EXMOUTH MARINA, RESORT AND RESIDENTIAL DEVELOPMENT

(EXTENSION TO EXMOUTH BOAT HARBOUR)

PUBLIC ENVIRONMENTAL REVIEW

LANDCORP
DEVELOPING LAND & COMMUNITY

March 1997

INVITATION

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

The Public Environmental Review (PER) proposes the development of the Exmouth Marina, Resort and Residential Development project in the Shire of Exmouth. In accordance with the Environmental Protection Act, a PER has been prepared which describes this proposal and its likely effects on the environment. The PER is available for a public review period of four weeks from 4th March 1997 closing on 1st April 1997.

Comments from government agencies and from the public will assist the EPA to prepare an assessment report in which it will make 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 document unless specifically marked confidential, and may be quoted in full or in part of each report.

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 PER 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 PER:

- 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 issues raised are clear. A summary of your submission is helpful;

- refer each point to the appropriate section, chapter or recommendation in the PER;

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

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

Remember to include:

- your name,
- address,
- date; and
- whether you want your submission to be confidential.

The closing date for submissions is: **1st April, 1997**

Submissions should be addressed to:

Environmental Protection Authority
Westralia Square
141 St George's Terrace
PERTH WA 6000

Attention: Ms Juliet Cole

LANDCORP
DEVELOPING LAND & COMMUNITY

EXMOUTH BOAT HARBOUR & RESORT/RESIDENTIAL PROJECT

PUBLIC ENVIRONMENTAL REVIEW

EXMOUTH MARINA, RESORT AND RESIDENTIAL DEVELOPMENT

IN CONJUNCTION WITH THE EXMOUTH BOAT HARBOUR

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Reference No: RI6336
March 1997

Summary of Environmental Factors, Potential Impacts and Proposed Management.
Exmouth Marina, Resort and Residential Development Extension to Exmouth Boat Harbour, Exmouth.

Environmental Factors	EPA Management Objective	Potential Impact	Proposed Management of Relevant Environmental Factors	Predicted Outcomes
BIOPHYSICAL IMPACTS				
Subterranean fauna.	To ensure that subterranean fauna are adequately protected, consistent with the *Wildlife conservation Act 1950*, and that the abundance, diversity, geographical distribution and productivity of subterranean fauna are protected.	Dewatering will result in minor drawdown impacts to troglobitic fauna site (Cameron's Cave)	Minimise length of dewatering. Conduct monitoring as outlined in Section 6.2 within a groundwater management and monitoring plan. Undertake contingency measures should unacceptable impacts be detected.	No impact on abundance, diversity, geographical distribution and productivity of subterranean fauna.
Terrestrial fauna	To ensure that, where possible, impacts upon regionally significant fauna and habitat are avoided.	No impacts on regionally significant fauna and habitat	No management required	No impacts on regionally significant fauna and habitat
Declared Rare Fauna	To protect Declared Rare fauna species, and their habitats consistent with the provisions of the *Wildlife Conservation Act 1950.*	No impacts on Declared Rare and their habitat	No management required	No impacts on Threatened Fauna and their habitat
Terrestrial vegetation	To ensure that, where possible, impacts upon regionally significant flora and vegetation communities are avoided and to ensure the abundance, diversity, geographical distribution and productivity of vegetation communities are protected.	No impacts on regionally significant flora and vegetation communities	No management required	No impacts on regionally significant flora and vegetation communities
Declared Rare Flora and Priority flora	To protect Declared Rare and Priority flora, consistent with the provisions of the *Wildlife Conservation Act 1950*, and to ensure the abundance, diversity, geographical distribution and productivity of vegetation communities are protected.	No impacts on Declared Rare Flora and Priority flora	No management required	No impacts on Declared Rare Flora and Priority flora
Dunes	To maintain the integrity, function and environmental values of the dune system	Dune system currently degraded to a greater or lesser extent by weed invasion and uncontrolled public access. Potential for earthmoving equipment to encroach into dune during construction. Potential for further spread of non-endemic species in dune system due to uncontrolled public access.	During construction, temporary fencing will be in place to prevent incursion of machinery into the dune system Proponent will prepare a Sand Dune Management Plan to focus on rehabilitation of degraded dunes and managed pedestrian pathways and access to the beach.	Reduction in degradation of the dune system by spread of introduced vegetation species. Rehabilitation of existing degradation. Well planned public access to beach and foreshore.
Sea level	To ensure that changes to sea level (including storm surge) do not result in unacceptable environmental impacts.	Manageable under planning process	Elevation of land levels surrounding the waterways so that peak water levels are contained.	No unacceptable environmental impact.
Surface Water	To protect the hydrological role of the flood plain.	Existing floodway would be intersected, resulting in potential flooding	Existing drainage to be diverted via formal open drainage systems to outlets for dispersal. Detailed design specifications for drainage of episodic flooding to be prepared prior to construction.	No disturbance to hydrological role of floodplain.

Summary of Environmental Factors, Potential Impacts and Proposed Management.
Exmouth Marina, Resort and Residential Development Extension to Exmouth Boat Harbour, Exmouth.

Environmental Factors	EPA Management Objective	Potential Impact	Proposed Management of Relevant Environmental Factors	Predicted Outcomes
POLLUTION MANAGEMENT				
Marine water quality	To meet the requirements of the EPA's Environmental Water Quality Objectives (EQO) and draft Western Australian Guidelines for Fresh and Marine Waters (EPA Bulletin 711), and ANZECC & NHMRC guidelines for the assessment and management of contaminated sites.	Potential contamination of marina water quality	Management of construction, operation and maintenance phases to ensure adequate flushing and minimal input of contaminants to proposed waterways, including: Dredging and dredge spoil disposal, management of turbidity; fuel storage, contingency plans for spillage, sewerage pump out facilities, marina facilities and nutrient load from drainage Flushing studies to ensure design meets SPC Policy DC1.8. Proponent to prepare Sediment and Water Quality Monitoring Program. Any disposal of dredge spoil will be subject to a Dredge Spoil Disposal Management Plan. Should maintenance dredging be required, plans for dredging and disposal of dredge spoil would be referred to the EPA prior to implementation Turbidity will be managed through the use of settling ponds during dewatering, use of silt screens, where appropriate, at connection of waterway with Boat Harbour. Fuel storage at the marina would include above-ground bulk storage tanks within a full capacity sealed bund. Fuel storage and boat refuelling facilities to comply with requirements of the Explosives and Dangerous Goods Division of DOME. All facilities and development will be sewered. Site drainage to be diverted via formal open drainage systems to outlets for dispersal. Design criteria for drainage would allow dissipation of 1 in 10 year storm event (less than cyclonic event) without overland flooding.	Negligible impact on receiving waters of Exmouth Gulf.
Groundwater quality	To maintain groundwater quality to ensure existing and potential groundwater uses are protected and to meet the requirements of ANZECC & NHMRC guidelines for the assessment and management of contaminated sites.	Potential increase in nutrient levels to groundwater due to increase grey water recycled from sewage treatment plant	Preparation and implementation of Groundwater Management and Monitoring Program	Minimal environmental impact
Noise and vibration	To protect the amenity of nearby residents from noise and vibration impacts resulting from activities associated with the proposal by ensuring that noise and vibration levels meet statutory requirements and acceptable standards	Potential noise and vibration problem in areas close to town site during construction. Blasting is not anticipated	Noise abatement (Neighbourhood Annoyance) Regulations 1979 and the proposed Environmental Protection (Noise) regulations (when promulgated), and any policies covering noise or vibration which have been endorsed by the EPA will be implemented. Construction activities will be confined to normal daylight hours.	Minimal environmental impact

Summary of Environmental Factors, Potential Impacts and Proposed Management.
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Environmental Factors	EPA Management Objective	Potential Impact	Proposed Management of Relevant Environmental Factors	Predicted Outcomes
Dust	To protect the surrounding land users such that dust emissions will not adversely impact upon their welfare and amenity or cause health problems	Potential dust problem in areas close to town site during construction.	EPA Guidelines for Assessment and Control of Dust and Windborne Material form Land Development Sites, updated 1995 will be implemented.	Minimal dust problems.
Soil Contamination	To ensure that the site is cleaned up to an acceptable level for proposed landuse in accordance with the ANZECC & NHMRC guidelines for the assessment and management of contaminated sites.	Potential for soil contamination in disused rubbish tip.	Site will be investigated and managed in accordance with ANZECC & NHMRC guidelines for the assessment and management of contaminated sites.	No unacceptable environmental or health risk
Solid waste/sewage	To encourage waste minimisation, recycling and sustainable use, and to ensure that solid waste and sewage from the development is disposed of in an environmentally acceptable manner	Potential increase in pollution levels	The proponent will encourage waste minimisation within the development, and encourage the Shire to implement recycling and environmentally acceptable solid waste disposal. The development will operate under a dedicated sewage system.	Minimisation of unacceptable pollution levels
SOCIAL SURROUNDINGS				
Heritage	To comply with statutary requirements in relation to areas of cultural or historic significance	No cultural or historic areas of significance anticipated.	Compliance with the *Aboriginal Heritage Act 1972-1980*, if required.	No unacceptable disturbance
Public Health	To ensure that the potential for mosquito breeding is minimised, and that mosquitoes do not pose an unacceptable health threat to people in the area.	No mosquito breeding habitat generated if water exchange criteria maintained. Potential public health threat from mosquitos identical to Exmouth township.	No management required. Management of existing mosquito problem by the Shire may be funded from increased revenue generated from the development.	No increase in mosquito levels. Reduction in existing health threat.

PUBLIC ENVIRONMENTAL REVIEW
EXMOUTH MARINA, RESORT AND RESIDENTIAL DEVELOPMENT

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1.0 INTRODUCTION

1.1 Summary of the Proposal

LandCorp proposes to develop an inner marina, resort and residential development immediately south of Exmouth township, as a land backed extension of the "Exmouth Boat Harbour", currently being developed by the Department of Transport (DOT), (Figure 1).

The proposal is the culmination of a number of investigations and proposals for the development of marina facilities at Exmouth during the past decade (Section 2.1). The concept plan put forward in this proposal has been formulated and evaluated with guidance from the Exmouth Development Steering Committee[1], following a request from Cabinet in March 1995. The Concept Plan for the project is presented as Figure 2.

The proposal comprises an inner boat harbour precinct for commercial fishing boats and associated marine industry totalling 42.5ha, a resort precinct of 25ha, and a residential canal precinct of 431 lots (62.5ha).

The proposed Concept Plan has been subject to a public consultation process which was initiated with a public information day in Exmouth on 17 October 1996. The closing date for written submissions regarding the concept plan was 15 November 1996. The outcome of the public consultation is discussed in Section 3.4.5.

This PER addresses the environmental factors associated with the proposal, discusses the potential environmental impacts, and proposes appropriate environmental management strategies.

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1 The Exmouth Development Steering Committee has the following membership:

- Gascoyne Development Commission
- Ministry for Planning
- Northwest Development - Western Australian Tourism Commission
- Department of Transport
- LandCorp
- Shire of Exmouth
- MG Kailis Group of Companies
- Western Australian Fishing Industry Council
- Department of Commerce and Trade
- Department of Fisheries
- Department of Land Administration (DOLA)

1.2 The Proponent

The proponent for this project is the Western Australian Land Authority (LandCorp).

The scope of this PER focuses on a conceptual design and planning for a waterways and residential development, with broad development guidelines for commercial and tourist components. LandCorp has sought and received expressions of interest from private developers to develop the various elements of the proposal, with emphasis on the Resort Precinct which will provide the impetus for the remainder of the project. LandCorp's selection of, and negotiation of a development agreement with, a preferred developer is currently in process.

It is recognised that some aspects of the Concept Plan may be modified by the selected developer during the detailed design planning. However the general concepts proposed herein remain, as will the environmental issues requiring assessment and management. LandCorp has informed the interested parties that changes to the current concept plan would require referral to the EPA.

1.3 Land Tenure and Ownership

Virtually all of the land included in the project area is currently in Crown ownership and includes the following:

- Reserve 34089: Vested in the Minister for Transport for Harbour Purposes (52.9ha);
- Reserve 41721: Vested in the Minister for Transport for Residential Purposes (53.2ha);
- Reserve 30074: Vested in the Shire of Exmouth for Racecourse and Recreation with power to lease (39.6ha);
- Reserve 29066: Vested in the Shire of Exmouth for Recreation with power to lease (131.2ha);
- Reserve 27489: Vested in the Shire of Exmouth for Cemetery Purposes (1.1ha);
- Vacant Crown land: site at intersection of Murat Road and Reid Street.

The exceptions are a small portion of the former North Cape lodge site which is required for a road reserve, and Lots 395 and 850, the former Drive-In Theatre site, which will be incorporated into the northern deviation of Murat Road. A land exchange for these private freehold lots is proposed.

Application for Native Title claims will be advertised by DOLA in Mid-March.

1.4 The Statutory Environmental Approvals Process

A number of Government Authorities will provide advice and/or be involved in the decision making process in the course of approving this proposal. These include:

- The Shire of Exmouth (the Shire)
- The Western Australian Planning Commission (WAPC) and the Ministry for Planning (MFP)
- The Department of Environmental Protection (DEP)
- The Environmental Protection Authority (EPA)
- The Department of Conservation and Land Management (CALM)
- The Water Corporation of Western Australia (WCWA)
- The Water and Rivers Commission (WRC)
- The Department of Transport (DOT)
- The Western Australian Museum (WAM)
- The Department of Land Administration (DOLA)
- Main Roads of Western Australia (MRWA)

Two aspects of the proposed development that require particular attention are groundwater management and drainage control. The approval and management of these aspects will require detailed consultation with the Water Corporation of Western Australia, the Water and Rivers Commission and the Shire of Exmouth.

The level of assessment set for this proposal by the EPA is a Public Environmental Review, which is normally made available for public review and comment for a period of eight weeks, during which time submissions may be made regarding the proposal. The review period for this PER is only four weeks due to:

- the similarity of this proposal to the previously approved Exmouth Marina

proposal by the Department of Transport (formerly the Department of Marine and Harbours); and

- the high level of recent public consultation which has already been conducted on this specific proposal.

At the conclusion of the public comment period the EPA will consider the proposal together with any public submissions. Public submissions are confidential, however the proponent will be asked to comment on any issues which are raised by the public, and summarised by the DEP.

When the assessment is completed, the EPA will prepare a report (Bulletin) which will summarise the issues and state whether the project is environmentally acceptable and under what conditions. Anyone can appeal against the recommendations of an EPA assessment report for a two week period.

Before a project may proceed, the Minister for Environment must give approval and will set conditions which must be met by the proponent. Only the proponent can appeal against Ministerial conditions which, when set, are legally binding.

1.5 Timing and Schedules

This PER was released on 4th March, 1997 and will be available for public comment for a four week period, closing 1st April, 1997. Details on how to make a submission are located at the front of this document.

1.6 Purpose and Structure of the Public Environmental Review (PER)

This PER has been structured in accordance with DEP Guidelines for the project (Appendix A).

This document has the purpose of describing the proposal, detailing the existing environmental characteristics of the site and surrounding area and any anticipated environmental impacts, and proposing environmental design and management strategies which will be required to mitigate any potential environmental impacts. The environmental

commitments proposed by the proponent are listed in Section 8.0.

The Appendices, which are the basis for summarised information in relevant sections of the PER , are presented in full under separate volume. The Appendices are available upon request (at additional $10.00 cost to the PER).

The document therefore brings together the information required to assist in the environmental assessment process.

2.0 PROJECT RATIONALE

2.1 Background to the Proposal

In January 1992, environmental approval was obtained for a proposal by the Department of Marine and Harbours (now Department of Transport (DOT)) to construct Stage 1 of the "Coral Coast Marina" (Bowman Bishaw Gorham, 1989; EPA Bulletin 498, 1991), subject to conditions.

The original Stage 1 marina proposal included a 15.5ha inshore excavated harbour basin with the provision of 250 berths for recreation and commercial craft; commercial marine facilities to service the users of the marina, including fisheries receivable areas, boat repair facilities, a fuel depot and boat refuelling facilities, and a public boat ramp with associated parking; a recreational holiday resort and associated facilities including holiday chalets, a motel and shopping centre; and a residential subdivision providing 337 fully serviced housing lots and approximately 6ha of Public Open Space inland of the marina. A quarry was also proposed to provide armour stone for the marina breakwaters and groyne. The layout of the project approved in 1991 is presented as Figure 3.

The original proposal also anticipated the future development of a Stage 2 marina and residential resort, which would be a southern extension of the Stage 1 marina development.

In 1993, a change to the proposal was presented under Section 46 of the *Environmental Protection Act, 1986* (Bowman Bishaw Gorham, 1995a). The changes to the original proposal, which involved reducing the size of the harbour and proposed development, included the following:

- The project name was changed from the "Coral Coast Marina" to the "Exmouth Boat Harbour" (to avoid confusion with the proposed "Coral Coast Marina" development at Point Maud, Coral Bay).

- The 15.5ha inshore excavated harbour basin was redesigned to become an offshore 4.4ha breakwater protected facility. The harbour depth was also reduced.

- Retention of the floodway through the harbour basin.
- Removal of sections of dunes on either side of the floodway in order to accommodate the floodway and access road.
- Deferral of the residential component which was to be revised by LandCorp and subject to a separate submission.

  and

- The proposal of an alternative quarry site west of the previously approved site.

This proposal by LandCorp is the separate submission referred to regarding the residential component, and is essentially a redesign of the originally proposed project (both Stage 1 and Stage 2). The LandCorp proposal also includes an inner harbour basin, resort/tourism commercial facilities and a residential component, together with an extension to the waterway.

Consequently, the new proposal addresses similar environmental issues as the original proposal.

2.2 Assessment under the Environmental Protection Act

As outlined in the Section above, the current proposal is very similar to the Exmouth "Coral Coast Marina" project which received environmental approval in January 1992, hence this project could have been assessed under Section 46 of the Environmental Protection Act as a change to the original proposal. However, the EPA and LandCorp agreed that the current concept plan should be assessed as a new proposal, for the following reasons:

- There is a change to the proponent: The Department of Transport will remain the proponent for the Exmouth Boat Harbour while the proponent for the inland marina/residential/resort/canal development area will be LandCorp.
- While the total area of land affected by both proposals is approximately the same, there is a re-configuration of the land involved.
- Stage 2 of the original proposal (extensions to both the marina waterway and

residential component) was not defined in the original "Notice of Intent" (NOI)[2] so was not assessed by the EPA nor approved by the Minister for the Environment.

- The five year time limitation to the approval for the original proposal expired in January 1997.
- The refinement of different elements of the concept design by different developers may result in future changes to the proposal.

2.3 Environmental Factors and Project Design and Management Objectives

Environmental factors and management objectives for the Exmouth Marina, Resort and Residential Development have been developed within the guidelines for the project provided by the Department of Environmental Protection (DEP) (Appendix A). Where appropriate, the management objectives have been incorporated into the design specifications of the project, thereby mitigating impacts at the outset.

In addition, the environmental concerns raised during the public consultation process (Appendix B) and the environmental factors and proposed management highlighted from the previous proposal have been recognised and incorporated into the project framework.

The EPA relevant environmental factors and management objectives are as follows:

BIOPHYSICAL

B1 Subterranean fauna.

To ensure that subterranean fauna are adequately protected, consistent with the *Wildlife conservation Act 1950*, and that the abundance, diversity, geographical distribution and productivity of subterranean fauna are protected.

[2] In September, 1989 the EPA revised its administrative procedures and renamed Notice of Intent documents as Consultative Environmental Review (CER) documents.

B 2 Terrestrial fauna

To ensure that, where possible, impacts upon regionally significant fauna and habitat are avoided and to protect Declared Rare fauna species, and their habitats consistent with the provisions of the *Wildlife Conservation Act 1950.*

B 3 Terrestrial vegetation

To ensure that, where possible, impacts upon regionally significant flora and vegetation communities are avoided and to ensure the abundance, diversity, geographical distribution and productivity of vegetation communities are protected and to protect Declared Rare and Priority flora, consistent with the provisions of the *Wildlife Conservation Act 1950.*

B 4 Dunes

To maintain the integrity, function and environmental values of the dune system

B 5 Sea level

To ensure that changes to sea level (including storm surge) do not result in unacceptable environmental impacts.

B 6 Surface Water

To protect the hydrological role of the flood plain so that any changes do not result in unacceptable environmental impact.

POLLUTION

P 1 Marine water quality

To meet the requirements of the EPA's Environmental Water Quality Objectives (EQO) and draft Western Australian Guidelines for Fresh and Marine Waters (EPA Bulletin 711), and ANZECC & NHMRC guidelines for the assessment and management of contaminated sites.

P 2 Groundwater quality

To maintain groundwater quality to ensure existing and potential groundwater uses are protected and to meet the requirements of ANZECC & NHMRC guidelines for the assessment and management of contaminated sites.

P3 Noise and vibration

To protect the amenity of nearby residents from noise and vibration impacts resulting from activities associated with the proposal by ensuring that noise and vibration levels meet statutory requirements and acceptable standards.

P4 Dust

To protect the surrounding land users such that dust emissions will not adversely impact upon their welfare and amenity or cause health problems

P5 Soil Contamination

To ensure that the site is cleaned up to an acceptable level for proposed landuse in accordance with the ANZECC & NHMRC guidelines for the assessment and management of contaminated sites.

P6 Solid waste/sewage

To encourage waste minimisation, recycling and sustainable use, and to ensure that solid waste and sewage from the development is disposed of in an environmentally acceptable manner

SOCIAL SURROUNDINGS

S1 Heritage

To comply with statutary requirements in relation to areas of cultural or historic significance

S2 Public Health

To ensure that the potential for mosquito breeding is minimised, and that mosquitoes do not pose an unacceptable health threat to people in the area.

2.4 Justification for the Development

2.4.1 Project Background

A number of investigations and proposals for the development of marina facilities at

Exmouth during the 1980's[3], culminated in the Exmouth "Coral Coast Marina" Project, which received environmental approval in January 1992. Although the potential of the North West Cape area for tourist development was strongly promoted by the former Department of Marine and Harbours, the project did not proceed beyond the "planning" stage due to a withdrawal of interested developers downturn in the international and national economies and a concern by the State Government at the high level of public expenditure proposed ($25 million in 1988).

In 1992, the town of Exmouth had to adjust to a major withdrawal of United States Navy resources from the Harold E Holt Naval Communication Station. This initially resulted in a decrease in population from 2,100 to 1,700 and caused concerns about the future development of the town.

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3 Prior to the development of the Exmouth Boat Harbour, the North West Cape did not have a main centre for boating. Commercial fishing operations are currently based at Learmonth, some 20km south of Exmouth, whereas recreational boating activity, centred on game fishing and exploration of Ningaloo Reef, operates from Bundegi and Tantabiddi.

In the 1980's, and at the request of the fishing industry, the then Department of Marine and Harbours prepared a design for an unloading/service jetty at Badjirrajirra Creek adjacent to the existing Kailis fish processing facility. The proposal consisted of a long approach jetty traversing the shallow rocky nearshore coast, with a jetty head in suitably deep water to allow trawlers to come alongside for unloading and refueling. No protected water or safe anchorage was incorporated in the proposal. The estimated cost of this facility was $3m and due to the nature of the facility, anticipated income from it was insignificant.. The then Department of Marine and Harbours considered that the expenditure could not be justified for a facility which afforded no protection to the vessels using it, generated little income, and did little toward meeting the needs of recreational boating in Exmouth.

In 1986, Skywest Holdings Pty Ltd (Skywest), then the owner of Norcape Lodge Resort, proposed to develop a marina resort adjacent to the northern boundary of the then existing Norcape Lodge (i.e. approximately 1 km north of the presently proposed site). The Skywest proposal was for a five-stage development, ultimately including 150 boat moorages, a boat ramp and a variety of resort accommodation. The proposal received strong support from the Exmouth Shire Council, as well as from local commerce, industry and sport and recreation bodies.

Skywest prepared a Public Environmental Report describing their proposal (Le Provost, Semeniuk and Chalmers, 1986), which was submitted to the EPA and made available for public review. However following the period of Government and public review and comment, but prior to the EPA formally assessing the proposal, the proponent sold Norcape Lodge Resort and withdrew the proposal. Therefore, the EPA did not publish its Report and Recommendations to the Minister.

Submissions received by the EPA regarding the Skywest marina proposal highlighted concern that the development would occur within the prescribed buffer zone for the Exmouth Wastewater Treatment Plant. The Skywest proposal otherwise received widespread community support.

Following the withdrawal of the Skywest proposal, other developers approached the then Department of Marine and Harbours with a view to constructing a similar facility. The fishing industry also continued to lobby the Department for a facility and requests for a jetty to cater for recreational/charter boating at Bundegi and Tantabiddi were also submitted.

In order to best assess the conflicting interest of various organisations the Minister for Transport established a Working Group comprising fishing industry representatives and senior officers from the Fisheries Department and the then Department of Marine and Harbours. The aim of the Working Group was to assess the financial viability of a marina development in the Exmouth Gulf Region and, pending that assessment, to recommend a suitable site.

There was strong community support for this initiative, particularly through the Exmouth Marina Development Committee, elected at a public meeting held in Exmouth on August 31, 1987.

The Working Group recommended a multi-user facility to service the requirements of the fishing industry, the tourist industry, the recreational boating public and the Royal Australian Navy. The recommended location, adjacent to Exmouth township, was selected from four alternatives as it would enable full utilization of the existing townsite infrastructure, and would provide a significant boost for the development of the town. It would also avoid conflict with the location of the wastewater treatment plant.

The Exmouth "Coral Coast Marina" proposal was the outcome of that recommendation,.

Although Exmouth is an isolated town in an arid environment, it has the advantage of infrastructure which was part of the navy operation, such as Learmonth Airport (international capability), recreational facilities, roads and houses. It is also just outside the Ningaloo Marine Park and ideally situated to access the Cape Range National Park and offshore islands. More recently, there has been evidence of growth in the town which can be linked largely to the ability of the local community to promote the natural attractions of the region (particularly the Ningaloo Reef Marine Park and the whaleshark phenomenon) and provide new accommodation and facilities for tourists.

The significance of the North West Cape area as a future tourist destination was again acknowledged by Cabinet in 1994 through its direction that a strategic planning study be prepared for the coastal areas between Exmouth and Carnarvon. The subsequent "Gascoyne Coast Regional Strategy" provides a strategic guide for future land uses based on sustainable planning and land management objectives, and regards the Exmouth "Coral Coast Marina" Project as an integral component of development of Exmouth's tourist industry. In addition to this regional study is the resolution of the Shire of Exmouth Council to prepare a new District Zoning Scheme, incorporating the marina development.

In order to advance the project, the Gascoyne Development Commission brought the Department of Transport and LandCorp together to resolve the planning and management issues associated with the project. In 1996, the Department of Transport proceeded to develop a scaled-down version of the original proposal which focussed on the marina facilities only (the "Exmouth Boat Harbour"). Development of the remainder of the facilities, including the resort and residential components, are to be released to private developers under the management of LandCorp. The proposed concept plan is the subject of this PER.

2.4.2 Regional Strategic Plan

The Gascoyne Coast Regional Strategy" released by the Minister for Planning in March 1994 supports Exmouth (in parallel with Carnarvon) as a centre for future tourism and related development.

Its infrastructure capacity and regional status in terms of administration and support industry provides Exmouth with the ability to service new developments without recourse to major new investment by the State.

In particular, Exmouth is seen as an area which has a natural environmental advantage to support increased growth.

2.4.3 Cabinet Direction

On 6 March 1995, the Deputy Premier and Minister for Regional Development submitted a Cabinet Minute on the Exmouth Boat Harbour and Associated Land Development proposing the construction of an outer boat harbour and an associated resort/residential development.

LandCorp was directed to prepare a concept plan which allowed for a range of development options. The various development options were to have a particular focus on private sector investment opportunities.

On 27 March 1995, Cabinet endorsed several recommendations including the Concept Plan proposed in this document, and the establishment of an "Exmouth Development Steering Committee"

2.4.4 Boat Harbour Progress

Following the Cabinet decision of 27 March 1995, planning for the $10 million outer Exmouth Boat Harbour commenced.

On 23 April 1996, the Premier officially launched the construction of the harbour which consists of the breakwater, harbour basin and entrance channel, together with two public boat ramps, service wharf, 60 boat pens, toilets, parking and landscaping.

The boat harbour development is managed by the Department of Transport and is due for completion in mid-1997.

2.5 Benefits of the Project

The benefits to the Region and the State from the Exmouth Boat Harbour and any associated development include:

- the diversification and strengthening of the local and regional economies;

- the potential for significant income from international and interstate tourists;and
- the opportunity to develop new industries associated with the Boat Harbour, capitalising on the existing service infrastructure (especially Learmonth airport);

2.5.1 Tourism

The Exmouth area has an abundance of natural attractions, several of which are of international significance. It also has an international airport which is likely to be upgraded with passenger facilities that give it a major advantage over competing destinations. The tourism potential of Exmouth is only recently becoming realised, and is likely to significantly increase in the near future.

The proposed development is expected to create a focus for the Exmouth area and to significantly contribute to the area's attractiveness and promotion as a tourist destination. Major resorts will provide the room capacity to cater for direct package flights from interstate and overseas.

The underlying increase in the population (see below) for the proposed development will also assist in providing the critical mass for the development of a hotel/resort facility, to further enhance tourist potential. Further, it should provide the Shire with the rate revenue to contribute significantly to the level of local community services as well as improving the attractiveness of the area for tourism.

2.5.2 Population/Employment

The current population of Exmouth is around 2,400 permanent residents. The employed population is almost 1,600 persons, resulting in a comparatively low unemployment rate of 2.9% (DEET, 1996).

The project proposes the development of housing sites that will accommodate around 440 dwellings, which could ultimately provide an additional 1,000 persons for Exmouth. However, it would be expected that a proportion of these may reside in Exmouth for only part of the year.

The increase in population will provide an increase in demand for goods and services at the local level, increasing the employment opportunities within local industries to service the

increased demand.

Construction of the major infrastructure and resort element of the project should have a direct, albeit temporary, impact of employing around 60-70 persons per annum. Once the commercial and resort facilities were operational, the level of permanent employment would increase significantly for the town.

Current employment statistics indicate that almost a third of employees in Exmouth are in the Public Administration and Defence areas. The largest employer is the Australian Defence Industries-Naval Communication Station. The employment generated by the project would dilute this reliance upon the single major employer and reduce the risk to the area if there was a structural shift in employment patterns.

These factors are considered to provide a significant, positive economic impact upon the Exmouth township and surrounding area.

2.5.3 Community Facilities

The existing and expanded local community of Exmouth will benefit greatly from the proposed development. A new range of facilities will be provided or encouraged by the project for use by the local community, including:

- proposed hotel/resort facilities;
- creation of new beaches, with public access and associated dune restoration;
- town beautification from associated improvements to streetscapes, entry statements and public open space landscaping;
- the opportunity to upgrade the existing golf course;
- provision of an new, upgraded racecourse;
- improved telecommunications, such as improved television, mobile communications and optic fibre transmissions, would be encouraged from the expected population increase; and

- improvement of civic and cultural facilities and activities due to the increased population base and its associated increase in local government rate revenues.

- potential improvement in the level of funding for the management of mosqitoes and public health risk from Ross River Virus due to increased local government rate revenues.

2.6 Evaluation of Alternatives

The proposal is a forecasted extension to the Exmouth Boat Harbour, currently under construction.

Feasibility studies and public consultation over the past 10 to 15 years have identified a definite need for a marina in the Exmouth Gulf region to service the requirements of the tourist industry, the fishing industry, and the recreational boating public. A "Do Nothing" option will result in these services being unavailable.

The economics of construction in the region dictate that only a multi-use facility catering to each of these requirements is feasible. It is not feasible to construct several separate special purpose facilities to cater exclusively for the individual requirements of each group. The feasibility study nominated the present location as the preferred site from three others, hence there is no other economic alternative to the current site (Bowman Bishaw Gorham, 1989).

2.7 Existing Policies and Guidelines

2.7.1 State Planning Commission Policy DC 1.8-Procedures for Approval of Artificial Waterways and Canal Estates

Current design and management requirements for waterways developments ensure high ongoing environmental performance and avoidance of unacceptable impacts upon the environment. The majority of these requirements have now been incorporated into engineering and planning design guidelines, namely SPC Policy DC1.8, formulated by the Department of Planning and Urban Development (DPUD) (now Ministry for Planning

(MFP)) in consultation with the Water and Rivers Commission (WRC), the DEP and the Department of Transport (DOT).

Policy DC 1.8 prescribes the "general principles and procedures which should be observed and followed by those proposing to undertake projects involving artificial waterways and canal estates".

In particular, the Policy sets out the minimum provisions relating to the following:

- Canal Management
- General feasibility of proposals
- Referral Authorities
- Seeking and securing approvals
- Town Planning Scheme requirements
- The design of canal estates
- Water quality
- A model 'canal' zone for insertion within Local Authority Schemes.

The Policy stipulates that determination of a canal estate proposal should involve initial referral to a number of Authorities to establish whether there are any fundamental grounds on which the proposal should not progress. Referral must be made to the following Authorities:

- Department of Transport
- Local Authority
- DEP and the EPA
- State Planning Commission
- Other agencies (eg Water and Rivers Commission)
- Minister for Planning

Upon securing endorsement for the development, proponents should then seek to rezone the relevant site through a Scheme Amendment. Any conditions required by the referral authorities should be imposed as 'deemed-to-comply' conditions of the Amendment.

SPC Policy DC1.8 also sets out the minimum design standards for canal design. Whilst the standards are not for minimum construction details, the Policy does stipulate design widths, mooring spaces and canal depths based on a 'design vessel'. The 'design vessel' represents the anticipated vessel type that would use the canals.

The specifications for the proposed marina and canal design will be in accordance with SPC Policy DC1.8. However, these guidelines were developed for the Mediterranean climate of the southwest of Western Australia hence certain elements of the Policy guidelines, particularly with respect to drainage, are unable to be applied to the hot, arid, cyclonic climate of Exmouth. These elements are addressed in detail in this proposal.

2.7.2 Other Policies and Guidelines

In addition to SPC Policy DC1.8, other policies and guidelines which apply to the project, and control both the land-based and waterways components of the proposed development, are as follows:

- Existing Zoning-Shire of Exmouth Town Planning Scheme Nos. 1 and 2. Development within the local authority is presently controlled by the provisions of the Shire of Exmouth Town Planning Scheme Nos. 1 and 2. A new Town Planning Scheme is currently being finalised. An interim development order obtained to allow construction of the Exmouth Boat Harbour to proceed prior to finalisation of the new Scheme, expired in November 1996.

- Proposed Zoning-Shire of Exmouth Town Planning Scheme No. 3. The Shire of Exmouth is presently undertaking a review of the existing Town Planning Scheme. Under the proposed Scheme (Town Planning Scheme No. 3), the subject land will reflect the approved concept plan, in accordance with The Exmouth Structure Plan (SPC, 1988) which recommends that the proposed marina site be used for "Tourist" purposes, and the proposed residential development site be used for "Residential" purposes.

- EPA Guidelines for Assessment and Control of Dust and Windborne Material from Land Development Sites, updated 1995.

- EPA's Environmental Water Quality Objectives (EQO).

- Waterways Commission Guidelines No 9 1995. Guidelines for Dredging and Preparation of a Dredge Spoil Disposal Management Plan. A dredging licence is also required from WRC.

The environmental management objectives and commitments of this proposal will comply with the above guidelines and policies.

3.0 DESCRIPTION OF THE EXISTING ENVIRONMENT

3.1 Physical Environment

3.1.1 Climate

Exmouth is located within a hot, semi-arid climatic zone. Summers (October to April) are very hot with temperatures frequently exceeding 30° and at times reaching a maximum of 45° in January, the hottest month. A temperate climate occurs over the remainder of the year, (average annual minimum temperatures range from 15° to 27°), with the coolest month being July.

Annual rainfall averages 300 mm, but is highly variable. Most rainfall occurs within a "wet season" from January to July with heaviest falls occurring early in the season (February to March) as a result of tropical cyclones (Logan *et al.*, 1976). Cyclones may result in rainfall as high as 400mm in 48 hours or higher, thereby causing extensive flooding in the region. The rainfall is offset by high evaporation rates which range from 1700-3050 millimetres per year, depending on seasonal conditions.

Exmouth's location on North West Cape results in the land/sea breeze system being a more complex interaction than simple coastal situations. Nevertheless, Exmouth does experience the diurnal land/sea breeze cycle.

Wind roses prepared from Bureau of Meteorology records (1967-1975) are presented as Figure 4. Southerly winds dominate the wind pattern with south to south-east winds between 5 and 30 km/hr occurring in the morning, with winds tending slightly more southeasterly in the winter months. During the summer, afternoon seabreezes arise from the west and south-west, while easterly directions are more common during winter afternoons. Strong winds from the north and north-east are infrequent but are commonly associated with tropical cyclones when they do occur.

Severe tropical cyclones with wind speeds in excess of 75-90km/hr occur every three to five years over Exmouth between November and April, but usually between January to March. Less intensive cyclones are experienced during the period January to March approximately two years in every three. Steedman Limited (1986) reports that 34 cyclones

passed within 370 km of Exmouth in the period from 1961 to 1982, equating to 1.7 cyclones per cyclone season.

Cyclones entering the Gulf mainly move south or southwest, occasionally southeast, at speeds of 10-30 km/hr. Winds that are induced are usually from the east and south-east swinging to north-east and north if the cyclone passes to the west of the Gulf, and the south and south-west if the cyclone passes to the east. Wind speeds of up to 100 knots (185 km/hr) may be sustained for several hours (Coleman, 1971).

3.1.2 Landform

Exmouth Gulf is a north-facing marine embayment occurring on the eastern side of the Cape Range geomorphic landform of the Exmouth Peninsula (North West Cape). The western gulf shoreline between Bundegi Beach and Learmonth is characterised by an intermittent coastal barrier of beach, beachridge and dune between an alluvial plain and the shore platform (Le Provost, Semeniuk and Chalmer, 1986).

The alluvial plain slopes gently seaward from the fan deposits at the base of Cape Range, about 4km inland. Although the plain is relatively flat, numerous creeks and drainage lines traverse the plain and may be incised up to 3-4m towards the seaward side. These low-lying areas may flood during high rainfall events.

The sandy shore comprises a coastal barrier of beach, beachridge and dune between the alluvial plain and the shore platform. The barrier is widest (up to 300 m) adjacent to the mouth of larger creeks, where it tends to prograde seawards across the shore platform. Elsewhere the barrier is usually 50-100 m wide.

The dune extends as a single low dune ridge generally 8-12m high along a large portion of the shoreline between Bundegi Beach and Learmonth. Along parts of the shore where the dune is less developed, alluvial plain materials are exposed at the shore with dune sands forming only a thin veneer.

The dunes peripheral to the proposed development site are comprised of a foredune/primary dune 2 metres wide and 1-3 metres high with a secondary dune to 8-10 metres high. The rear of the secondary dune slopes to low halophytic floodplain/grassland. South of the proposed boat harbour, the floodplain is utilised as the town's horse racing track.

The entrance channel to the existing marina passes through an existing (100 m) wide breach in the beach ridge and dune, initially caused by a drainage creek but now widened by its frequent use for off-road vehicle access to the beach. The marina and residential development would be constructed in the low-lying alluvial and marine sediments extending from the landward side of the dunes westward to approximately RL 10 m AHD.

Other than where it is breached at the proposed entrance channel location, the beachridge and dune are well developed (100-150 m wide and rising to 12 m AHD) throughout the shoreline of the proposed development area.

3.1.3 Geology and Soils

3.1.3.1 Regional

Cape Range is a prominent northerly trending peninsula approximately 80km long, 20km wide and has a rugged topography reaching a maximum elevation of 314m. The range is bordered on the west by the Indian Ocean and a narrow continental shelf about 12km wide containing the Ningaloo Reef, and to the east by the shallow Exmouth Gulf (Allen, 1993).

The geology of the Cape Range and the Exmouth area has been mapped at 1:250,000 by the Geological Survey of WA (Van de Graaff and Denman, 1977).

Cape Range is situated within the Exmouth Sub-basin of the Carnarvon Basin. The rocks immediately underlying, and forming the core of the range are a sequence of carbonate rocks of Paleocene-Miocene age about 500m thick. Several different rocks units reflecting different age sedimentation are recognised within the Cape Range group, namely the Pilgramunna Formation, Trealla Limestone, Tulki Limestone and Mandu Limestone. The coastal plain comprises Pliocene - Recent littoral, shallow water marine, alluvial and eolian sediments forming coastal limestone, sands and sandstone. The sediments of the coastal plain range from about 5m in thickness on the western side of the range to 10m in the east. The generalised geology of the Cape Range is presented as Figure 5.

The present physiography of the range results from intermittent uplift on an underling fault and exposure of predominantly calcareous sedimentary rocks of Tertiary age, of which the uppermost limits have karstified and extensively eroded. The karst system has developed in the relatively pure and porous Trealla and Tulki Limestones which overly the relatively

impermeable Mandu Limestone unit. The Trealla and Tulki units are about 100m thick and contain an extensive cave system which has mostly eroded on the crest of the Range but is still active on the flanks of the range and beneath the coastal plain.

These cave systems and karstic formations provide the major habitat for subterranean fauna (Section 3.2.4). The habitat of troglobitic (cave) fauna on the crest of the Range has probably existed and been relatively unaltered since the Range emerged above sea level in the Late Miocene-early Pliocene. In contrast, the habitat of stygofauna (aquatic subterranean fauna) on the coastal plain has probably varied significantly in response to the rise of Cape Range and especially sea level changes in the Pleistocene (Allan, 1993).

3.1.3.2 Site Geology

Several geological investigations have been conducted in the project area, in association with studies to assess the hydrogeology and hydraulic conductivity of the soils (see Section 3.1.5). For the "Coral Coast Marina" proposal, KH Morgan & Associates (1989) drilled 22 air-core holes to investigate the physical characteristics of rocks to be excavated at the site of the present project. All except one hole was drilled east of Murat Road. In 1996, Soil and Rock Engineering drilled an additional 22 air-core holes in the project area and excavated test-pits at two sites. Twelve of the holes were drilled west of Murat Road.

These previous studies have been reviewed by Rockwater Pty Ltd (Appendix C) for the current proposal, the findings of which are summarised below.

The project area lies on a coastal plain formed by colluvium and alluvium; clay, silt, sand and gravel, with unconsolidated and poorly consolidated quartzose calcarenite in dunes along the coast. The Mowbowra Conglomerate Member of the Bundera Calcarenite crops out about 400m west of Murat Road, and consists of a limestone pebble conglomerate and minor coralgal reef deposits (Van de Graaff and Denman, 1977).

The site geology is depicted in an east-west cross-section in Figure 6. Close to the coast (drillholes EX 7, 8, and 14) unconsolidated beach deposits crop-out and comprise unconsolidated to weakly cemented fine to coarse grain calcarenite with granule to pebble sized shells, coral and limestone.

Further from the coast and underlying the coarse-grained beach deposits (drillholes BH 4, 7 and 21 and Ex 6, 7, 8, 14, 18 and 22) is a poorly consolidated red-brown sandy clay and tidal flat deposits of abundant shell, coral and limestone fragments. These clayey

sediments overly limestone and calcarenite interpreted to be of Bundera Calcarenite of Pleistocene Age. The top of that formation is probably an erosional surface and generally slopes down towards the Gulf from about 0m AHD, at a distance of 200-300m west of Murat Road, to -2.5m to-4.0m AHD at the coast. The Bundera Calcarenite ranges from weak, broken, friable rock to very strong and well-cemented rock (KH Morgan & Associates, 1989). Locally, vuggy (small cavity) zones occur, and the rock is commonly porous.

3.1.4 Surface Drainage

Although average rainfall is low, the Exmouth region is characterised by cyclonic storm events yielding high volume storm flows.

The project site is located in an extensive "floodplain" depression behind the dunes and to the east of Murat Road, which receives surface drainage from two catchments (Figure 7). The catchments contains a number of creeks from the hills to the immediate west of the proposed development, and two streams extending several kilometres into the Cape Range. The high intensity rainfall events in the area, coupled with relatively low absorption capabilities of the upstream parts of the drainage catchment, can lead to significant storm flows towards the project area, which is low lying and subject to periodic flooding. Drainage in the area is generally absorbed behind the dunes within dissipation and infiltration areas.

A Flood Channel Investigation prepared for the Exmouth Boat Harbour by Evangelisti and Associates (1996) confirmed the presence of two significant drainage channels which flow into the depression east of Murat Road. The depression is effectively divided into two areas by the presence of Warne St, with drainage to the north of Warne St mostly flowing away from the project site. Drainage to the south of Warne St flows towards the project site and the Boat Harbour which is located on a previous break-out which existed in the dune system, being the downstream end of the catchment. However, significant cyclonic events (eg Cyclone Beverley in 1975) may cause water to build up north of Warne Street then to overflow south towards the project site (K. Graham pers. comm.).

The requirement for stormwater and periodic flood management will be require attention during the detail design phase of the project (Section 4.7.1).

3.1.5 Groundwater Hydrogeology

3.1.5.1 Regional Hydrogeology

The groundwater of the Cape Range Peninsula occurs in confined and unconfined aquifers. The unconfined aquifer of porous limestone along the eastern slopes of Cape Range between Learmonth and Exmouth contains substantial potable groundwater resources. This aquifer supplies Exmouth's water supply and is replenished by direct infiltration of rainfall, and indirectly by storm runoff from the Range. The groundwater discharges into Exmouth Gulf, and, in addition to the effects of seasonal recharge, there is natural variation in groundwater levels and saltwater intrusion due to tidal fluctuations in the Exmouth Gulf (Water Corporation, 1996).

The upper part of the aquifer is karst and has high permeability while the underlying limestone is less permeable (Water Corporation, 1996). In general, a layer of fresh groundwater up to 20-30m thick overlies a saltwater wedge, the transition zone of which lies about 5km from the coast. The overlying fresh groundwater diffusion zone in the karstic aquifer is a major habitat zone for stygofauna (Section 3.2.4). A general hydrogeological cross section of the Exmouth groundwater area is presented as Figure 8.

The water supply for Exmouth township is drawn from the northern part of this aquifer. The Water Corporation has operated the borefield for 30 years and no evidence of thinning of the freshwater has been found (Water Corporation, 1996). In the northern most sector of the borefield, where high abstraction rates, coupled with domestic bore use, some bores are experiencing increased salinity.

3.1.5.2 Site Hydrogeology

A review of the previous hydrological studies conducted by KH Morgan & Associates (1989, 1990) and Soil and Rock Engineering (1996) was undertaken by Rockwater Pty Ltd (Appendix C) for the current proposal and summarised below.

Depth to groundwater beneath the site ranges from 2m adjacent to the coast to approximately 6m on the western side of Murat Road. The soils of the site consist mostly of clay and silty clay containing limestone, coral and shell fragments. This unit, which ranges from -3.65m AHD to -5.3m AHD, is of low permeability and contains saline groundwater of a similar salinity to sea water, even at the water table, due to the presence

of low permeable clay at shallow depths separating this layer with the underlying aquifer. The groundwater salinity at the top of the main aquifer is shown in Figure 9.

In contrast to other areas along the eastern coastal plain, the majority of the site does not contain a layer of fresh groundwater overlying a saltwater wedge, hence no fresh groundwater diffusion zone occurs. At the northern end of the proposed canal and extending to the northwest of the project site, a small area of shallow gravels/conglomerate occurs that contains a thin layer (approximately 5m deep) of brackish groundwater. Salinity measurements from four shallow private bores over the superficial layer of brackish groundwater within one kilometre of the coastline have shown salinities from 1,100 mg/L TDS to 5,400 mg/L TDS (Martin, 1990), with the salinity of the bore previously measured at 1,100 mg/L increasing to 4,600 mg/L TSS (by conductivity) in December 1996. It is likely that salinity in this coastal area would increase when water levels are lower during the summer months (Rockwater, 1996).

The top of the main aquifer ranges from -1.1m AHD to -5m AHD in the area of the planned canal/harbour (Figure 10). Most of this flow is probably from the underlying Bundera Calcarenite which has moderate to high permeability in consolidated or weakly consolidated zones. No large cavities were intersected in any of the drill holes and there were only minor vuggy (porous) zones.

3.1.6 Flood Levels

3.1.6.1 Astronomical Tides

The Department of Transport, Western Australia (DOT) has measured the tidal variations at Exmouth for at least 10 years. The astronomical tides are predominantly semidiurnal (two cycles per day). During spring tides the daily range is typically about 1.8 metres, and during neap tides the daily range is about 0.6 metres (Table 1). The highest and lowest astronomical tides recorded at Town Beach are +1.4 m AHD and -1.4 m AHD respectively.

Table 1

Tidal Levels at Exmouth

(from M.P. Rogers & Associates-Appendix D)

	Chart Datum (CD)	Australian Height Datum (AHD)
Highest Astronomical Tide (HAT)	2.8m	1.4m
Mean High Water Springs (MHWS)	2.3m	0.9m
Mean High Water Neaps (MHWN)	1.7m	0.3m
Mean Sea Level (MSL)	1.4m	0.0m
Mean Low Water Neaps (MLWN)	1.1m	- 0.3m
Mean Low Water Springs (MLWS)	0.5m	- 0.9m
Lowest Astronomical Tide (LAT)	0.0m	- 1.4m

3.1.6.2 Storm Surge and Wave Set-up

In addition to the astronomical tide, tropical cyclone storm conditions can cause significant increases in the ocean water level through the combined effects of low atmospheric

pressure, strong onshore winds and large waves breaking nearshore. This increase in the water level is known as storm surge.

There have been a number of detailed studies investigating the frequency and severity of storm surges experienced along the coast from Carnarvon to Onslow. These investigations have included analyses of the long term tidal records at Carnarvon by the Department of Transport (DOT), as well a computer modelling of various cyclones at a number of locations by Steedman Limited (1986) and Steedman Science & Engineering (1989,1990). Table 2 summarises the 100 year return period storm surge for various locations in the region as estimated by these investigations.

Table 2

Storm Surge Estimates

(from M.P. Rogers & Associates-Appendix D)

Location & Reference	100 year RP Storm Surge	Method & Comments
Carnarvon, DMH (1988)	1.7 m	Based on 20 years of tidal records from Carnarvon
Denham, DMH (1988)	2.3 m	Correlation with Carnarvon tidal records & local flood level marks on buildings.
Coral Bay Steedman (1989)	2.0 m	Computer modelling, correlation with Carnarvon & excludes wave set-up.
Exmouth, Steedman (1986)	0.4 m (50 Year RP)	Computer modelling & excludes wave set-up.
Onslow, Steedman (1990)	2.4 m	Computer modelling & excludes wave set-up.
Exmouth MP Rogers & Associates (1996)	**2.4m** **1.5m** (25 Year RP)	

With the exception of data analysed from Exmouth, all of these studies conclude that severe cyclones cause large storm surges, indicating that the storm surge level determined for Exmouth may be an underestimate. This is supported by anecdotal evidence which suggest that the total water level at the Exmouth Homestead has exceeded 6 metres above mean sea level on two occasions since 1945 (Steedman Limited, 1986). Although the homestead is further south in the Gulf and the storm surge would be amplified at that point, the reports suggest that previous computer modelling has estimated lower than expected storm surge at Exmouth.

A revision of potential storm surge using the precautionary principle has been undertaken by MP Rogers and Associates, so that the data obtained for Onslow will be applied to this development (Table 2). This data (2.4m for 100yr RP; 1.5m for 25 Year RP) is 400% to 600% higher than the previous estimate (0.4m for 50 yr RP).

3.1.6.3 Greenhouse Effect

The current knowledge about possible climatic changes due to global warming remains limited. A discussion of the potential impacts of climatic change is presented by MP Rogers & Associates (Appendix D), and summarised below.

Possible impacts on the west coast of WA of global warming could be:

- increase in cyclone frequency,
- increase in sea level with associated flooding, and
- change in position of synoptic features causing a changed wave climate.

The Institution of Engineers, Australia (1991), presents three scenarios for possible changes in the Global Mean Sea Level for the years 2030, 2050 and 2100. These are presented in Table 3.

Table 3
Possible Global Sea Level Rise
(Institution of Engineers, Australia, 1991)

	Year		
Scenario	***2030***	***2050***	***2100***
Low Scenario	0.10 m	0.16 m	0.32 m
Medium Scenario	0.20 m	0.32 m	0.68 m
High Scenario	0.32 m	0.51 m	1.13 m

The average sea level rise that is predicted could be accompanied by significant changes in the occurrence of storms. This, together with the potential increase in tropical cyclones, would lead to an increase in the frequency of floods and erosion along the coastlines of the region.

In the event that these predictions are correct, the impacts on the Exmouth foreshore and

dunes are difficult to assess, although limited storm surge data suggests that the impacts would be greatest in the southern reaches of Exmouth Gulf, south of Learmonth, and less in the vicinity of the Exmouth Boat Harbour (DPUD, 1992).

The existing and future wave climate has been considered within the assessment and breakwater design of the Exmouth Boat Harbour.

3.2 Terrestrial Biological Environment

3.2.1 Vegetation and Flora

The Exmouth area is located within the Carnarvon Botanical District of the Eremaean Botanical Province, which extends from Shark Bay northwards to the Exmouth Gulf area.

The Cape Range is considered to have a rich flora for an arid zone environment due to the range of habitat types found over the Peninsula, with a low number of weed species (30) in comparison to the Carnarvon Botanical District (81). The highest numbers of weed species are found around Exmouth and human-altered environments, with nine species only found in those areas (Keighery and Gibson, 1993). The most serious and widespread weed is Buffel Grass (*Cenchrus ciliaris*) which has largely replaced *Triodia* grasslands because of fire and grazing pressure. Buffel grass is found almost all over the Peninsula.

The natural flora and vegetation communities of the project area are broadly typical of coastal fringe species found north of Geraldton (Oma *et al., 1992*). As with many coastal areas with relatively young sediments, the vegetation of the project area is relatively low in species diversity, and varies mainly in the proportion of the same predominant species.

The vegetation of the floodplain hinterland is generally dominated by low shrubs (predominantly wattles, *Acacia spp* . with numerous *Atriplex sp.* and a *Euphorbiaceae*) and the spinifex grass *Triodia basedowii* . Vegetative cover is generally sparse, although it is slightly denser within the diffuse floodway in the eastern area of the proposed project site, near Murat Road. *Cenchrus ciliaris* (buffel grass) has dominated most of the site, displacing most of the low native species.

The coastal dunes between the proposed marina site and the Gulf form a distinct vegetation

zone. Pioneer species such as *Spinifex longifolius, Salsola kali, Cakile maritima, Ipomea brasiliensis* and *Tetragonia decumbens* occur in the foredune/primary dune with *Ptilotus spp, Atriplex isatidea, Olearia axillaris, Scaevola crassifolia* and *Euphorbia sp.* in the swales.

Secondary dune species begin close to the foredune crest and continue landward into Acacia shrubland over sub-shrub and hammock grass communities. Species such as *Swainsonia pterostilis, Tribulus occidentalis, Canavalia rosea, Atriplex isatidea, Crotalaria cunninghamii, Gomphrena canescens, Tephrosia rosaea, Adriana tomentosa, Trichodesma zeylanicum* and *Triodia pungens* occur under scattered *Acacia bivenosa, A. coriaceae* and *A. tetragonophloia.*

In contrast with other coastal areas of the Exmouth Peninsula inspected during the study, the dune integrity and vegetation of the study area is in moderate to very poor condition.

Disturbance and deterioration of vegetation quality in the vicinity of the project site has been caused by several factors, as follows:

(i) Frequent pony/horse riding in the vicinity of the Boat Harbour site has created tracks of bare sand along both the primary and secondary dune crests approximately 1m to 0.5m wide, and are marked by exotic species which have spread along them (see (ii) below). Frequent use of the tracks has prevented the potential regeneration of vegetation over the bare sand.

Camel rides originating at the Yacht Club also occur, however the route used for this activity is unknown.

(ii) There has been a high level of weed invasion in the secondary dunes, particularly to the south of the Boat Harbour. Buffel grass (*Cenchrus ciliaris*) is spreading beachward into the secondary dunes from the floodplain/racing course area. The presence of other exotic species is coincident with horse trails. The invading weeds have significantly displaced endemic vegetation and reduced native species diversity in the secondary dunes.

(iii) There has been damage to the dune integrity caused by 4-wheel drive vehicles, particularly to the north of the Boat Harbour. Tracks suggest that vehicles are driven along the beach, then meander through the primary dunes to the higher secondary dunes.

(iv) Uncontrolled pedestrian access to the beach has also resulted in disturbance and deterioration to dune areas adjacent to Market Street

No regionally significant vegetation communities, plant taxa endemic or nearly endemic to the Cape Range Peninsula, Declared Rare or Priority flora occur on or in the vicinity of the project area.

3.2.3 Fauna and Habitats

The habitat types and potential fauna of the region have been extensively researched for the Maud's Landing Coral Coast Marina Project (ecologia, 1994; Bowman Bishaw Gorham, 1995b) on the west of Cape Range. Where applicable, information from that study can be applied to the Exmouth area, as follows:

3.2.3.1 Habitat Types

The project area contains fauna habitats associated with the sparsely vegetated beachfront, the coastal dune scrub-heath and low lying hinterland.

The beachfront habitat could support foraging of the intertidal zone and bands of tidal debris by waders and other birds, and roosting by birds and foraging by foxes and varanids (monitor lizards) along the beach front.

The coastal scrub-heath habitat is the most structurally diverse habitat within the project area and as a consequence would exhibit the greatest species richness. Coastal dunes are the preferred habitat of the cryptozoic surface burrowing reptiles such as the legless lizards, while the accumulated leaf litter constitutes an important micro-habitat for fossorial species of reptiles. The relatively dense shrub and grass layer affords suitable shelter and a regular food supply for reptiles and for small mammals while the shrubs are utilised by arboreal lizard species and small insectivorous birds.

The hinterland is a structurally poor habitat due to the prevalence of low hummock grasses and buffel grass and would support a low fauna species diversity.

The sparsely vegetated beach front and coastal heath/scrub habitats are widely distributed on a regional scale, and are both encompassed by the Cape Range National Park.

3.2.3.2 Vertebrate Fauna

A number of native mammalian species potentially occur in the project area, however most species, such as the Dingo *Canis familiaris dingo* and Gould's Wattled Bat *Chalinolobus gouldii* have Australia-wide distributions. Other bats which may use the site (Western Cave Eptesicus *Eptesicus finlaysoni* and Yellow-bellied Sheath-tail Bat *Saccolaimus flaviventris*) are near the southern limits of their range. Four species of introduced mammal potentially occur within the project area; the Cat *Felis catus*, the Fox *Vulpes vulpes*, the House Mouse *Mus domesticus* and the Rabbit *Oryctolagus cuniculus.* All four species are widely distributed over most of Australia and would undoubtedly occur within the project area.

Based on preferred habitat and distribution records, over 100 species of birds may occur in the project area from time to time. The majority of birds recorded or expected to occur have distributions which extend into all the zoogeographic sub-regions of Australia, including most of the migratory and highly nomadic species.

The project area encompasses habitats suitable for over 40 species of reptiles. Particularly well represented are the skinks and geckos, while the varanids (monitor lizards) are poorly represented with only one species expected in the area. Several species are endemic to the North West Cape, including the gecko *Diplodactylus rankini*, the skink *Lerista haroldi* and the legless lizard *Aprasia rostrata.* Five species including the Tree Dtella *Gehyra variegata*, Bynoe's Gecko *Heteronotia binoei* and Burton's Snake Lizard *Lialis burtonis* have Australia-wide distributions occurring mainly in arid and semi-arid habitats.

The project area is expected to contain fauna species which are generally widespread and abundant in similar habitats throughout the region, and is not expected to contain regional endemics or locally restricted species.

Under the *Wildlife Conservation Act 1950*, one Schedule 1 vertebrate taxa (Grey Falcon *Falco hypoleucos.*) one Schedule 4 species (Peregrine Falcon *Falco peregrinus*) potentially occurs within the project area. Both are mobile species which do not rely on the habitat of the site for survival.

A further three gazetted rare and currently extant species may have occurred in the area. The Western Barred Bandicoot *Perameles bougainville,* Bilby *Macrotis lagotis* and the Burrowing Bettong *Bettongia lesueur* are now considered to be extinct in the region.

3.2.4 Stygofauna and Troglobitic Fauna

The limestone aquifer beneath the Cape Range and the coastal plain supports a unique ancient subterranean fauna. The known distribution of many of the subterranean species is restricted to the North West Cape with some elements also found on Barrow Island (Humphreys, 1993).

Troglobitic fauna are terrestrial animals that are specially adapted to living underground in air-filled, high humidity caverns.

Fauna with an obligatory dependence upon aquatic subterranean environments are known as stygofauna. Most recorded species of stygofauna occur within the fresh-to-brackish groundwater lens which overlies the deeper saline groundwater of the Cape, although some stygofauna are only found below the salt water interface of inland caves connected at depth to the sea.

The nearest recorded site containing significant subterranean fauna is Cameron's Cave (C-452), located 1.9km south west of the study site, which supports a moderately rich fauna of cave-restricted (troglobitic) animals (WF Humphreys, pers. comm.). Cameron's Cave is significant for the following species:

- the only known location of *Stygiochiropus peculiaris* Shear & Humphreys (Diplopoda: Polydesmida), an highly cave-adapted genus endemic to the Cape Range peninsula;
- the only known location of *Hyella* sp. nov (Pseudoscorpionidia: Hyidae), a genus endemic to the Cape Range peninsula;
- the only known location of Phaconura *sp.* nov. (Hemiptera: Meenoplidae);
- one of two known locations on Cape Range peninsula for *Draculoides bramstokeri* Harvey & Humphreys (Chelicerata: Schizomida), a genus endemic to the Cape Range group and the only genus of Schizomida endemic to Australia;
- the only known location of an undescribed species of blind harvestman (Opilionida: Phalngodida).
- the location for several undescribed species of spiders of several families.

3.3 Conservation Significance

In addition to the degradation of the dune vegetation, large tracts of the alluvial plain are moderately degraded due to human activities, including the following:

- the area has been extensively used by trail bikes and off-road vehicles;
- there is a decommissioned rubbish dump immediately landward of the dunes at the proposed marina site which has been excavated and filled;
- the site of the marine industrial area is the Exmouth Racecourse;
- there is a second, disused rubbish dump in the northwestern part of the proposed residential development; and
- most of the proposed residential subdivision has been used for horse grazing.

Both the ecological significance and the conservation value of the proposed development area are considered to be minimal.

3.4 Social Environment

3.4.1 Landscape

The site is bounded to the east by a relatively high foredune system which must be retained for storm surge protection. To the west, Murat Road, the only access route to the Cape, forms the principle edge.

The body of the site is relatively flat and featureless with a gentle rise to the west from the toe of the foredunes.

Although the Cape Range and the Exmouth Gulf are prominent features to the west and east of the site respectively, the view from the site is significantly restricted due to the height of the foredunes (10-12m AHD).

3.4.2 Land Use

As stated in Section 1.3, and subject to Native Title claim, all of the land covered by the project area is in Crown ownership with the exception of a small portion of the former North Cape Lodge site required for a road reserve. Freehold lots 395 and 850, the former Drive-In Theatre site, will be incorporated within the northern deviation of Murat Road and will require a land exchange.

Several grazing leases and the existing Exmouth Racecourse are located on Reserve 30074. Alternative sites for the existing grazing leases and the Racecourse have been identified on Crown land located to the south of the proposed development area, and would be leased by the Department of Land Administration when required. The lease to the Exmouth Racing Club by the Shire has already expired and a new lease for a location west of Murat Road is currently being negotiated.

A site on Reserve 29066 is currently leased to the Exmouth Pony Club. Minimal improvements exist on the site. The Shire advises that the club could be re-located at the new racecourse with minimal expense.

The Exmouth Cemetery (Reserve 27489) occupies land between the marina and Warne Street. Up to half of this reserve is currently unused and could be incorporated within the project area if the existing plots are fenced and the surrounds substantially landscaped. A new cemetery site can be provided elsewhere in the town.

Coastal facilities in the vicinity of the project site include the boat ramp, parking areas and the yacht club premises at Town Beach (approximately 1 km to the north of the proposed northern breakwater to the Exmouth Boat Harbour). The waters at this site are used primarily for yachting and dinghy launching. Town Beach is infrequently used for swimming as most people prefer the cooler and clearer oceanic water which occurs at Bundegi and Point Murat.

Rural uses (horse grazing and a poultry farm), occupy the areas immediately to the west and south of the proposed project area.

3.4.3 Public Foreshore Reserves

The foreshore reserve south of Town Beach is frequently used by off-road vehicles, with access provided from Horwood Road. A number of trail-bike tracks occur through the dune and foredune, as well as across the proposed project site. As discussed previously (Section 3.2.1), horse riding and camel rides also occur within the public foreshore reserve in the vicinity of the project site.

3.4.4 Public Health

3.4.4.1 Midges

Three species of midge have been trapped in the vicinity of the project site, at Town Beach and the Yacht Club, namely *Styloconops* sp., *Culicoides marksi* and *Culicoides* sp. The activity of the dominant species (*Styloconops* sp.), which is active over daylight hours, is largely confined to shorelines, however can extend over water and to 50m inland (Health Department of WA pers. comm. 1997).

3.4.4.2 Mosquitoes

Mosquito nuisance and mosquito-borne disease are known to be of concern in the Exmouth area (Health Department of WA pers. comm. 1997). Ross River Virus is particularly active in May-July whenever heavy late autumn and early winter rains occur. The Health Department of WA has recorded high numbers of the mosquito *Aedes vigilax* whenever these environmental conditions occur, as a consequence of widespread breeding on the extensive salt affected areas around the VLF communications towers, some 10-15km from the project site. Other recorded mosquito breeding areas include Mangrove Bay which is located on the opposite, west side of the Cape.

Aedes vigilax generally range up to 10km in search of bloodmeals (Health Department of WA pers. comm. 1996) although distances of up to 50km have also been recorded (Health Department of WA pers. comm. 1997).

The project site will be subject to the same level of mosquito nuisance as the Town of Exmouth. The Health Department of WA has indicated that the Ross River virus problem at Exmouth can be effectively addressed subject to the availability of adequate financial resources and skilled personnel necessary to carry out an effective control program.

It is anticipated that the increase in Shire revenue as a consequence of the additional residential rates obtained from the development would allow such a mosquito control program to be implemented.

3.4.5 Public Response to Project

The proposed Concept Plan was subject to a detailed public consultation process conducted by the Department of Commerce and Trade and initiated with a public information day in Exmouth on 17 October 1996. The closing date for written submissions regarding the Concept Plan was 15 November 1996. The four week public consultation process (see attachment B) included:

- Key stakeholder meetings;
- Individual group briefing of the Ningaloo Preservation Society;
- Public meeting in Exmouth;
- One month public display of the concept plan in Exmouth;
- Distribution of an information brochure at key points around Exmouth;
- Survey feedback sheet; and
- Ongoing press releases.

Appendix B summarises the responses received from 113 survey forms and two written submissions.

Of the total submissions (130) 68 responses (60%) were "very supportive" and 12 (11%) were "totally opposed". The remainder of the responses were:

- "supportive" - 11 (10%);
- "neither supportive nor opposed" - 15 (13%); and
- "opposed" - 7 (6%).

Respondents were asked to name two positive aspects of the proposed concept plan. A total of 160 positive comments were recorded, cited as follows:

- improved employment and economic opportunities for Exmouth - (36%);
- additional tourism facilities and accommodation (18%);
- improved maritime facilities (14%);
- site selection specifically to keep development off the West Coast (11%)

- general improvement to Exmouth (12%); and
- increased availability of residential land (9%).

Of the 146 negative comments recorded, 21% considered the environmental aspects of the project to be a concern. Other aspects cited were as follows:

- lack of infrastructure such as water supply, roads and waste disposal (21%);
- the scale and type of development (19%);
- change in the character of Exmouth (17%);
- social impacts (9%);
- marine facilities (6%);
- public amenities (3%); and
- other (4%)

A full list of comments appears in Appendix B.

A final report of the results of the public involvement process is currently available from the Department of Commerce and Trade.

3.5 Aboriginal Heritage

The Western Australian Museum has evidence of Aboriginal occupation of the North West Cape area from 25,000 years ago until at least 400 years ago. Aboriginal people, from a tribe known as the Jinigudira, camped in the coastal dunes, in rock shelters of the Cape Range and in the foothills. The tribe exploited a wide variety of marine resources including fish, shellfish, crabs, turtle and dugong.

There are very few Aboriginal people alive today with any local knowledge of Aboriginal heritage in the North West Cape area, and there is no documentation to suggest an explanation for the retreat of Aboriginal people from the area.

Registered Aboriginal sites occur in the Cape Range National Park and additional sites have been identified in the North West Cape region. No archaeological or ethnographic sites are known to exist within the proposed development area.

Application for Native Title claims will be advertised by DOLA in Mid-March.

4.0 DESCRIPTION OF THE PROPOSAL

The description of the proposal is extracted principally from the cabinet submission document prepared by LandCorp, 1996.

4.1 Concept Design Philosophy

4.1.1 Overview

The proposal is focussed on creating a fully integrated and vibrant extension to Exmouth and a significant and attractive regional destination for tourism and marine based commercial industries. Importantly, the proposal aims to consolidate Exmouth's future as a major Australian tourist node.

The proposal described in this Section is particularly related to the submitted Concept Plan, however the design principles will apply to all other submitted concept designs.

4.1.2 Concept Design

The design takes the opportunity to reinforce the region's marine image by introducing an inland canal system. To maximise this element and to compensate for the town's limited Gulf outlook, the canals will form the primary focus with surrounding land recontoured to terrace up from the water body. Where canal views are not practical, the site will be terraced to maximise the view potential to Cape Range, the existing Exmouth townsite and in some areas, the Exmouth Gulf.

The design accommodates four key land use development opportunities, as follows:

- Marine based commercial precinct;
- Marine and general tourism based commercial and residential precincts;
- Marine based recreation areas; and
- Mixed residential precincts.

Other important design elements include:

- South of the inner Boat Harbour, a significant land parcel has been designated for potential growth of marine based commercial industries. A canal spur off the inner boat harbour will permit future possible expansion of direct water access in this area. In the event that future residential demand exceeds marine commercial, the land use in this area will remain flexible for development of water and beach related residential development.

- The design proposes the creation of a new arrival and entry landmark/node on Murat Road, with direct access to the central tourism precinct.

- In the future, if marine based commercial demand permits, the boat trailer facility could be relocated to the southern side of the boat harbour. This would permit the northern side to be essentially a tourism, public recreation and commercial precinct devoid of expansive and hardstand areas.

- The pedestrian bridge, apart from being an essential link, will provide a view point over the development with vistas to Cape Range and Exmouth Gulf.

- A secondary lookout vantage point is proposed at the northern head of the central waterbody, within the residential precinct. This is complemented with a parkland.

- A major parkland is proposed to enhance the existing cemetery, which also provides public access to the canal and is within walking distance to Town Beach.

- Town Beach and the beaches to the south of the boat harbour, including the foredune system, will be retained. The existing access to the north (near the former Norcape Lodge) is retained with a new access to the south being proposed. Access to the beach from the Resort Hotel would occur via a footbridge over the main entry/access road.

4.2 Development Elements

Essential elements of the development include :

- An inner harbour and industrial precinct of 42.5ha immediately inland of the Exmouth Boat Harbour.

- An adjoining tourist precinct of 25.3ha to include a Resort Hotel and Convention Centre site of about 4.3ha, with a tourism commercial and residential development of about 7.8ha adjoining a further extension of the boat harbour.

- A 67.2ha residential precinct comprising :
  - 91 "canal" lots forming the canal residential estate;
  - 21 "dunal" lots adjoining the yacht club and public boat ramp off Warne Street;
  - 318 "dry" lots focused around the canal lots;
  - a central western Public Open Space raised as a lookout feature with sweeping views to the ocean and or inland to Cape Range;
  - the existing cemetery;
  - a 5,800m^2 medium density site, and
  - a separately owned potential unit development site on the drive-in-theatre site immediately adjacent to the existing town.

A detailed description of each of the above elements is provided in Section 4.3.

The development will also incorporate the following engineering elements:

- deviation and reconstruction of Murat Road, the main road entry from the south to Exmouth Townsite;

- filling, contouring and stabilising development sites and lots for dwelling and other construction without the need for further substantial site works;

- construction of public roads connected to existing constructed roads in the town site to provide access to proposed development, existing facilities and the outer boat harbour facilities now under construction;

- grading of roadworks, shaping and filling of lots to ensure that the properties are protected from stormwater runoff and ocean storm surges;

- construction of reticulated potable water supplies to provide service to each lot in accordance with Water Corporation standards, and to link with the existing Water Corporation system (Section 4.8.2);

- construction of a reticulated sewerage service by either gravity or vacuum method, to remove wastewater from the development for delivery to the town wastewater

treatment system (Section 4.8.4);

- provision of underground power supplies (Section 4.8.5);
- provision of telecommunications services to link with existing and proposed Telstra network facilities; and
- extraction and transport of construction materials. Should limestone material be required, application for the quarrying within exiting quarry sites will be subject to a separate environmental impact assessment.

4.3 Description of Development Elements

The extension to the Exmouth Boat Harbour comprises three discrete land precincts connected via a waterway. The principle characteristics of each precinct, shown in Figures 2 and 11, are described below.

4.3.1 Inner Boat Harbour

Provision of an inner boat harbour is essential to fully support the long term recreational and commercial marine operations of the North West Cape.

The concept design provides for 16 commercial boat moorings with scope to provide a further 12 moorings in the future, based on demand. The inner boat harbour also has the scope to provide a small marina of 40 pens for recreational yachts and power boats. In addition, access is provided to land south of the harbour for the development of marine industry.

In the event of a cyclone, the inner boat harbour will provide improved shelter to that offered by the outer harbour. Space limitations allow the outer harbour to cater only for the existing commercial and charter fleets currently operating out of the Exmouth area, and the inner harbour will provide shelter to diverse other vessels operating in the region.

The concept design requires the inner boat harbour to be constructed concurrently with the resort and residential components.

4.3.2 Resort Precinct

Contiguous with the inner boat harbour is the resort precinct, which allows for the development of at least two separate resorts. The two sites are linked by a pedestrian bridge and the waterways.

The primary resort site integrates with boat harbour activities and backs onto the primary dune system and beach. The secondary resort site is designed to contain three components, to allow for more than one operator to develop tourist facilities. This area of the resort precinct is assumed to be the ideal location for tourist retail/commercial facilities in addition to accommodation.

Separating the two resort sites is a water body of 6ha which will permit boats to moor adjacent to each site.

4.3.3 Residential Precinct

The residential precinct proposed within the Concept Plan has been designed to provide views of either the canal or the Cape Range, and comprises 431 lots of which 91 are waterside lots, 21 are dunal lots, 318 are dry landbased lots and one is a medium density residential site of 5,800m^2 (Figure 2). Canal lot sizes average 800m^2 with a 15 metre frontage. The dry lots range in size from 570 to 870m^2 with an average size of around 700m^2.

The precinct is designed to be developed in seven stages. Waterside lots are proposed to be developed in the first four stages at a ratio of around one waterside to two inland lots.

There is also provision for a number of unit development sites adjacent to Murat Road and the secondary resort site.

Residential lots will enjoy views of either the water or Cape Range, due to the method of site contouring. The highest points of the proposed development are almost nine metres higher than the canal lots.

4.3.4 Waterbody

The navigable widths and depths of the canals and mooring areas have been determined from the dimensions of the " design boat", which will be sailing vessels up to 15 metres in the inner boat harbour and 15 metre motor cruisers with flybridge in the resort and residential canals.

The design requirements of the waterways are in accordance with SPC Policy DC1.8, which outlines specifications for the following:

- Canal dimensions
  - Depth of clear navigation section (at Mean Low Water)
  - Width of navigation section
  - Width across water between property boundaries
  - Mooring areas
  - Canal waterway length or area
- Shore Stability
- Layout for Navigation Safety
- Mooring, Jetties and Launching Ramps
- Property Boundaries
- Flood Mitigation

Specific design specifications relevant to the environmental assessment are provided in Section 4.4.

4.4 Design Specifications

4.4.1 Storm Surge and Minimum Building Levels

An assessment of extreme flood levels was undertaken by M. P. Rogers & Associates, the marine engineering consultants to the project (Appendix D). The assessment (Table 4) draws upon the most recent revised estimates of astronomical tide, the severity of the storm surge, wave set-up, possible change in mean sea level and a factor of safety. The joint probability of a large storm surge with a high astronomical tide has also been considered. Accordingly, the 100 year return period storm surge is coupled with the mean tide level for a first assessment of the appropriate building levels.

Table 4

Assessment of Building Levels

(from MP. Rogers & Associates-Appendix D)

Item	Allowance
Astronomical Tide	0.0 m AHD
100 Year RP Storm Surge	2.4 m
Wave Set-up	0.5 m
Climate Change Allowance	0.3 m
Factor of Safety & Freeboard	0.5 m
Recommended Building Level	**3.7 m AHD**

As a check on the above assessment, the 25 year return period storm surge is coupled with the high water level of the spring tides (Table 5). Both calculations suggest that the appropriate building level be set at 3.7 metres AHD, which is recommended as the lowest finished floor level for the resort and residential buildings in the proposed development. The development of the industrial areas associated with marine industries may be able to tolerate lower levels and a higher frequency of inundation.

Table 5

Alternative Assessment of Building Levels

(from MP. Rogers & Associates-Appendix D)

Item	Allowance
Astronomical Tide	0.9 m AHD
25 Year RP Storm Surge	1.5 m
Wave Set-up	0.5 m
Climate Change Allowance	0.3 m
Factor of Safety & Freeboard	0.5 m
Recommended Building Level	**3.7 m AHD**

4.4.2 Canal Depths

The assessments of the minimum depth of the waterways have been based on the recommendations in the Department of Transport's Strategic Plan for Maritime Facilities (DOT, 1995) which allow for slightly shallower water depths than indicated in the Concept Plan (Figure 2). A siltation allowance of about 0.3 metres has been used to accommodate future siltation of the waterways. This aspect is described further in Section 6.5.2. The calculations to derive the navigation depths of both the Inner Boat Harbour and the canals of the Tourist and Residential Precincts are presented in Tables 6 and 7 respectively.

Table 6

Navigation Depth-Inner Boat Harbour

(from MP. Rogers & Associates-Appendix D)

Item	Allowance
Low Tide Level	-1.4 m AHD
Design Draft for 15 m Yacht	-2.0 m
Boat Motion due to Waves	-0.2 m
Siltation Allowance	-0.3 m
Under Keel Clearance	-0.3 m
Recommended Navigation Depth	**-4.2 m AHD**

Table 7

Navigation Depth-Tourist & Residential Precincts

(from MP. Rogers & Associates-Appendix D)

Item	Allowance
Low Tide Level	-1.4 m AHD
Design Draft for 15 m Power Boat	-1.5 m
Boat Motion due to Waves	-0.2 m
Siltation Allowance	-0.3 m
Under Keel Clearance	-0.3 m
Recommended Navigation Depth	**-3.7 m AHD**

4.4.3 Typical Canal Cross-Sections

According to the DOT (1995), the minimum width of the navigable waterway should be 2 times the length of the design vessel. As the design vessel for the proposed development is 15 metres long, the minimum clear navigation way will be 30 metres wide. In the Residential Precinct, there will be private pens on each side of the waterway. For 15 metre boats these will be up to 6 metres wide. Consequently, the waterway will be at least 42 metres wide at the full navigation depth of -3.7 m AHD. Use of sloping revetments for the edge walling will increase the minimum width of the waterway to at least 54 metres at mean sea level (Figure 11).

4.4.4 Typical Lot Profile

Typical residential lots will be designed so as to facilitate the separation of stormwater drainage into its various components, as described in Section 4.7. It will also provide for the maximum lot elevation which can be achieved within the restrictions of availability of fill material.

It is proposed that the top of the canal edge walls should be +1.5m AHD. Immediately at the back of the wall will be a 1m wide paved area which will be graded away from the canal. The lot will then rise at a slope of 1 in 5 (vertical to horizontal) until a minimum lot level of +3.7m is achieved, in accordance with the assessed recommended minimum building level (Section 3.1.6.2). From this minimum level the block will rise at a varying grade, depending upon the location of the building lot, to a peak level approximately 7m inside the front verge which will approximate the building set back line. The lot will then slope back down at 2% to the road verge and the road verge will then slope at 2% towards the edge of kerb of the access road.

4.4.5 Canal Walls

The two geotechnical investigations completed on the site (Soil & Rock, 1996; KH Morgan & Associates, 1989) show that the general waterway area intersects three basic formations. The first is the sandy beach deposit that forms the coastal dunes, the second is a layer of clay and silty clay that lies beneath and inland of the coastal dunes, and the third is the Bundera Calcarenite below the clay and silty clays. At this stage only preliminary mapping of the strata has been completed. Consequently, the exact location of each of the

materials is not known and future concept designs should be flexible enough to accommodate possible variations in the extent of each material.

There are a number of edge wall treatments that could be used for the proposed waterways. Either vertical walls or sloping walls using a variety of materials including concrete, steel and rock would be suitable. However the simplest type of edge walling is a conventional revetment with riprap for armour. This walling is widely used because it is less expensive to construct and maintain. Aesthetically, it is preferable to minimise the amount of exposed riprap . This is usually achieved by using steep slopes for the revetment, in the order of 35° to the horizon (1.5 to 1 horizontal to vertical). As this may be difficult to achieve in the clay and silty clay layer that has been described in the geotechnical reports, some improvement works may be required, including compaction, geogrid fabric, localised replacement and reducing the slope.

The most appropriate option for canal wall construction will be selected during the detailed design and construction phase.

As stated above, the recommended level of the top of the walling should be +1.5 m AHD. This is approximately 0.6 metres above the mean high water spring tide level, and provides an allowance for very high tides and boat wash. Nevertheless, the top of the wall will be inundated in major storm events that coincide with high tides. The detailed design will be completed to ensure that this infrequent inundation does not cause damage to the top of the edge treatment.

The final canal wall details are subject to structural engineering design, will be to DOT approval and will have a minimum 50 years wall life. Repair and maintenance of the canal walls will be the responsibility of the waterways manager (Section 4.9).

Any quarrying operation required to extract the riprap and bedding layer will be subject to a separate environmental approvals process.

4.4.6 Bridges

A pedestrian bridge is planned between the inner harbour and the resort waters. While design of the bridge is still flexible, allowance has been made to accommodate a fixed bridge with 7 to 8 metre clearance or a lift bridge.

4.5 Earthworks and Construction

4.5.1 Earthworks Balance

An approximate earthworks balance for this concept plan has indicated a balance of cut to fill (Ewings Consulting Engineers-Appendix E). Consequently, there will be no requirement to import or dispose of fill, except for the importation of topsoil for garden areas and stone for the canal walls. Any changes to the concept plan which would result in either the need to import fill, or to dispose of fill outside of the project site, would be referred to the DEP.

4.5.2 Boat Harbour, Canal and Bulk Earthworks

A comparison of the feasibility of dredging vs dewatering for the construction of the waterways has been conducted by Halpern Glick Maunsell (Appendix F). The assessment indicates that dredging is not a feasible option for engineering and economic reasons.

The excavation of the 12.5ha canal system is therefore planned to be completed in the "dry". This is a technique where the area is dewatered and land-based equipment (scrapers, excavators and trucks) are used to remove sediments for transfer to areas requiring fill. Drilling and blasting are not anticipated to be necessary for the proposed concept. Groundwater levels at the site are between 0.0m and 0.5 m AHD, and dewatering will be required to excavate below this level.

The marina will be fully excavated and walling installed prior to excavating the entrance channel, to ensure that this work will not effect the Exmouth Boat Harbour and nearshore water quality.

The proposed waterway depth, as indicated in the Concept Plan, is approximately -4.4m AHD in the inner boat harbour through to -3.9m AHD in the residential canals. As described above, these depths could be reduced to -4.2m AHD and -3.7m AHD respectively. Soil types within the areas to be excavated vary from clayey sandy gravels, conglomerates of varying hardness and some hard rock, through to gravels in the northern end of the residential canals (Rockwater, 1996-Appendix C).

4.5.3 Placement of Fill

The results of geotechnical investigations (Appendix C) indicate significant variability of materials expected to be encountered during canal excavation and construction. Particle size distributions of the spoil will vary and, to a degree, will be a function of the excavation techniques used. Nevertheless, with careful control and testing of excavated materials, it is anticipated that spoil can be used to produce a well-mixed homogenous material suitable as fill to create the lot shapes required. Canal excavation spoil of approximately 1,100,000m^3 will be placed on the site.

It is not anticipated that significant amounts of material unsuitable for structural fill will be encountered. Nevertheless, any such materials will be disposed of in areas designated as Public Open Space or other areas not requiring structural grade fill.

4.5.4 Dewatering for Construction

Water from dewatering operations is expected to be saline and to contain silt and sediment from the excavation operations. Spoil water will be directed to settlement basins to ensure that only clear water returns to the ocean. Settlement control techniques to be investigated at the detail design stage would include discharge of waters behind a geofabric silt curtain within part of the boat harbour, and settlement within land-based settlement basins prior to overland discharge to the sea. Spoil water losses via infiltration to the superficial aquifer and evaporation (which is up to 3m per annum in this region), will also occur.

The stilling basin will have the capacity to provide an adequate detention time for turbidity in the water to settle out prior to discharge, so that the water discharged will be of similar water quality to the receiving waterbody.

The discharge of dewatering fluids will be subject to a dewatering management plan and be in accordance with WRC requirements, including the EPA's Environmental Water Quality Objectives (EQO).

4.5.5 Canal Wall Construction

It is anticipated that either limestone, precast concrete wall panels or other suitable material will be used for the bulk of the canal edge walls. They will be placed by mechanical equipment on prepared bedding material which will be accurately surveyed for compaction

and level.

A subsoil drain will extend over the length of the wall along its landward face to control the rise of groundwater at the back of the wall and will be relieved by seepage weepholes.

4.5.6 Dredging

The final connection of the canal waterway to the outer boat harbour will be excavated using a cutter suction dredge or large excavator following completion of the inland excavation of the waterways. The cutter suction dredge uses a rotating cutter to agitate the sediment towards a slurry pump to suck the sand into a hydraulic system and pump the sand and water slurry to a containment pond.

The dredging will be conducted in accordance with a dredge spoil management plan, to be prepared in accordance with WRC guidelines. Water quality in the constructed canals and tide, channel flow and weather conditions will be the primary factors in the scheduling of this work.

The spoil from the entrance channel dredging will be used for land fill on the site.

4.5.7 Noise and Dust Control

The development area is adjacent to the main access road into Exmouth (Murat Road) and in close proximity to the existing town site. Project construction will entail extensive site works, and the potential for nuisance noise and dust during site development will be carefully managed to minimise the impact on the surrounding community.

Noise levels will comply with the most recent EPA Guidelines. The operation of heavy equipment will be restricted to daylight hours and all vehicles will be fitted with noise suppressing devices and comply with current vehicle emission and noise regulations.

Materials excavated for fill purposes will be near or below groundwater table and particle sizes are expected to be such that, except for top surface, dust nuisance will be minimal. Nevertheless, dust levels will be managed and monitored in compliance with the EPA's "Guidelines for Assessment and Control of Dust and Windborne Material for Land Development Sites". The guidelines require a site classification to be carried out and

provide a procedure by which to prevent and/or suppress excessive dust volumes leaving the site during and after the construction of the works.

When appropriate, dust suppression and control measures such as watering and wind fencing will be implemented in accordance with those Guidelines.

4.5.8 Public Safety

Access to the development site during the construction phase will be restricted and temporary fencing and appropriate warning signs will be erected.

4.6 Supply of Construction Materials and Construction Management

4.6.1 Materials

Construction proposals for canal and harbour walls are discussed in Section 4.5.5 and the accompanying marine engineering report by MP Rogers & Associates (Appendix D).

The current proposal anticipates about 4km of limestone walling to be constructed, which will necessitate the quarrying and importation of approximately 45,000m^3 of nominal 0.5m size rip-rap, and bedding layer materials of the order of 13,500m^3.

In addition, roadworks will require the quarrying and importation of about 25,000m^3 of road base materials and associated aggregate for road sealing.

Other concept plans, to be proposed, may have different materials requirements.

The existing limestone quarries near Exmouth will require assessment to determine if they are capable of providing suitable supplies of such construction materials. Any quarrying operations required for the project will be subject to a separate environmental approvals process.

4.6.2 Materials Storage

Materials will be stored on site within nominated areas designated to minimise impact on adjacent areas.

4.7 Drainage and Pollution Management

4.7.1 Overland Flow and Resort Drainage

Rainfall in the area averages around 300mm per annum. Although this rainfall is low the area is characterised by cyclonic storm events yielding high volume storm flows.

The Exmouth Boat Harbour and the proposed residential resort development are located at a break-out which previously existed in the dune system at the downstream end of significant stormwater drainage catchments. The high intensity rainfall events in the area can lead to significant storm flows towards the project area. The extent of the immediate catchment, comprising about 5 km^2, together with the larger adjacent catchment to the north, are shown on Figure 6.

The Flood Channel Investigation for the Exmouth Boat Harbour (Evangelisti and Associates,1996) carried out culvert designs for the two road crossings of the floodway, to convey a 1 in 10 year recurrence interval storm without encroaching on roadways. Recommendations were made that flows in excess of the 10 year recurrence interval storm should pass over the access roads on a floodway totalling 50m in width.

Preliminary road gradings and designs confirm that appropriate culverts and floodways can be incorporated within the proposed project layout. However detailed subdivision design will need to recognise these floodway requirements and make appropriate allowances for overland flow towards the canals and harbour from both the immediate catchment and the larger catchment to the north. This detail design will require adherence to MRWA and Shire requirements pertaining to floodway widths, longitudinal gradients, pipe sizing for the 10 year recurrence interval storms, and appropriate scour protection at inlets and outlets and at discharge points to the canal water bodies.

Stormwater accumulates in the lowlying water courses to the immediate east of Murat Road and currently drains towards the previously existing dune break-out which now coincides with the Exmouth Boat Harbour. However, with the exception of very heavy episodic events, the stormwater reportedly does not often drain directly to the ocean by that break out, with drainage in the area being generally absorbed behind the dunes within dissipation and infiltration areas. Significant flows were last observed during Tropical Cyclone Beverley (in approximately 1975) when water to build up to the north of Warne Street

overflowed south towards the break-out (Mr K Graham. Exmouth Shire. pers. comm.).

The opportunity exists through this proposal for the formalisation of two settlement/absorption areas, which are shown in Figure 12 and located as follows:

- one immediately west of Murat Road adjacent the Tourist Precinct; and
- the other in Reserve 29066 immediately north of the proposed residential precinct.

It is anticipated that the majority of storm flows (re all but extreme cyclonic events) would dissipate within these two areas. In extreme cyclonic events, the capacity of these two basins would be exceeded and overflow would occur via the proposed culvert system and overland floodways to the canal water body. The sediment load carried by the stormwater during these extreme events would be attenuated by settlement within the infiltration basins so that settlement discharge to the canal waterway will be minimised.

Internal roadwork gradients will be designed so that internal stormwater runoff from the development area will be conveyed via the roadways to also discharge to the two dissipation basins. Detail design may indicate that some minor pipe collection systems are necessary to augment the overland flow systems, however these will be minimised to minimise construction and maintenance costs.

Detail design of the project will confirm the necessary sizings of the major dissipation basins and other flood and stormwater control measures. Design specifications will be formalised prior to construction in consultation with the DEP and the WRC and the Shire of Exmouth.

4.7.2 Nutrient Management

Acceptable control, treatment and management to minimise the inputs of nutrients to the canal waterway from stormwater runoff from the proposed development is recognised as an essential part of the project.

As outlined in Section 4.7.1, stormwater runoff from the residential resort will be directed towards the two infiltration basins where nutrients will be absorbed by the local soils as the stormwater infiltrates to the unconfined groundwater system. The development area that is outside of the infiltration basin catchments (ie the area near the inner and outer boat harbour) would be designed so that runoff from low intensity storms can infiltrate on site.

Stormwater from higher intensity storms would need to discharge via the infiltration basins to the canal waterway. However the volume of water during such intense rainfall events, and the low proportion of site runoff to the overall stormwater flows during such events, would allow nutrients from the project area tobe greatly diluted prior to entering the canal waterway.

Stormwater runoff from within the site can be segregated into the following categories, each of which will have different methods of control;

a) Road and road reserve verge runoff.
b) Front garden and driveway runoff from properties.
c) Roof runoff
d) Lower garden and landscaped areas adjacent to the canal wall.
e) The walkway adjacent to the canal wall.

Each category is discussed below:

4.7.2.1 Road Drainage

Stormwater runoff from roads will be collected and drained within roadworks in accordance with the requirements of the Shire of Exmouth. Roads will be graded towards the settlement/infiltration areas to allow removal of sediments and possible contaminants, and in the case of severe storms, before stormwater overflows via designated floodways to the canal waterway.

The road drainage management system will encompass all road surfaces within the project, together with road runoff from the adjacent Murat Road which currently discharges to the site.

4.7.2.2 Front of Lot Drainage

Lots will be graded so that the frontage will slope at a minimum grade of 2% towards the road reserve. Stormwater drainage from this area, including driveways and garden areas, will be drained to the street where it will be collected for discharge to the settlement/infiltration basins.

4.7.2.3 Roof Drainage

Roofs of dwellings in the development are not expected to be provided with rainwater gutters. Roof runoff will generally be allowed to fall on the lot to discharge either to roadways or the canal waterway.

4.7.2.4 Lower Garden/Landscaped Area/Walkway

It is proposed that the landscaped area between the houses and the canal wall will be graded towards the revetment walling. Runoff will be intercepted at the top of the revetment by the rockwall where it will infiltrate prior to subsurface drainage into the canal waterway.

4.7.3 Hardstand Areas

A large hardstand area is anticipated due to the extent of the proposed marine industrial facilites, and which will also need to compensate for the proposed absence of such facilities along the environmentally sensitivity west coast of the Cape.

The potential input of contaminant to the waterways is proposed to be minimised by appropriate design and management, as follows:

- Stormwater drainage from all marina hardstand areas will be directed away from the marina and discharged to general drainage via silt traps.

- The fuel storage facilities in the marina will be above ground and contained within a sealed bund capable of holding the entire tank contents.

- Boat refuelling hoses will have manually operated nozzle valves with automatic shut-off.

- The use of antifouling points containing tributyl tin (TBT) will be prohibited in the marina. This would be a condition of the lease of all boat repair facilities in the marina.

Section 6.4.4.1 discusses the potential sources and types of pollutants from hardstand areas.

4.7.4 Fuel storage and Refuelling areas

Fuel storage at the marina would include above-ground bulk storage tanks for diesel and possibly petrol. Each tank would be contained within a sealed bund capable of holding the entire tank contents without overflowing. This would allow for full recovery of fuel in the unlikely event of a spillage.

Boat refuelling facilities would include manually operated nozzle valves with automatic shut-off, to reduce the likelihood of significant spillages. The fuel storage and boat refuelling facilities would comply with the requirements of the Explosives and Dangerous Goods Division of the Mines Department.

4.8 Services

4.8.1 Pedestrian and Foreshore Access

The internal road layout as proposed will permit ready pedestrian and cycle movement within the Resort.

Pedestrian and cycle access from the southern and western parts of the Resort is proposed by a pedestrian bridge over the canal between the inner boat harbour and the tourist precinct.

A bridged pedestrian beach access is proposed from the Resort Hotel and Convention Centre over the dunes immediately east of that section of development. Beach and Yacht Club accesses are proposed over the dunes from the eastern boulevard. Beach accesses across the dunes will need to be designed and constructed to best fit the existing dune system. Accesses will be constructed to minimise impact on the dunes, with fenced walkways to ensure pedestrian movement remains on designated access routes. The proponent will prepare a foreshore reserve management plan for dune rehabilitation and protection.

4.8.2 Potable Water Supply

The Water Corporation advises that average annual total demand per residential equivalent

is 820 kilolitres (kL)with an average peak day volume of 3.35 kL per service (including some garden watering) for the size lots proposed, and that existing systems can be expanded to accommodate the proposed development subject to necessary approvals from the DEP and the WRC. Any variations in lot size would alter consumption per lot, however a higher density development may not increase total water demand due to the reduction in garden area.

The Water Corporation currently has capital projects in place to meet the future demand, including an extension to the existing bore fields to the south by an extent determined by water requirements for each stage and the timing of development. The Water Corporation anticipates that the proposed development will increase the town's current consumption by approximately 50% when completed.

4.8.3 Landscaping Water Supplies

Groundwater below the site contains salt concentrations which deem it unsuitable for irrigation. Consequently, landscaping water supplies will be provided via the reticulated potable system (scheme water).

4.8.4 Wastewater Collection and Treatment

Each lot to be created within the development will be provided with a connection for wastewater to a reticulated sewerage scheme so that all wastewater can be collected to be pumped away from the site for treatment. Readily available technology exists to allow for such collection. This would be by either vacuum sewerage or gravity means dependant on the outcome of final design and economic analyses of ongoing maintenance and running costs in addition to capital cost. Wastewater flows calculated drawing on Water Corporation experience in the area indicate that full development would produce in the order of 250,000 kilolitres of wastewater per annum.

A sewage pump-out facility will be incorporated for boats serviced at the boat harbour and will be connected to the reticulated sewerage system.

Apart from a portion of the town's light industrial area, the whole of Exmouth is deep sewered. Treated effluent from the sewerage treatment plant (located 1.5km north of the project areas) is currently recycled back onto the town's ovals and golfcourse, and contributes significantly to the greening of the arid townsite environment. An assessment

of the capacity of the Town's green space to support the additional effluent is provided in Section 6.6.

The Water Corporation has advised that the existing wastewater treatment plant has the capacity to accept increased inflow. The Water Corporation plans to relocate the wastewater treatment plant, and it is likely that the development of the Exmouth Resort, Marina and Residential development will expedite the relocation dependant on staging, timing of the development and obtaining the necessary approvals.

Wastewater collected at the Resort site would need to be pumped to the treatment facilities. Design of the overall scheme will be in accordance with the current Water Corporation design criteria for such a development.

4.8.5 Power Supply

The project will be provided with reticulated underground power in accordance with Western Power's standard requirements.

A diesel generating plant is currently operated by Western Power to supply the townsite. The plant is in the town's industrial area and has a capacity of 7.32 Megawatts. The generating station in Nimitz Road only sufficient for the existing town and Western Power does not plan to extend or enlarge the power station. Generation of power for the development will need to be subject of ongoing negotiations with the State and Authorities. It is possible that provision of a dedicated generation facility for the residential resort will be required. The location, sizing and timing of construction of generating facilities will be subject of ongoing planning and negotiations.

4.8.6 Disused Rubbish Dump Sites

There is a decommissioned rubbish dump immediately landward of the dunes at the proposed marina site. During the construction of the Exmouth Boat Harbour, the Department of Transport excavated the entire tipsite to bedrock and filled the site with clean sand.

A second, disused rubbish dump is located in the northwestern part of the proposed residential development. In addition, soils containing residual oil and hydrocarbons have

been used for stabilisation of the Exmouth Racecourse.

All of these areas will be subject to a site contamination investigation, and cleanup if necessary, in accordance with ANZECC & NHMRC guidelines for the assessment and management of contaminated sites.

4.8.7 Municipal Refuse Disposal

The collection and disposal of household and similar wastes from the proposed development would be expected to become a Local Government responsibility once construction is completed and individual lots created. Progressive upgrading and expansion of municipal tip facilities would be required as the development progresses.

4.9 Project Agreement and Management Program

The City of Mandurah has developed guidelines to clearly establish the responsibility for management and maintenance in canal/waterway developments, which have been successfully implemented. It is anticipated that these 'Waterways Management' guidelines will be used as a model for a Project Agreement and Management Program for both the Exmouth Boat Harbour and the Exmouth Marina, Resort and Residential Project. Agreement will need to be reached between the Shire of Exmouth and an agreed waterways manager. Table 8 summarises the potential guidelines for responsibility of various management aspects.

The model guidelines direct that the Local Authority's management responsibilities shall be funded by an up-front 'headworks' cost (dollars per lot) based on a calculation of the design life of the subdivision. The contribution will be payable at subdivision stage and secured by bank guarantee at rezoning stage. Owners can be individually levied under Section 548(4) of the Local Government Act for additional funds after an initial management requirement has been fulfilled by the proponent.

It should be noted that only ratepayers within the proposed development (residential subdivision and users of the waterway precinct) would be exposed to any management costs.

An initial management period will be the responsibility of the developer. After that period,

the Local Authority shall be responsible for:

(a) sea walls abutting public land;
(b) silting of canals and the entrance channel;
(c) water quality within canals;
(d) monitoring jetties; and
e) document transfer.

Table 8

Suggested Management Responsibilities and Means of Funding of Canal Estate Developments

(as outlined by example Draft Waterways Management Guidelines)

Management Responsibilities	Responsible Organisation	Means of Funding
Walls i. within privately owned land	Land Owner	Owner to fund
ii. abutting POS, roads etc	Shire	Developer contribution and general rating
Silting i. In canal/marinas	Shire	Developer contribution and general rating
ii. In entrance channel	Shire	Developer contribution and general rating
Water Quality i. In canals/marinas	Shire	Developer contribution and general rating
ii. In source body	Shire	Department of Transport to fund
Jetties	Shire and Department of Transport (or designated Waterways Manager)	Licence fee from owners
Speed Limits	Department of Transport (or designated Waterways Manager)	Department of Transport (or designated Waterways Manager)
Canal Signage (Navigation)	Department of Transport (or designated Waterways Manager)	Department of Transport (or designated Waterways Manager)

5.0 CONSTRUCTION PHASE ENVIRONMENTAL IMPACTS

5.1 Summary of Construction Impacts

The history of canal development in Western Australia has enabled the impacts of canal construction and operation on the natural and social environment to be confidently predicted and well understood. The majority of construction impacts are now addressed by standard engineering procedures defined within various statutory guidelines and policies for canal construction, which have approved management prescriptions to mitigate environmental and social impacts to minimal levels. As discussed in Section 4.0, these controls and management are an integral component of this proposal.

Based upon the evaluation of the existing environment as described in Section 3.0, and with regard to the mitigation of impacts due to the management proposals detailed in Section 4.0, the potential impacts of construction of the Exmouth Marina, Resort and Residential Development are summarised as:

- localised temporary drawdown of the shallow aquifer during dewatering operations which could cause a potential impact on subterranean fauna habitat;

- disturbance/removal of vegetation and fauna habitat

- potential contamination of marine water quality due to:
  - unacceptable turbidity during discharge of dewatering fluids;
  - potential dispersion of residual sediment into the Exmouth Boat Harbour and Exmouth Gulf during dredging of the connection channel; and
  - inappropriate disposal of dredge spoil.

- low level noise during construction which may impact residents of Exmouth;

- residual dust problems during construction; and

- potential disturbance to sand dunes during construction.

The potential construction phase environmental impacts are discussed in detail below.

5.2 Impacts of Dewatering

5.2.1 Extent of Drawdown

The magnitude of the drawdown effect for the construction of the marina and canal waterway has been simulated using a simple computer model, as discussed in Appendix C. The estimated drawdown after a period of 180 days indicates that a drawdown of about 0.5m could be induced up to 1km north, west and south of the excavation (Figure 13). Modelling suggests that if excavation takes 180 days, groundwater could be drawn into the excavation from distances of up to 400m.

5.2.2 Potential Impacts on Subterranean Fauna Habitat

The project is highly unlikely to cause any impact to either stygofauna or troglobitic fauna, for the following reasons:

- The immediate hydrogeological environment in the vicinity of the project site is considered to be unsuitable habitat for stygofauna or troglobitic fauna because;
  - the geomorphology of the project site is predominantly alluvial and tidal flat deposits which are not karst features.
  - there is no evidence of large cavities or caves within the project area which might support troglobitic fauna.
  - the water quality of the superficial aquifer under the site is significantly higher than the upper salinity tolerance recorded for stygofauna (Knott, 1993). Hence the project area is highly unlikely to contain stygofauna habitat.
  - the clay and silty clay deposits associated with the project site act to provide a barrier for vertical groundwater movement to the unconsolidated aquifer below .

- The nearest recorded location containing significant troglobitic fauna (Cameron's Cave) is approximately 1.9km from the site. Modelling of the drawdown during the construction period indicates that a <0.1m fall in the groundwater level is to be expected, which may result in a thinning of the brackish superficial groundwater lens, if present, by approximately 0.4m. This is highly likely to fall within the natural seasonal and tidal variation in the groundwater environment beneath the cave which is unlikely to result in a significant impact on the troglobitic fauna.

The Water Corporation has conducted recent research regarding the proportion of the aquifer and stygofauna habitat and population impacted by current pumping operations and the proposed extension of the abstraction borefield (WC, 1996). The results indicate that the Water Corporation has pumped water for over 30 years with little impact on stygofauna (less than 1% of the total habitat area) and that pumping does not affect the bulk of the stygofauna as most species occur on the walls and amongst flocculant sediment on the floor of karst features, and are rarely free swimming in mid-water which is the preferential flow path induced by pumping.

A groundwater management and monitoring plan will be established prior to dewatering to confirm the predictive natural fluctuations and drawdown levels of the groundwater.

5.3 Clearing of Vegetation and Fauna Habitat

As described in Sections 3.2.2 and 3.2.3, there are no regionally significant vegetation or fauna habitat on the site.

5.4 Discharge of Dewatering Spoil

As described in Section 4.5.4, discharge of dewatering spoil will be in accordance with EPA's Environmental Water Quality Objectives (EQO). The dewatering spoil will be held in stilling basins behind geotextile curtains of sufficient capacity to provide an adequate detention time for any turbidity in the water to settle out prior to discharge of the clear water to the Gulf.

5.5 Impacts of Dredging

5.5.1 Water quality

As discussed in Section 4.5.6, dredging operations will be limited to the opening of the canals to the outer Boat Harbour.

The short term contribution to water turbidity associated with the operation of the cutter

suction dredge is not expected to cause discernible impact upon the biota within the Exmouth Gulf. The Gulf ecosystem is highly dynamic and the composition and abundance of the resident fauna varies greatly on a seasonable basis and from year to year, partly because of variable water quality conditions. The turbidity in the Gulf can vary markedly in response to tidal and storm conditions. Turbidity from dredging a connection to the canals will be short term and would be unlikely to exceed naturally occurring fluctuations.

5.5.2 Disposal of Dredge Spoil

Dredge spoil generated during the opening of the canals to the outer Boat Harbour will be used for landfill on the site. Off site dredge spoil disposal is not anticipated to be required.

5.6 Noise

Noise from earthmoving machinery has the potential to impact Exmouth residents when construction occurs adjacent to the western and northern boundaries of the site. However, due to the distance involved, in is anticipated that this noise will be minor and relatively short term.

5.7 Dust

Dust generation will be managed in accordance with industry practice for sensitive environments, and will employ conventional water suppression and surface stabilisation techniques in order to maintain dust below acceptable levels. Due to the distances involved, the impacts of dust on the nearby residents is likely to be small. However, the possibility of residual dust is recognised and is addressed within the Monitoring and Management component of the proposal (Section 7.0).

5.8 Dune Protection

Dune areas may be encroached by contractors during the construction period, resulting in further spread of weed species and degradation of vegetation cover.

6.0 OPERATIONAL STAGE ENVIRONMENTAL IMPACTS

6.1 Summary of Impacts

The potential operational impacts of the Exmouth Marina, Resort and Residential Development are summarised as:

- localised permanent drawdown of the shallow aquifer during dewatering operations which could cause a potential impact on subterranean fauna habitat;
- increase in area of saltwater intrusion resulting from movement of the saltwater/freshwater interface within the superficial watertable to the west, with a potential to interfere with subterranean fauna habitat;
- canal and marina water and sediment quality impacts, associated with:
  - potential deterioration of water quality due to inadequate flushing;
  - contaminant inputs from residential land use; and
  - contaminant inputs from vessels and hardstand areas.
- potential for sedimentation within the waterway and requirements for maintenance dredging;
- potential for nutrient contamination of the groundwater through additional quantities of recycled water from the sewage treatment plant;
- potential for the dune system to be further degraded by weed invasion and uncontrolled public access.
- increased population and recreation pressure, which may result in:
  - additional pressure on commercial fishing; and
  - recreational fishstocks

These potential operational impacts are discussed in detail in this section.

6.2 Impact on Subterranean Fauna

The estimated residual groundwater drawdown one year following construction of the

waterways has been estimated as <0.1m in the vicinity of Cameron's Cave, 1.9km from the site (Figure 14). This is the same level of drawdown expected during the dewatering operations for construction of the waterways. As described in Section 5.2.1, and based on the Ghyben-Herzberg relationship, this may result in a thinning of the brackish superficial groundwater lens, if present, by approximately 0.4m. In practice the change is expected to be much less because of recharge and reduced evapotranspiration losses between the canals and the cave, and the heterogeneity of the aquifer (Rockwater, 1996 - Appendix C). Given that the natural variation in groundwater levels at Water Corporation production bores closest to the site has been measured as ranging from 0.1m to 0.2m, a minor change in groundwater level is unlikely to have a significant impact on motile, troglobitic fauna.

6.3 Saltwater Intrusion

The canals are to be developed over a naturally high saline groundwater area. Once the canal/harbour has been constructed and filled, seawater in them would flow to the west, north and south back into the aquifer for distances up to 120m from the canals over four months before the easterly hydraulic gradient was re-established and groundwater flowed back towards the canals.

No subterranean fauna habitat occurs within the range of influence of the expected saltwater intrusion.

6.4 Canal and Marina Water and Sediment Quality

The following information is extracted from Appendix D - MP Rogers & Associates.

6.4.1 Introduction

An important concept regarding canal flushing and water quality within canal developments is that such developments can only achieve water quality equal to the source water.

The resultant water quality in the marina and associated waterways will be dependent upon the following:

- the quality of the source water;
- the mixing and exchange processes; and

- the management of nutrient and pollutant inflow.

6.4.2 Source Water

The source water for the proposed waterway development will be the waters of the adjacent Exmouth Gulf. From time to time the Gulf waters become quite turbid under the action of strong tidal currents, waves and winds. This is an aesthetic factor only and the Gulf has previously been considered acceptable as a source water.

6.4.3 Mixing and Exchange

Mixing of water within the various waterways occurs through tides, winds, waves, and boat traffic. All of these mechanisms will ensure that the water bodies are regularly and well mixed.

Exchange between harbours and the adjacent source waters can be achieved via:

- density currents;
- inflow of ground water;
- astronomical tidal fluctuations; and
- wind induced currents.

Each factor is discussed below.

6.4.3.1 Density Currents

The density of the waterway water is expected to be almost identical to that of the source water in Exmouth Gulf, hence there will be little or no density gradients between the two water bodies that could set up density driven currents. Although density driven currents are important elsewhere, they will not be a significant mechanism in the water exchange at the Exmouth Marina, Resort and Residential Development.

6.4.3.2 Ground Water Inflow

Rockwater Pty Ltd predicts the ground water flow into the waterway to be very small and only in the order of 100 m^3/day (Phillip Wharton pers. comm.). In view of the small magnitude of the ground water inflow, this is not expected to be a means of significant water exchange with the source water.

The most important water exchange mechanisms therefore will be the astronomical tidal fluctuations and the wind induced currents. These are discussed below.

6.4.2.3 Astronomical Tidal Fluctuations

As outline in Section 4.4.1, the astronomical tides Exmouth are semidiurnal (two cycles per day) with the typical spring and neap ranges being 1.8 and 0.6 metres respectively.

The tidal prism ratio (TPR) is defined as the ratio of the volume of tidal flow entering the waterway from low to high tide to the total volume of water in the waterways, and gives a measure of the potential for tidal flushing. For the proposed development the TPR has been calculated to be about 45% for a 1.8 metre tidal range (spring tides) and about 15% for a 0.6 metre tidal range (neap tides). This means that the tidal action will cause a large percentage of the waterway volume to be moved into and out of the development.

Falconer (1980) indicates that under some conditions not all of the incoming source water will mix with the water in the waterways. The geometry can have a significant effect on the efficiency of mixing and effective exchange. A relatively ineffective shape for mixing and effective exchange is a long and relatively narrow canal. In such a case, the incoming tidal water can bank up the canal water at the far end of the canal with little effective tidal mixing, as much the same water that flows in during the flood tide flows out during the following ebb tide. The individual water particles are basically moved back and forth by the tidal action, but there is little effective exchange of water with the source water.

Falconer (1980) defines an exchange coefficient as the product of the TPR and an efficiency coefficient to account for these effects.

Exchange Coefficient = Tidal Prism Ratio x Efficiency Coefficient.

Based on Falconer's work, "efficiency coefficients" were estimated for the various parts of the proposed waterways (Table 9). These factors have then been multiplied by the above tidal prism ratios to obtain an estimate of the effective water exchange and flushing caused by the spring and neap tides. It should be noted that the values are for a single tidal cycle and there are two tidal cycles each day.

Table 9
Estimated Tidal Exchange
(from MP Rogers & Associates-Appendix D)

Waterway Location	Estimated Efficiency Coefficient	Estimated Tidal Exchange	
		Springs	Neaps
DOT Harbour	1	45%	15%
Inner Harbour	0.5	22%	7%
Tourist Precinct	small	small	very small
Residential Precinct	very small	very small	very small

The estimates described in Table 9 indicate that the DOT Boat Harbour will be well flushed by the astronomical tides. This waterbody will have a residence time in the order of 1 to 5 days and the resultant water quality will be close to that of the source water from Exmouth Gulf.

The Inner Boat Harbour would experience less flushing by the astronomical tides and residence times in the order of 5 to 10 days could be expected.

Astronomical tides will also play a minor role in flushing the canal waterways, hence the action of the wind over these areas of waterway will be far more significant in the mixing and exchange of water with the source water.

6.4.3.4 Wind Induced Currents

Winds blowing over closed-end waterways are known to create water motions that are important for water mixing and exchange. McKeehan (1975) specifically studied the effects of wind on water motion in artificial waterways. This work included a theoretical approach as well as presenting extensive measurements taken in existing residential canal

estates. This study shows that wind blowing over a closed-end waterway causes:

- a slope on the water surface, raising the level at the down-wind end of the waterway, and

- surface water movement in the down-wind direction, and an opposite motion in the bottom layer.

The water flow at the surface is usually taken to be in the range of 2 to 5% of the wind speed (Wu, 1973; Bishop, 1979; and McKeehan, 1975). The above suggests that the water speed decreases rapidly with depth and reaches zero at about one-third of the total depth. Underneath this level, there is a reverse flow to ensure a conservation of mass.

As outlined in Section 3.1, southerly winds are common throughout the year with speeds typically about 10 to 15 km/hr. The waterways for the tourist and residential precincts have been aligned to take full benefit of these common southerly winds. Local topography and the layout of the buildings along the waterway will funnel the southerly winds along these waterways and cause strong wind induced currents and associated water exchange with the Inner Boat Harbour.

Using the methods outlined in McKeehan (1975) it was calculated that a southerly wind of 15 km/hr will cause the top one-third of the water column to move at an average rate of about 0.05 metres per second. The waterways of the tourist and residential precincts are generally between 55 and 100 metres wide and about 4 metres. Consequently, it is approximated that 15 km/hr winds from the southern quarter will cause an inflow of about 10,000 to 15,000 m^3/hr from the Inner Harbour into the adjacent waterways. This would be accompanied by a return flow at the same volume flux in the bottom two-thirds of the water column. As the waterways for the tourist and residential precincts have a total water volume of about 360,000 m^3 at mean sea level, it would take about 30 hours for these wind induced currents to fully exchange the waterway with the Inner Boat Harbour water.

Examination of the anemometer records for Learmonth suggest that in most 5 to 10 day periods there will be sufficient southerly winds to cause the entire volume of water in the Tourist and Residential Precincts to be exchanged with the Inner Harbour water body.

However, there are significant periods of time without southerly winds. From the review of the Learmonth anemometer records, it would be reasonable to expect that at some times

it may take about 15 days for the southerly winds to cause the entire volume of water in the tourist and residential precincts to be exchanged with the Inner Harbour. This would mean a residence time in these waterways of about 15 days when the southerly winds are weak and infrequent.

6.4.4 Management of Nutrient and Pollutant Inputs

6.4.4.1 Inputs from Residential LandUse

The proposed nutrient and drainage management design (Section 4.7.2) provides for segregation of irrigation and stormwater runoff as detailed below:

- Rainwater and irrigation water from landscaped and paved areas within residential blocks will be directed to behind the canal revetment and will only enter the canals by subsurface seepage and soil adsorption of nutrients.
- Road drainage will be directed to the canals via the proposed settlement/ infiltration basins to minimise the discharge of soil sorbed contaminants, and only runoff from major events will overflow directly into the waterway.
- The development will be serviced with a reticulated sewerage system, and
- A sewage pumpout facility will be provided in the DOT Boat Harbour or the marina for vessel sullage.

6.4.4.1 Inputs from Hardstand Areas and Vessels

Monitoring studies in marinas elsewhere have shown that the primary sources of heavy metals to marina waters include the following:

1. Stormwater runoff from boat maintenance areas can introduce flakes and dust of paints stripped from boats. Mercury, tin and copper and common constituents in antifouling paints, while chromium, lead and zinc are constituents of paint primers. Cadmium is also used as a pigment in some marine paints. However, appropriate drainage design to direct stormwater runoff away from the marina, and incorporation of silt traps to reduce the suspended solids load, would minimise contributions from this source.

2. Continuous leaching of antifouling paints and sacrificial anodes (zinc or aluminium) from boats moored in the marina have a direct although minor contribution.

3. Exhaust from outboard motors contribute lead to the water column.

The potential sources of petroleum hydrocarbons to the marina at Exmouth include exhausts from marine engines, spillage at the fuel dock, discharge of bilge water and run-off from the public boat ramp. Other hardstand areas within the marina resort would not drain to the marina.

The Australian Environment Council[4] studied four marinas near Brisbane to determine, *inter alia*, the nature, extent and sources of petroleum hydrocarbon and heavy metal pollution. Specific findings of the study, with relevant comments pertaining to the proposed marina at Exmouth, were as follows:

- Sedimentary levels of total chromium, nickel and cadmium were not statistically different from those in the parent water body.

- Sedimentary levels of total copper, lead and zinc, and at one marine mercury, were significantly elevated in the marinas. Metal levels were highest in marinas with the highest boating density or where boat maintenance areas drained directly into the marina. It is noted that the proposed peak boat density at Exmouth would be approximately 16 boats per hectare of water area, which is substantially less than at the four marinas studies here (range of 45 to 80 boats/ha). Also, drainage from hardstand areas would be directed away from the marina.

- Copper, zinc and lead were accumulated significantly by oysters transplanted into the marinas. This was considered to be due to a combination of point sources (drainage, fuel dock and maintenance area drains) and non-point sources (motor exhaust and leaching of marine paint).

- There was no significant increase in total hydrocarbon concentrations in the water or sediments of the marinas, although a significantly higher proportion of the total hydrocarbon levels were petroleum hydrocarbons. Fuel docks were identified as

4 Australian Environment Council. 1988. Impact of Marinas on Water Quality. AEC Report No. 24.

a point source of elevated petroleum hydrocarbons. Concentrations in water also showed localised effects due to bilge discharges from vessels.

It was concluded overall that, while accumulation of metals and petroleum hydrocarbons in sediments and biota had been demonstrated, the levels were not considered indicative of any significant water pollution. There was no evidence of ecological impact due to heavy metals or petroleum hydrocarbons in any of the four marinas that were investigated.

Environmental monitoring studies in Western Australia marinas have established an extensive data base of sedimentary heavy metal levels inside marinas (V. Talbot, EPA, pers. comm., 1989). In those marinas oriented primarily towards recreational boating (e.g. Hillarys, Ocean Reef, Americas Cup Harbour), the sedimentary levels of heavy metals are not significantly different from those in the adjacent open-water environment. However, there has been significant accumulation of heavy metals in the sediments of marinas and harbours with substantial commercial activities or repair facilities, such as Geraldton Fisherman's Harbour, Geraldton Harbour, Fremantle Harbour, Fremantle Fishing Boat Harbour and Success Harbour. Each of these latter examples have shown elevated copper, lead and zinc levels, and individual harbours have also variously shown significant sedimentary accumulation of chromium, cobalt, nickel, iron, manganese, titanium and vanadium.

It is not possible to provide confident quantitative predictions of the potential pollutant loadings from the proposed hardstand areas, but they are expected to be low. As described in Section 6.4.3 above and Appendix D, the anticipated water flushing rate is considered adequate to ensure that water quality in the marina remains essentially similar to that of the adjacent Gulf.

As discussed in Section 4.7.3, the following design elements and drainage management is proposed for hardstand areas:

- All facilities within the marina, as well as in the proposed residential development, would be deep sewered.

- Stormwater drainage from all marina hardstand areas would be directed away from the marina and discharged to general drainage via silt traps.

- The fuel storage facilities in the marina would be above ground and contained within a sealed bund capable of holding the entire tank contents.

- Boat refuelling hoses would have manually operated nozzle valves with automatic shut-off.

- The discharge of sewage, hydrocarbons or litter from boats into the marina would be prohibited, and all users of the marina would be informed of this. Waste disposal facilities, including rubbish bins, oil recycling deposit bins and sewered toilets would be provided around the marina. A sewage pumpout facility would be provided for boats equipped with holding tanks.

- The use of antifouling points containing tributyl tin (TBT) would be prohibited in the marina. This would be a condition of the lease of all boat repair facilities in the marina.

These design precautions will ensure that the entry of nutrients and other contaminants to the canals and adjacent estuary will be minimal. Provision is also made for the removal of litter, accumulation and floating debris.

The use of antifoulants containing tributyl tin oxide (TBT) on vessels less than 25m and on marine structures is prohibited in Western Australia. The discharge to public waterways of sewerage, hydrocarbons and litter from vessels is also illegal.

Monitoring data from other canal estates in Western Australia have shown that appropriate canal estate design and management can minimise the risk of significant contaminant inputs to the canals. However, it is possible that low level inputs of heavy metals, petroleum hydrocarbons and nutrients may accumulate in the canal sediments over the long term. It is not possible to accurately predict rates of accumulation of any of these potential contaminants and appropriate monitoring is proposed to determine the possible need for ameliorative measures (Section 7.0).

6.4.5 Resultant Water Quality

The waterways have been designed, and will be managed, to achieve minimal inflow of nutrients and pollutants. Of the possible sources of nutrients and pollutants, the most significant are considered to be:

- the application of fertiliser and irrigation water to the garden areas adjacent to the waterways;
- the antifouling treatment on boats moored in the development; and
- accident situations which may release oil and fuel.

Given that the empirical calculations for the current canal design indicate that the inner sections of the waterways could at some times take about 15 days to effectively flush, the management of nutrient inflow into the waterway is essential. This will be addressed within the drainage management plan to be prepared for the project (Section 7.2).

It has been estimated that the typical boat moored in the waterways would release about 3 to 6 g/day of copper from its antifouling treatment. It is planned to have 160 boat pens and moorings in the Inner Boat Harbour, the Tourist Precinct and the Residential Precinct when fully developed. Assuming an occupancy rate of about 80%, these boats would release about 400 to 800 g/day of copper into the water body. With the minimum flushing rates estimated above, it has been calculated that the resultant concentration of copper in the waterway would be in the order of 10 to 30 µg/L. This is well within acceptable limits as determined by the EPA.

However, it should be noted that the copper concentrations may at some times exceed the 5 µg/L limit often used when considering the harvesting of molluscs for human consumption. Consequently, the waterway manager will monitor the situation and ban harvesting molluscs for human consumption if required.

A Water and Sediment Quality Monitoring Program will be developed and implemented to ensure that marine water quality is protected (Section 7.0).

6.5 Sedimentation

There are two possible sources of siltation for the waterways of the Inner Harbour, the tourist precinct and the residential precinct. These are:

- sediment carried in the runoff from the adjacent land drainage system; and
- the suspended sediment in the incoming water from the DOT Boat Harbour and

Exmouth Gulf.

Both of these potential sources are addressed below.

6.5.1 Sediment in the Surface Runoff

It is proposed to divert the surface runoff into soakage areas (Section 4.7.1). In extreme rainfall events, associated with thunderstorms and cyclones, the proposed settlement/infiltration basins will overflow via the floodways into the proposed waterways. In such events, the detention basins would reduce the velocity of the drainage flow and thereby act as a sediment trap for all but the very fine sediment. Consequently, the overflow water would contain little sediment to accumulate in the waterways.

In Section 4.4.2 (Tables 6 and 7), a siltation allowance of 0.3 metres was included in the calculation of the minimum waterway depths to accommodate the siltation arising from the overflow from the detention basins.

6.5.2 Suspended Sediment in the Source Water

Under severe storm or cyclonic conditions, turbid stormwater will be entering the marine environment on a regional scale.

Experience elsewhere has shown that, where the source water is turbid, a very small amount of sediment may settle out of the water column during each tidal cycle. Over a number of years or even decades, this may accumulate and silt up the waterway. In Port Hedland, the tug boat harbour has been silting up at about 0.05 m/year (Rogers & Associates, 1996). This is likely to be a much higher rate than what will happen at Exmouth because the Port Hedland source water is more turbid including a considerable silt load. Nevertheless, this mechanism of sedimentation requires to be investigated.
The closest available measurements of the suspended sediment settlement rate was completed by Bowman Bishaw Gorham in 1993 at the entrance to Exmouth Gulf near South Muiron Island. The site was in about 20 metres of water and about 25 km to the northeast of the DOT Harbour. The work comprised the measurement of the sediment settlement rates around the Loggerhead No 1 oil exploration well between the end of October 1992 and the beginning of December 1992. The background reference site showed a sediment settlement rate of about 10 g/m^2/day near the seabed.

Earlier, and more comprehensive work in the Dampier Archipelago was completed by Forde (1985). This indicated that the sediment settlement rates were quite variable throughout Mermaid Sound between the seasons, and were greatest under the effects of cyclone waves and currents. At the entrance to Mermaid Sound, Forde reported sediment settlement rates of between 30 and 120 g/m^2/day near the seabed, and 20 to 60 g/m^2/day at 6 metres above the seabed. Further into the Sound, the rates were more than twice these values. During a mild cyclone, the settlement rates increased by an order of magnitude.

In view of these results, it is conservatively estimated that the proposed waterway would experience sediment settlement rates in the order of 10 to 30 g/m^2/day from the source water. Given the very sheltered nature of the proposed waterways, the action of re-suspension is anticipated to be quite minor. Consequently, the waterways are likely to accumulate at a rate in the order of 10 to 30 g/m^2/day. This roughly equates to about 0.003 to 0.009 m/year. At these rates, the 0.3 metre siltation allowance would last between 30 and 100 years. This is believed to be more than adequate for the development.

In the event that silt is deposited to a level which impacts the navigability of the waterways, silt would be removed by maintenance dredging.

6.6 Groundwater Protection

Rockwater Pty Ltd has predicted that the canals will introduce saltwater to a distance of about 120m from the boundary of the development over four months following construction, before the easterly hydraulic gradient is re-established and groundwater flows back towards the canals. As the project site is located over existing groundwater of very high salinity, and is located downgradient, saltwater intrusion is not considered to cause a significant impact on the groundwater quality of the area.

It is anticipated that the additional quantity of wastewater effluent generated from the project (250,000 kL) will be included with the recycled wastewater used to irrigate the town's green areas, including the local golfcourse which is only marginally irrigated at present. Due to the very high average pan-evaporation of the region (exceeding 3,000mm (3 metres) per year), and the fact that average evaporation is significantly greater than

average rainfall for all months of the year[5], this quantity will not exceed the present demand for irrigation water. For example, annual irrigation requirements for an 18-hole golfcourse in the region have been previously estimated at 1,000,000 kL pre year (Bowman Bishaw Gorham, 1995b).

The annual nutrient load anticipated from irrigation with treated effluent is unknown. However, a preliminary assessment of the capability of soils in the vicinity of Maud's Landing to support irrigated turf indicates the following:

- coastal dune soils have a moderate ability to retain phosphorous (PRI (phosphorus retention index) = 8-10)
- fertiliser supplements (nitrogen and phosphorous) would be required to grow turf in coastal dune soils.

Monitoring and management of potential nutrient contamination of the groundwater is the responsibility of the Water Corporation, and outside the control of the proponent.

6.7 Foreshore and Dune Protection

As discussed in Section 3.2.1 and 4.8.1, the exiting foredunes are badly degraded in places and require rehabilitation and management to control access from pedestrians, 4WD, horses (and possibly camels). An large increase in the numbers of people wishing to access the beach is expected. Unmanaged access over the dunes will cause further degradation (loss of vegetation cover and spread of weeds).

6.8 Population Pressures

Additional recreation use of the Exmouth waters will inevitably place pressure on the fishery resources of the area. This is a regional impact of increased tourism and recreation in the area which is appropriately managed by the Department of Fisheries.

5 Climatic records from Learmonth, 1975 - 1996.

7.0 MANAGEMENT AND MONITORING

7.1 Introduction

The discussion presented in Sections 5.0 and 6.0 demonstrates that, with appropriate management, the proposed Exmouth Marina, Resort and Residential development will cause minimal adverse impact upon the environment. Prior to construction, an environmental management program (EMP) will be prepared to detail the specific design and management actions will be implemented to minimise the environmental impacts during construction and operation of the project.

Each component of the EMP will be prepared prior to construction and implemented during the construction and/or operation phases, as appropriate. Elements of the proposed development requiring environmental management and monitoring and which will be included in the EMP are as follows:

- Relevant to Planning and Design Phase (pre-construction)

  - drainage and flood control management, to include a detailed design of structures and prescriptions for ongoing management of episodic flood events, as well as the methods of minimising nutrient and contaminant input from residential and industrial areas, into the waterways;

  - foreshore protection to ensure dune rehabilitation and protection requirements, and management of public access, are incorporated into the project design;

  - contaminated site investigation, to ensure disused rubbish tips pose no threat to human safety or the environment;

- Relevant to Construction Phase

  - groundwater management and monitoring to ensure drawdown levels and saltwater intrusion resulting from dewatering are as predicted, and that the closest subterranean fauna habitat is protected.

- management to ensure marine water quality is protected during disposal of dewatering fluids;
- management to ensure the marine environment and water quality is protected should dredge spoil disposal be required;
- foreshore protection, to include restrictions on access during the construction phase unless required to implement rehabilitation plan and construct fencing and beach access paths;
- management of earthworks (noise and dust management);
- compliance with the *Aboriginal Heritage Act, 1982-80*;
- cleanup of the rubbish tip sites, in accordance with the results of the contaminated sites investigation, if required.

• Relevant to Operation Phase

- groundwater management and monitoring to ensure longterm impacts on subterranean fauna habitat are as predicted;
- foreshore reserve management, to include arrangements for ongoing maintenance and monitoring;
- maintenance of water quality in accordance with water quality criteria, to include contingency plans for unacceptable or accidental discharge of contaminants into the waterways;
- maintenance of navigability, to include monitoring and management of potential sedimentation;
- formulation and implementation of a legal agreement with the Shire of Exmouth for the future management of the waterways;

7.2 Drainage and Flood Control

As discussed in Sections 4.7 and 6.4.4, the project requires the construction of adequate

drainage and flood control with the following objectives:

- to divert internal stormwater runoff away from the proposed development area;
- to maintain the role of the flood plain and prevent flooding of adjacent low lying areas; and
- to minimise the nutrient and contaminant input into the waterways.
- to ensure minimum building levels allow for episodic high storm surge events

The proponent will prepare and implement a detailed drainage design and management plan (to include the necessary sizings of the major dissipation basins and other flood and stormwater control measures), to the satisfaction of the Shire of Exmouth, on advice of the DEP, prior to initiation of the construction phase.

7.3 Foreshore Reserve Management

Design Phase

As outlined in Sections 4.8.1, 5.8 and 6.7, prior to the commencement of construction, the proponent will prepare a foreshore reserve management plan in consultation with the DEP, MFP, and CALM and the Shire of Exmouth. The Plan will include:

- methods and design of foreshore protection (ie fencing);
- landscape and rehabilitation design and implementation;
- location of public access ways and paths;
- public access and signage;
- management responsibility.

The Plan should be integrated with the Sand Dune Management Plan prepared for the outer Exmouth Boat Harbour Project.

Construction Phase

During earthworks and construction, care would be taken to avoid undue damage to the foreshore reserve. If necessary, temporary fencing would be used to avoid any incursion

of machinery into the dunes.

Work would be initiated during the construction phase to construct formalised beach access ways and rehabilitate presently degraded areas of the dune and foredune, in accordance with the foreshore reserve management plan.

Operation Phase

Following an agreed period of maintenance, it is anticipated that the Reserve will eventually be vested in the Shire.

7.4 Groundwater Management

Modelling has predicted that drawdown levels and saline intrusion at the closest subterranean fauna habitat will be minimal. Prior to construction, a groundwater management and monitoring plan will be developed in consultation with the WA Museum, and the DEP.

The plan will be implemented prior to the commencement of construction, throughout the construction period, and following completion of the canal construction until groundwater parameters have reached equilibrium.

The plan will include;

- definition of the location of monitoring bores
- monitoring frequency
- a contingency program for dewatering operations should impacts be greater than predicted.

7.5 Water and Sediment Quality Management

7.5.1 Water Exchange

The assessment of flushing of the waterways suggests that, with the current concept plan, some areas would have residence times of about 15 days under some conditions. Given

that alterations to the canal design may occur during the detailed design phase, the proponent will ensure that the estimates of water exchange are refined using a computer model.

7.5.2 Water and Sediment Quality

Pre-construction phase

Prior to construction of the canal waterways, a water and sediment quality monitoring program will be prepared in consultation with DOT and the DEP.

The proposed water quality management and monitoring for the waterways will be maintained to the same standard as, and integrated with, the existing Water and Sediment Quality Monitoring Program (WSQMP) prepared for the DOT Exmouth Boat Harbour (Bowman Bishaw Gorham, 1997). The objectives and contents of the existing WSQMP are as follows:

1. To test for possible adverse impacts of the Exmouth Boat Harbour upon the adjacent waters of the Exmouth Gulf.

2. to assess the effectiveness of the management strategies in maintaining high water quality within the harbour, in order to highlight any possible need for corrective actions.

The WSQMP includes measurement of water quality, sediment chemistry and bioaccumulation. Water quality monitoring will include the physical, chemical and microbiological parameters necessary to enable direct comparison with applicable water quality guidelines for the protection of environmental values. Sediment monitoring will test for the possible accumulation of metals and hydrocarbons, which tend to partition with the sediments. Bioaccumulation testing will test for possible accumulation of metals and hydrocarbons in biological tissue.

The objective of the proposed water quality monitoring is to test whether water quality in the harbour deteriorates to a level that adversely affects water quality in the adjacent Exmouth Gulf. For assessment purposes, the measured water quality within and adjacent to the harbour will be compared with water quality guidelines defined in the "Western Australian Water Quality Guidelines for Fresh and Marine Waters (EPA Bulletin 711,

1993). The environmental values and associated water quality guidelines that apply to the Exmouth Boat Harbour are as follows:

- Protection of Aquatic Ecosystems: Table 2.2 of EPA (1993).
- Recreational Water Quality and Aesthetics: Table 3.2 of EPA (1993).

The objective of the proposed sediment monitoring program is to determine whether nutrients, metals and persistent hydrocarbons accumulate within the sediments to levels higher than in the sediments of the adjacent Exmouth Gulf. A significant accumulation of nutrients or toxic chemicals within the sediments (more than two times the background level as measured in Exmouth Gulf) would require further investigation to identify the cause and the associated environmental concern.

The objective of the bioaccumulation monitoring is to determine whether metals and hydrocarbons accumulate in the tissue of a filter feeding organism in the harbour to a greater extent than occurs in Exmouth Gulf. A significant increase in tissue loads of metals or hydrocarbons in test organisms held in the harbour (to more than twice the loads in test organisms held in nearby open waters) would trigger further investigation to identify the source and the associated environmental concern. For assessment purposes, tissue concentrations of contaminants will be compared with the Australian Food Standards Code for shellfish (A12).

Construction Phase

The management and monitoring of turbid water discharges which may occur during dewatering operations will be detailed in the WSQMP.

Material excavated from the canal and inner harbour is anticipated to be used entirely for fill within the project area. In the event that disposal of dredge spoil is required, the proponent will refer the issue to the DEP.

Operations Phase

The marinas and canal waterways would be inspected daily by the waterways manager and any corrective action required to maintain water quality and aesthetics to the required standard would be implemented immediately. Routine maintenance would include removal

of all rubbish and debris.

The use of antifouling paints containing tributyl tin (TBT) would be prohibited in the marina. This would be made a condition of the lease for all boat repair facilities in the marina.

The discharge of sewage, hydrocarbons or litter from boats into the marina would be prohibited, and all users of the marina would be informed of this. Waste disposal facilities, including rubbish bins, oil recycling deposit bins and sewered toilets would be provided around the marina. A sewage pumpout facility would be provided for boats equipped with holding tanks.

The WSQMP will include a comprehensive fuel and oil spill response plan to ensure that appropriate equipment and trained personnel are available for emergency response, so as to minimise any impacts from any accidental spills in the waterway.

7.5.2 Maintenance of Navigability

As discussed in Section 6.3.2, sedimentation within the waterways is expected to be minimal. However, if maintenance dredging is ever required, the plans for dredging and disposal of dredged material would be referred to the DEP by the waterways manager prior to implementation.

7.6 Noise and Dust Control

Although the project construction will entail extensive site works, the potential for significant nuisance noise and dust during site development will be minimal due to the separation distance between the project area and the town site. Nevertheless, the possibility of residual dust and nuisance noise is recognised and will be managed to minimise the impact on the surrounding community.

Noise levels will comply with the most recent EPA Guidelines. The operation of heavy equipment will be restricted to daylight hours with all vehicles to be fitted with noise suppressing devices and comply with current vehicle emission and noise regulations.

Dust levels will be managed and monitored in compliance with the EPA's "Guidelines for Assessment and Control of Dust and Windborne Material for Land Development Sites". The guidelines provide a procedure by which to prevent and/or suppress excessive dust volumes leaving the site during and after the construction of the works.

The present concept plan does not anticipate the requirement for blasting (Halpern Glick Maunsell pers. comm. 1996). However, should blasting be required, operations would be publicised through the local media and be limited to between 9.00 am and 5.00 pm on weekdays.

7.7 Aboriginal Heritage

The proponent will ensure all contractors comply with the *Aboriginal Heritage Act, 1982-80*.. The Contractor shall report any archaeological sites discovered during construction, shall cease all work in the area of the site immediately upon discovery, and leave the site undisturbed until advised by the Western Australian Museum.

7.8 Contaminated Site Assessment

Prior to commencement of construction, the proponent will conduct a contaminated site assessment of the two disused rubbish tip sites, in accordance with the ANZECC & NHMRC guidelines for the assessment and management of contaminated sites.

Should the investigations indicate a significant level of residual contamination, the sites will be cleaned up to the standard determined by the above guidelines.

7.9 Waterways Management

7.9.1 Waterways Management Agreement

Prior to the commencement of construction, the proponent will secure legal agreement with the Shire of Exmouth and the DOT whereby the Shire will accept the future responsibilities as the Waterways Manager and otherwise, as defined in SPC Policy DC1.8. It is anticipated that the proponent will be responsible for all elements of waterways

management for an initial period, with the Shire of Exmouth accepting ongoing responsibilities as outlined in Section 4.9. To assist in financing future work requirements associated with these responsibilities, it is anticipated that the proponent could contribute "seed" funding then the Shire will impose a "specified area" rating upon landholders. This will be accomplished so that there will be no impact on the existing ratepayers in the Shire of Exmouth.

7.9.2 Waterways Maintenance

The Waterways Manager (the proponent for an initial agreed period, then the Shire of Exmouth, subject to agreement) will maintain the canals and entrance channel depth to ensure adequate flushing and safe navigable depths. Depths will be monitored annually for the first five years, then as considered appropriate by the Shire of Exmouth, in consultation with DOT. Should dredging be required, the Waterways Manager will submit plans for dredging and disposal of dredged material to DEP for approval prior to their implementation.

8.0 SUMMARY OF COMMITMENTS

The principal project design and environmental management commitments given by the proponent in this PER are as follows:

1. The project design will incorporate adequate provision for drainage and flood control, meeting the objectives and specifications outlined in Section 7.2 of the PER. The preparation and implementation of the drainage design will be occur in consultation with the WRC and the Shire of Exmouth.

2. Prior to construction, the proponent will prepare a foreshore reserve management plan meeting the objectives and specifications outlined in Section 7.3 of the PER in consultation with the MFP, CALM and the Shire of Exmouth. The proponent will implement the plan during the construction phase construction (including demarcation of the sand dunes with temporary fencing during construction to prevent encroachment into the dune areas) and conduct regular monitoring and maintenance of the foreshore reserve for an agreed period to be specified in the plan, prior to management by the Shire of Exmouth.

3. Prior to construction, the proponent will prepare a groundwater management and monitoring program meeting the objectives and specifications outlined in Section 7.4 of the PER, in consultation with the WA Museum. The proponent will implement the groundwater management and monitoring plan prior to, during and for one year following the construction of the marina and waterways.

4. Prior to construction, the proponent will prepare a dewatering management plan to ensure minimal turbid water discharge, in accordance with WRC guidelines, in consultation with DOT and the WRC, to be implemented during the construction phase.

5. Should disposal of dredge spoil or excess excavation material outside of the project area be required, the proponent will prepare and implement a dredge spoil management plan in accordance with WRC guidelines, in consultation with DOT and WRC.

6. Prior to construction, the proponent will prepare a water and sediment quality

monitoring program (WSQMP) for the inner marina and canal waterways, meeting the objectives and specifications outlined in Section 7.5.1 of the PER, in consultation with DOT and the Shire of Exmouth. The WSQMP will be implimented by a waterways manager, to be agreed with the Shire of Exmouth, during the preparation of the program.

7. Prior to construction, the proponent will conduct a contaminated site assessment of the two disused rubbish tip sites, in accordance with the ANZECC & NHMRC guidelines for the assessment and management of contaminated sites, in consultation with the DEP. During construction, the proponent will implement any recommendations arising from the contaminated site assessment.

8. During construction, dust emissions from the project area during construction activities will be managed and monitored in compliance with the EPA's Guidelines for Assessment and Control of Dust and Windborne Material from Land Development Sites", upon advice from the Shire of Exmouth.

9. Prior to completion of construction of the marina and waterways, the proponent will enter into an agreement with the Shire of Exmouth and DOT which clearly delineates responsibilities for the physical maintenance and management of the waterways.

10. For and initial agreed period following construction, then subject to the agreement with the Shire of Exmouth, the proponent will annually monitor the depths of the canals and the entrance channel to ensure safe navigable depths, upon advice from the DOT and Shire of Exmouth. If and when required, the proponent (or the Shire of Exmouth subject to agreement) will submit plans for dredging and disposal of dredged material to the DEP for approval prior to their implementation.

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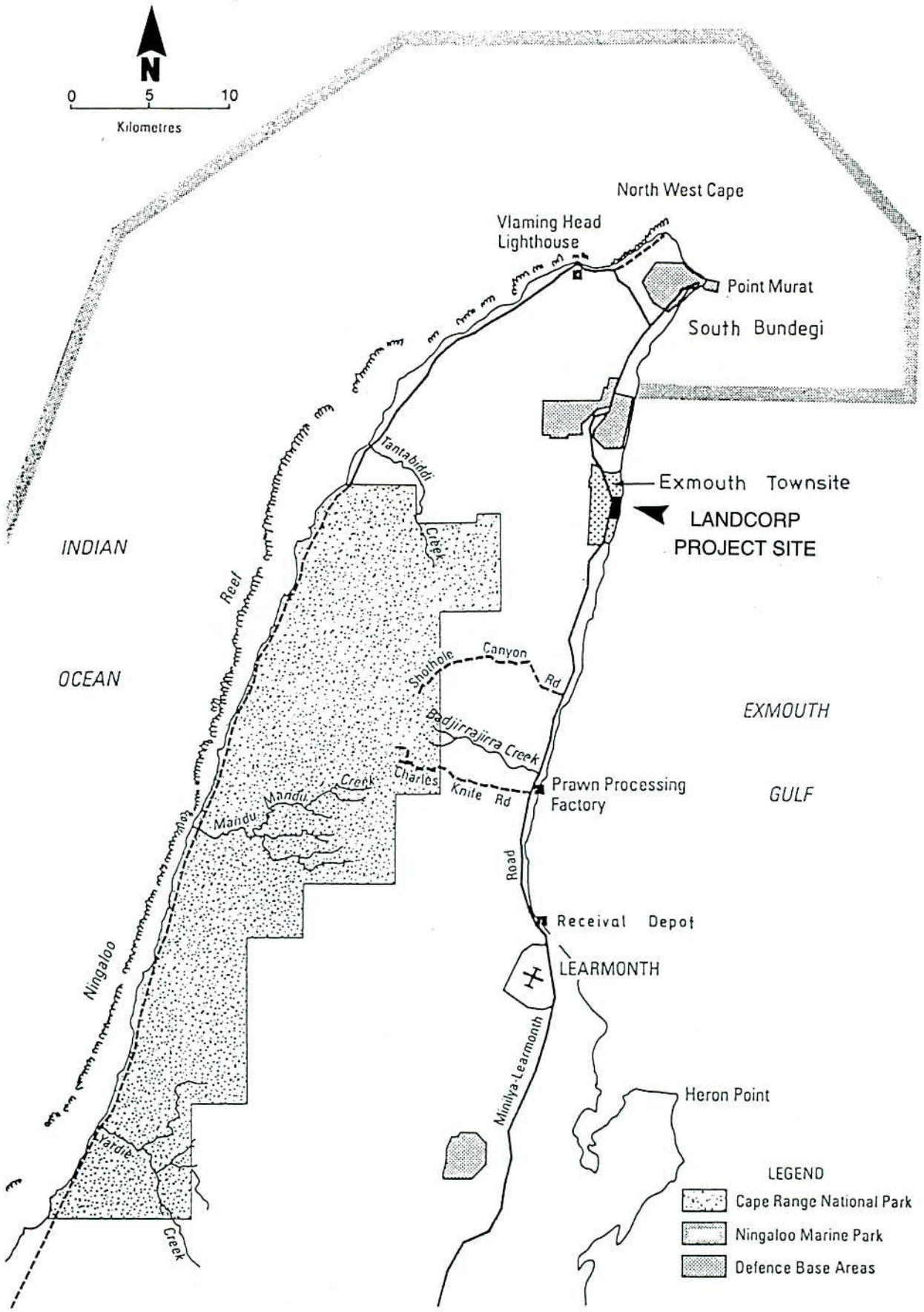
FIGURES



Location

Figure 1

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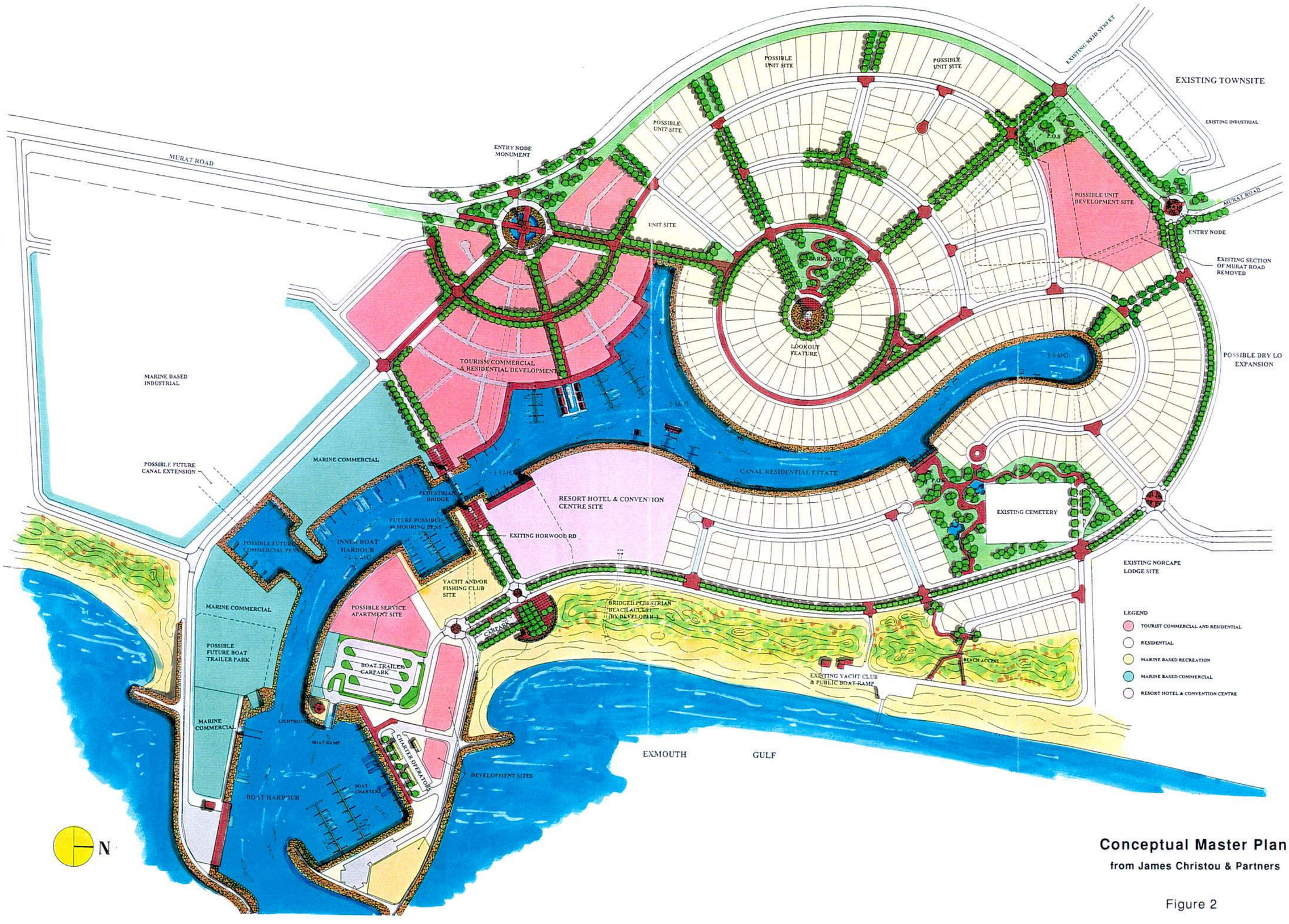

Conceptual Master Plan

from James Christou & Partners

Figure 2

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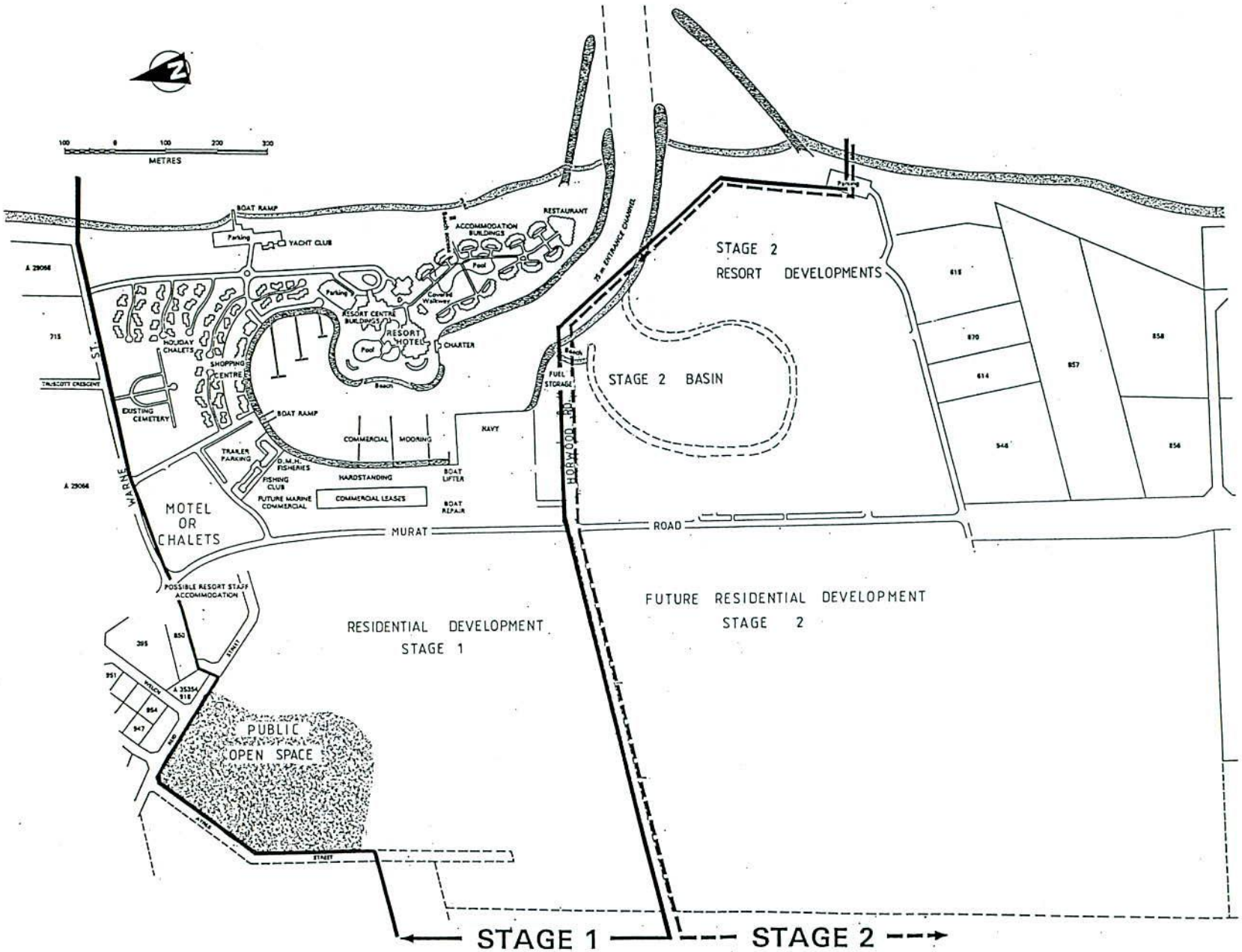

Layout of approved "Coral Coast Marina" project (1992)

Figure 3

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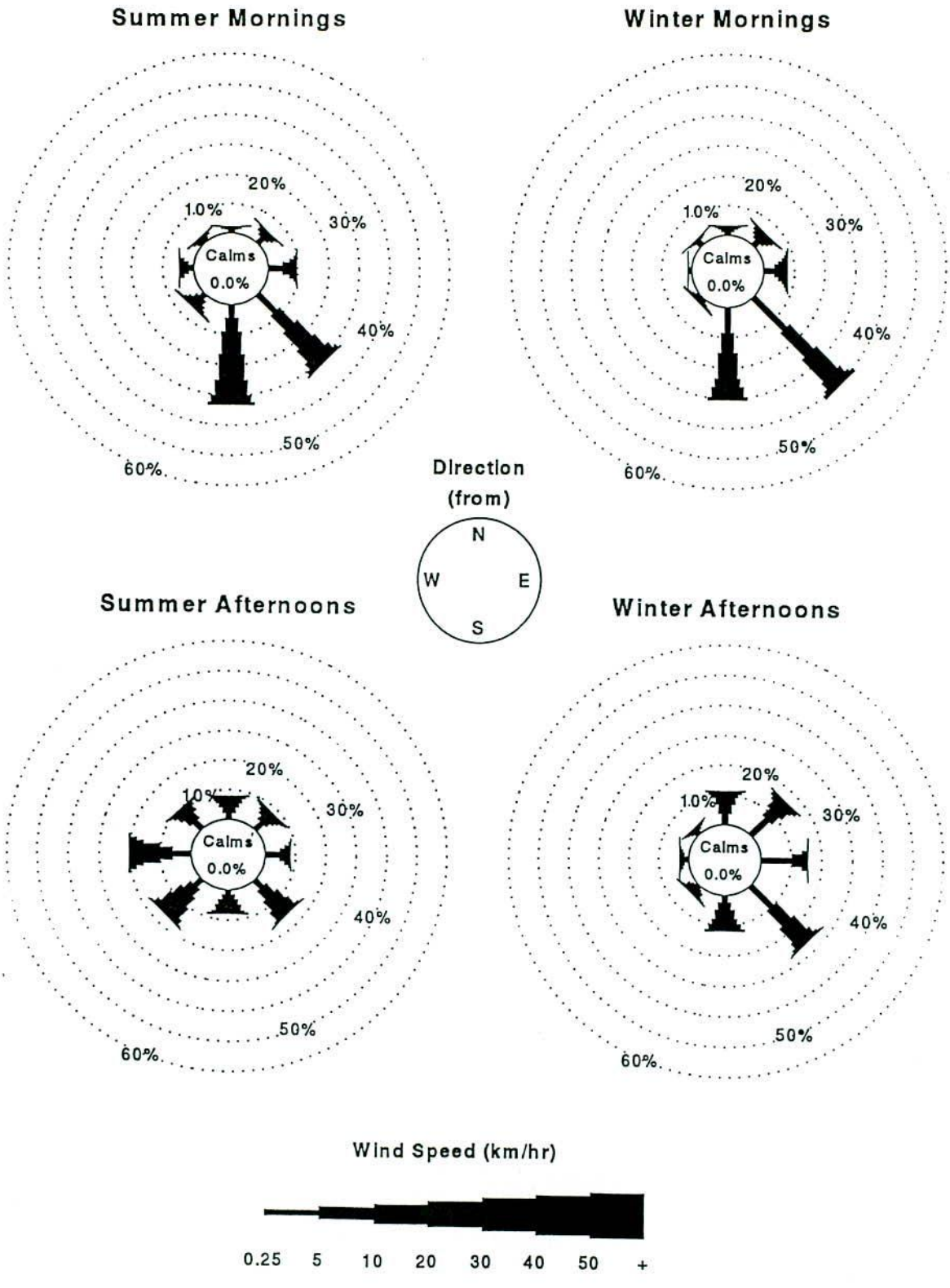

Exmouth Wind Roses
from MP Rogers & Associates 1996

Figure 4

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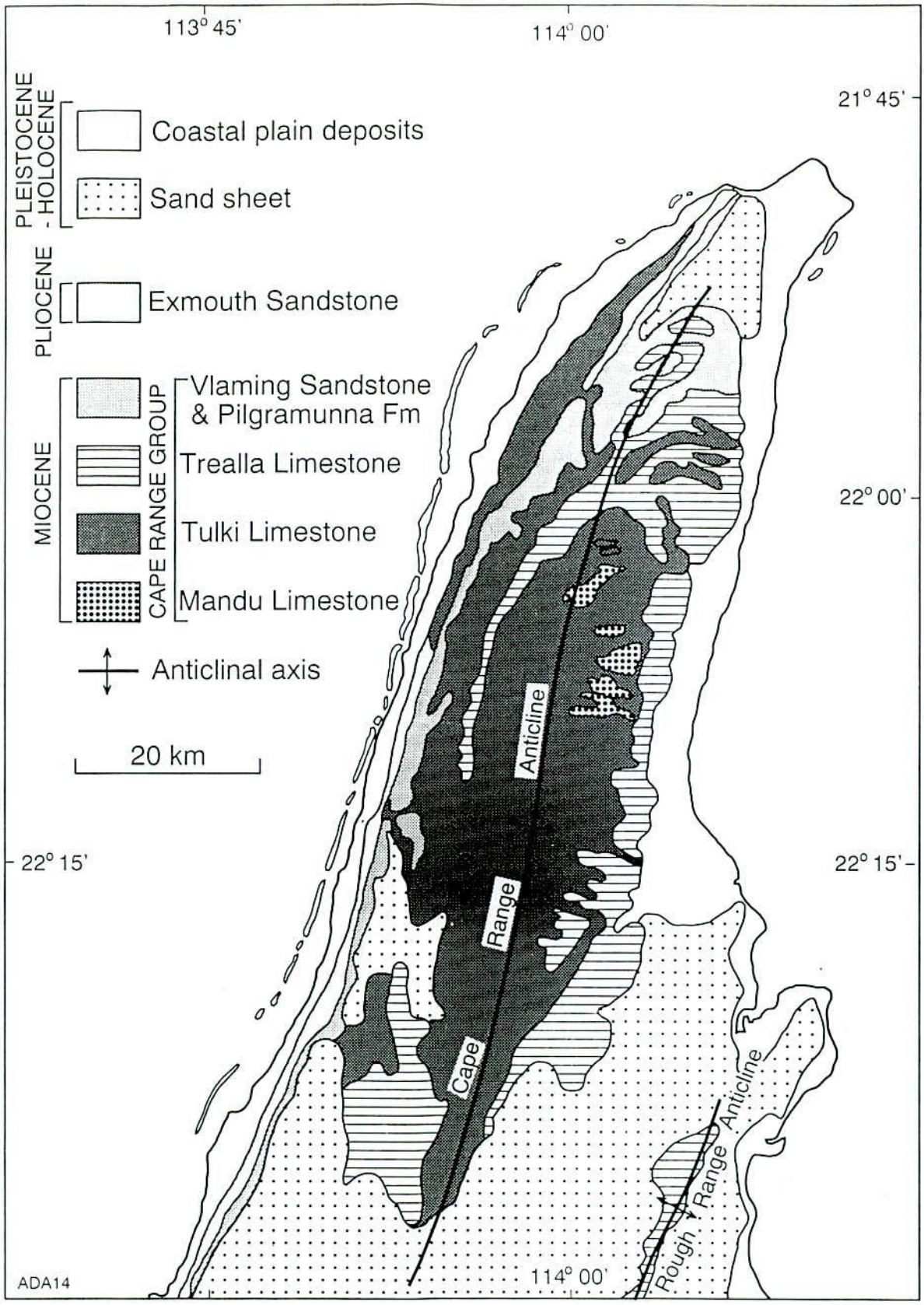
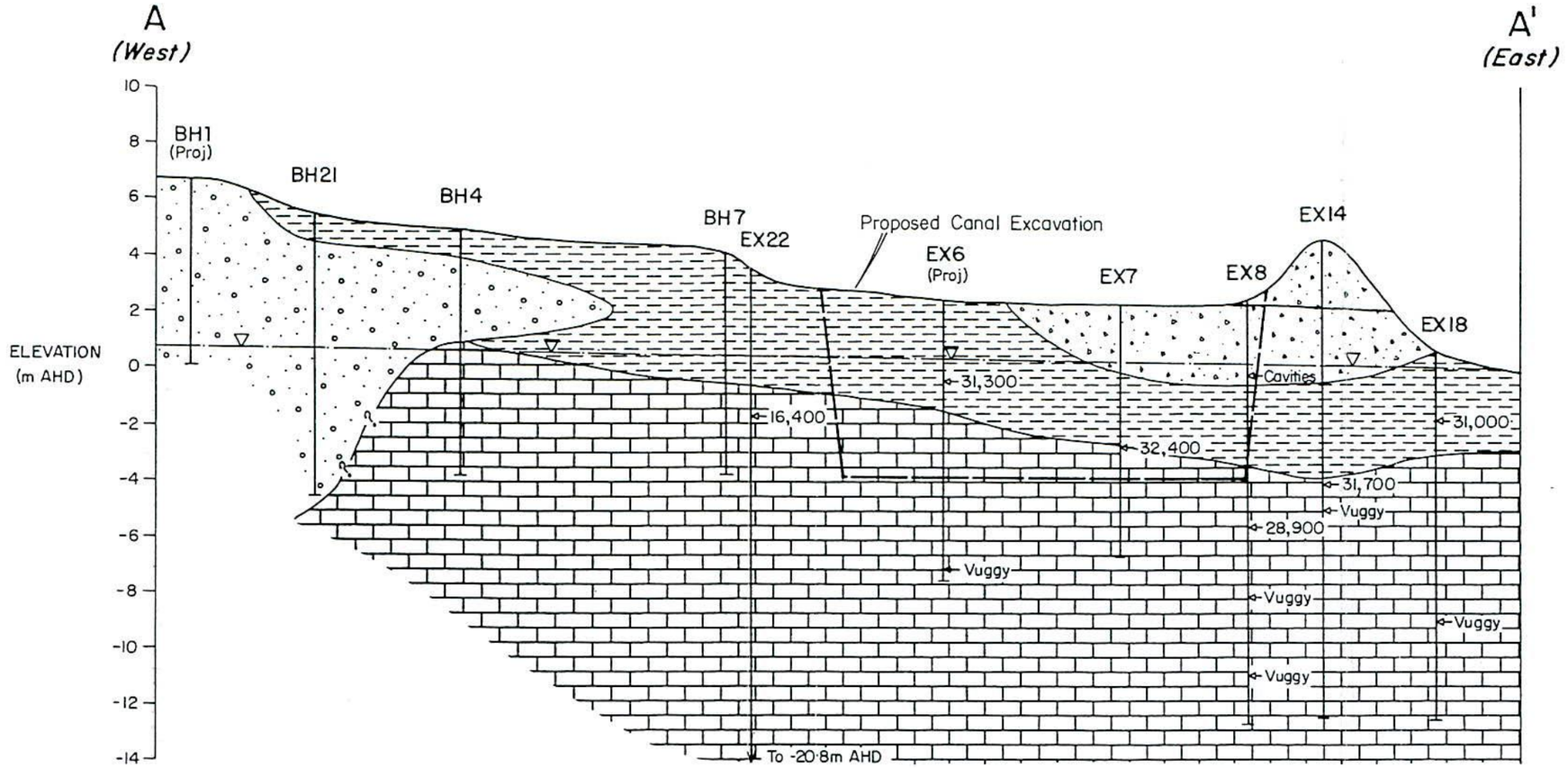


Geology of Cape Range

from Allen 1993

Figure 5



LEGEND

- Sand, some gravel (shells, coral and limestone) - beach deposit and coastal dunes
- Clay, silty clay with limestone, coral and shell fragments
- Mowbowra Conglomerate Member ? (Bundera Calcarenite) Calcareous sandy conglomerate
- Bundera Calcarenite (undifferentiated) Calcarenite to calcirudite with common pebbles, coralgal reef material and shells
- Water table
- 28,900 Groundwater salinity (mg/L TDS)

0 100 200
METRES

(20x Vertical Exaggeration)

Hydrologeological cross-section of site

from Rockwater 1996

Figure 6

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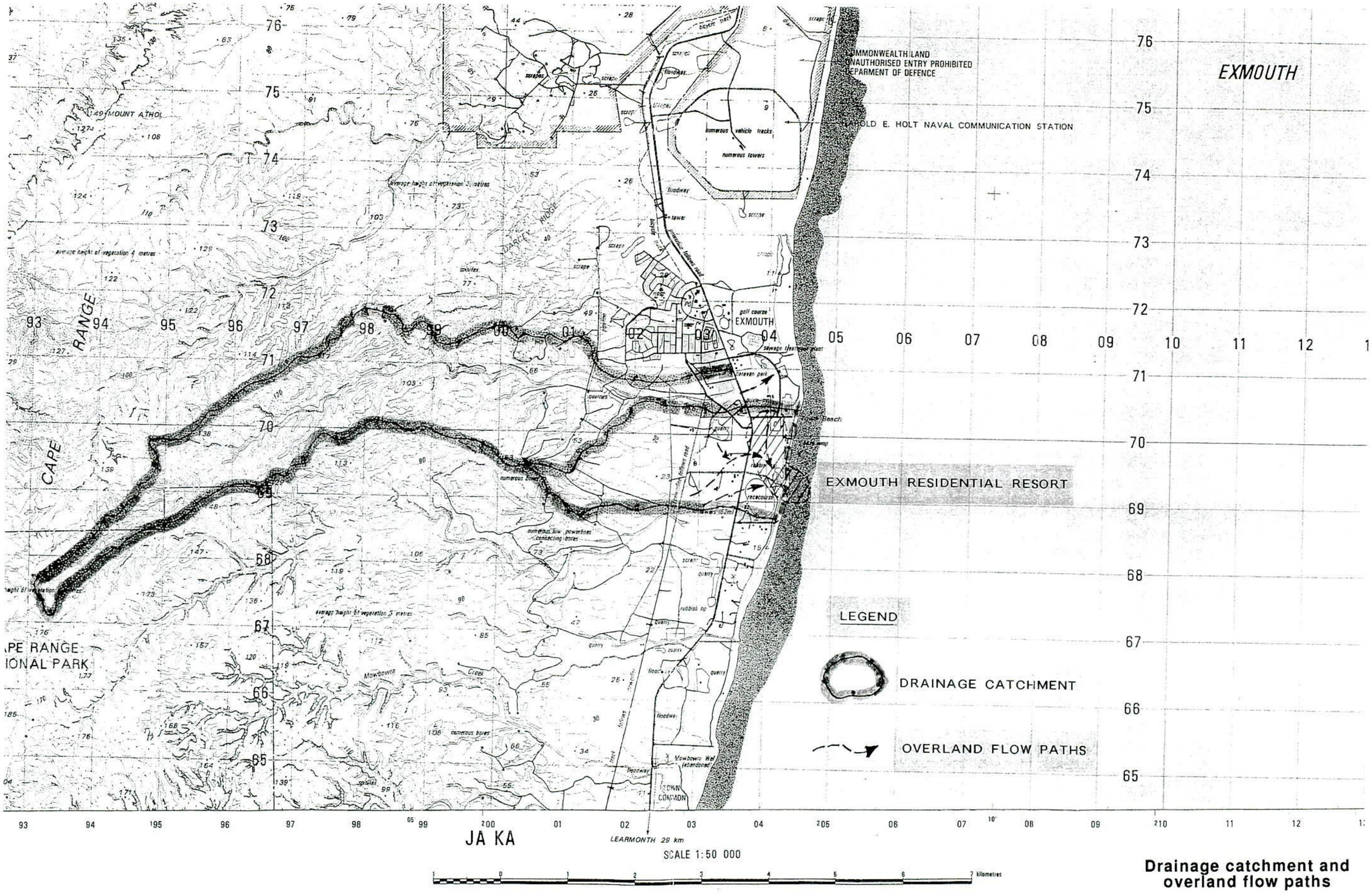

Drainage catchment and overland flow paths

from Ewing Consulting Engineers 1996

Figure 7

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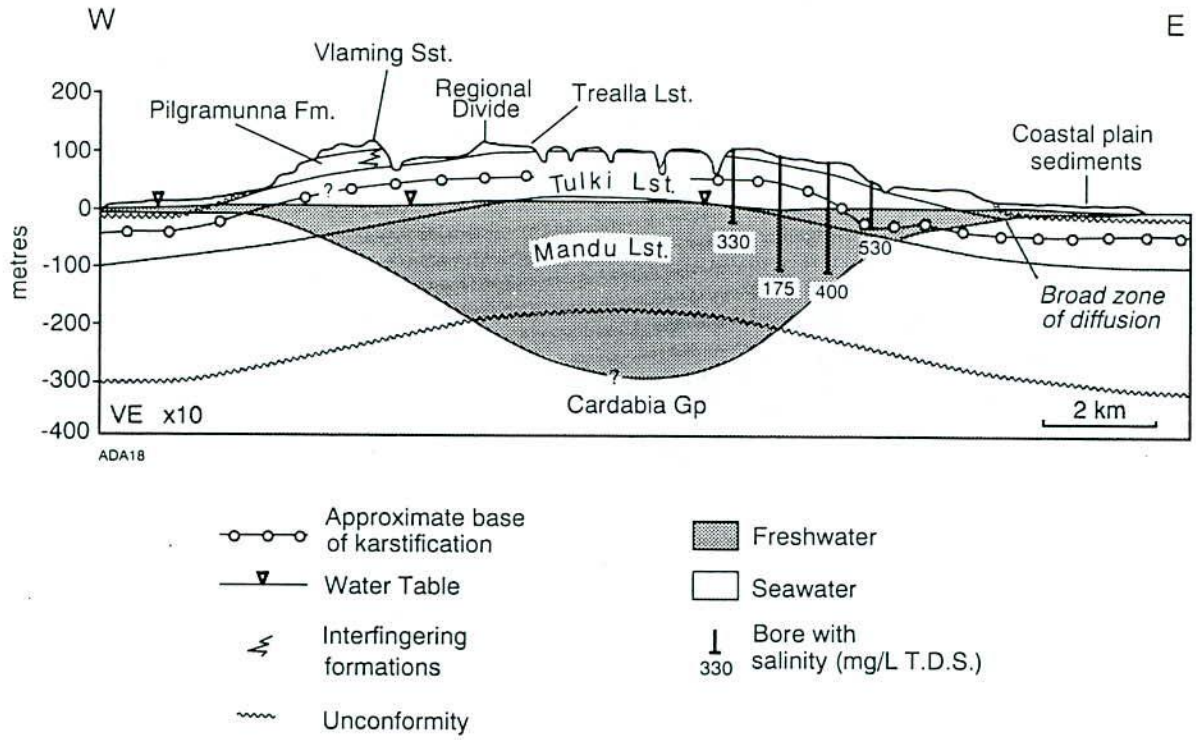
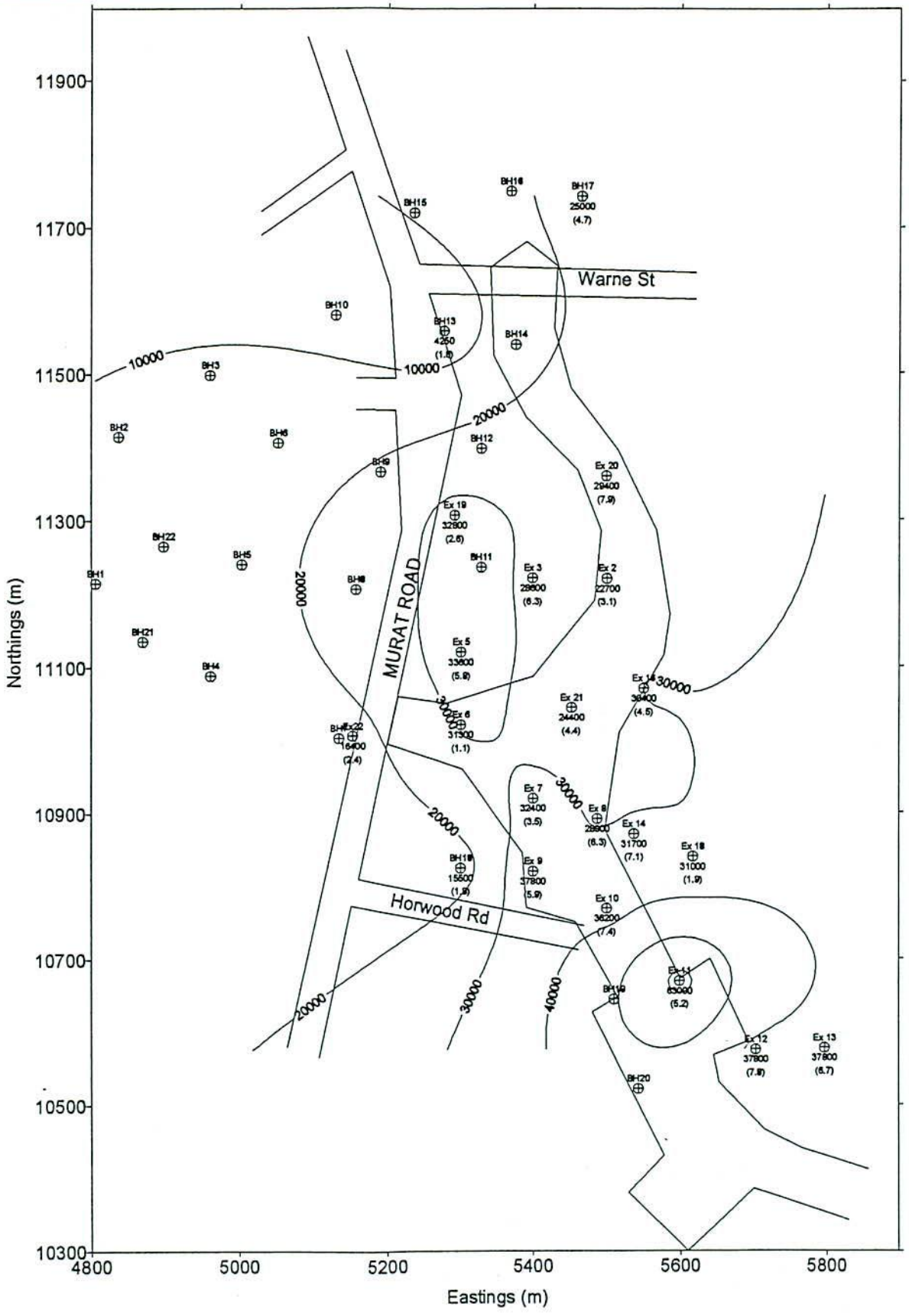


General Hydrogeological cross-section of the Exmouth groundwater area

from Martin 1990

Figure 8



(7.4) Sample depth, metres below water table

Groundwater salinity (mg/LTSS) near top of aquifer

from Rockwater 1996

Figure 9

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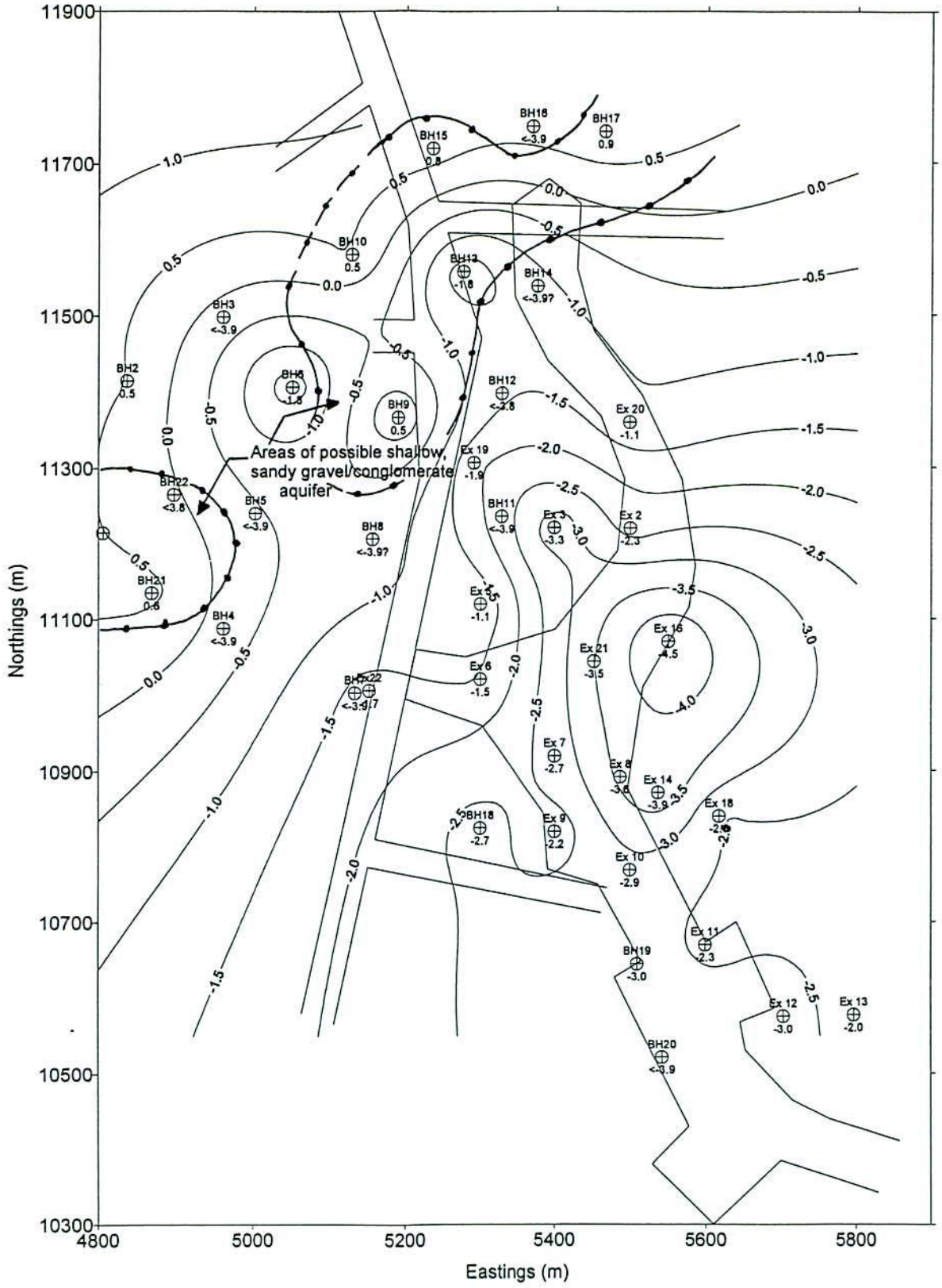
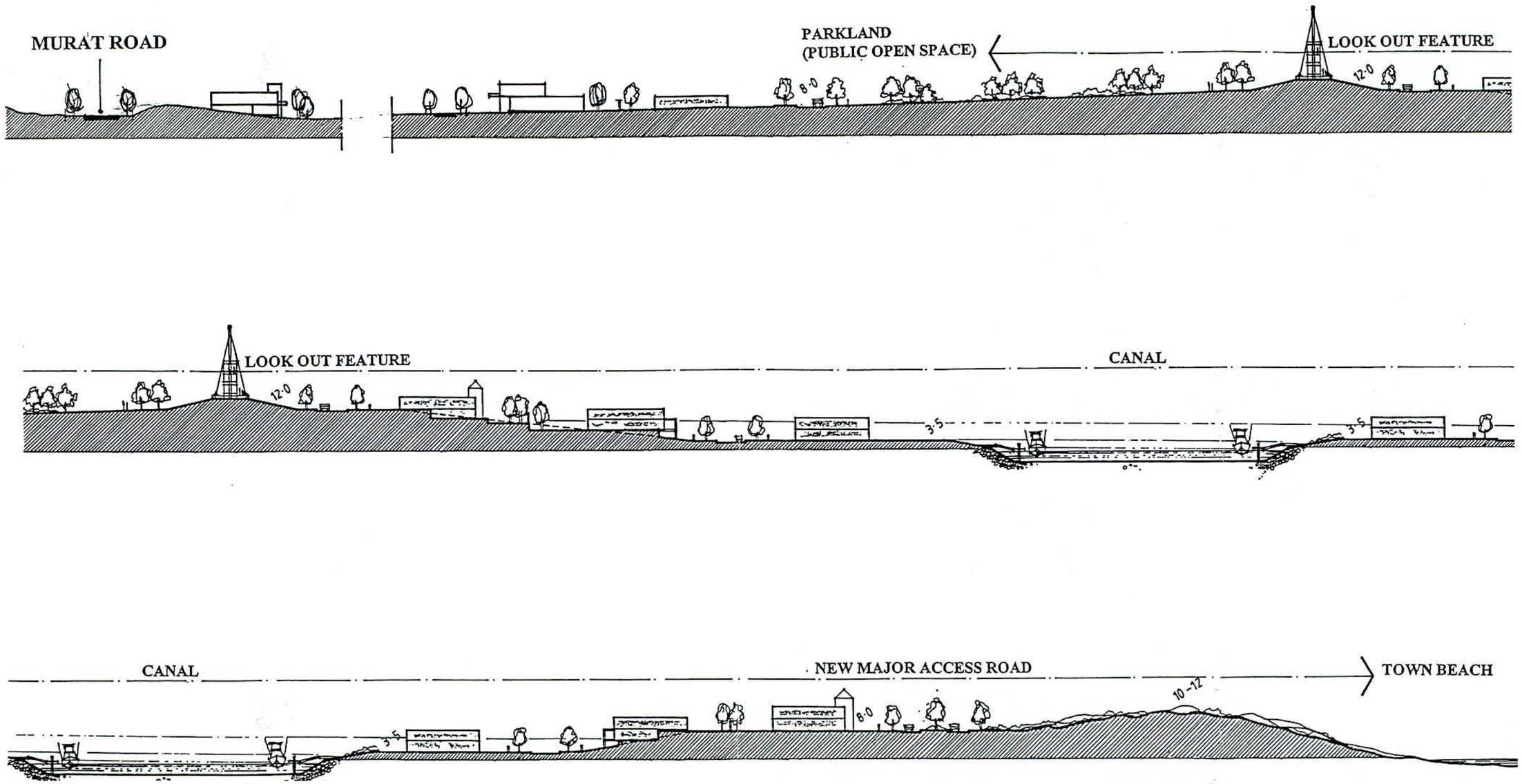


Elevation (mAHD) of Top of Main Aquifer

from Rockwater 1996

Figure 10



Typical Canal Cross Section

from James Christou & Partners 1996

Figure 11

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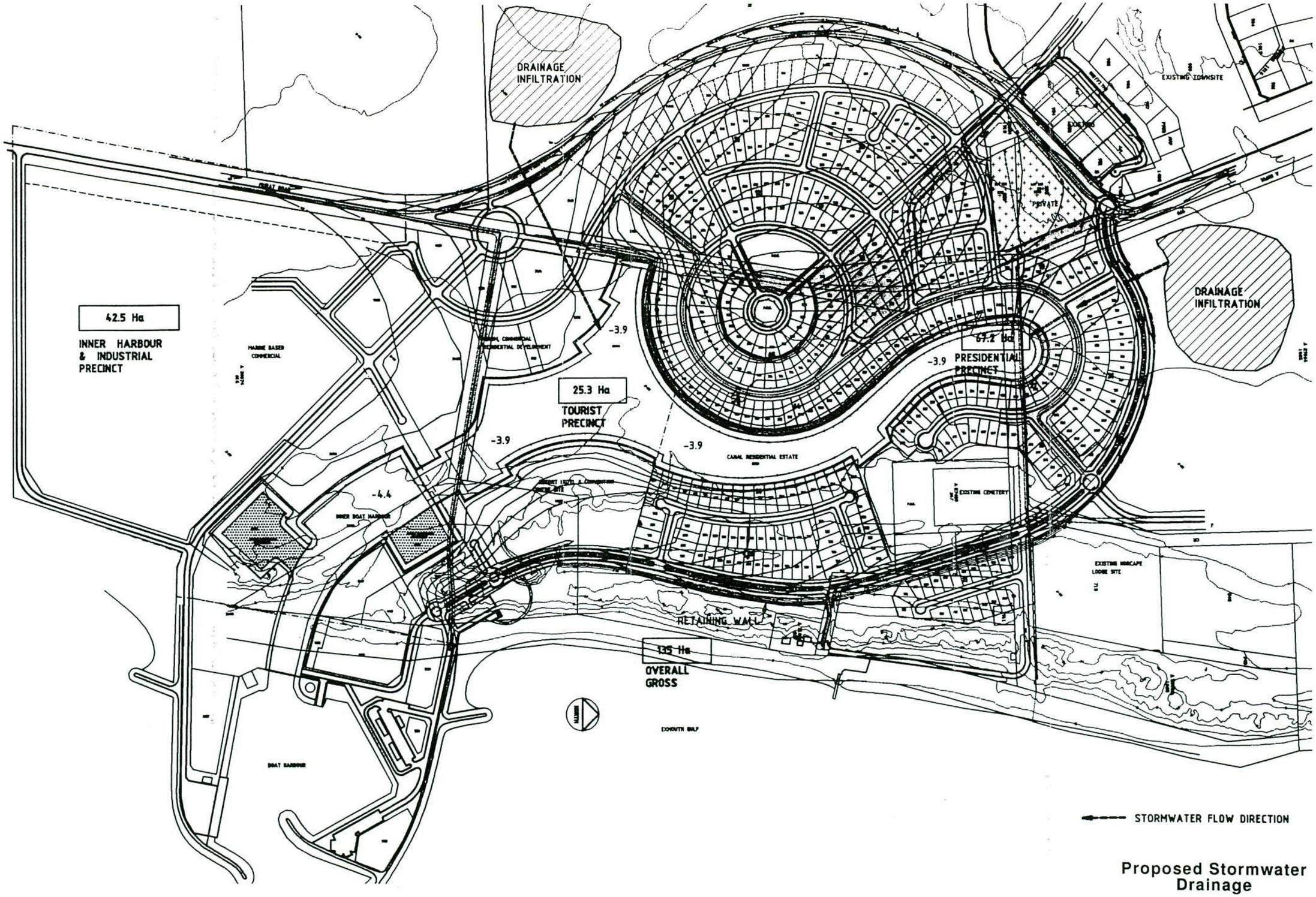
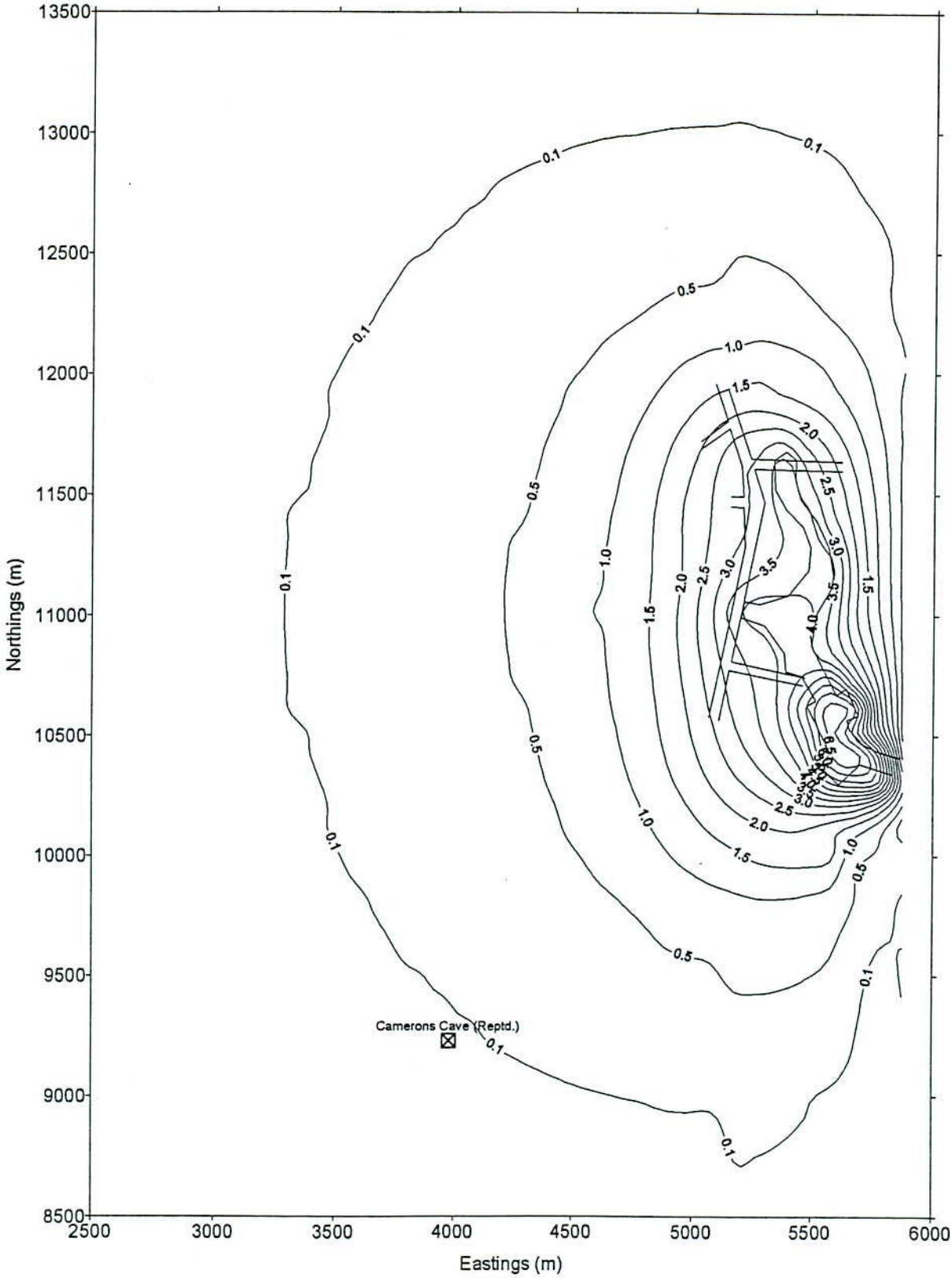
BBG97021



Proposed Stormwater Drainage

from Ewing Consulting Engineers 1996

Figure 12



Modelled Groundwater Drawdown after 180 days

from Rockwater 1996

Figure 13

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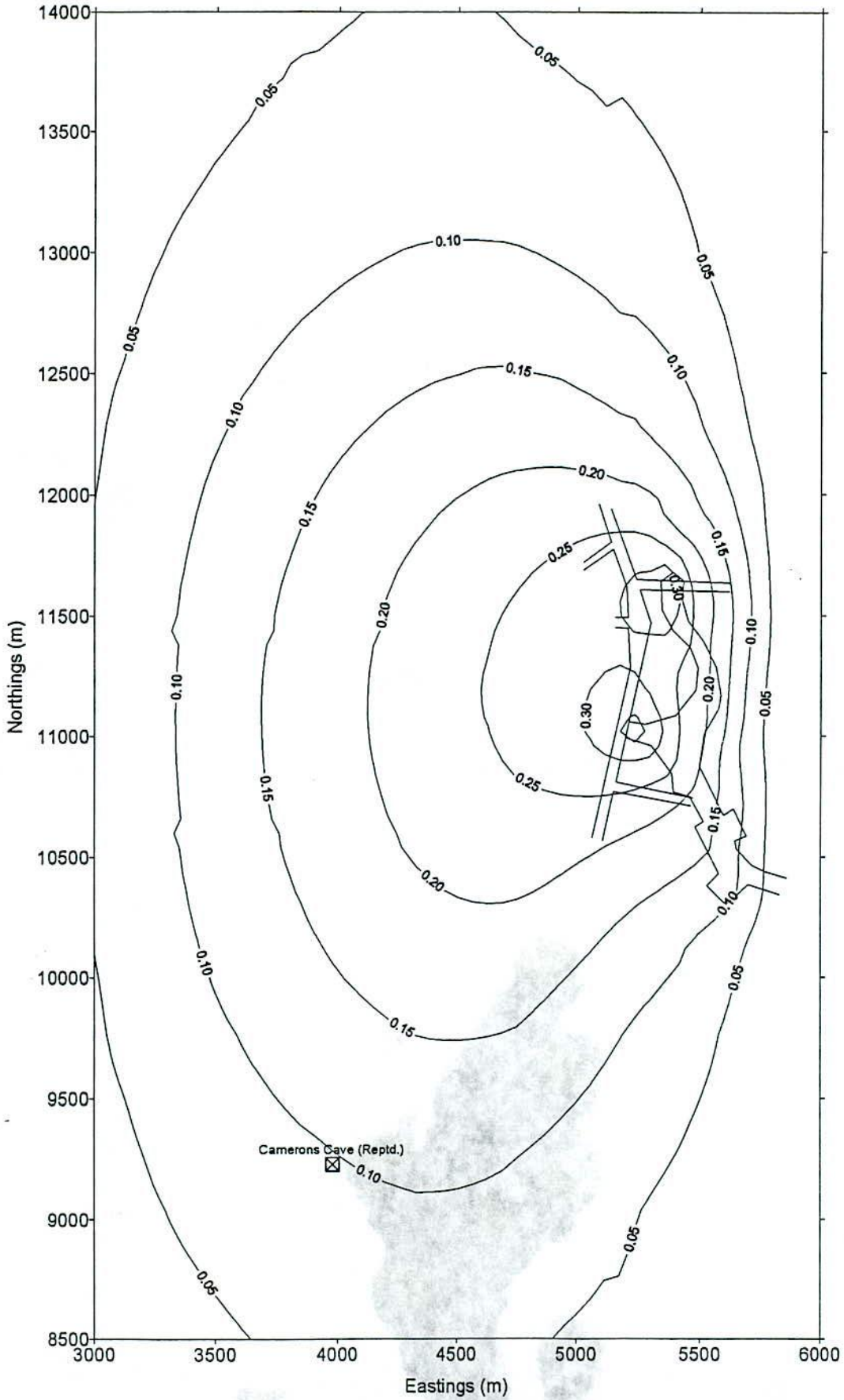

Model-Calculated Residual Drawdown One Year after Canal/Harbour Construction

from Rockwater 1996

Figure 14