PORT KENNEDY

PORT KENNEDY JOINT VENTURE

PORT KENNEDY REGIONAL RECREATION CENTRE

ENVIRONMENTAL REVIEW AND MANAGEMENT PROGRAMME

Volume II: Main Report

DECEMBER 1988

Binnie & Partners Pty Ltd
CONSULTING ENGINEERS

PORT KENNEDY REGIONAL RECREATION CENTRE

ENVIRONMENTAL REVIEW AND MANAGEMENT PROGRAMME

VOLUME II: MAIN REPORT

Prepared for Port Kennedy Joint Venture

by Binnie & Partners Pty Ltd

Project Co-ordinator: RI Allan Architect Pty Ltd

December 1988

PORT KENNEDY REGIONAL RECREATION CENTRE

ENVIRONMENTAL REVIEW AND MANAGEMENT PROGRAMME

INVITATION

The Environmental Protection Authority (EPA) invites people to make a submission on this proposal.

This Environmental Review and Management Programme (ERMP) for the proposed Port Kennedy Regional Recreation Centre has been prepared in accordance with Western Australia Government procedures. The report will be available for comment until 3 March 1989.

Comments from Government agencies and the public will assist the EPA in preparing an assessment report with recommendations to Government.

Why Write a Submission?

A submission is a way to provide information, express your opinion and put forward your suggested course of action - including any alternative approach. It is useful if you indicate any suggestions you have to improve the proposal.

All submissions received by the EPA will be acknowledged. Submissions will be treated as public comments, unless confidentiality is requested, and may be quoted either in full or in part.

Why Not Join a Group?

If you prefer not to write your own comments, it may be worthwhile joining with a group or other groups interested in making a submission on similar issues. Joint submissions may help to reduce the workload for an individual or group, as well as increase the pool of ideas and information. If you form a small group (up to 10 people), please indicate all the names of the participants. If your group is larger, please indicate how many people your submission represents.

Developing a Submission

You may agree or disagree with, or comment on, the general issues discussed in the ERMP or the specific proposals. It helps if you give reasons for your conclusions, supported by relevant data. You may make an important contribution by suggesting ways to make the proposal environmentally more acceptable.

When making comments on specific proposals in the ERMP:

- clearly state your point of view,
- indicate the source of your information or argument if this is applicable,
- suggest recommendations, safeguards or alternatives.

Points to Keep in Mind

By keeping the following points in mind, you will make it easier for your submission to be analysed:

- Attempt to list points so that the issues raised are clear. A summary of your submission is helpful.

- Refer each point to the appropriate section, chapter or recommendation in the ERMP.

- If you discuss different sections of the ERMP, keep them distinct and separate, so there is no confusion as to which section you are considering.

- Attach any factual information you wish to provide and give details of the source. Make sure your information is accurate.

Remember to include:

- your name,
- address,
- date.

The closing date for submissions is:
3 March 1989

Submissions should be addressed to:

The Chairman
Environmental Protection Authority
1 Mount Street
PERTH WA 6000

Attention: Mr J Singleton

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SECTION 1.0

PREFACE

1.0 PREFACE

1.1 ERMP ARRANGEMENT

The Environmental Review and Management Programme (ERMP) has been divided into three volumes:

- Volume I is a summary document containing a brief overview of the salient points of the ERMP.
- Volume II is the main report. It details the overall assessment of the project, with an integration of the specialist consultants' reports on the project's environmental impact and management requirements.
- Volume III contains detailed reports from the specialist consultants as Appendices.

1.2 EPA GUIDELINES

Guidelines for this project were prepared by the Environmental Protection Authority (EPA) and are included in Section 15.

The following specific issues were highlighted in the Preamble to the EPA guidelines:

- "The use and interpretation of existing available data from previous ERMP's for the region." In general it was found necessary to undertake detailed studies specific to the preparation of this ERMP. The balance between interpretation and extension of existing data and new field work represents the result of discussion with the EPA and other regulatory agencies during preparation of this ERMP.
- "The System Six recommendations for the Port Kennedy area (M106)." System Six aspects are addressed in detail in this ERMP in Appendix C and Sections 3.4, 4.4, 10.3 and 11.8. Note that as the System Six Report (Report 13, Department of Conservation and Environment, 1983) has been mentioned repeatedly in this ERMP, the document has been referred to as "System Six" throughout.
- "The landscape image and concept for the site." This is described in Section 5.4 and Section 6.4.

SECTION 2.0

INTRODUCTION

2.0 INTRODUCTION

2.1 PROJECT AND PROPONENT

The Port Kennedy Project is a **Regional Recreation Centre** which will provide facilities for local use as well as for interstate and international tourists. The project will ultimately incorporate a wide variety of recreation facilities and accommodation for different socio-economic groups ranging from a caravan park and budget chalets to international standard hotels. The project contains no urban residential component. Construction of the Port Kennedy **Recreation Centre** will be undertaken in stages. This ERMP has been prepared for Stage I of the project. Subsequent stages of the development will be subject to separate environmental impact assessment and review by the EPA when details are finalised.

The **Proponent** is the **Port Kennedy Joint Venture,** a 50/50 partnership between Fleuris Pty Ltd and the Western Australian Development Corporation. On completion of formal Agreements, a Management Board will be constituted to administer the site's ongoing development and management obligations.

2.2 THE SITE

Port Kennedy is located 50km south of Perth and 8km south of Rockingham as shown in Figure 1. The site incorporates Becher Point and borders on the southern portion of Warnbro Sound.

Port Kennedy is a large site covering an area of approximately 740ha (see Photographs of the Site). The site includes 7.5km of beach backed by a dune typically 6 to 15m high. The remainder is covered by low parallel dunes between 2 and 8m high. Much of the site, particularly the northern half, is badly degraded by existing unmanaged use.

The whole of Port Kennedy is in Crown ownership and is reserved for Public Purposes (Special Uses). The site is shown in Figure 2 and comprises:

- Part of Reserve C20716 for Government requirements, not vested.
- Reserve C33837 for Government requirements leased by the Community Welfare Department. This area is outside Stage I and also excluded from subsequent development.
- Vacant Crown Land including Peel Estate Lots 1316, 1317, 584, 606, 692, 695, 682, 698, 762, 764, 777 and 1096.
- Vacant Crown Land between lot boundaries and the low water mark.

Parts of the above parcels of land south of Becher Point are below low water mark due to erosion of the coastline.

The coastal strip is designated under the Metropolitan Region Scheme as a Parks and Recreation Reserve.

As shown in Figure 3, the land bordering the northern half of the site and abutting the southern boundary is zoned for urban development. The area to the east of the southern half of Port Kennedy is vacant Crown Land connecting to the Rockingham Lakes Regional Park.

2.3 BACKGROUND

Proposals for use of the area have been included in three planning studies in 1955, 1961 and 1978. All three studies incorporated recreational and holiday use as important components.

Port Kennedy forms the majority of System Six area M106. System Six recognises the site's potential for both conservation and recreation.

In March 1986, the Government of Western Australia advertised for submissions from the public and companies to register their interest in being appointed to carry out a development project on Crown Land at Port Kennedy.

The type of facilities envisaged by the State Government were set out in the Port Kennedy **Regional Recreation Centre** Development Brief prepared by the State Planning Commission (SPC, 1986). The proposed facilities included public rental and short term lease cottages and chalets, caravan parks, camping grounds, sporting facilities, a boat harbour, civic, commercial and cultural facilities and a hotel. An Interim Management Committee was established to evaluate submissions.

After considering the submissions, the Port Kennedy Interim Management Committee agreed that the Fleuris Pty Ltd proposal was the only one that adequately addressed the requirements set out in the Development Brief and provided a financial framework to ensure the project's viability.

In October 1986, Fleuris Pty Ltd was given an exclusive right to proceed in order to carry out feasibility studies. Upon the successful completion of these studies in November 1987, Fleuris Pty Ltd entered into a 50/50 joint venture with the Western Australian Development Corporation to develop the site.

Port Kennedy Joint Venture was subsequently given approval by the State Planning Commission to undertake the proposed Port Kennedy Development, subject to the completion of the environmental impact assessment to the satisfaction of the EPA.

2.4 OBJECTIVES AND BRIEF DETAILS OF THE PROPOSAL

The objective of this development is to provide coastal recreation facilities for the Western Australian population and visitors to the State.

It is the **Proponent's** policy that the management and maintenance of the development will not become the financial responsibility of the Government of Western Australia, its Agencies or the Local Council. The development will not result in initial or continuing cost to the community.

Stage I of the project is located in the northern part of the site. The site layout is shown schematically in Figure 4 and includes the following major components:

- a marina located at Bridport Point,
- marina accommodation and town centre,
- an international standard resort hotel,
- a private club house and 18 hole golf course,
- an 18 hole public golf course and facilities,
- an access avenue from Ennis Avenue (Perth-Mandurah Road) to the marina and carparking areas located behind the marina,
- two conservation areas covering approximately 32 percent of the Stage I area, and
- public open space covering a further 5 percent of the Stage I area.

Stage I will be constructed over a two year period with completion in 1991.

2.5 RESPONSIBLE AUTHORITIES AND STATUTORY REQUIREMENTS

Agencies having statutory responsibilities for this development are:

- Environmental Protection Authority,
- Shire of Rockingham,
- State Planning Commission,
- Water Authority,
- Department of Marine & Harbours,
- Department of Agriculture, and

o Department of Conservation & Land Management.

2.6 PROJECT AGREEMENT AND MANAGEMENT BOARD

2.6.1 Port Kennedy Project Agreement

The **Port Kennedy** project will be subject to an Agreement between the **Proponent** and the Western Australian Government. The Port Kennedy Project Agreement will be signed by the various parties which include the Minister for Planning and the Minister for Transport.

2.6.2 The Proponent's Obligations

Under the Agreement, **the Proponent** undertakes to progressively carry out the project in accordance with the preliminary planning framework shown in Figure 7. Land exchanges will be in accordance with an agreed property plan which identifies freehold, leasehold and option areas.

2.6.3 The State's Obligations

The State's obligations under the Agreement include:

a) the transfer to the **Proponent** in freehold of 25ha specified,

b) lease to the **Proponent** 180ha for a period of 25 years with an option to renew the lease for a further 25 years,

c) grant to the **Proponent** a Development Option over the remainder of the project area up to the end of 1995 for the establishment by the **Proponent** of ancillary support facilities, and

d) upon completion of the construction of the breakwater and harbour, the harbour bed will be leased to the **Proponent**.

2.6.4 Management Board

Under the Agreement, the State will appoint a Management Board which will act in a capacity similar to a local authority. The Board will oversee the development that takes place on the site and will ensure the continuous management of Port Kennedy. Under the direction of the Board a service and maintenance fund will be set aside from revenues generated by fees levied against leaseholders of the various site elements.

The proposed composition of the Management Board is as follows:

- o one member nominated by the Minister for Lands who shall act as President,
- o one member nominated by the Minister for Tourism,
- o one member nominated by the Minister for Planning,
- o one member nominated by the Minister for Transport,
- o one member nominated by the Minister for Local Government selected from a list provided by the Shire of Rockingham, and
- o two members representing **Port Kennedy Joint Venture.**

2.7 PURPOSE AND STRUCTURE OF VOLUME II OF THE ERMP

This volume of the ERMP is the main report and is structured according to the EPA guidelines as follows:

- o **Section 3** describes the need for the **Recreation Centre** and the anticipated benefits. Reference is also made to previous plans for Port Kennedy, System Six and the Development Brief,
- o **Section 4** reviews local and regional land use with respect to development, conservation and recreation,
- o **Section 5** details the overall concept for Stage I and its relationship to the site and the subsequent development stages,
- o **Section 6** evaluates alternative development and design options for the site and for specific elements,
- o **Sections 7, 8, 9 and 10** provide overall description of the existing physical, terrestrial, marine and human environments respectively,
- o **Section 11** assesses the anticipated impacts of the development during and after construction and identifies the potential impacts requiring monitoring and management,
- o **Section 12** describes the proposed monitoring and management programme,
- o **Section 13** lists commitments made by the **Proponent,**

- **Section 14** assesses the overall acceptability of the project in terms of its environmental impact, and

- **Section 15** includes the EPA guidelines.

- **Section 16** contains the bibliography and glossary of technical terms.

SECTION 3.0

NEED FOR THE DEVELOPMENT

3.0 NEED FOR THE DEVELOPMENT

3.1 GENERAL

Broad justification for the project is provided by the general planning requirements for the region, the benefits offered by the development and consideration of previous plans for the area. These aspects are considered in detail below.

3.2 PLANNING FOR THE REGION

In June 1986 the estimated population of the metropolitan region was 1.02 million (SPC, 1987). The average annual growth rate is approximately 2 percent giving an estimated population of 1.7 million by 2021. The coastal strip or south-west corridor is expected to be progressively developed in response to this increasing population. In addition to the land already zoned urban in the south-west corridor, Baldivis, south-east of Rockingham is proposed to be rezoned urban in the future (SPC, 1987).

Previous planning for the metropolitan area (MRPA, 1970) has resulted in reservation and acquisition of regional open space. The cost of maintaining these areas is now recognised as a major problem (SPC, 1987). Increasing leisure time, greater awareness of health aspects and the natural environment as well as the population growth has caused increasing demand for recreational facilities. Recent growth of the tourist industry will also cause increased pressure on recreation areas.

The proposed strategy for the metropolitan open space system envisages integration of conserved areas, passive and active recreation as part of a comprehensive, co-ordinated and managed network (SPC, 1987).

Port Kennedy will become one of the major focuses for recreation and one of the most significant remaining areas of coastal regional open space in the south-west corridor. Development of the site will complement proposed recreational facilities on the adjoining area of vacant Crown Land at Lark Hill (see Figure 3). The connection of Port Kennedy, Lark Hill and the adjacent Rockingham Lakes Regional Park (System Six area M103) will provide a variety of active and passive recreation facilities as well as conserving a range of representative natural environments. The project will provide the necessary initial capital and ongoing funds for conservation, restoration and management of Port Kennedy.

3.3 BENEFITS OF THE PROPOSAL

At a local level the following benefits of the development will be realised:

- Access will be provided to the attractive beach in Warnbro Sound. This is one of the few sheltered north facing beaches in the metropolitan area.

- The provision of facilities between Perth and Mandurah for use on a day-trip basis by both land and sea.

- The provision of a mainland alternative to Rottnest Island with advantages of access and variety of facilities.

- An attractive golf course will be provided for public use adjacent to the coast and in proximity to a number of other recreational facilities within the site.

- New local employment opportunities will be created in a district where the unemployment is higher than the average rate.

- Economic growth in the region will be stimulated by marketing locally produced goods, employing the available labour force and engaging required service industries.

- The immediate generation of projects for the Western Australian Building Industry.

- Value enhancement of the adjoining residential land.

The development will also result in the following benefits at both a local and regional level:

- The establishment of a regional recreation centre and an international standard tourist attraction.

- The retention of significant areas of conservation value.

- The availability of sporting and educational facilities for community groups and schools.

- The comprehensive range of these facilities, all integrated in the same complex.

- The effective promotion of all aspects of tourism.

- The additional influx of national and international tourists to the area.

- The retention of the major portion of landholdings as Crown Land.

- The substantial inflow of foreign investment funds into the State's economy.

- The long term revenue for government authorities.

3.4 PREVIOUS STUDIES OF THE SITE

A design concept for the site was prepared by the Metropolitan Regional Planning Authority in 1978 (MRPA, 1978). The following review of previous plans for Port Kennedy is taken from this reference.

"The origin of the present proposal dates back to 1949 when Surveyor General Fyfe, in a memo to the Under Secretary for Lands, expressed the opinion that Port Kennedy, being a few miles south of the holiday area at Safety Bay, had potential for a holiday township in the future. The then Town Planning Commissioner's views were sought but he considered the development of Port Kennedy to be premature."

"The site was subsequently assessed in the 1955 Stephenson Hepburn plan provisions. At that time, it was considered that residential development would extend adjacent to Warnbro Sound as far as Becher Point. The plan further recommended that Becher Point should remain in State Government ownership and in the longer term be developed as a recreational area."

"In 1961 the Town Planning Department produced a development plan for the area. The proposed plan included some subdivision in the north and south of the site with the remainder divided between sporting and recreation facilities and institutional sites."

"In 1971 Cabinet resolved that the whole of the Port Kennedy townsite area should be reserved for public recreational purposes. The way was then open for the development of Port Kennedy as a public recreation area with some housing and associated uses."

Following on from the Cabinet decision the Metropolitan Regional Planning Authority produced a design concept report and plan in 1978 (MRPA, 1978). The proposals for the site included public rental or leasehold cottages and chalets, caravan parks, camping grounds, organisation camps and sporting facilities, a boat harbour, civic, commercial and cultural facilities, and a hotel/motel.
As shown in Figure 2, the Port Kennedy site boundary includes more or less all of System Six area M106. System Six necessarily does not include detailed proposals for the area. Detailed evaluation of System Six aspects is included subsequently in Section 10.

3.5 DEVELOPMENT BRIEF

Following the 1978 MRPA concept plan, the Government of Western Australia invited applicants to register their interest in being appointed to carry out a development project at Port Kennedy, in March 1985. After considering submissions it was agreed that shortlisting of developer proposals should not take place prior to preparation of a brief covering overall proposals to which potential developers could respond in more detailed and definite terms.

The Development Brief for the project was issued by the State Planning Commission in March, 1986 (SPC, 1986). The salient points of the Development Brief are summarised below:

a) The development of Port Kennedy should occur as a well-planned year-round tourist and recreation facility available primarily to middle and lower income families and groups, as well as to whatever other market sectors are selected by the Developer, and be compatible with similar nearby development.

b) Proposals could include retail trading, tavern, hotel, low-rise condominium units, cottages for rent, civil and cultural entertainment, health resort and other forms of recreational or tourist development.

c) The Government would transfer 25ha of Crown Land to freehold ownership, preferably within the vicinity of Bridport Point.

d) Adjacent areas of the site could be developed on long-term leasehold for cottages, caravan parks, camping grounds and sporting facilities.

e) The development would require overall controls on building standards and materials as well as landscaping for shading and screening.

f) Vehicles, other than for trade and service purposes, shall not intrude into areas of the ultimate development.

g) The development would be undertaken on the basis that the Government would appoint a Management Board to manage the site.

Fleuris Pty Ltd was chosen from other groups and companies who submitted proposals to the State Planning Commission in response to the Development Brief.

SECTION 4.0

LOCAL AND REGIONAL LAND USE

4.0 LOCAL AND REGIONAL LAND USE

4.1 GENERAL

Port Kennedy is located between the sub-regional centre of Rockingham and the coastal resort town of Mandurah. The Becher Point area of the site forms the southern shoreline of Warnbro Sound.

The project lies near the southern boundary of the south-west corridor of the metropolitan region. The Metropolitan Region Scheme zoning of the site and surrounds is shown in Figure 3.

4.2 EXISTING PORT KENNEDY SITE USE

Although only readily accessible by off-road vehicles, Port Kennedy is already used for a variety of recreational pursuits. Approximately 100 squatters' shacks are located at Bridport Point. Beach areas are also used for camping and by fishermen, surfers, swimmers and sunbathers on a day trip basis. The interior of the site is used by off-road vehicles. This unmanaged use of the area has caused significant degradation of the environment, particularly within northern parts of the site. Excessively frequent fires, off-road vehicle activity, trampling and rubbish disposal have caused physical and ecological impacts, which are effectively irreversible.

4.3 ADJACENT LAND USES

4.3.1 Secret Harbour

As shown in Figure 3 the proposed Secret Harbour development abuts the southern tip of the Port Kennedy site. Secret Harbour is a water lifestyle-oriented residential and resort development and yacht harbour on a 469ha site. It is proposed to contain approximately 5,300 residential units/townhouses and houses and about 1,100 strata title living and holiday units with an international standard resort/hotel/convention/entertainment complex. The development as proposed would eventually support a population of 15,000.

The status of this project is unclear as no work has started since conditional environmental approval was gained in August, 1982. We have been advised by the Water Authority that the licence for groundwater abstraction has now lapsed and been revoked.

4.3.2 Westport

Westport is a proposed canal and urban subdivision located to the north and east of Port Kennedy as shown in Figure 3. Stage One of Westport comprises 234 fully serviced residential lots. Over the next seven years, it is proposed that facilities will be developed including a yacht club, marina and launching ramp, and a canal subdivision which will have approximately 2,500 residential lots. The

canals will be connected to Warnbro Sound via a channel cut through the coastal dunes. This channel is proposed to run 70m within the northern Port Kennedy boundary.

The initial stage of the dry land subdivision has already been constructed. At the time of writing this ERMP, the Westport development has been sold. It is understood that, subject to resolution of any outstanding approvals, it is planned to proceed with Stage I of the original canal development proposal, ie, the most northerly section.

4.3.3 Other Adjacent Urban and Industrial Land

South of the proposed Westport development, areas abutting the eastern boundary of Port Kennedy are zoned urban and industrial. There are proposed development plans for both the urban and industrial land. Development of this land is likely to proceed within the next two years.

4.3.4 Lark Hill

The area known as Lark Hill is located to the east of the southern half of Port Kennedy and extends to Ennis Avenue (Mandurah Road). The area is Crown Land held for community use.

The Southern Districts Thoroughbred Association leases approximately 90ha of Lark Hill close to Ennis Avenue. A 2,000m racecourse has recently been constructed on the site.

A Water Authority package sewage treatment plant is also located on land near Ennis Avenue.

4.4 SYSTEM SIX SITES

Consideration of the proposed use of Port Kennedy (System Six area M106) can be related to other adjacent System Six areas and other coastal System Six areas between Perth and the Mandurah area.

The adjacent System Six sites are as follows:

- **Rockingham Lakes Regional Park (M103)**

  The park abuts Lark Hill and extends north towards Kwinana. The State Planning Commission has prepared a report proposing a framework and strategy for the management and development of the Rockingham Lakes Region Open Space (SPC, 1980). The concept provides for a range of developments as well as retention of large tracts of bushland in order to achieve a balance between recreation/leisure uses and conservation objectives. The area covered is approximately 2,667ha of which 1,787ha is dry land.

Development within the Lakes Region Open Space will remain in abeyance until power to undertake and permit development is resolved and a Management Body is appointed.
The planning strategy for the south-west corridor includes the Rockingham Lakes Region Open Space as part of the overall open space system within the Corridor. The State Planning Commission report acknowledges that the rapidly increasing urbanisation of the surrounding region suggests that pressure to use the Lakes Region Open Space for recreation and leisure activities will increase.

- **Cape Peron, Shoalwater Bay and Warnbro Sound (M101)**

This marine site covers the offshore reef from Cape Peron to due east of Becher Point. A marine park is now proposed for the area, with the implication that it will be managed for sustainable public recreation. The park has not been formally named, and is commonly referred to as the M101 area.

Other relevant coastal System Six sites in the Perth and Mandurah area include:

a) Woodman Point (M90)

This area comprises coastal land that has previously been used for community and industrial purposes. However, valuable stands of coastal vegetation, notably Rottnest Cypress, have survived. The area is recognised as having significant recreational and conservation value.

The Department for Sport and Recreation, through a Working Party, is examining future development and management. A proposal to establish a high standard caravan park and recreation facilities is believed to be under consideration. Parts of the area have also been recommended for declaration as an "A" Class Reserve vested in the WA Wildlife Authority.

b) Reserve A24309 Coogee (M91)

This land comprises gently undulating sand over limestone terrain separated from the sea by a 6m limestone cliff. In parts the land has been severely degraded by limestone excavation. However, coastal heath in good condition has survived. The area is used for passive recreation and System Six recommends that a management plan be prepared.

Arrangement for regrowth or restoration of disturbed areas has also been suggested to be desirable.

c) Garden Island (M96)

Garden Island is owned by the Commonwealth Government and is being developed as a naval base. Public access is prohibited in some areas. More than 90 percent of the vegetated portion of the area is covered in low closed forest or closed scrub. Large areas of the island appear not to have been burnt for about 65 years and are especially important as an example of undisturbed coastal vegetation.

System Six recommends that the area be managed as proposed by the Garden Island Advisory Committee's management plan.

d) Peelhurst, Singleton and Madora (M107)

The purpose of these reserves is to provide buffer zones of landscape and vegetation near the main Mandurah Road and between areas of housing. The general area has extensive coastal dunes that are valuable for their coastal vegetation and for recreational and aesthetic reasons. However, their appearance and stability has been affected by new housing developments.

e) Yalgorup National Park (C54)

The Yalgorup National Park includes Lakes Clifton and Preston as well as coastal land containing vegetation types which are poorly represented in conservation reserves. The area has considerable recreational value as a result of the lakes, its proximity to the coast and its accessability. Not all of the land under the various tenures within the area has conservation and recreation as primary management objectives.

SECTION 5.0

DESCRIPTION OF THE PROPOSAL

5.0 DESCRIPTION OF THE PROPOSAL

5.1 STAGE I - GENERAL DESCRIPTION

The major components of Stage I of the **Regional Recreation Centre** are shown in Figures 5 and 6. The first stage of the Port Kennedy Development has been designed to have a 24 months construction period and to be completed in 1991 as a single undertaking at a projected construction cost of $161M. It will be developed on 330ha and will comprise three distinct areas as follows:

1. A marina development including a harbour, accommodation, town centre and associated facilities.

2. Golfing recreation areas consisting of:

   - an 18 hole public golf course and club house, and

   - a private resort complex including a 225 room international standard hotel, 18 hole golf course and associated facilities.

3. An area of 120ha reserved for conservation and passive recreation including:

   - 4km of beaches and 15ha of open space for public use,

   - a 29ha conservation zone at the north of the site including 1,400m of the foredune and primary dune (see Photograph 7) and 14ha behind the dunes, and

   - a 75ha conservation zone including Becher Point (see Photograph 8) and an area south of the marina.

Other areas of natural vegetation will be retained within the golf courses.

The international standard hotel, accommodation and associated developments will be located on approximately 10ha of the 25ha of freehold land granted to the **Proponent** under the terms of the Development Brief (SPC, 1986). The golf courses will be constructed on approximately 160ha of Crown Land leased from the Government for 25 years with a 25 year option. A further 40ha of land will be leased areas and public open space for the town centre, administration, access, carparking, picnic area and beach amenities. The remainder of the land within Stage I will remain Crown Land.

5.2 PRELIMINARY PLANNING FRAMEWORK FOR THE OVERALL DEVELOPMENT

The **Proponent** has an option over the balance of the site and intends to promote the development of additional facilities. No costs or revenue involved with future development have been included in this report.

The preliminary planning framework for the whole scheme is shown in Figure 7. This was prepared as part of the Proponent's previous submission to the State Planning commission. The elements included in Stage I have been highlighted in Figure 7 and re-arranged as shown in Figure 6.

No revised plans have been prepared for subsequent development stages. The arrangement shown in Figure 7 for the balance of the facilities should therefore be viewed as a planning framework only. The final layout will be subject to re-appraisal of specific engineering and environmental constraints.

As a result of detailed work undertaken as part of this ERMP, the Stage I layout, shown in Figure 6, has been varied in some aspects from the original concept shown in Figure 7.

- The marina has been located further east following a survey of seawater depths.

- The general layout has been rearranged to reflect specific environmental considerations.

These changes are emphasised to highlight that facilities planned for future stages will be subject to review during detailed planning and design and that subsequent stages will be subject to separate environmental impact assessment and EPA review.

Selection of facilities included in Stage I has been made primarily on the basis of marketing and financial studies undertaken by the **Proponent**. These studies have demonstrated that the proposed first stage will provide the financial base to support both the large initial injection of capital and the significant ongoing management costs. Economic assessments confirm that the elements included in Stage I will be capable of financing these requirements. Subsequent development will result from the funds generated by Stage I and the management of financially independent components.

5.3 DETAIL DESCRIPTION OF STAGE I ELEMENTS

5.3.1 Marina and Town Centre

The marina layout includes three small islands and a harbour area within conventional rubble mound breakwaters as shown in Figure 5. The area will provide a commercial, administration and accommodation core as well as protected moorings for recreational boating activities. It will be the social focus of the overall development.

The harbour area provides 130 moorings in fixed pens with finger jetties for casual and day visitors. Additional fixed pens will be provided for the permanent mooring of essential and service craft such as rescue, maintenance and charter boats.

Provision has been made in the marina area to accommodate the following essential services:

- sea rescue administration offices, accommodation and moorings,
- boat service and maintenance facilities, and
- office space for use by the Department of Conservation and Land Management, the Fisheries Department, the Department of Marine & Harbours and the Education Department.

Moorings associated with the island accommodation will provide for both rental and private boats being accommodated in close proximity to the island and harbour units. This accommodation will offer 125 holiday units orientated towards boating and water recreation sports. The island frontage will provide 250 boat moorings for both Stage I and subsequent stages.

The town centre provides a focus for the overall development. The area will provide the commercial, entertainment and administration core for Stage I and all subsequent stages.

The town centre is the point of arrival for the Stage I development. It is located to act as reception for holidaymakers and day visitors arriving by motor vehicle, private boat or ferry. The core area of the town centre will consist of the following:

- administration, offices and services,
- tavern,
- restaurants,
- nightclubs,
- retail area,
- community hall and childminding facilities,
- medical centre,
- yacht club with teaching facilities,
- surf club with kiosk and public amenities, and
- gymnasium and health facilities.

Traffic management techniques will be used to slow traffic and provide a safe environment for cyclists and pedestrians.

Other facilities provided adjacent to the beach and town centre will include:

- o cycle hire
- o beach hire facilities for small craft, and
- o outdoor kiosks.

Beach orientated accommodation will be provided in two separate developments located at the eastern and western extremities of the marina area (see Figure 5). These nodes will be self catering and provide accommodation for family holidays, as follows:

- o Beach Units 1
  - 80 self-contained units
  - restaurant seating 50 people
  - gymnasium
  - swimming pool and entertainment facilities.

- o Beach Units 2
  - 60 self-contained units
  - restaurant for 40 people
  - swimming pool and entertainment facilities.

5.3.2 Public Amenities

Public amenities will be provided in Stage I for day visitors who visit the development to utilise both the beach and the town centre facilities. In addition to the provision of boat moorings and vehicle parking to accommodate the casual visitor, facilities to be provided include:

- o picnic area,
- o barbecues,
- o pedestrian and cycle trails,
- o conservation interpretation areas,
- o shelters and shaded areas,
- o grassed playing areas,
- o toilets and change rooms, and
- o first-aid and surf livesaving station.

5.3.3 Private Resort Complex

The 225 bedroom/suite hotel is planned as a low rise building to harmonise with the gently undulating nature of the site (see Photograph 2). Its design will include a large ground floor and three floors of accommodation. The building will be located behind the primary dune. The hotel

facilities will include restaurants, entertainment and retail facilities. The golf club will be part of the hotel. In addition to the golf course, provision has been made for a variety of indoor and outdoor sporting activities within the hotel complex. These will include tennis courts, squash courts, a gymnasium, spa, swimming pool and bowling greens.

5.3.4 Public Golf Course

The public golf course will be of the same standard as the private course. The public course will be provided with a separate club house and adjacent carparking.

5.3.5 Services and Infrastructure

Preliminary discussions have been held with the Water Authority, the Main Roads Department, Telecom, the State Energy Commission, the Shire of Rockingham and the Department of Marine & Harbours to enable an assessment of roads and services to be made.

The Stage I development requires a basic infrastructure of roads and services to be established to suit the ultimate development. Therefore, the extent of initial infrastructure, in some cases, may be significantly beyond that required to service Stage I facilities alone.

The proposed infrastructure provisions are as follows:

a) **Approach Avenue.** The approach avenue will be a single carriageway road running from Ennis Avenue (Perth-Mandurah Road) to a point between the marina and the hotel. It is planned to amend the alignment shown on the Rockingham Town Plan (refer Figure 3) to minimise the impact on landform and allow for a landscape buffer of approximately 100m to 200m between the approach avenue and the areas zoned industrial and residential. The location of the junction with Ennis Avenue has been resolved following discussions with the relevant Authorities.

b) **Internal Accessways.** Roads, cycleways and walkways will be designed for low maintenance requirements and to suit the site's visual concept.

c) **Stage I Carparking.** Carparking facilities will be constructed near the marina for 950 cars with a further 400 car spaces for the public golf club and 300 for the hotel.

d) **Potable Water Supply.** The potable water supply will be obtained from extension of the Water Authority's scheme water system.

e) **Irrigation Water.** Groundwater will be used for irrigation. This aspect is evaluated in detail subsequently in this ERMP.

f) **Sewerage.** All components of the project will be deep sewered. Sewage will be treated at the existing Water Authority package treatment plant located close to Ennis Avenue.

g) **Drainage.** It is proposed that the extent of piped drainage be minimised by limiting use of kerbs and guttering. Maximum use will be made of any collected drainage water to recharge the groundwater.

h) **Power Supply.** All electrical services within the Port Kennedy Recreation Area are to be provided by the developer. Stage I will establish the overall distribution centre from which the services will be reticulated.

i) **Telephone Services.** Telephone services within the development site will be routed through a central PABX installation.

j) **Security of Emergency Services.** Provision has been made for a security system throughout the development with a central control and mimic panel located in the Administration Centre.

k) **Navigation Aids.** Navigation aids will be provided as required for boating safety.

5.4 LANDSCAPE DEVELOPMENT

5.4.1 Landscape Planning Considerations

When planning the overall landscape development of the **Recreation Centre**, the approach adopted by the **Proponent** included consideration of the following:

- the physical condition and characteristics of the site, such as landform, topography, slope, soil conditions, drainage patterns,
- vegetation - size, shape, form and texture,
- micro-climate, wind, sun and shade areas,
- visual amenities - on and off-site views, areas needing screening,
- relationships to surrounding land uses, building masses and circulation, and
- ecological characteristics.

5.4.2 General Development Elements

The Stage I development contains the following elements discussed here in broad terms:

- o approach avenue,
- o international standard hotel and accommodation areas,
- o town centre,
- o golf courses,
- o minor recreation facilities,
- o carparks and internal circulation routes, and
- o open space (other than conservation areas).

Stage I landscape types are shown schematically on Figure 10.

5.4.3 Approach Avenue

When siting the approach avenue, three areas contributing to visual impact and roadside amenity were considered, namely:

- o horizontal and vertical alignment,
- o landform modification, and
- o existing vegetation communities and planting design.

The approach avenue has been sited to provide gentle curves fitting in with existing landform. The approach avenue will be planted with predominantly Western Australian trees and shrubs in informal and formal stands to define the roadway alignment and to frame visual sight lines to the ocean, town centre and hotel. Formal entrances will be created at the junction of the approach avenue with Ennis Avenue and at entrances to accommodation sites.

5.4.4 International Standard Hotel and Accommodation Areas

The areas around the hotel and accommodation will be developed to create parkland and ornamental settings for approach roads, carparks, buildings and recreation facilities. The open space settings adjacent to the hotel will contain native and exotic trees, shrubs, ground covers and grasses. The open space will blend into areas of more traditional coastal development similar to the heavily used sections of coast in the metropolitan area.

The primary dune and foredune in the vicinity of the hotel will require rehabilitation after clearance of the existing shacks and rubbish in the area. The ocean side of the dune will be replanted with indigenous dune grasses and shrubs at the northern end, with a transition to more formal coastal landscaping in areas where human pressure will be more intense. The landward side of the dune

will be planted with native, ornamental and exotic trees and low shrubs. Major earthworks will be required for the hotel and associated facilities.

The accommodation areas will be designed to complement existing landforms and blend in with coastal vegetation units on the site.

Major buildings will be screened with appropriate landform and planting of trees and shrubs.

Landform and vegetation will be used to create windbreaks, provide shade and shelter, and provide views to natural and recreation settings.

5.4.5 Town Centre

The town centre has been planned to be visually unobtrusive when viewed from the land side of the site. After clearance of the squatters' shacks, the dune between the marina and the Stage I carpark will be rebuilt and planted with indigenous and exotic dune grasses, shrubs and trees.

Due to the intense human use of the area, the marina and town centre will contain minimal planted or grassed areas and will rely on carefully designed detail "hard landscape" items, such as lighting, walls, pavings, seats and railings. Some major trees, such as figs and palms, will be set into fill areas within and around buildings, civic plazas, piazzas and commercial areas.

The town centre will be located on a north facing coast which provides the ideal outlook and orientation for the development. The combined location and landform provide the opportunity to develop building forms which open up to the north and east and screen open squares and planting areas from the south and south-westerlies. The facilities of the town centre will be utilised all year round and will be designed to offer comfortable accommodation and access in both summer and winter.

5.4.6 Golf Course

The landscape treatment of the golf course will be divided into three areas as follows (see Figure 10):

a) Coastal Links: An area north of the hotel and behind the primary dune will retain, restore and enhance sections of the 10ha of natural vegetation between the fairways. The fairways will generally be located in swales. Existing landform will be retained and enhanced wherever possible.

b) Visual Buffer: One of the highest inland dune crests on the site runs roughly north-south for 1,500m through the centre of the golf course. This will be planted with tall native trees to

provide a visual screen between the Stage I development nodes and the adjacent land zoned for urban development.

c) Parkland Links: For golf holes radiating from the hotel and golf club and running adjacent to the site boundaries and the approach avenue the landform will be modified to increase degrees of course difficulty, provide visual interest and blend the course in with Stage I development. Visual buffering between Port Kennedy and the adjacent future developments is also an important consideration. The planting for this area of the golf course will consist of areas of indigenous vegetation enhanced with native and exotic trees, as well as areas of formal and informal planting. Some currently degraded seasonal wetlands lying within this area will be in part developed as ornamental lakes, and in part rehabilitated to near indigenous state using paperbark trees to provide the major structural landscape elements.

5.4.7 Minor Recreation Facilities

The passive recreation facilities and activities to be provided within the Stage I development (see Section 5.3.1) will be located within a range of settings and landscape types, overlooking beach areas and managed dune and conservation areas.

5.4.8 Carparks and Internal Circulation Routes

The carpark for the marina has been located within visually unobtrusive areas behind the primary dune. Landform and vegetation will be used to screen the carparks from walkways and roadways and to provide shade.

Walkways passing through dune areas will be properly constructed and fenced to prevent impact on dune vegetation.

Internal vehicle circulation corridors will be appropriately designed to limit vehicle speeds and modify driver behaviour to create safer roads for pedestrians, cyclists and motorists. Development of roadside planting, street furniture and pavement details will conform to high quality materials appropriate to small scale roadways.

Adequate facilities will be provided for limited mobility persons, in accordance with the Australian Council for Rehabilitation of the Disabled and Australian Standards (AS 1428).

5.4.9 Open Space

Approximately 15ha of open space have been planned within the Stage I development. These areas will include beach, dune, indigenous and parkland settings for passive recreation. The open space areas have been planned to complement landscape development and provide settings for buildings

and recreation development.

5.4.10 Irrigation Requirements

The estimated volume of groundwater required for irrigation during the first year, when establishing Stage I, is as follows:

	kL/year	kL/day
restored areas, parks and gardens	935,000	2,560
golf courses	1,065,000	2,920
Total	2,000,000	5,480

The irrigation water requirements will reduce annually until the fifth year when the estimated long-term Stage I usage will be:

	kL/year	kL/day
restored areas, parks and gardens	315,000	860
golf courses	1,065,000	2,920
Total	1,380,000	3,780

The long term requirements for the ultimate development are anticipated to be approximately double those of long term Stage I requirements. The grass used for the golf course will, if necessary, be tolerant of irrigation water with salinities in the range of 1,000 to 1,500mg/L. The irrigation system will be automatically controlled by measurement of soil moisture to minimise water application and fertiliser leaching.

5.4.11 Fertiliser Application

Fertiliser will be applied to the parklands, ornamental gardens and golf courses. Estimated application rates indicate that more than 95 percent of the fertiliser will be applied to the golf links. Approximate total application rates for the golf links are:

- Nitrogen - 30.0 tonnes/year
- Phosphorus - 2.4 tonnes/year

To minimise nutrient leaching it is proposed to apply fertiliser to the golf course in three forms:

- slow release 3 month/9 month fertilisers,
- use of liquid foliar fertiliser applied by boom sprays a little at a time at frequent intervals, and
- use of supplementary fertiliser application through soluble fertiliser applied by injection with the irrigation water during peak nutrient demand by the grass.

The remaining areas of the development will generally be treated with slow release fertilisers.

5.5 CONSERVATION ZONES

Approximately 105ha of Stage I will be reserved in two conservation zones as shown in Figure 8. Access through the conservation zones will be managed by tracks and fencing as necessary to prevent damage. The zones have been arranged to include the following areas of conservation value:

- Becher Point (see Photograph 8),
- the curvilinear dunes and vegetation south of the marina,
- the foredune and primary dune strip north of the hotel (see Photograph 7), and
- approximately 14ha at the northern boundary of the site retaining a representative transect of coastal vegetation and the dune ridge succession.

5.6 CONSTRUCTION AND EARTHWORKS

The construction period for the **Recreation Centre** will be approximately two years. Construction will commence no earlier than autumn 1989, as determined by the time required to obtain formal approvals to proceed with the project.

The approach avenue connecting to Ennis Avenue will be built at the start of the construction period. This will eliminate the need for heavy construction traffic to pass through the Warnbro urban area north of the project.

The marina breakwater will be constructed as a conventional rubble mound breakwater. Dredged spoil will be used to form the islands and build up the land adjacent to the marina.

Earthworks for the golf course and areas of the project within 1km of existing dwellings will be subject to the Shire of Rockingham moratorium on earthworks between October and March.

Stabilisation of earthworks on the site will depend on location:

- brush cut from cleared areas of the site will be used for restoration of small areas such as eroded tracks within conservation zones,

- larger areas of earthworks within the vicinity of the marina and hotel will be stabilised by bituminous emulsion or open mesh wire and a low nutrient value mulch of seaweed or sea meadowgrass (recovered from points where it washes up and collects along the coast as determined by availability).

These areas will either be allowed to revegetate or will be seeded and planted with appropriate vegetation.

5.7 ONGOING MANAGEMENT

Ongoing management of the site will be the responsibility of the Management Board. This will be defined by formal agreement between the **Proponent** and the Western Australian government.

Long term management responsibilities will include:

- management and monitoring of the potential impacts resulting from increased human pressure on the site,

- monitoring of the surface aquifer,

- surveying of the beach profile to monitor sediment transport,

- monitoring of vegetation condition and regeneration in the conservation zones and southern part of the site, and

- monitoring of the marina water quality.

SECTION 6.0

EVALUATION OF ALTERNATIVES

6.0 EVALUATION OF ALTERNATIVES

6.1 INTRODUCTION

From review of the background to this development, described in previous Sections of the ERMP, it is evident that the **Proponent** is committed to the Port Kennedy site. The **Proponent** is also committed to the components outlined by the Development Brief (SPC, 1986) and subsequent submissions. Evaluation of alternatives has therefore been addressed as follows:

- in general terms, why the proposed use of the site is the best option when compared to other principal alternatives,
- the basis for the layout of Stage I and the reasons for the selection of the particular Stage I components,
- the reasons for the proposed landscape and architectural treatment of the site outlined in Section 5.

6.2 ALTERNATIVE SITE USE

6.2.1 Background

The location of the **Regional Recreation Centre** at Port Kennedy was determined by the State Planning Commission. This decision was based on the perceived need for coastal regional open space to be reserved for recreational purposes between Perth and Mandurah and the availability of the site for such a purpose. Port Kennedy was also recognised in System Six as having both conservation and recreation potential.

The assessment of alternative development mixes has effectively been undertaken by the reports on the site dating back to 1955 and by the review of the 25 proposals submitted in response to the State Planning Commission's outline contained in the Development Brief. The **Proponent** conformed to the requirements of the Brief and provided the financial and marketing model which demonstrated the requirements could be achieved. The reasons for the general development approach can be justified by reviewing the two main alternatives.

6.2.2 No-Build Alternative

The first alternative is the no-build option. Reference to Figures 22 and 23 shows that previous use of the area has already caused significant degradation of the environment, particularly within northern parts of the site where use has been concentrated. Excessively frequent fire, off-road vehicle activity, trampling and rubbish disposal have caused physical and ecological deterioration

which is effectively irreversible. Human impacts will inevitably increase as urban development extends into land surrounding the site. Hence further degradation of the site will undoubtedly occur unless a co-ordinated management approach to the site is initiated in the near future. Development of some description is essential to provide the structure and the funding to meet the site's management requirements.

6.2.3 Partial Urban Development

The second alternative is mixed urban and recreation use. This undoubtedly could provide for the management requirements of the site. However, significant areas of the site would have to be rezoned for urban development. This would have the following disadvantages:

- the transfer of significant areas of Crown Land from public use to freehold would generally be regarded as undesirable unless the need could be demonstrated. At the present, there is no shortage of urban land in the area, and

- the loss of public open space with access to the coast in an area with conservation and recreation potential is undesirable.

Development of a **Recreation Centre** that can provide the funds required to manage the site is clearly desirable from both the conservation and public use viewpoints.

6.3 SELECTION AND LAYOUT OF STAGE I COMPONENTS

The twofold aim of the development is to establish the facilities necessary to encourage the recreational use of the site and to create a holiday destination. To meet these aims the following components have been included in Stage I.

- services and road access to the Bridport area to open up public access to the attractive beach frontages,

- a core area containing a marina, town centre and accommodation to attract and satisfy the holidaymaker and the day visitor,

- beach amenities, picnic areas, barbecues, shelter and shaded areas for passive recreation,

- boat and sailboard hire, boat charter and possible ferry access, for water orientated recreation,

- a public golf course to attract a wide range of users as well as participants holidaying in the core area, and

- a private hotel and golf course has been included to establish a financial base for the development.

The **Proponent** has not included a public boat launching ramp in the facility for the following reasons:

- in accordance with the Development Brief, it is proposed to exclude vehicles from the site in subsequent stages of development. At this time, the boat launching ramp would be removed,

- the ramp will be incompatible with the accommodation around the marina,

- use of the ramp would have to be subject to a curfew to prevent disturbance of the accommodation occupants, and
- inclusion of a ramp would increase boating impact on the offshore reef.

Further consideration of inclusion of a boat launching ramp will be made in the light of public response to this ERMP.

The arrangement of the Stage I layout is determined by the following considerations:

- the northern part of the site is currently the most degraded as a result of unmanaged human use (Figures 22 and 23). Further pressure will result if the proposed urban development proceeds around the north and east of the site. Priority has therefore been given to implementing development and management of this area,

- the section of beach in Warnbro Sound is the most protected and will attract the more concentrated use,

- for economic and engineering reasons the most cost-effective location of the marina is in the vicinity of Bridport Point. As discussed in the Sorrento Boat Harbour ERMP (Scott and Furphy et al, 1984), construction of rubble breakwaters becomes uneconomical in water depths greater than approximately 5m. In addition, to minimise sediment transport, the marina needs to be situated in Warnbro Sound and as far east from Becher Point as possible, and

- the accommodation node has been located behind the marina and generally limited to the area already degraded by the squatter shacks.

6.4 LANDSCAPE AND ARCHITECTURAL TREATMENT OF COMPONENTS

6.4.1 General Approach

The treatment of components is shown in Figures 9 and 10 and is primarily aimed at providing an attractive recreational setting within the constraints identified in this ERMP. The **Proponent's** aim is to create a built environment which is varied and interesting to act as a foil and haven from the open spaces of the beach and hinterland. Visually, it is considered important to provide a complex and involved core area which brings people into closer proximity with building forms and spaces which are not related to ordinary building types and uses.

The core area is located on a north facing coast which provides the ideal outlook and orientation for the development. The visually and physically reinforced dune formation behind the core area will provide the physical break between the actively occupied area and the undefined hinterland. The dune formation will also act as a physical barrier to the south and south westerly wind vectors.

The combined location and land form provide the opportunity to develop building forms which open up to the north and east with screened open spaces and planting areas screened from the south and south-west winds. The facilities of the core area are to be utilised all year round and are designed to offer comfortable conditions in both summer and winter.

The buildings in the marina and town centre will vary in height from one to three storeys. The variation will be used to create skyline interest, open up vistas and provide modelling to the building forms. The materials used for the buildings will be controlled to provide a consistency of colour which reflects a regional character. However, the development will have a range of forms and materials within the regional character to prevent the uniformity which can be produced by an exclusive or totalitarian attitude toward building materials and colour.

The commercial area of the town centre is located at a cross road between the holiday accommodation, public use areas and the central island which provides the entertainment centre. The commercial core also acts as the arrival point for the ferry service and will provide the first point of contact for arriving visitors or holiday guests. The entertainment island will be structured to attract visitors to a focal point. This will draw visitors through the commercial area and provide the maximum exposure for the retail component of the development.

The entertainment island and commercial area will include large internal areas as well as shaded open space to accommodate visitors in all seasons. Alternate routes will accommodate access through the commercial area in either shade for summer use, or under cover and out of direct wind for winter use.

The accommodation has been designed to provide a range of accommodation types, varying in size and rental cost. The rental cost of accommodation will also vary with the degree of service and level of facilities. Each of the core area units will be designed to provide accommodation in all seasons.

The core area accommodation units are sited and planned as a series of wind breaks to the south and south-westerly winds. The harbour units will be developed around protected courts, each will be screened from the wind for comfort. The island units are double sided with each unit facing both north and south. This offers protected access and comfortable outdoor accommodation under most wind and sun conditions.

6.4.2 Landscape Planning

Landscape treatment of the development has been determined by detailed investigations and analysis of environmental data, site surveys and interpretation of aerial photography. The site has been classified into zones according to ecological sensitivity and capability to sustain development.

The environmental constraints were then assessed with regard to requirements and aims of the recreation and accommodation development.

Criteria used in site zone classification were:

- coastal biogeographic processes,
- landform and terrain characteristics such as topography and slope,
- vegetation type and quality - biogeographic significance,
- microclimate and aspect especially winds,
- existing landscape character,
- structural vegetation characteristics such as heights, shape, form and attractiveness, and
- scenic quality, visual amenity, visual character and visual prominence.

A given area's ability to accept development of low and high impact was assessed on the basis of direct capability and capability with management.

Based on the above considerations, four general approaches to landscape treatment have been adopted:

- zones of high conservation value or low capability to sustain development will be protected and conserved,

- areas of high public use will be landscaped to provide shelter from the sun and wind and to prevent erosion using similar methods to those adopted for coastal areas within the metropolitan area,

- sections of the golf courses will be planted to provide a visual screen, visual interest and increase course difficulty, and

- an area around the hotel behind the primary dune will be modified to a level consistent with the visual requirements of the proposed market.

SECTION 7.0

EXISTING PHYSICAL ENVIRONMENT

7.0 EXISTING PHYSICAL ENVIRONMENT

7.1 GENERAL

Review of the site's physical environment indicates that the three major aspects requiring detailed attention are:

- The area of curvilinear dunes south of Bridport Point.
- The rate of sediment transport along the coastline (and the impact of the marina construction).
- The groundwater regime of the locality (and the impact of groundwater abstraction for irrigation purposes).

Detailed discussion of these aspects is contained in the Appendices and summarised in this Volume. Detailed evaluation of other aspects of the physical environment are contained in the Appendices.

7.2 CLIMATE

The climate at Port Kennedy is similar to that of Perth and Rockingham (Delta Holdings, 1986) as shown below:

- Temperature. Summer temperatures vary between an average $30^{o}C$ and $19^{o}C$ for maximum and minimum values respectively. In winter, the average daily temperature varies between $18^{o}C$ and $9^{o}C$.
- Rainfall. Mean annual rainfall is anticipated to be about 830mm with annual evaporation of approximately 2,000mm.
- Wind. The wind speeds and directions are similar to Fremantle. During a typical summer day, morning winds are from the east with a sea breeze developing in the afternoon. The sea breeze has a median speed of 7m/s and is generally from the south-west. In the winter, winds are generated by low pressure systems and arrive from the north-west, west or south-west with speeds of 5 to 20m/s. Occasional summer cyclones can generate significant wind speeds from any direction.

7.3 LANDFORM, GEOMORPHOLOGY AND STRATIGRAPHY (Appendix C)

7.3.1 Regional Context

The project site is located within coastal sand dune terrain which is recognised as the Quindalup Dune System. This landform type is widespread along the seaward fringe of the Swan Coastal Plain and typically consists of dunes formed from sandy sediments that were deposited on shore during the Holocene.

The Quindalup Dunes are often confined in their occurrence to a narrow band parallel to the coast, frequently less than 1km wide. However, there are a number of locations along the central south-western coast, of which the project area is one, where substantial local deposition of sediments has occurred. This has created a broad plain of low parallel dunes. The shape of the shoreline and hinterland is quite consistent between sites along the south-west coast where major Holocene sediment accumulation has occurred. The typical coastal landform consists of a triangular promontory which culminates westward in a cusp. The hinterland consists of a plain of consecutive parallel or curvilinear, relict foredunes. Creation of the broad foredune plain with consistent topographic and geomorphic form is controlled by the supply of marine sediments and consistent sea level and swell conditions.

Becher Point is one of five similar cusps within the Cape Bouvard to Trigg Island coastal sector.

7.3.2 Local Context

Substantial accumulation of Holocene sediments has occurred along the coast between Kwinana and Mandurah as a result of the depositional processes described above. The resultant landform is commonly referred to as the Rockingham-Mandurah Plain. The plain terminates to the east against the older sediments of the Spearwood dune system. The beach ridge plain has a width of approximately 6km at Becher Point and progressively tapers out at Kwinana to the north and Mandurah to the south.

The time plane diagram produced by Woods and Searle (1983) illustrates the seaward advance of the coastline through the recurring formation of beach ridges at successive coastline positions (Figure 11).

Deposition of sediments that form the eastern margins of the Rockingham-Becher Plain began some 6,500 years ago. Deposition of the sediments that would eventually form part of the Becher Point accretionary cusp began some 3,000 - 3,600 years ago and has continued until the present time. From Figures 11 and 16 it can be seen that the axis of Becher Point has remained reasonably stable for the last 2,000 years. Within Warnbro Sound, the shores are presently stable or slowly prograding. Some distance south of Becher Point there has been significant change to the coastline whereby up

to 200m of shore width have been removed by shoreline erosion.

Becher Point is recognised as a system where Safety Bay Sand is prograding over Becher Sand. The primary elements of the shallow stratigraphic sequence are:

- Safety Bay Sand,
- Becher Sand, and
- Tamala Limestone.

7.3.3 Specific Geomorphic Units

The distribution of geomorphic elements within the site is shown in Figure 12. Investigation and field survey have shown that the site contains five geomorphic units:

a) contemporary relict foredune plain (Qf4),
b) active or recently active foredune (Qf1),
c) relict foredune plain (Qf2),
d) prominent relict foredune (Qf2a), and
e) linear depressions and seasonal wetlands.

Due to the relationship between vegetation complexes on the site and the geomorphic elements and associated soil types, further discussion on this aspect is contained within the review of terrestrial habitats and ecology later in Section 8.

South of Bridport Point there is an area where the development of foredunes during very recent geological times has encroached upon much older foredunes to produce an area of curvilinear dunes. This has been caused by a period of foredune deposition followed by a period of erosion and then by a further period of deposition which has continued until the present time. Apart from a small area near Becher Point, this landform is not readily evident on the ground.

7.4 MARINE GEOMORPHOLOGY (Appendix E)

Becher Point lies within the geomorphic unit known as the Warnbro-Cockburn Depression (see Figure 13). The Point itself represents the terrestrial component of a sand barrier that extends across the Depression to the Garden Island Ridge. The submarine portion of this barrier is a shallow (2 to 5m deep) sand bank that is typical of other banks to the north (eg Parmelia and Success Banks).

North and south of the Becher Point sand barrier there are sandy embayments which vary in depth. The embayment to the north has been substantially infilled in recent geological times, leaving the relatively small, but deep (up to 20m) basin of Warnbro Sound.

Westward from Becher Point, there are five broad geomorphic units which lie parallel to the Warnbro-Cockburn Depression. These have been well-described in previous studies and are simply listed here, along with brief topographic information and typical range of water depths within each unit. The units are delineated on Figure 13.

Geomorphic Unit	Topography and Water Depth
Garden Island Ridge	Irregular, rugged reef (0 - 10m)
Parallel Ridge system	Variable, but low relief (10 - 15m)
Sepia Depression	Gently sloping (15 - 24m)
Five Fathom Bank	Rugged limestone reef (mostly 10m+)
Offshore Continental	Gently sloping Shelf (20 - 300m)

7.5 OCEANOGRAPHY (Appendix A)

7.5.1 General

The Port Kennedy site contains two lengths of coast of contrasting character (see Figure 14).

The length of coast within Warnbro Sound, included in Stage I, is sheltered by the sandy barriers at Becher and Mersey Points as well as the offshore Murray Reefs. As a consequence the wave heights and quantities of sediment transport are greatly reduced.

Offshore from the coastline south of Becher Point the Murray Reefs are less prominent, allowing more energy from seas and the dominant south westerly swell to reach the shore.

A detailed survey of the seabed depths (bathymetry) in the vicinity of Bridport Point was undertaken for this ERMP as shown in Figure 14. The bathymetry measured by this survey is different to that shown on Marine & Harbours chart DMH 277 which was based on more widely spaced soundings. The major difference is that the steep underwater slope present at the centre of Warnbro Sound continues around the shoreline to within 200m of Bridport Point before heading offshore approximately north-west. The nearshore bathymetry of the south half of the Sound is therefore quite similar to the northern half.

7.5.2 Tide and Sea Level Fluctuations

The three main factors affecting water level in the Warnbro Sound are astronomical tide, long period water level variations and extreme storm surge events.

- Astronomical tides typically have a daily variation of about 0.4m.

- Long period water level variations generally have periods ranging from 3 to 20 days and have a range of about 0.4m.

- Storm surges are the most significant influence of peak water levels resulting in levels up to 1.9m above Chart Datum for extreme events such as Cyclone Alby.

7.5.3 Wave Climate at Bridport Point

The wave climate at Bridport Point is mild, the offshore swells being significantly attenuated by the fringing reefs and large expanses of shallow sand banks.

A detailed knowledge of the nearshore, directional wave climate is required for the purposes of defining the coastal processes at Port Kennedy. Measured data was not available for the Port Kennedy site. A mathematical model was therefore developed using a technique known as hindcasting.

Waves are broken into two broad categories for wave hindcasting:

- Sea waves which are locally generated and generally short period waves.

- Swell waves which are generated from distant fetches and have left their generation area. Swell waves are generally longer period waves.

The mathematical model modifies the waves to allow for refraction, diffraction, shoaling, seabed friction and wave breaking to calculate the wave climate at Bridport Point.

Wave activity varies seasonally and so for reliable results a full year of hindcast must be obtained. The year chosen, from November 1984 to October 1985, was reasonably typical although a little on the severe side as a result of a significant south-west storm in the August of that year. A number of major storm events were also modelled. The significant wave heights and directions are shown in Figure 15.

This nearshore directional wave climate was then used for the preliminary design of breakwater profiles and entrances and also for comparison with Westport wave data in the evaluation of sediment transport at the site.

From the modelling it is concluded that:

- Waves at the site are dominated by those locally generated from within the Sound. Except for quite severe storm events, significant wave heights tend to be less than about 1.2m.

- Extreme offshore storm waves from the west to north-west can penetrate through gaps in the reef resulting in wave heights at Bridport Point up to 2.0m in amplitude.

A more detailed explanation of the modelling process is described in Appendix A.

7.5.4 Circulation and Currents

Little is known of the general circulation of the coastal waters offshore from the Perth metropolitan area. The CSIRO has undertaken a series of deep sea oceanographic cruises and buoy tracking experiments along the continental slope off the Western Australian coast, but it is difficult to reduce the scale of these studies, which span several thousands of kilometres, into a localised area. The available data from localised studies have been determined for the Water Authority wastewater effluent outlets such as those at Beenyup and Cape Peron.

In general there are two current regimes: flow parallel to the coast from south to north during summer (November to April) and from north to south during winter (Rochford, 1969; Cresswell & Golding, 1980). However, the currents are more influenced by local winds in water shallower than 20m, and are therefore more variable than further offshore.

Warnbro Sound is protected to the north and south by Point Peron and Becher Point respectively, and to the west by the Garden Island Ridge. Hence it would be expected that currents resulting from the regional circulation of the South Eastern Indian Ocean will be attenuated and locally steered within Warnbro Sound. It would be expected that currents within Warnbro Sound would behave similarly to those in Owen Anchorage, where a gyre develops under low current speed conditions and longshore flow dominates under higher current speed conditions induced by the normal sea breeze (Steedman, 1981). This mechanism is described in the Westport ERMP (Delta Holdings, 1986).

7.5.5 Coastal Zone Stability

Shoreline movement plans have been prepared by the Department of Marine & Harbours for the period between 1942 and 1979. These have been combined with survey information dating back to 1912. The results are shown in Figure 16 and are evaluated in detail in the ERMP and EPA Report for Westport (Delta Holdings 1986) (EPA 1987). The salient points of these reports are summarised below:

- The section of the coast between Becher Point and the southern boundary of Port Kennedy has suffered significant erosion between 1965 and 1979.

- Even though the coast south of Becher Point has recently been eroded, the Point has continued to extend seawards. During the formation of Becher Point the axis migrated south between 3000

and 2000 years ago. Subsequently the southward migration of the axis has slowed and then ceased. For the last 1000 years Becher Point has remained reasonably stable or trended slightly northwards.

- Between Becher point and Bridport Point the coastline accreted by approximately 200m between 1912 and 1979.

- North of Bridport Point the accretion of the shoreline tapers off to zero at about the northern boundary of Port Kennedy.

The foredune and primary dune within the Stage I area face west and north-west. As the coast does not face into the prevailing south or south-west winds, major wind erosion sites have not formed.

7.6 COASTAL PROCESSES (Appendix A)

7.6.1 General

The regional net movement of littoral transport is to the north as a result of the predominant south-westerly swells. The conceptual transport regime is shown in Figure 17.

Assessments of the rate of sand movement into the Becher area from the south vary, but are generally estimated to be in the 50,000 to 100,000m^3/year range, (Foster, Wallace 1983). Available historical surveys from the mid to late 1880's indicate that the sand flats between the reef and Becher Point have been accreting at much the same rate. The majority of sand entering the area from the south is deposited on the sand flats, although there is some leakage of sand around Becher Point and into Warnbro Sound.

As discussed before, Warnbro Sound is a deep, well protected embayment. The wave climate within the sound is mild as a result of the protection afforded by the large expanses of sand flats and the system of reefs and ridges at the sound entrance. As a consequence the sediment transport within the sound, both longshore and onshore/offshore, is significantly less than on the open coast.

Assessment of the sediment transport rate at Bridport Point, contained in Appendix A and repeated in this section of the ERMP, has therefore been based on:

- review of the known sediment transport rates at coastal sites either side of Bridport Point,

- review of wave regimes and resultant potential sediment transport mechanisms, and

- review of the coastal accretion rate around Bridport Point based on aerial photographs and surveyed shoreline changes since 1912.

7.6.2 Westport

Westport is located approximately 2.5km to the north of the proposed Port Kennedy marina. As part of the ERMP for the Westport project (Delta Holdings, 1986) a major coastal processes study was undertaken. This study included mathematical modelling of sediment transport and the construction of a temporary groyne to trap and measure littoral drift.

The study indicates that the net direction of sediment transport within the sound is cyclic, being generally to the south during the winter months between May and September, to the north between October and February and quiescent for the remainder of the year.

The south-westerly swell waves are a regular occurrence whereas the swell from the north and west tend to move sand during discrete storm events.

The total gross movement of sand is small, being less than 20,000m^3 in a year. The net movement in any one direction probably less than 5,000m^3/year.

The locally generated sea tends to have a cyclic effect, moving sand to the north in summer and south in the winter.

The direction of net movement at Westport is likely to vary from year to year depending on climatic conditions.

7.6.3 Bridport Point

The magnitude of littoral transport at the Port Kennedy site is somewhere between that occurring on the open coast south of Becher Point and the protected site at Westport.

The marina site at Port Kennedy has a mild wave climate as a result of the protection of the reefs and sand flats. However, it is influenced by the leakage of sand around Becher Point.

Shoreline movement plans are shown in Figure 16. It can be seen that the shoreline adjacent to Port Kennedy has accreted by approximately 200m in the 65 years between 1912 and 1979. If that accretion is assumed to have occurred between the AHD +2.0 contour and the AHD -1.0 to AHD -2.0 contour then it represents a total accumulation of about 750,000m^3 of sand or 10,000 - 15,000m^3/year.

The accretion of sand in this area results from a combination of factors:

- as the waves propagate across the sand flats they lose energy due to friction with the seabed. The waves therefore become progressively smaller as they move past Becher Point and are less

able to move sediment, leading to sand accretion, and

- as the waves approach the deep water of Warnbro Sound there is a confluence with the waves coming in through the entrance to the sound and tending to move sediment in the opposite direction. This area is characterised by a bump in the coastline indicating a deposition of sand.

7.6.4 Coastal Processes - Summary

The predominant south-westerly swells result in a net northerly movement of sediment of 50,000 - 100,000m^3/year approaching the region from south of Becher Point.

The vast majority of this sediment is deposited on the large shallow sand banks between the Murray Reefs and Becher Point.

There is some leakage of this sediment, 10,000 - 15,000m^3/year, around Becher Point and into Warnbro Sound. Most of this material is deposited on the coast between Becher and Bridport Points resulting historically in quite significant shoreline accretion in this area.

Within Warnbro Sound itself there is very little net littoral drift, probably less than 5,000m^3/year on average. The direction of sand movement is cyclic, being to the north in summer and south in winter. The direction of net movements is likely to vary from year to year depending on climatic conditions.

A conceptual model of the sediment transport in this region is illustrated on Figure 17.

It is concluded that, based on the work carried out for this ERMP, net littoral drift in the area under consideration is relatively insignificant. Refinement of quantities, most appropriately obtained by long-term physical measurements at Bridport Point, is not warranted.

7.7 HYDROGEOLOGY (Appendix B)

7.7.1 General Approach

Information on the groundwater regime is available from a number of sources:

- various Geological Survey reports and maps,

- Water Authority reports and hydrographic data. Long term variations in the surface aquifer have been monitored immediately north and south of the site,

- various reports relating to the hydrogeology of the Secret Harbour Development (Rockwater Pty Ltd, 1984a and b) to the south of Port Kennedy,

- hydrogeology relating to the Westport project (Delta Holdings, 1986) to the north and east of the site, and

- rainfall data for Mandurah and Rockingham from the Department of Meteorology.

The above data was used to develop a numerical model of the unconfined aquifer within the site and environs. The parameters used in the model were tuned to match the model responses to the measured rainfall and groundwater fluctuations.

Further explanation of the model used is detailed in Appendix B.

7.7.2 Local Hydrogeology

The surficial Safety Bay Sand aquifer (and Coastal Limestone unit) and the underlying Rockingham Sand aquifer are the two principal superficial unconfined aquifer systems.

The Safety Bay Sand unit is the main aquifer considered in the current study. It comprises fine to coarse grained sands with variable degrees of sorting and cementation. The unit attains a thickness of about 20m along the coastline and thins to the east, eventually pinching out against (coastal) limestones in the vicinity of Lake Walyungup to the east and Anstey Swamp to the south. At the contact between the Safety Bay sands and the coastal limestones, a thin sequence of intercalated clays and sandy clays is often present.

Coastal limestones form the pronounced ridges in the eastern part of the area near the Old Mandurah Road. These limestones dominate much of the coastal plains and comprise calcareous shell fragments and cemented sands. The unit attains thicknesses in excess of 20m and weathering produces the distinctive honeycombing texture. Marls and clays often dominate the lower zone.

Underlying the surficial aquifers is a succession of sands known as the Rockingham Sand unit. Sands are medium to coarse grains. The sequence may attain thicknesses greater than 100m. Beneath the sands occur the older slightly more consolidated materials of the Leederville and Yarragadee Formations.

7.7.3 Unconfined Groundwater

Groundwater occurs within the shallow Safety Bay sands as intergranular or intrinsic storage, the upper surface of which is a free standing or phreatic water table. The main source of recharge is rainfall. The contained water is generally of good quality with total dissolved solids (TDS) between

500mg/L and 1,000mg/L.

Although mapping of the water table south of Rockingham is incomplete it is known that groundwater mounding occurs in the zone between the coastline and the chain of swamps and lakes to the east. This mounding is a hydrogeologic phenomenon developed through rainfall recharge. It maintains hydraulic heads which induce flows to the east, where water is lost by evaporation and transpiration, and to the west where it is lost to the ocean. The geometry of the mound is directly related to the volume and extent of the rainfall as well as the geometry of permeable sands at depth and the distribution of aquifer hydraulic properties.

At the coast, a dynamic balance between the fresh groundwaters and more dense seawater establishes a salt water wedge underlying the outflow groundwater. The position of this wedge is governed by the local hydraulic gradients. It is essential to maintain a positive gradient towards the coast to ensure inland encroachment of this wedge does not occur.

After tuning of the numerical model, assumed calibration parameters for the aquifer are:

Hydraulic conductivity = 16m/day (Safety Bay area)
Hydraulic conductivity = 48m/day (remainder of the area)
Drainable porosity = 11 percent
Leakage = Nil
Rainfall recharge = 34.5 percent of annual rainfall

The average summer and winter groundwater mound contours are shown in Figures 19 and 20.

Other current users of the unconfined aquifer are the Southern Districts Thoroughbred Association and lot owners adjacent to Ennis Avenue, as identified in a shallow aquifer bore census for Secret Harbour (Rockwater 1984a). The proposed Westport development will also affect the shallow groundwater due to abstraction of water for irrigation and "loss" of water to the canals. Secret Harbour proposed to abstract water from the shallow aquifer but approvals for this development have now lapsed.

7.7.4 Leederville and Yarragadee Aquifers

Work for the Secret Harbour development indicates the Leederville aquifer has low throughflow rates in this area and hence the Water Authority will only consider an allocation of 100,000kL/year or possible intermittent use at 300,000kL/year. The salinity of this aquifer is anticipated to be about 900mg/L.

The Water Authority has indicated that up to 500,000 kL/year could be abstrated from the Yarragadee aquifer providing a section of acceptable salinity could be found. The Becher Point Bore

constructed for the Water Authority indicates that significant artesian reserves of between 2,600mg/L and 3,000mg/L are available.

There are presently no other proposed uses for these aquifers near Port Kennedy.

7.7.5 Water Authority Licensing

At present, abstraction of groundwater from the Leederville and Yarragadee aquifers, and from the unconfined aquifer in the south of the site, would be subject to licensing by the Water Authority. It is anticipated that requirements for licensing abstraction of the unconfined aquifer in the north of the site will come into force prior to completion of Stage I construction.

7.8 CLIMATE CHANGE (See Appendix G)

Worldwide concern has been expressed recently about potential global climatic changes resulting from man's activities. The aspect which has the potential to affect this development is called the greenhouse effect. It is suggested that the greenhouse effect will tend to increase the atmospheric temperature due to increasing levels of carbon dioxide and other gases retaining heat radiated from earth which would otherwise be radiated out into space.

Whilst there is no doubt that carbon dioxide levels have been rising steadily in the past and will continue to go on rising in the future, the effects on the climate are not easy to predict. Some of the projected changes which may occur are:

- a rise in Australia's mean temperature of between 1.5 and 4.5^{O}C,
- a rainfall reduction in south-west Australia of up to 20 percent, with consequent decrease in groundwater availability,
- an increase in cyclonic activity, and
- thermal expansion of ocean water leading to a sea level rise of between 0.2 and 1.4m.

As yet there is no conclusive evidence which can be used to evaluate accurately the projected changes or their timing. The positions adopted by various agencies are as follows:

- the Water Authority is considering strategies for progressively adapting to the regional effects of climate change,
- the Department of Marine & Harbours currently have no plans to change design criteria, and

- the Institution of Engineers, Australia is in the process of producing a position paper on the coastal impacts of the greenhouse effect. This repeats the predictions of possible increases in water levels of between 0.2 and 1.4m and examines the consequences of this on a range of coastal processes. However, it points out that change will be gradual over an extended period of time. It calls for careful monitoring of sea level changes around Australia and warns against precipitate action.

Faced with the current uncertainty on this matter and the fact that further research and a number of government initiatives are under way, the Proponent proposes to adopt the best advice available at the time of finalising design. In the knowledge that the change will occur gradually over the next 25 to 40 years, the Proponent has based the development on the following proposed interim positions:

a) Rainfall Reduction. Reduced groundwater availability would be compensated for, by using treated sewage effluent which will be available assuming continued expansion of the metropolitan urban area over the next 25 years.

b) Increased Storm Activity. Should this trend become evident, extra layers of armour would be added to the breakwater to increase both height and strength as necessary.

c) Increase in Sea Level. In considering the potential sea level rise a number of aspects have been evaluated:

    - The current maximum storm surge level is 1.15m AHD. To allow for wave set-up, wave breaking within the marina and a factor of safety, a minimum ground level on the islands of 2.0m AHD is required.

    - The major structures in the town centre and entertainment island will be constructed on ground levels of between +3.0m and +4.0m AHD.

    - One of the most recent published estimates at the time of writing (LeProvost, Semeniuk & Chalmer, 1988) assesses the sea level rise over the next 40 years in Western Australia to be 70mm to 180mm and from 180mm to 450mm over the next century.

    - The elements of the development most at risk are therefore the accommodation units on the islands. These units are rental accommodation with ownership retained by the developer. The risk will therefore not be transferred to individual members of the public as would be the case with urban land development. Furthermore, it is inherent in this type of facility that the tourist market will change over the next 25 years as it has over the last 25 years. It is considered unlikely that the rental accommodation provided on the islands will be retained in their current form much longer than their economic life of 15 to 20 years,

- From the point of view of the Proponent, the accommodation islands should be as close to the water level as possible to promote the visual appearance of the development and to emphasise the close link between the land and water facilities.

In evaluating the above factors, it is proposed to adopt a preliminary ground level of +2.2m on the accommodation islands. In the longer term, it is proposed to raise the island level if proved necessary.

d) Foreshore Erosion. There is a potential for increased foreshore erosion as a result of both the predicted increased sea levels and storm frequency. The beach units to the west of the marina are currently conservatively set back. In addition, the dominant mechanism causing accretion of sediments north of Becher Point will continue to operate for the foreseeable future. The beach units to the east of the marina will be sheltered by the marina and will be adequately protected by the public open space between them and the shoreline. In the unlikely event that remedial measures are required in the long term, then erosion would be controlled by construction of foreshore protection measures, such as groynes.

SECTION 8.0

EXISTING TERRESTRIAL HABITATS AND ECOLOGY

8.0 EXISTING TERRESTRIAL HABITATS AND ECOLOGY (Appendix C)

8.1 GENERAL

The area of the Port Kennedy site is approximately 740ha. It contains no rare or endangered flora so far as the vegetation surveys undertaken could determine. Stage I covers 330ha including 105ha (32%) in conservation areas and 15ha of public open space.

The terrestrial environmental investigations are detailed in Appendix C. These investigations have been undertaken for the entire site to allow full assessment of the Stage I development. The site investigation was undertaken in May 1988 and hence could not survey annual plants which were only just beginning to germinate and cryptophytes which had not yet emerged.

Review of the terrestrial habitats indicates that the more significant aspects requiring detailed inspection are the vegetation condition and the combination of well represented plants in unusual associations. Another feature of the site is a number of low lying swales which contain peaty soil and act as seasonal wetlands.

8.2 LANDFORM AND SOILS

As discussed earlier, investigation and field survey have shown that the site consists of five geomorphic units:

a) contemporary relict foredune plain (Qf4),
b) active or recently active foredune (Qf1),
c) relict beachridge plain (Qf2),
d) prominent relict foredune (Qf2a), and
e) linear depressions/seasonal wetlands.

The distribution of these geomorphic elements within the site is shown on Figure 12.

All the soil types that occur at the site could broadly be considered as Safety Bay sand, but differential development between the geomorphic elements has created subtle characteristic soil types that are definable at the scale of mapping employed in this investigation. As the distribution of soil types is closely related to the geomorphic elements, soil type descriptions are provided within descriptions of the geomorphic elements.

a) Contemporary Relict Foredune Plain (Qf4)

A narrow band of contemporary or recently deposited foredunes of very low relief (less than 2m AHD) lies behind the present active beach zone for a distance of some 2km along the Warnbro

Sound shoreline. Soils within this unit consist of white to grey sands that have been partially to well stabilised by pioneer vegetation.

Three small circular wetlands have developed on low lying ground within this landform near Becher Point. The wetlands are saline, very shallow and are based on saline groundwater which lies very close to the surface. Soils within the wetland are similar to foredune soils described above but have accumulated salt from seaspray and organic matter from the plants that have established within them.

b) Active or Recently Active Foredune (Qf1)

This unit is the primary dune formation behind the present shore. Within the Stage I area, this unit lies at 2 - 5m AHD near Becher Point and rises to approximately 5 - 10m AHD with some isolated higher ridges in the northern sector.

North of Becher Point, the unit has parallel dune and swale topography consistent with a relict beach ridge landform. However, at the very northern end of the Stage I project area the topography becomes more complex and displays some parabolic character. Surface soils consist of grey-white sand that closely resemble those of Qf4 but have very minor organic accumulation near the surface. This unit is stabilised by vegetation, which has also provided the organic detrital material in the form of minor leaf litter at the surface and root material in the shallow subsurface.

c) Relict Foredune Plain (Qf2)

This geomorphic unit forms much of the hinterland of Becher Point and the Rockingham-Becher Plain. It is characterised by a regular gently undulating surface with continuous linear or curvilinear ridges in parallel sequences that mark successive shoreline positions through time. Topographically the beach ridge plain generally lies between 4 - 8m AHD. However higher ridges up to 12 - 14m AHD and deeper swales (described in (e)),which may lie as low as 2 - 4m AHD, also occur.

The surface soils are grey-brown sands that feature minor organic accumulation in the upper 25 - 40m and overlie cream-buff coloured sands. These are analogous to the upper soil layer but lack significant accumulation of organic material.

d) Prominent Relict Foredune (Qf2a)

No land of this geomorphic form occurs within the Stage I area. A soil map (Department of Agriculture, 1985) shows this geomorphic form to the east of the Stage I area and along the coastline south of Becher Point. Both areas have topographic range of 5 - 10m AHD.

The unit is described as "more prominent relict foredunes occurring within unit Qf2 with linear swamps often developed within swales". Examination of aerial photographs during the present investigation indicated that south of Becher Point the land mapped as Qf2 does not closely comply with the type-description and is more characteristic of Qf1 (MacArthur and Bartle's, 1984, Q4), having long dune walls and some parabolic character.

Soils of the Qf2a geomorphic unit within the study area (outside Stage I) consist of fine-medium grained, grey-white, calcareous skeletal sands with little organic development other than within the uppermost few centimetres of the profile.

e) Linear Depression/Seasonal Wetland (See Photographs 3 and 4)

Whilst strictly speaking this geomorphic unit is a component of the relic foredune plain geomorphic unit (Qf2), for the purpose of detailed review of the area, separate discussion is included here.

Five major linear depressions and several minor linear depressions within the study area lie low in the landscape (<3m AHD) and are sufficiently close to the unconfined water table to experience inundation during periods of seasonally high levels. These areas have commonly been mapped as permanent wetlands by previous investigators. However, site inspections of vegetation and soils within the depressions located only one area of approximately $50m^2$ of apparent permanent surface water and suggested that inundation would be confined to the wet months of the year in the remainder of the linear depressions. Inspections also indicated that plant species characteristic of persistent or permanent surface water were absent from all but the one small area.

The soils within the major linear depressions consist of heavy, black, peaty soils that have been formed by the accumulation of decaying plant materials. These have a depth of approximately 1m. The apparently low permeability of these black peaty soils undoubtedly provides for surface ponding of rainfall, retention of soil moisture and therefore enhancement of seasonal wetland character. The high organic content of this soil type compared to the surrounding dune soils is consistent with perennially moist soil conditions and accumulation of organic detritus in a seasonally inundated soil horizon.

8.3 FLORA AND FAUNA

8.3.1 Flora

Seventy three species of flowering plants (angiosperms) were recorded while mapping the vegetation. This probably represented all of the perennial species (excepting cryptophytes) that would be recorded in the study area by a systematic search for flora. However, very few of the annual species that would be expected in the area were available for collection due to the survey being carried out in May.

8.3.2 Fauna

Evaluation of the fauna of the study area is based on the habitats available, opportunistic sightings during site inspection, Museum records and desktop review. The lower level of detail that has been assigned to this part of the ERMP is appropriate due to two factors:

i) much of the area has been severely burnt and now provides little value as habitat, and

ii) the low abundance of conspicuous fauna indicates very extensive field survey would be necessary to enable all species present to be identified.

A list of the potential fauna populations on the site is contained in Appendix C. Overall, the native fauna of the study area is likely to be relatively impoverished within a regional context. The abundance and diversity of species that are potential inhabitants are very low compared to those of the Rockingham Lakes Regional Open Space, due to the frequent fires in the northern section of the site, human disturbance of the vegetation, absence of extensive permanent wetlands and associated vegetation and invasion of introduced feral animals.

8.4 VEGETATION CONDITION AND DISTRIBUTION (Appendix D)

8.4.1 Vegetation Condition

Figure 22 shows the condition of vegetation on the site. The categories shown on the map are defined as follows:

Category A: Significant changes as a result of human influence, may have significant amounts of weeds including some of the more aggressive ones.

Category B: Has definite signs of human impacts (such as grazing) leading to some (but not substantial) changes.

Category C: Shows no evidence of human impact or shows signs of reversible impacts such as increased fire frequency, few tracks and little rubbish.

It will be appreciated that the dividing line between the above categories is not distinct except where existing tracks have acted as fire breaks or have channelled human use.

The approximate areas in hectares of vegetation in the three categories are shown below:

	Total Site	Stage I
Category A	170ha	150ha
Category B	230ha	80ha
Category C	340ha	100ha

Vegetation in the northern Stage I area is generally in worse condition than that in the southern half of the site. This is attributable to existing human use of the area and the resultant physical disturbance as shown in Figure 23.

8.4.2 Vegetation Distribution

The vegetation is described below in relation to soil types. The vegetation units are mapped in Figure 22. The key notation used in mapping is included in parentheses.

i) Strand and Contemporary Foredune

- o Arctotheca calendula, Cakile maritima Open Herbland (AC)
- o Spinifex longifolius Hummock Grassland (with Tetragonia decumbens) (S1)
- o Olearia axillaris Open Shrubland to Open Heath (Oa_1)
- o Olearia axillaris Closed Heath to Closed Shrub (Oa_2)

ii) Q4 Dunes

- o Scaevola crassifolia, Olearia axillaris Low Open Heath, Closed Heath, Open Scrub (SO_{1a})
- o Scaevola crassifolia, Olearia axillaris Low Open Heath, Closed Heath, Open Scrub (SO_{1b})

iii) Q2 Dunes

- o Lomandra maritama Closed Herbland, Mixed Low Open Shrubland, Low Closed Heath (Lm)
- o Acacia rostellifera Low Open Heath, Open Heath over Melaleuca acerosa (Ar2)

iv) Relict Foredunes

- o Jacksonia furcellata, Acacia saligna Complex (JA)
  - Jacksonia furcellata, Acacia saligna Open Shrubland (JA)
  - Jacksonia furcellata, Acacia saligna Open Shrubland over Acacia lasiocarpa Low Open Shrubland to Low Shrubland (JAAl)
  - Jacksonia furcellata, Acacia saligna Open Shrubland over Hemiandra pungens (JAH)
- o Olearia axillaris Complex (Oa Ac)
  - Olearia axillaris, Acacia cochlearis Shrubland over Acacia lasiocarpa (Low Shrubland (Oa Acl)
- o Olearia axillaris, Melaleuca acerosa Complex (Oa Ma)
  - Olearia axillaris, Acacia saligna Open Shrubland over Melaleuca acerosa Low Shrubland (Oa As Ma_1)
  - Olearia axillaris, Acacia saligna Open Shrubland over Melaleuca acerosa Low Open Shrubland to Shrubland (Oa As Ma_2)
  - Olearis axillaris, Jacksonia furcellata Open Heath (OJ_1)
  - Olearia axillaris, Jacksonia furcellata Open Heath (OJ_2)
- o Acacia lasiocarpa Complex (Al)
  - Jacksonia furcellata Open Shrubland over Acacia lasiocarpa Low Closed Heath (Al_1)
  - Jacksonia furcellata, Acacia saligna Open Shrubland over Acacia lasiocarpa Low Heath (Al_2).
- o Acacia rostellifera Complex (Ar)

v) Inland Stands

- o Acacia rostellifera Open Scrub over Melaleuca acerosa Low Shrubland (ArMa)
- o Stipa, Lepidosperma tenue Open Grassland/Sedgeland (SL)

vi) Stands near the Coast

- o Dipolaena dampieri, Acacia rostellifera Low Shrubland (Dd Ar)
- o Acacia rostellifera Low Open Heath to Closed Heath to Open or Closed Scrub to Low Forest (Ar)
- o Acacia rostellifera Low Open Shrubland over Stipa Open Grassland (ArSF)

vii) Seasonal Wetlands

- o Juncus sp Closed Sedgeland (J_1)
- o Juncus sp Open Sedgeland over Sarcocornia Closed Herbland (J_1)
- o Linear Wetlands (w)
- o Xanthorrhoea Swales.

8.5 REGIONAL SIGNIFICANCE

8.5.1 Regional Context

The biological environment is characterised on a regional basis using previously identified vegetation systems that have been investigated and mapped by biological researchers.

The project area lies within the South-West Botanical District, the Drummond Sub-District and the Rockingham System of (Speck, 1978) and (Smith, 1974) (Beard, 1979). The Rockingham System is considered to include Rottnest, Carnac and Garden Islands and the coastal vegetation from Fremantle, south to Cape Naturaliste (Beard, 1981).

Thus, vegetation and plant communities that are broadly typical of the project site extend along the coastal fringe of Quindalup Dunes between Fremantle and Cape Naturaliste. North of Fremantle, coastal dune vegetation is often largely similar but has been classified as the Guilderton System (Beard 1981).

8.5.2 Flora

No gazetted rare, endangered or geographically restricted species of indigenous flora were identified within the project area. All species identified are known or believed to occur at other locations along the south-western coastal plain. Representation within conservation reserves identified in System Six has not been evaluated on a species by species basis. However, it can be reasonably suggested that most of the characteristic species of the site would be represented in other coastal locations in this region.

8.5.3 Vegetation Complexes

Although the individual species identified are well represented elsewhere, the vegetation complexes that have been formed at Port Kennedy by the co-existence of particular species are not widely distributed along the coast and are under increasing pressure due to development of coastal land for urban purposes.

Much of the vegetation is not well represented in other conservation reserves in the region. Vegetation complexes found within the active or recently active relict foredune (primary dune) and those within the relict foredune plain are significant in this regard. Three units that occur within relict foredune areas are not known to occur outside the study area. These units are the Acacia lasiocarpa complex, the Olearia axillaris, Jacksonia furcellata Open Heath and the Olearia axillaris, Melaleuca acerosa complex. The latter two complexes fall within Stage I and these have been affected by previous use of the site.

SECTION 9.0

EXISTING MARINE HABITATS AND ECOLOGY

9.0 EXISTING MARINE HABITATS AND ECOLOGY (Appendix E)

9.1 GENERAL

The Warnbro Sound marine environment and offshore reefs are considered by the **Proponent** to be a major potential attraction for the development and hence their conservation is important both for their intrinsic value and for the development. Following discussions with the EPA, it was agreed that a short term localised field study would be of little value in the context of a longer term regional study proposed by the EPA. As a result, the **Proponent** has undertaken a desktop assessment in preparing this ERMP and has provided a commitment to contribute to the proposed EPA study (refer Section 13.0).

The marine investigation carried out for the **Port Kennedy Regional Recreation Centre** is described in Appendix E. This section summarises the results from that investigation as they relate to the existing marine habitat and ecology.

9.2 REGIONAL PERSPECTIVE

A short distance to the west of Port Kennedy are some limestone islets and emergent pinnacles marking the crest of the Garden Island Ridge, which has more prominent and well-known exposures further to the north (e.g. Penguin Island, Cape Peron, Garden Island and Carnac Island). The Garden Island Ridge may be described as an almost continuous, submarine to emergent limestone ridge, lying parallel to the mainland and extending from just north of Mandurah to Rottnest Island. This ridge, along with some other regional geomorphic and bathymetric elements, is illustrated on Figure 13.

The protection offered by the Garden Island Ridge provides relatively safe boating in Warnbro Sound, Cockburn Sound and Owen Anchorage. Becher Point is about the southern boundary of these protected waters. This suggests that boating and other recreational activity from Port Kennedy will tend to concentrate on the protected waters of Warnbro Sound and the offshore reefs to the north-west.

The area in the vicinity of the offshore reefs forms a proposed Marine Park (System Six area M101). Assessment of population growth, along with trends in boat sizes and usage, indicates that small boats launched from boat ramps in Rockingham and Safety Bay are potentially the greatest source of recreational impact in the shallow nearshore waters of the M101 area. Three projects have been approved in recent years without addressing or contributing to management requirements in relation to the nearby Marine Park proposal. Secret Harbour (1,000 - 1,200 boats), Rockingham Marina (300 boats) and Westport (572 waterfront lots) are all moderately large in terms of potential recreation impacts. It is also significant that none of these proposals has commenced development.

9.3 LOCAL GEOMORPHOLOGY

Becher Point lies within the geomorphic unit known as the Warnbro-Cockburn Depression. The point itself represents the terrestrial component of a sand barrier that extends across the Depression to the Garden Island Ridge. The submarine portion of this barrier is a shallow (2-5 m) sand bank.

Westwards from Becher Point, there are five broad geomorphic units parallel to the Warnbro-Cockburn Depression, as follows:

Geomorphic Unit	Topography and Water Depths	
Garden Island Ridge	Irregular, rugged reef	(0 - 10m)
Parallel Ridge System	Variable, but low relief	(10 - 15m)
Sepia Depression	Gently sloping	(15 - 24m)
Five Fathom Bank	Rugged limestone reef	(mostly 10m+)
Offshore Continental Shelf	Gently sloping	(20 - 300m)

9.4 MARINE HABITATS

Marine habitats may be broadly defined in relation to the geomorphic units, seafloor type (substrate) and other physical factors. The broad marine habitats that have been identified are as follows:

- Intertidal high reef platforms.
- Subtidal reefs and limestone pavement.
- Sandy seafloor (including seagrass meadows and shoreline zones).
- Silt-mud basins.

The distribution of these habitats is shown on Figure 24. It is apparent that the dominant habitat type in the vicinity of Becher Point is sandy seafloor.

Seagrass meadow is a conspicuous element on this substrate, although it is often patchy in occurrence. Another feature of Becher Point is the total absence of onshore, intertidal limestone platforms. These platforms are subject to intense recreational pressure elsewhere on the Metropolitan coast.

9.5 MARINE COMMUNITIES

A survey of plant and animal communities in the area was conducted by the Department of Conservation and Environment (DCE, 1986). The area surveyed was primarily within the proposed M101 Marine Park boundary, although some work was conducted inshore from the eastern boundary. Subsequently, a report was produced which described the marine communities in some

detail, and included the results of other studies and scientific research. A brief summary of survey results is presented below in terms of each of the broad habitat types in the area.

9.5.1 Intertidal High Reef Platforms

Plant communities are dominated by turf algae, with large seasonal changes in community structure. The algal communities observed on the reefs near to Becher Point (i.e. Murray Reefs and The Sisters) appear to be similar to those further north.

The dominant animals observed are common to most local reefs, including the commercially important abalone and common whelk. The Sisters reef flats appear to contain the most diverse animal life of the platforms surveyed.

The islands and rock pinnacles associated with these intertidal reef platforms are valuable as resting, breeding and nursery sites for a variety of mammals and birds. Whilst none of the fauna are year-round endemics to the islands, 18 species of birds use the islands for breeding.

9.5.2 Subtidal Reefs and Limestone Pavement

The subtidal reefs which form the Garden Island Ridge are dominated by brown algae such as kelp and Sargassum, with a variety of red algae (coralline and non-calcareous species). Biomass varies largely due to seasonal growth of kelp, which 'hides' much of the reef in summer. Superficial appraisal suggests the dominant species may be similar throughout the reef.

Attached animals include colonial and solitary ascidians, sponges, featherstars, hydroids and corals. The distribution of these fauna is patchy, although the diversity of many animals, such as the sponges, is believed to be very high. These reefs are nursery grounds for rock lobster, and abalone are also present.

9.5.3 Sandy Seafloor and Seagrass Meadow

Eight species of seagrass are known to occur in the area and none are unique to this location. There are extensive, healthy meadows of seagrass on the sand bank west of Becher Point. Seagrass meadows are host to numerous fish and invertebrates and there is normally a wide range of epiphytic plants and animals on the leaf stalks.

The fauna of bare sandy seafloor usually comprises burrowing animals such as molluscs. Demersal fish, including sole and flounder may occur, as well as pelagic species such as skipjack trevally.

9.5.4 Silt-mud Basin

The deep basin of Warnbro Sound has very little plant life due to the lack of light. However, animals are abundant. Anemones, sea-stars, holothurians and other echinoderms are conspicuous. Despite the sometimes high density of animals, the overall diversity appears to be low.

9.6 OVERVIEW OF THE MARINE ECOSYSTEM

Biologically, the marine environment adjacent to the Metropolitan area is known to be part of a zone of overlap between the northern coast, with its characteristic tropical species and the southern coast, with its temperate species. Therefore on a broad scale, the plant and animal species along the south-west coast are a mixture of both temperate species and representatives of the sub-tropical and tropical biota. Temperate species tend to dominate along the metropolitan coast, especially the algal assemblages. In the zone of overlap there are, of course, endemic species which are not found along the southern coast or in tropical waters. However, the number of species that are restricted solely to an area the size of M101 is likely to be small.

9.7 SIGNIFICANCE OF ECOSYSTEM COMPONENTS

9.7.1 General

Whilst the detailed ecology of the area is poorly understood, the importance of certain ecosystem components is well known. Two of these components, algal assemblages and seagrass meadow, are briefly discussed below.

9.7.2 Algal Assemblages

The algal assemblages, particularly on areas of limestone reef in shallow water, are important primary producers in the ecosystem. Species such as kelp and Sargassum are highly productive at certain times of the year. This production is utilised by grazing organisms and supports a variety of intricate food chains. The algae are capable of occupying many different micro-habitats within the reef structure and provide refuges for fish. They are rapid colonizers of hard substrates and form the basis of reef communities.

The large quantities of macrophytes that are detached from reefs during winter storms provide a mobile food source and shelter for juvenile fish as the material drifts with longshore currents.

Detached algae that accumulate in nearshore basins contribute to nutrient recycling.

9.7.3 Seagrass Meadows

The seagrass meadows on the sand banks surrounding Warnbro Sound and adjacent to Becher Point are important for a number of reasons, as outlined below:

- Seagrasses stabilise sand banks by dissipating wave energy and slowing the rates of current flow.

- The seagrass leaves provide a relatively stable substrate for colonisation of specialised plants and animals (epibiota).

- They are important contributors to primary productivity within the ecosystem.

- Seagrass meadows provide nursery areas for juvenile fish, as well as habitat for many adult fish species and invertebrates.

- The stabilising effect of seagrasses acts to trap organic material within the beds, thus contributing to nutrient recycling in shallow water areas.

- Dislodged seagrass leaves contribute to detrital food chains.

- Recolonisation by seagrass is very slow, therefore any reductions in seagrass cover through human influences should be avoided.

SECTION 10.0

THE HUMAN ENVIRONMENT

10.0 THE HUMAN ENVIRONMENT

10.1 HISTORICAL, ARCHAEOLOGICAL AND ETHNOGRAPHIC SITES

Detailed archaeological and ethnographic surveys of the site were undertaken.

The archaeological investigation was designed to provide a systematic sample survey of the proposed development area so that any archaeological sites would be predicted. Access was possible to all parts of the survey area by off-road vehicle and on foot. Surface visibility was not good due to the groundcover vegetation, plus the disturbance due to squatters' shacks, rubbish and tracks. However, it is considered that a satisfactory cross-section was sampled. No archaeological material was located as a result of the systematic sample survey.

The ethnographic survey involved three separate phases:

- examination of the existing ethnographic data base,
- consultation and discussions with key Aboriginal persons and organisations, and
- scouting of the proposed development area with Aboriginal assistants.

No sites of significance to Aboriginal people are known to occur on or near the proposed development.

Copies of the reports are not included in the Appendices as the results of both surveys were negative. Copies have been sent to the Western Australian Museum and are also available for review at the office of the Proponent's consultant, Binnie & Partners Pty Ltd.

Advice from the Maritime Museum indicates that the only known shipwreck in the vicinity of Port Kennedy lies some 700m west- north-west of Becher Point.

10.2 RECENT LAND USE

10.2.1 Defence Forces Usage

Before and during the Second World War, the land generally between the coast and the Lakes and south of Safety Bay Road was used by the Defence Forces as a practice range. It is not clear as to the precise location of the range.

Sections of the area have recently been searched by the State Emergency Services using a machine capable of detecting unexploded shells (UXO's) to a depth of 3m, with good reliability to 2m. This

search has covered the north and eastern part of the site (Lots 1316, 584, 1317, 692, 606, 762 and 764). It is understood that more than 100 UXO's were found of which about one-quarter contained live explosive.

The southern and western boundaries of these lots are thought to roughly correspond to the edge of the artillery range. However, a few scattered shells have been previously detected by shallow searching outside this area. Further expenditure on searching to 3m beyond these lots is deemed not to be cost effective by the Commonwealth Government.

The primary dune, foredune and squatter area have not been searched to 3m even within the known artillery range due to difficulty with operating the detector in areas covered with vegetation or man-made obstructions.

10.2.2 Squatters

Since the early 1950's fishermen and regular weekend holiday-makers have been constructing shacks at Port Kennedy and approximately 90 - 100 are currently inhabited (see Photograph 1). The shacks are mainly located adjacent to Bridport Point. There have been various attempts to evict the squatters since 1961 but none have been successful due to lack of other plans for the area.

The squatters and other visitors have been poor managers of the land. Household rubbish, food wastes, building materials, domestic appliances and old car bodies have been scattered over much of the site, particularly the dune country immediately south and east of Bridport Point (see Photographs 4, 5 and 6).

The proliferation of access tracks created by squatters and day visitors has also scarred the site and initiated many wind erosion problem areas.

Uncontrolled access has also resulted in weed invasion and degradation of the natural vegetation from excessively frequent fires.

10.2.3 Passive and Active Coastal Recreation

Beach areas both north and south of Becher Point have been used by fishermen, surfers, swimmers and sunbathers for many years. The section of beach along the northern sector of the project area has also been used as a nude sunbathing location for a number of years. Recognition of the recreational potential of the coastal parts of this area led the then Metropolitan Regional Planning Authority to reserve the coastal fringe of the project area for Parks and Recreation.

The Department of Community Services operates a "beach camp" holiday facility within a reserve at the southern margins of the study area. Beach activities as well as horse riding are the most

common pursuits of patrons.

10.2.4 Off-Road Vehicles

The relatively remote location of the study area, the gently undulating terrain and the generally sparse vegetation cover has attracted off-road vehicle users over a number of years. An area within the eastern sector of Stage I has been gazetted for off-road vehicle users. However, off-road vehicle activity appears to extend over the whole site, although in parts it is mainly restricted to existing tracks.

10.3 CONSIDERATION OF SYSTEM SIX

In reviewing the development layout, it is necessary to assess how the proposal relates to the specific aspects that have been set out for the area in the System Six. Interpretation of these specific System Six comments regarding M106 are shown below.

System Six Comment	Remarks
(i) "The MRPA has recognised the potential for recreation of Port Kennedy and has prepared a design concept for a regional recreation centre, to help cater for the anticipated future development of the district."	(i) The 1978 MRPA proposal, presumably prepared without detailed environmental review, allocated less than 20% of the site to "Landscaped and Preservation Nodes". Review of conservation potential of the site for this ERMP indicates that more of the site should be allocated to conserved areas.
(ii) "The peninsula consists of parallel, curving dunes, typical of the Coastal Plain south of Rockingham. Much of the area retains its natural vegetation, which is quite rich in species. Thickets of wattle are common and there are numerous tall shrubs typical of coastal species. There are also many perennial herbs - mostly common species, and a less frequently seen species of climbing milkwort. The area's conservation value is high, because there is little similar land available between Fremantle and Mandurah."	(ii) The completed investigation of the terrestrial environment, prepared for the ERMP, confirms these comments in general. The investigations have also further refined, on site, the conservation values that have been previously recognised. In addition, the areas where physical and biological degradation has occurred have been identified.

(iii) "The area has obvious potential for recreation, and is already used for fishing, camping and off-road vehicles".	(iii) The fishing and camping is generally concentrated around Bridport Point. Off-road vehicles are responsible for considerable destruction, particularly in the northern part of the site.
(iv) "The recreation potential could be even greater if a link is provided between Port Kennedy and the White Lakes Region Open Space".	(iv) This is incorporated in the proposed ultimate development.
(v) "Land tenure is varied and not all land has conservation and recreation as primary management objectives".	(v) In the ultimate development, less than 10% of the site is allocated for a range of holiday accommodation. The remainder of the proposed development will only include areas for conservation, passive and active recreation.
(vi) "..... to enhance these values the management structure requires co-ordination".	(vi) Management of the site will be co-ordinated by a Management Board.
(vii) "Important management considerations include encouraging the growth and regeneration of local indigenous flora; removing shacks and tracks from the area; and provide direct public access to the open space of regional significance at M103 (Lakes Cooloongup and Walyungup)".	(vii) These three considerations are embraced by the proposed development.

Two recommendations for Port Kennedy were made in System Six:

- "That the general recommendations on planning and management of Regional Parks be applied to this area."
- "That the Metropolitan Region Planning Authority consider "reserving" those portions not already "reserved" for Parks and Recreation under the Metropolitan Region Scheme."

Detailed consideration of the System Six comments and recommendations relating to M106 are therefore not considered to conflict conceptually with the proposed development.

In formulating the development layout, attention has thus been focused on maintaining compliance with System Six management recommendations in respect of the following aspects:

- The impact of the development on areas of specific conservation interest within the site.

- The broader conservation concept of System Six relating to the desirable balance between areas of conservation, passive recreation and active recreation.

10.4 LANDSCAPE VALUES

In terms of perceived human values the most attractive part of the site is the beach and the narrow coastal strip of primary dune and foredune. This applies particularly to the sheltered beachline backed by high dunes at the north end of the site in Warnbro Sound.

Except for the top of one or two inland dune crests the remainder of the site is lower than the foredune and does not offer many vantage points. Apart from a few stands of paperbark and some older patches of Acacia rostellifera the site is covered with low scrub and heath. Widely scattered rubbish and frequent burning have both detracted from the site's value.

SECTION 11.0

ENVIRONMENTAL IMPACTS

11.0 ENVIRONMENTAL IMPACTS

11.1 INTRODUCTION

In this section the impacts of the development are reviewed in the context of impacts already occurring in the area and impacts caused by other similar development.

Degradation of the existing terrestrial environment is already widespread. Only 30 percent of the Stage I area shows little or no previous impact by man. Although the remainder of the Port Kennedy site is in better condition, it is reasonable to assume that further degradation of the whole site will occur as the growth of the metropolitan area continues. The impact of the Stage I development on terrestrial habitats should therefore be considered against this background.

The impact of additional boating recreation resulting from the proposed marina should be considered in the light of environmental approval for two other proposed developments (Westport and Secret Harbour) and existing boat use in the Safety Bay and Rockingham region.

As with any project, several elements of this development have the potential to affect the environment. The more significant of these are as follows:

- The impact on landform.
- The impact of the marina on sediment transport.
- The impact of ground water abstraction on the shallow aquifer.
- The impact on terrestrial habitats.
- The impact of the marina construction on marine biota and water quality.
- The impact of increased human pressure on both terrestrial and marine aspects.

Discussion of the Stage I layout shown in Figure 6, compared to the preliminary planning framework shown in Figure 7 is included in this Section to demonstrate the Proponent's intention to mitigate and remove environmental impacts where possible. In general, the layout has been modified in accordance with the following constraints:

- limitation of the development node to the most degraded area of the foredune and primary dune,

- o rearrangement of the area behind the marina to restrict the impact on areas of conservation value,

- o alignment of the approach avenue and other roads to minimise the impact on areas outside Stage I, and

- o layout of conservation zones to protect areas of highest conservation value.

11.2 IMPACT ON LANDFORM AND GEOMORPHOLOGY

11.2.1 General

The majority of the earthworks for the project will occur within the golf courses and the areas adjacent to the marina and hotel. As a consequence, the development will have an impact on the following landforms (see Figure 12):

- o the foredune and primary dune,
- o the curvilinear dune area,
- o the linear seasonal wetlands, and
- o the inland relict foredune.

11.2.2 Foredune and Primary Dune

The Stage I layout shown in Figure 6 has been arranged to limit the impact on the foredune and primary dune to the area already eroded by squatters. This has been achieved by locating the resort hotel close to Bridport Point and ensuring the development node behind the marina is compact. The hotel is located behind the primary dune. The dune adjacent to the hotel and marina is typically 4-6m high and will be generally retained in its present form or built up and terraced with dredged spoil from the marina to emphasise the landform.

As shown in Figure 8 the foredune and primary dune to the north of the hotel and the dunes at Becher Point have been included in conservation zones.

The impact of additional human pressure on these areas will be controlled by management measures described later in Section 12.

The area of land that will be affected by the marina and hotel represents a small proportion of the total area of the site that has analogous landform. Significantly, this area has been badly affected by squatters. There are similar dune landforms to the north of the marina and on the south coast of the study area, that are in better physical (and biological) condition and which will not be disturbed. Therefore, the recontouring that will be necessary for marina and hotel construction will

not have a significant impact.

Stage I has no direct impacts on the foredune in the southern part of the site facing Madora Bay.

11.2.3 Curvilinear Dune Area

The majority of this unusual landform will be retained within the conservation area behind the marina. Due to the proximity of a section of curvilinear dunes to the marina, a small part of the more westerly and lower of these dunes falls within the area of temporary carparking included in Stage I. This impact should be considered acceptable as the remainder of this landform is conserved.

11.2.4 Seasonal Wetlands

Five major linear seasonal wetlands have been mapped on the site. Several other minor linear seasonal wetlands exist. In addition, three small roughly circular wetlands lie close to Becher Point.

The seasonal wetlands have been formed by accumulation of decaying plant materials within the dune swales. The consequent low permeability causes intermittent surface ponding of rainfall and retention of soil moisture.

The approach avenue has been realigned so that four of the five major linear wetlands will not fall within the Stage I area. The fifth and most northerly of the linear wetlands lies within the proposed golf course area. This seasonal wetland lies within a node of existing intensive off-road vehicle activity and forms the junction of several tracks (see Photograph 3). It has been cleared and burnt and its value is further diminished by weed infestation and rubbish. However, this wetland can be rehabilitated in part to near its natural condition and in part developed as an ornamental lake. Similar treatment can also be given to the group of minor wetlands further east.

Two of the three small circular seasonal wetlands will be included in the conservation zone at Becher Point. The third circular wetland falls within the marina accommodation area. This wetland has been degraded by weeds and rubbish due to its proximity to the squatter area.

11.2.5 Inland Relict Foredune

Earthworks for the hotel and golf courses will modify the relict foredune. Earthworks for the hotel will cover a relatively small area of about 10ha. Earthworks for the golf course will not be known in detail until the design is finalised. The design will work within the following parameters:

- generally fairways will follow the swales,

- generally excavation will be limited to less than 2m in depth (to minimise UXO searching), and

- the major north-south dune crest in the centre of the golf courses will be retained and emphasised to act as a visual screen.

The relict foredune plain that forms the site of the proposed golf course is extensive throughout the study area, in adjacent land to the east of Port Kennedy and throughout the Rockingham to Mandurah coastal plain in general. It is noted also that examples of relict foredunes are located within the Rockingham Lakes area (M103).

11.2.6 Landscape Stability

The development has the potential to impact upon the landscape stability of this sandy coastal site, both during the construction period and in the long term. Management of these impacts is described later in this ERMP. Particular attention will be paid to management of impacts within the coastal strip most subject to wind (and wave) erosion as defined by the coastal hazard line in a report prepared for the Shire of Rockingham (Department of Agriculture, 1985).

The numerous existing eroded areas and tracks will be restored and managed at the developer's expense.

11.3 COASTAL PROCESSES

11.3.1 Long Term Processes

The marina will have no impact on:

- the supply of marine sediments controlling the long term advance of the Warnbro Sound shoreline, and

- the transport of sand into the Becher Point/Warnbro Sound area from the south.

Over the last 1,500 years or more, the shoreline at Bridport Point has been subjected to periods of erosion and accretion within the long term advance. The marina will prevent periods of erosion recurring at Bridport Point.

11.3.2 Short Term Processes

To the west of the marina, the 10,000 to 15,000m^3/year which currently accretes between Becher and Bridport Points will continue to do so, resulting in the creation of a pleasant well protected

beach to the western side of the development. At the predicted rate of accretion, 40 to 50 years storage is available. Further storage can be obtained by increasing the length of the spur on the western breakwater.

To the east of the marina the small anticipated net sediment movement of 5,000m^3/year will either be:

- away from the marina resulting in potential minor erosion of the coastline north of the marina. Management of this potential impact is described in Section 12, or

- towards the marina, where the eastern breakwater has been designed to allow for approximately 40 to 50 years storage.

As shoreline accretion occurs, there is potential for some sediment to move along the breakwater face and into the harbour mouth. The short spurs on the breakwaters have been included to minimise this potential problem. These have been incorporated in Stage 1 although they will not be required for several years. The anticipated alignment of the shoreline resulting from accretion is shown in Figure 18.

The eastern breakwater has been located away from the bank slope to allow for sediment accumulation above the -2.0m (AHD) contour. This will prevent the sand accumulated to the east of the harbour being transported down the bank slope into the deeper Warnbro Sound basin and being lost to the system. The breakwater location will also minimise the coverage of the seagrass meadow by the sediment accumulation.

Review of the data in the ERMP's for Port Kennedy and Westport (Delta Holdings, 1986) indicates that the net sediment transport at both sites is expected to be 5,000m^3/year or less. Should this prove cumulative, such that the section of coast between the developments should receive 5,000m^3/year from the south past the Port Kennedy marina and 5,000m^3/year from the north past Westport, the total loss is still not large. The impact will be mitigated by management commitments incorporated in the Port Kennedy (Section 13.0) and Westport projects.

Most of the proposed development is located behind the marina or the primary dune where possible erosion during a storm event is not of concern. However, evaluation of this problem is necessary for accommodation located immediately to the east and west of the marina. During a storm event a quantity of sand in the beach zone is temporarily redistributed to an offshore bar. The volume of sand between the proposed accommodation units and the shoreline is between two and three times that likely to be redistributed offshore in a 1 in 100 year storm event.

11.3.3 Summary

The proposed marina is located on an unusually well protected section of the coast where mechanisms for large sediment transport movements do not exist.

In the context of other developments along more exposed sections of the south Western Australian coast, the impact of this proposed harbour on coastal processes is not expected to be significant. However, the impact will require some management and monitoring as described in Section 12.

11.4 IMPACTS ON HYDROGEOLOGY

11.4.1 General Approach

The general approach adopted in developing the irrigation requirements has been to maximise the use of the shallow aquifer consistent with minimising the impact on:

- saline intrusion,
- the chain of wetlands to the east, and
- other users of the resource.

Other potential sources have also been reviewed and the impact of their use evaluated.

11.4.2 Long Term Stage 1 Groundwater Requirements

The numerical model described in Section 7.7 indicates that prior to construction of the Westport canals, 4,000kL/day (estimated long term Stage I requirements) can be abstracted from the unconfined aquifer by the proposed line of 10 bores located as shown in Figure 21.

The impact of long term abstraction of 4,000kL/day on the groundwater mound contours is shown in Figure 21. It will be observed that:

- the 0.5m groundwater contour is retained between the borefield and the coast, preventing saline intrusion, and

- the groundwater mound contours to the east are not greatly affected and hence other users of the groundwater will not be greatly affected.

The model results indicate the groundwater flows from the mound towards Lake Walyungup will, on average, reduce by about 6 percent. The groundwater regime is not known in detail around Lake Walyungup, but if it is relatively similar along the whole periphery, then the reduction of 6 percent over the boundary closest to Port Kennedy would be equivalent to only a 2 percent overall reduction.

In practice, Lake Walyungup is not directly connected to the superficial aquifer, as the clay floor of the lake is relatively impermeable. The impact is therefore not expected to be significant.

In the longer term, the groundwater mound will change if Westport canals are fully developed. The model indicates that to prevent saline intrusion at the coast the safe abstraction rate at Port Kennedy, with Westport fully developed, will be 3,500kL/day. The impacts on the groundwater contours and saline intrusion are comparable to those described without Westport and with an abstraction rate of 4,000kL/day. To identify whether the combined impacts on Lake Walyungup were more significant, the model was run with Westport only and with Westport plus 3,500kL/day abstraction at Port Kennedy. The changes in flows to Lake Walyungup, directly attributable to the 3,500kL/day abstraction, could therefore be identified, and were shown to be much the same as with 4,000kL/day abstraction alone.

The model indicates that the dominant cause of change in flows towards Lake Walyungup with Westport canals and an abstraction rate of 3,500kL/day is due to the changes to the groundwater mound caused by the canals.

The effect of Secret Harbour has not been assessed as the Water Authority have advised these groundwater abstraction licences and approvals have lapsed.

11.4.3 Development of other Potential Groundwater Resources

Other existing and potential sources of irrigation water are as follows:

a) The surface aquifer at the borefield. The model simulation of groundwater abstraction is likely to be conservative as it takes no account of:

   - o the increased recharge likely to occur from local depression of the groundwater table adjacent to the borefield,
   - o the recharge to the surface aquifer resulting from irrigation,
   - o possible upward leakage from the Rockingham Sands aquifer, or
   - o the increase in recharge resulting from development on the site. This increase is expected to be nominal due to the small area and location of the development.

b) The surface aquifer. The proposed borefield for Port Kennedy has been located to minimise the ultimate effect of the Westport canals. When constructed, significant volumes of groundwater will be lost to these canals. If Westport does not proceed as planned, submission would be made to use this resource at Port Kennedy, either during the establishment phase

of Stage I or long term. As with the proposed borefield further south, the numerical model would be used as a tool to manage impacts.

c) Yarragadee aquifer. Saline groundwater from the Yarragadee aquifer would be blended with other groundwater to reduce the salinity to between 1,000 and 1,500mg/L. Use of this blended irrigation water would not impact on any other users, as the groundwater flow would pass directly into the ocean or seawater canals. There are no other users of the Yarragadee aquifer in the area. Estimated availability is 500,000kL/year (1,350kL/day).

d) Leederville aquifer. There are no plans to use groundwater from the Leederville aquifer for Stage I of Port Kennedy, due to the relatively small volumes available (300,000kL/year intermittent use).

e) Treated effluent. For subsequent stages of the Port Kennedy Recreation Centre, use of treated sewage effluent from the Water Authority Treatment Plant near Ennis Avenue would be considered when further development occurs in the area. At present there is only a small flow to the Treatment Plant and hence use of this resource is not currently feasible. Effluent would only be used after assessment of the environmental impact of the additional nutrients.

11.4.4 Initial Stage 1 Requirements

The initial irrigation requirements for Stage 1 are approximately 5,500kL/day reducing to the long term demand of approximately 4,000kL/day over five years. As the model indicates that abstraction in excess of 4,000kL/day from the shallow aquifer is unacceptable, it is proposed to obtain the balance in the short term from one of the following options:

- the use of resources lost to the Westport canals, providing construction of the canals has not commenced or has been abandoned. This matter cannot be confirmed at the time of writing the ERMP. Installation of a borefield for abstraction from the surface aquifer in the north of the site would be subject to further evaluation and submission to the EPA and the Water Authority,

- the additional recharge not accounted for by the conservative nature of the model. This will be determined by monitoring in conjunction with the Water Authority, once the borefield is operational, and

- use of the Yarragadee aquifer water. Development of this higher salinity source is proposed if the previous two options are not available.

In the event that Westport canals (Stage I) proceeds ahead of Port Kennedy, the Proponent proposes to obtain the supplementary irrigation water from the latter two options outlined above (ie, the

additional recharge not accounted for by the model or, the Yarragadee aquifer).

11.4.5 Impact of Dredged Spoil on Groundwater

Spoil dredged from the marina will be used to build up the foredune and primary dune in the area of the marina and hotel. Salt water trapped within the spoil will therefore only invade the freshwater aquifer immediately adjacent to the coast and hence will have no significant impact.

11.4.6 Summary

It is proposed to abstract 1,400ML/year (4,000kL/day) long term from the shallow aquifer and up to 2,000ML/year in the short term if monitoring of the impacts indicates this is acceptable. If monitoring of the impacts demonstrates this is unacceptable, Yarragadee water will be required to meet the first five years irrigation requirements unless construction of Westport canals does not proceed. If the Westport project does not proceed application will be made to use water from the shallow aquifer at the north of Port Kennedy.

It is concluded that the impacts of groundwater abstraction will be acceptable for both initial and long term requirements due to the proposed management and monitoring detailed in Section 12.

11.5 WATER QUALITY

11.5.1 Marina Water Quality

Water quality within the marina will be governed by the type and volume of pollutants entering the water within the marina and by the length of time required to flush the contaminated water out into Warnbro Sound. It is inevitable that operation of the marina will have some effect on water quality. The potential effects of such changes on the marine habitats are discussed in Section 11.9. The potential effects for users of the marina are discussed below.

Water quality criteria for marine and estuarine waters have been developed for the EPA (DCE, 1981). The criteria recognise 16 Beneficial Uses and set out a schedule of receiving water quality for each Beneficial Use. The Beneficial Uses which are appropriate for the Port Kennedy marina are:

Beneficial Use 2:	Harvesting of aquatic life (excluding molluscs) for food.
Beneficial Use 5:	Passage of fish and other aquatic life.
Beneficial Use 7(2):	Maintenance and preservation of aquatic ecosystems, Class 2 (high level of protection).

Beneficial Use 16: Navigation and shipping.

With sheltered north facing beaches either side of the marina it is not proposed to include a beach or other swimming facility within the marina. Thus it will not be necessary to satisfy the water quality criteria for Beneficial Use 1: Direct contact recreation, although occasional human immersion and wading can be anticipated.

The criteria for Beneficial Uses 5 and 16 are predominantly descriptive. The criteria for Beneficial Use 7 contain additional limits on the concentrations of specified parameters in the receiving water. Beneficial Use 2 is similar to Beneficial Use 7 with further criteria relating to metals accumulation and tainting agents.

As discussed in Section 12, a range of management controls will be included in the operation of the marina to minimise potential impacts on the marine habitats. It is expected that the management controls will result in maintenance of water quality adequate for the Beneficial Uses defined above. The main parameters of concern in drawing this conclusion are the concentration of the nutrients (nitrogen and phosphorus) and metals. The nutrients would be significant if their concentrations and residence time in the marina were great enough to cause algal blooms.

The residence time (or flushing time) of water in the marina has been analysed by the Centre for Water Research at the University of Western Australia; their report is included as Appendix F. In summary, exchange of water between the marina and Warnbro Sound will be governed by tides, wind-induced mixing and flushing, and gravitational circulation. The effect of each of these mechanisms has been calculated, resulting in estimates of flushing times of three days for gravitational circulation, nine days for astronomical tidal exchange, nine days for wind-induced shear and eddy dispersion in the absence of significant sheltering, and 20 days for wind-induced shear and eddy dispersion with significant sheltering. Hence flushing of the marina will be dominated by gravitational circulation and tidal exchange and the flushing time is expected to be in the range of three to nine days. This indicates the flushing of the marina will be adequate to prevent algal blooms occurring.

The conclusions from this analysis are consistent with results observed at other similar marinas along the coast.

11.5.2 Artificial Waterbodies

Within the development, there will be a number of artificial waterbodies. The water quality within these waterbodies will be maintained by a number of conventional means such as chlorination (where direct human contact will occur) as well as re-circulation and aeration.

The proposed waterbodies within the golf course present the biggest potential for reduced water quality, particularly during summer. However, these lakes will be used to store irrigation water during the day for use at night, and hence the flushing time for these lakes will be in the order of 4 days.

11.6 IMPACT OF NOISE AND DUST

11.6.1 Construction Phase

Earthworks for the golf course will be carried out immediately prior to the winter growing season. These works will be undertaken between 15 March and 30 September in accordance with the Shire of Rockingham's moratorium on earthworks. The majority of the remaining earthworks and construction activity will be in excess of 2km from the nearest dwelling.

As a consequence, the problem of noise and dust caused by the construction works on site will be minimal.

The approach avenue will be built at the start of the construction period. Construction traffic will therefore be able to gain access to the site via Ennis Avenue and the Port Kennedy approach avenue, rather than through residential areas to the north of the site. Noise and dust created by site traffic will therefore be minimised.

11.6.2 Operation Phase

During operation of the Recreation Centre dust problems will be minimised by windshading with landform or planting and management of any erosion sites. Noise will also be controlled by buffer planting and landform as necessary.

11.7 DRAINAGE AND SEWAGE

11.7.1 Drainage

Except for areas directly abutting the marina waterfront, drainage will be by soakage into the surface aquifer. Drainage on the islands within the marina will be to soakways with overflows to the marina. No adverse impacts are expected to result from the drainage system.

11.7.2 Sewage

A sullage pumpout station will be incorporated in the marina layout. Sewage from the pumpout station and land facilities will be collected and pumped to the Water Authority's treatment plant near Ennis Avenue. There will therefore be no detrimental impacts from this source.

11.8 IMPACT ON TERRESTRIAL HABITATS

11.8.1 Areas of Conservation Interest

The main areas of specific conservation interest identified on the site are:

- the seasonal wetlands,
- the foredune and primary dune coastal strip,
- the condition of vegetation,
- vegetation complexes, and
- the sequence of successive dunes and associated vegetation.

The impact of the development on the first two of these aspects has been reviewed previously in relation to landform and is briefly repeated below in relation to vegetation.

- One of the five major seasonal wetlands lies within the Stage I area. This wetland is already badly degraded. It has previously been cleared and burnt and its value is diminished by weeds and rubbish.

- Clearance of vegetation within the coastal strip generally will be limited to the area already degraded by squatters.

11.8.2 Condition of Vegetation

Figure 22 shows the condition of vegetation on the site. The categories shown on the map are defined as follows:

Category A Significant changes made by human influence, may have significant amounts of weeds including some of the more aggressive ones.

Category B Has definite signs of human impacts (such as grazing) leading to some (but not substantial) changes. Weeds present but not aggressive.

Category C Shows no evidence of human impact or shows signs of reversible impacts such as increased fire frequency, few tracks and little rubbish.

The dividing line between the above categories is not distinct except where existing tracks have acted as fire breaks or have channelled human use.
The Stage I development covers about 330ha including the conservation zones.

Stage I includes the following approximate areas of vegetation:

- o 150ha in Category A condition,
- o 80ha in Category B condition, and
- o 100ha in Category C condition.

The remaining 410ha of the site is generally in better condition than the land affected by Stage I. The 100ha (30%) in Category C condition in Stage I is confined to the area running parallel to the Warnbro Sound coast. Approximately 75ha (75%) of the 100ha will be restored as necessary and retained in conservation areas.

After removing tracks and rubbish, and re-vegetating areas south of Bridport Point and at the northern end of the site, an additional 30ha will be restored to near original condition. Thus for Stage I, a total of approximately 105ha out of 330ha will be retained as conservation areas.

11.8.3 Vegetation Complexes

Three areas of the site have been identified where common plant species have established in unusual floristic associations. These have been mapped at the level of "vegetation complex" and are described as follows:

- o Acacia lasiocarpa (AL) Complex. This complex lies in the southern part of the site and hence will not be affected by Stage 1.

- o Olearia axillaris, Jacksonia furcellata (OJ) Complex. This complex covers about 12ha and lies behind the primary dune south of Bridport Point. Much of the area is crossed by tracks and is badly littered. The Stage I layout will conserve approximately 50% of this complex within the conservation zone around Stage I. This area will be cleared of rubbish, restored and re-vegetated. The parts of development which will affect this complex are concentrated in the most degraded areas.

- o Olearia axillaris, Melaleuca acerosa (OaMa) Complex. This complex covers approximately 76ha and lies behind the OJ complex as well as behind the foredune further to the north. The southern 27ha (35%) of this complex will be cleared of rubbish as necessary, re-vegetated and incorporated in the conservation zone for Stage I. The central element of this complex will be covered by the hotel (see Photograph 2). The northern part of the vegetation complex will fall within the golf course and will be retained in part between the fairways. However, the character of the vegetation complex would undoubtedly change due to its low resilience to small amounts of increased moisture, nutrients, weeds and trampling. Management to preclude this change would be unlikely to be completely successful. It was concluded that the better approach would be to make the golf course more compact and enlarge the conservation area at the northern end of the site. This conservation area will contain approximately 3ha of the vegetation complex. Excluding areas within the golf course, nearly 40 percent of the

vegetation complex will be conserved.

The approach to the latter two vegetation complexes is a balance between retention of significantly sized representative areas in good condition compared to the current situation of a larger area in a degraded condition.

The remainder of the golf course area presently consists largely of Jacksonia furcellata, Acacia saligna complex. This is the most widespread complex within the study area and is also thought to extend into adjacent private land that is presently utilised for grazing. This area is also one of the most degraded within the site having been extensively dissected by tracks and frequently burnt. Therefore, clearing to enable golf course construction is considered to be environmentally acceptable.

None of the proposals to clear vegetation will result in the removal of any plant species that are rare, endangered or geographically restricted.

11.8.4 Dune Succession and Associated Vegetation

An area of about 14ha at the northern end of the site will be set aside to conserve the sequence of dunes and associated vegetation. About half of the area is in Category C condition. The remainder is dissected by tracks which will require restoration.

This conservation zone will adjoin the conservation zone along the coastal strip and contains areas of the following vegetation complexes.

- Jacksonia furcellata, Acacia saligna
- Olearia axillaris, Acacia cochlearis
- Olearia axillaris, Melaleuca acerosa
- Acacia rostellifera, Melaleuca acerosa.

The viability of the vegetation complexes in this conservation zone will be monitored and managed as described in Section 12.5 and Section 13.0

11.8.5 Fire

There is no intention of purposely encouraging or increasing the frequency of fire in vegetated areas that will remain adjacent to the developed areas. However, the increased fire risk that accompanies provision of greater access and consequent increased utilisation of the site for recreation is a potential impact.

The vegetation within the study area has already undergone detrimental change due to overly frequent burning. The need to institute control measures is apparent from the present condition of

vegetation in the northern sector of the project area.

The development will therefore incorporate fire management devices and procedures in detailed planning. Management to prevent or reduce fire to below the present frequency should be considered as a substantial benefit of the proposed development.

11.8.6 Hydrological Cycle

The abstraction of groundwater to provide supplies for potable and irrigation purposes will result in drawdown of the watertable within the superficial aquifer. Drawdown will be greatest in the eastern inland sectors of the site. Lowering of the watertable by 0.5 - 1.0m is anticipated in inland areas. The abstraction system will be designed and monitored to avoid drawdown along the coast, preventing saline intrusion.

It is probable that the drawdown will have some impact on the vegetation in the seasonal wetlands, although the change will be difficult to predict as seasonal surface ponding of rainfall and retention of moisture will continue to occur.

The swales forming the seasonal wetlands would typically be between 1 and 2m above the water table. On the basis that the seasonal wetlands in best condition are near the coast in the southern part of the site, where the drawdown will be 0.5m or less, the potential impact is not viewed as a constraint on development. However, monitoring of the potential impact as described in Section 12 is considered appropriate.

11.8.7 Nutrient Cycle

Nutrient dispersion from the Stage 1 landscaped area to the conservation zones and other parts of the Port Kennedy site will be minimal since lateral dispersion due to run-off through the surface environment will not occur because of the site topography.

11.8.8 Human Impacts

The increased use of the site has the potential to affect vegetation on the site. Management of these impacts is described in Section 12.

11.8.9 Approach Avenue

The avenue alignment is located within Government land reserved for public purposes. The junction with Ennis Avenue has been located as shown in Figure 3 following discussions with the Shire of Rockingham, State Planning Commission and the Main Roads Department. The approach avenue

between Ennis Avenue and the Port Kennedy boundary runs through land recently used for grazing and through landforms and vegetation well represented between Rockingham and Mandurah. The impact of the approach avenue on terrestrial habitats is therefore minimal.

11.9 IMPACT ON MARINE HABITATS

11.9.1 Introduction

The development of the **Port Kennedy Regional Recreational Centre** will result in some impact on the marine habitats described in Section 9. The potential impacts will result from changes in the quality of groundwater flowing into Warnbro Sound as well as from the construction and operation of the marina.

The expected potential impacts on the marine habitats are as follows:

- additional nutrient inputs to Warnbro Sound due to leaching of fertiliser into the groundwater and gradual transmission towards the coast,
- temporary degradation during the construction period of the marina due to increased turbidity,
- permanent change to the area occupied by the marina,
- provision of new habitats within the area occupied by the marina, and
- increased recreational impacts, including occasional degradation of the marine environment resulting from unavoidable occurrences such as fuel spills.

Each of these potential impacts is discussed in detail in Appendix E and briefly considered below. None of the impacts are considered to be significant.

11.9.2 Increased Nutrient Inputs

A supply of nutrients is essential for any ecosystem. A complex equilibrium exists between biological productivity, nutrient availability, and other factors. Excessive nutrient inputs can cause a shift in productivity to different, more opportunistic species, reducing the level of diversity within an ecosystem.

The input of nutrients to Warnbro Sound could increase due to an increase in nutrient loads in the groundwater flowing into the sound, or due to contamination of water inside the marina which is subsequently flushed into the Sound.

The sustainable nutrient loading of Warnbro Sound is dependent upon a number of aspects including volume, circulation and flushing. As discussed in Appendix E, the sustainable loading of Cockburn Sound is not known with certainly after many years of study. Comparable long term studies have not been commenced for Warnbro Sound and hence reliable data is not available. For the purpose of providing an indicative assessment of the potential impact the sustainable loading of Warnbro Sound is assumed to be in the order of 200kg/day of nitrogen by comparison with Cockburn Sound. However, the 200kg/day of nitrogen is considered likely to be a lower limit as the comparison with Cockburn Sound makes no allowance for the significantly better flushing that will occur in Warnbro Sound.

Due to current concern regarding nutrient inputs into marine environments, the Proponent proposes to adopt the following fertiliser application regime to minimise nutrient leaching from the golf course.

- use of slow release fertiliser with application timed to minimise nutrient leaching during winter,

- use of liquid foliar fertiliser applied by boom sprays a little at a time at frequent intervals,

- control of irrigation rates by automatic moisture measurement. This will eliminate, as far as practical, leaching of nutrients during high fertiliser application in summer,

- use of supplementary soluble fertiliser applied by injection with the irrigation water during peak nutrient demand by the grass. In conjunction with the automatic moisture control of irrigation, this application method will minimise nutrient leaching in summer,

- management and monitoring measures as described in Section 12.

As the sustainable loading of Warnbro Sound has not been rigorously assessed for reasons outlined above, the quantity of nutrients leaching into the groundwater as a result of the proposed fertiliser application regime has been produced by a similarly indicative assessment. The quantities of nutrients leaching into the shallow aquifer is based on the following considerations:

- Recharge of the shallow aquifer is by winter rainfall. Due to the high permeability and flat topography of the site, recharge is generally by direct infiltration. As only approximately 20 percent of the fertiliser is applied during winter, the amount of nutrients leaching into the shallow aquifer with rainfall recharge from this source is estimated to be in the order of 5 percent to 10 percent of the total applied annually.

- Even with the proposed fertiliser monitoring and irrigation controls, there is likely to be some leakage of nutrients into the shallow aquifer as a result of watering and rainfall during summer

as well as build up of nutrients caused by application of fertiliser. With appropriate management of the system, nutrient leaching from fertiliser applied in summer is estimated to be in the order of 5 percent to 10 percent of the total applied annually.

On this indicative evaluation, the total nutrient load leaching into the shallow aquifer seems unlikely to exceed 20 percent of the total applied. Twenty percent of the applied fertiliser is equivalent to an average of 16kg/day of nitrogen and 1.3kg/day of phosphorus. This will enter Warnbro Sound via the shallow aquifer along approximately 2km of the coast. Phosphorus is likely to be a less significant problem than nitrogen as the marine environment is deficient in phosphorus. In addition, the Quindalup dunes at Port Kennedy have a high calcareous content and are known to have some phosphorus attenuation ability.

From the above approximation the estimated 16kg/day of nitrogen leaching into Warnbro Sound is not likely to exceed eight percent of the nominal sustainable load capacity of Warnbro Sound. It should be noted that some nutrients from septic tanks and domestic garden fertiliser applications already enters Warnbro Sound.

It is concluded that the increase in nutrient loads from the Recreation Centre is unlikely to measurably reduce the existing waterbody quality.

If the proposed Westport canal development proceeds, the impact of nutrient leakage can be reduced by soil modification of all fairways adjacent to the canals to minimise leaching of nutrients through the soil.

The discharge of wastes within the marina will be controlled to minimise water pollution. The management steps which will be implemented to achieve this are discussed in Section 12. The management measures together with the predicted flushing of the harbour are expected to result in the marina water quality being better than, or similar to, that in other coastal marinas near Perth.

The potential exists for accidental discharges of sewage or stormwater run-off into the marina. These discharges, if they occurred, would be infrequent and would result in only small nutrient loads entering the marina and hence Warnbro Sound. Any such discharges would not have a significant effect on the marine habitats of Warnbro Sound.

11.9.3 Temporary Effects of Marina Construction

The principal effect occurring during the construction of the marina will be an increase in turbidity in the water adjacent to the area being dredged or in which rockfill is being placed.

Increased turbidity may result in a number of biological effects such as the following discussed in the Sorrento Boat Harbour ERMP (Scott & Furphy, 1984):

a) reduction of light penetration through the water and adverse effects on organisms which are dependent on photosynthesis for survival (such as algae and seagrass),

b) increase of particulate matter in the water and adverse effects on filter feeding organisms by clogging their filtering apparatus,

c) inhibition of growth and survival of sessile organisms and damage by abrasion,

d) interference to some species of fish and, in particular, to juvenile stages and larvae,

e) inhibition of larval recruitment,

f) oxygen depletion where some sediments suspended by spoils disposal exert a strong biochemical oxygen demand, and

g) nutrient enrichment by release of organic nutrients (where present) from muds.

The marina for the **Port Kennedy Regional Recreation Centre** will be located at Bridport Point in an area with a patchy seagrass meadow. Furthermore, coastal transport processes which have led to the formation of Bridport Point will tend to restrict the movement of suspended particles away from the construction area. The majority of suspended particles would be expected to settle within the buffer zone of essentially bare sand to the west and north-west of the marina site. Hence a significant impact from short term increase in turbidity is unlikely.

11.9.4 Permanent Alienation of the Marina Site

Construction of the marina will involve dredging and rock backfill. The marina will extend over an area of about 18ha which currently has patchy seagrass coverage estimated to be 40 - 50%. Hence dredging will remove perhaps 8 ha of seagrass. As the total area of seagrass within Warnbro Sound is 930ha (Hillman, 1984), the area lost by construction of the marina will be less than 1 percent of the total.

The relevant seagrass species are well represented throughout Warnbro Sound and along the metropolitan coast. Thus, the significance of the loss of the small area of seagrass within the marina breakwater will be minimal.

11.9.5 Provision of New Habitats Within the Marina

It is expected that the marina will provide new habitats as has been anticipated in ERMP's for similar developments (e.g. Westport, Rockingham Marina). The sandy bed will be inhabited by plants such as colonising species of seagrass and by fish and invertebrates typical of sand bottoms.

The breakwaters and structures within the marina will be colonised by a variety of attached algae and encrusting animals such as mussels, barnacles and sponges. It is also likely that juvenile fish will colonise the protected water body.

11.9.6 Increased Recreational Impacts: General

Water-based recreation is expected to be a primary component of activities pursued by visitors to the **Port Kennedy Regional Recreation Centre.**

The degree of impact of these activities on the marine environment will depend on such factors as the type of activity, the intensity of use and the sensitivity of a specific habitat or biota to a particular disturbance.

The potential activities which may result in an environmental impact, are beach activities (i.e. the use of onshore intertidal areas), the use of power boats, collecting on islands and reefs, and offshore amateur fishing.

11.9.7 Increased Recreational Impacts: Beach Activities

The beaches at Becher Point are attractive for line fishing, swimming and general beachcombing. There are no limestone platforms where reef harvesting would otherwise have been of concern. Fishing is the only beach activity which may directly affect biota. The main recreational fish of the nearshore waters are migratory species such as Australian herring, southern sea garfish, salmon, skipjack, trevally and tailor. These species all have wide distributions, extending across southern Australia, and their population status is not considered to be threatened. Other popular species such as whiting, sea mullet and yelloweye mullet are considered to be locally abundant.

Hence it is not expected that beach-related activities will have a significant effect on the nearshore marine environment at Becher Point.

11.9.8 Increased Recreational Impacts: Boating

The marina will cater for 380 boats, resulting in high boating activity during the summer months. The main potential impacts from this activity arise from discharges of wastes and fuel from the boats and from anchor damage.

Adequate facilities will be provided at the marina for disposal of wastes from boats. Hence in normal operation there will not need to be any discharge of wastes from boats into Warnbro Sound. However, it is likely that there will be infrequent accidental fuel and oil spillages. It would be expected that the volume of any spills would be small. The diesel and petrol/oil mixture used for fuel in small boats evaporates and disperses quickly, resulting in a short term aesthetic effect, but

not in major fouling of marine habitats. Hence fuel spills are not expected to result in a significant environmental impact.

Damage due to anchoring is an unavoidable consequence of boating activity. The existing swing moorings near Becher Point appear to have damaged the seagrass meadow. Widespread damage has resulted from swing moorings in the Mangles Bay area near Rockingham. This damage, caused by the anchor chain dragging across the sea bottom, does not occur with the fixed moorings proposed for the Port Kennedy marina. Swing moorings are not proposed outside the marina.

Boat excursions from the marina will invariably involve short-term anchoring at specific localities. The random nature of this phenomenon suggests that there will be no noticeable impacts, in comparison to a designated swing-mooring zone.

11.9.9 Increased Recreational Impacts: Fishing and Lobster Harvesting

Line fishing and spearfishing are popular activities wherever limestone reef occurs. In addition to fin fish, the reefs are also a rock lobster fishery and a source of cowries and other shellfish for collectors.

Reef fish that are commonly sought by recreational anglers and divers include dhufish, tarwhine, breaksea cod, blue groper, baldchin groper, queen snapper, harlequin fish and banded sweep. As recreational fishing pressure increases, catch rates may decline and the size of fish taken may be reduced. However, it is recognised that a decline in the catch rates may largely be due to greater numbers of people fishing, rather than a reduction in fish populations. There is a notable lack of scientific information regarding the present status of reef fish in the M101 area.

Anecdotal evidence collected in the area of the Marmion Marine Park strongly suggests that some fish species are significantly depleted and may be overfished. Species such as blue groper and baldchin groper may have markedly decreased population stocks in local areas. It is also clear from the anecdotal evidence that the resident populations of reef fish are more likely to have suffered changes in population structure, in comparison to pelagic and migratory species.

With respect to rock lobsters, there is a great deal of research information which suggests that the high larval recruitment of this species allows high levels of harvesting to be maintained without depleting stocks over long periods.

The productivity of the lobsters and existing management controls on the commercial fishery indicate that they are not in danger of over exploitation. However, when intensive fishing by amateurs and professionals is allowed in the same area, lobster stocks can be severely reduced.

It must be concluded that the Port Kennedy development will result in increased fishing pressure on nearby reefs. However, the reefs are already under pressure from existing use. This pressure can be expected to increase further as a result of the growing population of the area, irrespective of whether this particular project proceeds. It is also significant that two other proposals for the area, Secret Harbour (1,000 - 1,200 boats) and Westport (572 waterfront lots) have received approval to proceed but have not commenced development.

A consequence of the greater pressure on the reef will be a decline in catch rates per unit effort and a reduction in the mean size of animals caught. Whilst the sustainable yield of local populations of reef fish and shellfish is not known, that there is little risk of species extinction. However, management measures may be required to prevent severe local depletion of some species as a result of the combined impact of greater fishing effort.

11.9.10 Increased Recreational Impacts: Reef Harvesting

The high reef platforms associated with the offshore chain of islands and limestone pinnacles support a wide range of animals that are an attraction for people interested in harvesting and collecting. For example, sea urchins, turbo shells, mussels and Roe's abalone are known to occur. Indiscriminate and uncontrolled harvesting can significantly reduce the abundance of target biota and cause alterations to the species composition. However, the local animal populations have not been studied in detail and a statement regarding their status is not possible.

Whilst there are no high reef platforms in the vicinity of Becher Point that are accessible on foot, boat access is relatively easy.

However, it is difficult to predict the degree of reef harvesting that will occur as a result of the development and the ecological consequences can only be speculative.

Studies conducted in the Marmion Marine Park indicate that it is the onshore intertidal reef platforms that are most susceptible to harvesting pressure. This is obviously related to the easy accessibility of the onshore platforms. The nearest onshore platforms to Port Kennedy, at Cape Peron, are apparently already intensely harvested over the summer months. Harvesting pressure on the high reef platforms offshore from Becher Point will be less than onshore reef areas because periods of moderate swell and/or fresh breezes significantly reduce the accessibility of these platforms.

Whilst it is recognised that reef harvesting activities have the potential to reduce the abundance of certain organisms, the ecological significance cannot be quantified without further extensive study.

11.9.11 Summary

A number of potential impacts of the proposed development on the marine environment have been identified. Some of the potential impacts will be prevented or minimised by the adoption of relevant management practices to be developed in conjunction with the proposed study of the area by the EPA. In particular, there will be a need for careful management of recreational use of the proposed M101 Marine Park.

The perceived impacts in the immediate area of the marina are minor and are not considered to be an impediment to the development. Impacts on marine biota due to increased recreational fishing and harvesting are difficult to fully assess but will inevitably increase in the region regardless of whether particular developments proceed.

11.10 IMPACT ON THE HUMAN ENVIRONMENT

11.10.1 Recreational Use and System Six

The development will have a number of beneficial impacts for recreation as follows:

- provision of the first stage of a regional recreational centre supporting a wide range of active and passive recreational facilities,

- passive recreation in a natural setting on 3km of beaches beside the northern conservation zone and around Becher Point,

- passive recreation in the marina area and the sheltered beaches adjacent to the marina. This type of recreation has proved very popular at similar facilities on the coast at Fremantle and Hillarys,

- passive recreation within conservation zones at Bridport Point and behind the marina,

- provision of facilities for active recreation and water sports at the marina, and

- provision of a high standard golf course for public use.

System Six recognises the recreation potential of the site and hence the proposed development is considered consistent with the System Six requirements in this regard.

11.10.2 Visual Impact

The marina, accommodation units and hotel will all have a visual impact on the environment.

The rubble mound breakwater for the marina will be similar to a number of other marinas in the Perth metropolitan area and is thus not considered an unacceptable visual impact.

The accommodation units in the marina will be one or two storeys high. The town centre facilities and beach units will be one, two or three storeys high. These structures will all be less than the planning height limitation of 12m and, due to the lower ground levels, will have a similar visual impact to the residential area at the northern end of Warnbro Sound.

The hotel is located behind the primary dune on land some 3 to 4m lower than the primary dune. In the golf course to the east of the hotel, there is a relict dune, running north-south, of similar height to the primary dune. It is proposed that the hotel will have a ground floor level plus three floors of accommodation with views over the primary dune. The total building height will be 17m of which the lower 4m will not be visible from either land or seaward side. Both the primary dune and the dune within the golf course will be planted with trees to provide a visual screen. The golf course along the site boundary will also be planted with trees and shrubs to visually screen the development and screen the future residential areas from within the site.

11.10.3 Historical, Archaeological and Ethnographic Sites

As the survey of Port Kennedy did not reveal any archaeological or ethnographic sites, it is concluded there will be no impacts. The survey along the approach avenue between Ennis Avenue and the site also revealed no known sites. The **Proponent** will report any sites that might be uncovered during construction and be advised by the Western Australian Museum on appropriate action.

The only known shipwreck in the vicinity of Port Kennedy will not be affected by the marina construction or resultant shoreline accretion.

11.10.4 Existing Use: Squatters

The presence of squatters constitutes an unauthorised occupation of the land. Various attempts have been made to evict the squatters since 1961, but none have been completed due to the lack of concrete proposals for the site.

The squatters and other visitors have been poor managers of the land. Rubbish disposal has occurred on an ad-hoc basis in the dune country immediately east of Bridport Point. In addition to household refuse, discarded domestic appliances and food waste, car bodies have also been

deposited throughout the site, particularly within the northern sector. The proliferation of access tracks created by squatters and day visitors has also scarred the site and has initiated many wind erosion problem areas. This problem is emphasised by System Six, which states that removing of shacks and tracks are important management considerations.

The management offered by the development is considered a beneficial impact compared to the current unmanaged use of the site by the squatters and other visitors.

11.10.5 Existing Use: Fishing

The **Recreation Centre** will improve access for fishing from the shore. The current practice of launching boats for fishing from the beach will not be feasible from the proposed development. As outlined in Section 6.3, it is not proposed to include a public boat launching ramp in the marina, principally because in subsequent stages of the development it is planned to exclude vehicles from the site in accordance with the Development Brief (SPC, 1986).

11.10.6 Existing Use: Access to Beaches

Access to the beach for all members of the public is provided by this development. Previous access to the beach has generally been restricted to owners of off-road vehicles.

The beach, particularly within Warnbro Sound, is currently used by numerous off-road vehicles. This detracts from use of the beach at present.

The marina construction will remove 700m of beach from the 7.5km in the Port Kennedy site. Under the development agreement, a public accessway has been provided around all sections of waterfront within the marina. Provision of gazetted roads, public accessways and leasehold Crown Land will guarantee public access between the beach and the remainder of the site through the freehold land areas. As part of the **Recreation Centre** facilities a number of amenities will be provided for use by the general public.

On balance, the development will have a beneficial impact on use of this section of coastline by the majority of the public.

11.10.7 Off-Road Vehicles

Off-road vehicles will be excluded from the Stage I development. Access to the rest of the site will be prevented by use of log barriers or similar obstructions. In view of the indiscriminate impact on the site by off-road vehicles, relocation of this activity to a less sensitive area will be a benefit to the conservation of the site.

11.10.8 Traffic and Parking

As discussed previously, an objective of the ultimate development will be exclusion of vehicles from the site (except for trade vehicles and other essential uses). The parking area provided in Stage 1 is therefore temporary. The Stage 1 parking area has been located behind the primary dune to visually separate the marina development from the carparking.

Parking will be provided for 1,650 cars behind the marina and adjacent to the public golf club and hotel. Additional grassed areas will be used for overflow parking during golf tournaments and other special events.

During peak summer periods, the Stage 1 development is expected to attract up to 1,650 cars for day visits and long term use associated with the holiday accommodation. This is expected to generate a maximum of 3,000 trips per day. This traffic would approach the site from the north and south along Ennis Avenue (Perth-Mandurah Road) and the Port Kennedy Approach Avenue. The existing and proposed road system will adequately handle these flows.

The impact of traffic and parking is therefore expected to be minimal.

11.10.9 Services

The relevant Authorities indicate that the development will not over-tax the capacity of existing services and hence no impact is anticipated.

11.10.10 Construction Workforce

Construction will be undertaken by workers from Rockingham and Perth commuting to the site daily. As the construction site is remote and the approach avenue will be constructed at the start of the construction phase, any impacts will be minor.

The economic impact of increased employment will be beneficial.

11.10.11 Unexploded Ordnances (UXO's)

Within the areas of the site already searched for UXO's, excavation depths will only locally exceed 2m in a few instances for items such as service trenches and major foundations. These areas will be researched as necessary for each additional 2m of excavation depth.

Excavation outside previously searched areas will require clearing of surface obstructions (vegetation, rubbish etc) and searching prior to any digging commencing.

The above procedures will make the risk comparable with normal risks applying to major civil engineering construction work.

11.10.12 Existing Urban Communities

Benefit will be gained for areas to the south of Port Kennedy as a result of funding for extension of services beyond the existing development front. Additional benefit will be derived from the focus the Recreation Centre will provide for the economic development of the region generally. It is anticipated that the construction phase will have only relatively minor impacts on adjacent communities.

11.11 SYNTHESIS OF IMPACTS

11.11.1 General

The impacts of the Stage I development can be broadly categorised as follows:

- beneficial impacts
- minor or neutral impacts
- impacts on areas of specific conservation interest
- potential impacts requiring ongoing management and monitoring.

Synthesis of these impacts is presented below.

11.11.2 Beneficial Impacts

The major beneficial impacts of this development are as follows:

- provision of coastal and land based recreation facilities,

- co-ordinated management of the site, removal of rubbish and squatters' huts, restoration and regeneration of vegetation within conservation zones as recommended by System Six,

- management and particularly reduction of fire frequency in areas set aside for conservation of vegetation,

- provision of access to the beaches for the general public,

- provision of employment during both construction and operation of the Recreation Centre, and

- o regional and local economic benefits from tourism and development of the area.

11.11.3 Neutral, Minor or Acceptable Impacts

On the basis of detailed evaluations in preceding sections of this ERMP, it is concluded that there will be only neutral, minor or acceptable impacts with respect to the following aspects:

- o noise,
- o dust,
- o drainage,
- o services,
- o traffic and parking,
- o the approach avenue beyond the site boundary,
- o existing urban communities,
- o the terrestrial nutrient cycle outside the Stage I area,
- o water quality in Warnbro Sound,
- o artificial waterbody water quality,
- o marina construction,
- o damage or loss of seagrass, and
- o dredged spoil on groundwater or turbidity.

As no rare or endangered flora and fauna or historical sites were discovered during detailed investigation of the site, there will be no impact on these items.

11.11.4 Impacts on Areas of Specific Conservation Interest

Evaluation of the existing condition of the site has indicated that significant areas of the proposed Stage I area have been degraded by previous use and could be acceptably developed providing appropriate management measures are put in place. Specific conservation aspects are as follows:

a) Conservation zones: Of the 330ha included in Stage I, approximately 105ha (32%) will be included within conservation zones. Access through the conservation zones will be controlled and managed by tracks and fences.

b) Foredune and primary dune: The proposed development is limited to the area degraded by squatter use. The majority of these dunes, north of the development and at Becher Point, will be included within conservation zones.

c) Curvilinear dune: Except for a small part at the western end of the area of curvilinear dunes, this scientific reference zone will be retained within the conservation zone south of the marina.

d) Seasonal wetlands: The most degraded of the five major seasonal linear wetlands falls within Stage I. This will in part be retained in near natural form. The condition of the other wetlands will be monitored.

e) Inland relict foredune: The relict foredune plain is extensive throughout the Rockingham to Mandurah coastal plain and the general landform will be retained within the golf course.

f) Vegetation condition: Overall, 75ha (75%) of the vegetation complexes showing little evidence of impact by man (Category C condition, Figure 22) will be retained in conservation zones within Stage I. A further 30ha will be restored and re-vegetated as necessary for inclusion within conservation zones.

g) Vegetation Complexes: Three areas of the site have been identified where common plant species have established in unusual floristic associations. These vegetation complexes are described as follows:

- o Acacia lasiocarpa Complex. This complex lies in the southern part of the site and hence is not affected by Stage 1.

- o Olearia axillaris, Jacksonia furcellata Complex. Much of the area is crossed by tracks and is badly littered. The Stage I layout will conserve approximately 50 percent of this complex within the conservation zone around Stage I. This area will be cleared of rubbish, restored and re-vegetated. Development has been centred on the most degraded areas.

- o Olearia axillaris, Melaleuca acerosa The southern 27ha of this complex will be cleared of rubbish as necessary and re-vegetated and incorporated in the conservation zone behind the marina. A further small area will be included in the northern conservation zone. Overall, nearly 40 percent of the total vegetation complex will be retained.

The approach to the latter two vegetation complexes is a balance between retention of significantly sized representative areas in good condition compared to the current situation of a larger area in a degraded condition.

The golf courses are located largely on the Jacksonia furcellata - Acacia saligna complex. This is the most widespread complex within the study area, and is also thought to extend into adjacent private land that is presently utilised for grazing. This area is also one of the most degraded within the site, having been extensively dissected by tracks, and very frequently burnt. Clearing to enable golf course construction is therefore considered to be environmentally acceptable.

The approach avenue has been used to provide a barrier for weeds, nutrients and moisture between Stage I and the remainder of the site.

11.11.5 Potential Impacts Subject to Ongoing Management

A number of potential impacts will require ongoing monitoring and management as detailed below:

- increased human use during construction and operation and the resulting potential for fire and erosion,
- groundwater abstraction and the potential for saline intrusion as well as potential impact on the wetlands to the east, seasonal wetlands within the site, and abstraction by other users,
- interruption of existing sediment transport regimes and the impact of accretion and erosion,
- the effect of use of the site on regrowth within conservation zones and the vegetation condition in seasonal wetlands and other parts of the site outside Stage I,
- marina water quality,
- additional boating and fishing, and
- nutrient leaching.

These impacts and their proposed monitoring and management are discussed in Section 12.

SECTION 12.0

MANAGEMENT AND MONITORING

12.0 MANAGEMENT AND MONITORING

12.1 MANAGEMENT BOARD

The **Port Kennedy Joint Venture** will have continued involvement and a vested interest in the ongoing presentability and management of the project. The **Joint Venture** is represented by two of the seven members of the Management Board.

Once the Management Board is legally constituted the **Port Kennedy Joint Venture** will only retain responsibility for care of the freehold land and leasehold land such as the golf courses. The Management Board will take over the **Proponent's** responsibility for management and monitoring of other aspects of the development such as conservation zones and other areas of public open space. Funding from the Management Board will be provided by the Joint Venture.

12.2 MANAGEMENT OF INCREASED HUMAN PRESSURE

12.2.1 Construction Phase

Potential impacts will occur as soon as construction starts. Control of these impacts will be detailed in the Specification for the construction contract and will include the following management requirements.

- Installation of physical barriers (logs or similar) along the approach avenue to prevent off-road vehicular access south of the defined Stage I boundary from the start of construction.

- Provision of locked gates through the barriers (on existing tracks) to prevent access to the south of the site during Stage I construction, except for emergency vehicles.

- Construction of fire breaks around the Stage I area and around all conservation zones at the commencement of the construction work.

- Immediate delineation of the conservation zones to eliminate access except for construction of pedestrian and cycle tracks, clearing of rubbish, revegetation and restoration. When restored, conservation areas will be fenced off.

- Initial responsibility and, if necessary, implementation of a fire management plan as developed by the **Proponent** in conjunction with the Bush Fire Controls Board and the Department of Conservation and Land Management.

12.2.2 Site Layout and Development Facilities

Wherever possible, ongoing management requirements have been minimised by the arrangement of the site layout and by the provision of facilities to control impacts.

The site layout for Stage I has been arranged with the access avenue along the southern boundary to provide a barrier for weeds, additional moisture and nutrients between Stage I and the remainder of the site. Roads, secondary paths and cycleways will be used for the same purpose between conservation zones and other areas within Stage I. The conservation zone south of the marina will act as a buffer zone and will be used to control pedestrian access from the area of most intense human use to the southern part of the site.

Paved pedestrian and cycle trails will be provided throughout the site to manage the impact of additional foot traffic.

Accessways will be fenced through the more sensitive areas of vegetation and landform such as the primary dune and beach areas in the same manner as other managed dune areas. Comprehensive signage and education boards will be provided to direct and manage pedestrian traffic.

12.2.3 Landscape Stability

During and after construction exposed sand areas, cuts, temporary roads and earthform areas will be sealed and rehabilitated on a temporary or permanent basis using bituminous seals (free of petroleum products), brush, temporary grass, nurse crops, trees and shrubs.

Inspection and reporting on landscape stability and erosion will be undertaken annually.

12.2.4 Fire Management

A comprehensive fire management plan will be developed in conjunction with the Bush Fire Control Board and the Department of Conservation and Land Management. The fire management plan will include the following aspects:

- provision and maintenance of fire breaks around the conservation zones, the Stage I boundary and the Port Kennedy site boundary,

- provision of trained personnel and equipment to suppress fires, in conjunction with other fire fighting organisations,

- to preserve diversity of species in the conservation zones, fire will be precluded, and

- o in the southern part of Port Kennedy, outside Stage I, certain existing tracks, as identified by the fire management plan, will be maintained as fire breaks and for access in event of fire.

12.2.5 User Education

A programme of education will be used to raise visitor awareness of the recreation potential of the terrestrial and marine habitats and their environmental limitations.

12.3 SEDIMENT TRANSPORT

The sediment transport will be monitored and managed as follows:

- o the shoreline on both sides of the harbour will be surveyed on a regular basis, six monthly for the first two or three years until seasonal trends are established, and then annually,

- o bypassing of sand, as required from time to time, to replenish beaches to the north of the development. The extent and frequency will be small. Access will be provided from the road to the beach on both sides of the marina to allow for cartage of the sand,

- o the entrance bathymetry will be monitored on an annual basis. There is adequate capacity for sediment storage against the breakwaters on the east and west sides of the development to cater for expected accretion over the next 40 to 50 years. There should be no significant sedimentation of the harbour entrance in that time, and

- o extension of the spur groynes could be undertaken at some time in the future after the anticipated 40 to 50 years storage has been used, to increase sediment storage capacity if required, or to prevent leakage of small quantities of sand along the breakwater, should problems occur.

12.4 GROUNDWATER MONITORING AND MANAGEMENT

The numerical model, developed as part of the preparation of this ERMP, will be used for ongoing management of the shallow aquifer. The model will be further refined by field testing at the production bore site and monitoring of short and medium term responses to abstraction.

Monitoring of the aquifer will include:

- o a line of five monitoring bores to automatically record groundwater levels between the coast and Ennis Avenue,

- the monitoring bores between the borefield and the coast will be designed to monitor the location and possible movement of the saline interface,

- annual testing of water quality at the monitoring bores and of the abstracted water,

- volumes of groundwater abstracted and local rainfall will be recorded to allow further calibration of the model.

Monitoring requirements will be resolved in conjunction with the Water Authority. The irrigation water pumped from the shallow aquifer will be adjusted in response to the results from the monitoring programme and the requirements of the Water Authority. In the event that sufficient water is not available from the shallow aquifer then the supply will be supplemented by use of the deeper Yarragadee aquifer.

12.5 MONITORING OF IMPACTS ON TERRESTRIAL HABITATS

The proposed development will be planned and managed to have minimal impact on the conservation zones incorporated in Stage I and on terrestrial habitats in the remainder of the site. However, in view of the conservation value of the site the **Proponent** proposes to monitor on an annual basis the vegetation species diversity and condition at six sites in the conservation zones, restored areas and the areas outside Stage I including the seasonal wetlands. The selection of these sites will be resolved in conjunction with the Department of Conservation and Land Management.

In addition to monitoring vegetation in the seasonal wetlands, six monitoring bores will be installed in two of the wetlands to record water level changes in the shallow aquifer.

Management measures will be implemented to minimise impacts on terrestrial habitats in accordance with the requirements of the EPA and the Department of Conservation and Land Management.

12.6 MARINE AND HARBOUR WATER QUALITY

12.6.1 Management

Management of the marina will incorporate measures to control and, where necessary, remove the following potential environmental problems:

- sea grass wrack accumulation,
- sullage from boats,
- oil, fuel, antifouling and antifouling scrapings,
- flotsam, foodstuffs and other rubbish, and
- accidental spillages.

At this preliminary stage, design of proposed fuel areas, drainage and similar facilities has not been undertaken in detail. The proposed measures will be similar to other marinas in the metropolitan area. When completed, these detail design aspects will be submitted for review by the EPA if requested.

12.6.2 Sampling and Testing

In the first year of operation, monitoring of water quality will be undertaken quarterly at three locations inside the marina and one location outside. Thereafter, testing will be six monthly at a single location inside and outside the marina. Testing will include:

- pH,
- temperature,
- dissolved oxygen,
- total nitrogen,
- total phosphorus,
- chlorophyll a,
- bacteria, and
- light penetration at depth intervals of 0.5m.

Sediment sampling will be carried out annually at locations inside the marina, at the marina mouth and outside the marina. These samples will be tested for:

- lead,
- copper,
- tin,
- zinc,
- total nitrogen,
- total phosphorus, and
- bacteria.

If testing reveals problems, management measures and additional testing programmes will be initiated in conjunction with the Environmental Protection Authority and the Department of Marine & Harbours.

12.7 ADDITIONAL BOATING AND FISHING

Contemporary surveys of the marine life in the System Six M101 area are limited in scope. There is a need to undertake further study and complete a management plan for the area. The Proponent has made a commitment to contribute to the funding of a proposed EPA study of the marine environment of the region with a view to facilitating development of a management plan for the

area. The **Proponent** will institute a programme of education to advise visitors of the requirements of the management plan.

It is the **Proponent's** view that control of impacts on the proposed M101 Marine Park resulting from additional boating and fishing should be the responsibility of the Department of Conservation & Land Management and the Fisheries Department. The **Proponent** proposes to provide office space within the administration centre for use by these officers.

12.8 NUTRIENT LEACHING

The **Proponent** will minimise leaching of nutrients by managing fertiliser application as follows:

- using slow release fertilisers,
- using foliar fertiliser applied by boom spray,
- using soluble fertiliser applied with irrigation water,
- inclusion of automatic moisture control to minimise overwatering, and
- regular tissue sampling to determine fertiliser requirements and to minimise over-application throughout the year.

To monitor fertiliser application, sampling of the nutrient concentration in the shallow aquifer will be undertaken at various depths in two monitoring bores located between the golf course and the beach. Additional management measures will be implemented as necessary to reduce leaching of nutrients to acceptable levels as resolved with the EPA.

12.9 REPORTING AND REVIEW

Results of the monitoring programme will be reported to the Environmental Protection Authority and to the following Government Departments:

- The Department of Agriculture, Soil Conservation Service - landscape stabilisation and foreshore management,

- The Department of Marine & Harbours - sediment transport and marine water quality,

- The Water Authority - groundwater management.

SECTION 13.0

COMMITMENTS

13.0 COMMITMENTS

1. The Developer shall underwrite the Management Board for maintenance of all facilities as required by the Development Agreement. The Development Agreement will incorporate EPA conditions. The Development Agreement will be conditional upon granting of environmental approvals.

2. On completion of the construction period, the **Proponent** guarantees public access shall be provided between gazetted roads and public beaches and other areas of public open space in accordance with the diagrammatic representation shown in Figures 5 and 8.

3. On completion of the construction period, the **Proponent** guarantees public access shall be provided along all beaches and in all sections of the marina between freehold land and the waterfront.

4. On completion of the construction period, the Developer shall hand over to the Management Board public amenities as described in Section 5.3.2 and in accordance with the requirements of the Development Agreement.

5. The **Proponent** shall construct a minimum of 100 pens for use by the public on a long and short term rental basis after the end of the construction period in accordance with the requirements of the Development Agreement.

6. The **Proponent** shall construct an 18 hole golf course for use by the public after the end of the construction period in accordance with the requirements of the Development Agreement.

7. The **Proponent** shall ensure that representative areas of conservation value, as shown diagrammatically in Figure 6, shall be marked out from the start of the construction work. These areas shall be set aside and managed as described in detail in Section 12.2.

8. The **Proponent** shall arrange that existing tracks, existing potential erosion zones and areas exposed during construction are sealed and rehabilitated during the construction period by inclusion of the requirements in the contract specification. The proposed methods for stabilisation and ongoing monitoring shall be as described in detail in Section 12.3.

9. The **Proponent** shall develop a fire management plan in conjunction with the Bush Fire Control Board and the Department of Conservation and Land Management The fire management plan shall be implemented at the inception of construction by inclusion of the requirements in the construction contract. At the completion of the construction period, the **Proponent** shall take over responsibility for the fire management plan. The proposed fire management plan shall be as outlined in Section 12.2.4.

10. The **Proponent** shall monitor all impacts on terrestrial habitats as described in Sections 12.2 and 12.5. The **Proponent** shall provide the necessary labour and equipment to implement corrective measures.

11. Subject to resolution of requirements with the relevant Government Departments, the **Proponent** shall incorporate, in the final design, office space for use by an inspector or ranger from each of the Fisheries, Marine & Harbours and Education Departments and the Department of Conservation and Land Management.

12. Prior to commencing construction, the **Proponent** shall initiate monitoring of the shoreline at the marina site. Ongoing monitoring and management of sediment transport and sand bypassing shall be undertaken by the **Proponent** as described in Section 12.3.

13. The **Proponent** shall monitor and manage groundwater abstraction as described in Section 12.4. Field testing of the shallow aquifer will commence after environmental approval for the project is received in order to define the need or otherwise for use of supplementary sources such as the deeper Yarragadee aquifer.

14. Following completion of construction the **Proponent** shall monitor the marine and harbour water quality as described in Section 12.5. If monitoring reveals problems the **Proponent** shall undertake further assessment, testing and remedial measures as resolved with the Environmental Protection Authority and the Department of Marine & Harbours.

15. The **Proponent** shall contribute an amount of money, to be resolved with the Environmental Protection Authority, as an equitable portion of the total cost of a proposed regional study of the currents and marine biota between Rottnest Island and Becher Point.

16. The **Proponent** shall implement fertiliser management and monitoring as described in Section 12.8 after construction of the golf course. In the event that Westport canals are constructed to the east of the golf course, fairways and tees adjacent to the canals will be modified by soil amendment to reduce nutrient leakage.

17. The **Proponent** shall arrange any additional UXO searching as required during the construction period.

18. The **Proponent** shall take all necessary construction measures to mitigate impacts of dust, erosion and noise as resolved with the Shire of Rockingham and Department of Agriculture. Planting of trees, shrubs and grass for the development shall be undertaken as soon as practical following completion of the earthworks.

19. The **Proponent** shall include in the construction contract requirements that the Contractor report any archaeological sites discovered during construction and leave undisturbed until advised by the Western Australian museum.

SECTION 14.0

CONCLUSIONS

14.0 CONCLUSIONS

14.1 PROJECT BENEFITS

It is concluded that the two major benefits of the proposal are management of the site and provision of recreation facilities as discussed below.

Compared to continued unmanaged use of the site the development offers significant advantages with regards to conservation. Parts of the site within the proposed Stage I development area are badly degraded by the impact of previous human use. The development will provide the management structure and funds to conserve areas of high value. The development layout has been arranged to include approximately one third (32%) of the Stage I site in conservation zones. The conservation zones incorporate about three quarters of the vegetation which has not suffered degradation. In addition, the zones incorporate representative areas of landform and vegetation complexes of conservation value.

The project will be of significant benefit to the community in providing recreational facilities for local, interstate and international visitors. The facilities provided in Stage I will complement other recreation and conservation proposals for the remainder of Port Kennedy as well as Lark Hill and Rockingham Lakes to the east.

Further benefits of the project are detailed in Section 3.0.

14.2 ENVIRONMENTAL IMPACTS

The immediate environmental impacts of the development are expected to be on the terrestrial habitats. By rearrangement of the site and delineation of conservation zones, the following aspects of the site will be restored and managed as part of the development:

- the foredune and primary dune and associated vegetation north of the hotel and at Becher Point,
- the curvilinear dunes south of the marina,
- the inland relict foredune and associated vegetation sequence at the north of the site,
- three quarters of vegetation showing little evidence of human impact (Category C condition), and
- representative areas of two unusual vegetation complexes.

The major degraded seasonal wetlands within the golf course will be in part restored to near indigenous form and in part developed as an ornamental lake.

The development areas have generally been located on the most degraded parts of the site as well as on terrestrial habitats represented elsewhere on the site or in the Perth-Mandurah area.

A number of potential impacts will result from construction and use of the proposed **Recreation Centre**. The impacts and the **Proponent's** proposals for management and monitoring of the impacts are as follows:

a) The increased human use of the site could result in increased erosion and fire frequency. It is proposed to manage erosion using conventional dune management techniques. A fire plan will be initiated from commencement of construction.

b) Groundwater abstraction will be managed by use of the numerical model developed for the ERMP and ongoing monitoring and abstraction rates, aquifer levels and rainfall.

c) Should survey of the beach alignment indicate erosion problems resulting from interruption of sediment transport by the marina, the **Proponent** undertakes to transport sand around the marina as necessary. Evaluation of net transport at the marina indicates the volumes involved will be small.

d) Although experience with coastal marinas along the Western Australian coast does not indicate a water quality problem is likely to occur within the marina, regular monitoring will be carried out by the **Proponent**.

e) Recreation pressures on the offshore reef and proposed Marine Park will increase due to the proposed development. The **Proponent** will implement his obligations in regard to any Management Plan drawn up for the Marine Park and will incorporate office facilities within the administrative area for use by officers of the relevant responsible authorities.

A number of other environmental impacts identified and discussed in this ERMP are considered minor or acceptable.

It is concluded that the proposed layout of the Stage I elements and the proposed management and monitoring commitments result in a proposal that is environmentally acceptable.

14.3 CONCLUSIONS

The proposed balance between the development of recreation facilities and conservation and management of the site to preserve its character and long term viability will be an advantage to

both the public and the **Proponent**. Retention of the public interest will be ensured by the proposed formation of the Management Board which will be responsible for environmental commitments for Stage I and control of subsequent development.

The environmental impacts resulting from this development are considered acceptable in the context of the existing degradation of the site and the likelihood of further degradation that would be caused by continued and increasing unmanaged use of the site.

SECTION 15.0: EPA GUIDELINES

ENVIRONMENTAL PROTECTION AUTHORITY
1 MOUNT STREET, PERTH, WESTERN AUSTRALIA 6000
Telephone (09) 222 7000

Port Kennedy Joint Venture
294 Rokeby Road
SUBIACO WA 6008

Your Ref:
Our Ref: 110/81/M106
Enquiries: Mr J Singleton

Dear Sir

Please find attached the guidelines for the Environmental Review and Management Programme.

I trust these will assist in the preparation of the ERMP.

Yours faithfully

P Johnston
DEPUTY CHAIRMAN

6 May 1988

Enc

PORT KENNEDY DEVELOPMENT PROPOSAL

GUIDELINES FOR ENVIRONMENTAL REVIEW AND MANAGEMENT PROGRAMME

PREAMBLE TO GUIDELINES

The following guidelines have been prepared for an Environmental Review and Management Programme on the proposed development of a major tourism and recreation resource at Port Kennedy.

As an introduction to these guidelines the following comments are made:-

1. The referral document indicates the intention to use information and conclusions established by the Westport and Secret Harbour ERMP's. While this is acceptable and can avoid unnecessary duplication of research already undertaken, the ERMP should ensure that existing data is meaningful and interpreted sufficiently to apply to the Port Kennedy proposal.

2. The status of the System 6 Report and the recommendations for the Port Kennedy area (M106) should be addressed with care.

   The System 6 Report indicates that the Port Kennedy area has important environmental values associated with the parallel dune system and their associated ecology. The referral document appears to largely ignore this fact. The proposal should reflect the intent and objectives of the System 6 recommendations.

3. The design concepts in the promotional brochure, and the sketch designs in the referral document convey a particular landscape image for the proposal in what is a highly infertile and arid summer environment. The ERMP, should directly comment on the practicality and appropriateness of such visual images. It is important that the landscape concept in the minds of both decision makers and the community is realistic and achievable without adverse impacts on some other aspect of the environment.

These guidelines are issued as a checklist of matters which the Environmental Protection Authority considers should be addressed in the ERMP. They are not exhaustive and other relevant issues may arise during the preparation of the document: these should also include the ERMP.

It should also be noted that the guidelines are not intended to convey the Authority's wishes with respect to the format of the document. The format is a matter for the proponent and its consultant.

A copy of these guidelines should appear in the ERMP.

GUIDELINES - PORT KENNEDY ERMP

1. SUMMARY

This section should contain a brief summary of:

- salient features of the proposal;
- alternatives considered;
- description of receiving environment and analysis of potential impacts and their significances;
- environmental monitoring, management and safeguard and commitments thereto; and
- conclusions.

2. INTRODUCTION

This introduction should include:

- identification of proponent and responsible authorities;
- background and objectives of the proposal;
- brief details and timing of the proposal;
- relevant statutory requirements and approvals procedures; and
- purpose and structure of the ERMP.

3. NEED FOR THE DEVELOPMENT

This section is concerned with the justification for the project and projected costs (in the broadest sense) and benefits at local and regional levels. This should also include reference to the Development Brief prepared by the Port Kennedy Interim Management Committee, previously adopted concept plans for Port Kennedy, and the recommendations from the Systems 6 Study for the area.

4. EVALUATION OF ALTERNATIVES

This is one of the more important parts of the ERMP. A discussion of alternative development and design options should be given, including those concerned with the landscape design options for the site as a whole and for the various specific landscape elements. A comparison of options in the context of the stated objectives should be included as well as costs and benefits at both construction and operational stages. In this way the rational for choosing the preferred option should be clear.

5. DESCRIPTION OF THE PROPOSAL

The ERMP should provide details of:

- the overall concept, including stages A and B and the way in which stage A relates to the full site potential;
- location and layout showing clearly those portions of the project proposed to be subject to freehold tenure and those remaining as Crown Land;
- private resort complex and golf course;
- beachfront resort, marina, towncentre and accommodation;
- infrastructure and service provision;
- access and traffic generation;
- water supply and stormwater discharge;
- effluent treatment and waste disposal;
- landscape planning and design details with particular regard to water and nutrient requirements, and long term site stability;
- the construction period
  - construction schedule and methods of construction;
  - including earthworks and dune stabilization;
- ongoing management
  - operation after construction;
  - statutory and legal agreements including those covering long term management responsibilities; and
  - monitoring.

6. EXISTING ENVIRONMENT

This ERMP should provide an overall description of the environment and an appraisal of physical and ecological systems likely to be affected by the proposal. It should then concentrate on the significant aspects of the environment likely to be impacted by the development (ie in particular the processes sustaining the system). Only the processes, habitats, resources and potential resources which could be influenced should be defined. Detailed inventories should be placed in appendices to the ERMP.

Wherever possible in the discussion of physical and biological processes that are essential determinants in the maintenance of habitats and resources, conceptual and where possible, qualitative models or diagrams should illustrate and synthesize the interactions between the processes.

This discussion should include:

PORT KENNEDY

- Physical
  - landform and soils;
  - geomorphic stability;
  - climate, climatic change (eg rainfall, sealevel) and meteorology; and
  - hydrogeology.
- Biological
  - flora (with particular reference to rare or protected species, and available stock of representative vegetation systems); and
  - fauna.
- Human
  - archaelogical and historic factors;
  - recent and existing occupiers and land users;
  - adjacent land uses, developments and community;
  - System 6 status and recommendations; and
  - existing landscape values.

WARNBRO SOUND COASTAL ZONE AND SHORELINE

- Physical
  - coastal and marine geomorphology, and processes;
  - coastal zone stability; and
  - oceanography, littoral drift.
- Biology
  - marine biota. Special attention should be given to the near 'pristine' conditions of the reefs (ie Murray Reefs) and their importance to professional fishing, to the seagrass meadows, and to the Warnbro Sound deep basin.

7. ENVIRONMENTAL IMPACTS

This is the most important part of the ERMP and the result should show the overall effect on the total ecosystem and social surroundings of the location during and after construction.

The objective is to synthesize all information and predict potential impacts upon the environment. This should include an assessment of the resilience of the systems identified in 6 to natural and man-induced pressures. Impacts should be quantified where possible. Criteria for making assessments of their significance should be outlined. In some cases there will be an advantage in discussing construction and operation impacts separately.

It will be necessary to determine impacts on individual components of the environment before a final overall synthesis of potential impacts is made.

The ERMP should include but not be limited by consideration of the following:

- oceanography;
- frequency of storm events ;
- coastal processes (in particular gross and net sediment movements) shoreline migration;
- offshore and beach zone biota (in particular seagrass meadows, reef communities and littoral zone communities);
  - anchor damage on seagrass meadows;
  - should consider effects of increased recreational fishing etc on offshore reefs;
  - impacts of boating activity on shallow seagrass communities;
  - potential impacts from nutrient input to the marine environment from the development site (golf course in particular).
- terrestrial plant and animal communities (in particular loss of diminishing representative plant communities);
- drainage;
- flushing times and water quality in the marina water body and any other enclosed water bodies (ie ornamental lakes or artifical wetlands);
- groundwater quality, drawdown, long term equilibrium, and potential for saline intrusion also any possible long term consequences for the Rockingham Lakes System;
- impact on other groundwater users;
- land surface stability, with particular reference to foredunes;
- landscape (impact on the Safety Bay and adjacent landscapes);
- local and regional significance of foreshores;
- historical, archaeological and ethnographic sites;
- emissions (air, water waste disposal and noise);

- access roads, internal site movement and traffic generation in the locality;
- continued access of the public to and along the beachfront;
- service provision, and
- construction and operation factors.

The final synthesis should include an assessment of the significance and timing of the various potential impacts identified.

8. ENVIRONMENTAL MANAGEMENT

An environmental management programme should be described on the basis on (a cross-reference to) the synthesis of potential environmental impacts described in 7.

It is important that specific commitments are given to all components and procedures of the management programme.

9. COMMITMENTS

The ERMP should contain a list of commitments that are being made as part of the proposal. These should be clearly stated and responsibility assigned to each commitment.

10. CONCLUSION

As assessment of the environment acceptability of the project in terms of its overall environmental impact and in the context of the proposed management programme should be given.

11. REFERENCES

Glossary (definitions of technical terms, abbreviations)

ERMP Guidelines

Appendices

SECTION 16.0: BIBLIOGRAPHY AND GLOSSARY

16.0 BIBLIOGRAPHY AND GLOSSARY

16.1 BIBLIOGRAPHY

Abbreviations:

DCE	Department of Conservation & Environment
EPA	Environmental Protection Authority
MRPA	Metropolitan Region Planning Authority
SPC	State Planning Commission

Australian Standard 1428 (1977). Code of Practice for Design Rules for Access by the Disabled.

Beard JS (1979). The Vegetation of the Pinjarra Area Western Australia 1:250,000 Series. Vegmap Publications, Perth.

Beard JS (1981). Vegetation Survey of Western Australia, Swan. Vegmap Publications, Perth.

Brian J O'Brien & Associates Pty Ltd (1988). Draft Environmental Guidelines for Tourism Developments.

Cresswell, GR and Golding TJ (1980). Observations of a South-Flowing Current in the South-Eastern Indian Ocean. Deep Sea Res., 27A, 449-466.

DCE (1981). Water Quality Criteria for Marine and Estuarine Waters of Western Australia. Bulletin 103.

DCE (1982). Bulletin 121. Report on Secret Harbour.

DCE (1983). The Darling System - System Six, Report 13.

DCE (1985). Bulletin 196. Report on Sorrento Boat Harbour ERMP.

DCE (1985). Bulletin 200. Report on Mindarie Keys ERMP.

DCE (1986). Bulletin 254. Report on Rockingham Marina PER.

DCE (1986). Bulletin 264. Marine Communities of the Cape Peron Shoalwater Bay and Warnbro Sound Region.

DCE (1987). Bulletin 281. Report on Westport ERMP.

Delta Holdings (1986). Westport ERMP.

Department of Agriculture (1985). Report 44. Shire of Rockingham - A Study of Land Resources and Planning Considerations.

Department of Conservation of Land Management (1987). Strategies for Conservation and Recreation on CALM Lands.

Foster & Wallace (1983). Assessment of Littoral Drft, Secret Harbour, Western Australia.

Halpern Glick (1983). Secret Harbour ERMP and Supplementary Reports.

Hillman, K (1984). Seagrass in Warnbro Sound and the Possible Impact of the Westport Development. Westport ERMP Volume II, Appendix I.

John Holland Constructions et al (1985). Rockingham Marina PER.

LeProvost, Semeniuk & Chalmer (1988). Port Geographe ERMP.

McArthur and Bartle (1980). Landforms and Soils as an Aid to Urban Planning in the Perth Metropolitan Northwest Corridor, Western Australia. Land Resources Management Series No 5 CSIRO.

MRPA (1970). The Corridor Plan for Perth.

MRPA (1978). Port Kennedy Regional Recreation Centre Design Concept.

Public Works Department, NSW (1985). Marina Guidelines. Report No 85015.

Rochford, DF (1969). Seasonal Interchange of High and Low Salinity Surface Waters off South-West Australia. CSIRO Div. Fisheries and Oceanography Tech. Paper No. 29.

Rockwater (1984a). Secret Harbour Development. Bore Census.

Rockwater (1984b). Secret Harbour. Bore SH1 Completion Report.

Scott & Furphy, LeProvost Semeniuk & Chalmer (1984). Sorrento Boat Harbour ERMP.

Scott & Furphy, LeProvost Semeniuk & Chalmer (1985). Mindarie Keys ERMP.

SPC (1980). Rockingham Lakes. Region Open Space Planning and Development.

SPC (1986). Port Kennedy Regional Recreation Centre, Development Brief.

SPC (1987). Planning for the Future of the Perth Metropolitan Region.

SPC (1988). Cape Peron Study. A Framework for the Future Tourist/Recreation Development.

Smith GG (1973). A Guide to the Coastal Flora of South Western Australia. Botany Department UWA Handbook No 10, West Australian Naturalists Club, Perth.

Steedman & Associates (1981). Cape Peron Ocean Outlet ERMP - Dispersion Studies. Report for Metropolitan Water Supply, Sewerage & Drainage Board, Perth, WA.

Waterways Commission (1984). Recommendations for the Development of Canal Estates. Report by Steering Committee on Canal Developments.

Woods PJ and Searle DJ (1983). Radiocarbon Dating and Holocene History of the Becher/Rockingham Beach Ridge Plain, West Coast, Western Australia, Search 14:44-46.

16.2 GLOSSARY

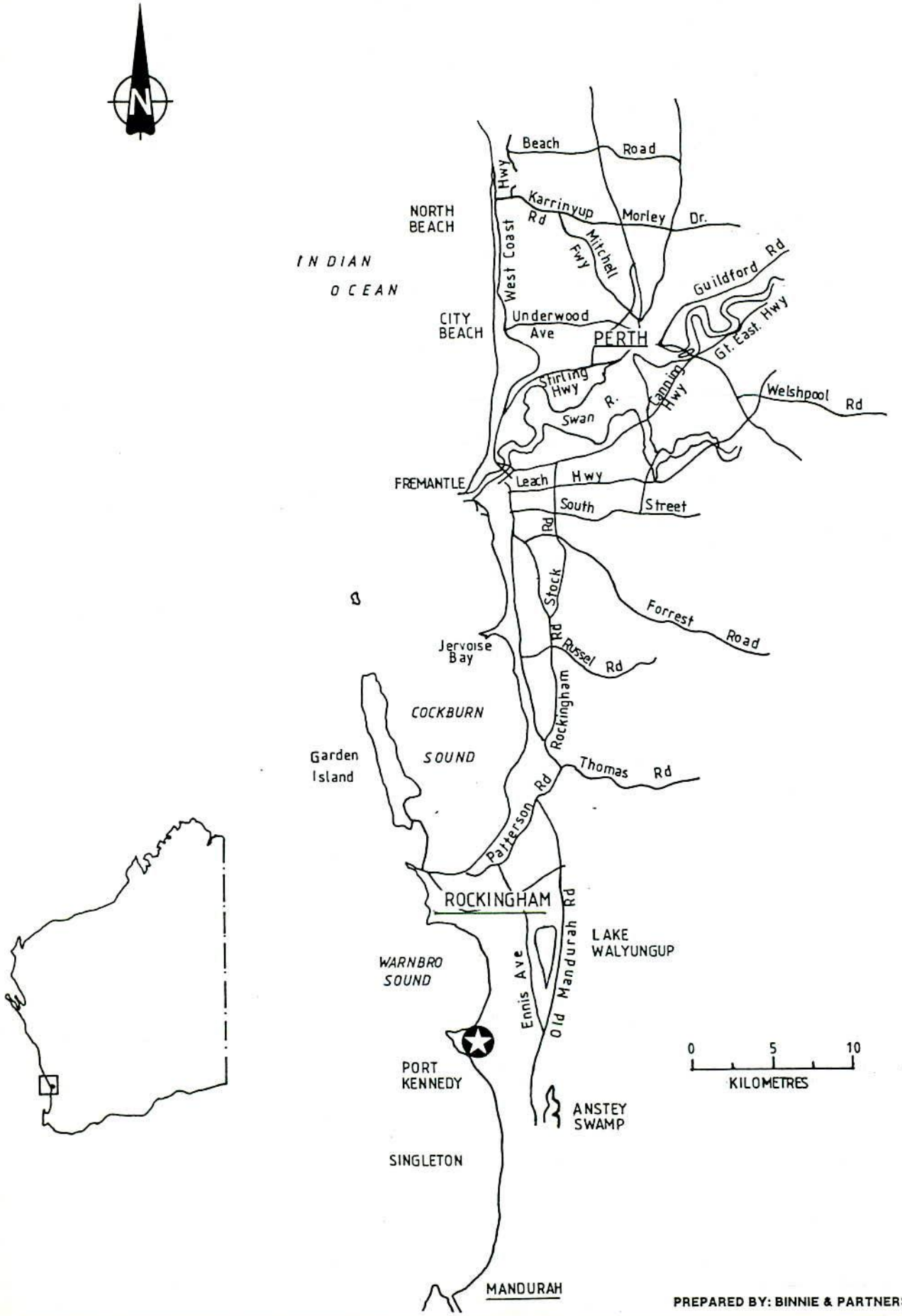
Accretion	growth of a shoreline by deposition of sediments
AHD	Australian Height Datum
Bathymetry	seabed depths
Curvilinear	curved lines (of dunes)
Cusp	a sandy point of land
Diffraction	deflection of waves around the corner of an obstruction
Geomorphology	the form of the earth's surface
Gyre	circular movement
Hindcast	a technique used to calculate wave heights
Holocene	a geological time period
Indigenous	originating on the site

Intercalated	inserted between
Intergranular	between grains of sand
Littoral drift	water movement within the shore zone
Prograding	movement of the shoreline seawards
Refraction	modification of wave form as it travels over the seabed
Relict Dune	surviving form of old primary dune
Saline intrusion	movement of saline groundwater (from under the sea) towards a bore or borefield
Sediment transport	alongshore movement of sediment in the shore zone
Surficial	the upper part of the superficial aquifer
Swale	low lying area between two dune crests
Turbidity	cloudiness in water caused by fine suspended particles.

PHOTOGRAPHS AND FIGURES

PHOTOGRAPHS OF THE SITE

FIGURES



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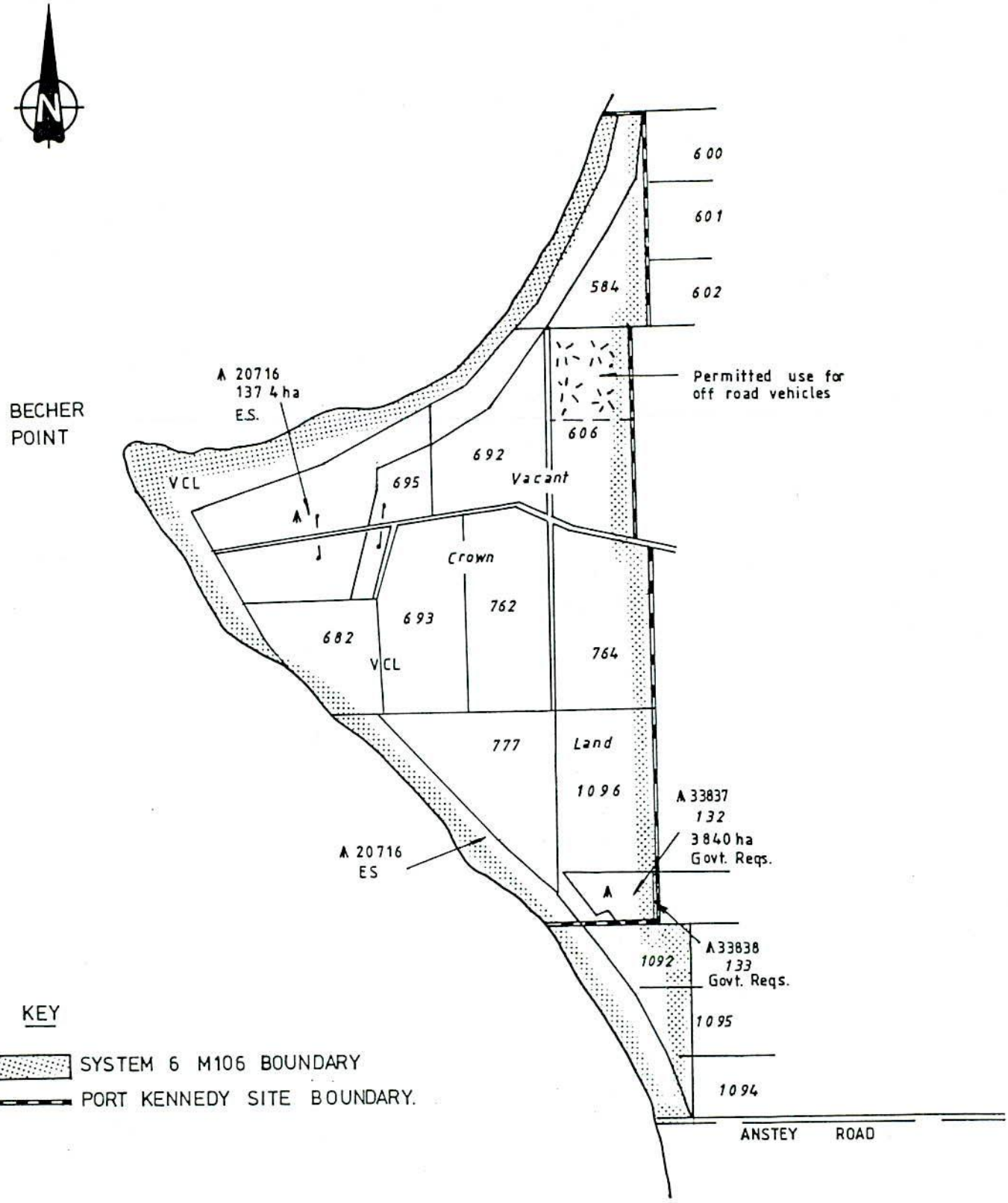
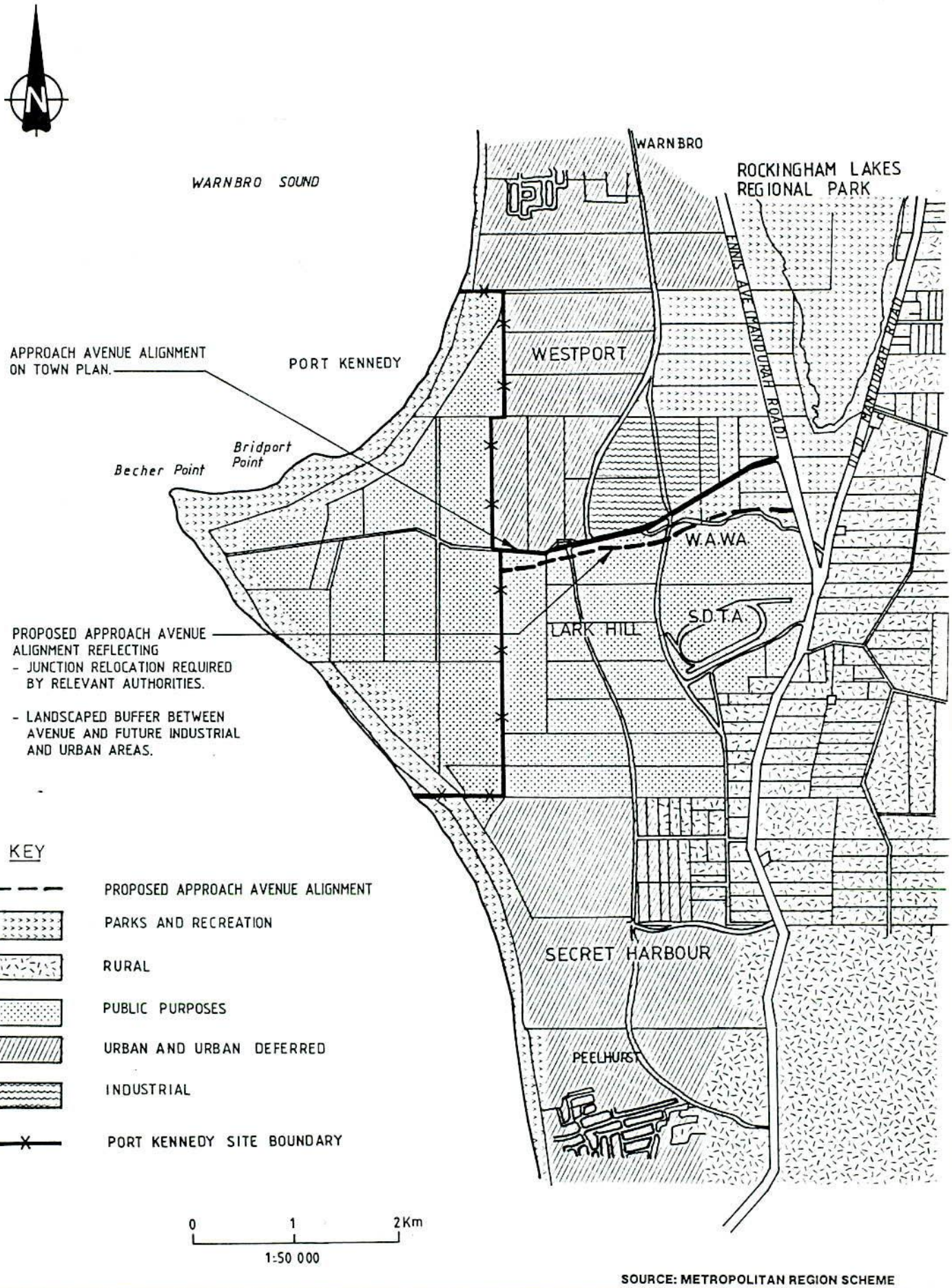
PORT KENNEDY JOINT VENTURE STAGE 1 ERMP	PORT KENNEDY	GEOGRAPHICAL LOCATION FIGURE 1



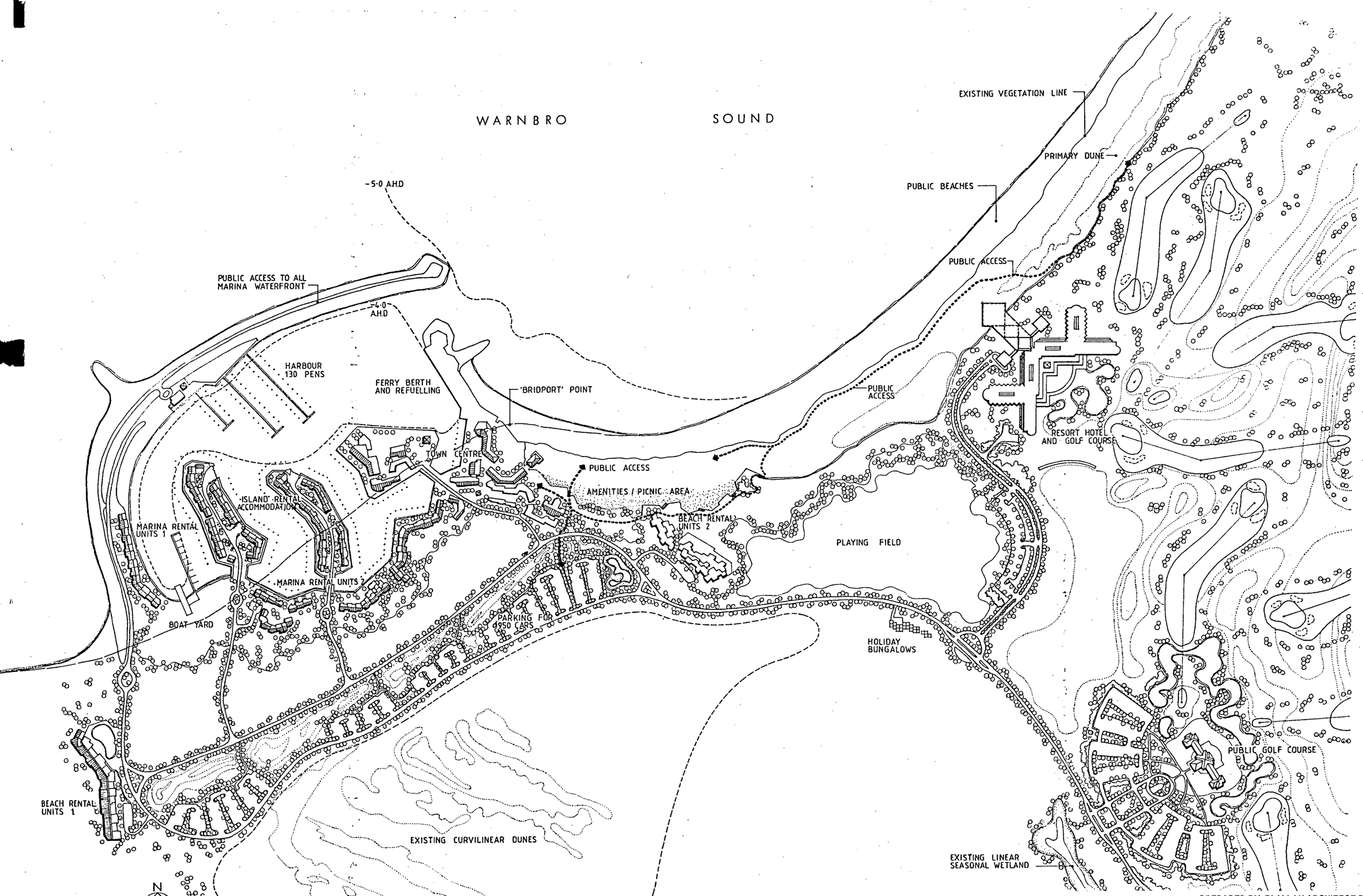
SOURCE: SYSTEM SIX REPORT (DCE, 1983)

PORT KENNEDY JOINT VENTURE STAGE 1 ERMP	PORT KENNEDY	SITE LOTS AND BOUNDARIES FIGURE 2



SOURCE: METROPOLITAN REGION SCHEME

PORT KENNEDY JOINT VENTURE STAGE 1 ERMP	PORT KENNEDY	REGIONAL RESERVES AND ZONING FIGURE 3



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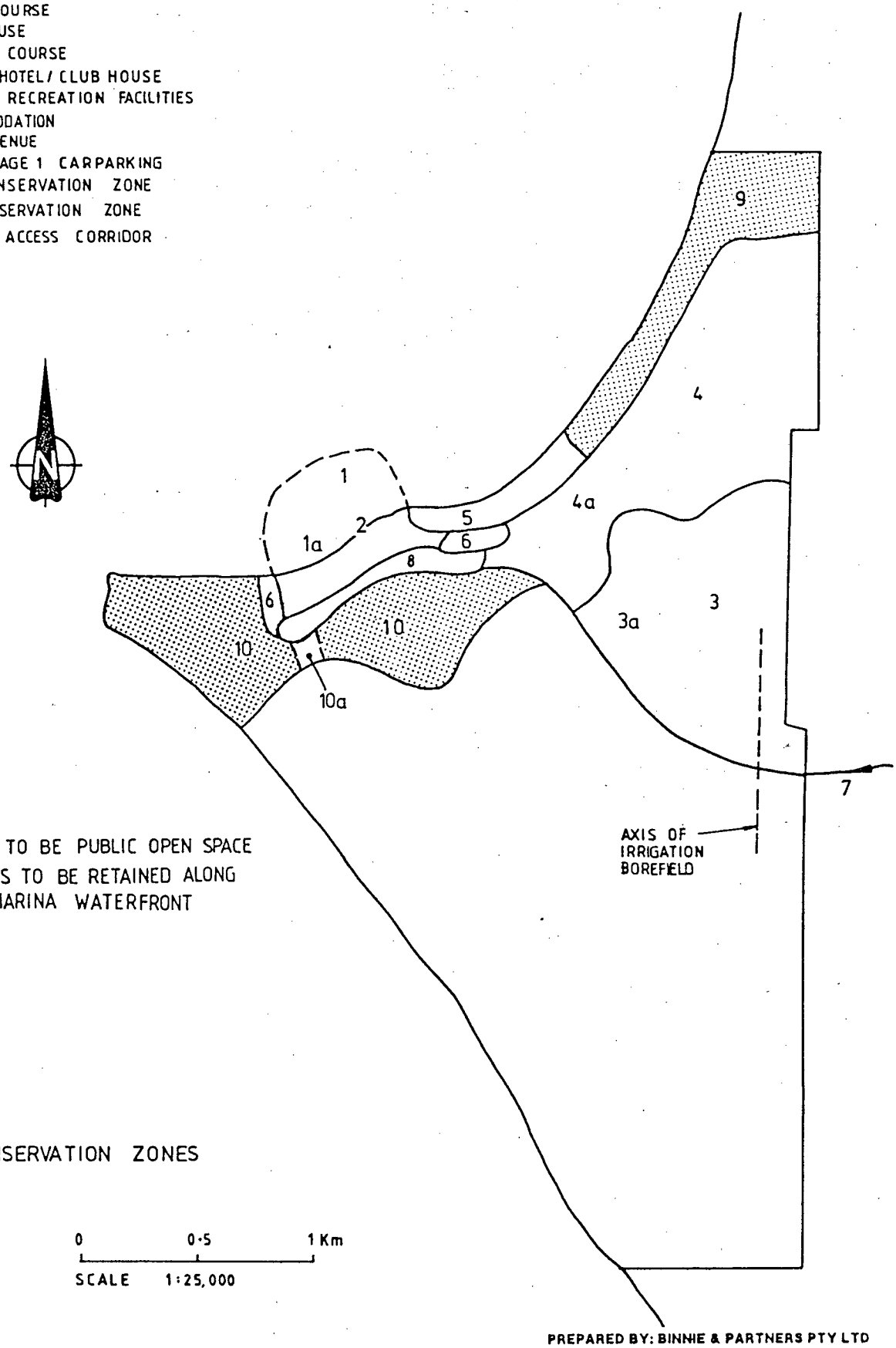
PORT KENNEDY JOINT VENTURE STAGE 1 ERMP	PORT KENNEDY	DETAIL ARRANGEMENT FIGURE 5

1. MARINA
   1a MARINA RENTAL ACCOMMODATION
2 TOWN CENTRE / ADMINISTRATION
3 PUBLIC GOLF COURSE
   3a CLUB HOUSE
4 PRIVATE GOLF COURSE
   4a RESORT HOTEL / CLUB HOUSE
5 PUBLIC BEACH RECREATION FACILITIES
6 RENTAL ACCOMMODATION
7. APPROACH AVENUE
8 TEMPORARY STAGE 1 CARPARKING
9 NORTHERN CONSERVATION ZONE
10 SOUTHERN CONSERVATION ZONE
   10a FUTURE ACCESS CORRIDOR



NOTES

1. ALL BEACHES TO BE PUBLIC OPEN SPACE
2. PUBLIC ACCESS TO BE RETAINED ALONG ALL OF THE MARINA WATERFRONT

KEY

CONSERVATION ZONES

0 0·5 1 Km

SCALE 1:25,000

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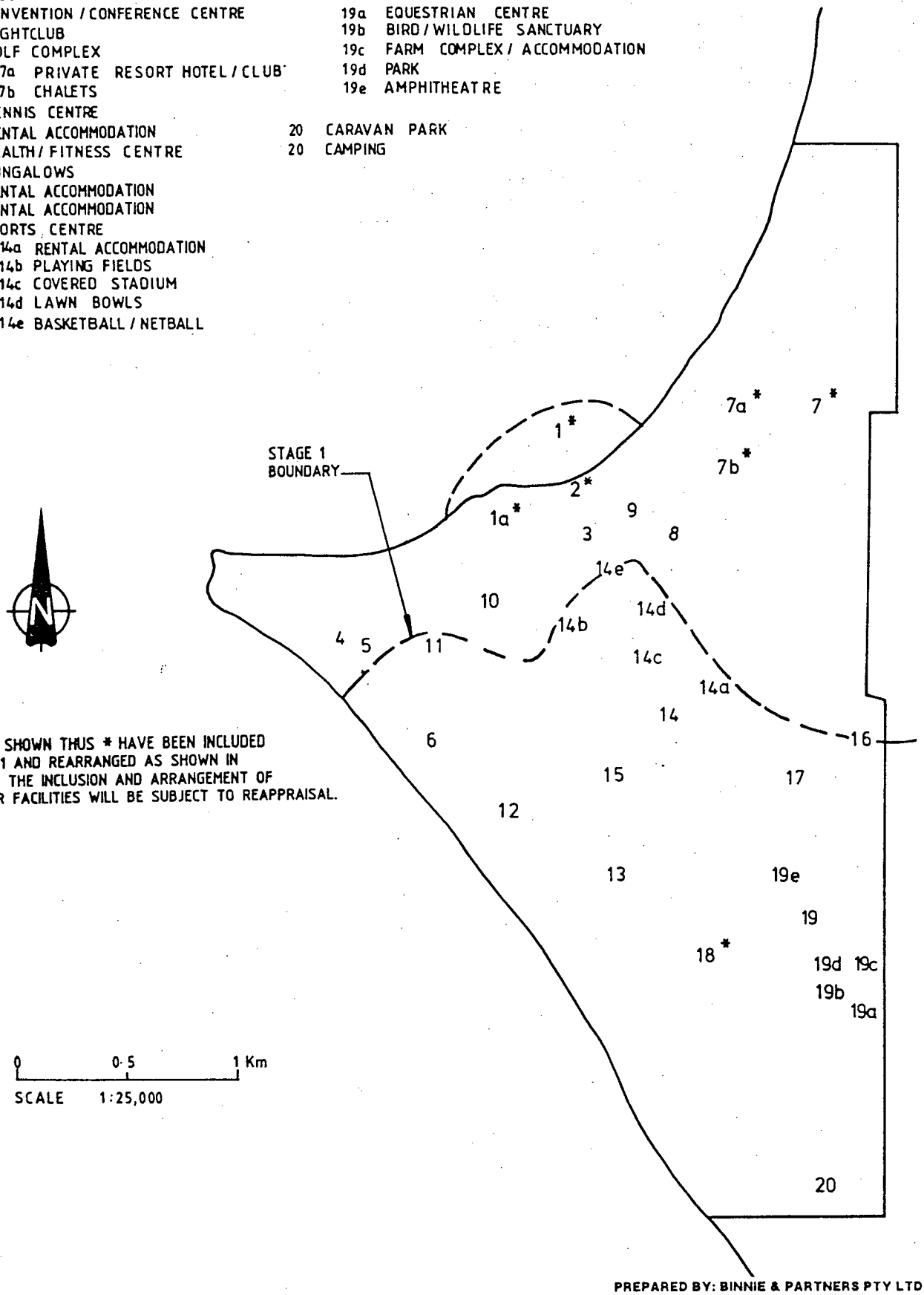
PORT KENNEDY JOINT VENTURE STAGE 1 ERMP	PORT KENNEDY	STAGE I: SCHEMATIC LAYOUT FIGURE 6

1. MARINA
   1a. RENTAL ACCOMMODATION
2 TOWN CENTRE / ADMINISTRATION
3. HELIPAD
4 RESORT HOTEL
5 CONVENTION / CONFERENCE CENTRE
6 NIGHTCLUB
7 GOLF COMPLEX
   7a PRIVATE RESORT HOTEL / CLUB
   7b CHALETS
8 TENNIS CENTRE
9 RENTAL ACCOMMODATION
10 HEALTH / FITNESS CENTRE
11 BUNGALOWS
12 RENTAL ACCOMMODATION
13 RENTAL ACCOMMODATION
14 SPORTS CENTRE
   14a RENTAL ACCOMMODATION
   14b PLAYING FIELDS
   14c COVERED STADIUM
   14d LAWN BOWLS
   14e BASKETBALL / NETBALL
15 AMUSEMENT PARK
16 PARKING
17 COMPLEX CONTROL CENTRE
18 PUBLIC GOLF COURSE
19 ADVENTURE CENTRE
   19a EQUESTRIAN CENTRE
   19b BIRD / WILDLIFE SANCTUARY
   19c FARM COMPLEX / ACCOMMODATION
   19d PARK
   19e AMPHITHEATRE
20 CARAVAN PARK
20 CAMPING



NOTES

FACILITIES SHOWN THUS * HAVE BEEN INCLUDED IN STAGE 1 AND REARRANGED AS SHOWN IN FIGURE 6. THE INCLUSION AND ARRANGEMENT OF ALL OTHER FACILITIES WILL BE SUBJECT TO REAPPRAISAL.

0 0·5 1 Km

SCALE 1:25,000

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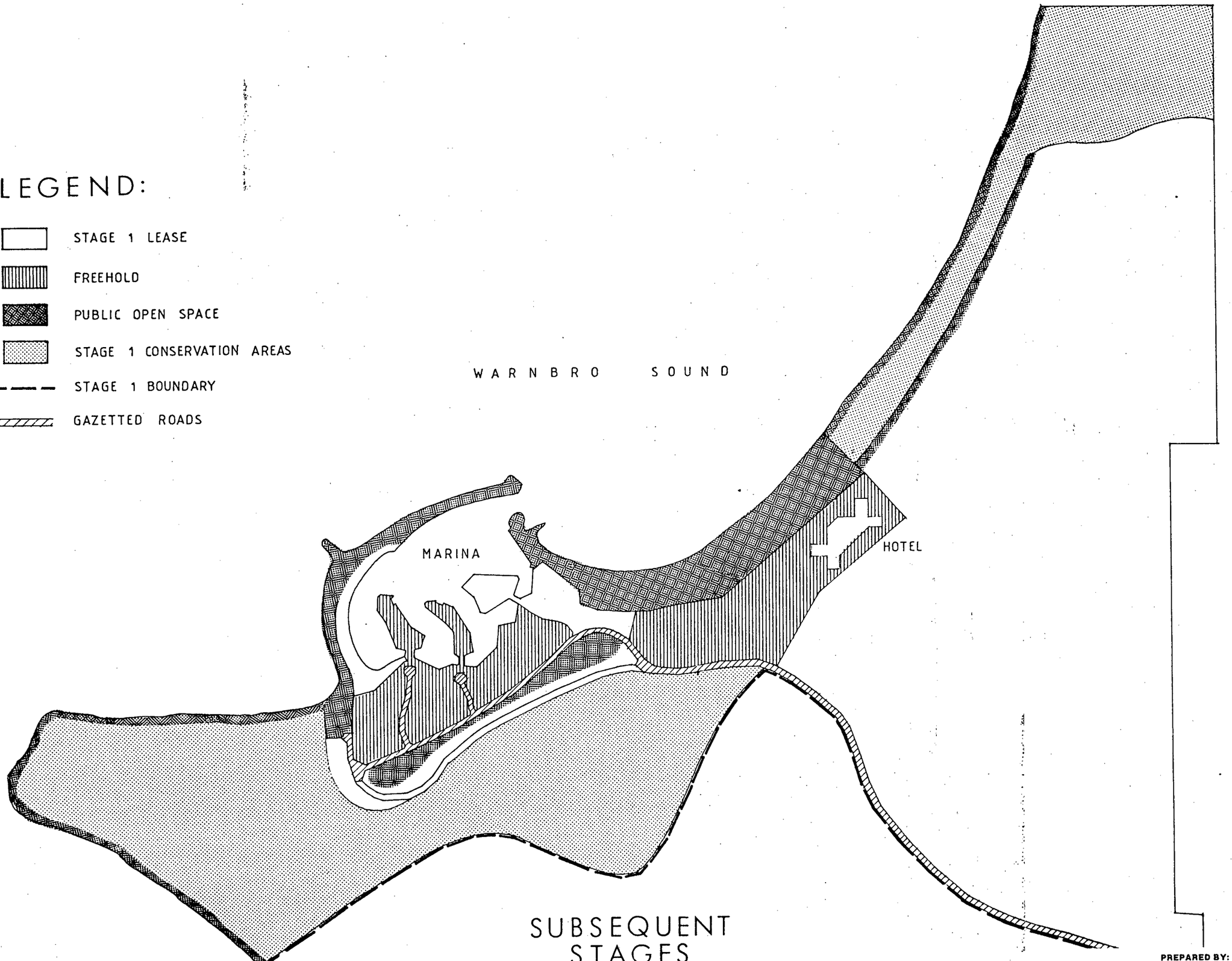
PORT KENNEDY JOINT VENTURE STAGE 1 ERMP	PORT KENNEDY	PRELIMINARY PLANNING FRAMEWORK FIGURE 7

LEGEND:

- STAGE 1 LEASE
- FREEHOLD
- PUBLIC OPEN SPACE
- STAGE 1 CONSERVATION AREAS
- STAGE 1 BOUNDARY
- GAZETTED ROADS



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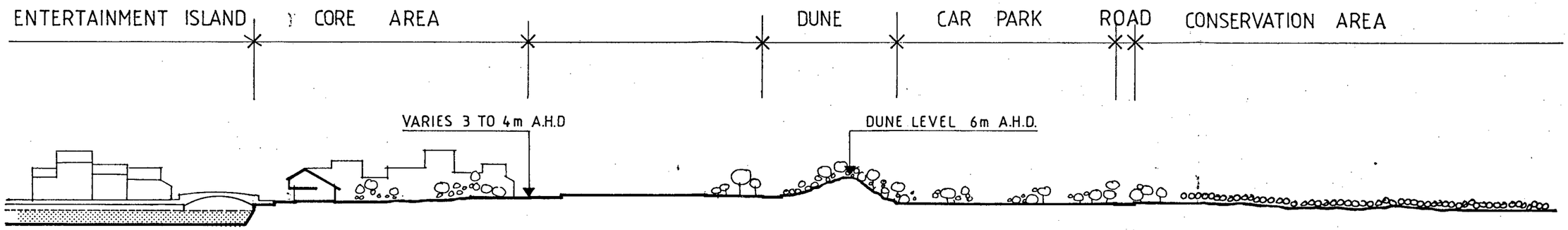
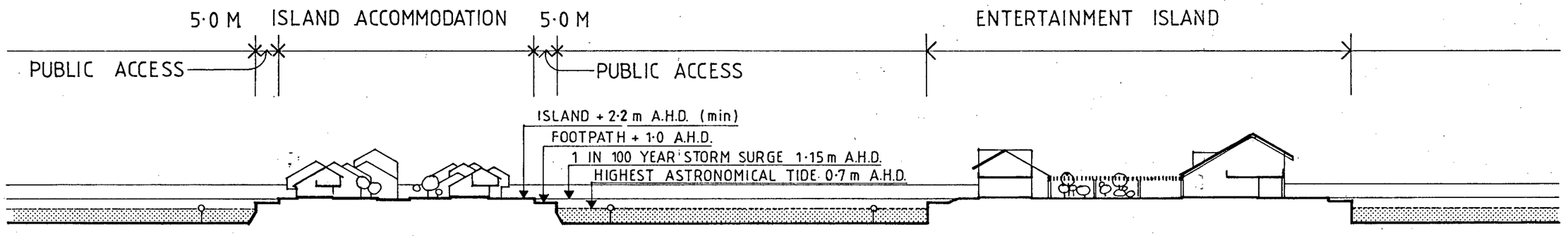
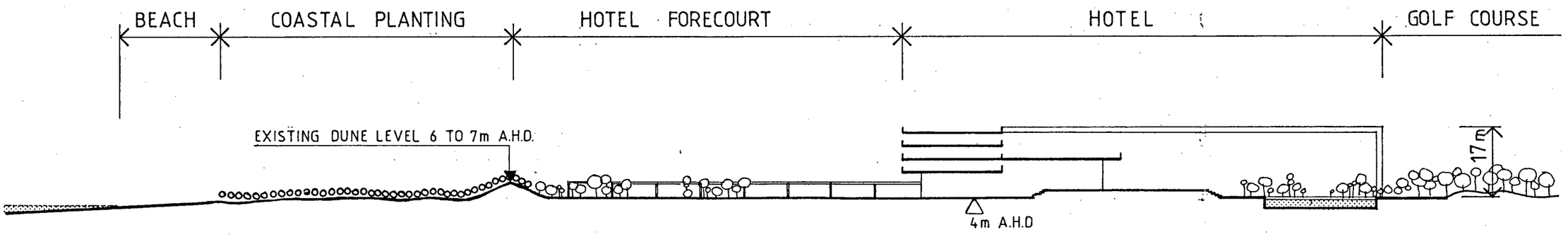
PORT KENNEDY JOINT VENTURE STAGE 1 ERMP	PORT KENNEDY	DEVELOPMENT PLAN FIGURE 8



TOWN CENTRE SECTION



MARINA SECTION



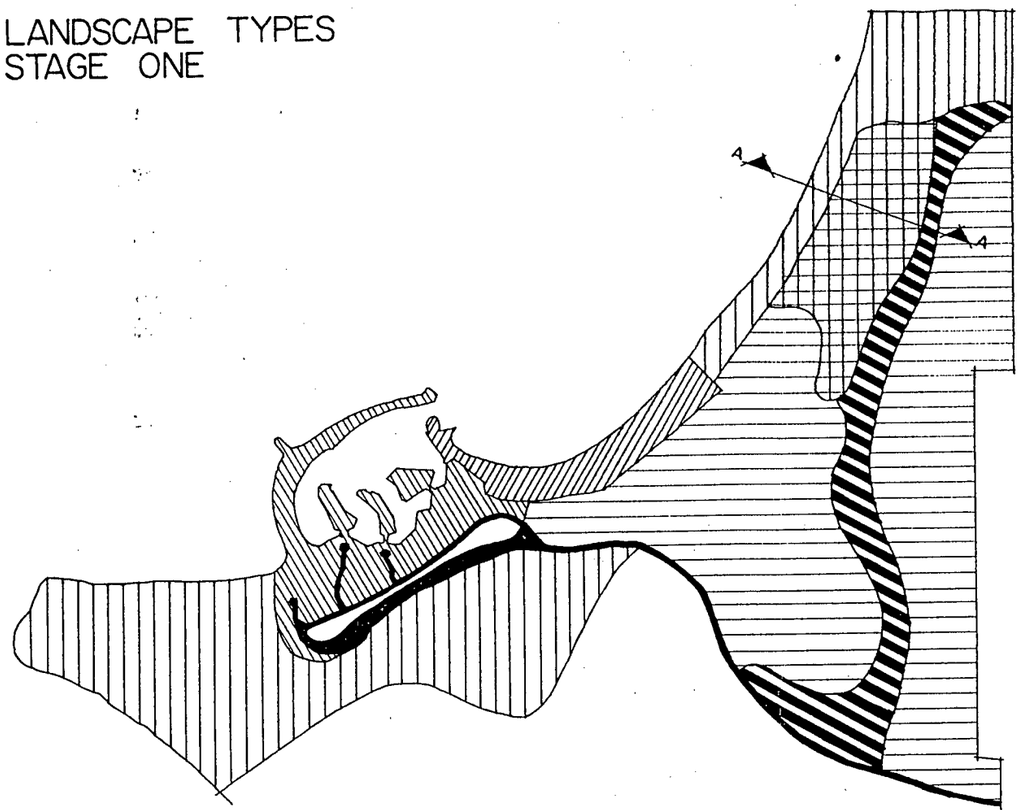
RESORT HOTEL AND GOLF COURSE SECTION

SCALE 1:1000

PREPARED BY: RI ALLAN ARCHITECT PTY LTD

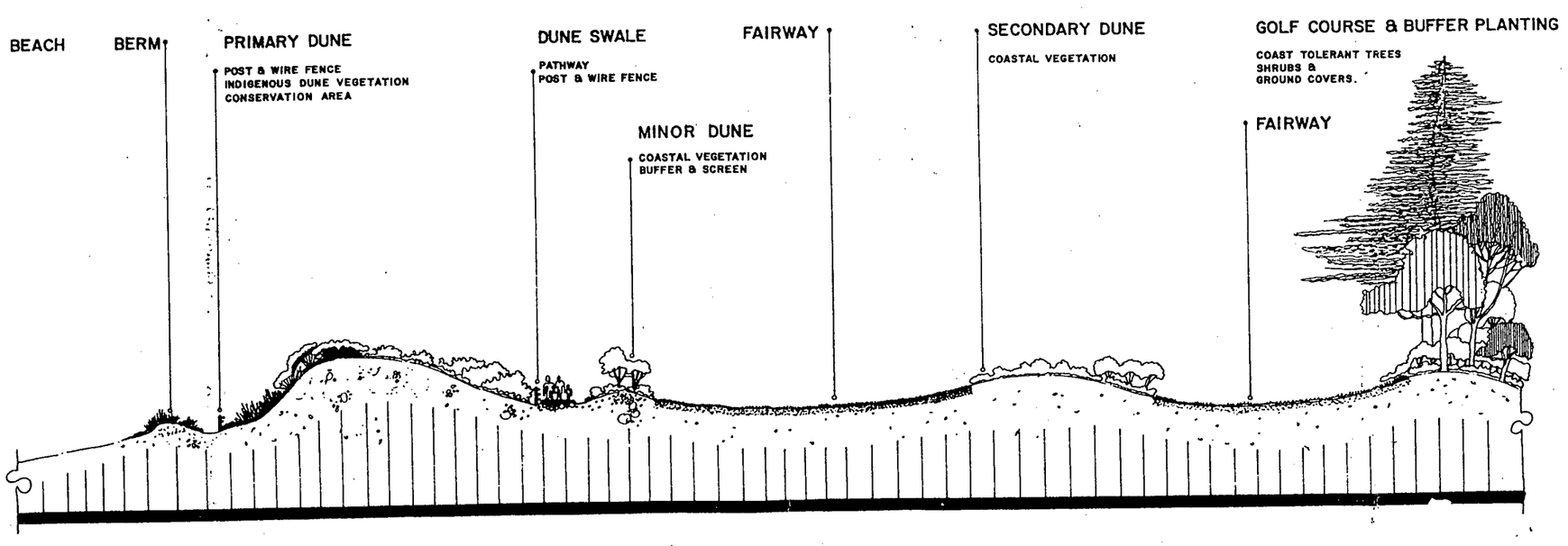
PORT KENNEDY JOINT VENTURE STAGE 1 ERMP	PORT KENNEDY	SECTIONS THROUGH DEVELOPMENT FIGURE 9

LANDSCAPE TYPES
STAGE ONE



LEGEND

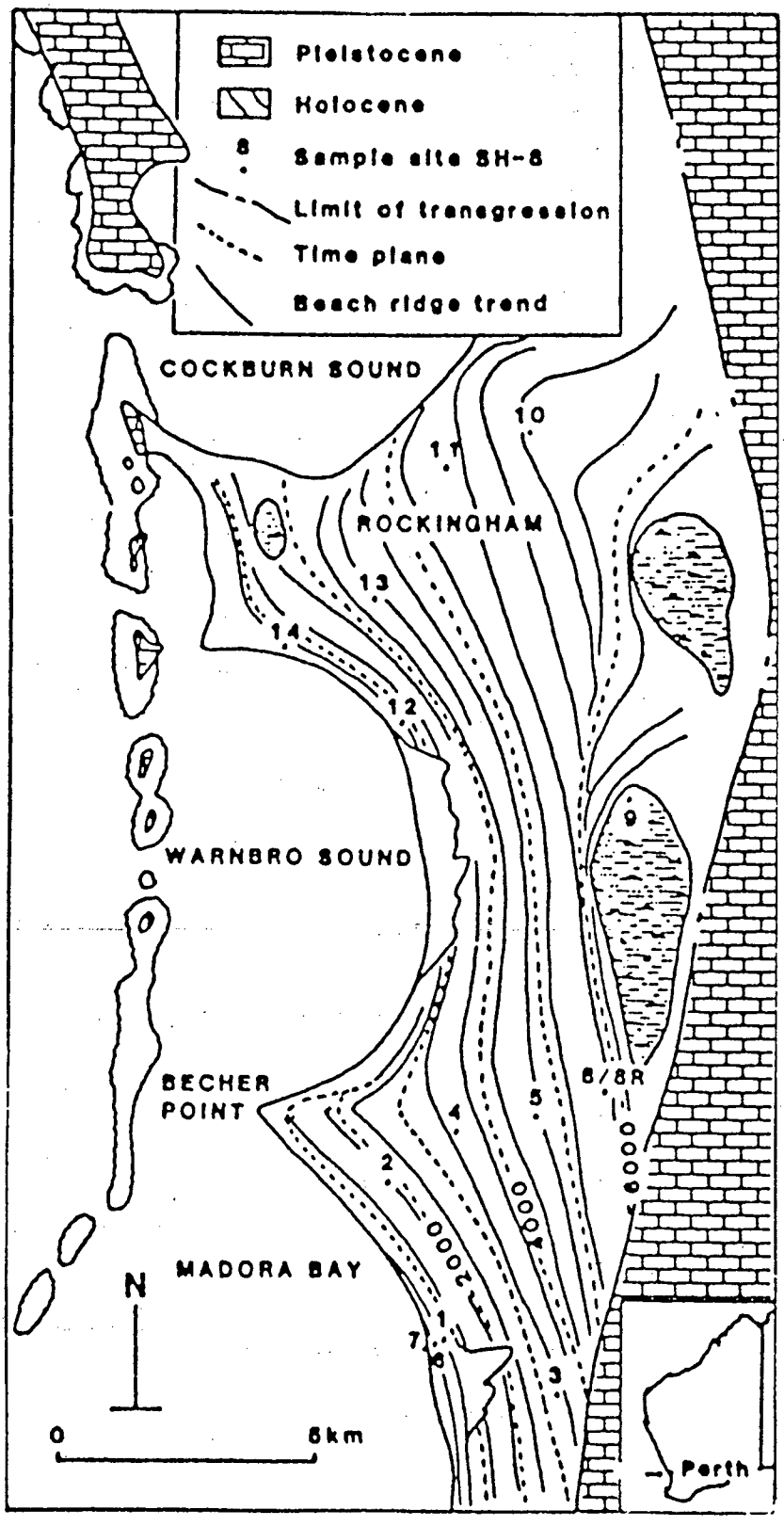
- CONSERVATION ZONES
- BUFFER COASTAL BUSHLAND & PARKLAND
- ORNAMENTAL & PARKLAND
- HARD LANDSCAPE & ORNAMENTAL
- BEACH, HARD LANDSCAPE, PARKLAND, ORNAMENTAL & COASTAL BUSHLAND
- BUFFER — VISUAL SCREEN
- COASTAL BUSHLAND BETWEEN FAIRWAYS
- ACCESS ROADS



SECTION A-A. TYPICAL SECTION THROUGH GOLF COURSE

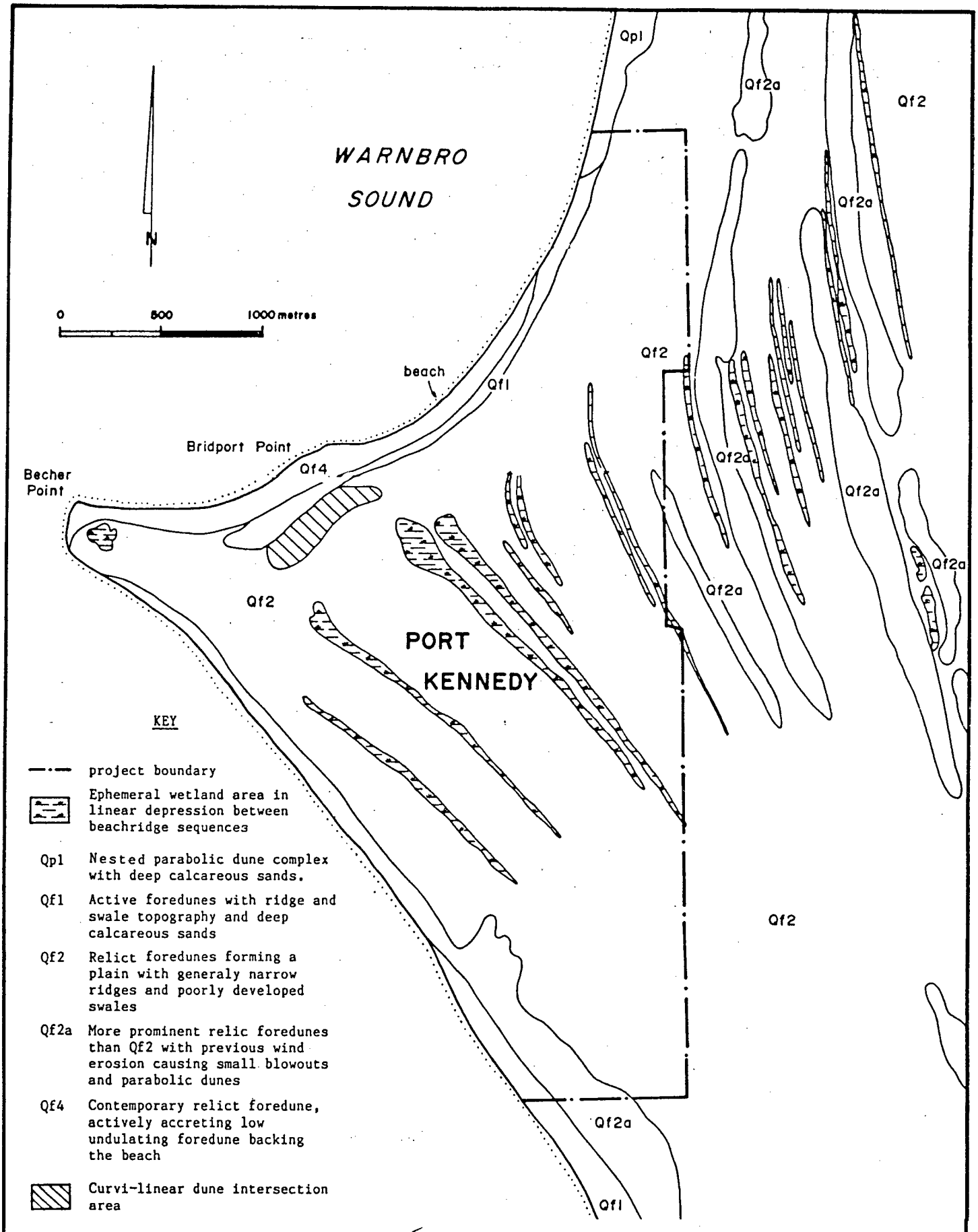
PREPARED BY: JORDAN PREGELJ, LANDSCAPE ARCHITECT

PORT KENNEDY JOINT VENTURE STAGE 1 ERMP	PORT KENNEDY	LANDSCAPE DEVELOPMENT FIGURE 10



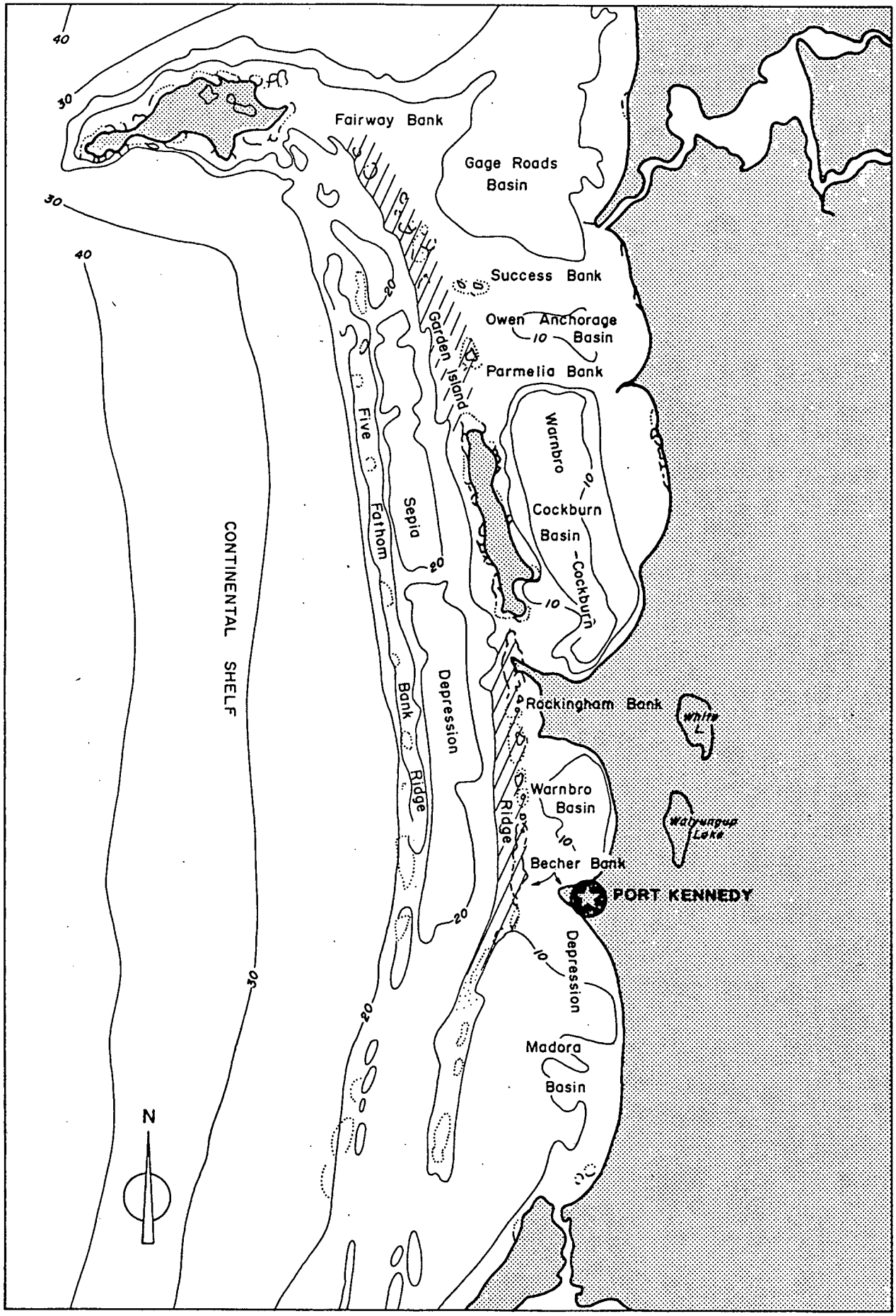
SOURCE: WOODS AND SEARLE, 1983

PORT KENNEDY JOINT VENTURE STAGE 1 ERMP	PORT KENNEDY	TIME PLANE DIAGRAM FIGURE 11



SOURCE: BOWMAN BISHAW & ASSOCIATES (Appendix C)

PORT KENNEDY JOINT VENTURE STAGE 1 ERMP	PORT KENNEDY	GEOMORPHOLOGY FIGURE 12

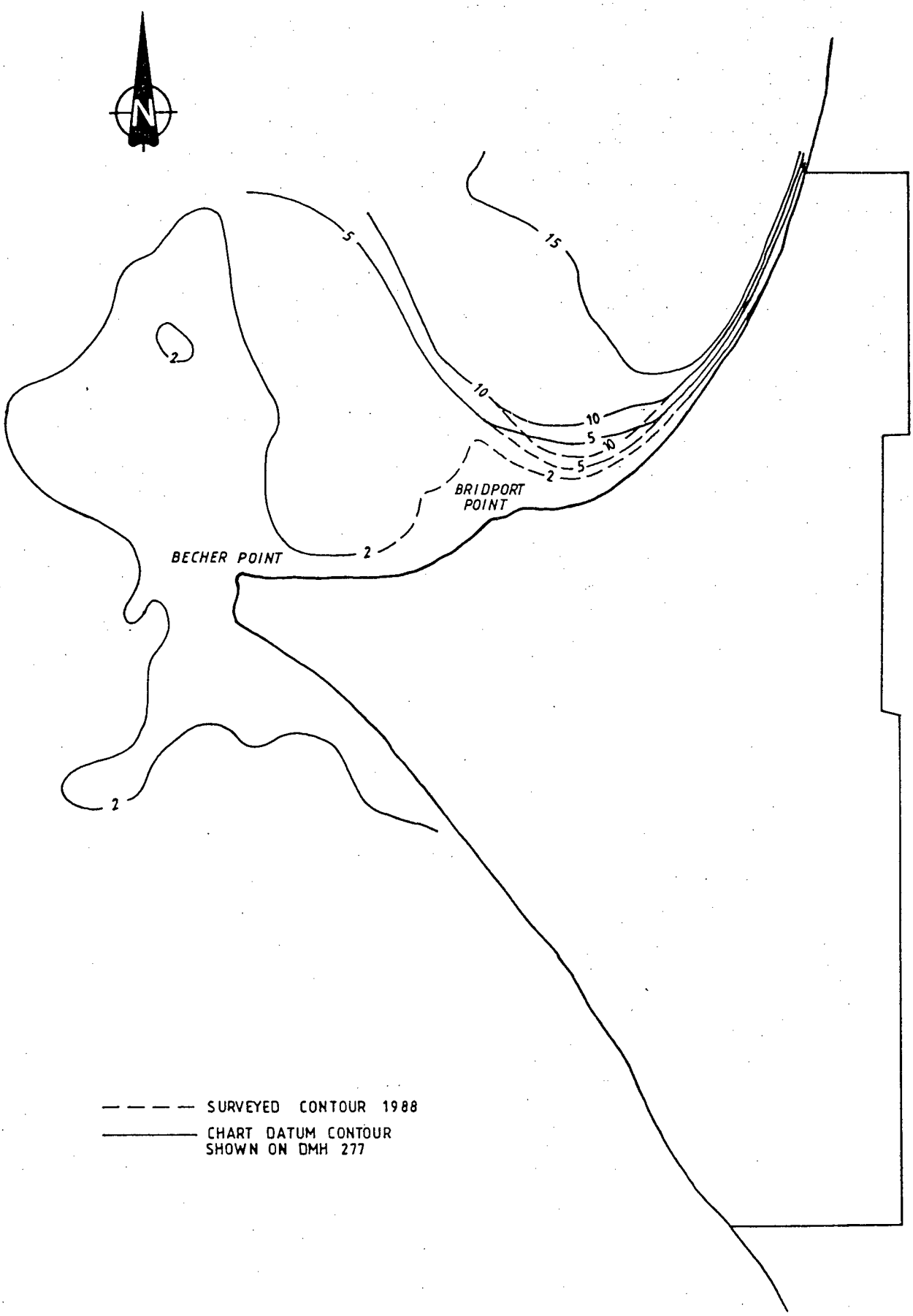


Crest of Garden Island Ridge

0 2 4 6 8 10 km

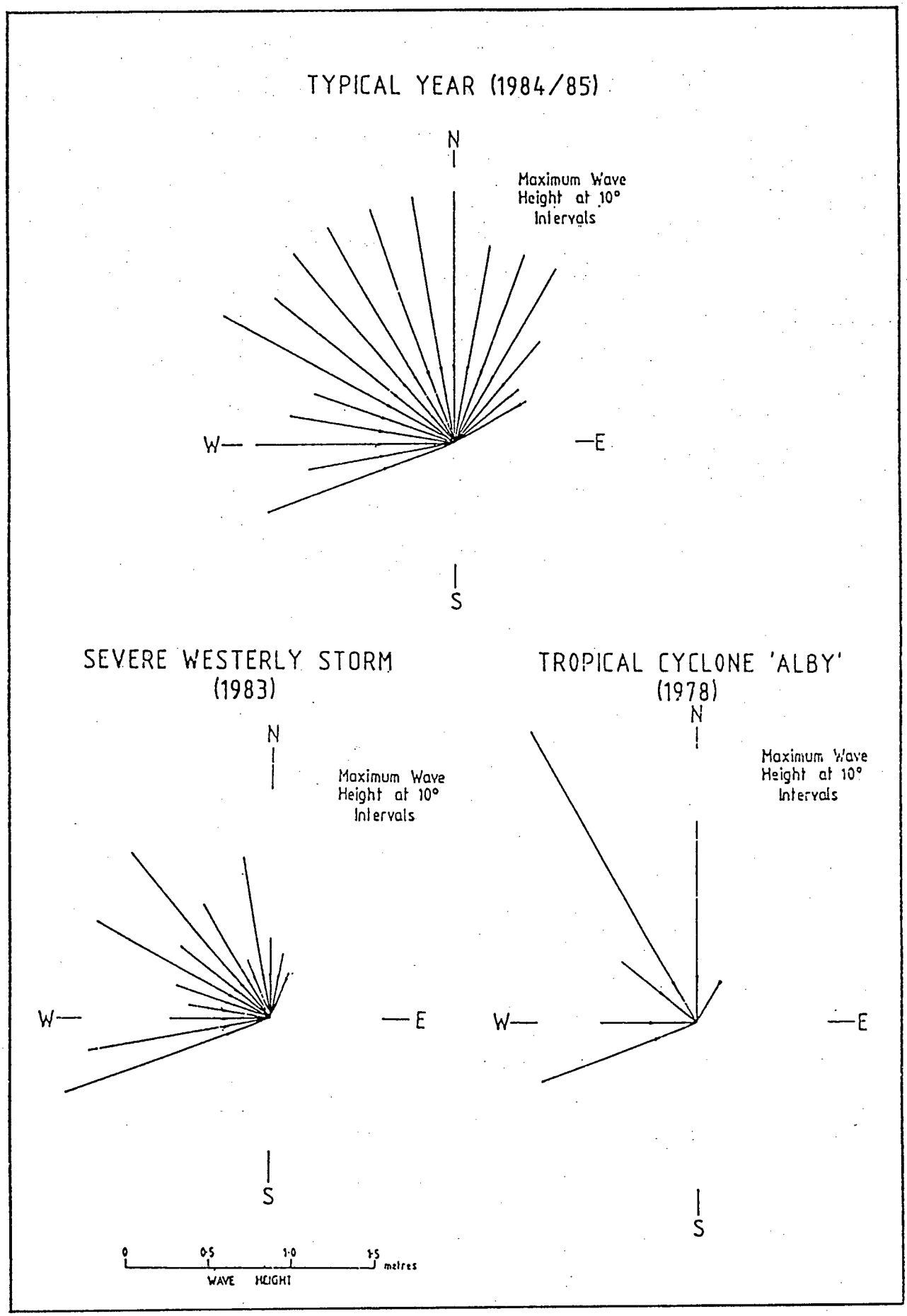
SOURCE: BOWMAN BISHAW & ASSOCIATES (Appendix E)

PORT KENNEDY JOINT VENTURE STAGE 1 ERMP	PORT KENNEDY	MARINE GEOMORPHIC ELEMENTS FIGURE 13



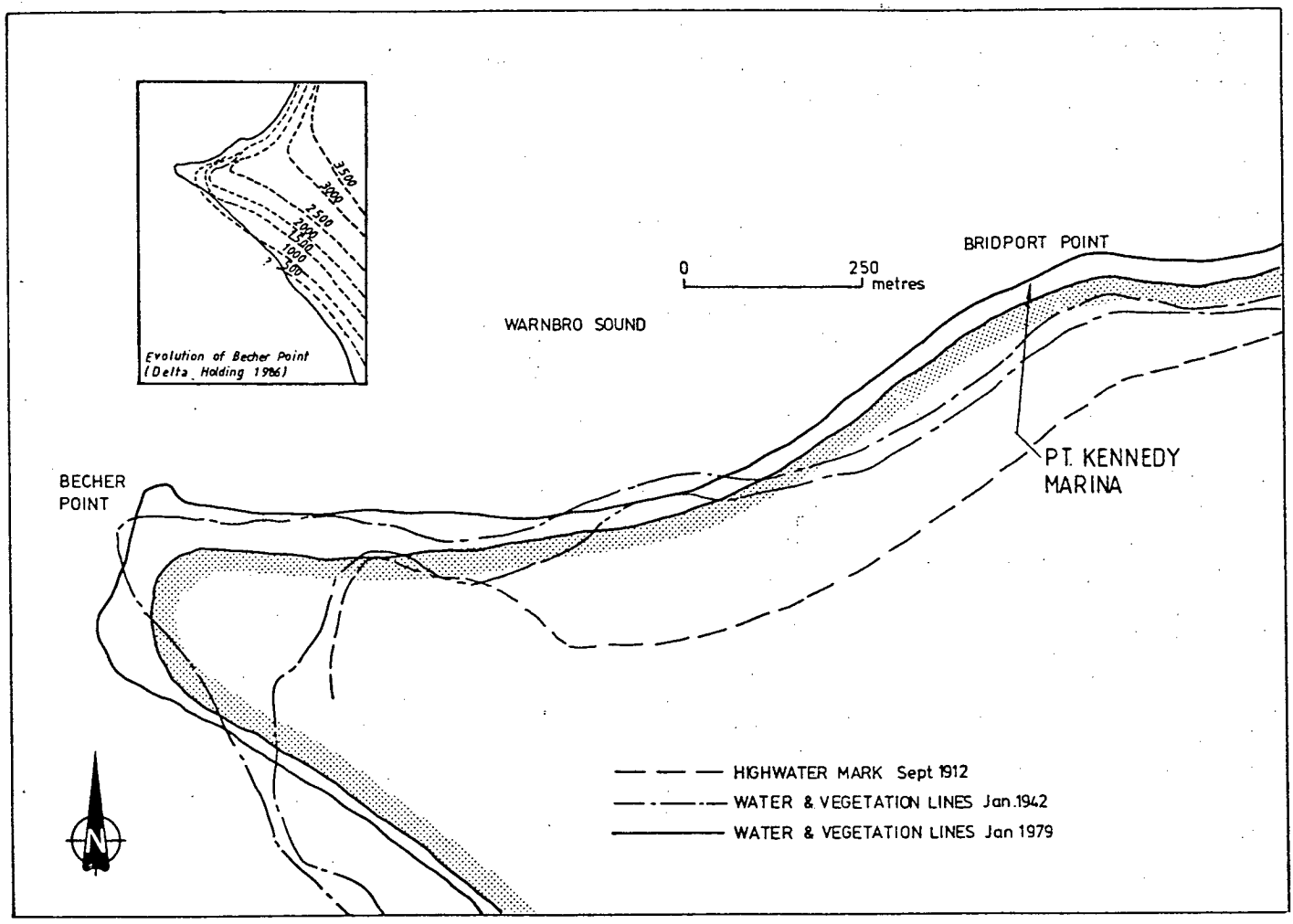
PREPARED BY: BINNIE & PARTNERS PTY LTD

PORT KENNEDY JOINT VENTURE STAGE 1 ERMP	PORT KENNEDY	SEABED DEPTHS (CHART DATUM) FIGURE 14



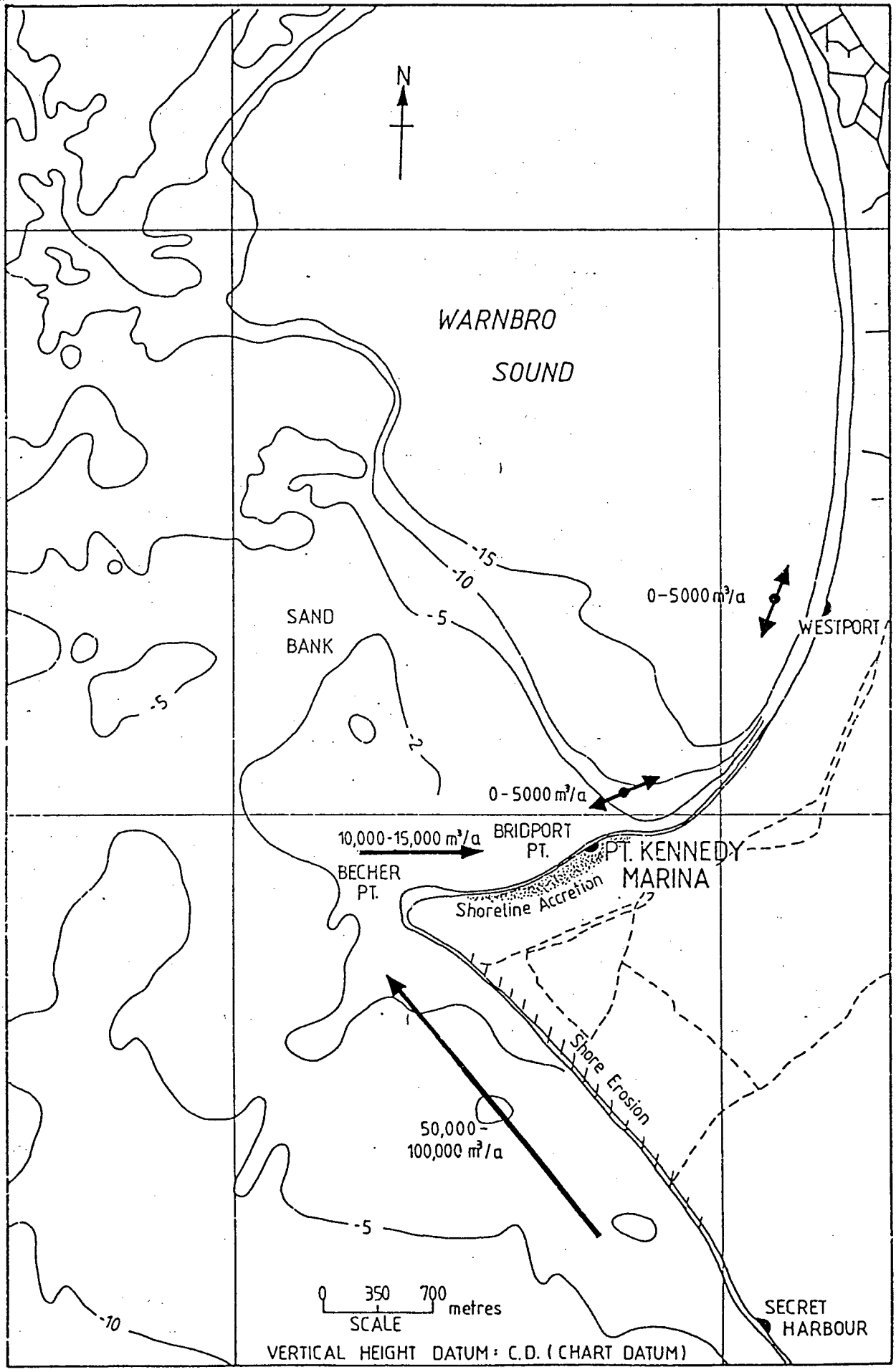
SOURCE: RIEDEL & BYRNE PTY LTD (Appendix A)

PORT KENNEDY JOINT VENTURE STAGE 1 ERMP	PORT KENNEDY	WAVE HEIGHTS FIGURE 15



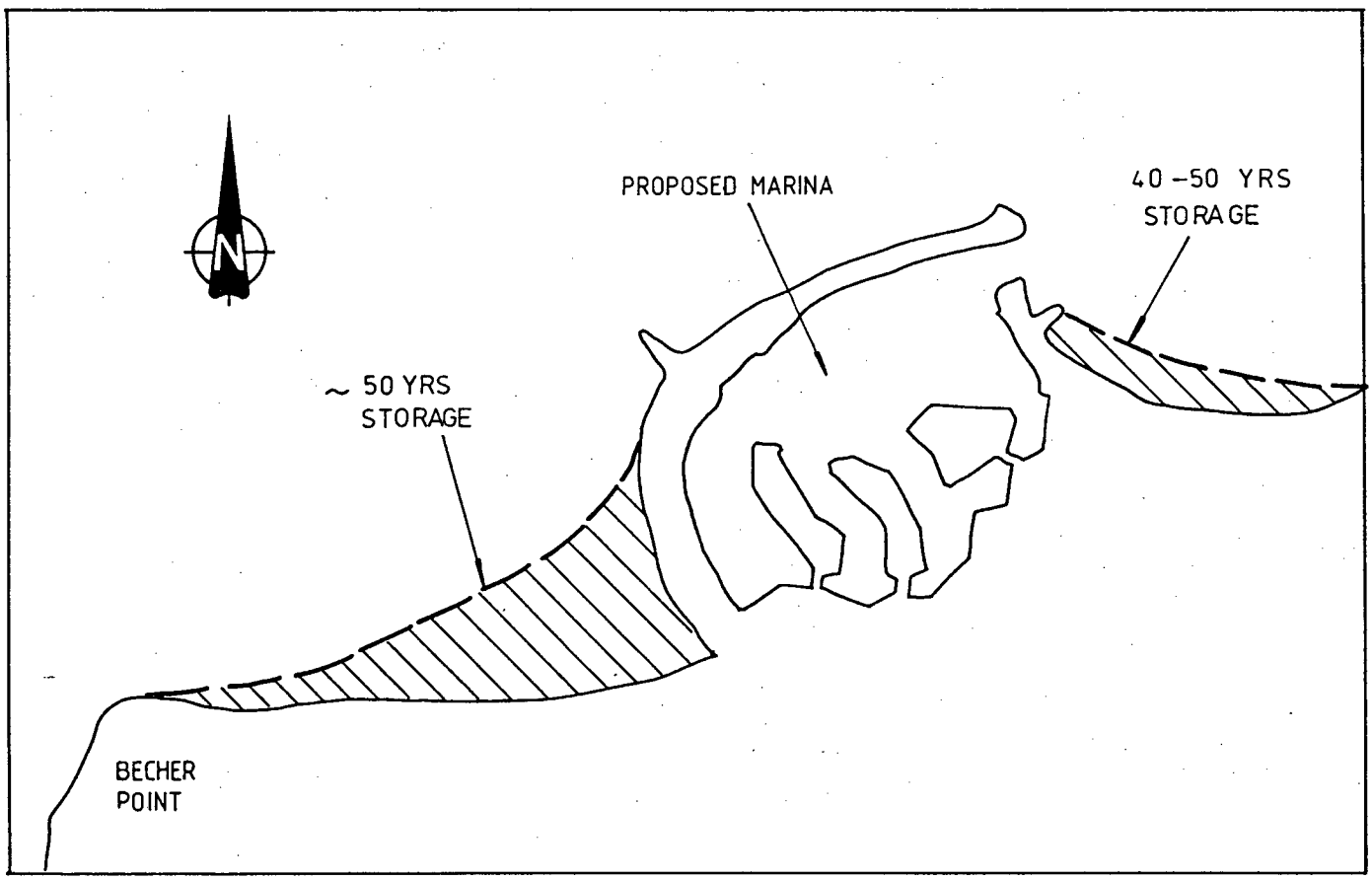
SOURCE: PWD DRG NO. 52624-6-1

PORT KENNEDY JOINT VENTURE STAGE 1 ERMP	PORT KENNEDY	SHORELINE MOVEMENTS FIGURE 16



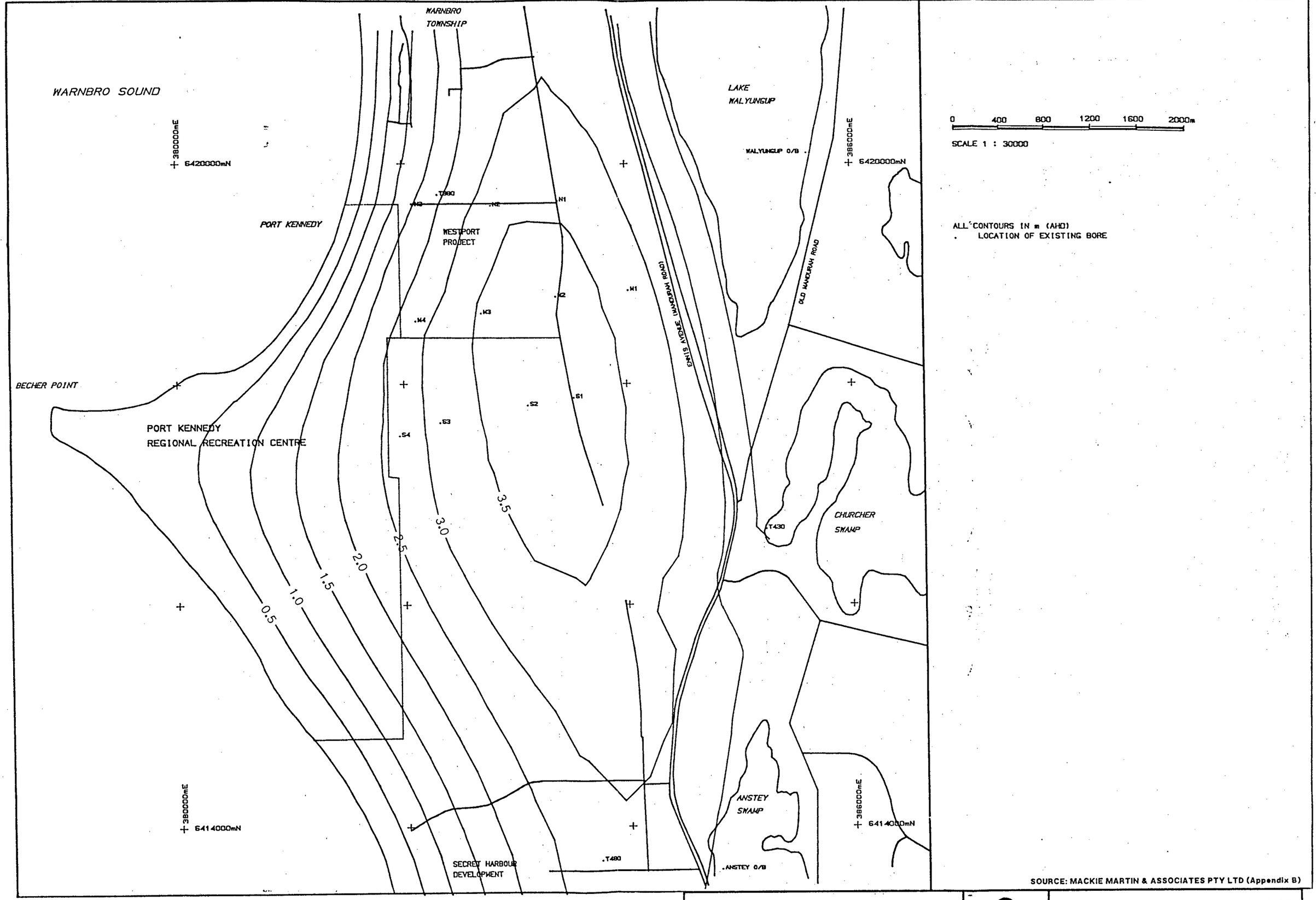
SOURCE: RIEDEL & BYRNE PTY LTD (Appendix A)

PORT KENNEDY JOINT VENTURE STAGE 1 ERMP	PORT KENNEDY	CONCEPTUAL SEDIMENT TRANSPORT FIGURE 17



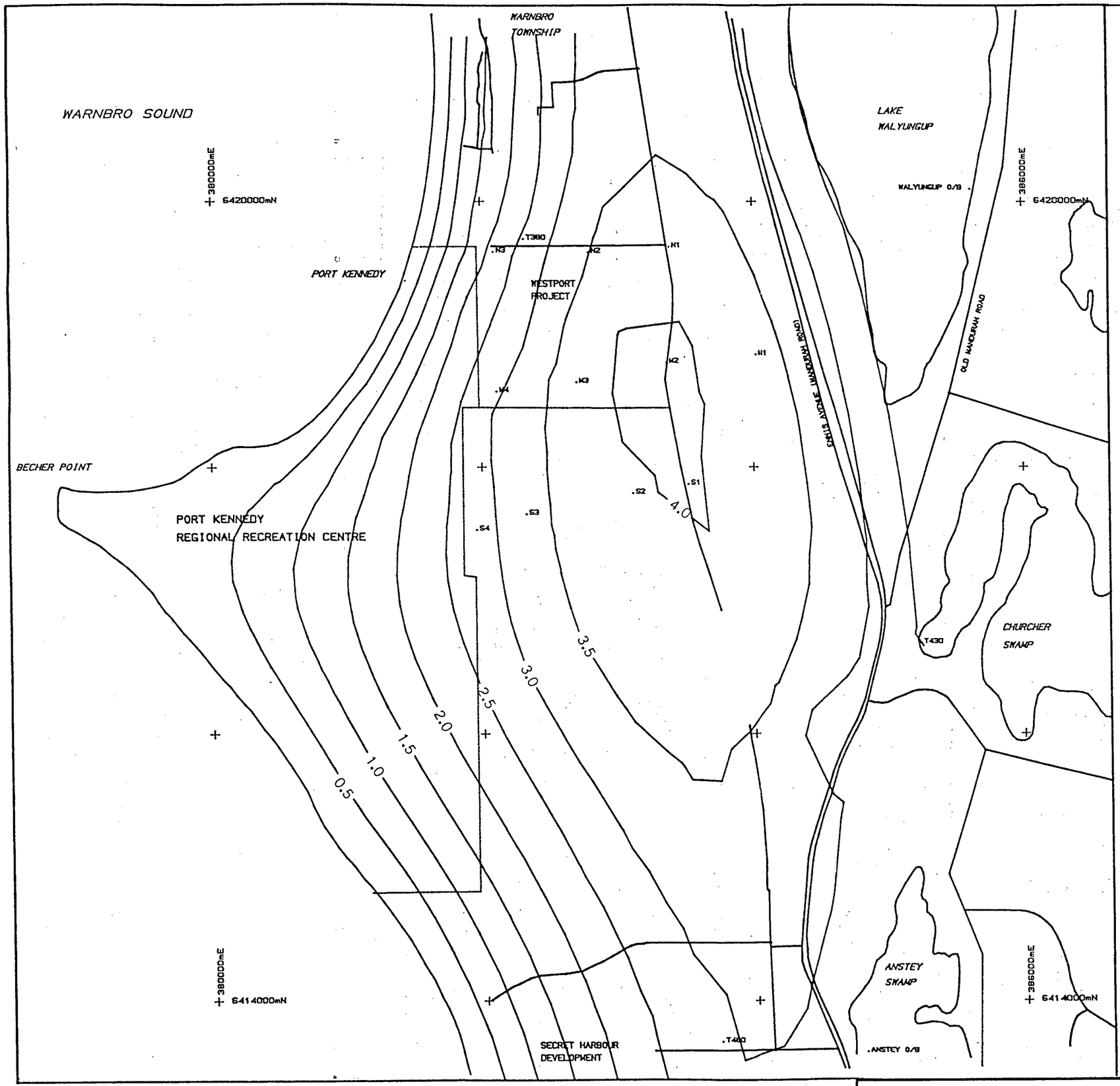
SOURCE: RIEDEL & BYRNE PTY LTD (Appendix A)

PORT KENNEDY JOINT VENTURE STAGE 1 ERMP	PORT KENNEDY	SEDIMENT BUFFER ZONES FIGURE 18



SOURCE: MACKIE MARTIN & ASSOCIATES PTY LTD (Appendix B)

PORT KENNEDY JOINT VENTURE STAGE 1 ERMP	PORT KENNEDY	WATER TABLE CONTOURS - SUMMER FIGURE 19



0 400 800 1200 1600 2000m

SCALE 1 : 30000

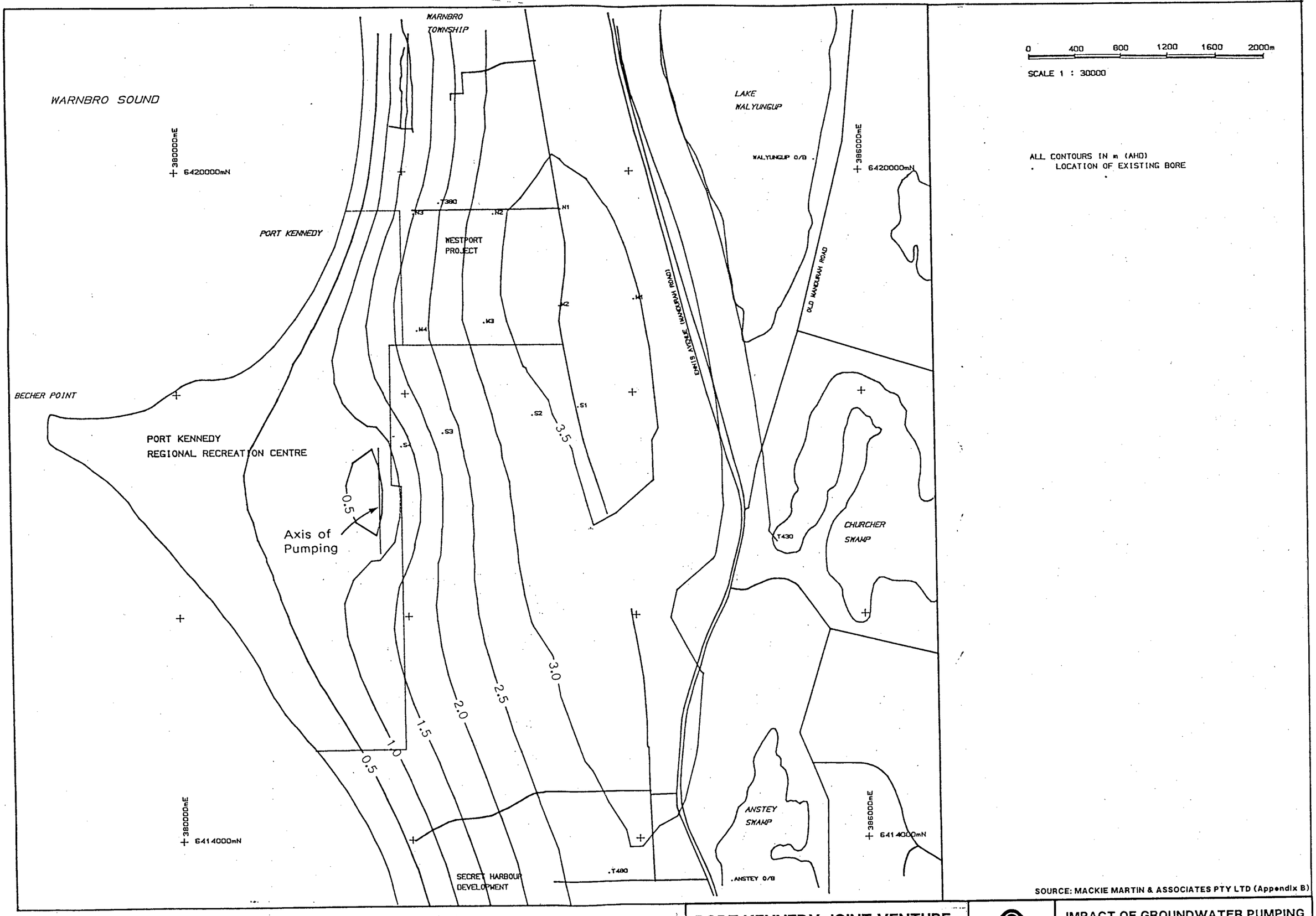
ALL CONTOURS IN m (AHD)
. LOCATION OF EXISTING BORE

SOURCE: MACKIE MARTIN & ASSOCIATES PTY LTD (Appendix B)

PORT KENNEDY JOINT VENTURE
STAGE 1 ERMP

PORT KENNEDY

WATER TABLE CONTOURS - WINTER
FIGURE 20



SOURCE: MACKIE MARTIN & ASSOCIATES PTY LTD (Appendix B)

PORT KENNEDY JOINT VENTURE

STAGE 1 ERMP

PORT KENNEDY

IMPACT OF GROUNDWATER PUMPING (4,000kL/day)

FIGURE 21

STRAND AND STABILISING DUNES

AC *Arctotheca calendula*, **Cakile maritima* open herbland

Sl *Spinifex longifolius* hummock grassland (with *Tetragonia decumbens*)

Oa_1 *Olearia axillaris* open shrubland to open heath

Oa_2 *Olearia axillaris* closed heath to closed scrub

Q4 DUNES

SO_{1a} *Scaevola crassifolia*, *Olearia axillaris* low open heath to closed heath to open scrub

SO_{1b} *Scaevola crassifolia*, *Olearia axillaris* low open heath to closed heath to open scrub

Q2 DUNES

RELICT FOREDUNES

JA *Jacksonia furcellata*, *Acacia saligna* Complex

OaAc *Olearia axillaris*, *Acacia cochlearis* Complex

OaMa *Olearia axillaris*, *Melaleuca acerosa* Complex

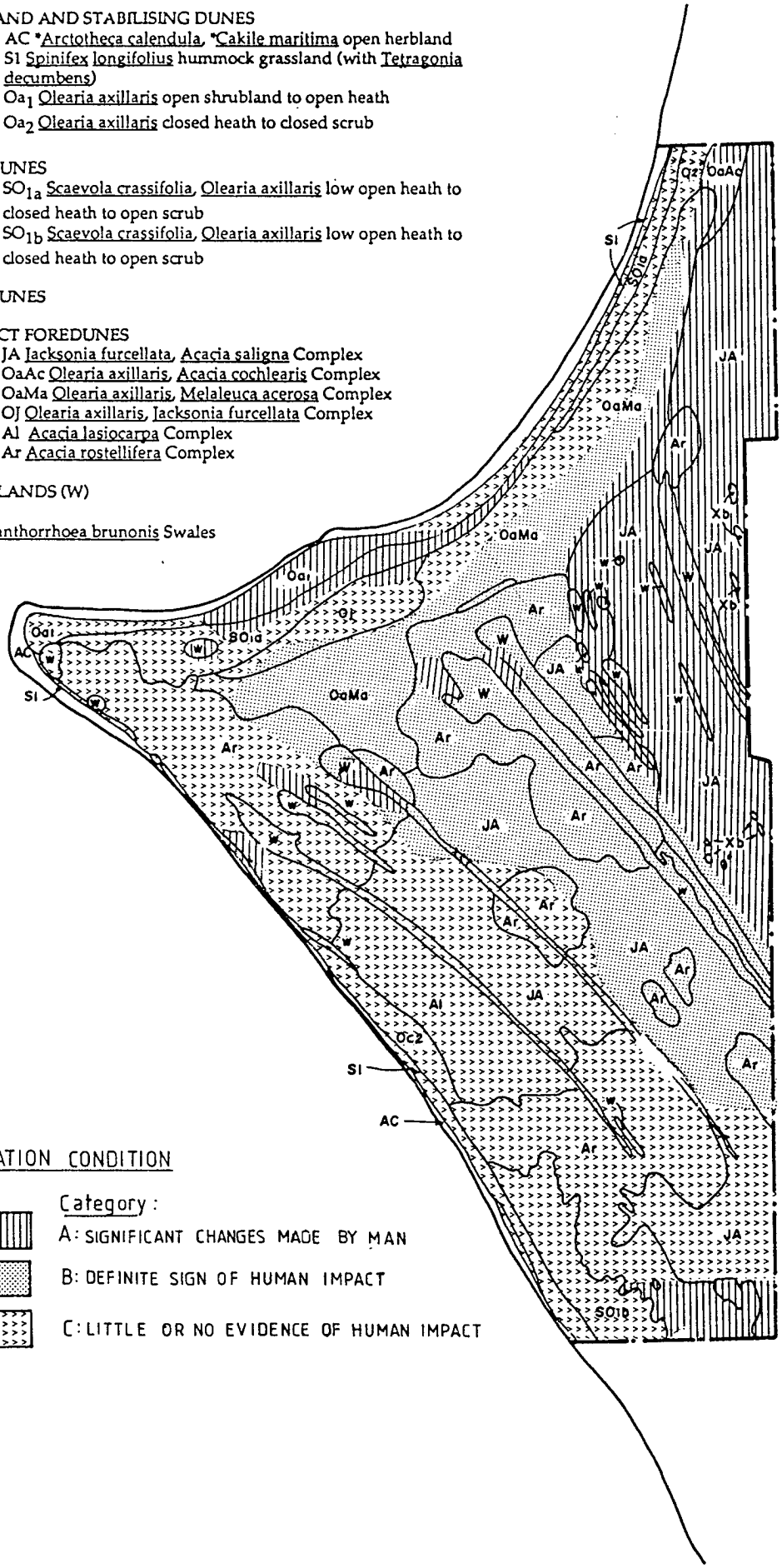
OJ *Olearia axillaris*, *Jacksonia furcellata* Complex

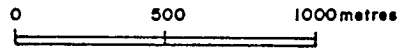
Al *Acacia lasiocarpa* Complex

Ar *Acacia rostellifera* Complex

WETLANDS (W)

Xb *Xanthorrhoea brunonis* Swales





VEGETATION CONDITION

Category :

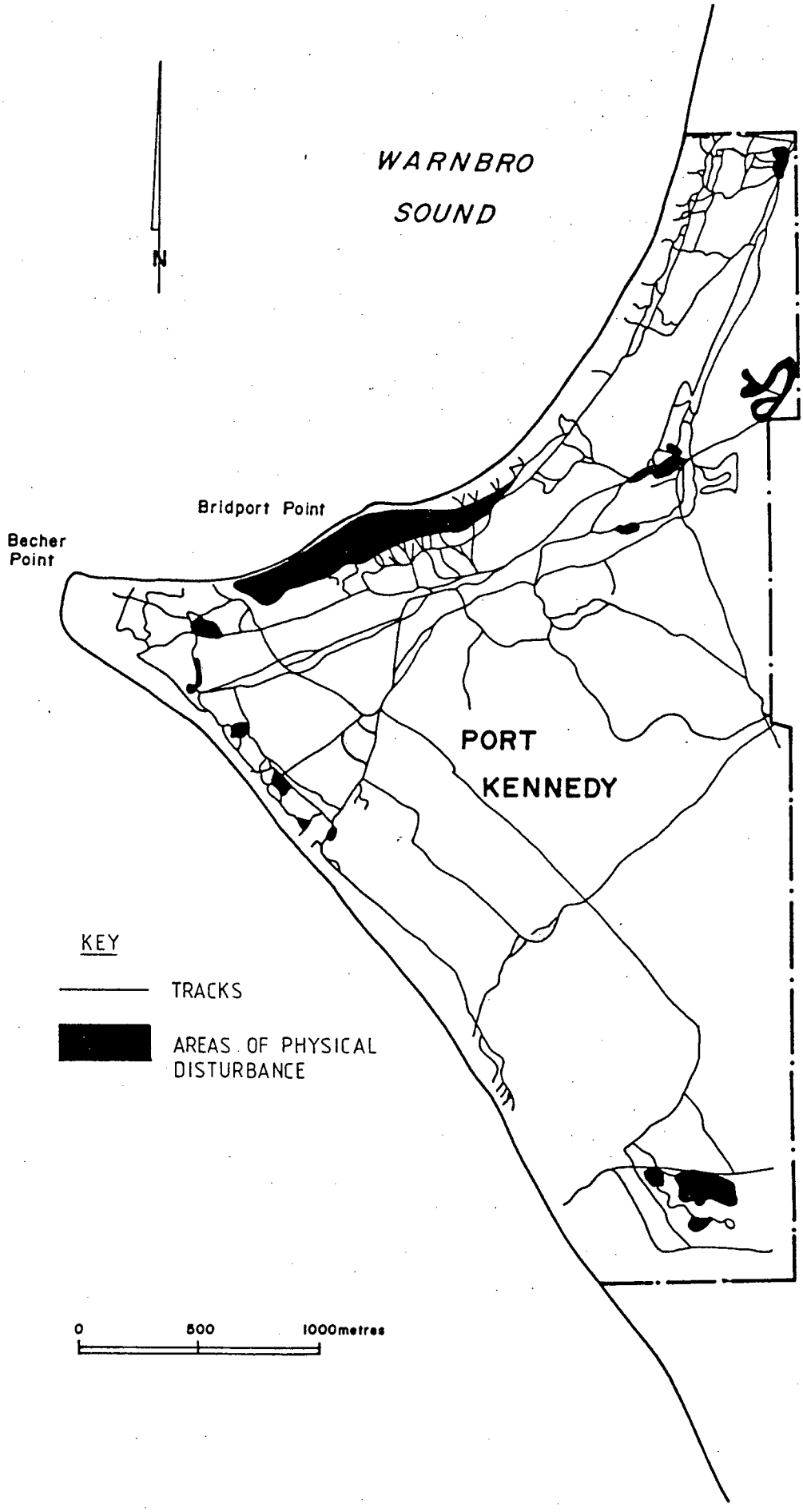
A: SIGNIFICANT CHANGES MADE BY MAN

B: DEFINITE SIGN OF HUMAN IMPACT

C: LITTLE OR NO EVIDENCE OF HUMAN IMPACT

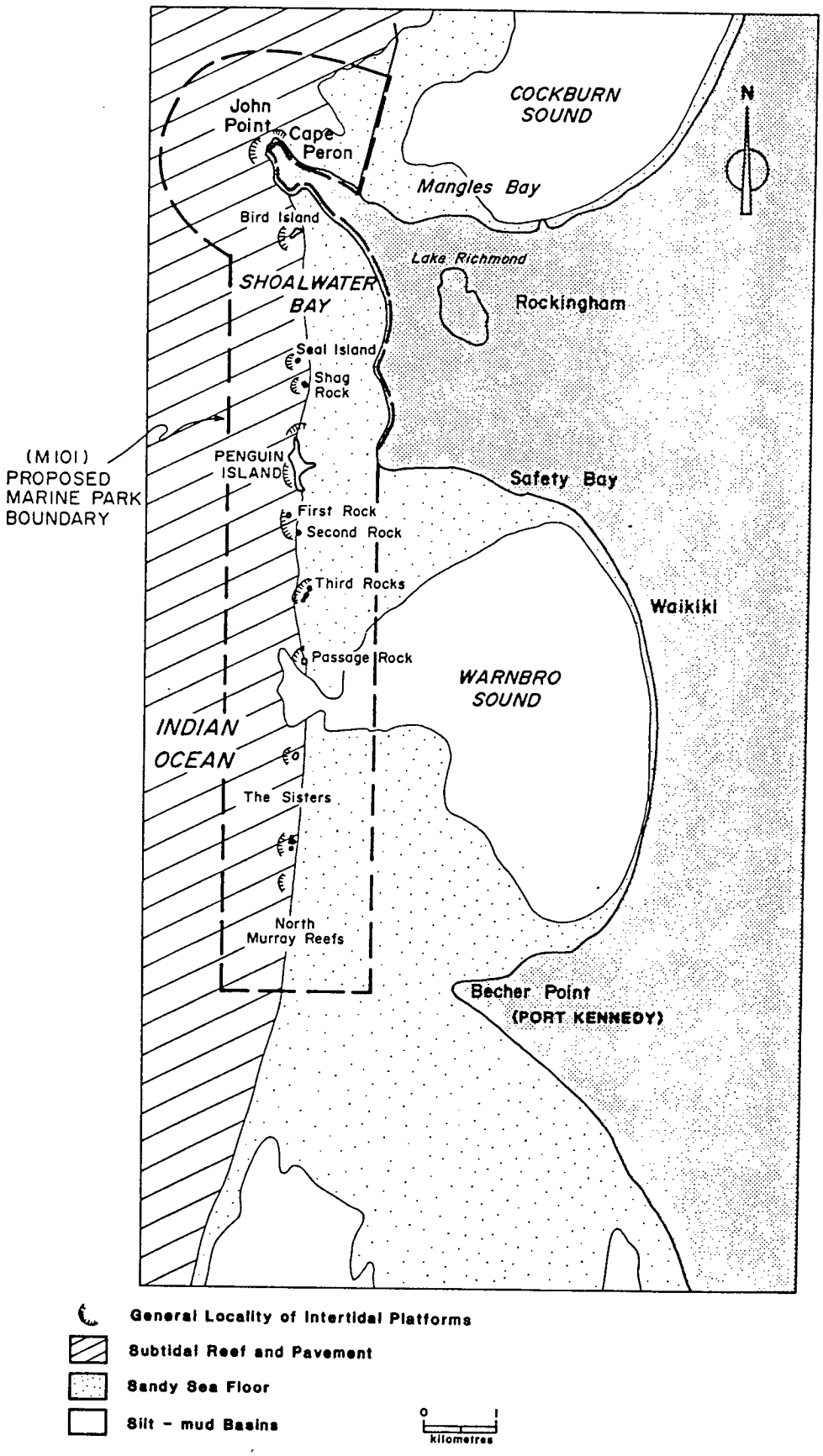
SOURCE: BOWMAN BISHAW & ASSOCIATES (Appendix C)

PORT KENNEDY JOINT VENTURE STAGE 1 ERMP	PORT KENNEDY	VEGETATION TYPES AND CONDITIONS FIGURE 22



SOURCE: BOWMAN BISHAW & ASSOCIATES (Appendix C)

PORT KENNEDY JOINT VENTURE STAGE 1 ERMP	PORT KENNEDY	AREAS OF PHYSICAL DISTURBANCE FIGURE 23



SOURCE: BOWMAN BISHAW & ASSOCIATES (Appendix E)

PORT KENNEDY JOINT VENTURE STAGE 1 ERMP	PORT KENNEDY	MARINE HABITATS FIGURE 24