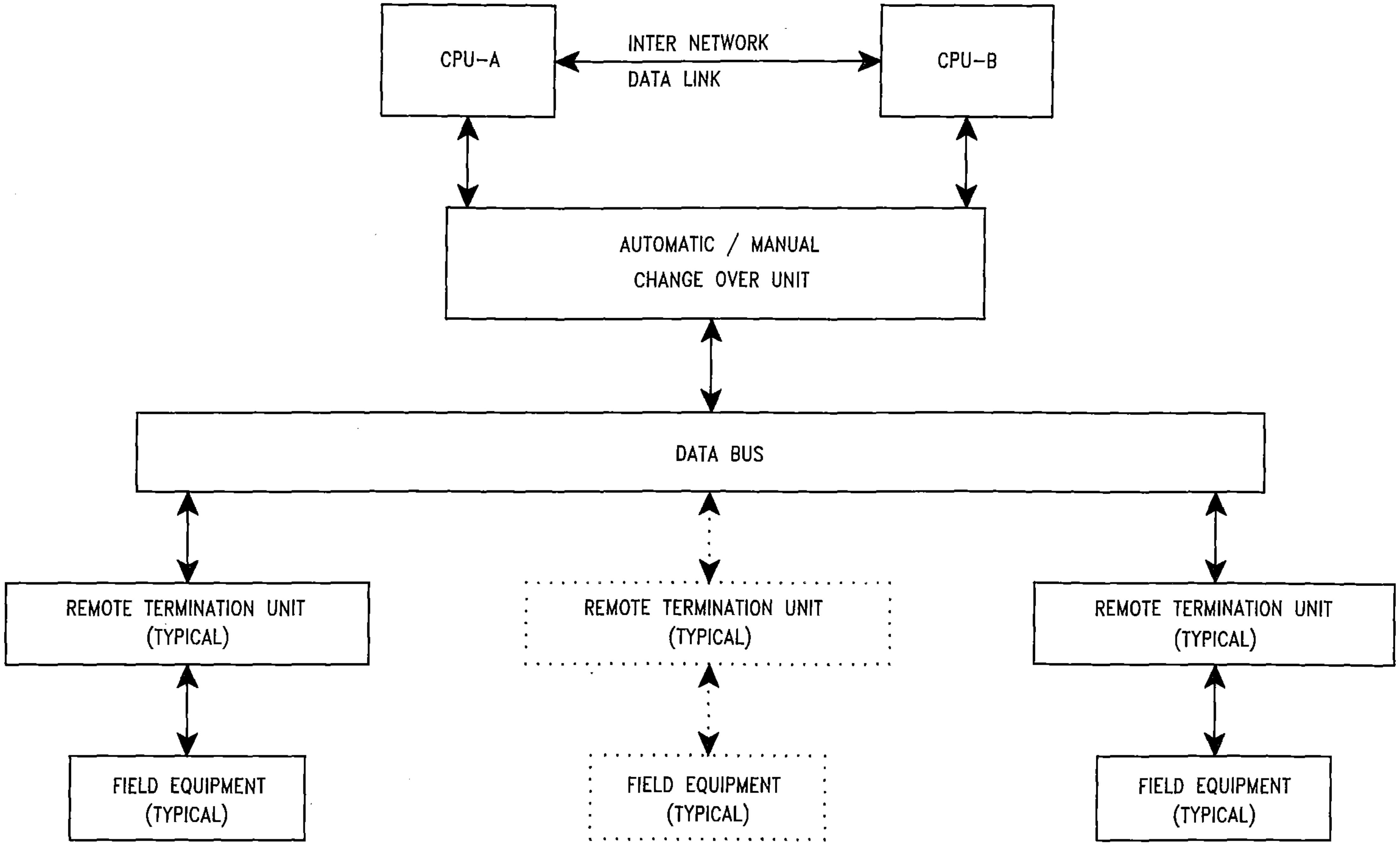
1. DOTTED LINES DENOTE THE THEORETICAL LUMINANCE REDUCTION CURVE.
2. SOLID LINES DENOTE THE THEORETICAL STEPWISE APPROXIMATION OF THE LUMINANCE REDUCTION CURVE.

LUMINANCE DIAGRAM AT TUNNEL PORTAL

(DESIGN SPEED 85 km/h)

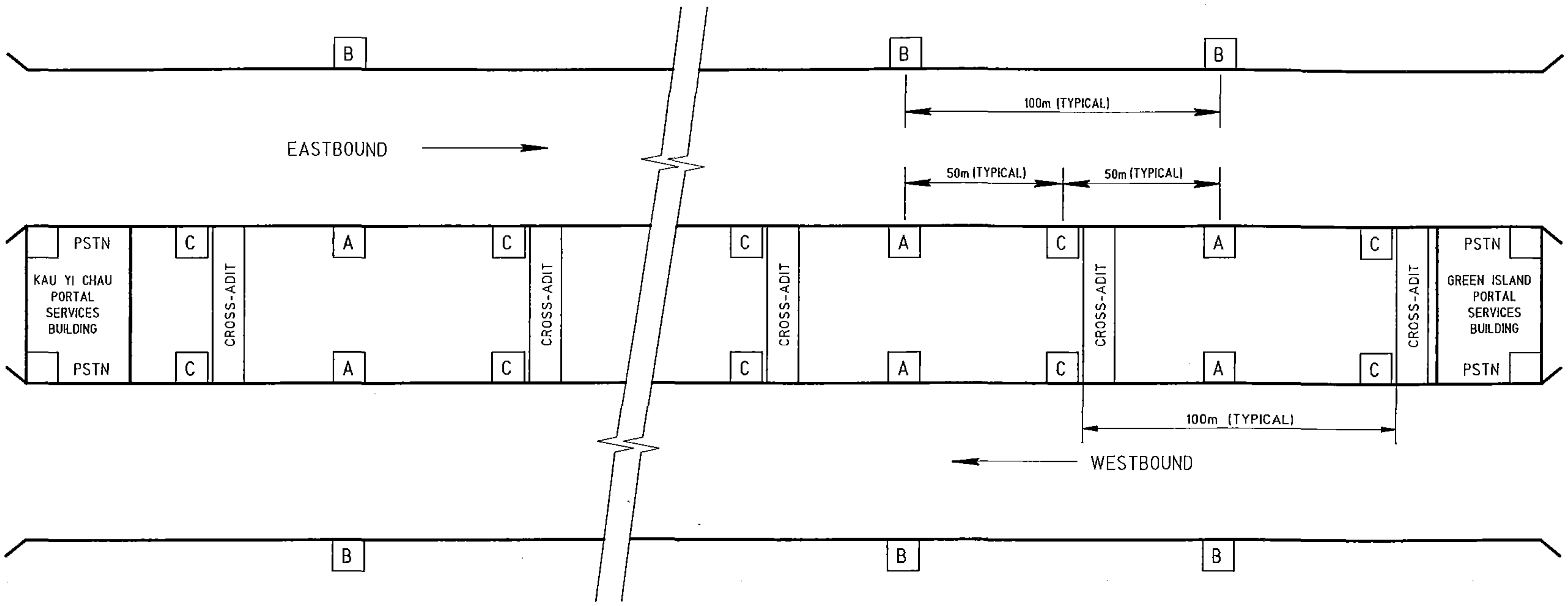
GREEN ISLAND LINK PRELIMINARY FEASIBILITY STUDY

PAPM CONSULTANTS	LUMINANCE DIAGRAM		FIG. 6.2
HIGHWAYS DEPARTMENT	DESIGNED L C F I DRAWN C P CHAN CHECKED DATE FEBRUARY, 1992	GIL/304.1/6 DIMENSIONS ARE IN SCALE AS SHOWN	



SCHEMATIC OF TRAFFIC COMPUTER SYSTEM

GREEN ISLAND LINK PRELIMINARY FEASIBILITY STUDY		
PAPM CONSULTANTS	TRAFFIC CONTROL SCHEMATIC	FIG. 6.3
HIGHWAYS DEPARTMENT	DESIGNED L C F I	GIL/304.1/7
	DRAWN C P CHAN	DIMENSIONS ARE IN
	CHECKED	
	DATE FEBRUARY 1992	SCALE



SAFETY EQUIPMENT INSIDE NICHES

LEGEND

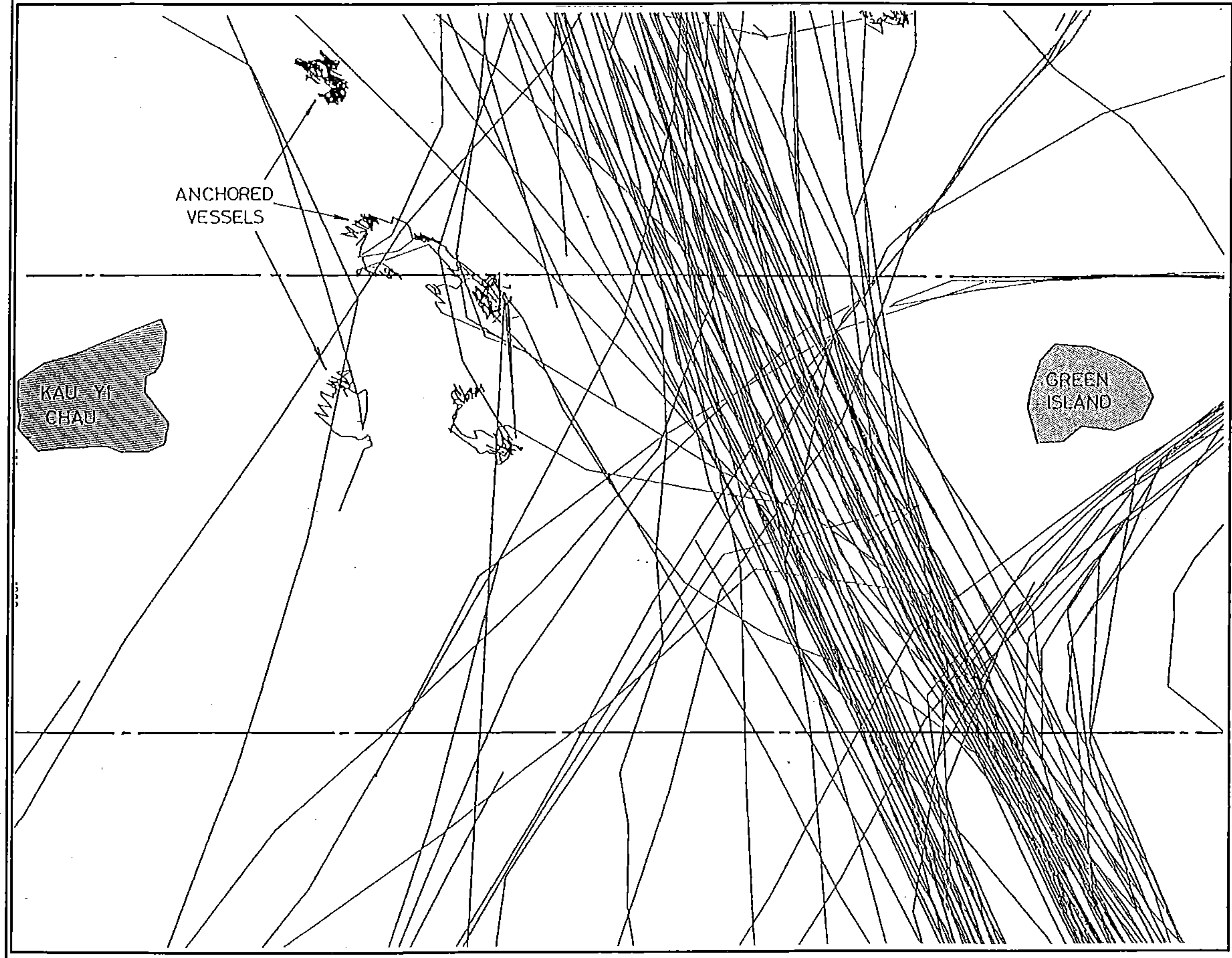
- A — NICHE TYPE A CONTAINING BG, ET, FE, FH, HR & SO
- B — NICHE TYPE B CONTAINING BG, ET, FE & SO
- C — NICHE TYPE C CONTAINING BG & HR

ABBREVIATION

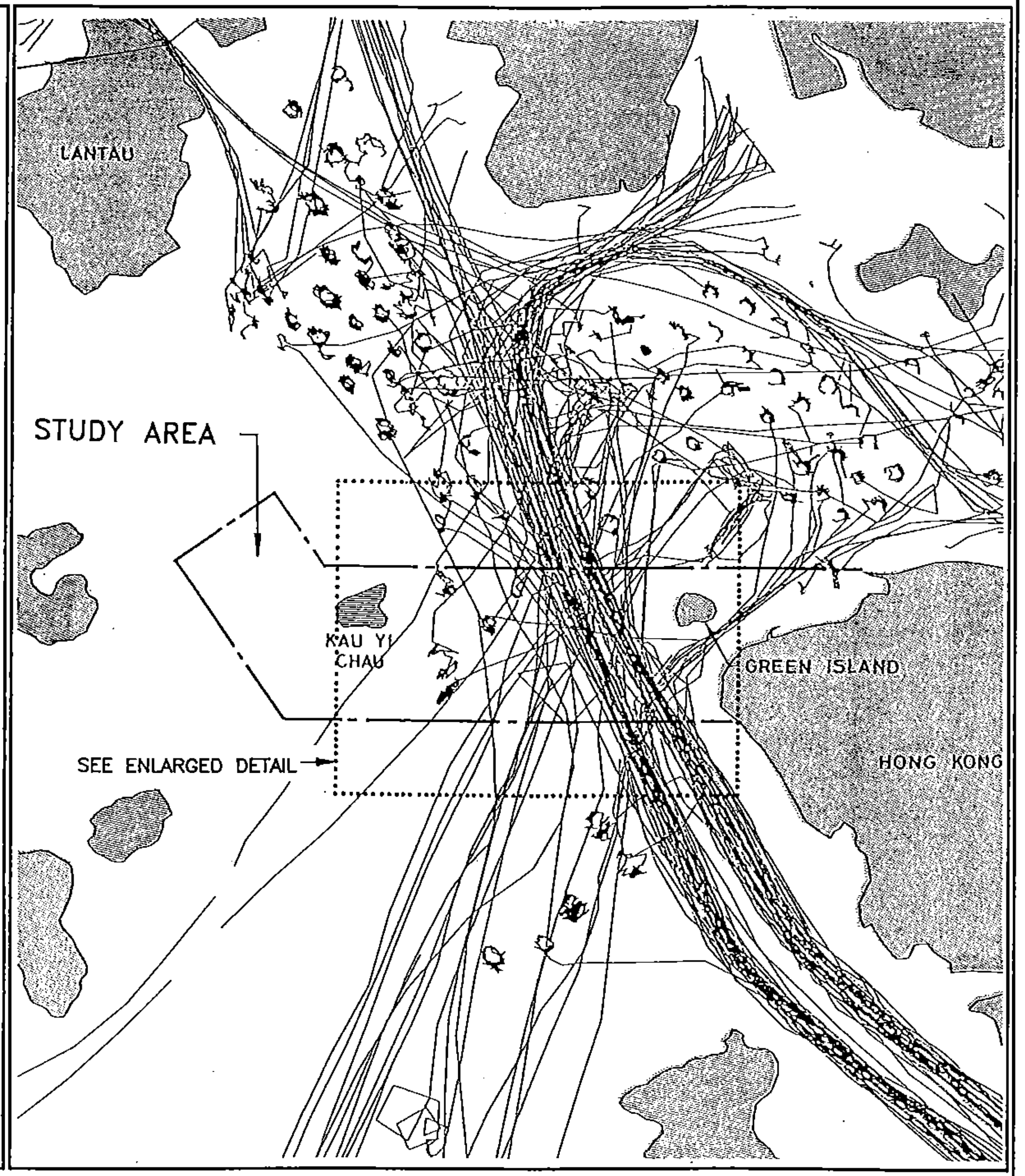
FH	FIRE HYDRANT
FE	FIRE EXTINGUISHER
BG	BREAK GLASS FIRE ALARM
HR	HOSE REEL
ET	EMERGENCY TELEPHONE
SO	SOCKET OUTLET
PSTN	PSTN TELEPHONE OUTLET

GREEN ISLAND LINK PRELIMINARY FEASIBILITY STUDY

PAPM CONSULTANTS	EQUIPMENT NICHES	FIG. 6.4
HIGHWAYS DEPARTMENT	DESIGNED L C F I; DRAWN C P CHAN; CHECKED [signature]; DATE FEBRUARY, 1992	GIL/304.1/8; DIMENSIONS ARE IN; SCALE N.T.S.



ENLARGED DETAIL

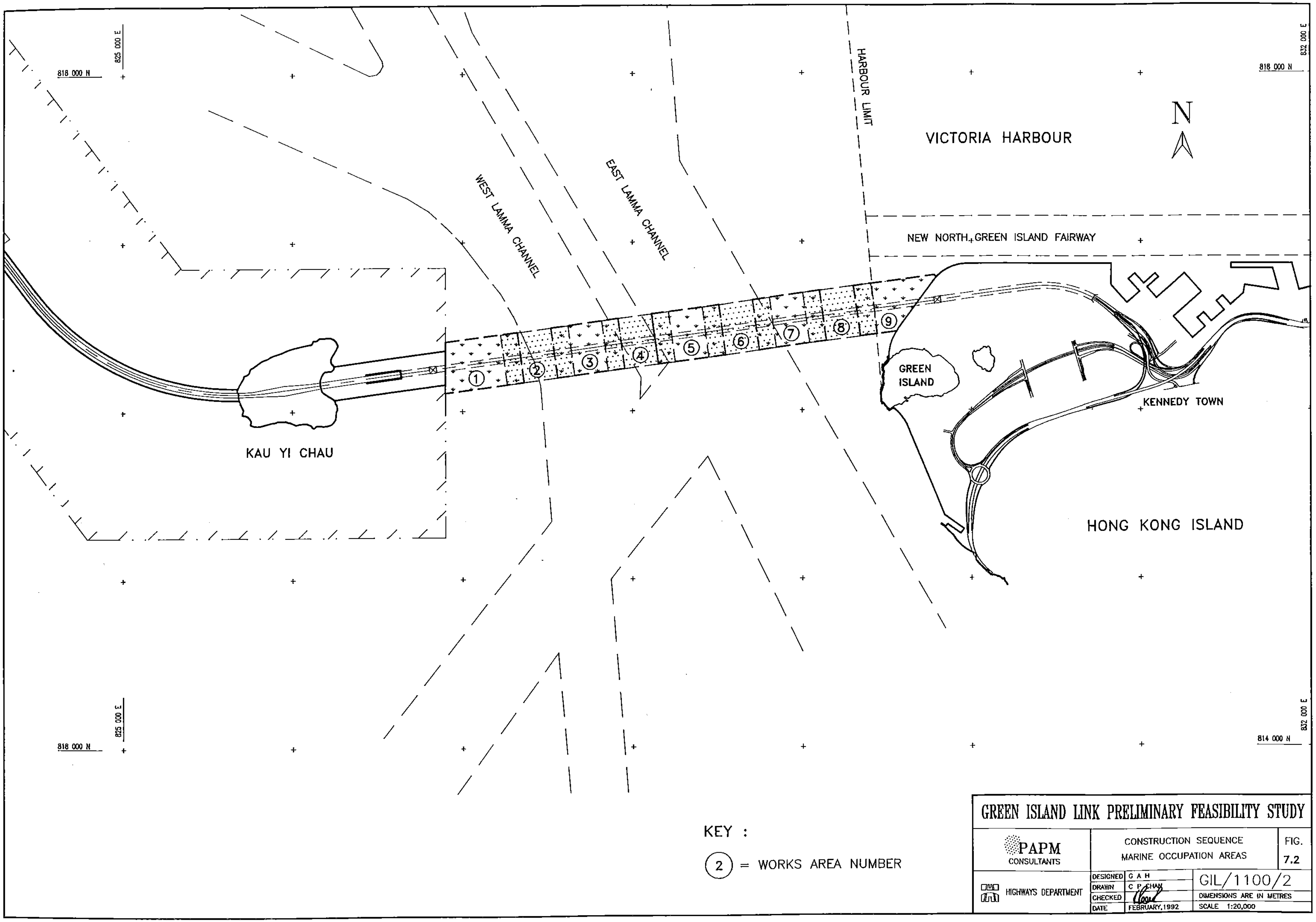


WESTERN HARBOUR

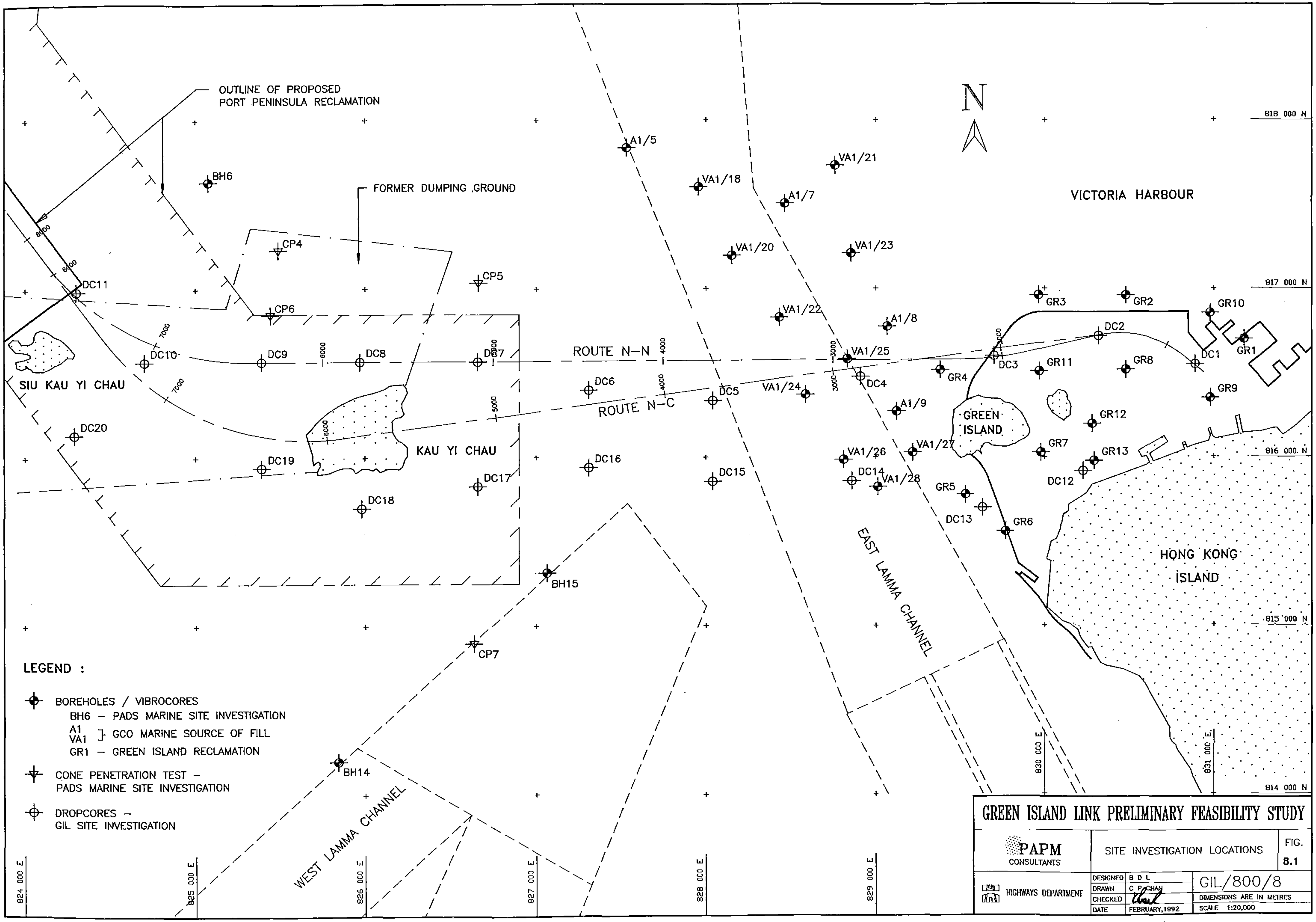
NOTE :

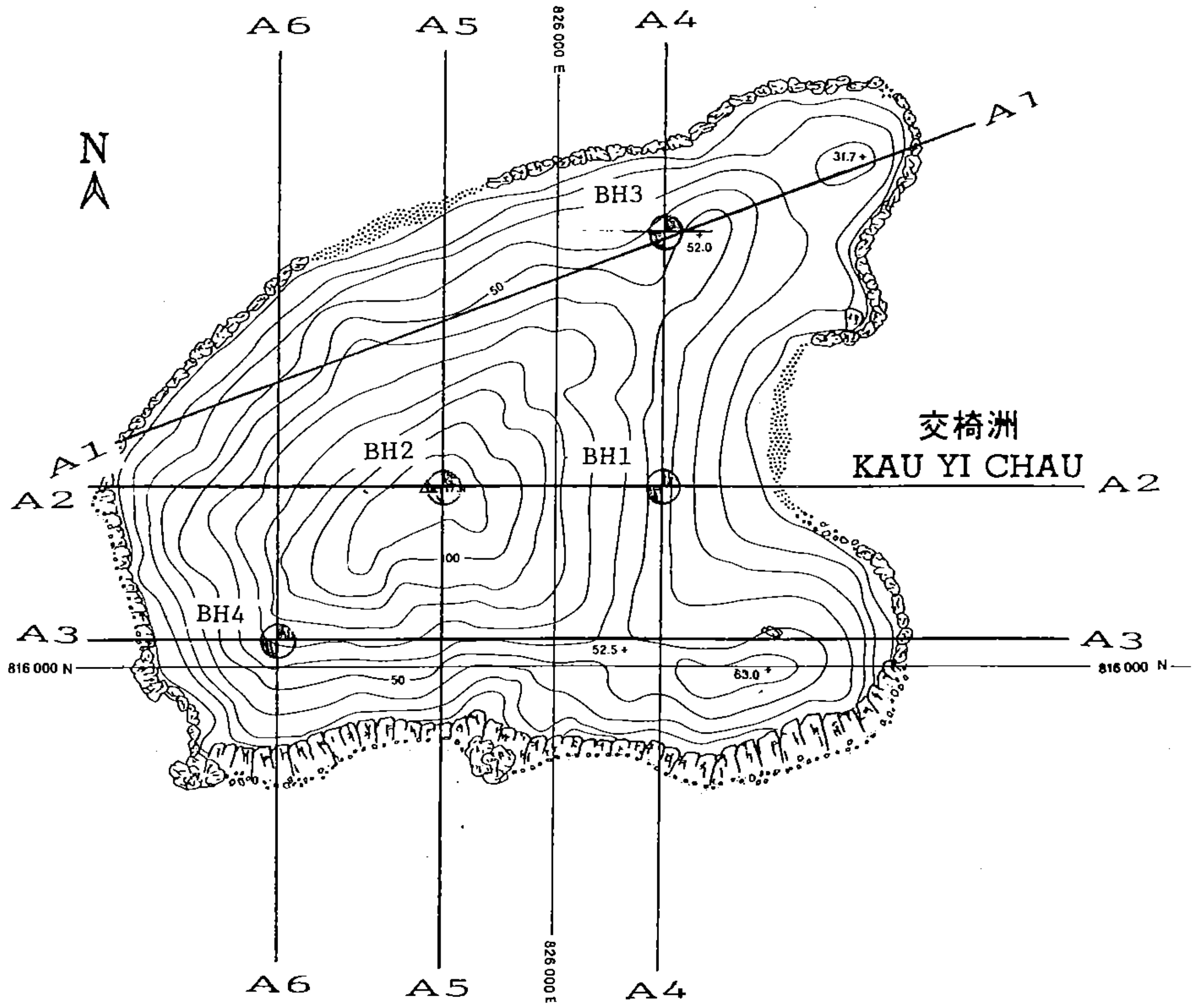
VESSEL TRACKS FOR 24 HR PERIOD – 15MAY1991

GREEN ISLAND LINK PRELIMINARY FEASIBILITY STUDY			
PAPM CONSULTANTS	VESSEL TRACKS		FIG. 7.1
HIGHWAYS DEPARTMENT	DESIGNED G F H	GIL/1100/3	
	DRAWN C P CHAN		
	CHECKED	DIMENSIONS ARE IN	
	DATE FEBRUARY,1992	SCALE AS SHOWN	



818 000 N
825 000 E
832 000 E
818 000 N
814 000 N
N
VICTORIA HARBOUR
HARBOUR LIMIT
WEST LAMMA CHANNEL
EAST LAMMA CHANNEL
NEW NORTH GREEN ISLAND FAIRWAY
1
2
3
4
5
6
7
8
9
GREEN ISLAND
KENNEDY TOWN
KAU YI CHAU
HONG KONG ISLAND
KEY :
2 = WORKS AREA NUMBER
GREEN ISLAND LINK PRELIMINARY FEASIBILITY STUDY
PAPM CONSULTANTS
CONSTRUCTION SEQUENCE
MARINE OCCUPATION AREAS
FIG. 7.2
HIGHWAYS DEPARTMENT
DESIGNED G A H
DRAWN C P CHAN
CHECKED
DATE FEBRUARY, 1992
GIL/1100/2
DIMENSIONS ARE IN METRES
SCALE 1:20,000


OUTLINE OF PROPOSED
PORT PENINSULA RECLAMATION
FORMER DUMPING GROUND
N
VICTORIA HARBOUR
SIU KAU YI CHAU
KAU YI CHAU
GREEN ISLAND
HONG KONG ISLAND
ROUTE N–N
ROUTE N–C
EAST LAMMA CHANNEL
WEST LAMMA CHANNEL
BH6
BH14
BH15
CP4
CP5
CP6
CP7
A1/5
A1/7
A1/8
A1/9
VA1/18
VA1/20
VA1/21
VA1/22
VA1/23
VA1/24
VA1/25
VA1/26
VA1/27
VA1/28
DC1
DC2
DC3
DC4
DC5
DC6
DC7
DC8
DC9
DC10
DC11
DC12
DC13
DC14
DC15
DC16
DC17
DC18
DC19
DC20
GR1
GR2
GR3
GR4
GR5
GR6
GR7
GR8
GR9
GR10
GR11
GR12
GR13
818 000 N
817 000 N
816 000 N
815 000 N
814 000 N
824 000 E
825 000 E
826 000 E
827 000 E
828 000 E
829 000 E
830 000 E
831 000 E
LEGEND :
BOREHOLES / VIBROCORES
BH6 – PADS MARINE SITE INVESTIGATION
A1
VA1 } GCO MARINE SOURCE OF FILL
GR1 – GREEN ISLAND RECLAMATION
CONE PENETRATION TEST –
PADS MARINE SITE INVESTIGATION
DROPCORES –
GIL SITE INVESTIGATION
GREEN ISLAND LINK PRELIMINARY FEASIBILITY STUDY
PAPM
CONSULTANTS
SITE INVESTIGATION LOCATIONS
FIG.
8.1
HIGHWAYS DEPARTMENT
DESIGNED B D L
DRAWN C P CHAN
CHECKED
DATE FEBRUARY,1992
GIL/800/8
DIMENSIONS ARE IN METRES
SCALE 1:20,000



LEGEND :

BH3 ⊕ BOREHOLE

NOTE :

(1) 10 METRES CORING IN ROCK.

(2) SPT WITH LINER SAMPLES 2m C/C

(3) GEOPHYSICAL SURVEY IN PROGRESS (DEC.,1991).

	NORTHING (APPROX.)	EASTING (APPROX.)
BH1	816127.19	826083.67
BH2	816133.17	825914.83
BH3	816314.98	826079.64
BH3	816016.83	825793.82

GREEN ISLAND LINK PRELIMINARY FEASIBILITY STUDY

PAPM CONSULTANTS

KAU YI CHAU GEOPHYSICAL SURVEY TRAVERSE LINES

FIG. 8.2

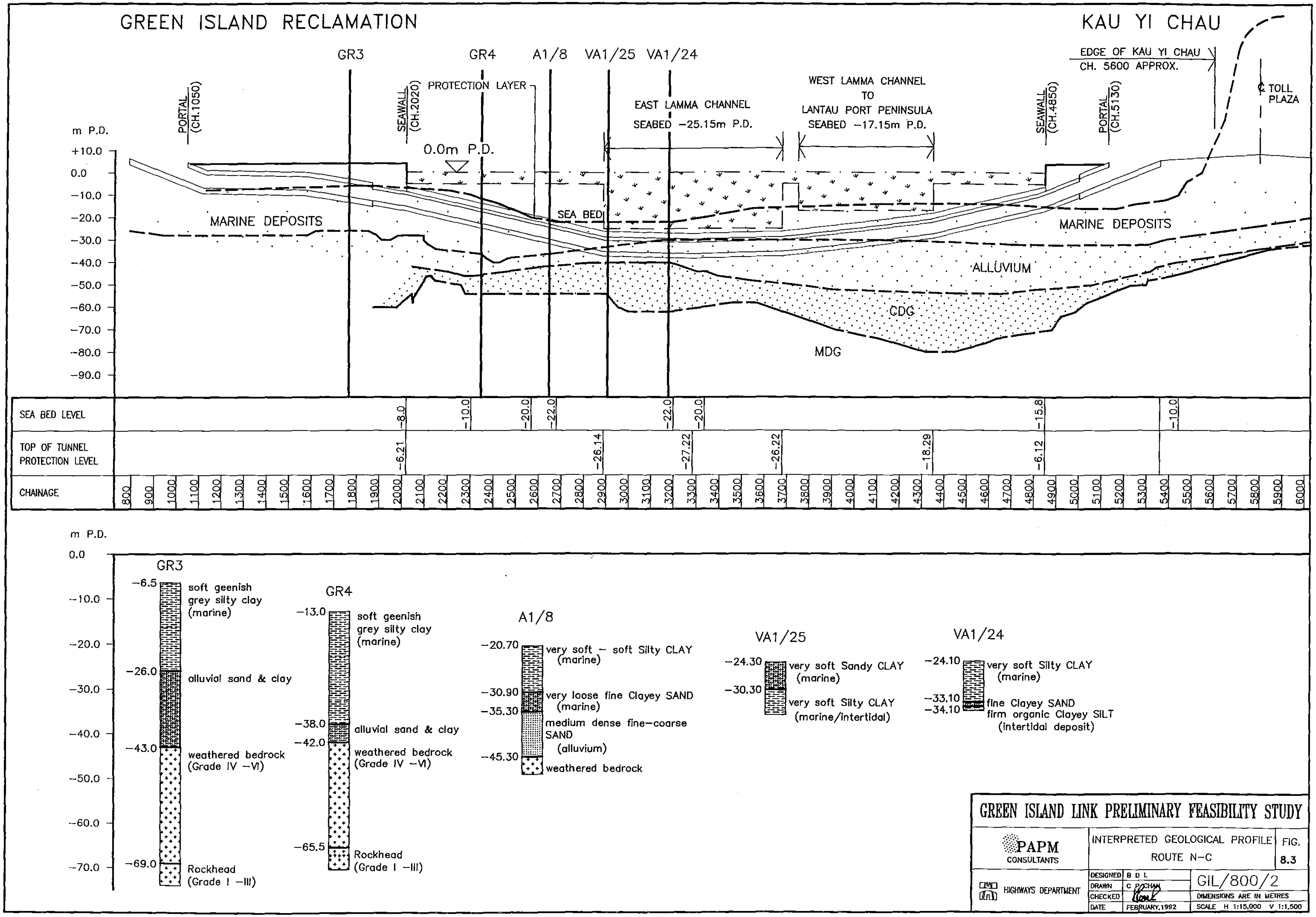
HIGHWAYS DEPARTMENT

DESIGNED	B D L
DRAWN	C P CHAN
CHECKED	
DATE	FEBRUARY,1992

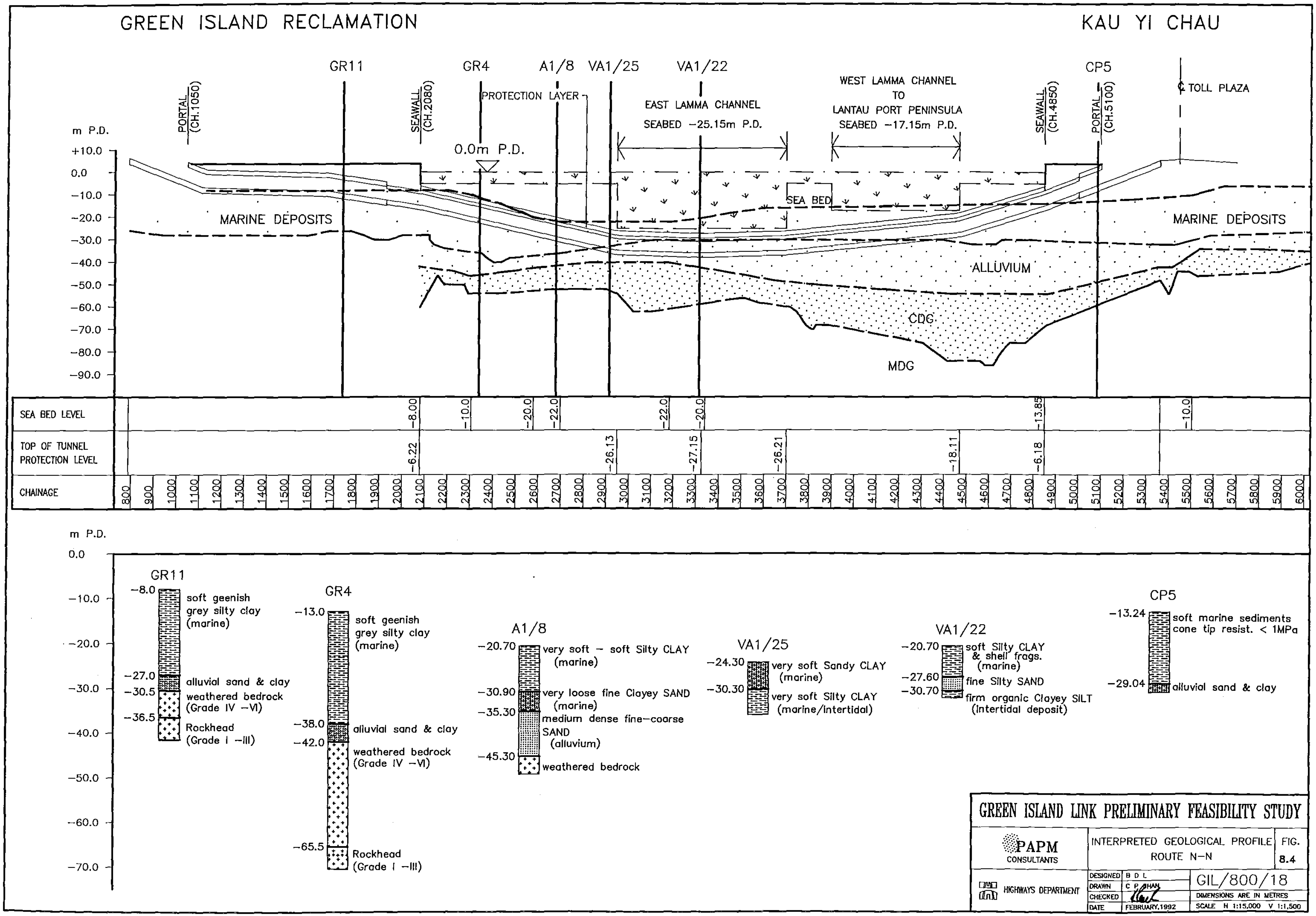
GIL/800/10

DIMENSIONS ARE IN METRES

SCALE 1:5,000



GREEN ISLAND RECLAMATION
KAU YI CHAU
GR3
GR4
A1/8
VA1/25
VA1/24
EDGE OF KAU YI CHAU CH. 5600 APPROX.
PORTAL (CH.1050)
SEAWALL (CH.2020)
PROTECTION LAYER
EAST LAMMA CHANNEL
SEABED −25.15m P.D.
WEST LAMMA CHANNEL TO LANTAU PORT PENINSULA
SEABED −17.15m P.D.
SEAWALL (CH.4850)
PORTAL (CH.5130)
℄ TOLL PLAZA
m P.D.
+10.0
0.0
−10.0
−20.0
−30.0
−40.0
−50.0
−60.0
−70.0
−80.0
−90.0
0.0m P.D.
SEA BED
MARINE DEPOSITS
MARINE DEPOSITS
ALLUVIUM
CDG
MDG
SEA BED LEVEL
−8.0
−10.0
−20.0
−22.0
−22.0
−20.0
−15.8
−10.0
TOP OF TUNNEL PROTECTION LEVEL
−6.21
−26.14
−27.22
−26.22
−18.29
−6.12
CHAINAGE
800 900 1000 1100 1200 1300 1400 1500 1600 1700 1800 1900 2000 2100 2200 2300 2400 2500 2600 2700 2800 2900 3000 3100 3200 3300 3400 3500 3600 3700 3800 3900 4000 4100 4200 4300 4400 4500 4600 4700 4800 4900 5000 5100 5200 5300 5400 5500 5600 5700 5800 5900 6000
m P.D.
0.0
−10.0
−20.0
−30.0
−40.0
−50.0
−60.0
−70.0
GR3
−6.5 soft geenish grey silty clay (marine)
−26.0 alluvial sand & clay
−43.0 weathered bedrock (Grade IV −VI)
−69.0 Rockhead (Grade I −III)
GR4
−13.0 soft geenish grey silty clay (marine)
−38.0 alluvial sand & clay
−42.0 weathered bedrock (Grade IV −VI)
−65.5 Rockhead (Grade I −III)
A1/8
−20.70 very soft − soft Silty CLAY (marine)
−30.90 very loose fine Clayey SAND (marine)
−35.30 medium dense fine−coarse SAND (alluvium)
−45.30 weathered bedrock
VA1/25
−24.30 very soft Sandy CLAY (marine)
−30.30 very soft Silty CLAY (marine/intertidal)
VA1/24
−24.10 very soft Silty CLAY (marine)
−33.10 fine Clayey SAND
−34.10 firm organic Clayey SILT (intertidal deposit)
GREEN ISLAND LINK PRELIMINARY FEASIBILITY STUDY
PAPM CONSULTANTS
INTERPRETED GEOLOGICAL PROFILE ROUTE N−C
FIG. 8.3
HIGHWAYS DEPARTMENT
DESIGNED B D L
DRAWN C P CHAN
CHECKED
DATE FEBRUARY,1992
GIL/800/2
DIMENSIONS ARE IN METRES
SCALE H 1:15,000 V 1:1,500



GREEN ISLAND LINK PRELIMINARY FEASIBILITY STUDY

PAPM CONSULTANTS

HIGHWAYS DEPARTMENT

INTERPRETED GEOLOGICAL PROFILE ROUTE N−N

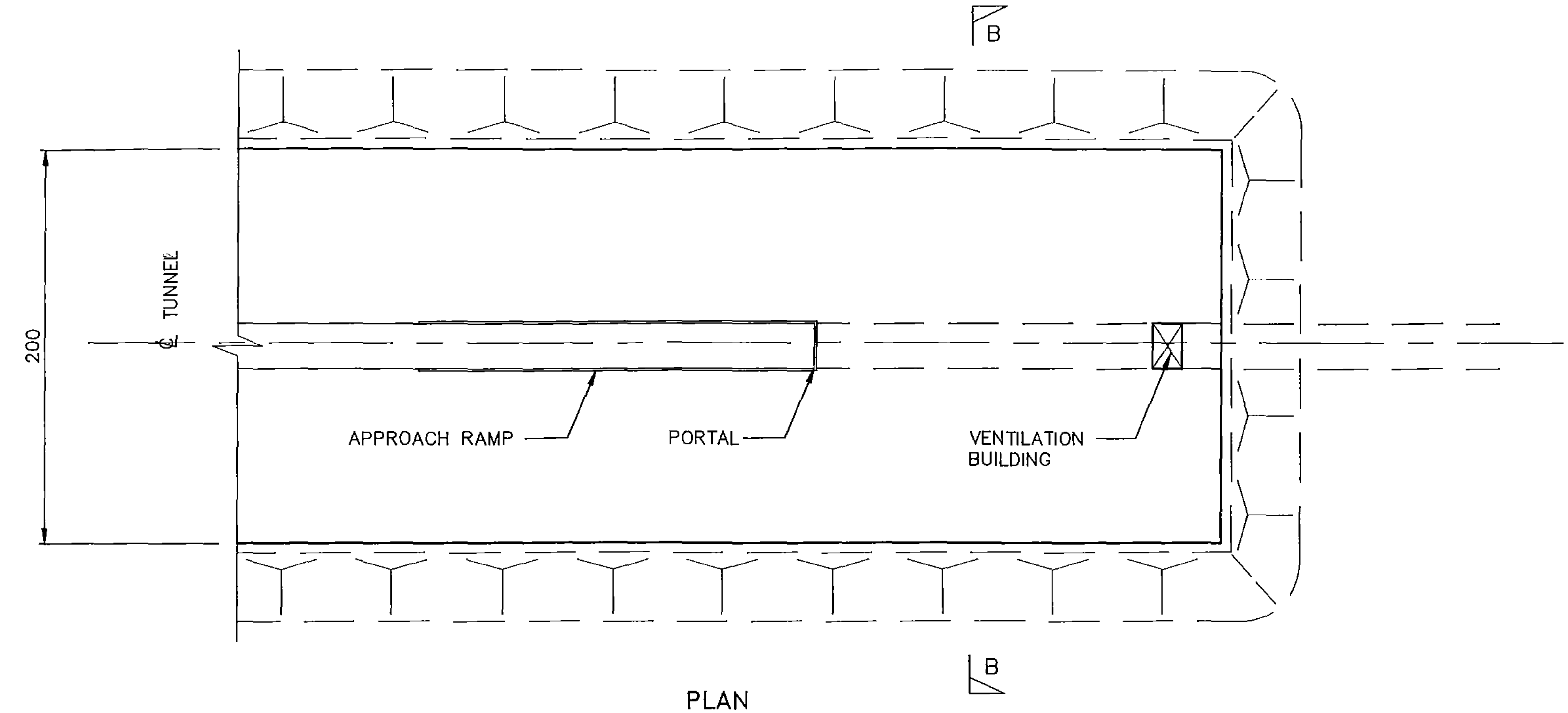
FIG. 8.4

DESIGNED	B D L
DRAWN	C P CHAN
CHECKED	
DATE	FEBRUARY,1992

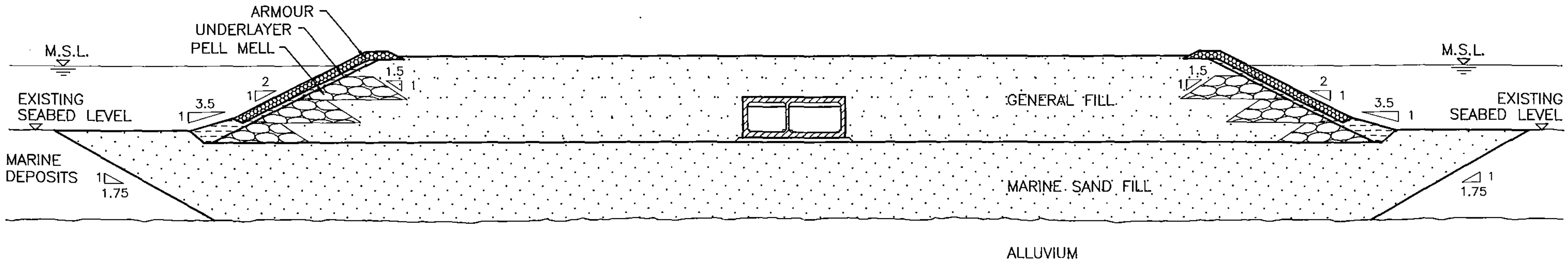
GIL/800/18

DIMENSIONS ARE IN METRES

SCALE H 1:15,000 V 1:1,500



PLAN
1:2500



SECTION B–B
1:1000

GREEN ISLAND LINK PRELIMINARY FEASIBILITY STUDY

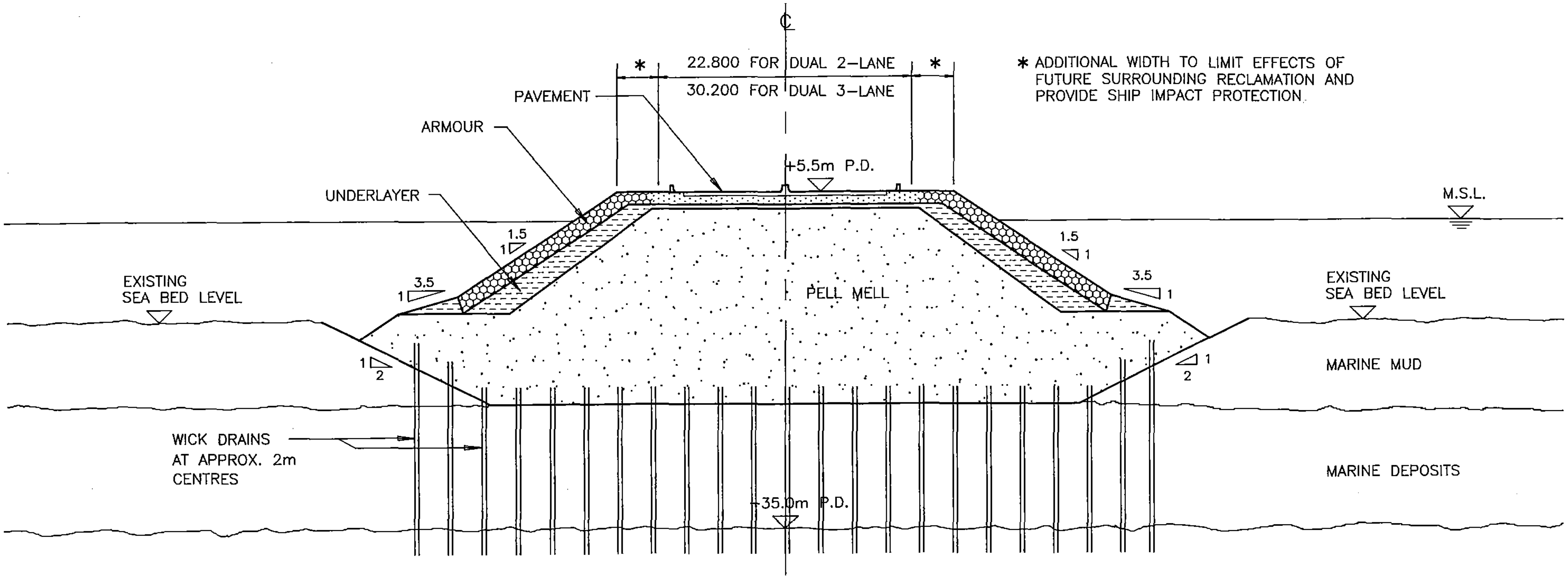
PAPM CONSULTANTS

KAU YI CHAU LANDFALL

FIG. 8.5

HIGHWAYS DEPARTMENT

DESIGNED	G A H	GIL/303.2/5
DRAWN	W H WONG	
CHECKED		DIMENSIONS ARE IN METRES
DATE	FEBRUARY,1992	SCALE AS SHOWN



GREEN ISLAND LINK PRELIMINARY FEASIBILITY STUDY

PAPM CONSULTANTS

KAU YI CHAU CAUSEWAY
TYPICAL SECTION

FIG. 8.6

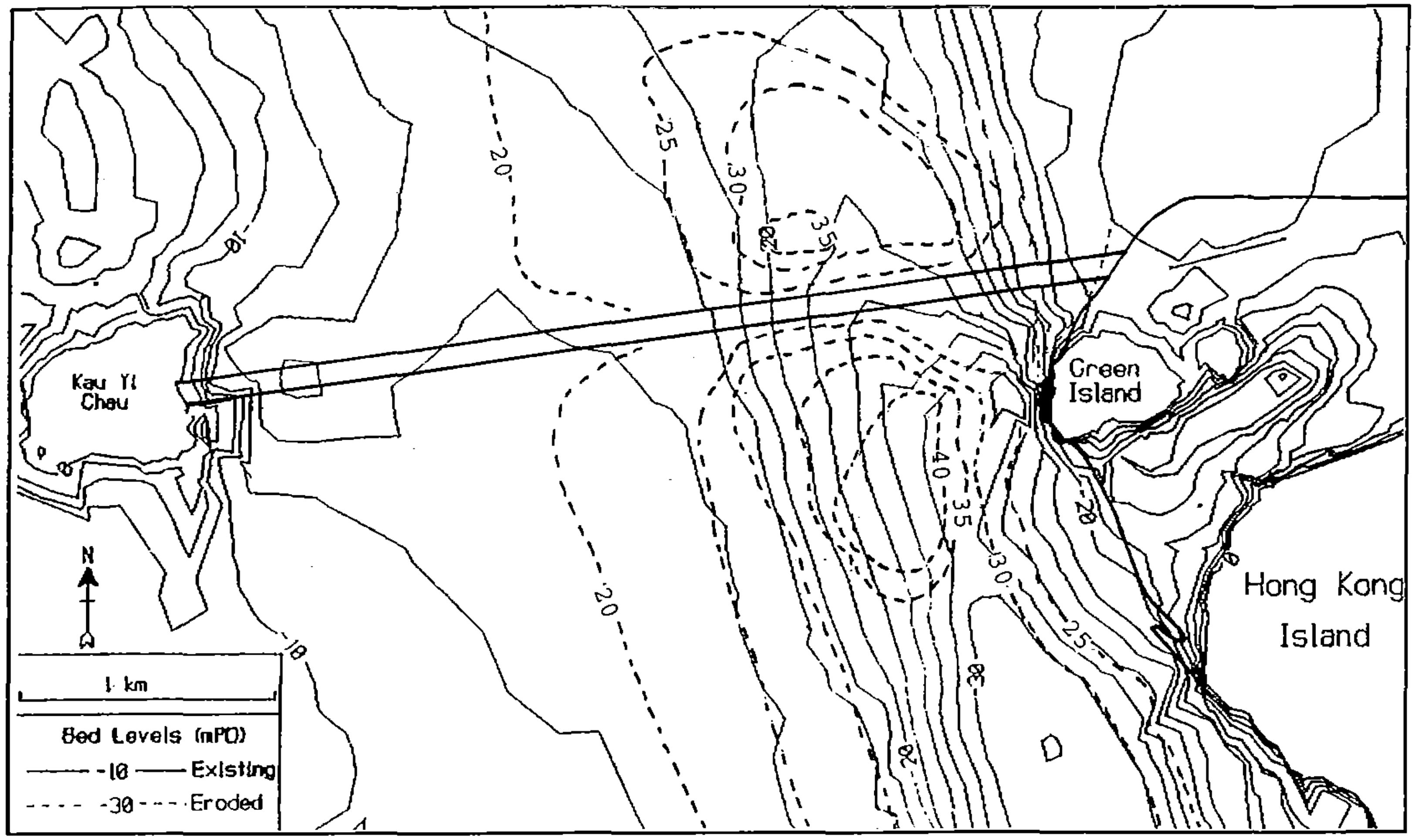
HIGHWAYS DEPARTMENT

DESIGNED	B D L
DRAWN	C P CHAN
CHECKED	
DATE	FEBRUARY, 1992

GIL/800/19

DIMENSIONS ARE IN METRES

SCALE 1:500



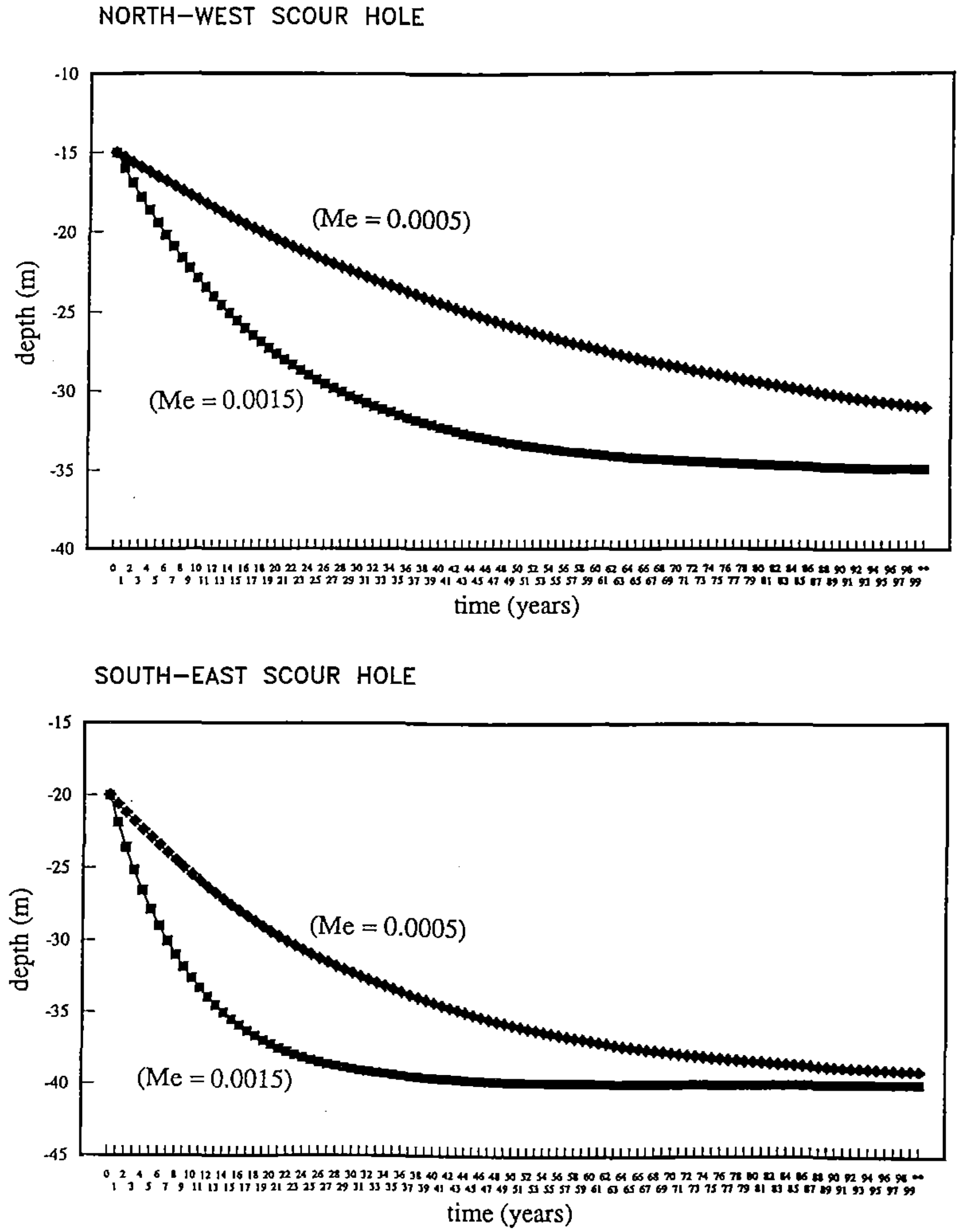
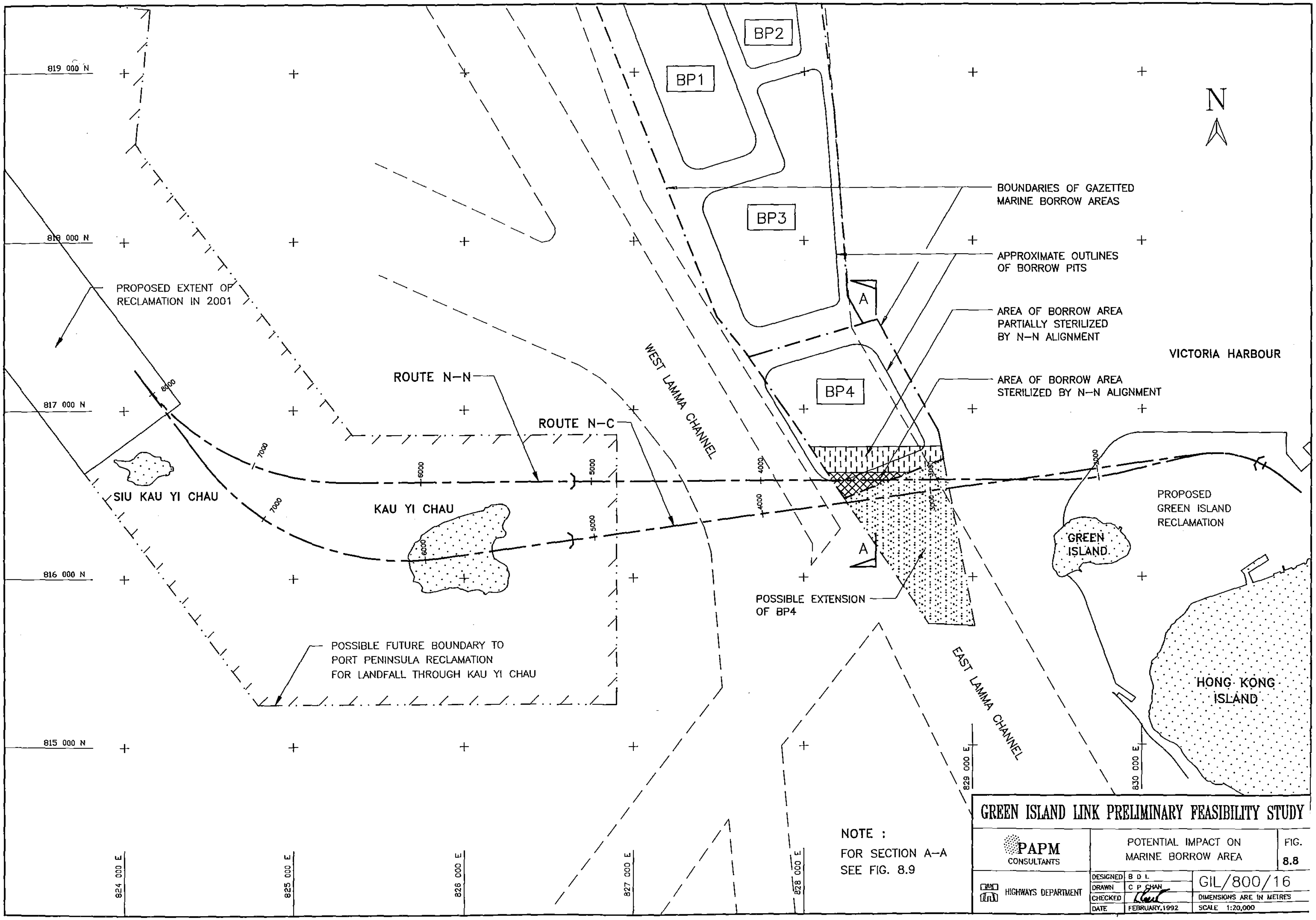
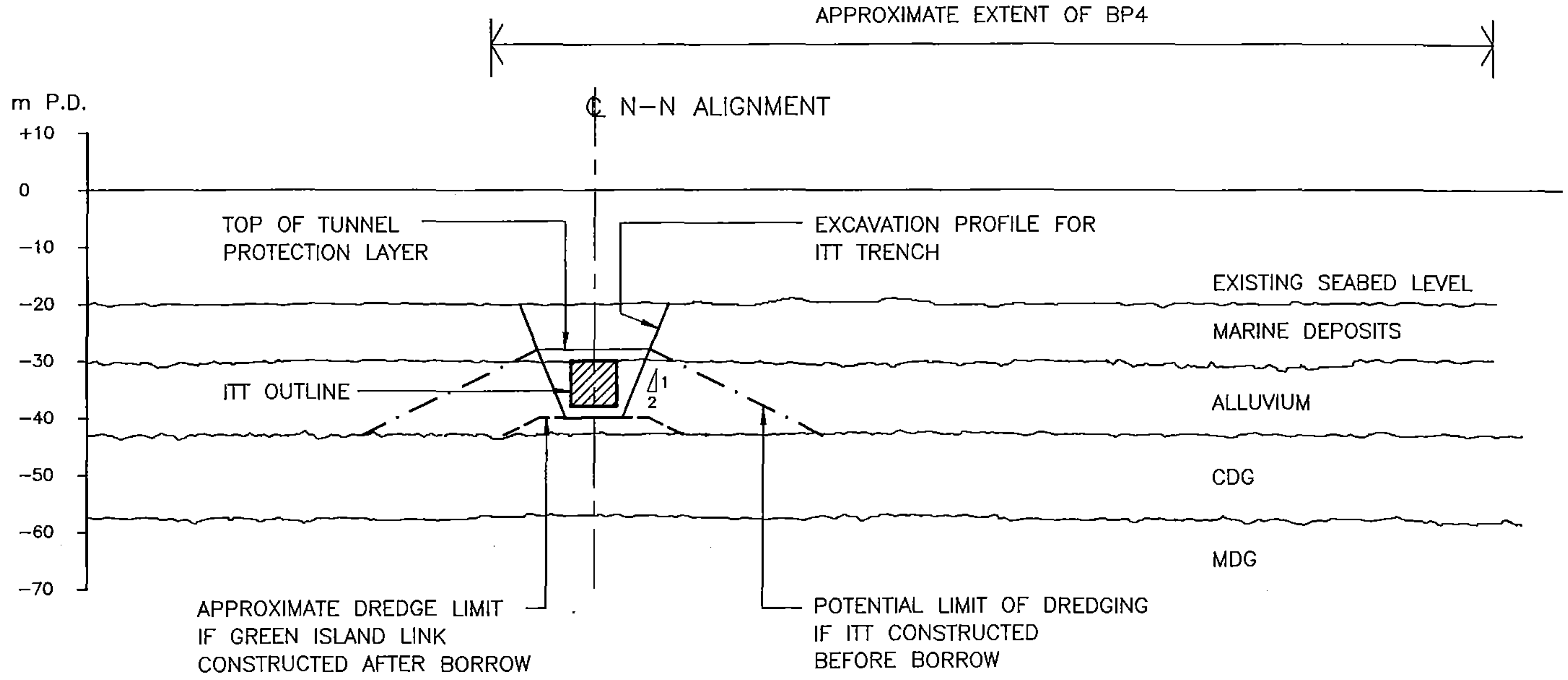


FIG.7B PREDICTED RATE OF DEEPENING OF SCOUR HOLES

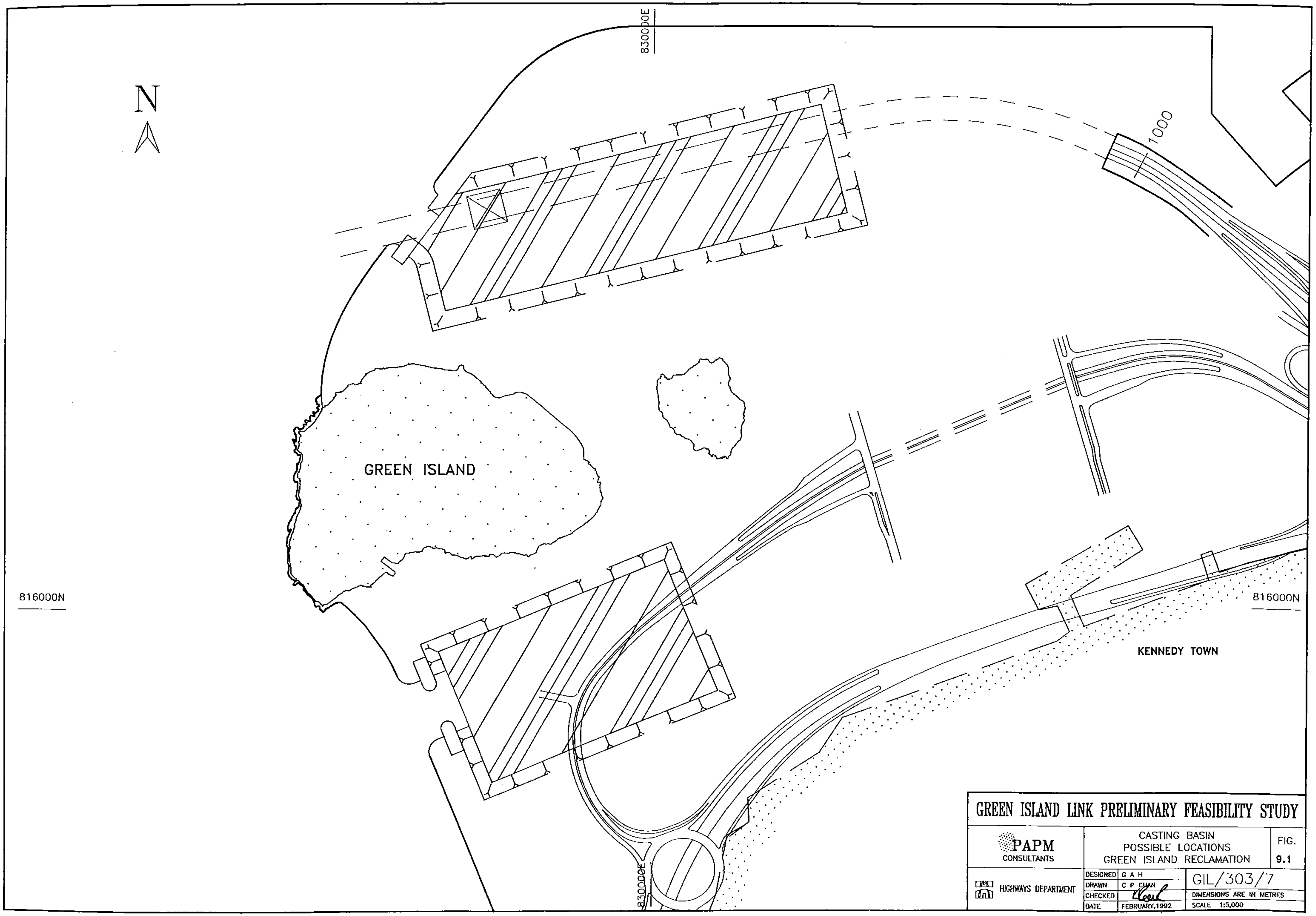
GREEN ISLAND LINK PRELIMINARY FEASIBILITY STUDY			
PAPM CONSULTANTS	ESTIMATED ERODED BED LEVELS		FIG. 8.7
HIGHWAYS DEPARTMENT	DESIGNED B D L DRAWN C P CHAN CHECKED [signature] DATE FEBRUARY,1992	GIL/800/22 DIMENSIONS ARE IN METRES SCALE AS SHOWN	


BP1
BP2
BP3
BP4
N
819 000 N
818 000 N
817 000 N
816 000 N
815 000 N
824 000 E
825 000 E
826 000 E
827 000 E
828 000 E
829 000 E
830 000 E
BOUNDARIES OF GAZETTED MARINE BORROW AREAS
APPROXIMATE OUTLINES OF BORROW PITS
AREA OF BORROW AREA PARTIALLY STERILIZED BY N–N ALIGNMENT
AREA OF BORROW AREA STERILIZED BY N–N ALIGNMENT
VICTORIA HARBOUR
PROPOSED EXTENT OF RECLAMATION IN 2001
ROUTE N–N
ROUTE N–C
WEST LAMMA CHANNEL
EAST LAMMA CHANNEL
SIU KAU YI CHAU
KAU YI CHAU
PROPOSED GREEN ISLAND RECLAMATION
GREEN ISLAND
HONG KONG ISLAND
POSSIBLE EXTENSION OF BP4
POSSIBLE FUTURE BOUNDARY TO PORT PENINSULA RECLAMATION FOR LANDFALL THROUGH KAU YI CHAU
A
A
8000
7000
7000
6000
6000
5000
5000
4000
4000
3000
3000
2000
NOTE :
FOR SECTION A–A SEE FIG. 8.9
GREEN ISLAND LINK PRELIMINARY FEASIBILITY STUDY
PAPM CONSULTANTS
HIGHWAYS DEPARTMENT
POTENTIAL IMPACT ON MARINE BORROW AREA
FIG. 8.8
DESIGNED B D L
DRAWN C P CHAN
CHECKED
DATE FEBRUARY,1992
GIL/800/16
DIMENSIONS ARE IN METRES
SCALE 1:20,000



SECTION A-A

GREEN ISLAND LINK PRELIMINARY FEASIBILITY STUDY		
PAPM CONSULTANTS	POTENTIAL IMPACT OF THE TUNNEL ON BORROW PIT BP4	FIG. 8.9
HIGHWAYS DEPARTMENT	DESIGNED B D L; DRAWN C P CHAN; CHECKED [signature]; DATE FEBRUARY,1992	GIL/800/21; DIMENSIONS ARE IN METRES; SCALE H 1:5,000 V 1:1,000



GREEN ISLAND LINK PRELIMINARY FEASIBILITY STUDY

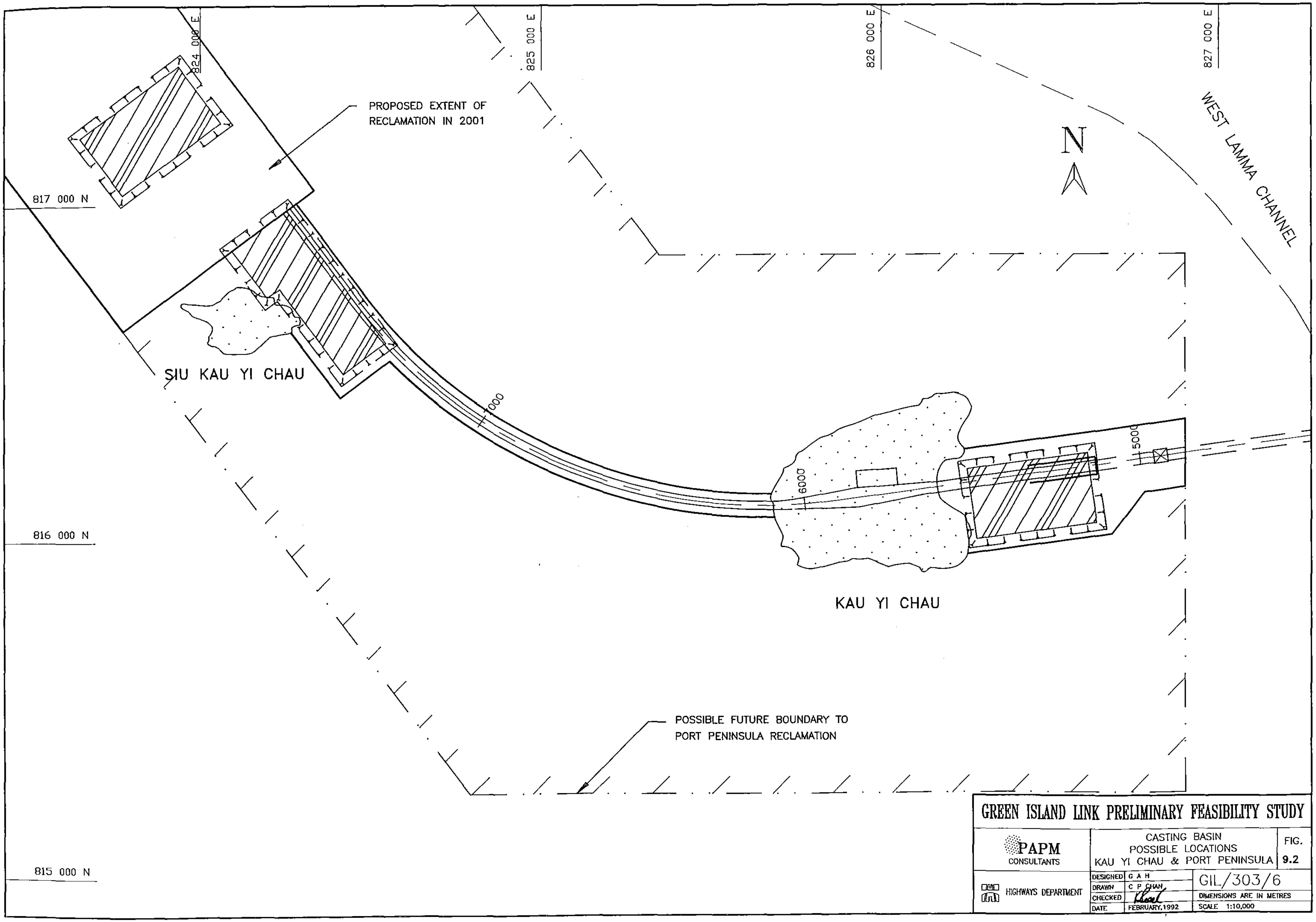
PAPM CONSULTANTS

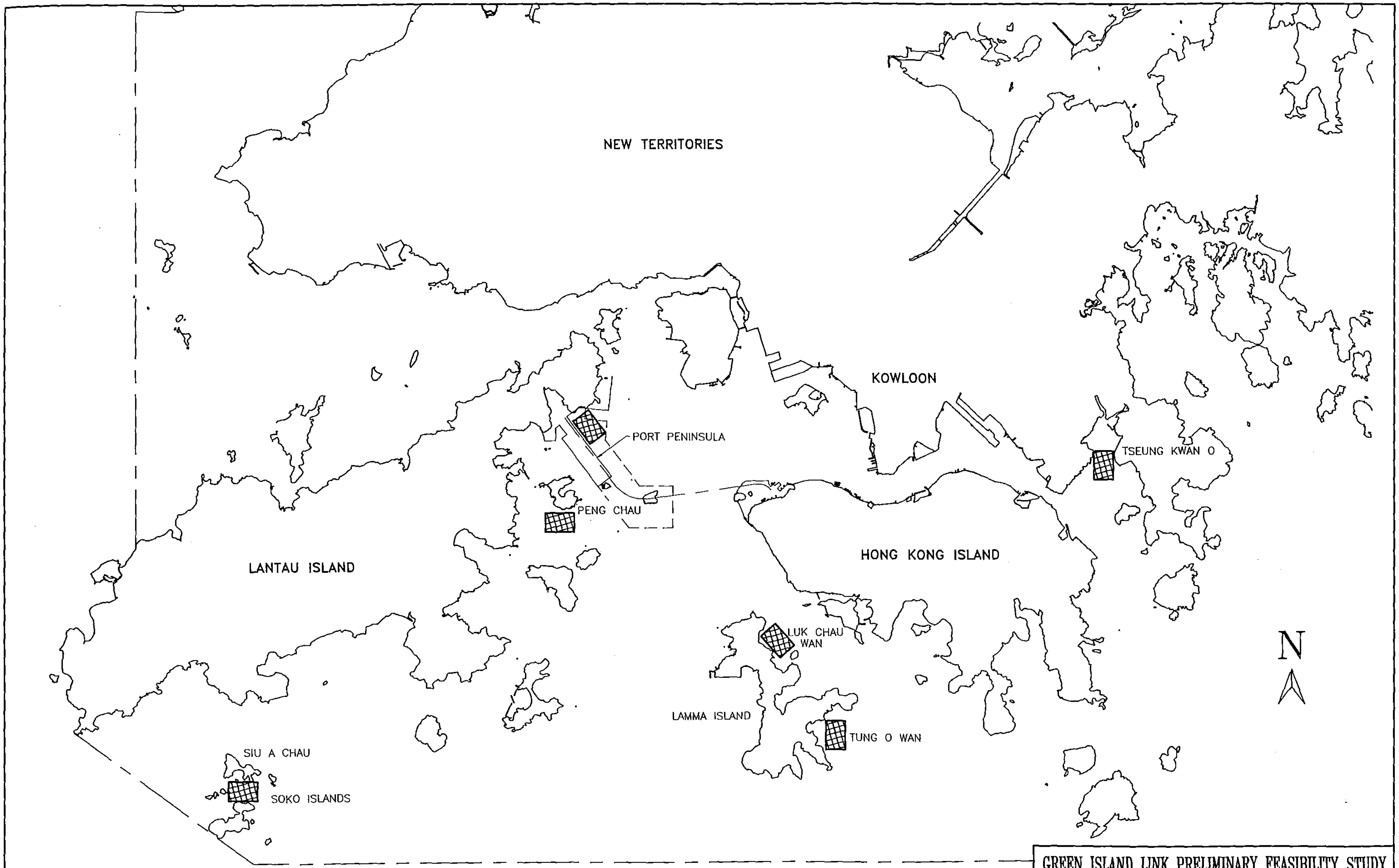
CASTING BASIN
POSSIBLE LOCATIONS
GREEN ISLAND RECLAMATION

FIG. 9.1

HIGHWAYS DEPARTMENT

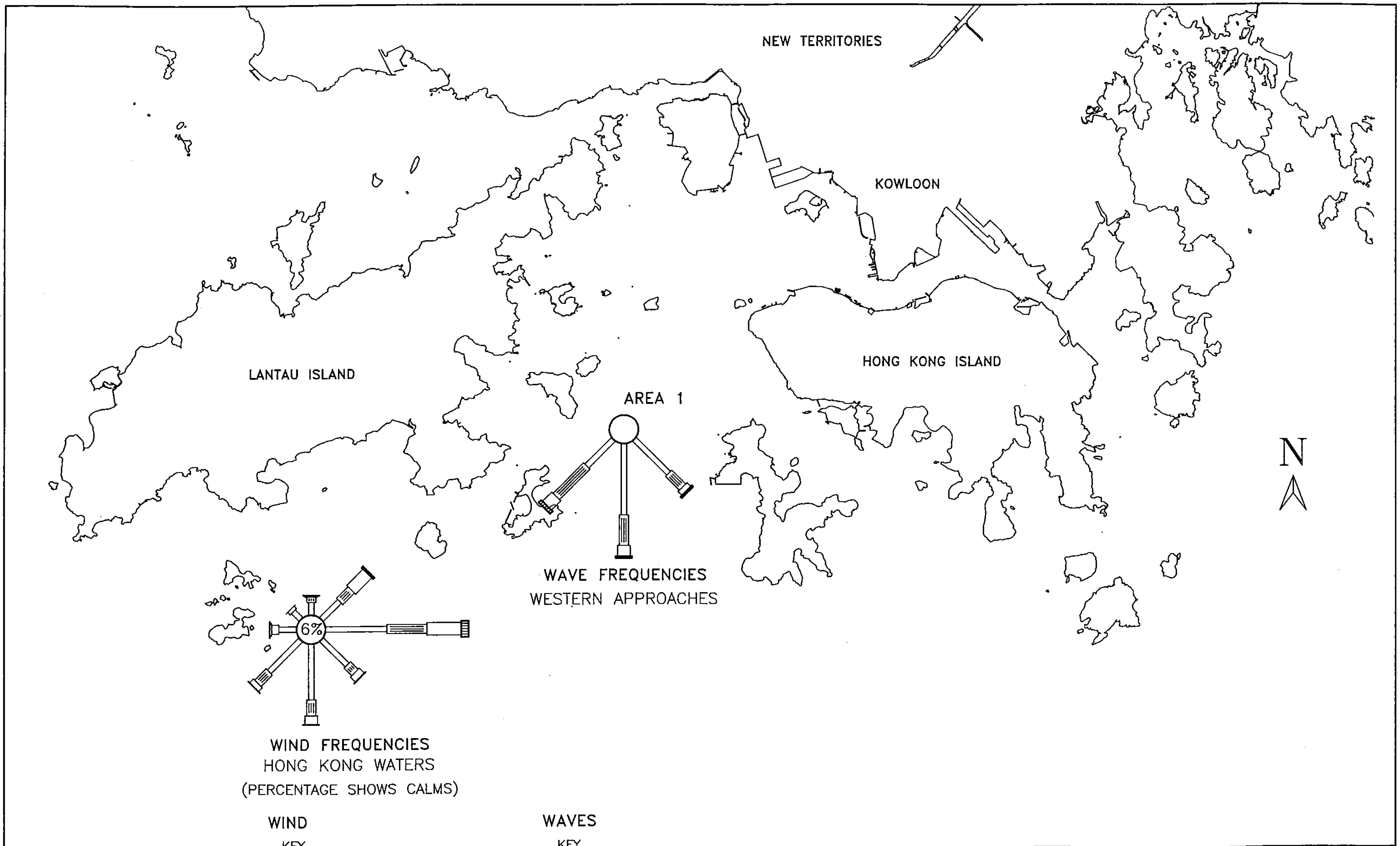
DESIGNED	G A H	GIL/303/7
DRAWN	C P CHAN	DIMENSIONS ARE IN METRES
CHECKED	[signature]	SCALE 1:5,000
DATE	FEBRUARY,1992	


824 000 E
825 000 E
826 000 E
827 000 E
817 000 N
816 000 N
815 000 N
PROPOSED EXTENT OF RECLAMATION IN 2001
N
WEST LAMMA CHANNEL
SIU KAU YI CHAU
1000
5000
6000
KAU YI CHAU
POSSIBLE FUTURE BOUNDARY TO PORT PENINSULA RECLAMATION
GREEN ISLAND LINK PRELIMINARY FEASIBILITY STUDY
PAPM CONSULTANTS
CASTING BASIN
POSSIBLE LOCATIONS
KAU YI CHAU & PORT PENINSULA
FIG. 9.2
HIGHWAYS DEPARTMENT
DESIGNED G A H
DRAWN C P CHAN
CHECKED
DATE FEBRUARY,1992
GIL/303/6
DIMENSIONS ARE IN METRES
SCALE 1:10,000



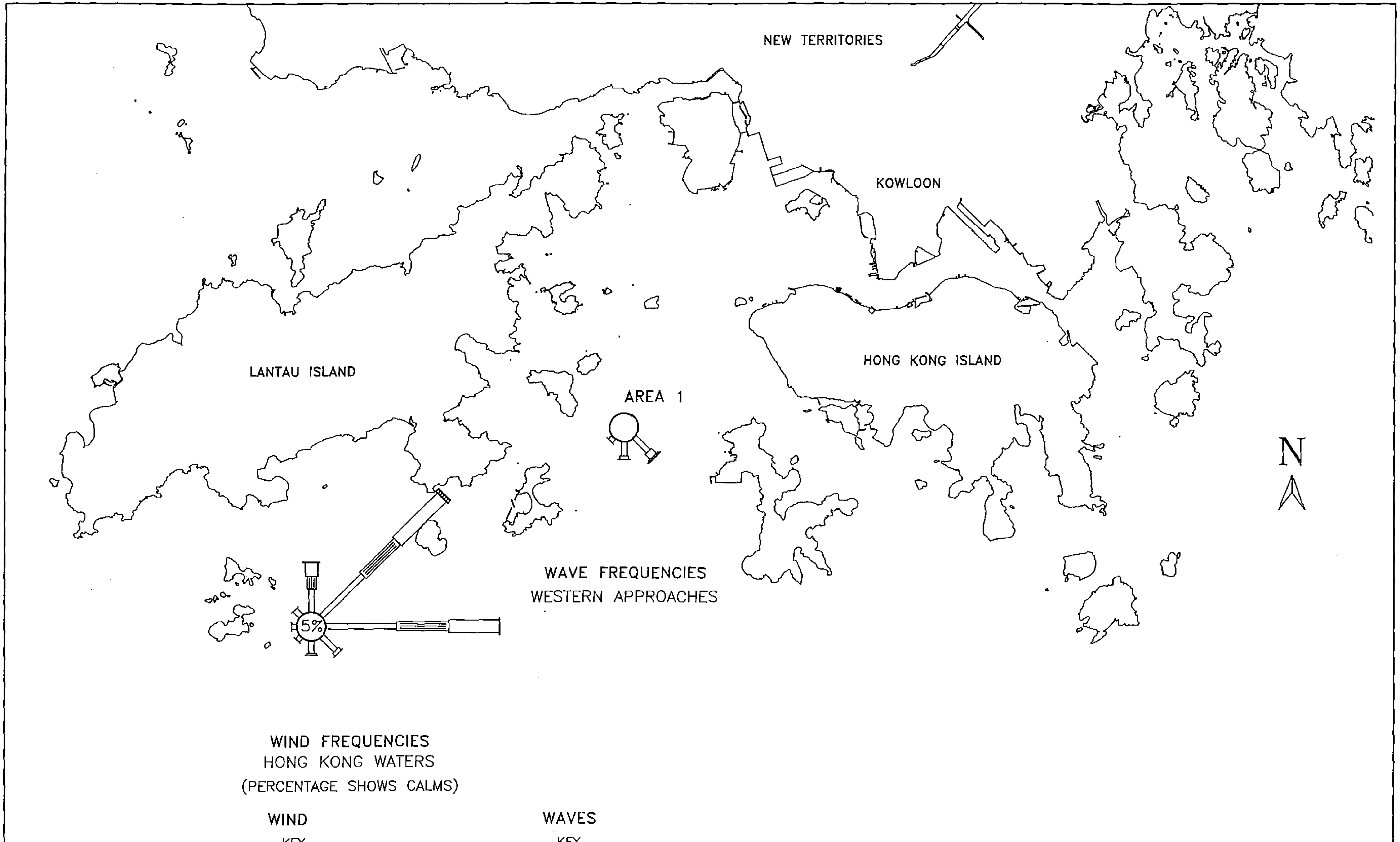
▦ IMMERSED TUBE TUNNEL UNITS – STORAGE AREAS

GREEN ISLAND LINK PRELIMINARY FEASIBILITY STUDY			
PAPM CONSULTANTS	STORAGE OF TUNNEL UNITS MOORING LOCATIONS		FIG. 9.3
HIGHWAYS DEPARTMENT	DESIGNED: G A H DRAWN: C P CHAN CHECKED: [signature] DATE: FEBRUARY,1992	GIL/303/9 DIMENSIONS ARE IN SCALE 1:150,000	



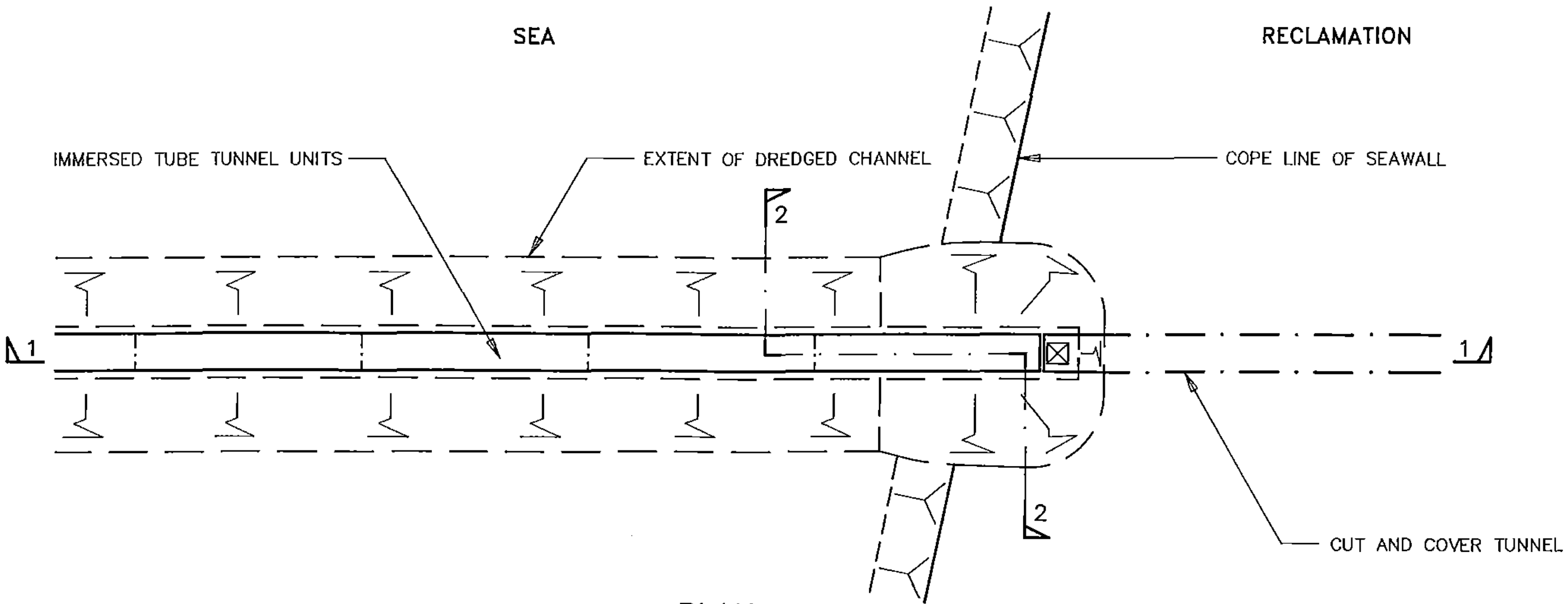
GREEN ISLAND LINK PRELIMINARY FEASIBILITY STUDY

PAPM CONSULTANTS	WEATHER EXPOSURE WIND AND WAVES ROSES FOR MAY – OCTOBER	FIG. 9.4
HIGHWAYS DEPARTMENT	DESIGNED G A H DRAWN C P CHAN CHECKED [signature] DATE FEBRUARY, 1992	GIL/1300/3 DIMENSIONS ARE IN SCALE 1:150,000



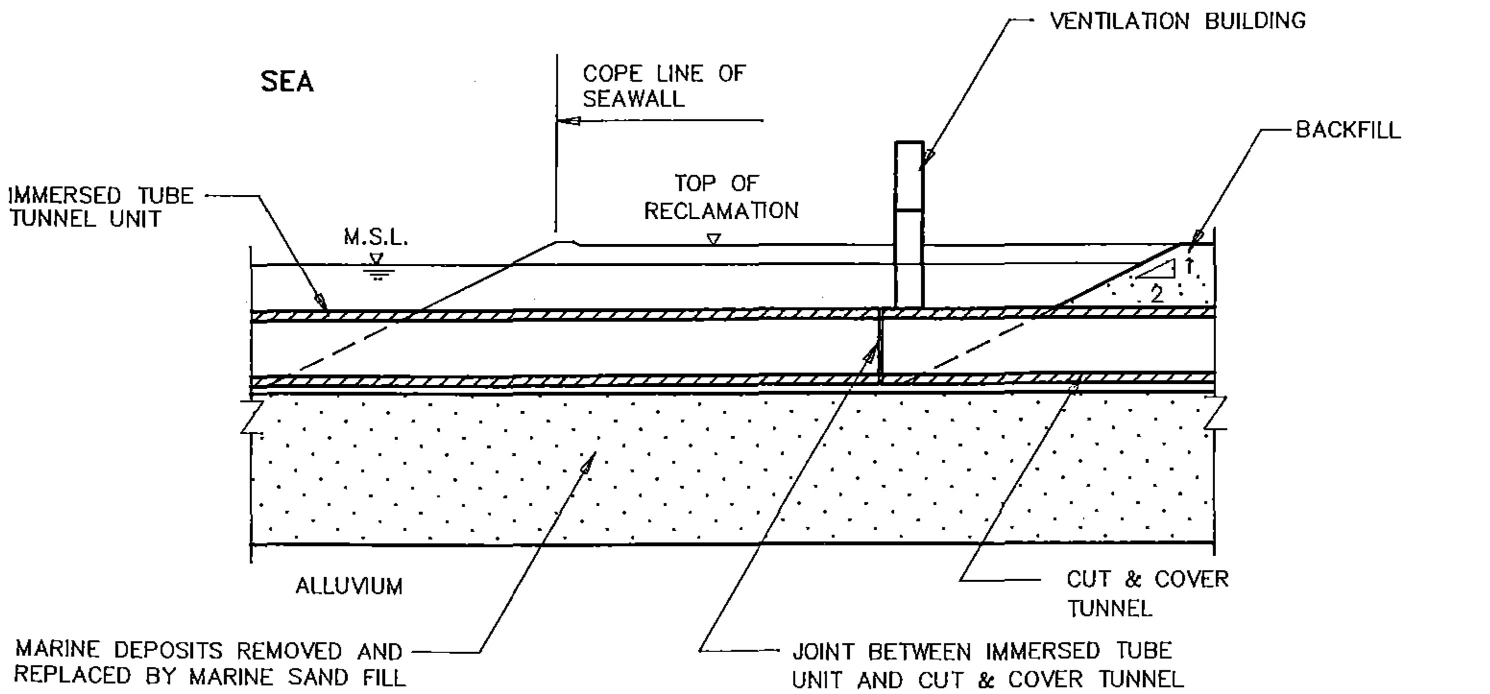
GREEN ISLAND LINK PRELIMINARY FEASIBILITY STUDY

PAPM CONSULTANTS	WEATHER EXPOSURE WIND AND WAVES ROSES FOR NOVEMBER – APRIL	FIG. 9.5
HIGHWAYS DEPARTMENT	DESIGNED G A H; DRAWN C P CHAN; CHECKED [signature]; DATE FEBRUARY, 1992	GIL/1300/4; DIMENSIONS ARE IN; SCALE 1:150,000



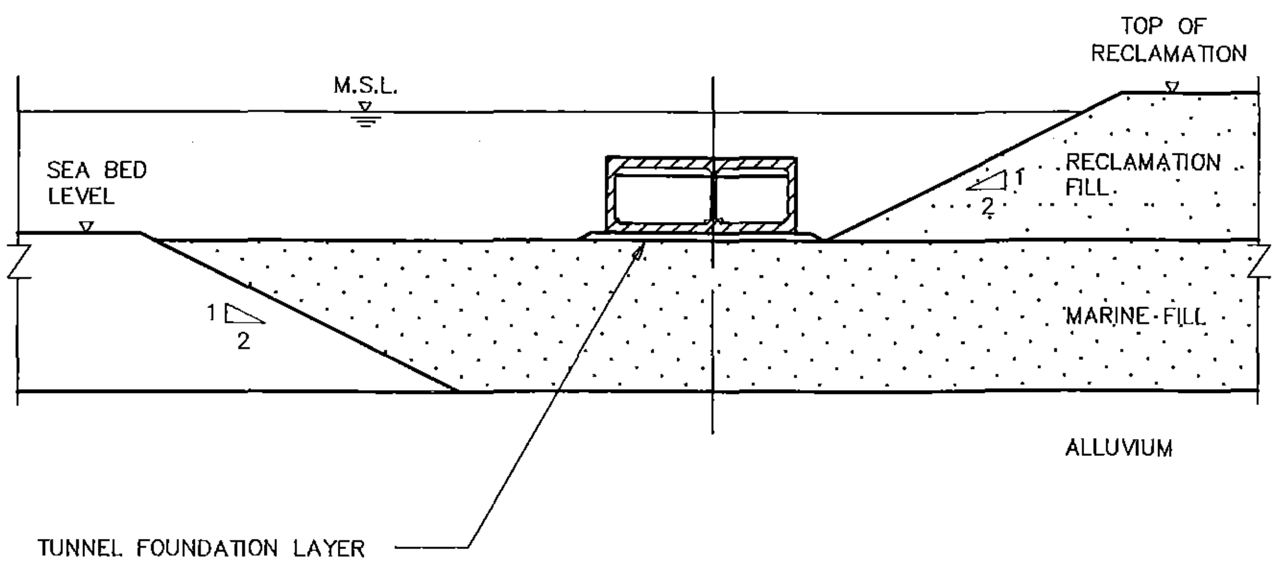
PLAN

1:4000



SECTION 1–1

1:1000



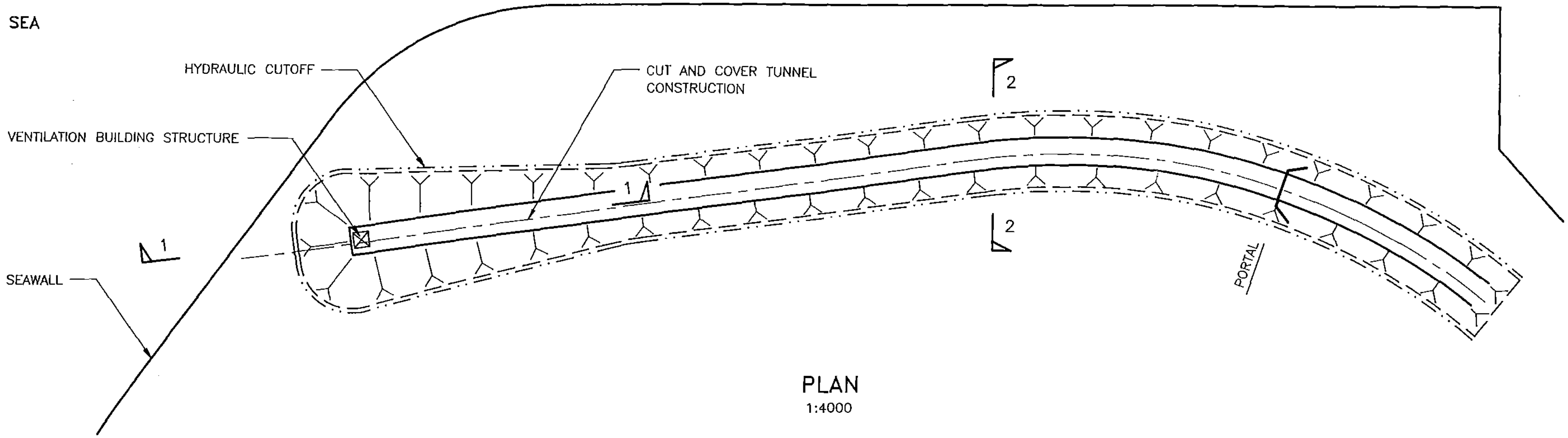
SECTION 2–2

1:1000

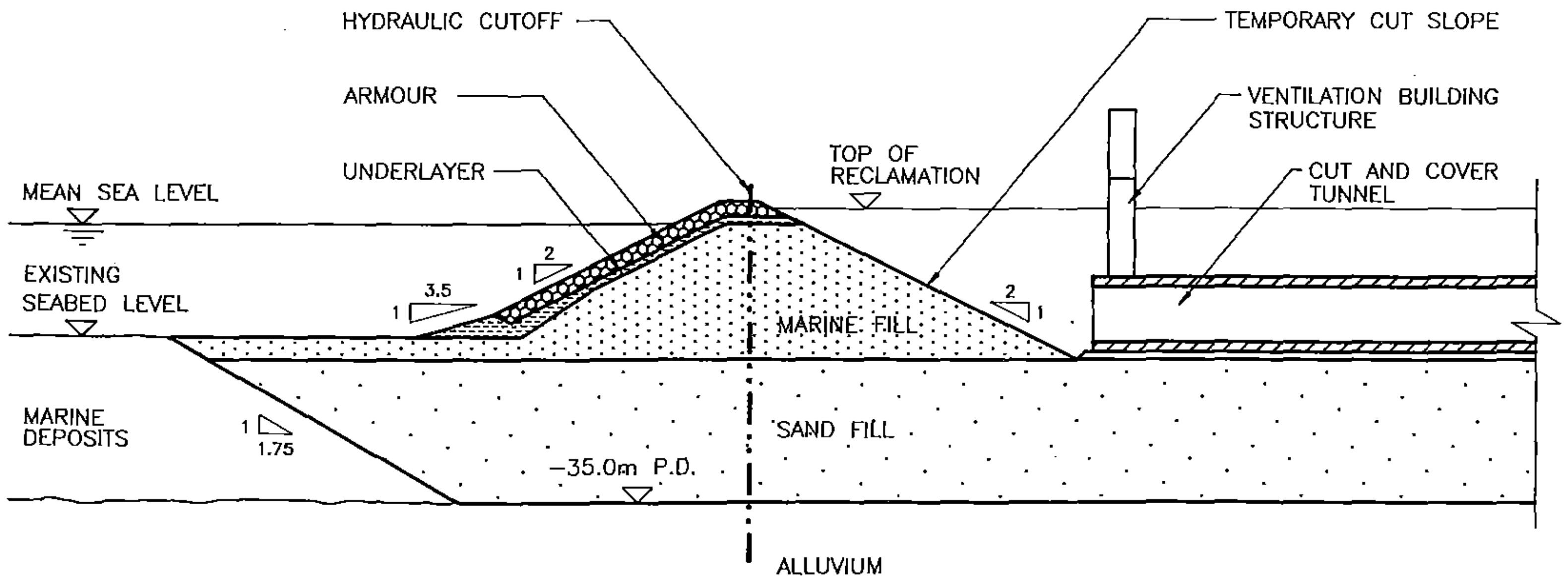
NOTE :

THE APPROACH AND VENTILATION BUILDING ARE CONSTRUCTED WITH AN OPEN EXCAVATION AS SHOWN IN FIG. 9.7
AFTER COMPLETION, THE SEAWALL IS REMOVED AND THE IMMERSED TUBE TUNNEL UNITS ARE INSTALLED.

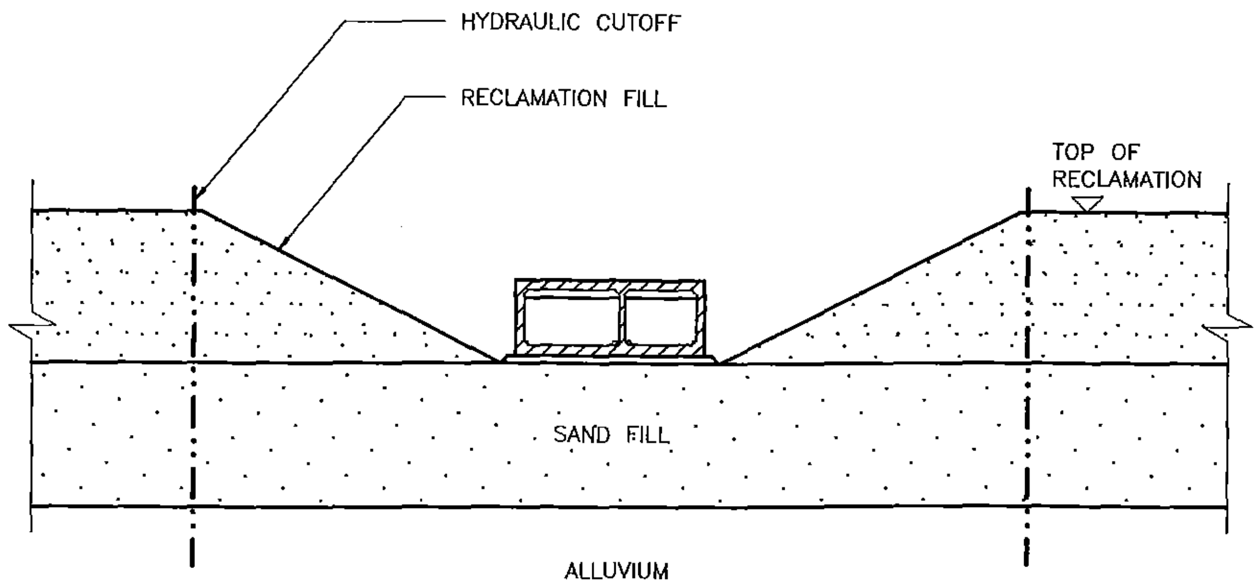
GREEN ISLAND LINK PRELIMINARY FEASIBILITY STUDY		
PAPM CONSULTANTS	IMMERSED TUBE INSTALLATION AT SEAWALL	FIG. 9.6
HIGHWAYS DEPARTMENT	DESIGNED G A H DRAWN W H WONG CHECKED DATE FEBRUARY,1992	GIL/303.1/14 DIMENSIONS ARE IN METRES SCALE AS SHOWN



PLAN
1:4000

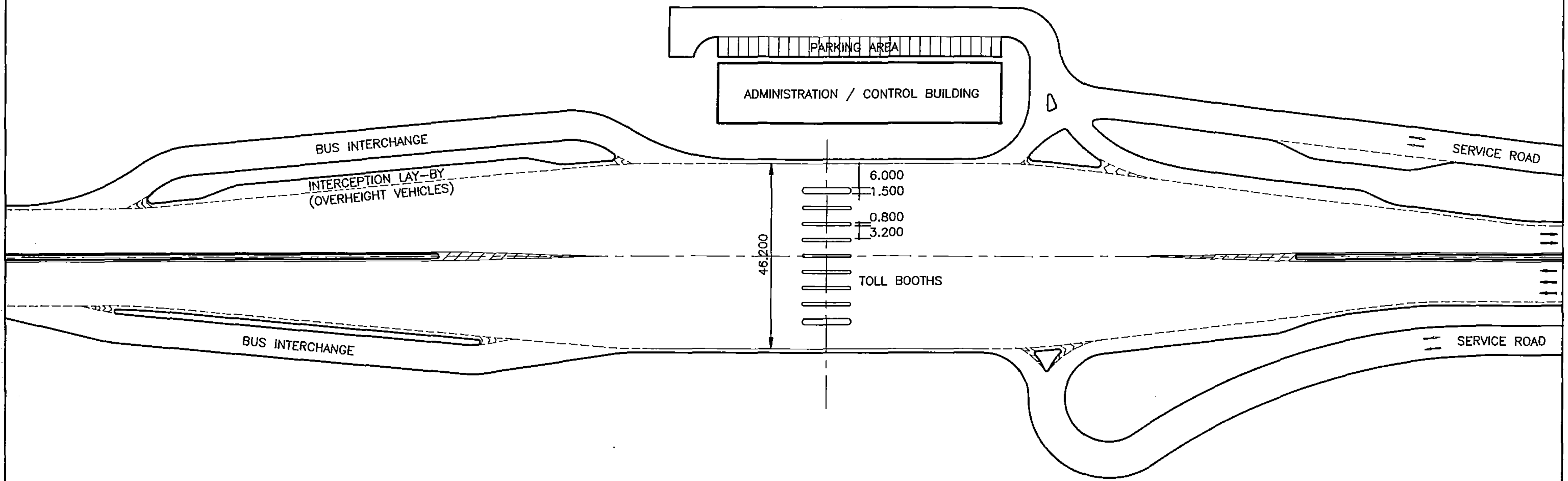


SECTION 1–1
1:1000



SECTION 2–2
1:1000

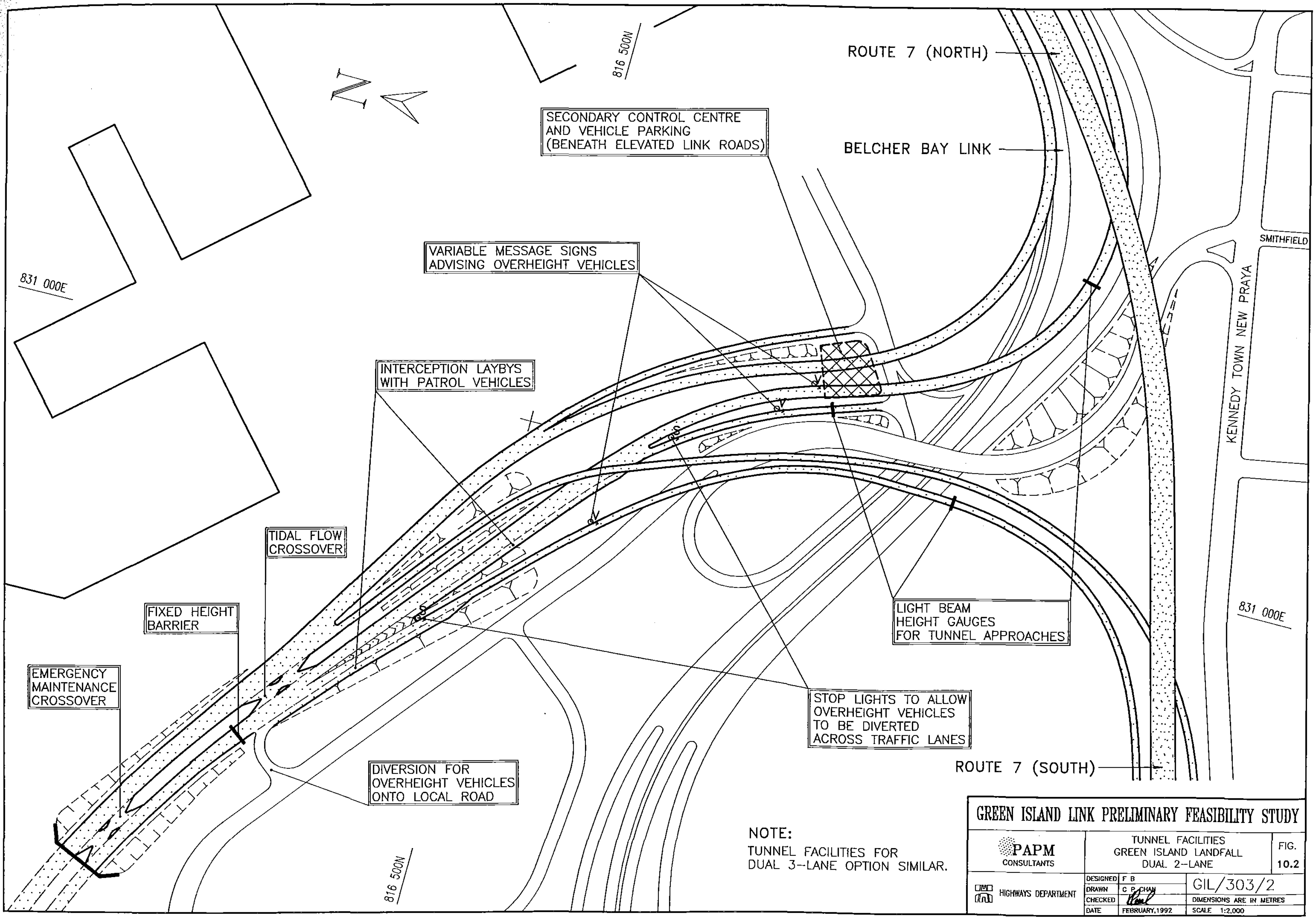
GREEN ISLAND LINK PRELIMINARY FEASIBILITY STUDY			
PAPM CONSULTANTS	CUT AND COVER TUNNEL CONSTRUCTION METHOD		FIG. 9.7
HIGHWAYS DEPARTMENT	DESIGNED: G A H DRAWN: W H WONG CHECKED: [signature] DATE: FEBRUARY,1992	GIL/303.2/4 DIMENSIONS ARE IN METRES SCALE AS SHOWN	



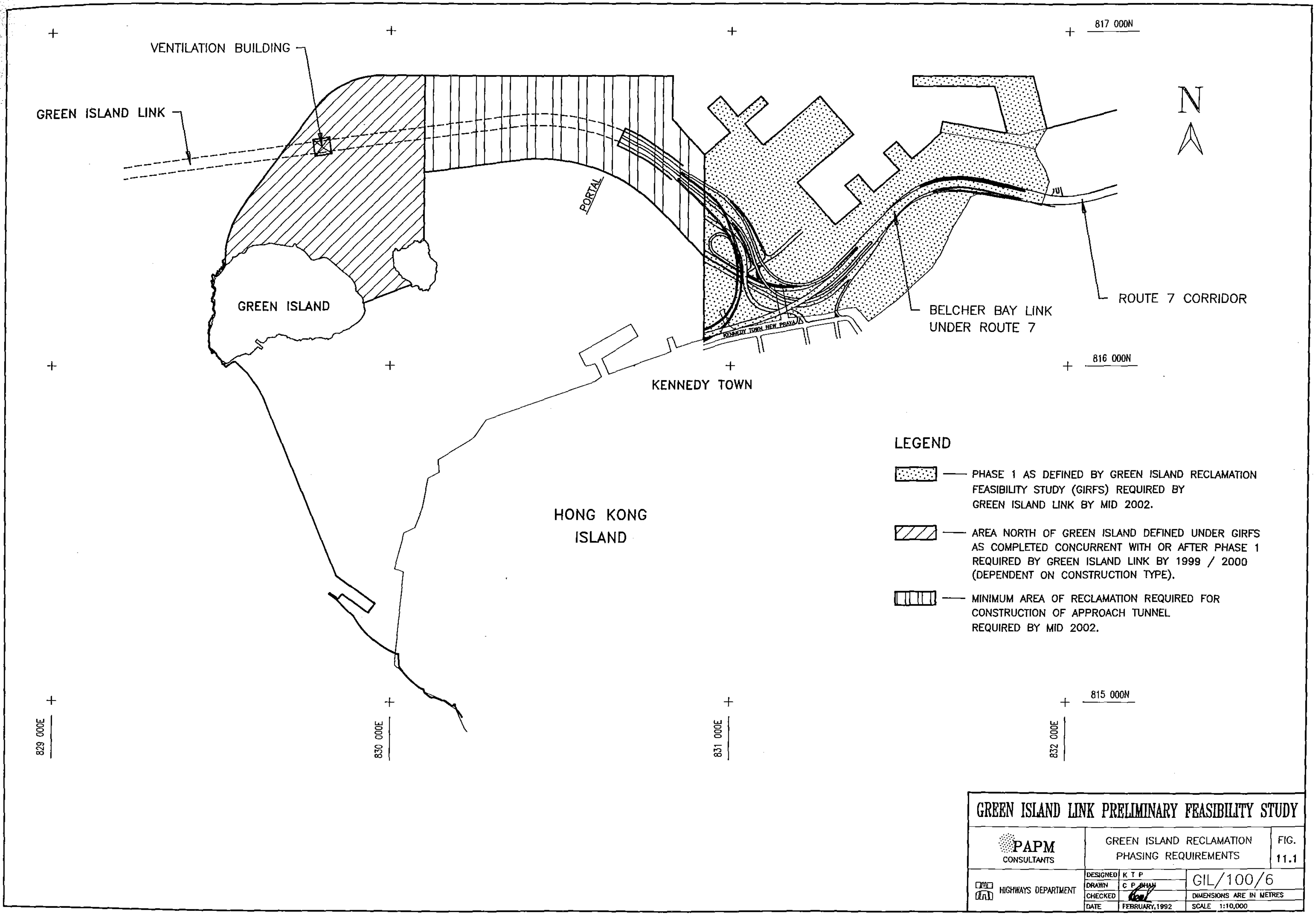
NOTE :

LAYOUT SHOWN IS FOR DUAL 2-LANE TUNNEL, THE LAYOUT FOR THE DUAL 3-LANE TUNNEL WILL BE SIMILAR EXCEPT THAT MORE TOLL BOOTHS ARE REQUIRED.

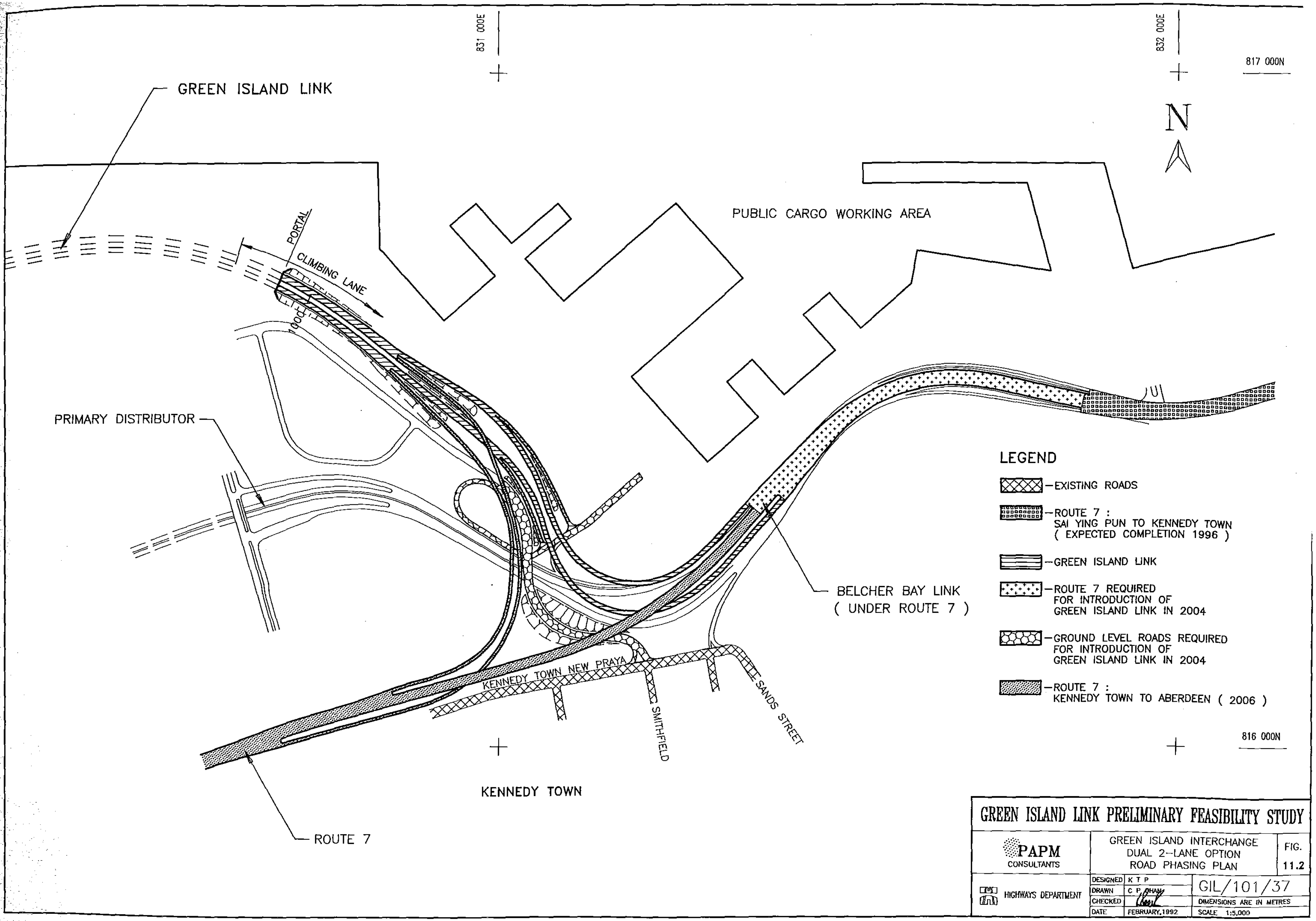
GREEN ISLAND LINK PRELIMINARY FEASIBILITY STUDY			
PAPM CONSULTANTS	TOLL PLAZA LAYOUT DUAL 2-LANE		FIG. 10.1
HIGHWAYS DEPARTMENT	DESIGNED: F B	GIL/101/29	
	DRAWN: C P CHAN	DIMENSIONS ARE IN METRES	
	CHECKED: [signature]		
	DATE: FEBRUARY, 1992	SCALE 1:1,000	

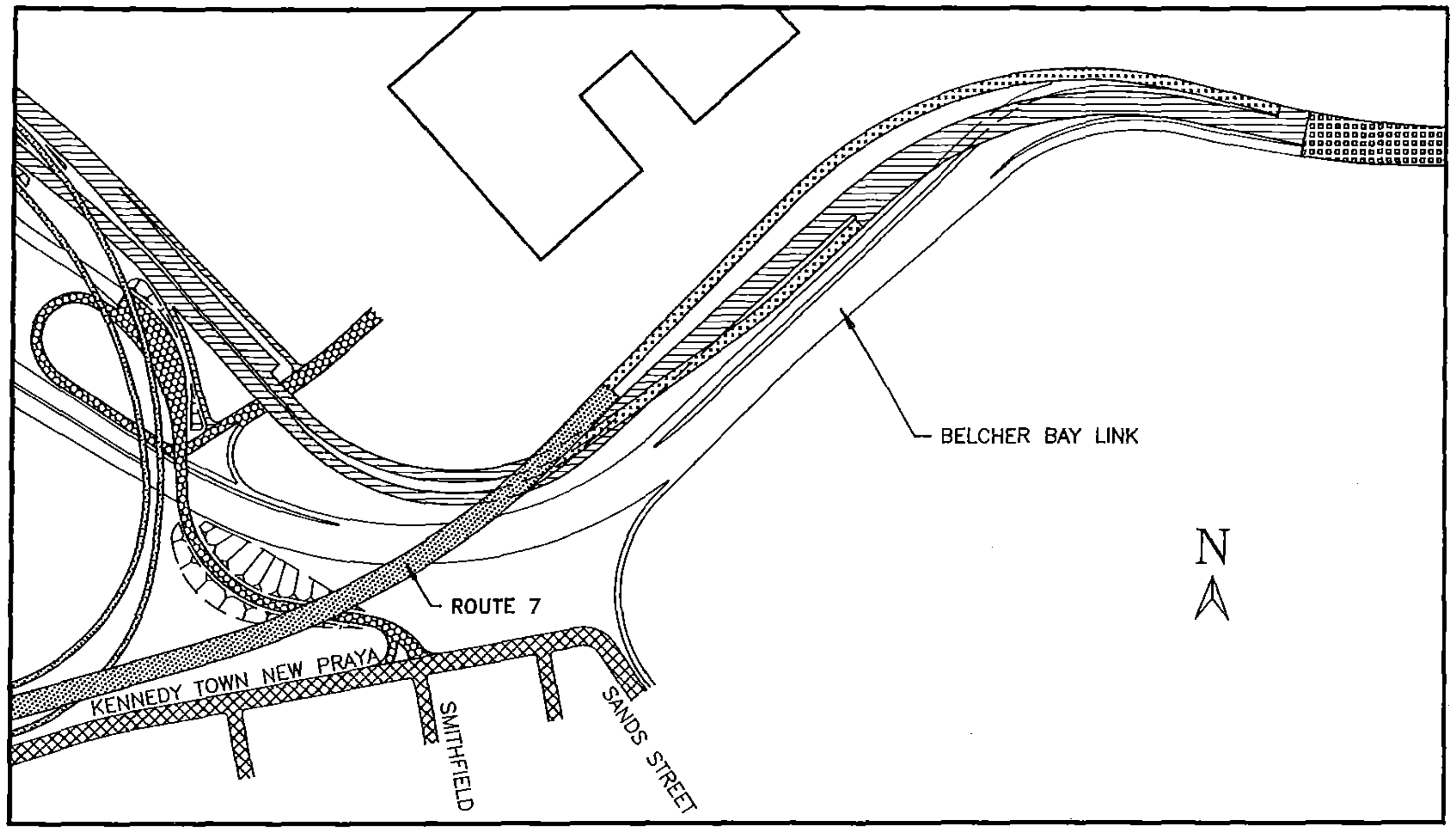


ROUTE 7 (NORTH)
BELCHER BAY LINK
SECONDARY CONTROL CENTRE AND VEHICLE PARKING (BENEATH ELEVATED LINK ROADS)
VARIABLE MESSAGE SIGNS ADVISING OVERHEIGHT VEHICLES
INTERCEPTION LAYBYS WITH PATROL VEHICLES
TIDAL FLOW CROSSOVER
FIXED HEIGHT BARRIER
EMERGENCY MAINTENANCE CROSSOVER
DIVERSION FOR OVERHEIGHT VEHICLES ONTO LOCAL ROAD
LIGHT BEAM HEIGHT GAUGES FOR TUNNEL APPROACHES
STOP LIGHTS TO ALLOW OVERHEIGHT VEHICLES TO BE DIVERTED ACROSS TRAFFIC LANES
ROUTE 7 (SOUTH)
KENNEDY TOWN NEW PRAYA
SMITHFIELD
816 500N
831 000E
816 500N
831 000E
NOTE:
TUNNEL FACILITIES FOR DUAL 3-LANE OPTION SIMILAR.
GREEN ISLAND LINK PRELIMINARY FEASIBILITY STUDY
PAPM CONSULTANTS
TUNNEL FACILITIES
GREEN ISLAND LANDFALL
DUAL 2-LANE
FIG. 10.2
HIGHWAYS DEPARTMENT
DESIGNED F B
DRAWN C P CHAN
CHECKED
DATE FEBRUARY,1992
GIL/303/2
DIMENSIONS ARE IN METRES
SCALE 1:2,000



817 000N
816 000N
815 000N
829 000E
830 000E
831 000E
832 000E
N
VENTILATION BUILDING
GREEN ISLAND LINK
PORTAL
GREEN ISLAND
KENNEDY TOWN NEW PRAYA
KENNEDY TOWN
BELCHER BAY LINK
UNDER ROUTE 7
ROUTE 7 CORRIDOR
HONG KONG
ISLAND
LEGEND
PHASE 1 AS DEFINED BY GREEN ISLAND RECLAMATION FEASIBILITY STUDY (GIRFS) REQUIRED BY GREEN ISLAND LINK BY MID 2002.
AREA NORTH OF GREEN ISLAND DEFINED UNDER GIRFS AS COMPLETED CONCURRENT WITH OR AFTER PHASE 1 REQUIRED BY GREEN ISLAND LINK BY 1999 / 2000 (DEPENDENT ON CONSTRUCTION TYPE).
MINIMUM AREA OF RECLAMATION REQUIRED FOR CONSTRUCTION OF APPROACH TUNNEL REQUIRED BY MID 2002.
GREEN ISLAND LINK PRELIMINARY FEASIBILITY STUDY
PAPM
CONSULTANTS
GREEN ISLAND RECLAMATION
PHASING REQUIREMENTS
FIG.
11.1
HIGHWAYS DEPARTMENT
DESIGNED K T P
DRAWN C P SHAH
CHECKED
DATE FEBRUARY, 1992
GIL/100/6
DIMENSIONS ARE IN METRES
SCALE 1:10,000

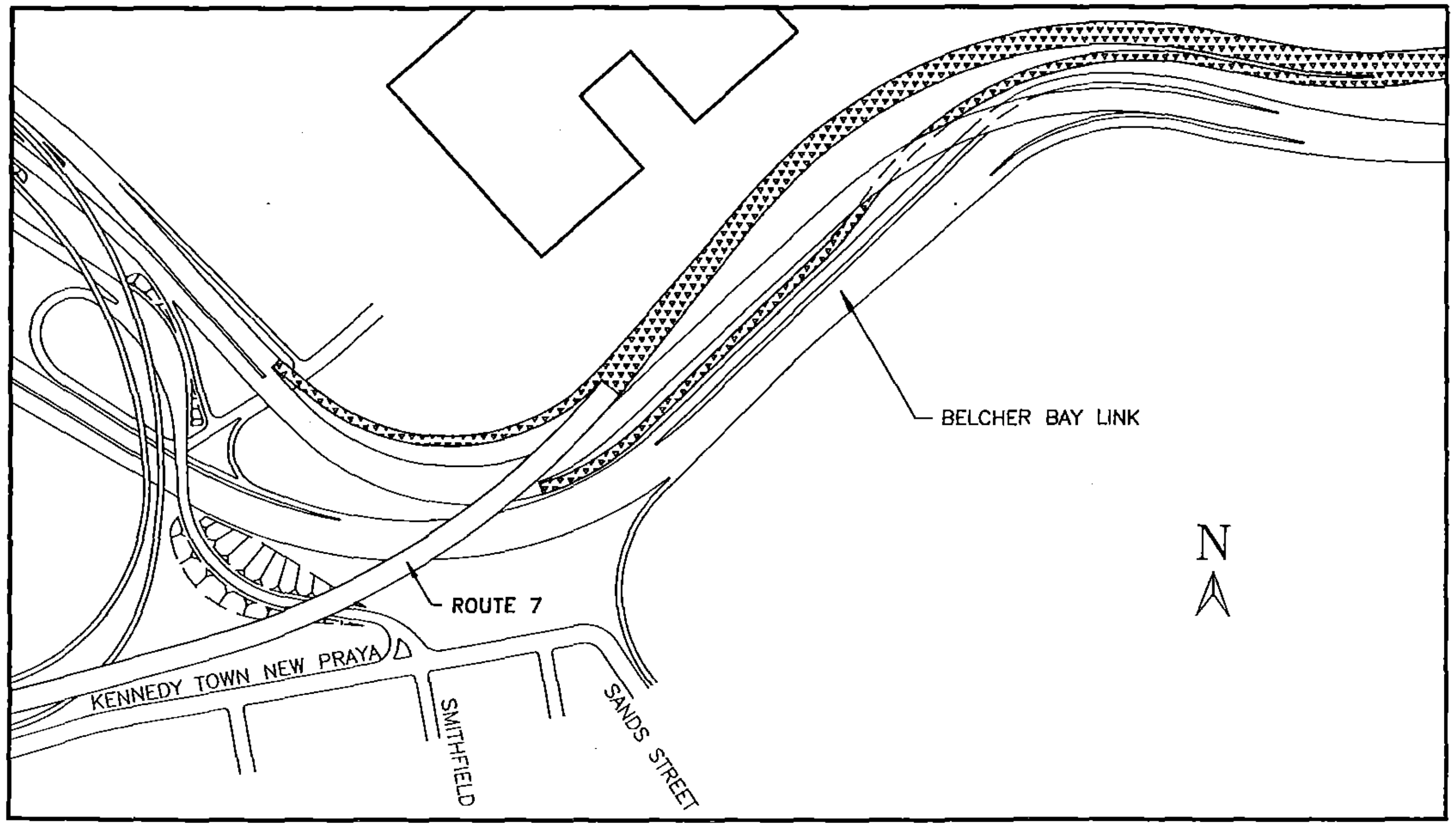

831 000E
832 000E
817 000N
816 000N
N
GREEN ISLAND LINK
PORTAL
CLIMBING LANE
PUBLIC CARGO WORKING AREA
PRIMARY DISTRIBUTOR
BELCHER BAY LINK
(UNDER ROUTE 7)
KENNEDY TOWN NEW PRAYA
SMITHFIELD
SANDS STREET
KENNEDY TOWN
ROUTE 7
LEGEND
—EXISTING ROADS
—ROUTE 7 :
SAI YING PUN TO KENNEDY TOWN
(EXPECTED COMPLETION 1996)
—GREEN ISLAND LINK
—ROUTE 7 REQUIRED
FOR INTRODUCTION OF
GREEN ISLAND LINK IN 2004
—GROUND LEVEL ROADS REQUIRED
FOR INTRODUCTION OF
GREEN ISLAND LINK IN 2004
—ROUTE 7 :
KENNEDY TOWN TO ABERDEEN (2006)
GREEN ISLAND LINK PRELIMINARY FEASIBILITY STUDY
PAPM
CONSULTANTS
GREEN ISLAND INTERCHANGE
DUAL 2-LANE OPTION
ROAD PHASING PLAN
FIG.
11.2
HIGHWAYS DEPARTMENT
DESIGNED K T P
DRAWN C P CHAN
CHECKED
DATE FEBRUARY,1992
GIL/101/37
DIMENSIONS ARE IN METRES
SCALE 1:5,000



LEGEND

PHASE 1 : ROUTE 7 ONLY

- EXISTING ROADS
- ROUTE 7 : SAI YING PUN TO KENNEDY TOWN (EXPECTED COMPLETION 1996)
- GREEN ISLAND LINK
- ROUTE 7 : KENNEDY TOWN TO ABERDEEN (2006) (PERMANENT CONSTRUCTION)
- TEMPORARY ROUTE 7 CONNECTIONS (TO BE REPLACED BY CENTRAL BYPASS)
- GROUND LEVEL ROADS REQUIRED FOR INTRODUCTION OF GREEN ISLAND LINK IN 2004



PHASE 2 : CENTRAL BYPASS

- CENTRAL BYPASS AND PERMANENT CONNECTIONS

GREEN ISLAND LINK PRELIMINARY FEASIBILITY STUDY

PAPM CONSULTANTS	GREEN ISLAND INTERCHANGE DUAL 3-LANE OPTION ROAD PHASING PLAN	FIG. 11.3
HIGHWAYS DEPARTMENT	DESIGNED K T P; DRAWN C P CHAN; CHECKED [signature]; DATE FEBRUARY,1992	GIL/101/38 DIMENSIONS ARE IN METRES SCALE 1:5,000

HIGHWAYS DEPARTMENT - WESTERN HARBOUR LINK OFFICE

GREEN ISLAND LINK

PRELIMINARY FEASIBILITY STUDY

FINAL REPORT

FEBRUARY 1992

Volume 3: SITE INVESTIGATION

PAPM
CONSULTANTS

A joint venture of
PYPUN-HOWARD HUMPHREYS LIMITED
OVE ARUP & PARTNERS HONG KONG LIMITED
PARSONS BRINCKERHOFF (ASIA) LIMITED
MAUNSELL CONSULTANTS ASIA LIMITED

in association with
MVA ASIA LIMITED
LLEWELYN DAVIES PLANNING
CREMER & WARNER LIMITED
HYDRAULICS RESEARCH (ASIA) LIMITED

GREEN ISLAND LINK PRELIMINARY FEASIBILITY STUDY

FINAL REPORT

VOLUME 3

SITE INVESTIGATION

CONTENTS

GREEN ISLAND LINK PRELIMINARY FEASIBILITY STUDY

FINAL REPORT

VOLUME 3

SITE INVESTIGATION

CONTENTS (CONTINUED)

1 INTRODUCTION

1.1 GENERAL

1.1.1 The geotechnical investigation for the Green Island Link Preliminary Feasibility Study consisted of a desk study of existing site investigation data supplemented by further site investigation where appropriate. The existing information available at the commencement of the Study, which is detailed in Appendix A, was considered to be sufficiently comprehensive for this Preliminary Feasibility Study with two exceptions. At the start of the Study there was no information on the heavy metal content of the marine deposits as an indication of contamination, or any subsurface information of Kau Yi Chau.

1.1.2 A limited site investigation and laboratory testing programme was therefore carried out for the Green Island Link Preliminary Feasibility Study which consisted of three distinct elements :

- geophysical survey of Kau Yi Chau;
- borehole investigation of Kau Yi Chau; and
- dropcore investigation and laboratory testing of the marine mud in the area of the Green Island Link tunnels.

1.2 FORM OF THIS VOLUME

1.2.1 The objective of this Volume is to describe the details and present the results of the site investigation carried out for this Study. Further site investigations will be required as part of subsequent study and/or design stages.

1.2.2 Chapter 2, following this introduction describes the regional geology of the area of the proposed Link and details the site investigation and laboratory tests undertaken. Chapters 3 and 4 discuss the relevance of the results in an engineering context, and summarise the conclusions. A full description of the influence of the results on the engineering feasibility of the Link is more thoroughly provided in Volume 1 of this Report.

2 GEOTECHNICAL DATA

2.1 REGIONAL GEOLOGY

2.1.1 The Green Island Link (GIL) corridor traverses an area where the geological succession is typical of offshore conditions in Hong Kong. Examination of existing site investigation data confirms that the geological succession consists of marine deposits overlying alluvium and decomposed granite (soil) and granite bedrock.

2.1.2 The marine deposits are predominantly very soft to firm clay and silt. Marine sand deposits have been identified on the northern side of the GIL corridor within the Lamma Channel. Around the former dumping ground areas to the north of Kau Yi Chau the top layer of the marine deposits is expected to contain construction debris and other waste materials.

2.1.3 The alluvium consists of interbedded layers of silt/clay, sand and gravel deposits. Both the thickness and base level of the alluvium varies along the alignments of the proposed submerged link. However, around Kau Yi Chau and in the area of proposed reclamation on the southern edge of the Lantau Port Peninsula the level at the top of the alluvium is reasonably uniform at -28mPD. The alluvium is thought to be part of the Chek Lap Kok Formation, and of Pleistocene Age. As a result the alluvium would be a relatively stiff material and would probably be over consolidated. Within the Green Island Link Corridor, the existing borehole information described in Appendix A indicates that the alluvium is predominantly a granular material comprising mostly silty gravelly sand.

2.1.4 The mantle of decomposed granite soil (CDG) also varies in thickness along the proposed alignments. In general rockhead is at between -40mPD and -75mPD. The CDG underlying the sediments is characteristically a very stiff material being the in situ weathering product of the granite bedrock.

2.1.5 The East Lamma Channel is inferred to follow the alignment of the fault system which is orthogonal to the Tolo Channel/Lai Chi Kok lineament shown on the 1:20000 Geological Series published by the GEO.

2.2 GEOPHYSICAL SURVEY

2.2.1 The geophysical survey of Kau Yi Chau was carried out by Electronic & Geophysical Services Limited (EGS) as part of Civil Engineering Services Department Term Contract GC/91/01 works order no. PW7/2/313. The survey was carried out between 2nd and 14th of November 1991.

2.2.2 The objectives of the survey were to map the depth below ground level to grade III/II/I rock. From this information volumes could be obtained for both soft and rock fill assuming that Kau Yi Chau would be levelled to approx. +4.5mPD.

2.2.3 Details of the geophysical survey are contained in EGS factual report ref. HK60291 dated December 1991.

2.2.4 Seismic refraction measurements were carried out along twelve spreads the lengths of which were either 110 metres or 230 metres. In all, 6 traverses of Kau Yi Chau Island were surveyed, the locations of which are shown in Figure G1.

2.2.5 The seismic sound source was HDP primer explosives. Between 1 and 4 lbs of explosives were used at each shot with the depth of shot holes being between 0.5 and 1.5 metres. The seismic record was recorded by an EG & G ES-2401 24 channel seismograph.

2.2.6 The interpretation of the seismic refraction data was carried out using the Hagerdoorn "Plus Minus" method, the procedures which are outlined in the EGS factual report.

2.2.7 The empirical relationship between weathering states of granite type rocks and seismic velocities which were adopted are shown in Table 2.1.

TABLE 2.1 RELATIONSHIP BETWEEN WEATHERING STATES OF GRANITE TYPE ROCK AND SEISMIC VELOCITY

State of Weathering	Weathering Grade	Bulk Velocity (m/ms)
Soil and colluvium	VI	0.3 - 0.6
Completely weathered rock	V	0.3 - 0.8
Highly weathered rock	IV	0.8 - 3.0
Moderately weathered rock	III	3.0 - 4.0
Slightly weathered-fresh rock	II - I	4.0 or more

2.2.8 For interpretation of all of the data a three layer model was postulated, showing the following velocity ranges :

(i) An upper layer velocity of between 0.35 and 0.6 m/ms corresponding to unsaturated soil, colluvium or completely weathered rock (Grades V-VI).

(ii) An intermediate layer which has a seismic velocity ranging between 0.5 and 2.5 m/ms indicating that it is completely to highly weathered.

(iii) A third layer or main seismic refractor the velocity of which is between 4.1 and 6.1 m/ms suggesting that it is fresh to slightly weathered. The exception to this is the southern part of seismic profile section A6-A6 shown on Figure G7, which has a seismic velocity of 3.3 m/ms suggesting moderately weathered rock.

2.2.9 The results of the six traverses are presented as a series of seismic profiles shown in Figures G2 to G7.

2.2.10 In most cases there is a large velocity contrast between the intermediate layer and the main seismic refractor which suggests that there is a sharp boundary between the completely to highly weathered and the sightly weathered to fresh rock.

2.2.11 The weathering profile over the island varies, with depths to the main refractor ranging between 3 and 28 metres. In general the rock tends to be more deeply weathered towards the top of the hill. A notable exception to this occurs on the northern part of seismic profile section A6-A6 shown on Figure G7, where depth to rock head reaches 26 metres on the flank of the hill. This increased depth of weathering is possibly due to a lateral variation in lithology.

2.2.12 Towards the northern part of the island the velocity of the main refractor tends to be lower. This area corresponds to that shown to be underlain by quartz porphyry and feldspar porphyry dyke swarms on the geological map of the area. Its slightly lower velocity suggests that it has been more intensely weathered than either the granite or the tuff surrounding it.

2.2.13 The boundary between the granite and the tuff could not be determined from the results of the survey.

2.2.14 Fault zones of less than 20 metres wide were identified on seismic profile sections A3-A3, A5-A5 and A6-A6 shown on Figures G4, G6 & G7, but from the available data it is not possible to determine their nature or orientation. These have therefore not been plotted on the sections.

2.3 BOREHOLE INVESTIGATION

2.3.1 The borehole investigation on Kau Yi Chau was carried out by Geotechnics and Concrete Engineering (Hong Kong) Ltd as part of the Civil Engineering Services Department Term Contract GC/89/08 works order PW7/2/30.142. The site work was carried out during the period from 20th November to 7th December 1991.

2.3.2 The works consisted of sinking four boreholes to a depth of 10 metres into bedrock and taking rock core samples. Standard Penetration Tests and associated liner samples were also taken.

2.3.3 The four boreholes were located along the seismic refraction traverses carried out by EGS shown in Figure G1. The borehole information was used to confirm the accuracy and results of the seismic survey.

2.3.4 The fieldwork is summarised in the factual report produced by Geotechnics and Concrete Engineering Ltd in January 1992. The boreholes logs are contained in Appendix B to this report.

2.3.5 The boreholes indicated that there is a thickness of between 15 to 20 metres of colluvium and insitu weathered soil. Underlying the soil overburden is generally a moderately jointed intrusive rock of granite origin.

2.3.6 The geological map of the Island indicated the solid geology could be split into 3 rock types. To the northwest quartz porphy and feldspar porphy dyke swarms, the central and southern area granite whilst to the east is a quartz monzonite tuff. The island is traversed by a number of feldspar porphy dykes which have a general trend of northwest to southwest.

2.3.7 In the site investigation borehole BH1 indicated bedrock to be a tuff, boreholes BH2 and BH3 feldsparphyic rhyolite and borehole BH4 a coarse grained granite. This essentially confirmed the geology shown on the published maps.

2.3.8 The descriptions of some of the rock encountered in the boreholes is open to interpretation especially where highly weathered. For example the weathered rock between 2 to 5 metres in borehole BH4 is described as a weathered tuff by the consortia's geologist, where as an alternative description given by Government's geologist is a weathered granite.

2.4 MARINE MUD INVESTIGATION

Dropcores

2.4.1 A series of dropcore samples were carried out along proposed routes of the Green Island Link between the proposed Green Island Reclamation and the proposed port peninsula reclamation. The marine deposits obtained from the dropcore samples were subsequently tested in the laboratory.

2.4.2 The dropcore sampling was carried out by Electronic and Geophysical Services Limited as part of the Civil Engineering Services Department Term Contractor GC/91/01, works order No. PW7/2/31.3A. A total of 20 dropcore samples were taken. The locations of the dropcores are indicated in Figure G8 and the co-ordinates of each dropcore location are given in Table 2.2.

TABLE 2.2 DROPCORE LOCATIONS

SAMPLE NO. (m)	EASTING	NORTHING
DC1	830 890	816 550
DC2	830 320	816 720
DC3	829 700	816 600
DC4	828 910	816 480
DC5	828 040	816 340
DC6	827 310	816 400
DC7	826 660	816 570
DC8	825 970	816 570
DC9	825 390	816 570
DC10	824 700	816 570
DC11	824 300	816 990
DC12	830 230	815 920
DC13	829 630	815 700
DC14	828 860	815 860
DC15	828 040	815 860
DC16	827 031	815 940
DC17	826 660	815 830
DC18	825 980	815 700
DC19	825 390	815 940
DC20	824 290	816 140

2.4.3 The object of taking dropcores was to obtain surface samples of the seabed. A report of the dropcore sampling works was not required of the contractor. The dropcores samples were 38mm diameter and a length of between 1.5 and 2.0 metres. To obtain sufficient weight of sample for testing the sample was extruded and mixed.

Laboratory Testing

2.4.4 The testing was carried out by The Hong Kong Standards and Testing Centre Ltd. The testing was carried out on 26 September 1991.

2.4.5 The objective of the testing was to assess the heavy metal content of the sea bed material along the proposed tunnel alignments with a view to assessing its degree of contamination. Particle size distribution curves were also obtained for each of the samples tested. The results of chemical and particle size distribution tests are given in Tables 2.3 and 2.4 respectively. The grading curves are also reproduced in Figures G9 to G12 of this Report.

2.4.6 Details of the laboratory testing results are contained in The Hong Kong Standards and Testing Centre Ltd Report Reference HC16921/390 dated October 1991.

TABLE 2.3 DROPCORE HEAVY METAL ANALYSIS

SAMPLE NUMBER	DETERMINANT (mg/kg)						
	Cd	Cr	Cu	Pb	Hg	Ni	Zn
DC1	0.5	18	7	23	0.04	11	41
DC2	0.6	16	9	23	0.04	9	42
DC3	0.7	14	7	23	0.07	9	41
DC4	0.6	16	6	20	0.03	10	39
DC5	0.7	20	6	26	0.13	13	49
DC6	0.6	23	22	30	0.13	10	62
DC7	0.7	24	27	28	0.13	12	58
DC8	0.6	21	30	26	0.09	11	58
DC9	0.7	13	17	31	0.07	9	55
DC10	0.5	12	14	41	0.06	7	48
DC11	0.6	16	25	33	0.07	9	59
DC12	0.7	16	16	20	0.06	10	55
DC13	0.6	13	9	16	0.03	9	37
DC14	0.6	15	9	19	0.04	10	40
DC15	0.7	18	26	31	0.14	10	67
DC16	0.5	19	19	32	0.14	10	61
DC17	0.7	19	33	27	0.10	10	59
DC18	0.4	7	5	32	0.06	3	24
DC19	0.5	2	12	13	0.04	2	27
DC20	0.5	14	18	24	0.10	7	48

2.4.7 The chemical tests were carried out to determine the following:

- Heavy metals content for cadmium, lead mercury, chromium (total), nickel, copper and zinc;
- Ammonical Nitrogen;and
- Total Kjeldahl Nitrogen.

2.4.8 The following testing methods were adopted:

(i) cadmium, copper, lead nickel and zinc - Direct Air Acetylene Flame method;

(ii) total chromium - Direct Nitrous Oxide - Acetylene Flame method;

(iii) total mercury content - Cold-Vapour Atomic Absorption Spectrometric method;

(iv) total Kjeldahl Nitrogen - 4500-NH_3B preliminary distillation step followed by the 4500-NH_3E Titrimetric method; and

(v) ammonia content - 4500-NH_3B preliminary distillation step was followed by the 4500-NH_3D Phenate method.

2.4.9 The details of the testing procedures are contained in the standard methods for Examination of Water and Wastewater 17th Edition.

2.4.10 The grading curves were obtained adopting the methods set out in BS1377 - 1975 for both sieve and the hydrometer analysis.

TABLE 2.4 PARTICLE SIZES

SAMPLE	PERCENTAGE			
	GRAVEL	SAND	SILT	CLAY
DC1	2	26	62	10
DC2	0	23	71	6
DC3	0	37	57	6
DC4	2	25	67	6
DC5	16	22	54	8
DC6	15	34	43	8
DC7	11	20	56	13
DC8	0	3	34	13
DC9	16	54	23	7
DC10	22	47	26	5
DC11	9	30	49	12
DC12	0	3	78	19
DC13	0	10	78	12
DC14	1	21	57	11
DC15	3	30	51	1
DC16	10	24	51	15
DC17	0	7	71	22
DC18	4	32	48	16
DC19	41	57	1	1
DC20	7	49	34	10

2.4.11 Additional testing was also carried out at the Government laboratories to determine the dry weight ratio and Polychlorinated Biphenyl (PCB) content of the sample. The samples were tested on 18 December 1991 the results are contained on Government Laboratory report lab no. WCY 14755/14794. The results are also indicated in Table 2.5.

TABLE 2.5 GOVERNMENT TEST RESULTS

SAMPLE MARK	DWR (w/w)	PCB (ug/kg)
DC1	.59	7
DC2	.57	16
DC3	.55	6
DC4	.58	<5
DC5	.65	12
DC6	.64	16
DC7	.62	12
DC8	.41	11
DC9	.72	10
DC10	.75	7
DC11	.61	15
DC12	.44	<5
DC13	.46	7
DC14	.52	<5
DC15	.52	21
DC16	.54	11
DC17	.44	8
DC18	.75	7
DC19	.85	7
DC20	.66	<5

DWR = Dry weight/wet weight ratio
PCB = Polychlorinated biphenyl

3 DISCUSSION

3.1 KAU YI CHAU

3.1.1 The object of the geological survey and borehole investigation of Kau Yi Chau was to identify the thickness of soft fill and rock which would need to be removed to reduce the level of Kau Yi Chau to +4.5m Datum.

3.1.2 The seismic profile satisfactorily established the rockhead profile and therefore the approximate volumes of soft and rock material to be removal were determined. For the present preliminary studies it was not considered necessary to delineate actual details of the faults and dykes that were indicated on the seismic traces.

3.1.3 The volume of soft material and rock to be removed is 1 million cubic metres and 6.3 million cubic metres respectively. The overburden can be excavated by traditional earthmoving equipment. To remove the rock, blasting will be required, the typical blast patten depending on the end use of the rock. In some areas by careful blasting it would be possible to produce some rock suitable for inclusion in the seawalls causeway. In other areas, most notably in the southern part of the Island where the joint sets are closely spaced, block blasting can be adopted to achieve maximum daily output of rock fill.

3.2 MARINE BED

3.2.1 The particle size distribution curves obtained from the dropcore samples have been grouped into 5 types which are shown in Figures G9 to G13. On area basis there is some limited correlation in that the samples near Green Island tend to have greater proportion of silt size particles whilst those in the former dumping ground between Kau Yi Chau and Siu Kau Yi Chau have the smallest percentage of silt size particles and greatest sand content. These variations in grading are not considered critical, and are consistent with the particle size parameters adopted for the hydraulic modelling and assessment of scour described in Section 8.8 of Volume 1 of this Report.

3.2.2 The results of the heavy metals testing have shown that the samples can be considered to be within the limits associated with uncontaminated marine sediments and that it will not be necessary to take special precautions in the disposal of any of the marine mud. This aspect is discussed further in Section 2.6 of Volume 4 of this Report.

4 SUMMARY

4.1 The objectives of the additional site investigation works carried out was to supplement existing information with additional data regarding :-

(i) soil and rock profiles on Kau Yi Chau; and

(ii) preliminary assessment on the chemical content of the sea bed.

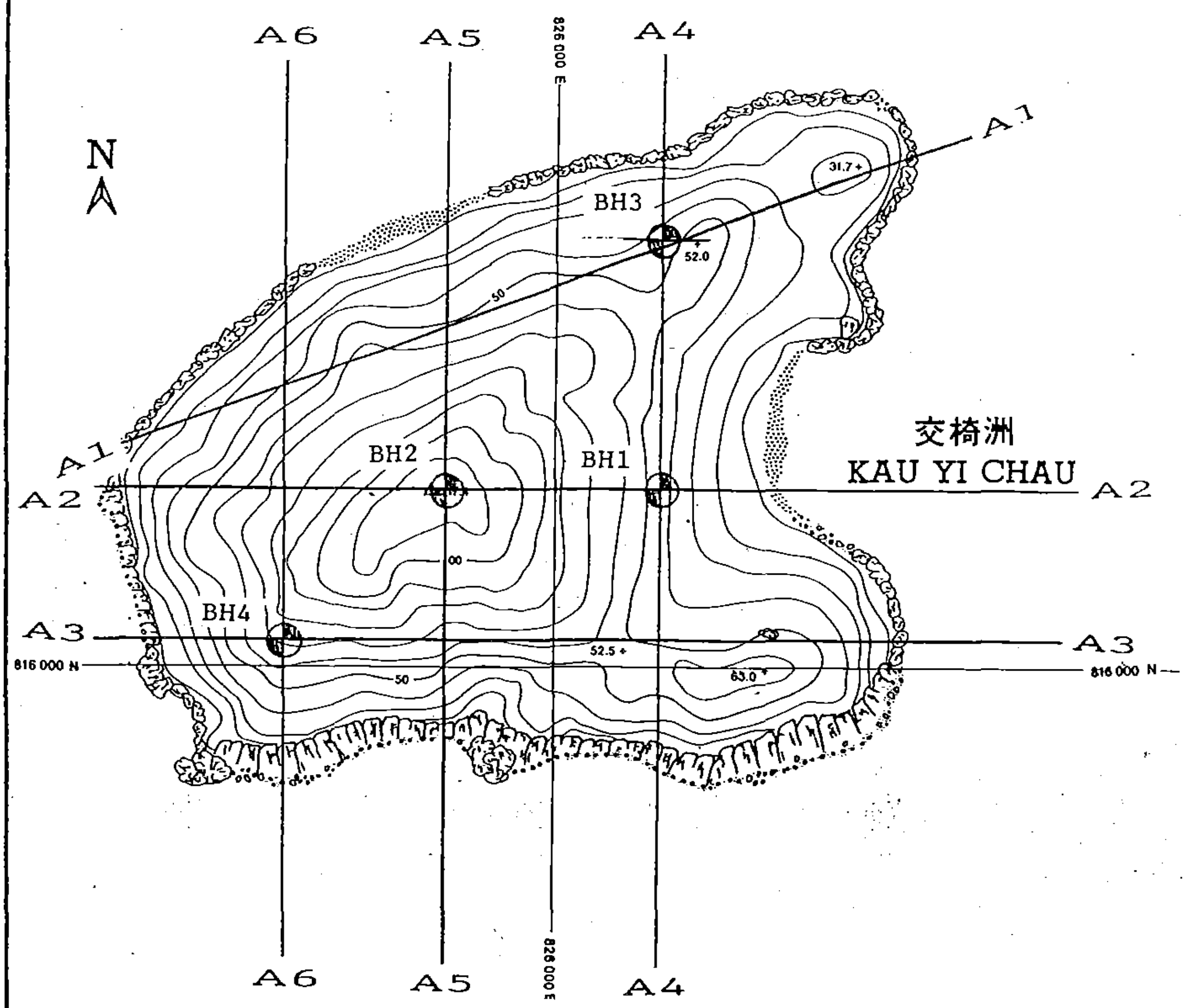
4.2 The geological sequence determined on Kau Yi Chau consisted of fill/colluvium overlying weathered rock overlying bedrock. Depth to bedrock varies between 3 and 28 metres across the Island. The depth to rockhead obtained from the seismic refraction profiles compares reasonably well with the borehole records within the limitations of the seismic refraction method.

4.3 The seismic profiles also located fault zones of less than 20m width but the nature and orientation of the faults could not be determined and are not critical to this Preliminary Feasibility Study.

4.4 The dropcore samples were analysed for : Cadmium, Chromium, Copper, Lead, Mercury, Nickel, Zinc as indicators of heavy metal contamination. All samples analysed fall within the limits associated with uncontaminated soils.

4.5 The grading curves for samples taken from the former dumping ground tend to exhibit the highest proportion of coarse materials (Samples DC 19, 9, 10, 20). The samples with the highest fines content tended to be in the eastern part of the study area near of Green Island. The variations in grading are not considered significant in determining the effects of scour.

FIGURES



LEGEND :

BH3 ⊕ BOREHOLE

	NORTHING (APPROX.)	EASTING (APPROX.)
BH1	816127.19	826083.67
BH2	816133.17	825914.83
BH3	816314.98	826079.64
BH4	816016.83	825793.82

NOTE :

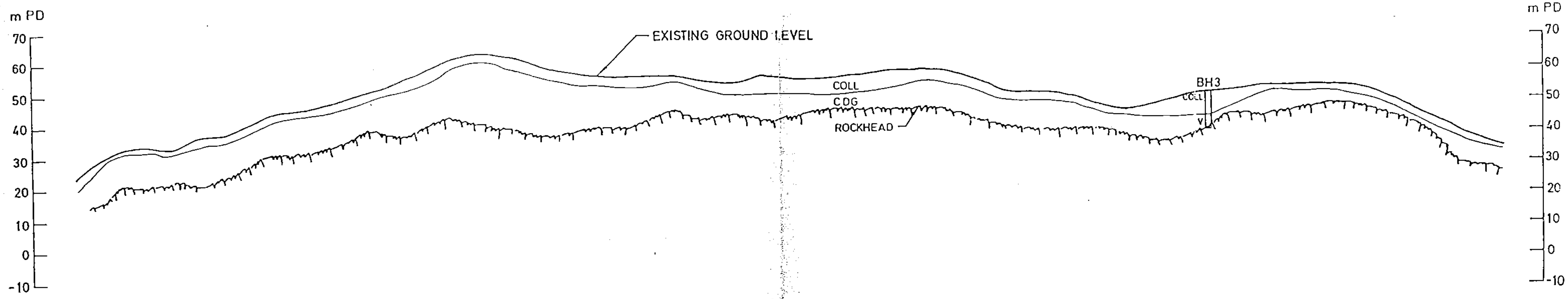
(1) 10 METRES CORING IN ROCK.

(2) SPT WITH LINER SAMPLES 2m C/C

(3) GEOPHYSICAL SURVEY IN PROGRESS (DEC.,1991).

GREEN ISLAND LINK PRELIMINARY FEASIBILITY STUDY

HIGHWAYS DEPARTMENT	SEISMIC PROFILE SECTION A1–A1	PAPM CONSULTANTS	FIG. G1



A1 - A1

GREEN ISLAND LINK PRELIMINARY FEASIBILITY STUDY

PAPM CONSULTANTS

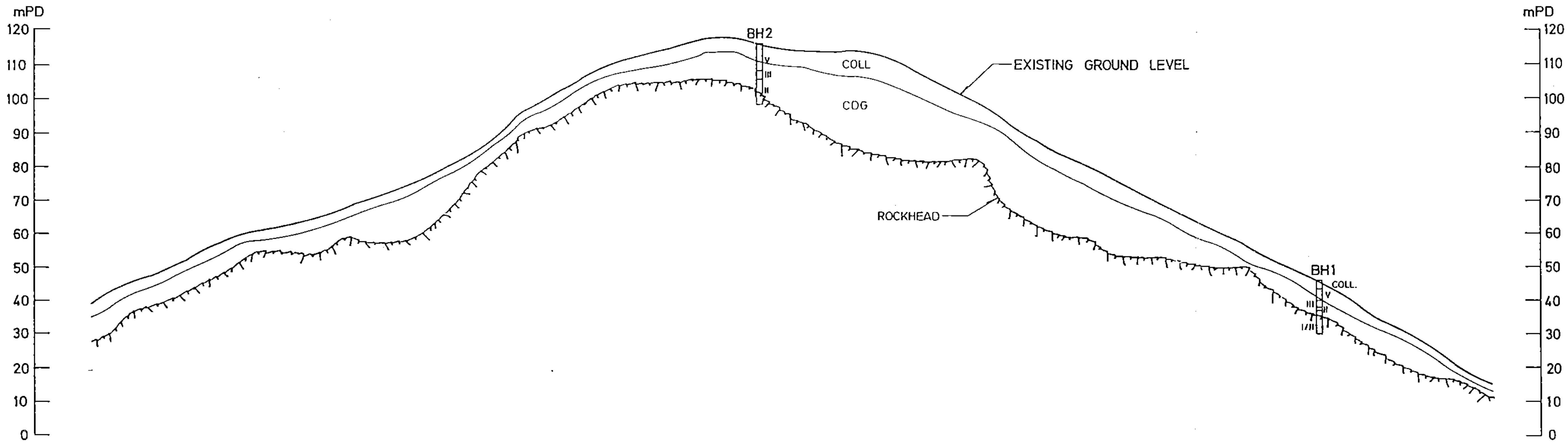
SEISMIC PROFILE
SECTION A1–A1

FIG. G2

HIGHWAYS DEPARTMENT

DESIGNED	
DRAWN	W NG
CHECKED	
DATE	JUNE, 1992

DIMENSIONS ARE IN



A2 - A2

GREEN ISLAND LINK PRELIMINARY FEASIBILITY STU

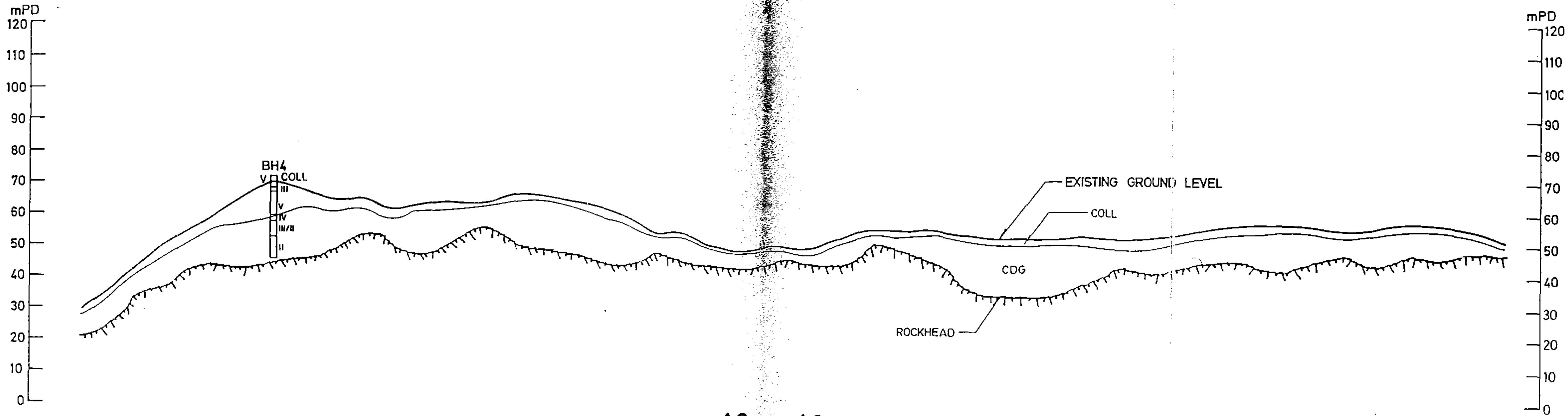
PAPM CONSULTANTS

SEISMIC PROFILE
SECTION A2-A2

HIGHWAYS DEPARTMENT

DESIGNED	
DRAWN	W NG
CHECKED	
DATE	JUNE, 1992

DIMENSIONS ARE IN



A3 - A3

GREEN ISLAND LINK PRELIMINARY FEASIBILITY STUDY

PAPM CONSULTANTS	SEISMIC PROFILE SECTION A3–A3	FIG. G4

HIGHWAYS DEPARTMENT	DESIGNED		
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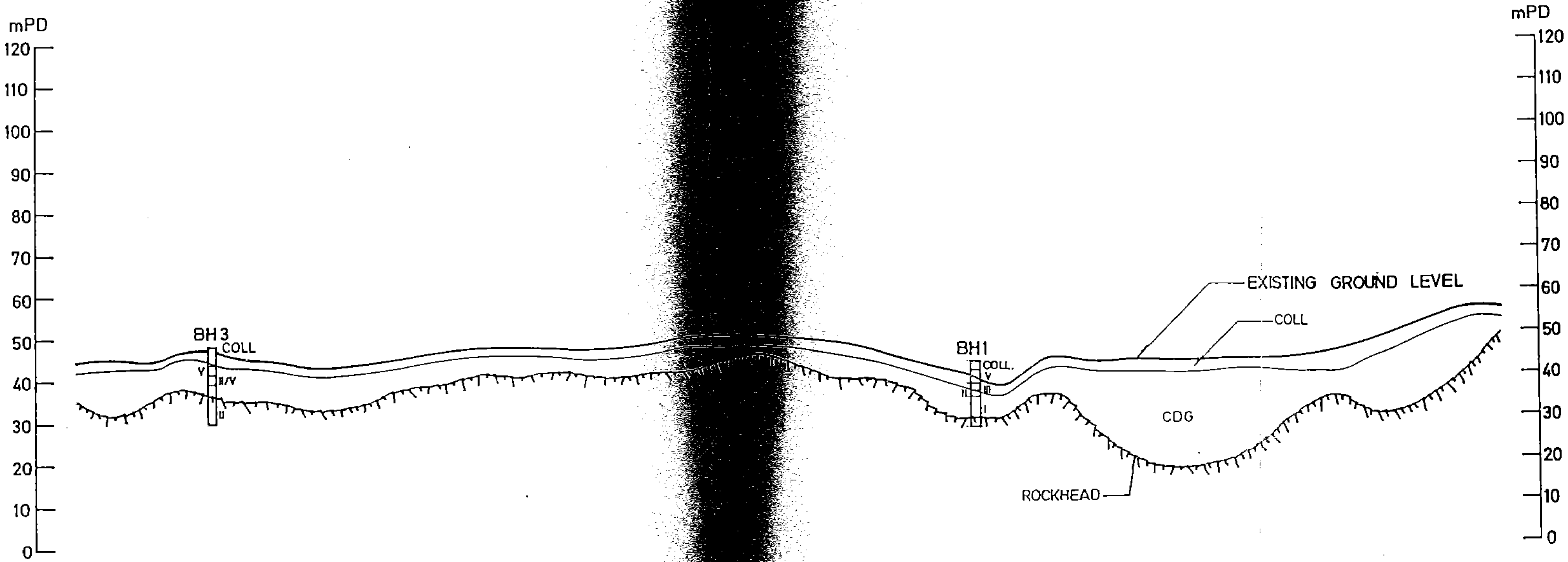
	CHECKED		DIMENSIONS ARE IN
	DATE	JUNE, 1992	



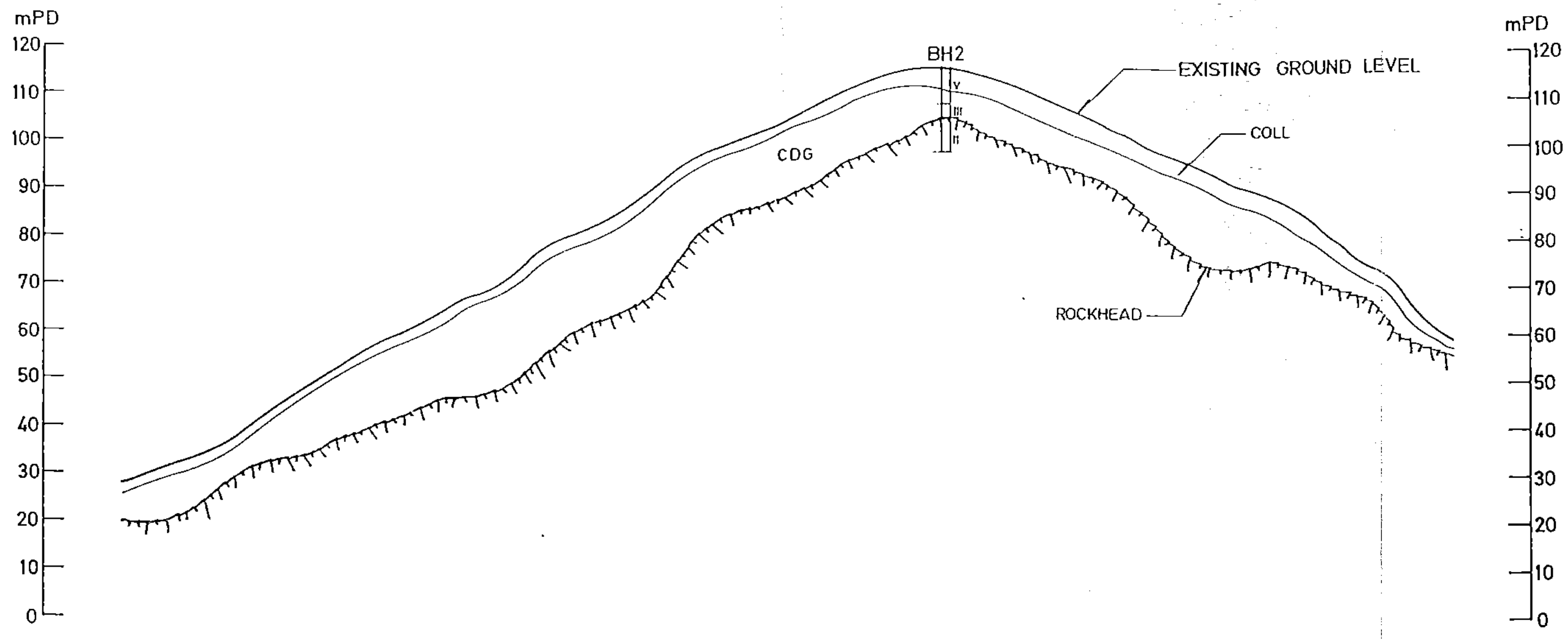
A4 — A4

GREEN ISLAND LINK PRELIMINARY FEASIBILITY STUDY

PAPM CONSULTANTS	SEISMIC PROFILE SECTION A4–A4	FIG. G5

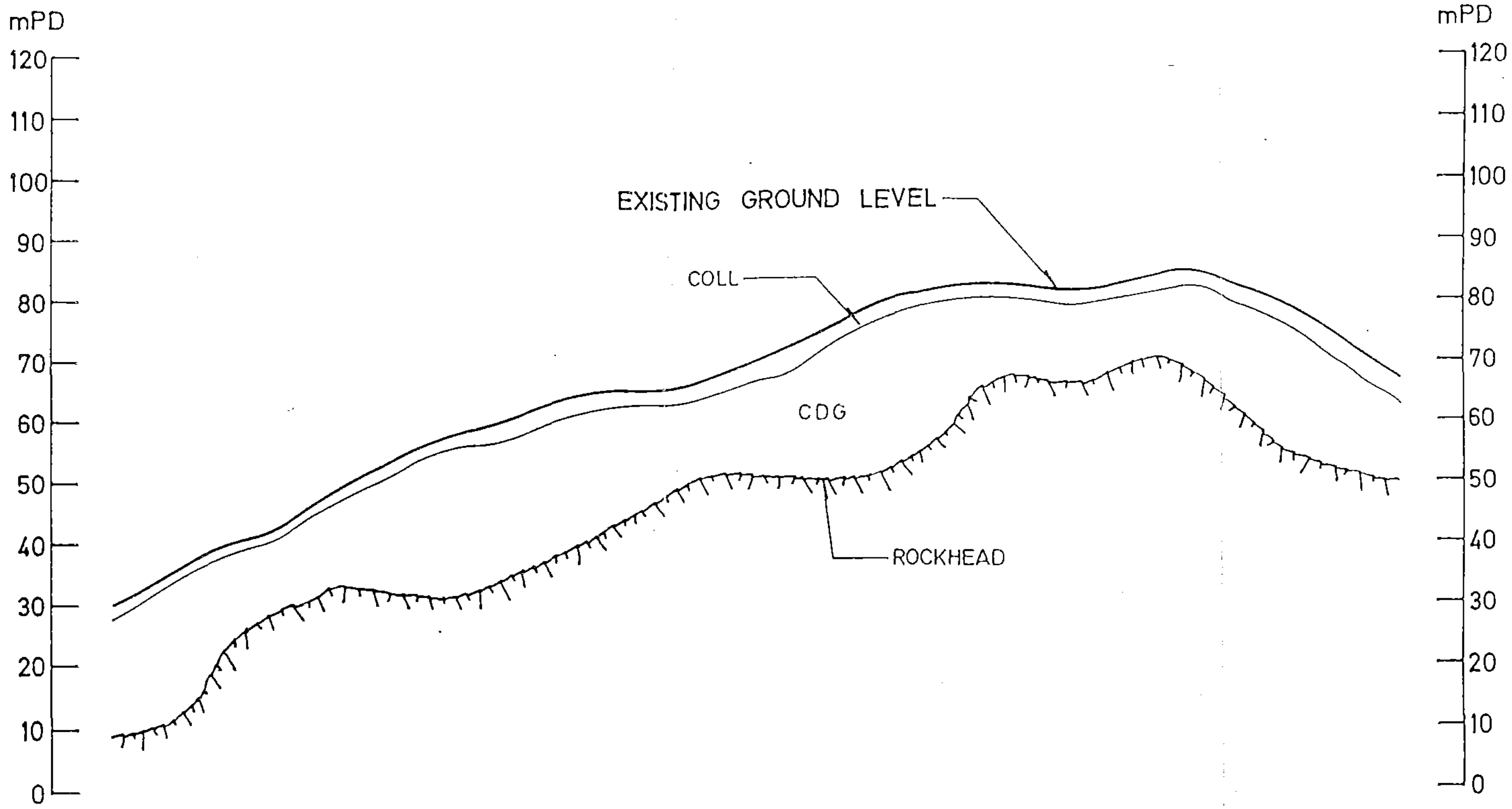
HIGHWAYS DEPARTMENT

DESIGNED		
DRAWN	W NG	
CHECKED	,	DIMENSIONS ARE IN
DATE	JUNE, 1992	



A5 - A5

GREEN ISLAND LINK PRELIMINARY FEASIBILITY STUDY		
PAPM CONSULTANTS	SEISMIC PROFILE SECTION A5–A5	FIG. G6
HIGHWAYS DEPARTMENT	DESIGNED DRAWN W NG CHECKED DATE JUNE, 1992	DIMENSIONS ARE IN



A6 - A6

GREEN ISLAND LINK PRELIMINARY FEASIBILITY STUDY

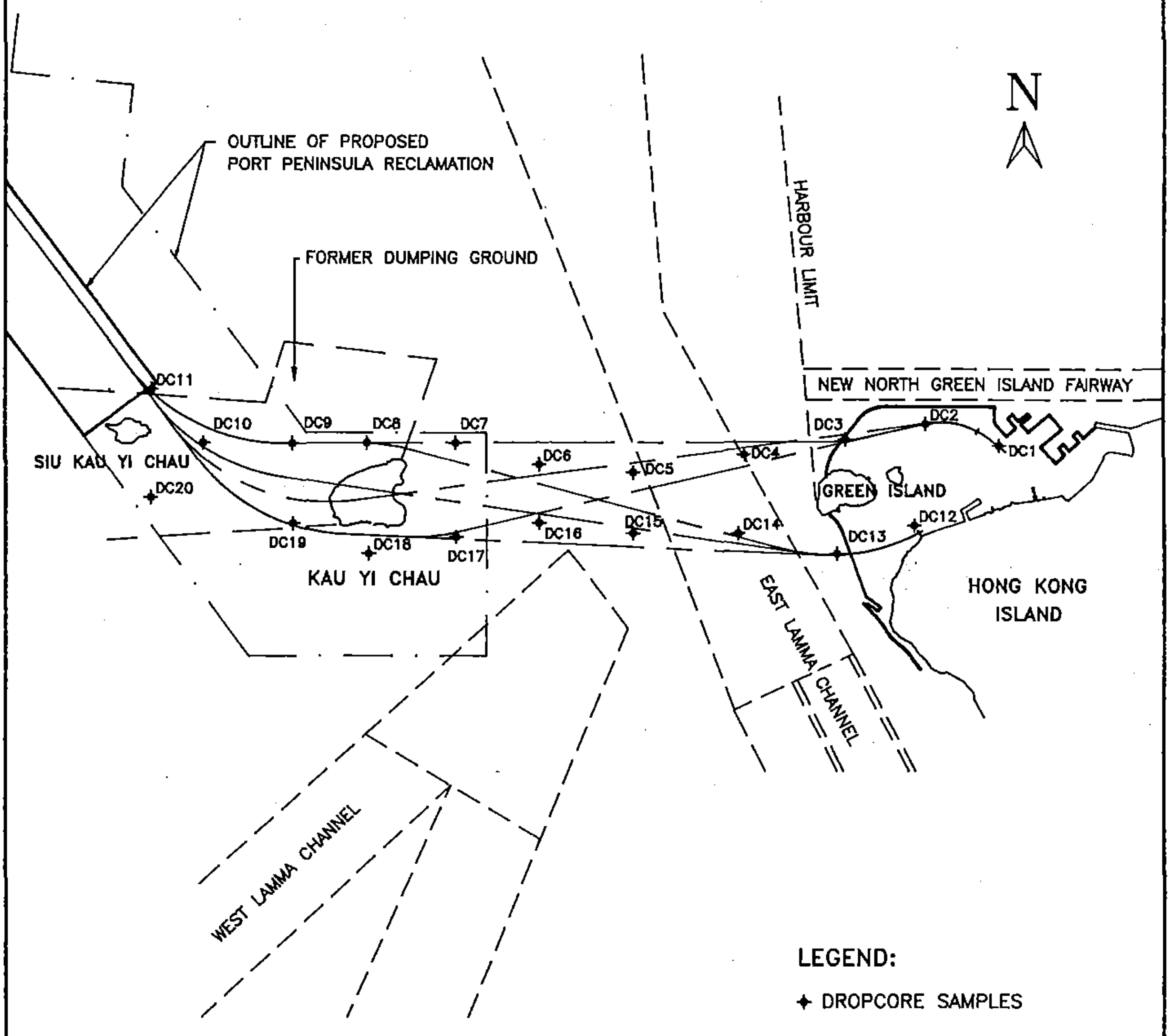
PAPM CONSULTANTS

SEISMIC PROFILE
SECTION A6–A6

FIG. G7

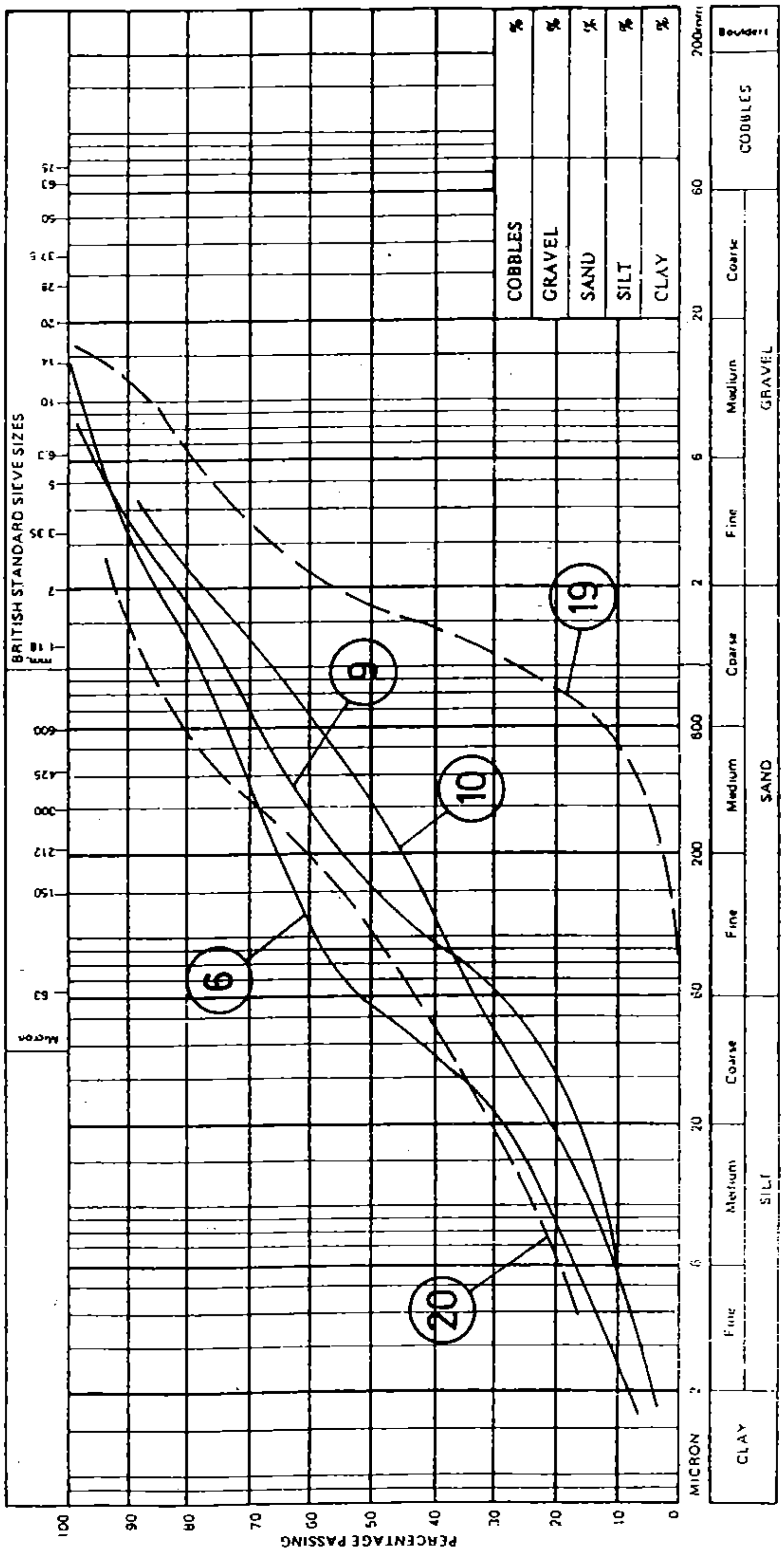
HIGHWAYS DEPARTMENT

DESIGNED		
DRAWN	W NG	
CHECKED		DIMENSIONS ARE IN
DATE	JUNE, 1992	



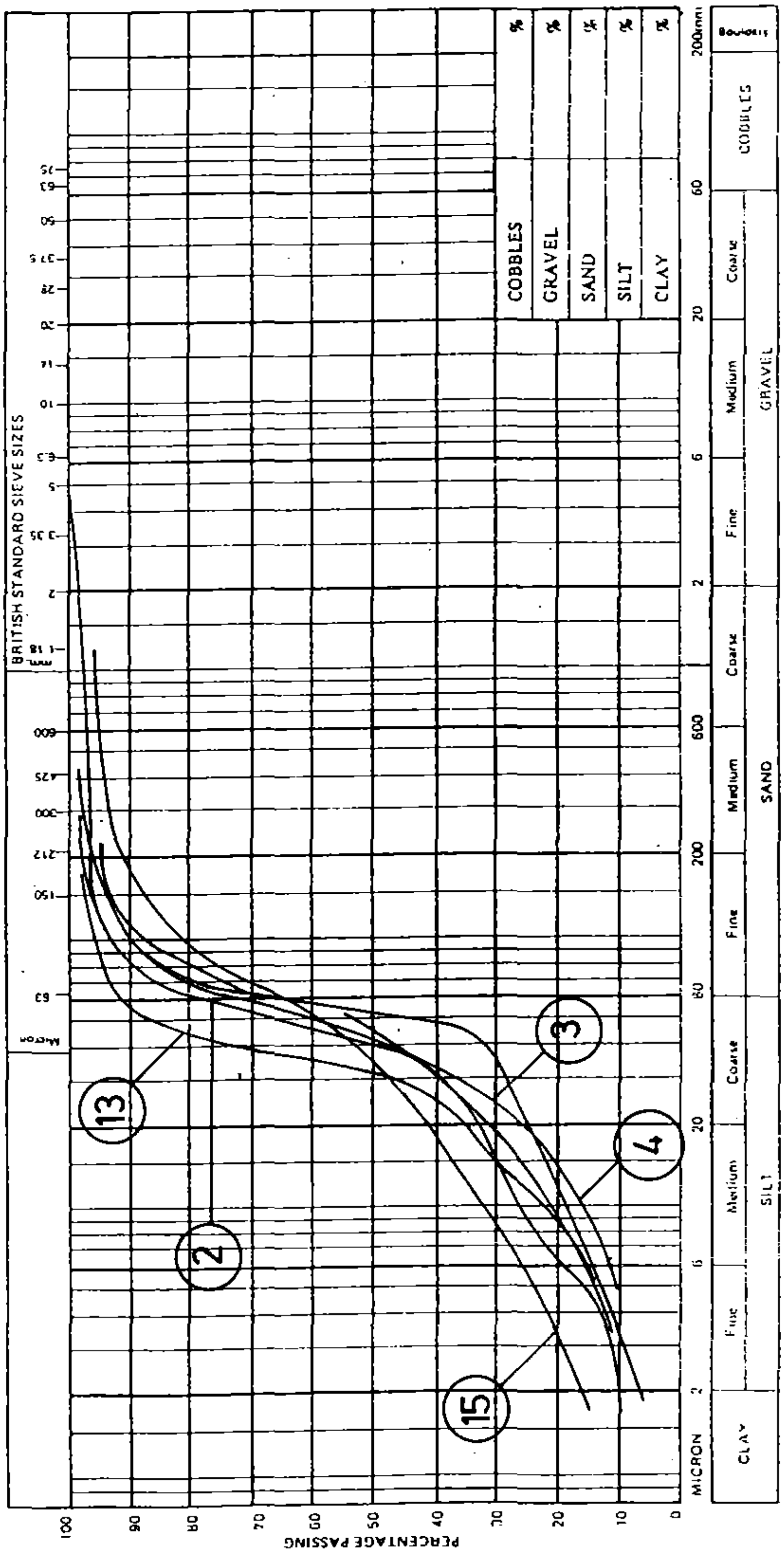
GREEN ISLAND LINK PRELIMINARY FEASIBILITY STUDY

HIGHWAYS DEPARTMENT	DROPCORE SAMPLING LOCATIONS	PAPM CONSULTANTS	FIG. G8



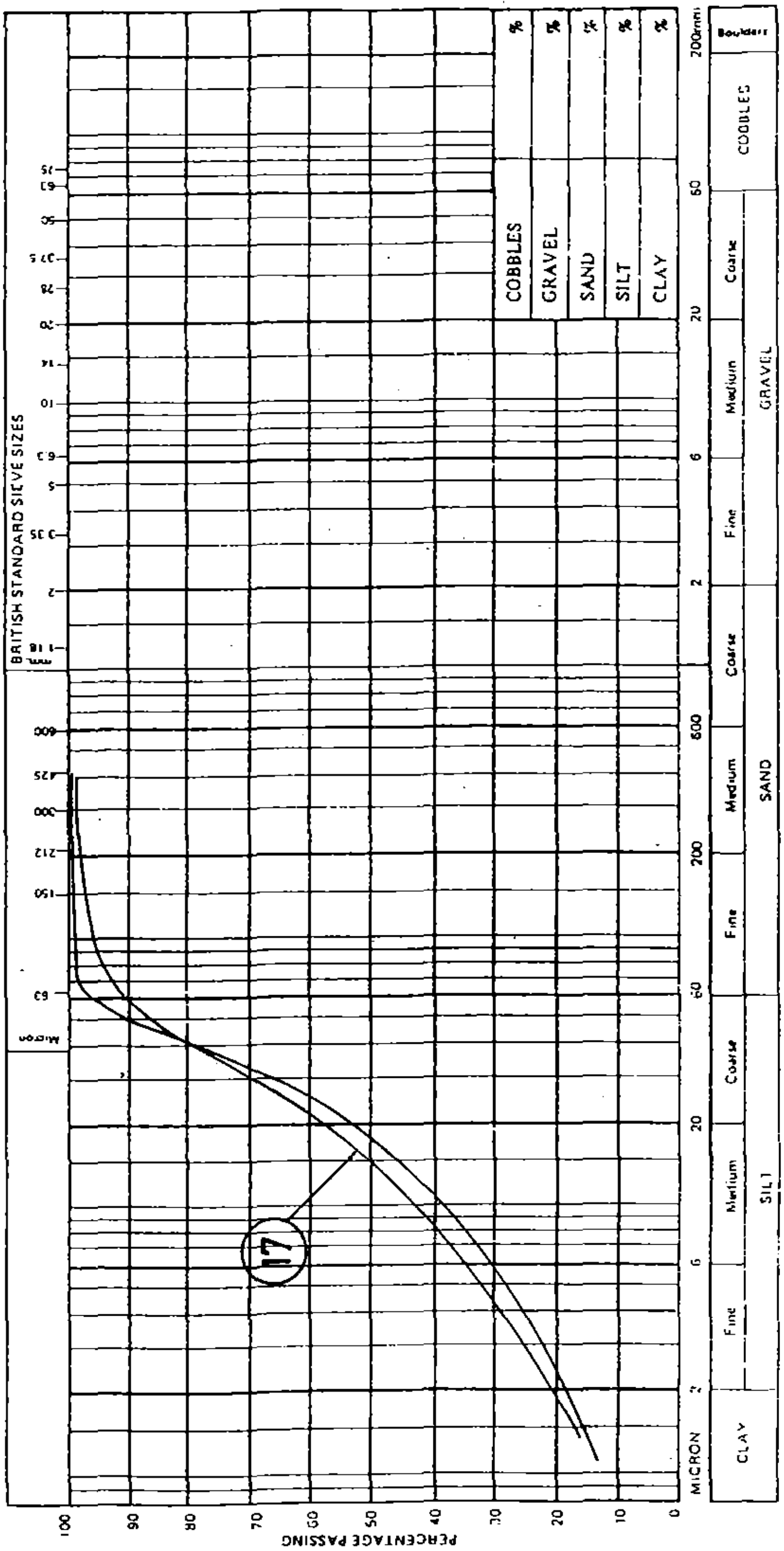
PARTICLE SIZE SUMMARY

FIGURE G9



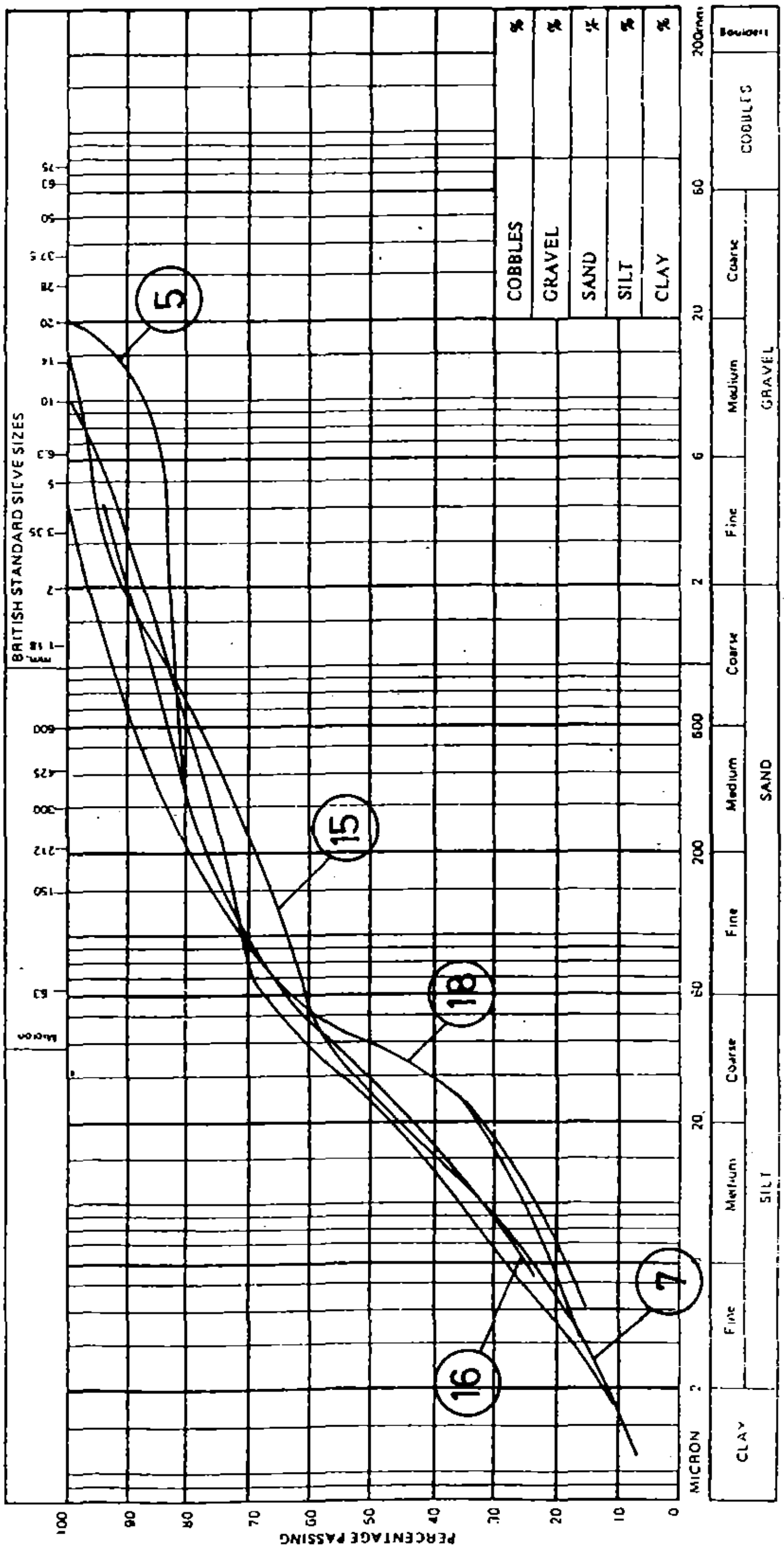
PARTICLE SIZE SUMMARY

FIGURE G1



PARTICLE SIZE SUMMARY

FIGURE G11



PARTICLE SIZE SUMMARY

FIGURE G12

APPENDIX A

EXISTING SITE INVESTIGATION INFORMATION

A APPENDIX A

A.1 EXISTING SITE INVESTIGATION INFORMATION

A.1.1 The geotechnical conditions along the proposed alignments have been examined by studying the following existing data:

- Marine Source of Fill Study, 1988 - Lamma Channels;
- Port and Airport Development Strategy, 1988 - Western Harbour, particularly Kau Yi Chau and Siu Kau Yi Chau;
- Green Island Reclamation Feasibility Study, 1989 - Green Island;
- Study of Harbour Reclamation and Urban Growth, 1983 - Green Island;
- Route 7 Study, Kennedy Town to Aberdeen, 1982 - Green Island;
- A Study of Gas in Marine Sediments in Hong Kong - Geotechnical Report - NGI, August 1990;
- The Search for Evidence of Neotectonic Movement along Faults and Variations in Bedrock Character using Continuous Reflection Profiles in Hong Kong Waters - Evans, 1990;
- Hong Kong Geological Survey Memoir No. 2; and
- HKGS 1:20,000 Scale Map - Sheets 10 and 11.

A.1.2 The marine geophysical information and site investigation information which have been obtained are listed in Tables A.1 and A.2 respectively. The locations of the existing site investigation are shown in Figure 8.1 (Volume 2 of this Report). Figures 8.3 and 8.4 (Volume 2 of this Report) show the interpreted geological profiles along alignments N-C and N-N respectively.

APPENDIX B

BOREHOLE LOGS

GEOTECHNICS & CONCRETE ENGINEERING (H.K.) LTD.
6 KO SHAN RD., GROUND FL., HUNG HOM, KOWLOON, HONG KONG.
TEL.: 365 9123-6, 333 6482 FAX NO.: 852-765 8034

CONTRACT NO. GC/89/08

DRILLHOLE RECORD

W.O. NO. PW7/2/30.142
HOLE NO. BH1
DATE from 5-12-91 to 7-12-91

PROJECT Green Island Link Preliminary Feasibility Study

METHOD Rotary
MACHINE & NO. DR74
FLUSHING MEDIUM Water
CO-ORDINATES E 826083.67 N 816127.19
ORIENTATION Vertical
ROCK COREBIT T.C. & Diamond
HOLE DIA. Hx T2101 TNW
GROUND LEVEL +45.16 m.P.D

Drilling Progress	Casing/Bit depth/Size	Water level/time/date	Water Recovery%	Total core Recovery%	Solid core Recovery%	RQD	Fracture Index/m	Tests	Samples	Reduced Level	Depth (m)	Legend	Grade	Zone	Description
05/12 1991	T2101			100						+45.16	0.15, 0.45				Stiff, moist, reddish brown, sandy clayey SILT. (COLLUVIUM) Occasional corestone of dark grey slightly decomposed coarse ash tuff at 0.15-0.45m.
								3,2, 3,2, 4,4 N=13	L●1		1.00, 1.45				
										+43.16	2.00				
	Hx												V		Extremely weak, brown some with parple patches, completely decomposed TUFF (Stiff, sandy SILT)
								3,2, 4,4, 5,7 N=20	L●2		3.00, 3.45				
			80					4,7, 10,11, 13,14 N=48	L●3	+39.56	5.00, 5.45				
				100	56	38	12.5, >15				5.60, 6.00, 6.40		III		Moderately strong, grey and brownish grey spotted with white and dark grey, moderately decomposed coarse ash TUFF with very closely to closely spaced limonite and manganeses stained joints some coated with kaolin and brown clay material, rough planar and stepped, extremely to very narrow, dipping 10-20 deg., 20-30 deg., 40-50 deg. (2 sets) and 70-80 deg.
		2.70m ▼ 18:00		100	31	0	>15			+37.57	7.52				
06/12 1991	TNW	5.90m ▼ 8:00		100	70	58	7.5			+36.63	7.59, 8.45		II		Strong, grey spotted with dark grey and white some streaked with dark grey, slightly decomposed coarse ash TUFF with very closely to widely spaced limonite and manganese stained joints some coated with kaolin, dipping 10-20 deg., 30-40 deg. and 70-80 deg.
				100	100	92	1.0				8.53, 9.41		I		Very strong, dark grey spotted with white and dark grey, fresh, coarse ash TUFF with few dark greenish lithic pyroclasts up to 20mm. Joints are widely to very widely spaced, rough planar, clean, dipping 45 deg.
				100	100	100	1.4				10.00				

● SMALL DISTURBED SAMPLE L S.P.T. LINER SAMPLE ▼ WATER LEVEL M MAZIER SAMPLE
‡ BULK DISTURBED SAMPLE ▲ WATER SAMPLE ♦ STANDARD PENETRATION TEST ■ UNDISTURBED SAMPLE
⊢●⊣ PERMEABILITY TEST HE HAND EXCAVATION LOGGED BY: [signature] F FRACTURED
REMARKS: DRAWN BY: [signature] CHECKED BY: Ko

GEOTECHNICS & CONCRETE ENGINEERING (H.K.) LTD.
6 KO SHAN RD., GROUND FL., HUNG HOM, KOWLOON, HONG KONG.
TEL.: 365 9123-6, 333 6482 FAX NO.: 852-765 8034

CONTRACT NO. GC/89/08

DRILLHOLE RECORD

W.O. NO. PW7/2/30.142
HOLE NO. BH1
DATE from 5-12-91 to 7-12-91

PROJECT: Green Island Link Preliminary Feasibility Study

METHOD: Rotary	CO-ORDINATES: E 826083.67, N 816127.19	ROCK COREBIT: T.C. & Diamond	
MACHINE & NO.: DR74		HOLE DIA.: Hx T2101 TNW	
FLUSHING MEDIUM: Water	ORIENTATION: Vertical	GROUND LEVEL: +45.16 m.P.D	

Drilling Progress	Casing/Bit depth/Size	Water level/time/date	Water Recovery%	Total core Recovery%	Solid core Recovery%	RQD	Fracture Index/m	Tests	Samples	Reduced Level	Depth (m)	Legend	Grade	Zone	Description
	TNW		80	100	100	100	14				10.00–10.10		I		Very strong, dark grey spotted with white and dark grey, fresh, coarse ash TUFF with few dark greenish lithic pyroclasts up to 20mm. Joints are widely to very widely spaced, rough planar, clean, dipping 45 deg.
				100	100	100	0				10.10–11.37				
				100	100	100	0				11.37–12.17				
				100	100	100	0				12.17–12.98				
										+31.96	13.20				
				100	82	82	4.3				12.98–14.14		II		Strong, dark grey spotted with white and dark greenish grey, slightly decomposed coarse ash TUFF with closely to medium spaced limonite and chlorite stained joints, smooth and rough planar, extremely narrow, dipping 20-30 deg., 50-60 deg. and 70-80 deg.
06/12 1991		3.35m ▼ 18:00		100	100	75	4.2				14.14–15.10				
07/12 1991		9.50m ▼ 8:00		100	100	68	7.9			+29.43	15.10–15.73				

Bottom of hole

● SMALL DISTURBED SAMPLE
‡ BULK DISTURBED SAMPLE
—●— PERMEABILITY TEST
L S.P.T. LINER SAMPLE
▲ WATER SAMPLE
HE HAND EXCAVATION
▼ WATER LEVEL
STANDARD PENETRATION TEST
M MAZIER SAMPLE
■ UNDISTURBED SAMPLE
F FRACTURED

REMARKS:

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DRAWN BY: [signature]
CHECKED BY: Ko

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DRILLHOLE RECORD

CONTRACT NO. GC/89/08		W.O. NO.	PW7/2/30.142
		HOLE NO.	BH2
		DATE from	21-11-91 to 23-11-91
PROJECT	Green Island Link Preliminary Feasibility Study		
METHOD	Rotary	CO-ORDINATES E 825914.83 N 816133.17	ROCK COREBIT T.C. & Diamond
MACHINE & NO.	DR74		HOLE DIA. Hx T2
FLUSHING MEDIUM	Water	ORIENTATION Vertical	GROUND LEVEL +115.23 m.P.D

Drilling Progress	Casing/Bit depth/Size	Water level/time/date	Water Recovery%	Total core Recovery%	Solid core Recovery%	R Q D	Fracture Index/m	Tests	Samples	Reduced Level	Depth (m)	Legend	Grade	Zone	Description
21/11 1991	Hx (0.00–7.00)		80							+115.23	0.00	+ + +	V		Extremely weak, pinkish brown some spotted with white and green, completely decomposed FELDSPARPHYRIC RHYOLITE (Medium dense to dense, silty fine to coarse SAND)
								2,2, 2,3, 4,3 N=12	L ● 1		1.00 – 1.45				
								6,6, 4,6, 11,15 N=36	L ● 2		3.00 – 3.45				
		2.10m ▼ 18:00													
22/11 1991		Dry ▼ 8:00						2,4, 7,9, 10,12 N=38	L ● 3		5.00 – 5.45				
	T2101 (7.00–10.00)			100	63	0	7.1			+108.23	7.00 – 7.70	+ +	III / II		Moderately strong to strong, pinkish grey and light brownish grey spotted with green and white and some pink, moderately to slightly decomposed, fine to medium grained, porphyritic (feldspar up to 8mm) FELDSPARPHYRIC RHYOLITE. Joints are very closely to medium spaced with limonite and manganese staining, smooth and rough planar, extremely narrow, dipping 0-10 deg., 20-30 deg., 60-70 deg. and 80-90 deg. very closely spaced parallel subvertical joints at 9.20-10.10m. Local moderately decomposed rock and fractured at 7.52-7.57m, 7.88-7.95m, 8.30-8.35m, 8.70-8.75m and 9.10-9.20m.
				100	70	39	14.7				7.70 – 9.20				
				100	22	15	9.2				9.20 – 10.00				

● SMALL DISTURBED SAMPLE — L S.P.T. LINER SAMPLE — ▼ WATER LEVEL — M MAZIER SAMPLE
↕ BULK DISTURBED SAMPLE — ▲ WATER SAMPLE — ↓ STANDARD PENETRATION TEST — ■ UNDISTURBED SAMPLE
⊢◆⊣ PERMEABILITY TEST — HE HAND EXCAVATION — LOGGED BY: — F FRACTURED

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DRILLHOLE RECORD

CONTRACT NO. GC/89/08

W.O. NO. PW7/2/30.142
HOLE NO. BH3
DATE from 28-11-91 to 2-12-91

PROJECT Green Island Link Preliminary Feasibility Study

METHOD Rotary	CO-ORDINATES E 826079.64 N 816314.98	ROCK COREBIT T.C. & Diamond
MACHINE & NO. DR74		HOLE DIA. Hx Nx T2 TNW
FLUSHING MEDIUM Water	ORIENTATION Vertical	GROUND LEVEL +48.24 m.P.D

Drilling Progress	Casing/Bit depth/Size	Water level/time/date	Water Recovery%	Total core Recovery%	Solid core Recovery%	RQD	Fracture Index/m	Tests	Samples	Reduced Level (+48.24)	Depth (m)	Legend	Grade	Zone	Description
28/11 1991	Hx		80					1.00–1.45: 2,2, 3,2, 3,2 N=10; 3.00–3.45: 1,2, 3,4, 6,5 N=18	L●1 (1.00–1.45); L●2 (3.00–3.45)	+44.24	0.00–4.00		VI		Stiff, moist, reddish brown, sandy clayey SILT. (COLLUVIUM)
	Hx							5.00–5.45: 3,4, 5,6, 6,6 N=23	L●3	+42.09	4.00–6.15		V		Extemely weak, yellowish brown, completely decomposed FELDSPARPHYRIC RHYOLITE (Medium dense, silty fine to medium SAND)
	T2101 Nx			100	86	51	7.2			+40.84	6.15–7.40		III / II		Moderately strong to strong, pinkish and brownish grey spotted with green mottled with pink, moderately to slightly decomposed, fine to medium grained, porphyritic FELDSPARPHYRIC RHYOLITE.
	Nx									+40.19	7.40–8.05		V		Nil core recovery. Inferred completely decomposed FELDSPARPHYRIC RHYOLITE.
	TNW			98	96	96	2.9				8.05–9.43		II		Strong, pinkish grey spotted with green mottled with pink and white, slightly decomposed, fine to medium grained, porphyritic FELDSPARPHYRIC RHYOLITE with abundant euhedral phenocrysts of feldspar ranging from 10-30mm in length. Joints are very closely to widely spaced stained with limonite and manganese some coated with kaolin, rough planar dipping 20-30 deg., 40-50 deg. and 55-65 deg. (2 sets). Local moderately decomposed rock and fractured at 9.68-9.78m, 10.50-10.65m and 12.53-12.58m.
	TNW			100	73	72	7.7				9.43–10.00		II		

● SMALL DISTURBED SAMPLE — L S.P.T. LINER SAMPLE — WATER LEVEL — M MAZIER SAMPLE
↕ BULK DISTURBED SAMPLE — ▲ WATER SAMPLE — STANDARD PENETRATION TEST — ■ UNDISTURBED SAMPLE
PERMEABILITY TEST — HE HAND EXCAVATION — F FRACTURED

LOGGED BY:
DRAWN BY:
CHECKED BY: Ko

REMARKS:

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DRILLHOLE RECORD

CONTRACT NO. GC/89/08

W.O. NO. PW7/2/30.142
HOLE NO. BH3
DATE from 28-11-91 to 2-12-91

PROJECT Green Island Link Preliminary Feasibility Study

METHOD Rotary	CO-ORDINATES E 826079.64 N 816314.98	ROCK COREBIT	T.C. & Diamond
MACHINE & NO. DR74		HOLE DIA.	Hx Nx T2 TNW
FLUSHING MEDIUM Water	ORIENTATION Vertical	GROUND LEVEL	+48.24 m.P.D

Drilling Progress	Casing/Bit depth/Size	Water level/ time/ date	Water Recovery%	Total core Recovery%	Solid core Recovery%	RQD	Fracture Index/m	Tests	Samples	Reduced Level	Depth (m)	Legend	Grade	Zone	Description
											10.00	+ + +			
	TNW		80	100	73	72	7.7				10.85	+ + +	II		Strong, pinkish grey spotted with green mottled with pink and white, slightly decomposed, fine to medium grained, porphyritic FELDSPARPHYRIC RHYOLITE with abundant euhedral phenocrysts of feldspar ranging from 10-30mm in length. Joints are very closely to widely spaced stained with limonite and manganese some coated with kaolin, rough planar dipping 20-30 deg., 40-50 deg. and 55-65 deg. (2 sets). Local moderately decomposed rock and fractured at 9.68-9.78m, 10.50-10.65m and 12.53-12.58m.
28/11 1991		3.40m ▼ 18:00		100	91	91	3.5				12.00	+ + +			
29/11 1991		8.35m ▼ 8:00		100	94	94	5.7				13.41	+ + +			
				100	100	100	0				13.94	+ + +			
				100	93	93	6.0				14.94	+ + +			
		2.82m ▼ 18:00		100	90	72	6.7			+32.41	15.83	+ + +			
02/12 1991		9.50m ▼ 8:00		100	100	92	2.9				16.85	+ + +	II		Strong, dark grey spotted with green mottled with pink, slightly decomposed very fine grained to fine grained, porphyritic FELDSPARPHYRIC RHYOLITE with medium to widely spaced limonite and manganese stained joints some coated with kaolin, rough planar and stepped, dipping 10-20 deg. and 50-60 deg.
				100	100	100	0.8			+30.11	18.13	+ + +			
															Bottom of hole

● SMALL DISTURBED SAMPLE
‡ BULK DISTURBED SAMPLE
•—• PERMEABILITY TEST
L S.P.T. LINER SAMPLE
▲ WATER SAMPLE
HE HAND EXCAVATION
▼ WATER LEVEL
↓ STANDARD PENETRATION TEST
M MAZIER SAMPLE
■ UNDISTURBED SAMPLE
F FRACTURED

REMARKS :

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CONTRACT NO. GC/89/08

DRILLHOLE RECORD

W.O. NO. PW7/2/30.142
HOLE NO. BH4
DATE from 2-12-91 to 5-12-91

PROJECT Green Island Link Preliminary Feasibility Study

METHOD Rotary
MACHINE & NO. DR86
FLUSHING MEDIUM Water
CO-ORDINATES E 825793.82 N 816016.83
ORIENTATION Vertical
ROCK COREBIT T.C. & Diamond
HOLE DIA. Px Hx T2
GROUND LEVEL +71.19 m.P.D

Drilling Progress	Casing/Bit depth/Size	Water level/time/date	Water Recovery%	Total core Recovery%	Solid core Recovery%	RQD	Fracture Index/m	Tests	Samples	Reduced Level (+71.19)	Depth (m)	Legend	Grade	Zone	Description
02/12 1991	Px										0.00				Stiff, moist, brown, sandy clayey SAND. (COLLUVIUM)
								2,2, 3,3, 3,3 N=12	L ● 1		1.00–1.45				
										+69.19	2.00		V		Extremely weak, light greyish brown, completely decomposed TUFF (Dense, silty fine to coarse SAND)
								4,5, 7,8, 8,10 N=33	L ● 2	+67.49	3.00–3.45, 3.70				
	T2101			88	0	0	F			+66.19	5.00		III		Moderately weak to moderately strong, light brownish grey, moderately decomposed, coarse ash TUFF. Highly fractured with limonite and manganese stained joints and some coated with sandy silt material.
	Hx		80					7,8, 10,10, 10,13 N=43	L ● 3		5.45		V		Extremely weak, pinkish and greyish light brown, completely decomposed GRANITE (Dense to very dense, silty fine to medium SAND with relict brown stained joints)
								8,15, 21,23, 28,34 N=106	L ● 4		7.00–7.45				
								6,9, 10,10, 9,11 N=40	L ● 5		9.00–9.45				
											10.00				

● SMALL DISTURBED SAMPLE | L S.P.T. LINER SAMPLE | WATER LEVEL | M MAZIER SAMPLE
↕ BULK DISTURBED SAMPLE | ▲ WATER SAMPLE | STANDARD PENETRATION TEST | ■ UNDISTURBED SAMPLE
PERMEABILITY TEST | HE HAND EXCAVATION | LOGGED BY: | F FRACTURED

REMARKS:

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DRILLHOLE RECORD

CONTRACT NO. GC/89/08

W.O. NO. PW7/2/30.142
HOLE NO. BH4
DATE from 2-12-91 to 5-12-91

PROJECT Green Island Link Preliminary Feasibility Study

METHOD Rotary	CO-ORDINATES E 825793.82 N 816016.83	ROCK COREBIT T.C. & Diamond
MACHINE & NO. DR86		HOLE DIA. Px Hx T2
FLUSHING MEDIUM Water	ORIENTATION Vertical	GROUND LEVEL +71.19 m.P.D

Drilling Progress	Casing/Bit depth/Size	Water level/time/date	Water Recovery%	Total core Recovery%	Solid core Recovery%	RQD	Fracture Index/m	Tests	Samples	Reduced Level	Depth (m)	Legend	Grade	Zone	Description
	Hx							7,13, 20,25, 31,41 N=117	L● 6	+59.19	10.00 – 11.00 – 11.45 – 12.00	+ + +	V		Extremely weak, greyish brown, completely decomposed GRANITE (Very dense, silty fine to medium SAND)
02/12 1991	Hx	2.20m 18:00						10,35, 75,125, 0,0 200/150mm	L● 7	+57.19	12.00 – 13.00 – 13.30 – 14.00	+ + +	IV		Weak, greyish brown, highly decomposed GRANITE (Very dense, sandy GRAVEL of rock fragments) / Moderately weak to moderately strong, pinkish and brownish light grey, moderately decomposed, fine to medium grained, altered (silicified) GRANITE. Highly fractured as angular coarse gravel and cobbles with limonite and manganese staining.
03/12 1991	T2101	8.10m 8:00	80	100	0	0	F				14.00 – 14.50	+ + +	III		Moderately strong to strong, light pinkish grey, moderately to slightly decomposed, fine to medium grained, altered (silicified) GRANITE with very dense microfractures. Joints are very closely to medium spaced stained with limonite and manganese, rough stepped and planar, dipping 20-30 deg., 30-40 deg., 40-50 deg. and 60-70 deg. Local moderately decomposed and fractured rock at 16.80-17.00m, 18.55-18.95m.
				100	0	0	F				14.50 – 15.20	+ + +	III		
				100	0	0	F				15.20 – 15.65	+ + +	III		
				100	0	0	F				15.65 – 15.90	+ + +	III		
				100	67	45	F / 8.0 / F / 10.0			+54.89	15.90 – 16.30 – 16.80 – 17.00 – 17.40	+ + +	III / III/II / III		Strong, pinkish grey spotted with green, pink and light green mottled with pink, slightly decomposed coarse grained GRANITE with much very coarse grained irregular potassium feldspar thoughout core and plagioclase sometimes alteration to light green (epidote). Joints are very closely to medium spaced stained with limonite, manganese, chlorite and epidote some coated with kaolin, rough planar and stepped, extremely narrow, dipping 20-30 deg., 40-50 deg. (2 sets) and 70-80 deg. Dense to very dense, microfractures. Local moderately decomposed rock at 19.95-20.05m, 20.86-20.98m and 24.05-24.30m.
				100	63	59	10.4 / F / F			+52.24	17.40 – 18.55 – 18.80 – 18.95	+ + +	III/II / III		
		3.60m 18:00		100	85	70	7.4				18.95 – 20.00	+ + +	II		

● SMALL DISTURBED SAMPLE L S.P.T. LINER SAMPLE ▼ WATER LEVEL M MAZIER SAMPLE
‡ BULK DISTURBED SAMPLE ▲ WATER SAMPLE ⧫ STANDARD PENETRATION TEST ■ UNDISTURBED SAMPLE
PERMEABILITY TEST HE HAND EXCAVATION F FRACTURED

REMARKS :

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DRILLHOLE RECORD

CONTRACT NO. GC/89/08

W.O. NO. PW7/2/30.142
HOLE NO. BH4
DATE from 2-12-91 to 5-12-91

PROJECT Green Island Link Preliminary Feasibility Study

METHOD	Rotary	CO-ORDINATES	E 825793.82 N 816016.83	ROCK COREBIT	T.C. & Diamond
MACHINE & NO.	DR86			HOLE DIA.	Px Hx T2
FLUSHING MEDIUM	Water	ORIENTATION	Vertical	GROUND LEVEL	+71.19 m.P.D

Drilling Progress	Casing/Bit depth/Size	Water level/time/date	Water Recovery%	Total core Recovery%	Solid core Recovery%	RQD	Fracture Index/m	Tests	Samples	Reduced Level	Depth (m)	Legend	Grade	Zone	Description
03/12-1991				100	75	70	7.4				20.00 – 20.30	+ + +	II		Strong, pinkish grey spotted with green, pink and light green mottled with pink, slightly decomposed coarse grained GRANITE with much very coarse grained irregular potassium feldspar thoughout core and plagioclase sometimes alteration to light green (epidote). Joints are very closely to medium spaced stained with limonite, manganese, chlorite and epidote some coated with kaolin, rough planar and stepped, extremely narrow, dipping 20-30 deg., 40-50 deg. (2 sets) and 70-80 deg. Dense to very dense, microfractures. Local moderately decomposed rock at 19.95-20.05m, 20.86-20.98m and 24.05-24.30m.
04/12-1991		9.75m ▼ 8:00		100	77	49	11.3				21.80	+ + +	II		
				100	86	63	7.1				22.50	+ + +	II		
	T2101	4.10m ▼ 18:00	80	100	96	69	6.3				23.30	+ + +	II		
05/12-1991		10.50m ▼ 8:00		100	45	25	>15				24.05	+ + +	II		
											24.30	+ + +	III		
				100	93	83	6.9				25.74	+ + +	II		
		4.10m ▼ 12:00		100	54	36	14.0				26.24	+ + +	II		

Bottom of hole

● SMALL DISTURBED SAMPLE L S.P.T. LINER SAMPLE ▼ WATER LEVEL M MAZIER SAMPLE
↕ BULK DISTURBED SAMPLE ▲ WATER SAMPLE ↓ STANDARD PENETRATION TEST ■ UNDISTURBED SAMPLE
●—● PERMEABILITY TEST HE HAND EXCAVATION F FRACTURED

REMARKS:

LOGGED BY: To
DRAWN BY: To
CHECKED BY: Ko

APPENDIX C

RESPONSES TO COMMENTS

GREEN ISLAND LINK PRELIMINARY FEASIBILITY STUDY
DRAFT FINAL REPORT
RESPONSES TO COMMENTS RECEIVED (VOLUME 3)

Department	Reference	Comments	Response
Geotechnical Engineering Office J B Massey GCP1/10/433-4II 22 April 1992	General	This volume of the Draft Final Report presents only a summary of the results of the site investigation programme with little engineering interpretation. It relies heavily on references to the reports produced by the site investigation and laboratory testing contractors. The Consultants' engineering interpretations should be included in this volume. This should refer to the excavation conditions prevailing on Kau Yi Chau and an assessment of the results of the particle size distribution tests for the seafloor deposits.	Noted. See specific responses below.
	Para 1.2	To obtain the maximum benefit from the site investigation programme, one of the purposes of this volume should be the production of a preliminary engineering interpretation of the site conditions or confirmation of previous assessments made in the light of other relevant site investigation data.	Noted. See specific responses below.
	Para 2.3	I suggest that all six traverses should be included in this volume in view of the references to interpreted fault zones.	Noted although the traverses are not extensive enough for an interpretation of fault zone.
	Para 4.1	The details of the dropcore sampling such as length of samples and core recovery have not been reported. These should be included in the final version to aid in assessing how representatives the samples are of the underlying seafloor materials.	Noted. The length of the drop core samples are not available since the samples were to put into bags immediate after sampling.
	Para 4.1.2	The last sentence should be amended to 'A total of 20 dropcore samples were taken'	Noted. Change made.

Department	Reference	Comments	Response
	Para 4.2	The methodology for the heavy metal testing of the dropcore samples has not been discussed. The relevant testing standards used such as BS or ASTM should be stated. Since an exponential decline in contaminants with depth would be expected, the locations of the test sections from within the dropcore samples should be noted.	The testing procedures are detailed in the revised text. The contamination is considered low and an exponential decline was not noted since the whole length of sample was used in the testing.
	Para 4.2	The particle size distribution (PSD) of the dropcore samples should be interpreted in terms of likely provenance and engineering implications. In particular, the PSD's of samples at the former dumping ground between Kau Yi Chau appear to be coarser than the others. The influence of the PSD's on the scouring effect and the rate of erosion along the proposed route (as discussed in paras.8.8.7 to 8.8.11 of Volume 1) should be discussed.	The source of the dropcore samples and their engineering implications are discussed. The influence of the PSD on scour in this study is considered to be insignificant.
	Para 4.2.2	The chemical tests are actually testing only the heavy metal content and 'heavy metal tests' should be used instead of 'chemical tests' in this paragraph in para. 5.1 (ii). The results of the PSD tests should preferably be presented in graphical form showing the range of particle sizes encountered.	Noted.

Department	Reference	Comments	Response
	Para 5.2	There is unlikely to be any fill on Kau Yi Chau. If the source of this interpretation is one of the contractors' reports, the accuracy of the identification should be assessed. I do not understand why there is a difference of ground levels between borehole BH3 and the seismic survey. The Consultants should have resolved such a discrepancy on site with the Contractors involved as the reliability of future engineering assessments based on these results will be reduced.	On checking the records the ground profile on the geophysics traces was interpolated between survey points. The borehole location was between these survey points and therefore the ground profile has been redrawn between survey points.
	Para 5.3	The report notes the existence of fault zones from an interpretation of the seismic profiles. The basis of the interpretation should be described in the report together with the evidence from the seismic traces. If these fault zones have engineering implications, their existence and nature should be verified from borehole information, probing or otherwise. The locations of these fault zones should be illustrated in the traverses as appropriate.	For the Preliminary Feasibility Study the faults have no relevance, since the object was to determine in broad terms the volumes of soft and rock excavation produced by the levelling of Kau Yi Chau. The frequency of the traces was not sufficient to detail the faults.
	Borehole BH4	Borehole BH4. The 'TUFF material' from depth 2.0m to 5.0m is silicified and brecciated, and is possibly a fault zone within the granitic rock rather than tuff. The Hong Kong Geological Survey has identified the rock type encountered in this borehole to be 'porphyrite medium-grained Granite'.	The difference in opinion on the description of the 3 metres of highly weathered rock is noted, but is not considered significant to the purpose of the boreholes which is to determine the quantities of hard and soft material for excavation.

HIGHWAYS DEPARTMENT - WESTERN HARBOUR LINK OFFICE

GREEN ISLAND LINK

PRELIMINARY FEASIBILITY STUDY

FINAL REPORT

FEBRUARY 1992

Volume 4: PRELIMINARY ENVIRONMENTAL ASSESSMENT

PAPM CONSULTANTS

A joint venture of
PYPUN-HOWARD HUMPHREYS LIMITED
OVE ARUP & PARTNERS HONG KONG LIMITED
PARSONS BRINCKERHOFF (ASIA) LIMITED
MAUNSELL CONSULTANTS ASIA LIMITED

in association with
MVA ASIA LIMITED
LLEWELYN DAVIES PLANNING
CREMER & WARNER LIMITED
HYDRAULICS RESEARCH (ASIA) LIMITED

FINAL REPORT VOLUME 4

PRELIMINARY ENVIRONMENTAL ASSESSMENT

CONTENTS

CHAPTER 1

1 INTRODUCTION

1.1 BACKGROUND

1.1.1 This document constitutes the Preliminary Environmental Assessment undertaken as part of the Green Island Link Preliminary Feasibility Study. The Study was undertaken to confirm the engineering feasibility and environmental acceptability of constructing an immersed tube road tunnel from the proposed Green Island Reclamation to the proposed Lantau Port Peninsula.

1.1.2 The Study commenced on 30 April 1991 and progressed through a series of stages to the present report which provides a preliminary environmental assessment of the proposals. The preliminary nature of the Study means that this assessment can only be considered as a review of the key issues. A more detailed assessment must be undertaken at a later time, when detailed designs become available to identify the full scope of the ameliorative measures which must be utilised to minimise adverse environmental impact.

1.2 STUDY APPROACH

1.2.1 The work of the Study was split into two main phases of work:

- establishment, development and evaluation of conceptual designs and selection of outline schemes; and
- development of the selected schemes.

1.2.2 Environmental concerns have been a key feature throughout the study period. One of the earliest papers produced - Working Paper WP2 Preliminary Environmental Planning Assessment provided an initial assessment and evaluation of likely environmental impacts and identified "ground rules" for the design team.

1.2.3 Working Paper No.4, Conceptual Designs, published in August 1991, addressed the main issues that influenced the choice of the tunnel corridor and landfalls. The issues addressed were:

- traffic;
- highway;

- geotechnical;
- tunnel;
- land use and environment;
- marine and hydraulic; and
- tunnel operations.

1.2.4 Based on consideration of these issues the conceptual designs were evaluated and conclusions as to preferred outline schemes formulated.

1.2.5 The selected schemes underwent further development and are the subject of this environmental assessment. The location of the landfall at Green Island and Kau Yi Chau are referred to as north/central and north/north respectively. The schemes, looked at in as much detail as is possible at the present time, are for:
- north/central (N-C) dual 2-lane tunnel
- north/north (N-N) dual 3-lane tunnel.

1.3 THE PROPOSALS

1.3.1 The eventual timing of the construction of the Green Island Link will be determined by growth of traffic demand, in particular growth associated with development of the Lantau Port Peninsula, with Chek Lap Kok Airport, and with development on North Lantau. During the period prior to introduction of the Link commitments will need to be made as to the form, pace and phasing of developments associated with the Port Peninsula and Green Island Reclamation.

1.3.2 These commitments must be consistent with the incorporation of the Link and this Study of the Link was undertaken at this time to define the necessary context for decisions about Lantau Port Development and about the Green Island Reclamation.

1.3.3 The Study is also important in order to define the impact of the Link on the source of marine fill west of Green Island, and to determine to what extent this source can be exploited without prejudicing the future introduction of the Link. This aspect has been considered in Volume 1 of this Report.

1.3.4 The principal elements of the proposals that are considered here are shown in Figure E 1.1. This figure indicates the N-C dual 2-lane and N-N dual 3-lane configurations taken forward to outline design level. A detailed description of the Project is contained in Volume 1 of this Report.

1.3.5 The Study examined various corridor alignments and concluded that a northern landfall at Green Island was the most appropriate. Landfalls at Kau Yi Chau to the north of the island and through the centre were both preserved for outline design. In the latter case the island would be required to be fully excavated almost to sea-level.

1.3.6 A major interchange on Green Island Reclamation provides the connection between the Link and Hong Kong Island.

1.3.7 Outline designs for both dual 2-lane and dual 3-lane configurations have been prepared, both having the portal of the eastern tunnel landfall situated to the north of Green Island.

1.3.8 The immersed tube tunnel will run under the Lamma Channel between Green Island and Kau Yi Chau. The tunnel will be constructed using either reinforced concrete or steel shell units, the necessary fabrication yards for a concrete tunnel being a dedicated construction facility.

1.3.9 The western tunnel portal will be in the vicinity of Kau Yi Chau; two locations have been identified for further study; one to the north of the existing island, the other through the centre of the island which would be razed to accommodate the highway.

1.3.10 It is unlikely that the limit of the Port Peninsula, at the time of commencement of construction of the Green Island Link will have reached Kau Yi Chau. A causeway or viaduct will connect the western portal with the Port Peninsula in its interim extent.

1.3.11 Portal related development will include a toll plaza located at the western landfall and two ventilation buildings, one at each end of the tunnel.

1.3.12 The location of the construction areas used to fabricate the tunnel units have yet to be identified. A casting basin would be necessary to form the reinforced concrete tunnel sections.

1.3.13 Dredging will be required to excavate the marine deposits from the area under both the tunnel and the causeway.

1.4 OBJECTIVES OF THE REPORT

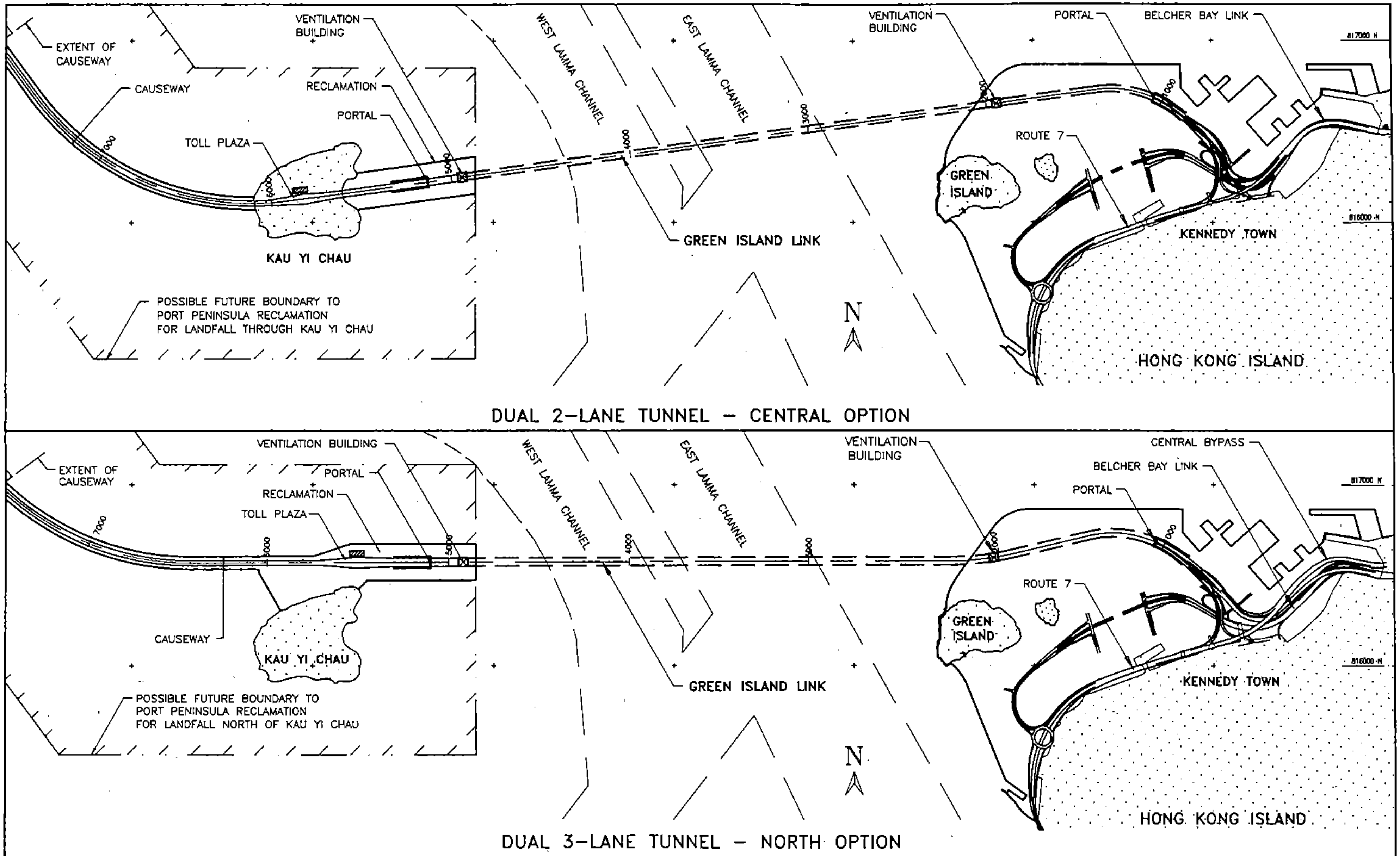
1.4.1 The objectives of this environmental assessment are to:

- describe the proposed installations and related facilities and the requirements for their development;
- identify and describe the elements of the community and environment likely to be affected by the proposed development;
- minimise pollution and nuisance arising from the development and its operation and environmental disturbance during construction and operation of the project;
- identify and evaluate at a planning level the net environmental impacts and cumulative effects with other transport modes expected to arise during the construction and operation of the development in relation to the existing and planned community and neighbouring land uses;
- identify methods, measures and standards to be included in the preliminary design which may be necessary to mitigate these impacts and reduce them to acceptable levels;
- recommend environmental monitoring and audit requirements necessary to ensure the effectiveness of the environmental protection measures adopted; and
- identify any additional studies which may be necessary to fulfil the objectives or requirements of this Preliminary Environmental Assessment.

1.4.2 This assessment has been conducted at the preliminary feasibility stage in order to identify the key issues and to provide sufficient information to assist in the evaluation of route options.

1.4.3 During the course of detailed design of the project, further information will became available, both for the project itself, and for the adjacent areas and land uses, and this will then enable production of a full Environmental Impact Assessment.

1.4.4 At this stage, the scale of the potential problems, and the extent of the necessary mitigation measures, have been identified. It has not been possible to identify specific sensitive receivers in the vicinity of the development. This is due to the fact that both tunnel landfalls are to be located on land that at present time does not exist. The approach to this Study has been to consider the location and potential land uses to which the area may be put.



GREEN ISLAND LINK PRELIMINARY FEASIBILITY STUDY

PAPM CONSULTANTS	OUTLINE DESIGN ALIGNMENTS		FIG. E1.1
HIGHWAYS DEPARTMENT	DESIGNED: K T P DRAWN: C P CHAN CHECKED: [signature] DATE: FEBRUARY, 1992	GIL/101/40 DIMENSIONS ARE IN METRES SCALE 1:20,000	

CHAPTER 2

2 EXISTING ENVIRONMENT

2.1 GENERAL

2.1.1 In many respects the assessment of the existing quality of the environment into which the proposals would be introduced is difficult to quantify. This is because the present proposals form a part only of the overall proposals for development of the area. The reclamation at Green Island is not fixed in extent or land use although outline plans have been drafted to conform to Metroplan requirements. There are no existing sensitive receivers that can be identified and used for calculation of diverse effects, as at both landfalls there is as yet no development and indeed no land. The proposals for the Green Island Reclamation Feasibility Study identify land use as predominantly residential and it has been assumed that development at the Port Peninsula will be industrial in nature and therefore relatively insensitive to noise or air pollution.

2.2 CLIMATE

2.2.1 The meteorological and associated climatic variations which have a direct influence on the distribution of air pollution have been recorded in Hong Kong by the Royal Observatory for a number of years. The Hong Kong climate is sub-tropical, tending towards temperate for nearly half the year.

2.2.2 Table 2.1 gives the monthly climatological normals based on the period 1951-1980. The data from which this table is compiled show that the prevailing wind direction is easterly at an average velocity of 7-9 knots (about 4 m/s). The mean annual rainfall is 2225mm and there is a total evaporation of 1762mm. Mean air temperature is 22.3°C and the relative humidity averages 79%.

2.2.3 The monthly normals shown in Table 2.1 show the persistence of the easterly air flows. Winds blow from the ENE - ESE sector for 70% of the year. For the remaining portion, winds are southwesterly occurring mostly during summer. Wind velocities are generally quite high, averaging 4.3 m/s in winter and 3.7 m/s during summer.

2.2.4 Mean monthly measurements of evaporation can be compared to mean monthly rainfalls. This analysis indicates the months of rainfall deficit. During the period of October to March, Hong Kong experiences conditions of water deficit, conducive to entrainment of dust from open sources.

2.2.5 Calm periods seldom persist for very long within the territory and ventilation is aided by the diurnal thermal variation and by topographical effects. In the complicated topography of Hong Kong surface winds may vary widely both in speed and direction over quite short distances.

TABLE 2.1 CLIMATOLOGICAL NORMALS (1951 - 1980)

Month	Maximum Air Temp (°C)	Mean Air Temp (°C)	Minimum Air Temp (°C)	Mean Humidity (%)	Total Rainfall (mm)	Prevailing Wind Direction (°)	Mean Wind Speed (km/h)
January	26.9	15.6	0.0	71	26.9	070	23.8
February	27.8	15.9	2.4	78	41.9	070	23.1
March	30.1	18.5	4.8	82	54.8	070	21.4
April	33.4	22.1	9.9	83	139.4	080	19.0
May	35.5	25.9	15.4	83	298.1	090	18.8
June	35.6	27.7	19.2	84	431.8	090	20.9
July	35.7	28.6	22.2	81	316.8	230	18.9
August	36.1	28.2	21.6	83	413.4	090	18.2
September	35.2	27.5	18.4	79	320.4	090	21.4
October	34.3	25.0	13.5	72	121.2	090	26.1
November	31.8	21.3	6.5	69	34.7	080	26.8
December	28.7	17.7	4.3	69	25.3	080	24.9

2.2.6 In addition to the normal variations in speed and direction the vertical distortion produced by surface roughness effects may also be modified by the diurnal thermal effects of daytime anabatic winds enhanced by the sea breeze effect, and the night-time katabatic winds enhanced by land breezes. Such topographical effects are clearly shown in the variation of wind speed and direction data recorded hourly at the Royal Observatory meteorological stations sited in Kowloon, on Cheung Chau and on Waglan Island.

2.2.7 Good dispersion of air pollutants is assisted by rapid wind fluctuation in both vertical and horizontal directions. High atmospheric stability is characterised by low lapse rates, found frequently in winter which limits the vertical dispersion of pollutants. Negative lapse rates occur at temperature inversions which are very stable features. In an inversion, a layer of warm air lies above a layer of cooler air. The normal decrease in air temperature with increasing altitude is reversed, inhibiting vertical dispersion. Airborne pollutants can be trapped below the inversion.

2.3 AIR QUALITY

2.3.1 The air of Hong Kong is affected by industrial and vehicle emissions. The rapid industrial and urban development of the 1970's and 1980's have caused a deterioration in air quality that affects the whole territory. To redress this deterioration a set of air quality objectives have been set which are designed to maintain levels of air quality which protect the health and well being of the community. Air quality objectives for seven ubiquitous air pollutants have been set to control the impact of emissions on local communities and environments, and these Air Quality Objectives are shown in Table 2.2.

2.3.2 To help achieve these goals there are several programmes which are being undertaken by the Environmental Protection Department (either directly or in an advisory capacity), the most significant of these programmes in relation to the present study are:

- the control and abatement of emissions from stationary sources under the Air Pollution Control Ordinance; and
- control of smoke and other emissions from motor vehicles.

2.3.3 In assessing the impact of any new proposals the predicted air quality resulting from a combination of the existing situation plus the contribution from the proposals must be compared with the air quality objectives and judged against the existing situation.

2.3.4 Existing air quality data for Hong Kong are collected from a network of fixed monitoring stations throughout the territory. Stations are located so as to obtain measurements for typical levels of pollutants to which the general population in an area or district is exposed. Figure E 2.1 shows the annual average pollutant concentrations, and maximum daily pollutant concentrations recorded at air quality monitoring stations. Table 2.3 gives annual average pollutant concentrations recorded at the Central/Western monitoring site between 1986 and 1990.

2.3.5 As can be seen from the table the existing levels of sulphur dioxide are well within the annual AQO; particulate levels are high however, and the AQO is not being adequately achieved. With regard to NO_2 the annual air quality objective is being achieved but levels recorded at Central/Western are higher than for some other stations elsewhere on Hong Kong, away from significant concentrations of vehicles.

2.3.6 The EPD initiatives designed to reduce vehicle emission will help to reduce NO_2 concentration. Steps are also being taken to reduce the number of smoke emitting diesel vehicles which will help in reducing the particulate concentration recorded.

2.3.7 The 24 hour NO_2 objective was exceeded by maximum daily pollutant loadings.

TABLE 2.2 HONG KONG AIR QUALITY OBJECTIVES

AIR QUALITY OBJECTIVES						HEALTH EFFECTS
Pollutant	Concentration in micrograms per cubic metre (i)					Health effects of pollutant at elevated ambient levels
	Averaging Time					
	1 Hour (ii)	8 Hours (iii)	24 Hours (iii)	3 Months (iv)	1 Year (iv)	
Sulphur Dioxide	800		350		80	Respiratory illness; reduced lung function; morbidity and mortality rates increase at higher levels.
Total Suspended Particulates			260		80	Respirable fraction has effects on health.
Respirable (v) Suspended Particulates			180		55	Respiratory illness; reduced lung function; cancer risk for certain particles; morbidity and mortality rates increase at higher levels.
Nitrogen Dioxide	300		150		80	Respiratory irritation: increased susceptibility to respiratory infection: lung development impairment.
Carbon Monoxide	30000	10000				Impairment of co-ordination; deleterious to pregnant women and those with heart and circulatory conditions.
Photochemical Oxidants (as Ozone) (vi)	240					Eye irritation; cough; reduced athletic performance; possible chromosome damage.
Lead				1.5		Affects cell and body processes; likely neuropsychological effects, particularly in children; likely effects on rates of incidence of heart attacks, strokes and hypertension.

Legend:
(i) Measured at 298°K (25°C) and 101.325 kPa (one atmosphere).
(ii) Not to be exceeded more than three times per year.
(iii) Not to be exceeded more than once per year.
(iv) Arithmetic means.
(v) Respirable suspended particulates means suspended particles in air with a nominal aerodynamic diameter of 10 micrometres and smaller.
(vi) Photochemical oxidants are determined by measurement of ozone only.

2.3.8 The Green Island Reclamation Feasibility Study considered the effects of the reclamation proposals on the air quality of the area. It was concluded that the attention given throughout the development of the RODP (Recommended Outline Development Plan) to air quality resulted in minimising adverse impact by providing the potential for good dispersion and by zoning housing away from industrial emissions. However, the study also concluded that acceptable levels of vehicular pollutants may not be achievable at all locations due to the planning brief and the need for the two strategic highway links and residential land use. Estimates of the likely worst case situations indicated that some areas close to strategic highways may be adversely affected by vehicle pollution.

TABLE 2.3 AIR QUALITY SUMMARY CENTRAL/WESTERN 1986 - 1990

Year	Pollutant Concentrations (Annual Average $\mu g/m^3$)				
	SO_2	NO_2	O_3	TSP	RSP
1986	17	67	23	89	57
1987	15	63	21	90	68
1988	19	32	19	102	71
1989	16	60	15	84	53
1990	19	50	19	75	54
Objective (1 year averaging time)	80	80	-	55	-

2.4 NOISE

2.4.1 Noise levels in Hong Kong are considered to be high. The population density is high; industry, transport and residential areas are often intimately mixed, meaning that noise sources and sensitive receivers must exist in close proximity. It is recognised that noise can adversely affect the quality of life of the community. To minimise the extent to which this occurs, the Environmental Protection Department pursues:

- statutory control of noisy activities and products;
- prevention of noise by careful planning; and
- provision of measures to abate existing noise problems.

2.4.2 Table 2.4 gives the noise control legislation in effect as at 31 December 1990. The Noise Control Ordinance has allowed significant improvements to be made in achieving a reduction in environmental noise. The provisions of the Noise Control Ordinance cover three primary areas:

- Construction Noise;
- Industrial and Commercial Noise; and
- Neighbourhood Noise.

Table 2.5 summarises noise standards applicable to various land uses.

TABLE 2.4 NOISE CONTROL LEGISLATION IN EFFECT AS AT 31 DECEMBER 1990

Noise Source	Legislation	Description of Control	Control Authority
Construction Noise: General	Noise Control Ordinance	Controlling construction noise from the use of powered mechanical equipment between 7pm and 7am and on general holidays by construction noise permits	Permits issued by DEP according to relevant statutory Technical Memorandum, enforcement by RHKPF
Construction Noise: Percussive Piling	Noise Control (General) Regulations	Restricting the working hours of percussive piling by construction noise permits	
Industrial/ Commercial Noise	Noise Control (Appeal Board) Regulations	Controlling noise from factories and commercial activities including ventilation noise	DEP
Neighbourhood Noise	Noise Control Ordinance	Controlling annoying noise between 11pm and 7am, all times on holidays and particular noise sources all day	RHKPF
Individual motor vehicles	Road Traffic (Construction & Maintenance of Vehicles) Regulations	Offence to drive a motor vehicle with no silencer or a modified or defective silencer	RHKPF Commissioner for Transport
Aircraft noise	Civil Aviation (Aircraft Noise) (Certification) Regulations/Civil Aviation (Aircraft Noise) (Aircraft Classes) Notice	Requires all subsonic jet aircraft taking off or landing in Hong Kong to be certificated in accordance with the Convention on International Civil Aviation	Director of Civil Aviation
	Civil Aviation (Aircraft Noise) (Limitation on Landing or Taking Off of Aircraft) Notice	Limits the landing or taking off of aircraft during the restricted hours unless in cases of emergency or for technical reasons which are not reasonably foreseen by the aircraft operator or owner	Director of Civil Aviation
	Civil Aviation (Aircraft Noise) (Limitation on Operation of Engines and Auxiliary Power Units) Regulations	Limits the noise emission due to ground operation especially the auxiliary power units during the restricted hours	Director of Civil Aviation RHKPF
Noise in the countryside	Country Parks Ordinance	General Provisions for nuisance abatement, particularly in respect of radios, portable cassette players, etc	Director of Agriculture & Fisheries
Noise on beaches	Public Health & Municipal Services Ordinance		Urban Council & Regional Council

TABLE 2.5 SUMMARY OF NOISE STANDARDS

Noise Source	Aircraft Noise Exposure Forecast (NEF)		Helicopter Noise L_{max} dB(A)	Road Traffic Noise L_{10} (1 hour) dB(A)	Rail Traffic Noise	Fixed Noise Source
Uses	Kai Tak Airport	New Chek Lap Kok Airport				
All domestic premises including temporary housing accommodation	30	25	85	70	(a) L_{eq} (24 hr) 65 dB(A) and (b) L_{max} (2300 - 0700) 85 dB(A)	(a) 5 dB(A) below the appropriate Acceptable Noise Levels shown in Table 3 of the Technical Memorandum for the Assessment of Noise from Places Other than Domestic Premises, Public Places or Constructio n Sites and (b) the prevailing background noise levels
Hotels and hostels	30	25	85	70		
Offices	30	30	90	70		
Educational institutions including kindergartens, nurseries and all others where unaided voice communication is required	30	25	85	65		
Places of public worship and courts of law	30	25	85	65		
Hospitals, clinics, convalescences and homes for the aged - diagnostic rooms wards	30	25	85	55		
Amphitheatres, and auditoria, libraries, performing arts centres and Country Parks	Depend on use, extent and constr-uction	Depend on locations and construction				

Notes:

1. The above standards apply to uses which rely on opened windows for ventilation.
2. The above standards should be viewed as the maximum permissible noise levels at the external facade.
3. The NEF contours for the new Chek Lap Kok Airport will need to be inserted when these are finalized.

2.4.3 Noise surveys undertaken in connection with the Green Island Reclamation Feasibility Study in the Kennedy Town area showed that ambient noise levels varied considerably throughout the area, depending on the proximity of busy roads. It is expected that a similar situation would occur on the reclamation once occupied and the most significant contributor to noise in the new area will be vehicle traffic.

2.4.4 Where high vehicle numbers and residential land use are in close proximity difficulties in achieving standards may ensue, particularly where housing in the public sector may be involved. Detailed design will be an important feature in achieving standards. Standards may be achieved with high cost penalties.

2.4.5 At the proposed Port Peninsula landfall the stage of development and information available to the study team is limited and there is no "existing" situation. It is anticipated, however, that the Port Peninsula Development will largely be comprised of industrial and commercial land use. The likelihood of sensitive receivers in close proximity to the western landfall of the Green Island Link road system is small.

2.4.6 Although new developments are designed to meet the appropriate noise standards, in many situations the existing noise climate exceeds the standards, exposing the community to unacceptably high noise levels.

2.4.7 The Green Island Reclamation will contain a high proportion of residential land (as determined by Metroplan requirements), but will also contain major highway networks distributing traffic from Hong Kong Island north around to the west and south of the Island and, in addition from the Island west to the new port and airport area. The quantities of traffic will be very high. The design standards necessary to limit noise exposure will similarly need to be high to meet the necessary noise standards.

2.4.8 Estimates of road traffic generated noise made during the course of the Green Island Reclamation Feasibility Study indicated that some areas close to the strategic links will be badly affected by traffic noise. This was despite the efforts made to optimise the zoning of the reclamation to minimise the adverse effects of traffic noise, other planning constraints being such that acceptable levels of traffic noise cannot be achieved at all locations with all possible building configurations. It was further concluded that noise mitigation measures are therefore likely to be required and it was recommended that:

- a sound absorbing road finish be used for all roads within the development with the exception of the local roads;
- single aspect housing is stipulated for all new developments along Route 7;
- sports halls and other non-sensitive buildings be used as acoustic screens; and
- roadside acoustic barriers be included along the Route 7/Green Island Link interchange.

2.4.9 The noise environment of the Green Island Reclamation is likely to be dominated by road traffic noise whereas the existing noise climate of Kennedy Town may be improved by virtue of the removal of traffic from congested local flows on to free flowing traffic routes.

2.5 WATER QUALITY

2.5.1 The Hong Kong Government is acutely aware of the importance of water quality throughout the Territory and aims to improve water quality where possible. Water quality objectives have been formulated to protect the Territory's many uses which vary according to location but include domestic water supply; cooling; flushing and industrial use; recreation and food source. Section 6 of the Water Pollution Control Ordinance gives the Director of Environmental Protection a duty to work towards the Water Quality Objectives in each control zone. To achieve this a comprehensive data set must be available that identifies the present state of the waters. To meet this need the Environmental Protection Department (EPD) runs a full water monitoring programme.

2.5.2 The growing population around Victoria Harbour has caused a steady decline in the quality of the Harbour's water since full records began in 1972. However, recent evidence suggests that in the more open and better flushed harbour waters the steeply declining trend has flattened as a result of pollution control measures.

2.5.3 The proposed Green Island Link lies in the Western Buffer, water quality control zone designated by the EPD. Adjacent zones are the Southern Waters Zone, Victoria Harbour Zone and North Western Waters Zone. (See Figure E 2.2).

2.5.4 There are several monitoring stations at which EPD sample to assess marine water quality and which provide data relevant to the present project. These monitoring results can be compared with water quality objectives.

2.5.5 Of particular interest to this project are water quality parameters of transparency and light penetration that are affected by suspended particles such as clay, silt, finely divided organic and inorganic matter. The transparency and light penetration of waters of Hong Kong, in particular the western waters, are to a large extent influenced by the Pearl River, which discharges a substantial quantity of suspended solids.

2.5.6 Water quality in the Southern Water Zone is generally good except where the Pearl River brings a high nutrient load that increases the risk of red tides. The recently published EPD report on Marine Water Quality in Hong Kong (1990) presents summary statistics for 1989 for a variety of locations which are indicative of conditions in the relevant water bodies for this Study. These are the western extremities of Victoria Harbour Zone, the Western Buffer Zone, and Southern Water Zone as shown in Figure E 2.2. These statistics are reproduced in Table 2.6.

TABLE 2.6 SUMMARY STATISTICS FOR 1989 WATER QUALITY

DETERMINAND		LOCATION					
		Harbour West		West Lamma Channel		HK Island West	
		Range	Annual Mean	Range	Annual Mean	Range	Annual Mean
Temp °C	Surface	(15.3 - 28.4)	22.7	(15.9 - 27.4)	22.5	(16.5 - 28.6)	22.9
	Bottom	(15.3 - 28.2)	22.5	(15.4 - 26.2)	22.1	(16.4 - 27.6)	22.2
Salinity ppt	Surface	(19.1 - 33.1)	30.6	(28.5 - 33.4)	31.3	(11.7 - 34.0)	29.8
	Bottom	(25.9 - 33.3)	31.3	(29.7 - 34.2)	32.2	(30.2 - 33.7)	32.1
DO % Satn	Surface	(38.6 - 130.9)	74.4	(61.3 - 139.0)	91.3	(70.5 - 117.8)	87.8
	Bottom	(26.3 - 98.6)	68.8	(25.7 - 97.0)	79.6	(22.8 - 97.3)	78.6
Turbidity NTU		(2.5 - 37.0)	8.8	(2.9 - 27.3)	5.7	(2.9 - 15.4)	7.0
SS (mg/l)		(2.0 - 30.0)	8.6	(1.0 - 29.8)	7.4	(0.0 - 18.0)	4.8
E Coli (no./100ml)		(0 - 11133)	960	(0 - 24)	2	(5 - 1250)	89
BOD_5(mg/l)		(0.1 - 3.2)	0.9	(0.2 - 2.6)	0.9	(0.1 - 1.5)	0.7

2.5.7 Water quality objectives have been set for the Southern Water Zone and are designed to allow the beneficial uses identified for the zone to be supported. When the remaining Zones are gazetted (including Victoria Harbour and the Western Buffer), the objectives will be set to allow beneficial uses identified for these zones to be met. Table 2.7 sets out the beneficial uses for each of the zones of interest and Table 2.8 summarises the water quality objectives for Southern Waters.

TABLE 2.7 NINE IDENTIFIED BENEFICIAL USES FOR HONG KONG WATERS

Control Zone(1)	SW	WB	VH	NWW
1. A source of food for human consumption	+	+	-	+
2. A resource for commercial exploitation	+	+(2)	-	+
3. A habitat for marine life generally	+	+	+	+
4. Primary contact recreation - bathing	+	+	-	+
5. Secondary contact recreation - diving, sailing, windsurfing etc.	+	+	-	+
6. Domestic and industrial supply	+	+	+	+
7. Navigation and shipping	+	+	+	+
8. Abstraction for water supply by desalination	-	-	-	-
9. Aesthetic enjoyment	+	+	+	+

Notes: 1 SW = Southern Waters VH = Victoria Harbour; WB = Western Buffer; NWW = Northern Western Waters
2 Except in those parts of the buffer zone where fishing is prohibited - Aberdeen Harbour, Kwai Chung and Tsuen Wan Bays.

2.5.8 Western water and Victoria Harbour (appropriate sampling areas for the present study) generally have lower transparency than the eastern and southern waters. Typical annual results for Secchi Disk disappearance vary between 0.5m and 1.9m. In Victoria Harbour the low transparency of waters have been accredited to waste discharge from sewage outfalls and urban stormwater runoff.

TABLE 2.8 WATER QUALITY OBJECTIVES FOR THE SOUTHERN WATER ZONE AND PROPOSED FOR NORTH WESTERN WATERS AND WESTERN BUFFER ZONE

WATER QUALITY PARAMETER	OBJECTIVE	SUB-ZONE
Offensive odour, taints and colours	Not to be present	Whole Zone
Visible foam, oil, grease, scum, litter	Not to be present	Whole Zone
E. coli	Not to exceed 1000/100 ml in more than 60% samples. 5-day running median not to exceed 1000/100 ml.	Secondary Contact Recreation Zone. Bathing Beaches
D.O. within 2 m of bottom	Not less than 2 mg/l for 90% samples.	Whole Zone
Depth Average D.O.	Not less than 4 mg/l for 90% samples. Not less than 5mg/l for 90% samples.	Whole Zone except fish culture zone. Fish culture zone
pH	To be in the range 6.5 - 8.5 change due to waste discharge not to exceed 0.2.	Whole Zone except bathing beaches
Salinity	Change due to waste discharge not to exceed 10% of natural ambient level.	Whole Zone
Temperature Change	Change due to waste discharge not to exceed 2°C	Whole Zone
Suspended Solids	Waste discharge not to raise the natural ambient level by 30% nor to cause accumulation of suspended solids.	Whole Zone
Toxicants producing significant toxic effects	Not to be present	Whole Zone
Ammonia	Annual mean not to exceed 0.021 mg/l calculated as unionised form	Whole Zone
Nutrients	Quantity shall not cause excessive algal growth. Annual mean depth average inorganic nitrogen not to exceed 0.1mg/l.	Whole Zone

2.6 ADDITIONAL STUDIES

2.6.1 During the course of this Study samples of material have been obtained from the sea bed along the tunnel alignment for geotechnical purposes. The opportunity was taken to assess the chemical content of sea bed material along the tunnel alignment with a view to assessing its degree of contamination.

2.6.2 The survey sought to identify the potential scale of any contamination. Samples were taken from 20 sites along the length of the study area. Sampling locations are shown in Figure E 2.3

2.6.3 The samples were analyzed for: Cadmium, Chromium, Copper, Lead, Mercury, Nickel, Zinc as indicators of the extent of heavy metal contamination. Results of these analyses (performed by Hong Kong Standards and Testing Centre Ltd) are given in Table 2.9. Typical values for uncontaminated soils are given at the bottom of the table.

TABLE 2.9 HEAVY METAL CONTENT - DROP CORE SAMPLES

Sample Number	Determinant (mg/kg)							
	Cd	Cr	Cu	Pb	Hg	Ni	Zn	PCB
DC1	0.5	18	7	23	0.04	11	41	0.007
DC2	0.6	16	9	23	0.04	9	42	0.016
DC3	0.7	14	7	23	0.07	9	41	0.006
DC4	0.6	16	6	20	0.03	10	39	<0.005
DC5	0.7	20	6	26	0.13	13	49	0.012
DC6	0.6	23	22	30	0.13	10	62	0.016
DC7	0.7	24	27	28	0.13	12	58	0.012
DC8	0.6	21	30	26	0.09	11	58	0.011
DC9	0.7	13	17	31	0.07	9	55	0.010
DC10	0.5	12	14	41	0.06	7	48	0.007
DC11	0.6	16	25	33	0.07	9	59	0.015
DC12	0.7	16	16	20	0.06	10	55	<0.005
DC13	0.6	13	9	16	0.03	9	37	0.007
DC14	0.6	15	9	19	0.04	10	40	<0.005
DC15	0.7	18	26	31	0.14	10	67	0.021
DC16	0.5	19	19	32	0.14	10	61	0.011
DC17	0.7	19	33	27	0.10	10	59	0.008
DC18	0.4	7	5	32	0.06	3	24	0.007
DC19	0.5	2	12	13	0.04	2	27	0.007
DC20	0.5	14	18	24	0.10	7	48	<0.005
Typical values for clean marine sediments (2)	<2	50	25	90	0.13	45	115	(1)

Notes: 1. United Kingdom range in urban/rural soils 0.002 to 0.444mg. No UK guidance on levels of concern/action. Dutch Standards indicate: ≤0.05mg/kg - background; 1.0 mg/kg - further investigation; 10 mg/kg - remedial action.

2. Ministry of Agriculture, Fisheries and Food: Fisheries Research Technical Report No. 62 *The Field Assessment of the Effects of Dumping Wastes at Sea*, 6. The Disposal of Sewage Sludge and Industrial Waste off the Humber.

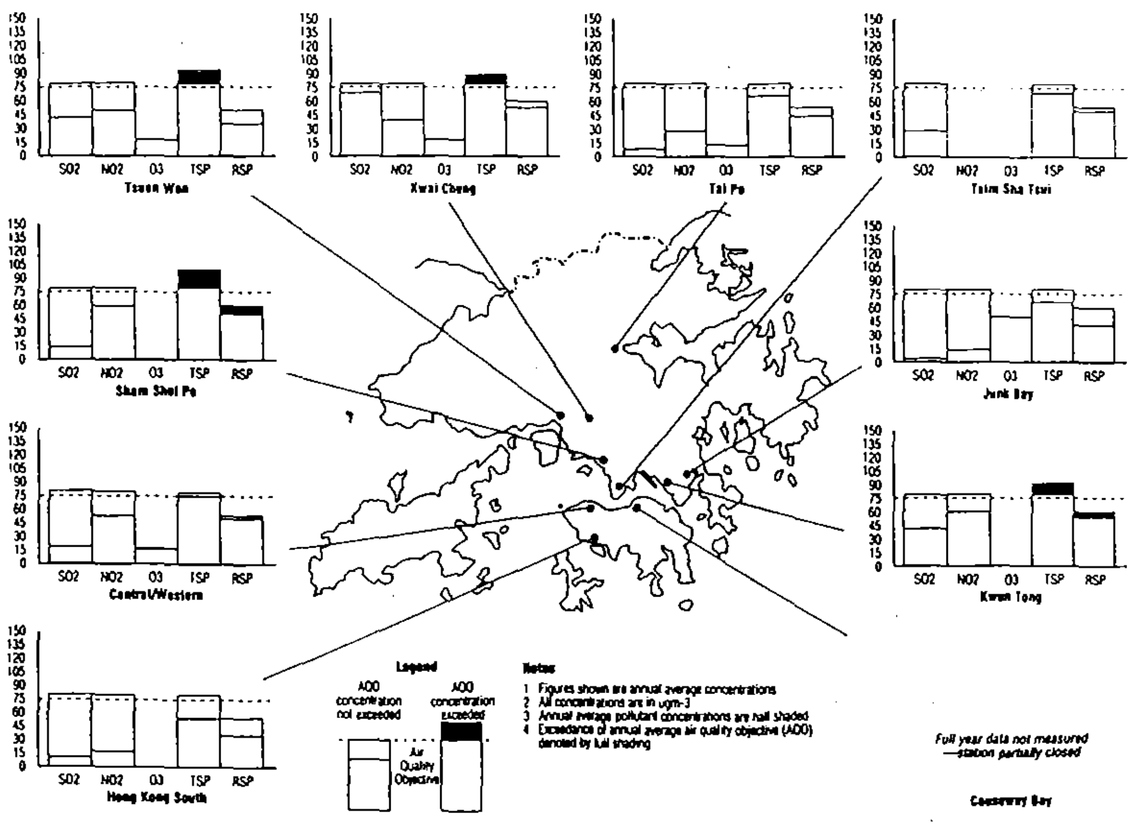
2.6.4 All samples analyzed fall within the limits associated with uncontaminated marine sediments and soils, and it can be concluded that these results show that contamination of muds is not likely to be a problem. Samples were also analyzed for particle size distribution as shown in Table 2.10.

2.6.5 Sample numbers DC8, DC12, DC13 and DC17 exhibit a high percentage (greater than 90%) of fine particles. The quantity of fine particles has implications for impacts on water quality that may be caused during the dredging process. Loss of fines during dredging will result in increased suspended solids and turbidity in the water column.

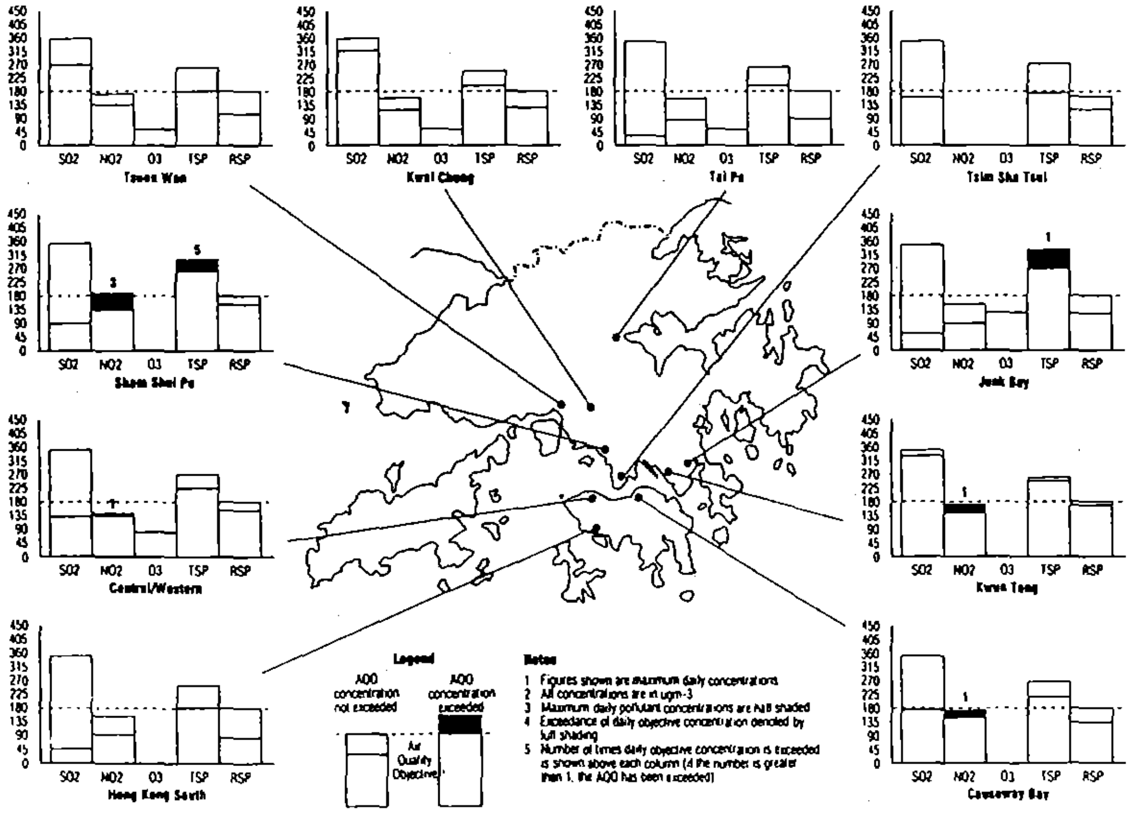
2.6.6 Conversely, DC19 exhibits a high proportion of coarse material. D8 is located west of Kau Yi Chau within an area previously used as a dumping ground. DC17 is located about 500m east from Kau Yi Chau at approximately 20m water depth. DC12 is within the limit of Green Island Reclamation. DC13 is close to the sea wall of the reclamation on the southern alignment.

TABLE 2.10 PARTICLE SIZES DISTRIBUTION - DROP CORE SAMPLES

Sample	Percentage			
	Gravel	Sand	Silt	Clay
DC1	2	26	62	10
DC2	0	23	71	6
DC3	0	37	57	6
DC4	2	25	67	6
DC5	16	22	54	8
DC6	15	34	43	8
DC7	11	20	56	13
DC8	0	3	84	13
DC9	16	54	23	7
DC10	22	47	26	5
DC11	9	30	49	12
DC12	0	3	78	19
DC13	0	10	78	12
DC14	1	21	67	11
DC15	3	30	51	1
DC16	10	24	51	15
DC17	0	7	71	22
DC18	4	32	48	16
DC19	41	57	1	1
DC20	7	49	34	10



Annual average pollutant concentrations recorded at Air Quality Monitoring Stations during 1990.

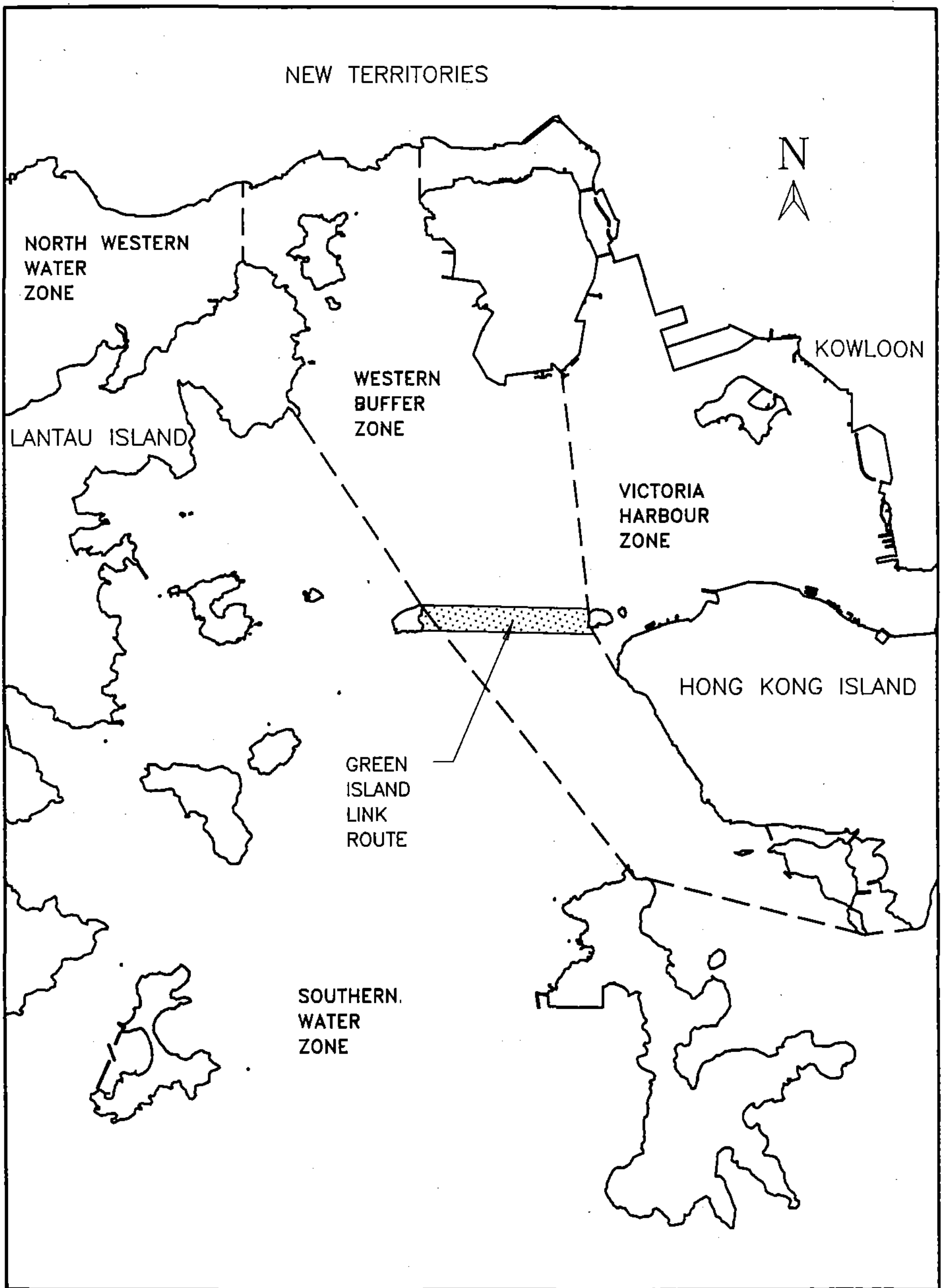


Maximum daily pollutant concentrations recorded at Air Quality Monitoring Stations during 1990.

REPRODUCED FROM ENVIRONMENT HONG KONG 1991 BY EPD

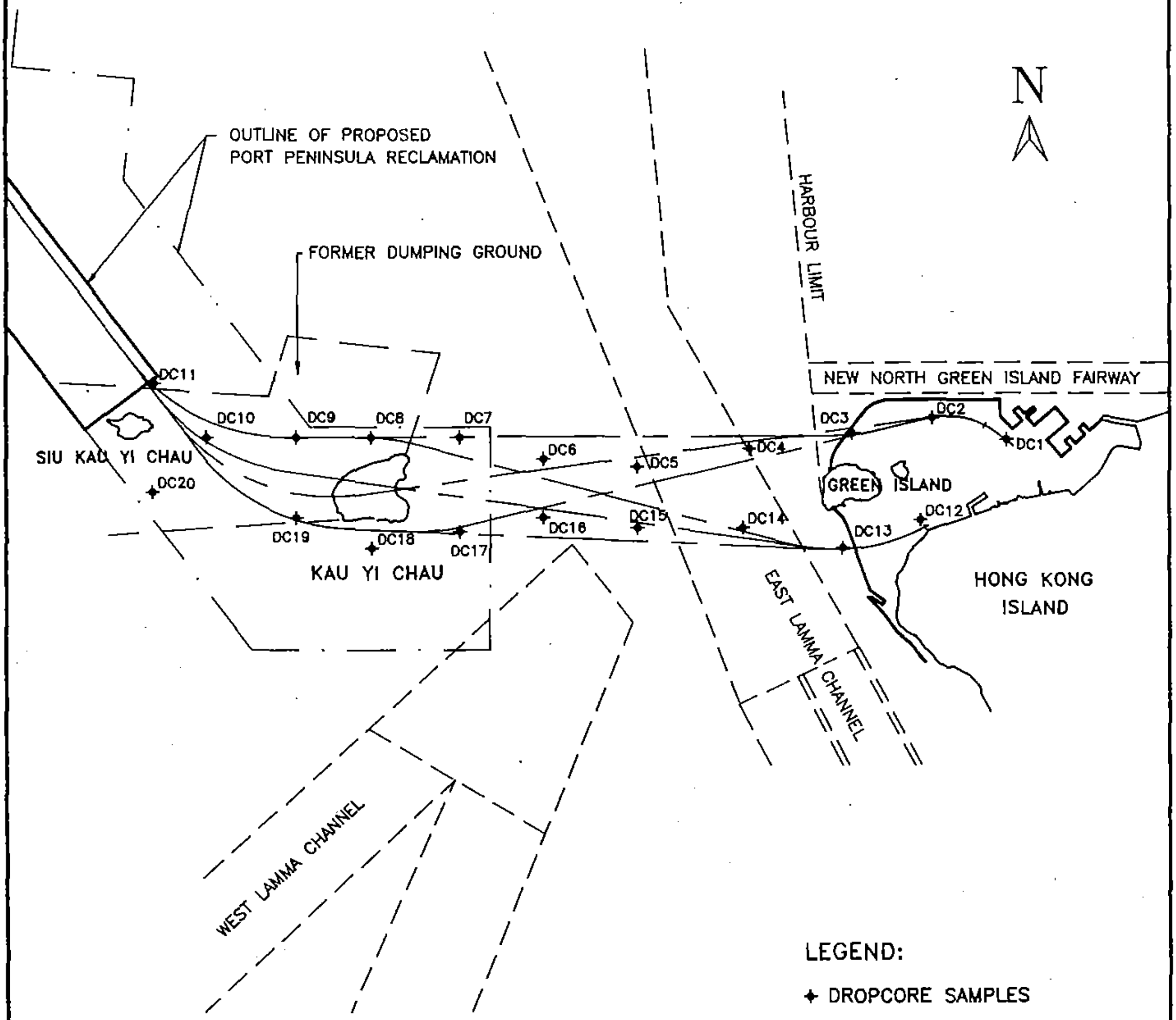
GREEN ISLAND LINK PRELIMINARY FEASIBILITY STUDY

HIGHWAYS DEPARTMENT	AIR QUALITY RECORDS	PAPM CONSULTANTS	FIG. E2.1



GREEN ISLAND LINK PRELIMINARY FEASIBILITY STUDY

HIGHWAYS DEPARTMENT	LOCATION OF THE WATER QUALITY CONTROL ZONES	PAPM CONSULTANTS	FIG. E2.2



GREEN ISLAND LINK PRELIMINARY FEASIBILITY STUDY

HIGHWAYS DEPARTMENT	DROPCORE SAMPLING LOCATIONS	PAPM CONSULTANTS	FIG. E2.3

CHAPTER 3

3 AIR QUALITY IMPACTS

3.1 GENERAL

3.1.1 The impacts of the proposals may be divided into two phases - those associated with the construction phase, and those associated with the operation of the Link. The impacts of the project considered here should not be dealt with in isolation. The pace of change in Hong Kong is rapid and the impacts of all the proposed development projects will interact to have cumulative effects throughout the region. It is important that at some appropriate stage in the integration of the individual projects the overall impacts are assessed. As yet assessments have been undertaken for only some of the components. It is stressed that further assessments must be undertaken at the appropriate stage of detailed design.

3.2 CONSTRUCTION

3.2.1 The impact of construction work on air quality will occur as a result of fugitive emissions associated with earth moving and construction activity, emission of exhaust fumes associated with vehicles involved in construction, emissions associated with tunnel fabrication, fitting out etc. Of these the emission of fugitive dust is considered to be the most significant although the other sources identified may have localised effects.

Fugitive Dust

3.2.2 Construction activities have been identified as a major source of fugitive dust in Hong Kong. Dust emissions can be generated by two basic physical phenomena - the entrainment of dust particles by the action of turbulent air currents and the pulverisation and abrasion of surface materials by the application of mechanical force. In addition to fugitive emissions from disturbed surface materials, wind losses from stockpiles can also contribute to the overall dust burden of the atmosphere and give rise to nuisance on deposition. Other sources of dust associated with construction include the handling of construction materials - particularly cement.

Vehicle Emissions

3.2.3 In addition to particulates that may be generated by vehicles traversing construction sites, vehicle engines will also emit pollutants as a function of the combustion of fuel. The number of vehicles involved in the construction process will be small relative to the numbers of vehicles emitting exhaust gases on the local road networks. However, in certain circumstances the emissions from construction traffic could lead to local effects and must be included in the overall assessment. For example, where vehicles are stationary but need to run their engines (for pumping or mixing purposes) the dispersion of pollutants could be impaired. In a confined space, concentrations of pollutants could become unacceptable for short periods. Such conditions are unlikely to last for significant periods however and are more likely to affect the worker environment than the ambient environment.

Tunnel Fabrication

3.2.4 Emissions to atmosphere associated with tunnel fabrication will be associated with the use of cement and emissions of dust during cement handling; welding and emission of welding fume; and emissions of metal dust from cutting/grinding operations.

3.2.5 The handling of cement has the potential for dust emission which could potentially affect a wide area. Welding emissions may cause a localised problem affecting the worker environment but are unlikely to affect the ambient environment provided that sufficient emission controls are in place. Metal dust may similarly cause local effects but it is unlikely to be a significant widespread environmental impact.

Impacts

3.2.6 Although it is not yet possible to predict the extent of construction related air quality impacts it is possible to identify a range of control measures that should be implemented during the construction period to mitigate the impacts caused. Construction activities have the potential to cause significant disturbance and nuisance to nearby sensitive receiver. However, quality project management, good site practices, local consultation, and effective project supervision can minimise the impact.

3.2.7 These impacts are considered in more detail below for each of the major construction areas:

- Green Island landfall; and
- Kau Yi Chau landfall and causeway.

Green Island Landfall

3.2.8 The most important factor in the assessment of impact associated with tunnel and link construction at Green Island will be the phasing of other development located on the reclamation. The earlier the tunnel and associated ground and road works can be completed the smaller the opportunity for the adverse impacts associated with construction to affect nearby sensitive receivers. If work can be implemented before sensitive receivers are in occupation the opportunity for adverse impact is minimised. On the reclamation the tunnel can be considered as two principal elements - the tunnel portal area and the length of cut and cover tunnel. Clearly occupation of the cut and cover area cannot occur until construction is complete. However, it is recommended that a buffer between construction activity and occupied areas is also maintained. The tunnel portal area is some 100m from the Public Cargo Working Area (PCWA). The PCWA is likely to be utilised early in the reclamation scheme and hence this area can be identified as a potential sensitive receiver of construction related air quality impacts. Other known receivers at Kennedy Town are likely to be sufficiently distant from construction activities to be unaffected by air quality impacts in most circumstances.

3.2.9 The deposition of dust onto goods awaiting export or distribution through or from the PCWA is likely to be the most significant potentially adverse impact. Whereas this dust may not actually harm the goods in most circumstances the nuisance and perceived depreciation of value may be considerable, leading to compensation claims by merchants against the contractors engaged in construction. Steps should be taken to prevent dust nuisance occurring.

3.2.10 Control methods to mitigate dust from construction activity include:

- site watering;
- speed limits;
- covering stockpiled materials;
- dust filters on cement batching plants;
- chemical stabilisers; and
- good site practices.

3.2.11 To ensure that all methods are used appropriately and efficiently good site supervision and management is essential.

3.2.12 Although the prevailing winds will also serve to reduce the occurrence of dust nuisance, occasioned by the construction activity affecting the PCWA, it will nevertheless be important to include all such controls into any construction contract. Abnormal weather conditions do occur from time to time. Good site controls will also serve to reduce the residual impact of the dust cloud reaching Kennedy Town or other sensitive receivers.

Kau Yi Chau Landfall

3.2.13 At Kau Yi Chau, if the central landfall is adopted, there will be the additional dust source associated with the levelling of the island to form a construction platform or to accommodate the landfall. The drilling, soil clearance, blasting and haulage of blasted material could result in substantial quantities of dust being liberated. The location of Kau Yi Chau means that there will be few sensitive receivers for the potential adverse impact. Appropriate controls must nevertheless be incorporated into the contract for although there may not be any sensitive receivers in the vicinity, worker health and safety must be maintained.

3.2.14 The nearest sensitive receiver to the activity centred on Kau Yi Chau and causeway construction will be the southern extent of the Port Peninsula reclamation. The extent of occupation of the reclamation is dependant on the development phasing and is not yet known. It is likely, however, that the reclamation will concentrate on industrial land use with warehousing container storage and port back up facilities. If development of the Port Peninsula is well advanced with occupancy already being taken up - the deposition of dust generated by construction of the Link could create nuisance. It is recommended that such factors are carefully considered when any phasing schedules are assessed. It is possible that dust sensitive cargo handling and warehousing could be planned for some areas of the Port Peninsula during the period of construction. If this is the case, they should be sited well away from the construction - based dust sources at Kau Yi Chau.

3.3 OPERATIONAL IMPACTS

3.3.1 Air quality will be influenced by vehicles utilising the link. The numbers of vehicles are likely to be high as the link will form the principal connecting route between Hong Kong Island and the port and airport facilities on Lantau Island. A high proportion of these vehicles will be goods vehicles.

3.3.2 Prediction of the air quality impact of vehicle emissions is based on several factors - traffic flow characteristics (traffic volume, vehicle type and mix and emission rates of pollutants) and dispersion characteristics (wind speed, the constraints to dispersion caused by building/street canyon effects, turbulence due to vehicle movements, etc).

3.3.3 The present Study is being carried out at the pre-feasibility stage to determine the environmental acceptability of the project. The outline designs prepared during the course of the project have been used for this Environmental Assessment and it has been necessary in some areas to make conservative assumptions. The predictions are based on "worst case" situations which combine to give worst case atmospheric pollutant concentrations.

3.3.4 In the absence of known sensitive receiver sites, predictions are based on the general vicinity and do not relate to any specific location except by reference to distance from the source.

3.3.5 In assessing the affects of the operational link on ambient air quality consideration has been given to the emission of ventilation air from the vent buildings, to the emission of tunnel air at the portals and to vehicle emitted pollutants utilising the above ground link roads.

3.3.6 The tunnel air quality has been assessed on the basis of PIARC Standard B vehicle emissions. The Hong Kong Government Environmental Protection Department have stated that the Hong Kong vehicle fleet will meet these standards by the time that the link would be operational in or after the year 2000. This indicates emission rates for passenger cars of :-

Carbon Monoxide CO	0.3	m^3/hr
Nitric Oxide NO	0.03	m^3/hr

3.4 VENTILATION BUILDING EMISSIONS

3.4.1 A model utilizing standard Gaussian dispersion was used to calculate the maximum ground level concentration caused by the dispersion of the plume from the ventilation building.

3.4.2 The modelling approach has been to identify worst case conditions where maximum ground level concentration could be expected. A wind speed of 2m/s, stability class D and mixing height of 500m were used. The volume flow rate of emitted air is high and the concentration of pollutants in this emitted air, although meeting tunnel air quality standards, does not conform to air quality objectives. It is necessary therefore that this air be released from a ventilation building that aids in the initial dispersion of tunnel air into the general atmosphere and in the dilution of the contaminants. It is further assumed that the conversion of NO to NO_2 varies between approximately 20% for those areas of the plume close to the ventilation building to about 60% for areas where the plume has remained in the atmosphere for longer. These conversion rates are those recommended by PIARC. They are likely to be conservative estimates and will also predict worst case situations. The effect of receiver height on concentrations was also investigated in the modelling.

3.4.3 The heat difference between tunnel air and ambient air was found to be a crucial factor in the dispersion. It has been assumed that a small increase in tunnel air temperature above that of the ambient air will always occur. Even a small difference (approx 1°C) provides sufficient plume rise to allow plume dilution to occur. It is considered that in reality temperature differences greater than this will occur - hence the predictions are conservative estimates. The modelling assumed a 10m/s exit velocity, and Table 3.1 sets out the gas discharges from the various tunnel portals and vents in m^3/s. Lead concentrations have not been modelled at the present time, as it is likely that AQO for lead may be achieved by virtue of a change to unleaded vehicle fuels; although the relative consumption of unleaded fuel to leaded fuel at the design year is unclear at this time. The requirement to fit catalytic converters to all new passenger cars registered after 1992 will definitely have a significant effect on the increase in consumption of unleaded petrol.

3.4.4 Table 3.2 sets out results for the ventilation buildings located at Green Island for both dual 2-lane and dual 3-lane tunnels. These results are indicative of results for the Kau Yi Chau landfall ventilation building. The plume from the Kau Yi Chau ventilation building is smaller in volume and pollution concentration and hence will be less polluting. The Green Island predictions are thus worst case.

3.4.5 The resultant conditions, taking into account NO_2 conversion, are that for ground level receivers carbon monoxide and nitrogen dioxide concentrations are predicted to be 94 and 11 $\mu g/m^3$ and 148 and 18 $\mu g/m^3$ for dual 2-lane and dual 3-lane respectively. For elevated receiver locations the results show that close to the vent building (within 100m) pollutant concentrations will be high and conditions will be such that the nitrogen dioxide AQO will not be met. The AQO for carbon monoxide is met in all cases. At the present time therefore, it is recommended that the ventilation building is isolated by a buffer zone. The size of this buffer zone is dependant on a variety of conditions including the building form, height and how it is ventilated (i.e. with openable windows or by sealed building air conditioning). Table 3.2 shows that for a 30m receptor height the buffer zone should be greater than 100m.

TABLE 3.1 TUNNEL VENTILATION

Tunnel Type	GIR Portal	KYC Portal	GIR Ventilation Building	KYC Ventilation Building
D3 Concrete N-N	620	410	1050	800
D2 Concrete N-C	430	280	680	540
D2 Steel	480	350	670	540
Pollutant concentration within each air stream vary: CO 68.7 mg/m³ - 35.6 mg/m³ (60 - 31 ppm) NO 10.7 mg/m³ - 7.9 mg/m³ (8.9 - 6.6 ppm) NO_2 2.4 mg/m³ - 1.9 mg/m³ (1.3 - 1.0 ppm)				

TABLE 3.2 VENTILATION BUILDING PLUME DISPERSION

	Maximum Pollutant Concentration ($\mu g/m^3$)			
	Dual 2-lane Tunnel		Dual 3-lane Tunnel	
Sample Height	1.5m	30m	1.5m	30m
CO	94 @ 2.9km	16390 @ 100m 462 @ 200m 101 @ 2.6km	148 @ 2.9km	25687 @ 100m 725 @ 200m 158 @ 2.6km
NO	14 @ 2.9km	2433 @ 100m 69 @ 200m 15 @ 2.6km	22 @ 2.9km	3814 @ 100m 107 @ 200m 24 @ 2.6km
NO_2	3 @ 2.9 km	582 @ 100m 16 @ 200m 4 @ 2.6km	5 @ 2.9km	914 @ 100m 26 @ 200m 6 @ 2.6km

3.4.6 EPD have conducted studies on other tunnels which indicate air temperature differences in the range 3.5°C to 6.6°C, but the base data for these conditions is not known and may not necessarily relate to this specific tunnel design. Accordingly the predicted plume dispersion given in Table 3.2 is based on the more conservative value of 1°C for the purpose of this preliminary study. As more information and detail becomes available on the land use and building form it in probable that this buffer zone can be reduced.

3.5 TUNNEL PORTAL EMISSIONS

3.5.1 Simple tunnel outlet prediction methodology was used to establish worst case peak hourly concentrations in the vicinity of the tunnel portals. Assumptions included a mean wind speed of 2 m/s flowing parallel to the tunnel jet axis for a dual 3-lane option.

3.5.2 The results (shown in Table 3.3) conclude that AQO is achieved at distances greater than 75 m. Further work will be required once details of the structures in the vicinity of the portal are known. The position, height, and orientation of these structures will help to confirm that a 75 m buffer distance will be necessary around the portals.

TABLE 3.3 TUNNEL PORTAL EMISSION DISPERSION

Distance from portal	Pollutant Concentrations from portal Emission $\mu g/m^3$				
	50 m	75 m	100 m	150 m	200 m
CO	9200	2720	760	50	3
NO_2†	609	179	49	4	0.3

(†Includes 20% conversion of NO_x to NO_2)

3.6 GREEN ISLAND LINK APPROACHES

3.6.1 The prediction of traffic generated pollution in the vicinity of the link roads and tunnel portals has been undertaken using CALINE4 methodology. One hour worst case concentrations were modelled.

3.6.2 The input parameters used for emission rate were based on PIARC B year 2000 emissions. These were used for the internal tunnel atmospheric environment assessment and design parameters. The emission rates of 9.35g/mile per vehicle for carbon monoxide and 4.3g/mile per vehicle for nitrogen oxides are similar to those derived from AP42 references and are considered appropriate to use in the present preliminary feasibility study. The complex issue of emission rates needs careful assessment as many assumptions have to be made based on projected traffic fleet mix, age, emission standards, maintenance, legislation etc.

3.6.3 To identify the possible worst case pollutant conditions worst case meteorological conditions and peak hour traffic flows were used for the predictions. The traffic composition used for the modelling was 32% petrol and 68% diesel engine with the following vehicle mix breakdown.

Car	25%
Motor cycle	2%
Taxi	10%
Light goods	29.5%
Medium goods	20%
Heavy goods	11%
Single deck bus	0.5%
Double deck bus	2.0%

3.6.4 Results are calculated for peak hour flows at various distances from the carriageway. The results are applicable for both the Green Island Reclamation and Kau Yi Chau road ways. The results of this analysis are shown in Table 3.4. Due to the uncertainty of surrounding land use the approach used has been to make predictions close to the road edge.

TABLE 3.4 VEHICLE POLLUTANT CONCENTRATIONS PEAK HOUR FLOWS

Tunnel Size	Receptor Location	Meteorological Conditions	Pollutant Concentration $\mu g/m^3$		
			CO	NO_x	NO_2
Dual 2	4m from approach road edge	0.5 m/s G 2 m/s D 3 m/s D	5332 1659 1185	2412 762 508	482 152 101
Dual 2	Tunnel entrance, 2m from road edge	0.5 m/s G 2 m/s D 3 m/s D	5562 2014 1422	2539 889 635	508 178 51
Dual 3	4m from approach road edge	0.5 m/s G 2 m/s D 3 m/s D	7820 2607 1777	3682 1270 889	736 254 118
Dual 3	Tunnel entrance, 2m from road edge	0.5 m/s G 2 m/s D 3 m/s D	8057 3318 2370	3682 1270 1143	736 254 229

Note: Pasquill Stability Classifications D: Neutral G: Most Stable

3.6.5 The conversion rate from NO_x to NO_2 is a crucial parameter in assessing the impact of nitrogen oxides emissions. It is usual for a conversion of 20% to be applied for situations close to the carriageway. Where distances are longer, and the plume has had a greater time to undergo conversion (this rate is also a function of temperature and sunlight incidence) the conversion factor is higher.

3.6.6 The results show that the air quality objectives for carbon monoxide and nitrogen dioxide are met in the most likely worst case scenario, although higher levels may be experienced in uncommon situations. These predictions relate to mobile sources; to gain an overall picture of the development the impacts of mobile sources, ventilation, buildings and ambient concentrations need to be combined.

3.7 IMPACTS

3.7.1 When combined, the effects of these pollutants together with the likely ambient conditions is to raise the concentration of nitrogen dioxide in ambient air above that specified by the air quality objectives. This occurs only in close proximity to the roads during peak traffic flows and during unusual meteorological condition.

3.7.2 Measures are necessary therefore to limit pedestrian access to the roadside and this can be achieved by separating dedicated footways from the highway by buffer areas of about 25 m, except near the tunnel portal where the distance should be greater than 75 m.

3.7.3 It will also be necessary to consider in detail the location of sensitive buildings to ensure that they do not impede dispersion, or that they are not sited such that the plume from the ventilation building or the tunnel portals is intercepted by them. A buffer zone of more than 100m is recommended at this time, although this buffer distance is only relevant for sensitive receivers that rely on natural ventilation or for the intake of ventilation systems. It is suggested that the necessary buffer zones are reassessed as the study progresses through feasibility to the detailed design stage.

3.7.4 The administration building, located close to the toll plaza at Kau Yi Chau, could occasionally experience undesirable concentrations of vehicle emitted pollutants. The air conditioning intake for the building and toll booths should be positioned away from the road system. Over-pressure within toll booths will be used to prevent ingress of polluted air.

CHAPTER 4

4 NOISE AND VIBRATION IMPACTS

4.1 GENERAL

4.1.1 It is necessary to consider the noise and vibration impacts of the proposals in two phases - construction and operation. It is often the case that higher noise levels can be tolerated for periods of short duration as may be the case with construction work and different criteria may be set for the two phases.

4.1.2 The overall impact of the various proposals for development that will eventually form the built environment of Green Island must be integrated at the appropriate time and a comprehensive assessment of the whole area made. At this preliminary feasibility stage of the Green Island Link it is possible to identify the potential of the Link to cause impact but not to identify the extent of the impact in terms of the numbers of sensitive receivers that might be affected. This noise study will require refinements later, as will the air and water implications.

4.2 CONSTRUCTION NOISE

4.2.1 The major noise sources associated with the construction phase will be:

- construction vehicle activity;
- piling;
- fixed noise sources (compressors, etc);
- blasting;
- dredging;
- causeway construction; and
- tunnel section fabrication/outfitting.

4.2.2 The degree of impact by the various activities will be determined largely by the proximity of sensitive receivers to the noise sources which will in turn depend on the project phasing. It is anticipated that certain stages of construction will be able to proceed with little adverse noise impact and requiring minimal control (i.e. good management and normal site standards).

4.2.3 For example, during blasting on Kau Yi Chau to raze the island there are no nearby sensitive receivers as classified by EPD. Similarly, dredging activity will occur some way off shore and the nearest occupied land is Hong Kong Island itself. Causeway construction (by barge and land based tipping) will be remote from sensitive receivers.

4.2.4 There may be the need for some piling activity to construct tunnel fabrication areas (for the casting basin for concrete units). This will be subject to the provisions of the Noise Control Ordinance. However, piling will take place early in the project lifetime and before many sensitive receivers are in occupation on the Green Island Reclamation. It is clear that phasing of total development will be a crucial feature in minimising the potential for impact.

4.2.5 Construction activities and tunnel section outfitting require the deployment of considerable fixed and mobile plant, and will therefore be principal sources of noise and vibration throughout the construction period. Depending upon which areas are in operation during construction and their proximity to sensitive noise receivers, it may be necessary to impose restrictions on the hours of working.

4.2.6 It is recommended that restrictions to the various construction related activities are imposed as follows in Table 4.1. These restrictions are dependent on the degree of occupancy of the reclamation areas and may be adjusted as more information becomes available.

TABLE 4.1 RESTRICTIONS TO CONSTRUCTION ACTIVITIES

Activity	Day	Evening	Night
Construction vehicle activity	✓	*	x
Piling	✓	x	x
Fixed noise source	✓	*	*
Blasting	✓	x	x
Dredging	✓	*	*
Causeway construction	✓	*	*
Tunnel section fabrication/outfitting	✓	*	x

Key:
✓ No restriction (but in accordance with Technical Memorandum Guidance).
* Some restriction - dependent on the number of plant items.
x Not allowed.

4.2.7 The location of the likely construction areas (e.g. tunnel portal area and cut and cover sections) means that the construction work will be some 500m distant from existing (Kennedy Town) sensitive receivers. This may mean that evening work may be possible at Green Island - depending on the degree of occupancy. If no new sensitive receivers are located on the Green Island reclamation, then lorries, dump trucks and graders could be utilised in the vicinity of the cut and cover section and the tunnel portal during evening periods. At Kau Yi Chau, there may not be any sensitive receivers and construction work may be possible around the clock. This would need to be carefully assessed at detailed design and implementation phase.

4.2.8 The location where the tunnel sections for a steel shell tunnel will be fabricated is not known at this stage, as it does not have to be close to the crossing.

4.2.9 The fitting out of tunnel sections prior to their placement along the alignment may take place in the vicinity of the tunnel portal locations. It is recommended that casting basins and associated laydown areas be located as far as possible from existing sensitive receivers, and it may be environmentally preferable for such activities to be concentrated at the western end of the link in the vicinity of Kau Yi Chau.

4.3 OPERATIONAL NOISE

4.3.1 Once Green Island link becomes operational road traffic will become a significant source of noise and vibration. Noise will also be associated with air movement and tunnel ventilation. The number of vehicles using the link will be high and the percentage of HGV's are also forecast to be high.

Traffic Noise

4.3.2 Traffic noise levels have been calculated based on the procedures given in "Calculation of Road Traffic Noise, HMSO 1988". These procedures have been followed to identify worst case conditions, and have included the assumption of wide angle of view. Predictions are based on peak design flows which will be achieved after 2011. The vehicle mix is taken from figures given in Working Paper WP4 which quotes the heavy goods vehicle fraction to be 33.5% of the total flow. The results of these calculations are presented in Table 4.2 and the key locations are shown on Fig E 4.1.

4.3.3 At this stage in the project sensitive receivers cannot be identified. However, it is possible to identify the general levels of noise that may be experienced. In order to meet the noise standards in HKPSG, an unattenuated ground level dual 3-lane road would require a separation distance of 270 m from the nearest noise sensitive premises. However, a number of noise control methods may be used to reduce the impacts of road traffic noise. These methods and their effect on the noise levels are summarised in Table 4.3. These levels will need to be further refined as more information becomes available to identify the nature of controls that will need to be incorporated into the detailed design of roads and residential blocks. As more information becomes available detailed assessments should be undertaken.

TABLE 4.2 PREDICTED NOISE LEVELS

Location	Speed (km/h)	Noise Prediction * (dBA)					
		Dual 2-lane			Dual 3-lane		
		10m	25m	100m	10m	25m	100m
A	70	84.9	82.2	76.2	87.6	84.9	78.9
	50	83.7	81.0	75.0	86.4	83.7	77.7
	15	86.4	83.7	77.7	89.0	86.3	80.3
B	70	81.4	78.7	72.7	82.6	79.9	73.9
	50	80.2	77.5	71.5	81.4	78.7	72.9
C	70	85.2	82.5	76.5	87.1	84.4	78.4
	50	84.0	81.3	75.3	85.9	83.2	77.2
D	70	80.0	74.3	71.3	83.9	81.2	75.2
	50	78.8	76.2	70.1	82.7	80.0	74.0

* At the indicated distance from the edge of the carriageway.

TABLE 4.3 NOISE REDUCTION DUE TO CONTROL METHODS

	Distance from Road		
	10 m	25 m	100 m
Base case (dual 3-lane at 70 km/h)	87.6	84.9	78.9
With surface road treatment	82.6	79.9	73.9
With 2 m barrier, 2 m from road side	71.9	69.8	64.1
With surface treatment and barrier	66.9	64.8	59.1

4.3.4 The results show that traffic noise standards would be exceeded. The separation necessary to achieve the standards should be established with caution as other noise sources will also contribute to the levels experienced.

4.3.5 The table shows that the use of high absorption road surface and/or screening will be necessary to achieve the desired standards for domestic premises. Noise sensitive uses that require more stringent standards - educational institutions, place of worship, law courts, hospitals and clinics should not be placed in proximity to this high flow road system.

4.3.6 The administration building and toll booths will be located in an area that will expose them to high traffic generated levels of noise. They will need to be designed to attenuate these levels to ensure a satisfactory internal environment for tunnel operatives and administrators. This would include the use of sealed window units and air conditioning.

4.3.7 Vibration may be produced by the passage of vehicles through the tunnel which could be transmitted to sensitive receivers above ground. Vibration isolation methods may need to be employed to reduce the likelihood of disturbance, particularly within nearby residential buildings. The levels of vibration will never be high enough to cause structural damage to adjacent development.

4.3.8 Nevertheless vibration due to traffic should be considered in the detailed design stage and good design practices included to minimise the potential for vibration. This will include smooth road surfaces, level manhole covers, etc. A high quality of workmanship during tunnel construction will be essential to minimise adverse vibration impacts. Hong Kong building standards sufficient to withstand MTR generated vibration levels would be adequate for the road tunnel situation.

Ventilation Building Noise

4.3.9 The large volumes of air that it will be necessary to move to allow adequate ventilation of the tunnel will result in noise being generated by the fans and motors. This noise will be attenuated by silencers to the appropriate levels outside the building.

4.3.10 Standards for noise from places other than domestic premises, public places or construction sites, shows that noise from such sources should be no higher that the prevailing background noise level or at the appropriate Acceptable Noise Level as defined in EPD's technical memorandum. The Acceptable Noise Levels from the Technical Memorandum are reproduced in Table 4.4.

TABLE 4.4 ACCEPTABLE NOISE LEVELS

Time Period	Area Sensitivity Rating (dBA)		
	A	B	C
Day/Evening 0700-2300	60	65	70
Night 2300-0700	50	55	60

From Environmental Protection Department Technical Memorandum

Green Island Ventilation Building

4.3.11 Background levels in the vicinity of the ventilation building on the Green Island reclamation are expected to be in the region of 55 dBA during quiet night time conditions. For periods during peak hour traffic flows the L_{90} is expected to be in the region of 62-65 dBA.

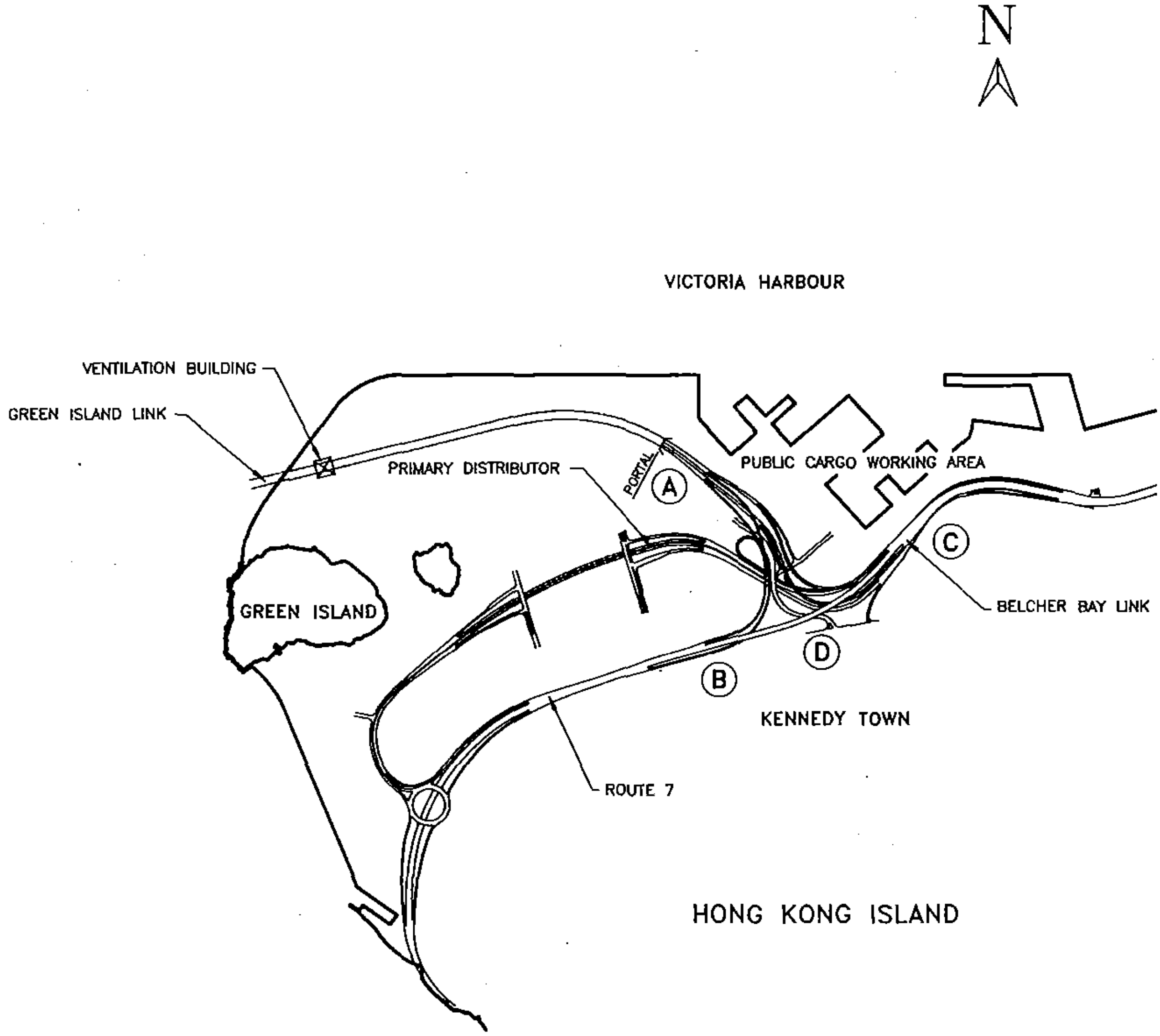
4.3.12 The noise associated with ventilation service will be less than the figure above due to distance attenuation and enclosure of the fans within the ventilation building. However, the potential for nuisance is clearly evident from the sound power level given above. It will be necessary to design the ventilation building with due regard to the need for control of noise. This will include consideration of the size of fan and associated motors, the use of mufflers and silencers on the air moving plant and enclosure of the noisy elements within a building to shield residual noise from neighbouring buildings. The emission ports of the vent building should be designed so that they face away from any sensitive receivers.

4.3.13 The ventilation building is located in an area designated for residential blocks. This means that design of the ventilation system will be crucial to the acceptability of the proposals. At the present time information is available only on the size of air flows necessary to achieve satisfactory tunnel air quality. Detailed design has yet to be formulated. When they are, noise will be a vital part of these calculations and design procedure.

4.3.14 The fans and motors associated with the ventilation equipment will need to be mounted in such a way to minimise the transmission of vibration to the vent building.

Kau Yi Chau Ventilation Building

4.3.15 The ventilation building at Kau Yi Chau will probably be in a less sensitive area than Green Island, although similar design standards should apply.



GREEN ISLAND LINK PRELIMINARY FEASIBILITY STUDY

HIGHWAYS DEPARTMENT	TRAFFIC NOISE LOCATIONS	PAPM CONSULTANTS	FIG. E4.1

CHAPTER 5

5 WATER QUALITY IMPACTS

5.1 CONSTRUCTION IMPACTS

Representative Sensitive Receivers

5.1.1 Within the immediate vicinity of the proposed tunnel and associated land based works there are no sensitive biological receivers such as fish culture zones or identified spawning grounds. There are however fish culture zones located further afield at Ma Wan, Sok Kwu Wan and Lo Tik Wan. As a consequence of the development of the island at Ma Wan it is anticipated that the mariculture zone situated there will, subject to the identification of an environmentally suitable site, be relocated.

5.1.2 There are seventeen gazetted bathing beaches within the possible zone of environmental impact these are identified as:

- Ma Wan - Tung Wan;
- Hong Kong South - Chung Hom Kok, Deep Water Bay, Middle Bay, Repulse Bay, South Bay;
- Tsuen Wan District - Anglers, Approach, Casam, Gemini, Hoi Mei Wan, Lido, Ting Kau; and
- Islands - Hung Shing Yeh, Kwum Yam Wan, Lo So Shing, Tung Wan (Cheung Chau).

5.1.3 The two power stations located on Tsing Yi and Lamma Island have marine cooling-water intakes.

5.1.4 Sixteen seawater intake points on the south and west sides of the Kowloon peninsular and to the west of Central on Hong Kong Island were identified in Volume 5 of the Western Harbour Crossing Study Final Report. Eleven of these are scheduled to be relocated as part of the proposed West Kowloon and Central Reclamations.

Dredging Activities

5.1.5 Dredging will be required during the construction phase, both at the site of the tunnel in order to create the trench and at the site of the borrow ground allocated for the provision of backfill material.

5.1.6 Increases in water column concentrations of suspended solids will be the most significant effect which result from the dredging, backfill recovery and placement, and disposal activities. Additional potential effects on water quality include the temporary stimulation of marine phytoplankton growth due to the release of nutrients, particularly nitrogen species, from the interstitial waters together with temporary increases in water column oxygen demand due to disturbance of organically enriched sediments. Since the sediments in the construction area are not contaminated with heavy metals (Table 2.9) toxic effects due to their release and that of trace contaminants from the dredged spoil are not likely to occur.

Filling Activities

5.1.7 Following the excavation of the tunnel trench, the formation of a stable bed on which to support the tunnel sections and their placement, the trench will be backfilled before being protected with rock armour. Backfill will be in relatively coarse and granular material from which most of the fines have been removed at the time of recovery from the borrow site. As particle size is relatively large, there will be little potential for significant movement from the trench. The size of the rock armour material used to protect the tunnel roof from damage due to anchors and erosion due to propeller wash will be sufficiently large to discount any impact on water quality.

Land Based Activities

5.1.8 In addition to the submarine activities there will be land based activities which could have an impact on water quality. These include surface run-off from the construction site during periods of rainfall, construction debris washout from casting basin during float out, water used for washing plant, workforce sewage, water pumped from trenches and the tunnel access roadways. These will predominantly contribute to the suspended solids loads. Fuel storage and refuelling of vehicles carry an additional risk of contaminating the run off with fuels directly or adsorbed on dust.

Assessment of Impact

5.1.9 It is expected that the dredging of the existing sediments will result in the formation of a plume in which the concentration of suspended solids will be increased above the ambient background value. No additional model simulations of sediment transport in the water column have been carried out at this stage of the environmental impact study. However, the hydrodynamics of Victoria Harbour and adjacent areas and the behaviour of dredged sediment are known. Experience in this field indicates that the likely maximum excursions of the concentration isopleths for increases in concentration of suspended solids of 25 mg/l and 50 mg/l could extend 13 and 7 km respectively in the direction of the prevailing tide stream from the site of dredging activity. In order to give more precise indications of the extent of the plume, model simulations taking account of the prevailing hydraulic regime resulting from the presence of the Port Peninsular and the Western Breakwater should be carried out at full feasibility stage.

5.1.10 Concentrations of suspended solids in the water column are routinely monitored by the Hong Kong Environmental Protection Department. Annual concentration ranges for the years 1988, 1989 and 1990 for five monitoring site in the Water Quality Control zones adjacent to the proposed site for the link are given in Table 5.1.

5.1.11 It can be seen that there is wide variation in concentration between sites in the same year and between years at the same site. In addition there is a wide range within any one year at a particular site. Superimposed on those variations, but not evident from the table, are the variations throughout the day resulting from the differences within and between the tidal cycles.

TABLE 5.1 SUSPENDED SOLIDS CONCENTRATION

	1988 mg/l	1989 mg/l	1990 mg/l
Victoria Harbour West	2-57	2-30	1-28
West Lamma Channel	2-17	1-30	1-20
Lantau North	5-30	3-17	2-9
Tsing Yi Island West	2-39	0-24	1-15
Hong Kong Island West	1-28	0-18	1-13

5.1.12 Other data demonstrating the within tide and between season variations in *inter alia* suspended solids, have been collected on behalf of the EPD for other projects, in particular the calibration of the WAHMO and extended WAHMO models, which should be taken into account when a detailed impact study is carried out.

5.1.13 Based on the provisional predictions of the extent of the plume resulting from the dredging activities (para 5.1.9) it could be expected that during the flood tide cycle the maximum concentrations at the Tsing Yi Island West location could increase by up to 50 mg/l. It is not possible to determine from the EPD annual summaries whether the reported maximum were observed on a flood or ebb tide. It is therefore not possible to calculate conclusively the potential maximum, however assuming the worst case it could rise to 89 mg/l, (50mg/l superimposed on the 39 mg/l maximum observed in 1988). Similarly for the West Lamma Channel the worst case would be an increase up to 80 mg/l (50mg/l superimposed on the 30mg/l maximum observed in 1989).

5.1.14 The maximum concentrations predicted for Tsing Yi Island West and the West Lamma Channel can be considered as representative of those to which the power stations on Tsing Yi and Lamma might be exposed. The tolerable upper limit for suspended solids concentrations in water used for cooling water applications lies in the range 150-200 mg/l. The predicted maximum concentrations of 89 mg/l and 80 mg/l at these locations are significantly less than the given range and therefore are unlikely to give rise to siltation or excessive abrasion in the cooling water systems.

5.1.15 The concentrations which might occur at the Victoria Harbour West location and at the space cooling-water intakes serving buildings between Central and Kennedy Town, and Tsim Sha Tsui and Yau Ma Tai are more difficult to predict since on the flood tide the predominant tidal flow is to the north and north-west of the dredging site. Again considering the worst possible case the concentration could increase to 108mg/l (50mg/l superimposed on the 57mg/l maximum observed in 1988); as in the case of the power stations this is less than the lower value for the upper limit for suspended solids in the intake water.

5.1.16 In addition to the cooling water users, the other sensitive receivers are the mariculture zones. Little quantitative data are available on the impact of transient increases in suspended solids concentrations on juvenile and adult marine or freshwater fish. Those data which are available relate to the maintenance of natural fish populations and so take account of the impact of suspended solids on spawning sites, eggs, larvae, fry, juveniles and adults. In the case of mariculture zones the impact will be predominantly on juvenile and adults and hence less than the whole population. Good to moderate freshwater fisheries can usually be found in suspended solids concentrations in the range 25-80 mg/l and in some cases above 80 mg/l.

5.1.17 The Beneficial Use of Commercial Exploitation, q.v. Commercial Fishing, has been allocated to the Western Buffer Zone and Southern Waters. The upper concentrations of suspended solids in these waters, which might be expected due to dredging activity, are of the order of 80-89 mg/l. Such concentration increases are likely to be transient and therefore the impact on natural fisheries or mariculture activities can be regarded as minimal.

5.1.18 A higher value of 107mg/l is predicted for Victoria Harbour West; in this zone there are no mariculture activities and the Victoria Harbour Zone has not been allocated the Commercial Exploitation Beneficial Use. Any fish in the zone will therefore have the freedom to move, if necessary, out of the plume should it be carried into the Harbour without affecting legitimate commercial fin fisheries.

5.1.19 Within the construction area where sediment removal and direct backfilling take place the effect on the benthic communities will be catastrophic. However members of these communities tend to be prolific reproducers and affected areas will be recolonised in a relatively short time. Communities within the plume area but not physically removed will be subjected to stress and interference with their feeding processes, particularly the filter feeders, bivalve molluscs and fan-worms. Much work has been carried out on the effect of suspended solids on the feeding rate of bivalves, in particular the Blue Mussel, *Mytilus Edulis*, which indicates that concentrations of suspended solids up to 100 mg/l have little effect on feeding. Higher concentrations, up to 200 mg/l, can result in significant inhibition. Those animals with burrows where sedimentation from the plume is taking place will be able to maintain contact with the sediment/water interface. The existence of significant benthic flora in the plume area is unlikely since the light intensity will be below compensation level thus preventing net primary production.

5.1.20 The effect the pelagic community, other than fish, may be a limited reduction in primary production due to reduced light penetration. This effect would not be dissimilar to that resulting from the suspended solids carried down the Pearl River during the wet season. Microcrustacii in the water column may exhibit some inhibition of feeding but again this would not be dissimilar to effects which could be caused by the Pearl River.

5.1.21 It is considered that the peak current velocities in the region of the dredging activities for the tunnel trench will be of the order 0.7-1m/s. Such velocities will be sufficient to provide adequate flushing to prevent any problems caused by algal growth stimulated by the release of nitrogen species from the sediments.

5.1.22 Anthropogenic organic compounds exhibit a strong affinity for suspended solids and it is unlikely that there will be significant desorption.

5.1.23 Heavy metals which are commonly present in the sediments in Victoria Harbour show a marked decline in concentration in the western part of the harbour as illustrated by the test results referred to in Section 2.6. Heavy metals are also bound to the sediments and copper, in particular, is strongly complexed in sea water. These factors will minimise any potential toxicity effects.

5.1.24 Disposal of dredged spoil will be to a designated spoil disposal ground. The environmental impact of disposal of spoil at these sites will have been addressed by studies carried out prior to the gazetting of the spoil grounds.

5.1.25 Similarly the environmental impact of the operation of the borrow grounds should have been addressed at the time of their identification and are not part of the present study.

5.1.26 As fill material will be coarse granular material, losses to the water column during placement of fill will be minimal.

Mitigation Measures for Dredging Activities

5.1.27 At this stage it is not known what techniques will be used for the excavation of the tunnel trench. Bucket ladder, hydraulic suction and grab techniques may all be used at different stages of the preparation of the trench. It is likely that losses will occur both during the removal of the finer marine muds when the ladder and suction techniques are employed and when the alluvial deposits and decomposed granites are removed by the mechanical grabs. Such losses will primarily contribute to the suspended solids plume. Environmental considerations should be taken into account when choosing plant and operating procedures.

5.1.28 The release of suspended solids can be minimised in a number of ways. During the removal of the fine marine muds overflow from the receiving barges must be controlled since it is the overflow which carries the finer particles which will remain in the water column for long periods.

5.1.29 The leaking of water from mechanical grabs can be reduced by using sealed grabs and controlling the overflow from the receiving barges.

Mitigation Measures for Filling Activities

5.1.30 The laying of the bed for the tunnel sections and the subsequent backfilling around the tunnel will use material which has been taken from a marine environment and will contain some fines but generally less than those removed from the tunnel site. The further release of fine material can be minimised by the careful placing of the fill in the trench with a bucket rather than by release from a barge at the surface. The use of an underwater tube or extended chute will also reduce the potential for release of the fines.

Mitigation Measures for Land Based Activities

5.1.31 All surface water run-off and wash water should be collected by a network of culverts and pipes and led to a series of underground, appropriately baffled, sediment traps. In order that these function correctly they must be regularly cleared of accumulated sediment. The traps should also incorporate a baffle to prevent carry over of floating oils. Debris within the casting basin should be removed prior to implementation of float out procedures.

5.1.32 On site fuel storage tank and vehicle refuelling areas should be within bunds having adequate storage capacity. The bunds should also have provision for the controlled release of accumulated uncontaminated rainwater to the drainage system.

Water Quality Monitoring

5.1.33 Baseline data relating to the major water quality parameters, suspended solids and dissolved oxygen should be gathered prior to the commencement of construction activities. The appropriate location of monitoring stations will be identified by the use of the sediment transport model; it is expected that the monitoring stations would be located along the main flood and ebb streams.

5.1.34 The details of the monitoring programme should be established in agreement with the EPD Water Policy Group prior to the preparation of the dredging and fill contracts. Such an approach will allow monitoring experience and other baseline data acquired during other Port Peninsular related projects to be taken into consideration. An early start to gathering of baseline data could establish a reliable background and ensure that seasonal and tidal effects are fully considered.

5.2 OPERATIONAL IMPACTS

5.2.1 The tunnel will not significantly affect currents in the area, although these currents will have been significantly altered by the Port Peninsula and Green Island Reclamation. As a consequence it is unlikely that there will be a realignment of the tide flow with the consequent potential for influencing the concentrations of pathogenic bacteria and viruses on the bathing beaches identified in section 5.1.2.

5.2.2 It is expected therefore that any potential for impact on water quality will result from surface run-off from the tunnel approach and discharges from within the tunnel road drainage system which will receive limited rainwater and road washing water but may be subject to contamination by accidental spillages of fuel and materials being transported by road. In addition foams and chemicals use in fire fighting may reach the system.

Mitigation Measures

5.2.3 The drainage will need to be a pumped system operating from a series of sumps which should include the provision of oil and grit separators. Contamination of the pumps and sumps is unlikely if restrictions on the carriage of hazardous materials, as exist for the present cross harbour tunnels, are implemented.

5.3 OTHER PROJECTS

5.3.1 The greatest impact on the water quality to the west of Victoria Harbour will result from the combined effect of the Lantau Port Peninsula, the Western Breakwater between Cheung Chau and Lamma, and the interim strategic sewage outfalls from Stonecutter's Island and Mount Davis at the west end of Hong Kong Island.

5.3.2 The tunnel will, when constructed, be below the level of the existing seabed over most of its length, but after local scouring has taken place it is possible that the tunnel will then be above the scoured level of the seabed. This is unlikely to have any significant effect on water quality, although it should be noted the other major projects in the Western Harbour, including both the Port Peninsula and the Western Breakwater will cause major changes in the region, and these may affect water quality.

CHAPTER 6

6 VISUAL IMPACTS

6.1 GENERAL

6.1.1 The visual impacts of the proposals have been considered only briefly at this stage. It will be necessary for a full assessment to be undertaken at the appropriate stage of the study when landscaping measures can be considered.

6.2 SHEK TONG TSUI

6.2.1 Shek Tong Tsui is situated at the eastern end of the existing Kennedy Town Praya. The area is similar in character to Kennedy Town, consisting of old residential blocks, godowns and flatted industry. Shek Tong Tsui will experience the progressive development of the Belcher Bay reclamation and link, Route 7 development, Green Island Reclamation and the construction of the Green Island Link.

6.2.2 The visual environment of Shek Tong Tsui will experience considerable change over a number of years and overall, the impacts can be expected to be large. The most significant influence on this will be the changing character of the port area, from a relatively simple waterfront operation to a potentially more complex operation with ships of various sizes carrying a wide variety of goods using the concentrated port area.

6.2.3 The influence of the tunnel portal area on the visual environment of Shek Tong Tsui is expected to be small in comparison to the port area and will be on the limits of the road network envelope visible from the area.

6.3 KENNEDY TOWN

6.3.1 The existing views from Kennedy Town are dominated by the proximity of the sea wall and by the industrial developments along it. The public cargo working area means that there is always an air of activity with often large numbers of vessels unloading and loading. The water frontage is further dominated by the stacks of the refuse incinerator and the abattoir. The landform is such that it is possible to gain height and find vantage points along Victoria Road from which it is possible to view Green Island and the waters of Victoria Harbour. To the south the wooded slopes of Mount Davis form the backdrop to the general setting.

6.4 GREEN ISLAND RECLAMATION

6.4.1 The Green Island Reclamation Feasibility Study considered the landscape and visual quality of the reclamation area. A series of principles were proposed for the development on the reclamation to retain the beneficial landscape elements of Green Island, Little Green Island and introduce visual corridors from the sea towards Mount Davis. These visual corridors were designed to link major elements and to provide a layout on which to structure the form of the development on the reclamation. The corridors will function to allow views to be maintained across the reclamation towards the harbour waters from Mount Davis/Kennedy Town or vice versa.

6.4.2 The reclamation and reprovisioning will remove from the landscape the stacks of the incinerator and abattoir from the existing sea wall. The reclamation will introduce a large number of housing blocks. Due to the height and spacing the blocks will not dominate the landscape. The sky lines of Mount Davis and Green Island have been protected to ensure that this is the case.

6.4.3 The Link portal area will be visually associated with the public cargo working area. The major road system will of course become a significant visual feature of the local area. It is not expected that the Link will be visually more intrusive in the location identified than elsewhere on the reclamation. Lighting associated with the tunnel portal is not expected to be unduly intrusive bearing in mind the levels of lighting associated generally with urban areas of Hong Kong. The landtake of the tunnel portal is relatively large (with lane interchanges and traffic management requirements) and it is anticipated that there will be scope to landscape the area to make it visually interesting.

6.4.4 Housing blocks to the west of the portal will have an open view of the whole portal area. The view of harbour facing rooms will be dominated by the road system.

6.4.5 The ventilation building needs to be located on land close to the sea wall along the tunnel alignment. The land use allocation given to the area in the Green Island Reclamation Feasibility Study Recommended Outline Development Plan is residential and urban fringe park. There is thus a conflict in positioning the ventilation building between exposing residents to potential exhaust emissions and noise or placing a building in the urban fringe park which is designed to be free from man-made structures.

6.4.6 It is considered that placing a building in the fringe park may be preferable but would be acceptable only if it could be designed to minimise visual intrusion, and also to act as a focal point of distinctive design separating the urban fringe park from residential areas.

6.4.7 Although the ventilation building could be designed to fit into the residential blocks the overall design intent may be compromised for example by moving the blocks. It is also possible that the costs involved in designing the vent building to enable it to be accommodated within a residential area will be high. It may be possible to incorporate the ventilation building into the structure of another building. If this could be done without compromising the design intent of either facility this may provide an interesting solution of the siting problem.

6.5 KAU YI CHAU

6.5.1 The proposals as set out for a central Kau Yi Chau landfall require that the island be razed. This will have significant visual/landscape effects but in the context of the overall development it is considered that the proposal to eliminate the island is reasonable.

6.5.2 The island is small rising to some 115m, and is approximately 600m long and 400m side. Sui Kau Yi Chau is 300m long and 100m wide and rises to some 36m at its highest point.

6.5.3 At the present time the islands are only closely viewed from the sea. From vantage points from Hong Kong Island and Lantau, Kau Yi Chau and Siu Kau Yi Chau are viewed against a backdrop of other peaks and islands which in general terms mean that the islands do not dominate the landscape but form part of a wider picture of the archipelago of islands that are Hong Kong.

6.5.4 The vegetation cover of Kau Yi Chau is dense consisting of elephant grass species and low shrubs. There has been periodic burning of parts of the island which has discouraged larger floral species. The same is true of Siu Kau Yi Chau although the island is more barren than Kau Yi Chau.

6.5.5 The south west coast of Kau Yi Chau is the only known nesting site of the Reef Egret within Hong Kong territories. There are other confirmed nesting sites on the Chinese coast, and the birds may be present on other outlying islands, but these have not been documented. Siu Kau Yi Chau appears to be a popular roosting area for black kites but there is no evidence of nest sites on Kau Yi Chau.

6.5.6 The reclamation proposals for the Lantau Port Peninsula Development are such that the reclaimed land will eventually surround the islands. This means that the islands could no longer be utilised as a nesting site by the Reef Egret. Thus the island would be of limited ecological value if retained.

6.5.7 There could be landscape benefits in retaining the island to provide relief from the industrial backdrop that will develop with the Port Peninsula and perhaps as a visual relief for drivers leaving the tunnel. These benefits will be addressed by the Lantau Port Peninsula Development Study.

6.5.8 The proposed developments - the tunnel portal area, toll plaza and ventilation building will become part of a much larger built environment as the Port Peninsula development proceeds. The landscape of the area will change dramatically from that which presently exists. The design of buildings and layout of developments around the highway and toll plaza will be important in establishing the quality of the built environment that will develop.

CHAPTER 7

7 CONSTRUCTION FACILITIES

7.1 GENERAL

7.1.1 The construction facilities necessary for the completion of the project will be wide ranging and hence care will be needed in siting the facilities to minimise the potential environmental impact.

7.1.2 The portal area on Green Island runs into a closed approach tunnel constructed by cut and cover technique. This approach tunnel will support a ventilation building. The seaward end of the cut and cover tunnel forms the interface with the immersed tube tunnel. The units will be laid and joined in a trench in the seabed and subsequently backfilled. At Kau Yi Chau the proposals are for the immersed tube tunnel to emerge with only a short section of cut and cover tunnel. A road connection on causeway is required from the Kau Yi Chau landfall to the of limit of the Port Peninsula at Siu Kau Yi Chau.

7.1.3 The immersed tube tunnel can be either of two distinct types. Concrete units will be constructed ready for sinking in a casting basin capable of containing some 6 to 10 units, whereas steel shell units will be fabricated as a continuous process in a water front area. Construction activities that may be associated with tunnel construction are shown in Table 7.1.

7.1.4 The impacts associated with the construction facilities will principally be as identified in Sections 3, 4, and 5: dust, noise and water pollution.

7.1.5 The construction of this major civil engineering project will inevitably have the potential for significant impact. Siting of the construction facilities at the greatest possible distance from sensitive receivers will reduce the potential for impact. Strict attention to management, operations and site protocol can minimise the adverse environmental impact. Concentrating the construction facilities into small areas will also have some benefit in terms of the ability to control emissions but should be weighed against efficiency of operation and a sensible compromise reached.

TABLE 7.1 CONSTRUCTION ACTIVITIES

Operation	Activity
Concrete Units Casting Basin	Reclamation landfill by pumping, or land or marine based dumping; Sea wall construction; Sheet piling; Bulk excavation below sea level by grab dredging; Bulk excavation above sea level by land based earth moving equipment; Rock excavation by blasting; Pumping out of basin; Placing of granular backfill and/or concrete as a working base; Installation of dewatering system.
Tunnel Construction	Delivery/stockpiling of reinforcement, aggregate, cement and other construction materials; Cutting, bending and fixing of reinforcement; Construction, erection and dismantling of concrete framework in timber and/or steel; Batching, mixing and placing of concrete; Fabrication, welding and erection of temporary works in steel; Sand/grit blasting of steelwork; Spray painting of steelwork; Spray application of epoxy/polyurethane/bitumen waterproofing membrane; Maintenance pumping of ground water/surface water/spillage from basin;
Steel Shell Units Fabrication Area	Delivery/stockpiling of steel plate; "Can" manufacture using bending rolls, manipulators, etc; Oxyacetylene and saw-cutting and grinding of steel plate; Automatic and manual welding
Slipway	Assembly of cans; Automatic and manual welding; Grit/sand blasting of steel plate; Spray painting; Launching
Fitting Out Berth	Mixing and transport of concrete; Delivery/stockpiling, cutting, bending and fixing of steel reinforcement; Placing and vibration of concrete; Delivery/assembly of temporary fitments such as bollards, tow brackets, etc.
Towing & Sinking Preparation	Laying of anchors/anchor blocks; Towing and mooring of units; Work boats for security checking; Assembly onto unit of temporary fittings; Fabrication and/or assembly of temporary fittings involving cutting, welding, sand/grit blasting, spray painting and use of air driven tools; Installation of temporary concrete ballast involving placing and vibration of concrete, including batching and mixing; Testing of ballasting installation involving intake, storage in internal tanks and discharge of harbour water;
Sinking	Installation of anchors and/or anchor blocks; Towing and mooring of units; Ballasting of unit by pumping harbour water into internal tanks; Operation of electric or diesel winches; Operation of tugs, work boats and anchor barges; SCUBA and hard hat diving for inspection purposes.
Foundation	Mooring and manoeuvring of work boats and barges; Grab unloading from barges of granular material; Pumping of sand/water mixture into void; Discharge of excess water; SCUBA and hard hat diving for inspection.
Backfilling	Mooring and manoeuvring of work boats and barges; Grab unloading and placement of granular and general filling materials; Bottom dumping of general fill; Grab unloading and placement of quarried rock as armour; Borrow area operation on land and/or sea.

CHAPTER 8

8 STATEMENT OF ENVIRONMENTAL IMPACT

8.1 GENERAL

8.1.1 The size and engineering complexity of the proposals that form the basis for this Study are such that there will inevitably be environmental impacts, some beneficial and some adverse. Beneficial impacts include the management of traffic onto an efficient highway system that transports the population quickly and easily to their destination without delay caused by road systems unable to carry the traffic generated. This will result in a reduction in traffic from local road systems which in turn will improve the air quality and noise climate experienced locally. The wider proposals for Green Island Reclamation include provision for open space and urban fringe park that meets the necessary standards and hence will improve access to such places for residents of Kennedy Town and Shek Tong Tsui. The development on the reclamation will be laid out to maximise the landscape opportunities and to minimise visual impact of the built environment. Further, the layout has been designed incorporating the Breezeway concept to maximise the opportunities for enhanced natural dispersion and dilution of air pollutants. This feature will be of significant value in dispersing the vehicle generated pollutants.

8.1.2 Nevertheless, the traffic volumes that will utilize the Green Island Link tunnel are anticipated to be very large. These large numbers will affect the noise and air quality in the vicinity of the road and tunnel portals and will, in some cases raise ambient conditions (conditions that will be experienced by individuals in the area) above those of the relevant standards and objectives.

8.1.3 This exceedance, recognised and included in the planning developed by the Green Island Reclamation Feasibility Study, places, as stated therein, constraints on the design of residential blocks in the area and requires high standards of construction materials and methods to be utilized. A quiet road surface will be necessary and the use of non sensitive uses to shield residential blocks will be necessary in some locations to achieve the desired standards.

8.1.4 Air quality close to the road system will be adversely affected by traffic emissions. In worst case conditions the Air Quality Objectives could be exceeded for short periods. It is recommended that pedestrians should not gain access to the highways and that separate footways are provided as necessary.

8.1.5 Careful planning at the design stage will eliminate the severance problems that this requirement could cause and will ensure adequate provision of walkways linking sections and access points.

8.2 NET ENVIRONMENTAL IMPACTS

Construction

8.2.1 The construction stage of the project will create environmental impact in the fields of air and water quality, noise and visual impact. The activities at Kau Yi Chau will affect the flora and fauna of the island.

8.2.2 Air quality impacts will stem from materials handling and construction vehicle movements creating dust.

8.2.3 Water quality impacts will be incurred within the marine environment as a result of elevated levels of suspended solids in the water column. It is unlikely that contamination by heavy metals of marine deposits to be removed during the construction process will be a problem. Further tests will however be necessary to confirm the absence of complex organic contaminants.

8.2.4 Noise impacts will occur as a result of the use of heavy plant and machinery - both land and sea based during the construction period.

8.2.5 The extent of perception by sensitive receivers of the air and noise impacts so caused depends on the phasing programme of the respective proposals (ie. Green Island reclamation and occupation, Link completion etc.)

8.2.6 Water quality impacts identified will affect sensitive downstream receptors regardless of phasing of developments.

8.2.7 If the island is retained, effects on the flora and fauna of Kau Yi Chau will arise as a result of construction activities around and on the island. The long term effects however will occur as a result of the Port Peninsula proposals which will make the habitat unsuitable for the Reef Egrets. The Reef Egrets will be initially displaced by the Link proposals however. It may be necessary to transplant flora from Kau Yi Chau (notably Phoenix Palms) prior to excavation of the island.

8.2.8 The visual impacts caused by construction will be similar to those for any large project with the exception of the substantial changes implied if Kau Yi Chau is razed.

8.2.9 Construction effects have the potential to cause significant impact. It will be necessary to control these impacts by the implementation and operation of a comprehensive construction management plan, designed according to best industry practice and standards. This would include, for example, giving due regard to any material handling and storage, cement batching dust control, implementation of BS5228 and EPD guidance.

8.2.10 The two tunnel types being considered - Concrete Box and Steel Shell - will have different impacts associated with various construction stages. Table 7.1 sets out the construction steps.

8.2.11 The principal impacts associated with concrete box tunnels will be the cement handling and hence potential dust and the noise associated with sheet piling for the casting basin. All impacts associated with the construction and installation will be concentrated in a relatively small area and hence the effects may also be expected to be greater than if the activity were dispersed over a wider area.

8.2.12 The principal impacts associated with the steel shell tunnels will be noise from metal fabrication and cement dust from the fitting out process. Fitting out will take place close to the Link development and hence can be controlled to the necessary standards.

8.2.13 Both types of construction methods have environmental costs associated with them. With adequate control and supervision it is considered that the environmental impacts can be controlled. The residual impacts of either construction method are likely to be of the same order of magnitude, but the relative merits of the two forms of construction may be further determined by a "life-cycle" analysis during the full feasibility study.

8.2.14 Water quality effects of the construction phase will stem from the release of potentially large quantities of sediment into the water column and its resultant effect on turbidity, dissolved oxygen content and suspended solid load. These effects will arise due to dredging and will be similar for both steel tube and concrete box tunnels. It is further expected that differences between dual 2-lane and dual 3-lane tunnels will be small with regard to impact on water quality.

Operation

8.2.15 Once operational the link will carry large volumes of traffic. This traffic will produce noise and exhaust emissions which will have an adverse impact on the surrounding environment.

8.2.16 The traffic numbers are sufficient to cause noise and air quality standards to be exceeded in a number of locations in the vicinity of the proposed project. This means that the use to which land in the vicinity of the highway and tunnel portal area can be put is restricted and it may not be appropriate to include sensitive land uses in close proximity. Noise tolerant land uses that could be positioned close to these facilities include:

- multistorey car parks;
- multistorey markets;
- Offices (with acoustic insulation);
- godowns; and
- community uses (eg. sports complexes, community centres etc.).

8.2.17 Although the likely land use at Kau Yi Chau includes noise tolerant facilities the proposed layout at Green Island does not at the present time identify their presence. The detailed design of the Green Island Link will need to carefully reassess the noise implications of the preferred (primarily residential) land use in order to identify satisfactory noise solutions.

8.2.18 The impact on water quality caused by the tunnel, once operational, is likely to be small.

8.3 CUMULATIVE EFFECTS

8.3.1 As indicated, it is impossible to consider the proposals for the Green Island Link in isolation. The link forms an integral part of the future development of the whole of the territory of Hong Kong.

8.3.2 The development of Hong Kong is based in part on its continued importance as a port. The port facilities proposed for Lantau are a significant feature in the territory's future. The future also lies in an ability to transport people and goods from A to B. This requires an efficient transport system and it is this that introduces the need for the strategic highway links that the Green Island Link is a part.

8.3.3 Predicted traffic volumes that will utilise Route 7 and the Green Island Link are large - the potential for subsequent environmental impact is also large.

8.3.4 The population of Hong Kong has been predicted to experience substantial growth in the near future. Living accommodation to high environmental standards is a reasonable expectation for residents. The new land created by the Green Island Reclamation has been designated as an area to accommodate some of the new residents. The RODP was developed on the basis of Metroplan requirements for new housing.

8.3.5 The need to locate housing and strategic road links together provides a conflict with sensitive users placed in close proximity to sources of pollution and this is also evident in the GIRFS study and in this report. Although steps being taken in Hong Kong to reduce harmful emissions of vehicles will also reduce air quality problems, the noise issues remain.

8.4 ENVIRONMENTAL MONITORING AND AUDIT

8.4.1 It is recommended that as the study from pre-feasibility (completed) through feasibility to detailed design continues and as the proposals leave the design stage and continue through to operational status, means of auditing and monitoring the environmental performance of the project are included.

Air Quality

8.4.2 It is recommended that in view of the scale of the proposals for the area as a whole, EPD are asked to consider setting up an ambient air monitoring station to record the effects on air quality of the construction and operation phases of the proposals. This monitoring station should record climatic variables and concentrations of major pollutants of concern (SO_2, CO, NO_x, O_3). It is suggested that a location on Green Island would be suited to the task. This information would be of value in checking construction and operation predictions and also for providing information on changes in air quality caused by major civil engineering projects. The information thus gained would be useful not only for the Green Island related development but also for establishing guidelines for other large development projects. Notwithstanding the above, it is the responsibility of the contractors to carry out construction stage dust monitoring so that remedial measures could be taken in the event of AQO exceedance.

8.4.3 With regard to ensuring implementation of satisfactory control measures it is recommended that guidelines be drawn up that set out best practice standards that should be followed during the construction process. These guidelines should cover material handling, controls necessary for effective dust control during cement batching, storage of any materials (sand, cement, aggregate etc), dust control from open areas and haulage roads(watering, chemical sealant), speed controls, good site practices, etc.

8.4.4 Contract tenders should be awarded only on the demonstrated ability of contractors to achieve good site standards and practices.

Noise

8.4.5 It is recommended that noise monitoring be undertaken during the construction phase to ensure that nearby sensitive receivers are not exposed to noise levels above the appropriate standards. The extent of monitoring and measurement locations will be dependant upon the extent of nearby reclamation occupation and the phasing and development of this and other related proposals, and also on the eventual location of construction sites.

Water

8.4.6 It is recommended that a comprehensive water quality monitoring programme be undertaken prior to and during marine activity. The monitoring should be designed to establish the ambient conditions and to subsequently identify, as part of an appropriate control programme, any adverse effects on water quality as a result of the construction activity associated with the tunnel.

8.4.7 Water quality and flow pattern are likely to change due both to the Green Island Reclamation, the Port Peninsula and to the construction of the Green Island Link tunnel. It may be difficult to identify the specific cause of any changes as all projects are interlinked. However it is considered important that any changes are recorded. These data will be useful in identifying the scale of changes that might occur at sites of other major reclamation projects. The data will also be of use in verifying the WAHMO prediction methodology. Measured changes should be compared with the predicted changes.

8.5 MITIGATION METHODS

8.5.1 In order to minimise the effects of the environmental impacts associated with the proposed development it will be important to include mitigation methods. These methods of mitigation include:

- following standard guidelines;
- following specific guidelines developed for the Green Island Link Project;
- management of construction activity;
- consideration given to appropriate phasing;
- engineering design; and
- locational/zoning controls.

8.5.2 Other factors that will serve to mitigate the impacts associated with the project include ongoing improvements implemented by EPD concerning vehicle emission standards. This ongoing programme is designed to significantly reduce the concentration of pollutants emitted by vehicles, and will have significant effect on the quality of air in the vicinity of highways.

8.5.3 An additional area that it is recommended EPD consider is the value that could ensue from the introduction of quiet vehicles. Substantial international research exists on the methods available to reduce engine and silencer noise from heavy goods vehicles. It is suggested that the introduction of such vehicles would make a difference, and reduce the noise levels associated with Hong Kong's vehicle fleet. If, when purchasing new vehicles, fleet owners were required to purchase vehicles with strict noise limits, benefits would accrue.

Guidelines

8.5.4 A variety of guidance literature exists which should be consulted when implementing the construction phases of the proposals. These include:

- EPD guidelines on construction noise limitation;
- BS 5228 1984 Noise Control on Construction and open sites;
- Deep Bay Guidelines on Dredging, Reclamation and Construction; and
- water quality monitoring guidelines.

8.5.5 It is suggested that specific guidance documents are also drawn up for the Green Island Reclamation, Green Island Link, and Port Peninsula Developments which take account of the specific conditions inherent in the implementation of these proposals. These guidance documents should be drawn up and should contain information on the types of measures necessary to minimise dust, noise and water quality impacts as indicated in Table 8.1. The documents should also specify penalties to be imposed in the case of proven non-compliance.

TABLE 8.1 ENVIRONMENTAL GUIDANCE DOCUMENTS

Control Subject	Control Method
Dust	Use of enclosed stockpiles and water sprays to dampen stored materials; spraying of long term stockpiles with chemical bonding agents. Hard surfacing of areas subject to regular movement of vehicles. Design controls for construction equipment and construction vehicles to minimise dust release (eg. hoods or where conveyors are used maximum permissable drop heights). Wheel washing facilities for vehicles leaving the site. On site routing of construction vehicles to avoid spread of dust. Regular housekeeping/clean up measures at loading/off loading areas. Speed restrictions for construction site traffic.
Noise	Use of silencers on construction equipment; Regular maintenance of construction vehicles and equipment; Restricted hours of working to avoid night-time and weekend disturbance; Restricted hours and routing of construction traffic; Physical or natural screen around the site to minimise off-site disturbance (also consider machine noise emission and orientation of machinery relative to sensitive receiver;
Water Pollution	Timing and programming the work; Selection of borrow areas and layout of dredging work; Rate and method of dredging Technical requirements Good housekeeping requirements Supervision and monitoring guidelines should also specify personnel experienced in turbidity reduction methods; Mechanical dredging equipment; grabs used in mechanical dredging should be designed so that they seal tightly when lifted. Closed type grab buckets should be used in sensitive areas; Cutter-suction dredging, cutter blades should be designed for the depth at which dredging is to take place. The suction should be designed with maximum pick up capability. The use of a suction tube mounted cutter should be considered in sensitive areas. Cutter heads should be hooded to reduce loss of materials; Dredge ladders; ladder design should include measures that minimise bed disturbance; Pipelines; the need to specify leak-free joints and the flushing of pipelines prior to disconnection should be taken into account where pipelines are likely to be used; Equipment maintenance; dredging equipment should be regularly maintained to ensure that all seals/control mechanisms are in full working order; this will help to minimise re-release and loss of fine materials.

Phasing

8.5.6 As indicated throughout this report the phasing of the various projects will be a significant feature in nuisance prevention during construction operations. If occupancy occurs prior to completion of all construction related work then the opportunity for adverse impacts will be significantly higher than if all civil work were completed prior to occupation.

Design and Layout

8.5.7 The noise and air quality impacts associated with the operational proposals are significant. It will be important to continue to optimise the design and layout plans to reduce the impacts as far as possible. They are more significant at the eastern portal than the west, and more for the dual 3-lane than for the dual 2-lane tunnel.

8.5.8 For noise this will include the use of a sound absorbing road finish on the link highway and roadside acoustic barriers at the Link/Route 7 interchange.

8.5.9 For air, the layout principles embodied in GIRFS to promote natural dispersion must <u>not</u> be compromised.

8.5.10 As the detailed design are developed it will be necessary to continue the assessment procedure to refine the predictions accuracy. This will ensure that the detailed designs are able to meet the objectives of:

- providing strategic highway connections;
- meeting the Air Quality Objectives / Noise Standards / Water Quality Objectives; and
- maintaining the environmental quality of local residents.

8.5.11 This refinement of prediction may also take into account any changes in the requirements for population to be located to Green Island Reclamation and in traffic numbers utilising the road tunnels.

8.5.12 It should be stated that the environmental quality of the area will be affected by the volume of traffic usage. If this volume could be reduced (by use of railway links, MTR links etc) the adverse impacts could also be reduced.

APPENDIX A

Department	Reference	Comments	Response
Environmental Protection Department (T Tsang) 7 Feb 1992	Para 3.3 to 3.6	The report only gives sketchy information on the modelling of the air quality impacts. Being absent are the technical particulars of the models for simulating the impacts of the ventilation stack and the modelling parameters chosen for the execution of CALINE4. The report has recommended buffers for the roads associated with the link and for the ventilation stack. The orders of magnitude of the buffer requirements seem to be reasonable. As there will be a reassessment (recommended in Para 3.3.1, 3.6.3 and 8.5.10) of the buffer requirements at a later stage, I would not pursue for further submission on the modelling details. However, it will be advisable for the consultants to agree with us the modelling methodology before carrying out the modelling work of the reassessment.	Noted.
	Para 3.4.3 & Table 3.1	Air quality impacts from tunnel portal emissions have not been assessed and addressed in this report. Doesn't it mean that the portal jet emission has no impact to the adjacent landuses? Please clarify and identify any further assessment.	Simple tunnel outlet prediction methods used in previous studies show that highest pollutant concentrations occur when the wind is parallel to the tunnel jet axis, AQO's for NO_2 are exceeded close to the tunnel portal by portal emissions alone. At 75m from the portal, pollutant concentration have below the AQO. At this stage an increase in the roadside buffer of 25m to 75m is suggested for limiting pedestrian access to the immediate tunnel portal area. As with the buffer zones discussed in paragraphs 3.6.2 & 3.6.3 this buffer zone should be necessary as the study progresses. (Cont'd)

Department	Reference	Comments	Response
Environmental Protection Department (Cont'd)			(Cont'd) Pollutant Concentrations from Portal Emission $\mu g/m^3$

	50m	75m	100m	150m	200m
CO	9200	2720	760	50	3
NO_2+	609	179	49	4	0.3

(+ Includes 20% conversion of NO_x to NO_2)

The TOP[1] model has been used to predict the variation of maximum pollutant level up to a distance of 200m from the portal. A worst case situation was assumed; average weather, wind direction and speed were not considered for the Preliminary Environmental Assessment.

[1] Ukeguchi N, Okamoto H, and Ide I, Prediction of Vehicular Emission Pollution around a Tunnel Mouth, 4th International Clean Air Congress, Tokyo 1977.

Department	Reference	Comments	Response
	Para 3.4.4 & Table 3.1	Would the consultants please clarify why the ventilation system is designed in such a way that the emission in GIR is greater than that in KYC. In terms of air quality impacts, it would be better to have more discharge in KYC instead of GIR as less sensitive development would be placed there.	Gradients and lengths of tunnel at GIR are the cause of more emissions on that side. Agreed that discharge at KYC would be better, but the cost of so doing is likely to be so high as to be judged prohibitive.
	Para 3.7.2	The consultants should provide information on how the 25m buffers arrived.	The 25m buffer is considered a suitable value to achieve a good standard in all conditions.

Department	Reference	Comments	Response
Environmental Protection Department (Cont'd)	Para 3.7	Although the order of magnitude of the buffers are considered reasonable, the exact requirements will only be known after the detailed study. As a result, the RODP for the GIR and KYC landfall should be subjected to review after detailed environmental assessment of the GIL in later stage.	Agreed. The exact dimensions may be determined by detailed study and inclusion of all factors including GIRFS, RODP and landscaping requirements.
		The consultants are preoccupied with sensitive receptors. The AQOs being ambient air quality standards do not seem to have been recognized.	The use of the term sensitive receiver has been used in its broadest sense to include communities and the environment.
	Chapter 4 General	The Report fails to fulfil the Technical Requirement per Appendix II of the DFR (Vol.1) in the following aspects relating to the Construction Phase and Operation Phase: i) Identification of NSRs (In particular, the proposed land uses in the GIRFS should be related) ii) Assessment of Construction Noise Levels iii) Proposals for Noise Amelioration Measures (The Report in its present form does not contain the type, extent, location and effectiveness of likely measures)	It is possible at this time to identify noise sensitive receivers. The impact in broad planning terms has been assessed with regard to the expected land use proposals. However, more detailed examination is not possible in the absence of information on development layout and phasing. With regard to construction noise, the tunnel will be constructed in areas of reclamation before development takes place. For noise amelioration measures to be determined, noise levels and status of neighbouring developments need to be known. Noise amelioration methods will be necessary including good management, restricted hours of working, reference to EPD guidelines and to the Noise Control Ordinance. As detailed design stages are reached more specific guidance on noise amelioration measures can be provided including type of equipment, shielding, method of work etc.

Department	Reference	Comments	Response
Environmental Protection Department (Cont'd)		Traffic Noise	
	Para 4.3.2	i) What is the design year for the noise prediction presented in Table 4.27 What are the parameters for the prediction in terms of projected traffic flow in veh/hr, traffic mix, road surface type, receiver height, ... etc?	Noise predictions are based on peak design flows which will be achieved after 2011, with a vehicle mix of 33.5% HGV devised from table 2.6 Working Paper 4, that identifies 20% medium goods, 11% heavy goods, 0.5% bus (single deck), 2% bus (double deck), totalling 33.5%. Receiver height is at 1.5m. It is noted that detailed assessments should be undertaken as more information become available.
		ii) For areas where the NSR facade is not yet known (e.g. those in the RODP of the GIRFS), minimum buffer distance from the noisy roads to meet HKPSG requirements should be shown to indicate severity and the likely measures should be proposed. Maybe Table 4.2 could be modified to serve this purpose.	Distance attenuation to meet HKPSG is costly in terms of land take and screening will be required. At the large distance required for meeting HKPSG other noise sources become important to the overall contribution. To meet HKPSG, guidance for domestic premises of $70dBA_{L10}$ a distance of about 270m between the roadside and the noise sensitive receiver is necessary. However, a number of noise control methods may be used to reduce the impacts of road traffic noise. These methods, and their effects on the noise levels are summarised in Table 4.3.

Department	Reference	Comments	Response
Environmental Protection Department (Cont'd)		Ventilation Building Noise	
	Para 4.3.10	According to HKPSG, all fixed noise sources should be located and designed that when assessed in accordance with the Technical Memorandum (TM), the level of the intruding noise at the facade of the nearest sensitive use should be at least 5dB(A) below the appropriate ANL shown in Table 3 of the TM or, in the case of the background being 5dB(A) lower than the ANL, should not be higher than the background.	Noted. The ventilation building will be designed to meet the appropriate standards. In the absence of measurable background noise levels the appropriate Acceptable Noise Limit from the TM would be used as the design figure taking into account the 5dBA reduction necessary.
	Para 5.1.8	Other potentially important sources of marine pollution which should be considered by the developer during construction include workforce sewage and general construction debris.	Noted.

Department	Reference	Comments	Response
Environmental Protection Department (Cont'd)	Para 5.1.9 - 5.1.20	The impact of suspended solids (which is likely to be the major water quality impact of the proposed development) is not adequately addressed by the consultant. The discussion (here or in subsequent documents submitted to EPD) should centre on the following points:- - what background data is available - interpretation of available data - identification of shortcomings in data - water quality requirements of beneficial users/ sensitive receptors - predicted impact of proposed development activities - mitigation requirements - monitoring/audit proposals including target and trigger levels and outline action plan if trigger level exceeded It is accepted that some of the above points may be beyond the scope of a preliminary EA. Nevertheless the background situation should be set out more clearly with particular reference to the predicted <u>impact</u> of the development.	The background situation will be set out more clearly in the Final Report.
	Para 5.1.9	What is the relevance of the quoted suspended solid concentration increases of 25mg/l and 50mg/l to the proposed development. The consultant should relate these to the anticipated concentrations arising as a result of construction activities and local tidal conditions. The basis for the conjectured extent of isopleth excursion should be referenced stated.	The relevant explanations and the basis of isopleth excursion will be set out in the Final Report.

Department	Reference	Comments	Response
Environmental Protection Department (Cont'd)	Para 5.1.10	The basis for these "typical" suspended solid concentrations should be given. Recent published EPD monitoring data (See "Marine Water Quality in Hong Kong", EPD, 1990 and 1991) suggests a tighter range of concentration than is presented in the draft report, with lower maximum values. Data for 1989 and 1990 were reported by EPD as follows:-	Data was extracted from EPD data from 1988 and will be revised to reflect the figures supplied.

	1989 (mg/l)	1990 (mg/l)
Victoria Harbour West	2 - 30	1 - 28
West Lamma Channel	1 - 30	1 - 20
Lantau North	3 - 17	2 - 9
Tsing Yi Island West	0 - 24	1 - 15
Hang Kong Island West	0 - 18	1 - 13

Department	Reference	Comments	Response
	Para 5.1.11	On what basis are the tidal variation in suspended solid concentrations (of up to 50mg/1) quoted. These statements should be supported by appropriate references.	These figures were identified on the basis of interpretation of information assembled from previous relevant studies.

Department	Reference	Comments	Response
Environmental Protection Department (Cont'd)	Para 5.1.14	A figure of 80mg/1 is given for the "upper concentration which might be expected due to dredging activity". The consultant should clarify whether this refers to the maximum increase as a consequence of dredging or the maximum total (i.e. including background). There should also be an explanation as to how this figure was derived. Note that background levels may already be high (up to 110mg/1 as given by the "worst case" quoted by the consultant). Thus consideration may need to be given to the construction derived suspended loading either "tipping the balance" or even worsening an already unacceptable situation.	The required clarification and explanation will be included in the Final Report.
	Para 5.1.21	Environmental considerations should influence the choice of plant and operating procedures.	Noted.
	Para 5.1.28	The baseline data gathering programme should be commenced at the earliest opportunity to establish a reliable background and ensure that seasonal/ tidal effects are fully considered.	Noted.
	Para 5.3.2	Have any scoping predictions been made regarding the possible extend of seabed scouring? The depth of the tunnel should be sufficient to guarantee that it will not protrude above seabed level with adverse effects on flushing characteristics.	More detail is contained in Working Paper WP3. Tunnel depth is discussed in Vol 1 4.3.2, 4.3.3 and Appendix A2.7.

Department	Reference	Comments	Response
Environmental Protection Department (Cont'd)		Statement of Environmental Impact	
	Chapter 8	The noise impact and mitigation methods contained in this chapter are only described in general terms. Specific relevancy and practicality to the project with a view to achieving the acceptable levels should be discussed.	Noise impact and mitigation methods have been addressed as specifically as it is possible to do at this preliminary feasibility stage. More specific study will be undertaken at full feasibility stage.
	Page 8-6	The waste disposal strategy for the construction period needs to be assessed. However, this issue was not addressed within the report. The solid waste management scheme for the Link operation and other future developments need to be assessed.	Disposal of dredged spoil will be to designated disposal areas, which will be identified at detail design stage. The environmental impact at these sites will have to be addressed by later studies prior to gazetting of the spoil grounds. A waste disposal strategy for the construction period and a solid waste management scheme for the Link during operation may be more suitably addressed at Full Feasibility stage. Solid waste management of other future developments is outside the scope of this Study.
	Para 8.2.3	Please explain why there is unlikely any problem during removal of marine deposits.	The heavy metal test results do not indicate contamination of the marine deposits and therefore it is unlikely that removal of these deposits will be problematical.
	Para 8.2.16	Multistorey markets, offices and community uses are not appropriate landuses in areas where AQOs are exceeded.	The listing refers to noise tolerant uses. Noise tolerant uses are not necessarily air pollution tolerant uses.
	Para 8.4.2	It is the responsibility of the contractors to carry out construction stage dust monitoring so that remedial measures could be taken in event of AQO exceedance. Whether or not EPD would set up air monitoring station in Green Island would depend on the availability of resources.	Noted.

Department	Reference	Comments	Response
Environmental Protection Department (Cont'd)	Para 8.4.3 & 8.4.5	The advantages of employing large diameter bored piles over the driven piles are:-	
		(i) the boulder size of the fill material for reclamation will pose no significant adverse effect on bored piles.	Noted.
		(ii) Bored piles will have much less noise emission that the driven piles.	Noted.
	Para 8.4.6	The proposal for a comprehensive monitoring programme prior to and during construction is supported. This should go beyond identifying adverse effects on water quality. It should be used as the first step in an appropriate control programme to ensure that the danger signals are picked up and acted upon.	Noted.
	Para 8.4.7	The proposal to monitor changes occurring as a consequence of the extensive reclamation activities in the region and verification of predictive computer models is supported.	Noted.
	Para 8.5.4	"Deep Bay Guidelines on Dredging, Reclamation and Construction" is established for works within Deep Bay only, though reference to the recommendations in the document can be made for construction elsewhere.	The literature will be consulted. (rather than "followed")
	Para 8.5.9 & 8.5.11	Recommendations are supported.	Noted.

Department	Reference	Comments	Response
Civil Engineering Department (PDO) (C H Lam) (13) in L/M PD 5/3/4 II 31 Jan 1992	Para 5.1.2	Consideration should be given to include Discovery Bay in the areas within the possible zone of environmental impact.	Noted. Discovery Bay is not a gazetted beach, but there is no reason why it should not be included in any future studies.
Electrical and Mechanical Services Department (W K Lo) EM/PAD 30/10 29 Jan 1992	Para 3.4.3	The requirement to fit catalytic converters in all new passenger cars registered after 1992 will definitely have a significant effect on the increase consumption of unleaded petrol, especially when the tunnel is operational in 2004.	Agreed.
	Section 3.6	Environmental impacts in terms of air quality on manual toll booths need to be addressed in this section.	Agreed. It will be incorporated in Para 3.7.4.
	Para. 4.3.6	The effect of traffic noise on manual toll booths should be discussed.	The effect of traffic noise on toll booth operators is a matter to be addressed during detail design. When detail design of the booths is made, sound proofing is expected to attenuate noise to levels which comply with occupational health standards.
Royal Hong Kong Police Traffic Wing (G J Bailey) (12) in CP/T/TMB 22/79 II 30 Jan 1992	Volume 4	As regards volume 4, I note Table 8.1 and have nothing to add.	Noted.

Department	Reference	Comments	Response
Agriculture & Fisheries Department (M.K. Cheung) 13 Feb 1992	General	From the conservation point of view, the information on flora, fauna and possible ecological impacts appear too scanty for drawing any reliable conclusion. At least the consultant should find out the answers to the following questions.	Noted.
		a) Are there any rare animals/plant which may be adversely affected by the proposed development? (Incidentally, Phoenix hanceana is no longer on the Schedule of the Animals and Plants (Protection of Endangered Species) Ordinance Cap. 187.	Refer to volume 4, 6.5.4 and 6.5.5. More detailed studies will be carried out at the Full Feasibility stage.
		b) Are there important bird roosting and nesting sites on the islands to be affected?	The Reef Egret is discussed in 6.5.5.
		c) If so, what will be the consequences of the proposed development and what mitigation measures should be taken to minimise the impacts?	Construction of the Port Peninsula will eliminate the marine shoreline (but not necessarily the nests or on-land habitate), and this is expected to be unacceptable to the birds. Mitigation is therefore unlikely. It is probable that there are other nesting sites elsewhere undocumented, as these are not the last existing Reef Egrets.
	Para 6.5.1	Specially I am concerned about the statement on paragraph 6.5.1 that "require that the island be razed".	The Lantau Port Peninsula Development Study is expected to make recommendations on the future of the island and the recommended route of the Green Island Link at the Kau Chau end. That decision does not lie with the GIL study.

Department	Reference	Comments	Response
Agriculture & Fisheries Department (Cont'd)	Para 6.5.6	Moreover I cannot agree to the last 2 statements made on paragraph 6.5.6 that "This means that the islands could no longer be utilised as a nesting site by the Reef Erget. Thus the island would be of limited ecological value if retained". In my view, the proper approach is to look for mitigation measures to retain its ecological value instead of saying that "since we have destroyed the valuable habitat, there will be not need to preserve the islands".	Refer to the comment above.
		Apart from the above conservation comments, I believe that the proposed development may have impacts on the fishing activities in or near the area. I should therefore be grateful if you could send us a copy of the full report on the Preliminary Environmental Assessment so that our Fisheries colleagues can comment further.	Noted.
Planning Department (Y.L. So) (6) in HK-R/TT/206	Para 2.4.8	It should be clearly stated that some of the mitigation measures identified in the GIRFS, e.g. single aspect housing, have yet to be accepted by concerned government departments. Moreover, the cost-efficiency and feasibility of the other mitigation measures, e.g. acoustic barriers and land use buffer, should not be over-estimated.	Noted. The suggested mitigated measures are included as recommendations to be carried forward for the next, more detailed design stage.
	Para 3.6.2 & 3.6.3	With regard to the suggested buffer area, will it carry any bearing on the overall land use budget on the reclamation area?	The mitigation measures proposed are intended to address predicted environmental impacts. Planned land use scenarios have not been considered at this preliminary stage.

Department	Reference	Comments	Response
Planning Department (Cont'd)	Para 6.4.4	If the harbour-facing rooms are to be dominated by the road system, will their exposure to traffic noise acceptable?	The effect of road traffic noise on adjacent residential users is a major consideration and is addressed in Section 4.3 of Volume 4.
	Para 6.4.7	What is the exact meaning of integrating the ventilation structure into "another building"? Approximate dimension and possible outlook of the ventilation structure on GIR should be indicated.	The incorporation of the ventilation exhaust system into a non-residential building may have less impact than a purpose built structure. The final solution to the siting of the ventilation building and the exact orientation and dimensions of the structure will be the subject of further study in the detailed design stage of the project.
	Ch. 6	As far as visual impacts are concerned, the scope of possible landscape treatment of the proposed highway structures should be indicated.	Landscape treatments to the exposed parts of the proposal will be devised at the detailed design stage of the project.
	Para 8.2.16	The general conclusion that a number of locations in the vicinity of the project will exceed the noise and air quality standards in the operation stage is noted. Bearing in mind that mitigation measures at the detailed land use planning stage may not be cost-effective or desirable, comments/ agreement of DEP at the preliminary planning stage will be relevant.	Noted.