MINISTER FOR RESOURCES DEVELOPMENT

OAKAJEE DEEPWATER PORT
PUBLIC ENVIRONMENTAL REVIEW

N TINGAY & ASSOCIATES
and
VIRONMENTAL CONSULTANCY

MAY 1997

MINISTER FOR RESOURCES DEVELOPMENT

OAKAJEE DEEPWATER PORT
PUBLIC ENVIRONMENTAL REVIEW

ALAN TINGAY & ASSOCIATES
and
WELKER ENVIRONMENTAL CONSULTANCY

MAY 1997

REPORT NO: 96/93

AN INVITATION TO COMMENT ON THIS PUBLIC ENVIRONMENTAL REVIEW

This Public Environmental Review (PER) proposes the establishment of a deepwater port adjacent to the proposed Oakajee Industrial Estate, north of Geraldton.

The PER has been prepared to describe this proposal and its likely effect on the environment in accordance with the requirements of the Environmental Protection Act, 1986.

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

The PER is available for public review for four weeks from 12 May, 1997 to 9 June, 1997.

After receipt of comments from Government agencies and from the public the EPA will prepare an Assessment Report with recommendations to the Government, taking into account issues raised in public submissions.

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 documents and may be quoted in full or in part in each report unless specifically marked confidential.

Submissions may be fully or partially utilised in compiling a summary of the issues raised or where complex or technical issues are raised, a confidential copy of the submission (or part of it) may be sent to the proponent.

The summary of issues is normally included in the EPA's Assessment Report.

Why not join a group?

If you prefer not to write your own comments, it may be worthwhile joining a group or other groups interested in making a submission on similar issues.

Joint submissions may help to reduce the work for an individual or group, while increasing the pool of ideas and information.

If you form a small group (up to ten 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 items in the review document:

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

Points to keep in mind

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

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

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

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

Remember to include:

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

The closing date for submissions is:

Monday, 9 June 1997.

Submissions should be addressed to:

Environmental Protection Authority
8th Floor, Westralia Square
141 St George's Tce
PERTH WA 6000

Attention: Ms Eve Bunbury

DISCLAIMER

This report has been prepared on behalf of and for the exclusive use of the client, and is subject to and issued in accordance with the agreement between the client and Alan Tingay & Associates. Alan Tingay & Associates accepts no liability or responsibility whatsoever for it in respect of any use of or reliance upon this report by any third party.

Copying of this report without the permission of the client or Alan Tingay & Associates is not permitted.

As part of our Quality System, documents are checked then approved prior to distribution.

Document Reference:	TS536 - Report No. 96/93
Project Number:	A96127
Draft:	Final
Checked:	T. Sewell
Approved:	A. Tingay AT.
Date:	7/05/97

TABLE OF CONTENTS

Cover Photograph: Cover photograph kindly supplied by the Geraldton Port Authority

LIST OF FIGURES

LIST OF APPENDICES

SUMMARY

1. The Deepwater Port Proposal

This Public Environmental Review (PER) provides a description and analysis of the environmental implications of a proposal by the Government of Western Australia, through the Minister for Resources Development as proponent, to establish a deepwater port at Oakajee. The port will be located approximately 23km to the north of the City of Geraldton in the Mid West Region of Western Australia, and will be adjacent to a proposed industrial estate.

During the preparation of this PER, the Minister for the Environment sought early environmental advice from the Environmental Protection Authority (EPA) pursuant to Section 16(e) of the Environmental Protection Act, 1986 on the development of a port at Oakajee. As this advice was required prior to the finalisation of the formal approval process for this PER, the Department of Resources Development (DRD) commissioned the preparation of a separate environmental document on the port proposal.

The initial environmental review was a strategic assessment based on existing information and did not necessarily detail environmental management strategies which are addressed fully in this PER.

The EPA has recently considered the initial environmental review under Section 16(e) of the Environmental Protection Act, 1986 (as amended). This advice, which has recently been published (EPA, 1997), advised that "The EPA has made a number of recommendations for management and further studies... If these measures are implemented, and subject to study results, implementation of the port concept is capable of being managed so as not to compromise the EPA's objectives." This PER takes into consideration the recommendations of the EPA's Section 16(e) assessment.

The feasibility of siting two major industries within the Oakajee Industrial Estate is currently being assessed. These are the Geraldton Steel Plant (GSP) (a component of the Mid West Iron & Steel Project) which will produce 2.4 million tonnes of steel each year and a hot briquetted iron (HBI) plant which will produce 2.1 million tonnes of HBI each year. The port will serve both of these export industries and will provide the capacity to fully load 65,000 DWT ships. In comparison, ships only up to about 30,000 to 35,000 DWT can be loaded at the existing port of Geraldton. It is expected that future industries serving the Mid West Region or based on resources in that region, which involve large scale exports or imports or other requirements which cannot be met at the Port of Geraldton also will be located at Oakajee.

The detailed design of the deepwater port and final location at Oakajee has not been determined at this stage and is the subject of ongoing specialist engineering studies. However, the preferred port option is for an inshore port. Therefore, the proponent is seeking environmental approval to construct the port within a defined area.

This area, referred to as the Port Location Area extends from approximately 1km north of the Buller River to just north of the Oakajee River and west from the boundary of the industrial estate extending to about 3km offshore. It is emphasised that the port and associated facilities will occupy only a portion of this area.

In order to facilitate the assessment of the potential impacts of the port, the Port Location Area has been divided into three separate sectors; central, northern and southern. The port will be located in one of these sectors, or in a portion of two adjacent sectors. The final port location will not be determined until further geotechnical studies and detailed design work have been completed.

2. Environmental Implications

2.1 Relevant Factors

The Environmental Protection Authority (EPA), in its guidelines for this PER, has defined a series of relevant factors which it considers are particularly important for its assessment of the Oakajee Deepwater Port proposal. Relevant environmental factors are defined as those which have the potential to have significant environmental impacts and which the EPA therefore may be required to report on to the Minister for the Environment. The EPA also has provided objectives applying to each of the relevant factors.

The implications of the deepwater port proposal for each of the relevant factors is summarised in Table A and is described below.

2.2 Marine Environment

For the purposes of assessment it is assumed that the entire block of marine habitat encompassed by the port could be altered or modified. The total sea floor area where habitat may be directly impacted is approximately 170ha. However, the extent of impact on marine habitats varies from sector to sector according to the proportion of habitat within each sector. The greatest impact on marine habitats is likely to occur in the central and southern sectors, with the least impact occurring in the northern sector.

The high reef supports diverse biota including reef fish and is an important habitat for rock lobsters. The shallow limestone platform supports less biota and is colonised by algae and kelp but is a habitat for the rock lobster. The deep limestone platform in comparison is virtually devoid of biota.

All of these marine habitats and their associated biota are typical in waters of equivalent depth in the Geraldton region and generally in south-western Western Australia.

TABLE A

SUMMARY OF THE ENVIRONMENTAL FACTORS AND POTENTIAL MANAGEMENT

RELEVANT FACTOR	EPA OBJECTIVE	EXISTING ENVIRONMENT	POTENTIAL IMPACT	POTENTIAL MANAGEMENT	PREDICTED OUTCOMES
BIOPHYSICAL					
Marine					
Marine Fauna	To maintain the abundance, species diversity and geographic distribution of marine fauna.	Marine habitat is similar to that recorded elsewhere along the western coast down to Perth.	A maximum of 170ha of shallow and deep reef, sand and limestone pavement habitat may be affected. The greater proportion of impact will occur from the shoreline out to the 10m depth contour.	Not Applicable.	No significant impact on habitat or fauna.
Seagrass	To maintain the abundance, species diversity and geographic distribution of seagrass.	No seagrass meadows on the site. Seagrasses occur in association with algae in patches on low reefs and limestone pavements in shallow waters.	No seagrass meadows will be removed. Some seagrasses in association with algae will be removed. The amount removed will vary according to the sector in which the port is located but will not exceed 80ha.	Not Applicable.	No seagrass meadows will be impacted. No significant impact on seagrasses/algae communities.
Macroalgae	To minimise interference with the process of nutrient and carbon cycling from beach-cast seaweed.	Substantial amounts of seaweed accumulate on local beaches which may be significant sources of nutrients and carbon for nearshore ecosystems.	The distribution of seaweed on local beaches may be impacted However, nutrients and carbon will remain in the ecosystem. Accumulation of seaweed can give rise to offensive odours.	Potential management may include mechanical relocation of macroalgae onto beaches or into the littoral stream. Accumulation of macroalgae around the port will be monitored. Design options to reduce disruption of the macroalgal drift and sediment transport will be considered at the detailed design stage. Monitoring of macroalgae accumulation and nutrients	Distribution of beach-cast macroalgae on nearby beaches may be altered. Minor changes in the productivity of near shore areas may occur. No offensive odour situations are anticipated.
Threatened and priority marine fauna	To protect threatened and priority marine fauna consistent with the provisions of the Wildlife Conservation Act, 1950.	Some specially protected fauna migrate or visit the area. The low water temperature discourage the presence of dugongs.	Construction of port may interfere with migration and feeding areas of protected fauna.		No significant impact on the migration or food sources of protected fauna.
Introduced marine organisms	To minimise the risk of introduction of unwanted, non-indigenous marine organisms.	No introduced organisms observed to date.	Risk of ballast water and hulls of vessels introducing exotic marine organisms.	Application of Australian Ballast Water Management Strategy. Continuing research on introduced marine organisms. Monitoring for introduced species.	Risk of introduction of exotic marine organisms is minimised.
Coastal					
Shoreline	To maintain the stability of beaches.	Beaches are subject to accretion or erosion. The coast is regarded as a high energy environment. Net longshore sediment transport is small. Further studies are underway to further define shoreline movement and sediment transport.	Construction of the port may interfere with sand movement along the coast. This may potentially affect nearby beaches.	Investigation of shoreline movement and ocean circulation. Investigation of design options to minimise sand build up. Sand by-passing as required. Monitor beach erosion/accretion and sand accumulation at breakwaters.	No significant impact on beaches.
Terrestrial					
Vegetation Communities	To maintain the abundance, species diversity, geographic distribution and productivity of vegetation communities.	No regionally significant vegetation occurs on site. Low risk of dieback spread.	Construction of the onshore storage facilities will impact on up to 50ha of coastal vegetation. A 100m wide services corridor will be constructed between the industrial estate and the port. The actual impact will vary according to which sector the port is located in.	Rehabilitation procedure to include use of endemic species. Weed control. A spring flora survey will be undertaken in spring of 1997.	No significant impact on vegetation communities.
Rare and priority flora	To protect declared rare and priority flora consistent with the provisions of the Wildlife Conservation Act, 1950.	No declared rare or priority flora have been recorded on site.	No impact.	Further field studies.	No impact on declared rare or priority flora.
Terrestrial Fauna	To maintain the abundance, species diversity and geographic distribution of fauna.	No significant fauna occur on site. Habitat is fragmented and has been disturbed.	See Vegetation Communities.	See Vegetation Communities.	No impact on significant fauna.
Threatened and Priority Fauna	To protect threatened and priority fauna consistent with the provisions of the Wildlife Conservation Act, 1950.	No endangered or rare faunal species are likely to occur on the site.	No impact.	Not Applicable.	No impact on threatened or priority fauna.

RELEVANT FACTOR	EPA OBJECTIVE	EXISTING ENVIRONMENT	POTENTIAL IMPACT	POTENTIAL MANAGEMENT	PREDICTED OUTCOMES
POLLUTION					
Marine water and sediment quality	To maintain water and sediment quality to protect environmental values of recreation, aesthetics, aquatic life for human consumption and maintenance of ecosystems in agreed areas.	Marine water quality is near pristine but high turbidity levels are common. Sediment quality is affected by Oakajee and Buller Rivers but sediment from this source is unlikely to be significantly contaminated.	Water quality may be potentially affected by oil spills, accidental waste discharges from ships, turbidity from dredging and breakwater construction. Sediments in the harbour and shipping areas may become contaminated by tributyl tin and zinc. The offshore harbour option is expected to have better flushing characteristics.	Disposal of wastes at a suitable onshore site. Development of marine management plan with reference to the EPA's environmental quality objectives and criteria as appropriate and management of TBT accumulations and the ANZECC Australian Water Quality Guidelines for fresh and marine waters. Development of management plans for oil spills, accidental spillage, and dredging and reclamation activities. Preparation of water and sediment quality management and monitoring programs.	Risk of water and sediment contamination is minimised.
Dust	To protect the surrounding land users such that dust emissions will not adversely impact upon their welfare and amenity or cause health problems and meet EPA Guidelines for Assessment and Control Of Dust and Windborne Material from Land Development Sites (updated 1995), and the Environmental Protection Policy (Atmospheric Wastes) (Kwinana).	The closest residence to the port is approximately 4km away.	The distance of the port from residences and the application of best management practices during construction and operation should mitigate against adverse impacts on amenity or health.	All construction work will be in accordance with the EPA Guidelines for Assessment and Control Of Dust and Windborne Material from Land Development Sites (updated 1995). Dust from port operations is dependant upon the materials shipped, and will be minimised through best management practice procedures.	Adverse impacts from the port are unlikely given the location of the nearest residences.
Noise and vibration	To protect the amenity of nearby residents from noise and vibration impacts by ensuring noise and vibration meet criteria in the Noise Abatement (Neighbourhood Annoyance) Regulation 1979, and the proposed Environmental Protection (Noise) Regulations (when promulgated).	The closest residence to the port is approximately 4km away.	The distance of the port from nearby residences, and also the application of best management practices should mitigate against any adverse impacts on amenity.	Application of noise suppression techniques, where applicable. The port will meet the requirements of the Noise Abatement (Neighbourhood Annoyance) Regulations, 1979 and the proposed Environmental Protection (Noise) Regulations when promulgated.	Adverse impacts from the port are unlikely given locational advantages and application of best practice environmental management.
SOCIAL SURROUNDINGS					
Public health and safety	To ensure risk is as low as reasonably achievable and complies with acceptable standards **(eg. Bulletins 611, 627 & 730)**.	Closest residence will be approximately 4km. The nearest residential area is at Drummonds Cove, approximately 6 km to the south. The highest level of recreation in the area is at Coronation Beach, approximately 3 km to the north.	Short to medium term port activity poses no hazard to present recreational uses. The shipment of hazardous material cannot be determined at this stage. Restriction on public access in the vicinity of the port will be determined following a full risk assessment.	Proposals will be evaluated by DOME, DOT and DEP to establish potential risks. Preparation of emergency response plans. Preparation of port safety plan with community review.	No unacceptable risk is posed to significant recreation areas or residences. Public access may be restricted in the vicinity of the port depending on the findings of a full risk assessment.
Heritage (indigenous and non-indigenous)	To comply with statutory requirements in relation to areas of cultural and historical significance.	Archaeological and ethnographic surveys of the coast have been conducted between the Oakajee and Buller Rivers . One archaeological site is located within the Port Location Area. No post colonisation heritage sites have been established in the vicinity of the proposal.	On-shore development has the potential to disturb significant sites.	Onshore development to be in accordance with the statutory requirements. Preparation of a Heritage Management Plan which will include consultation with AAD on Aboriginal heritage matters.	Compliance with statutory requirements for significant sites.
Recreation	To ensure that the recreational uses of the area, as developed by planning agencies, are not compromised.	Coastal orientated (including fishing, swimming, diving, surfing, windsurfing) recreational pursuits are particularly significant to the north at Coronation Beach. Minimal recreational use between the Oakajee and Buller Rivers.	Reduced scope for recreational development between the Oakajee and Buller Rivers. Present informal recreation between these rivers may continue for offshore harbour option in the long term pending a full risk assessment. Approximately 2.0km of shoreline may be permanently excluded from recreational usage with the inshore harbour option.	Formal development of recreation facilities between Buller and Oakajee Rivers will be opposed. Develop recreation plan for the coast between the Oakajee and Buller Rivers which considers public safety issues and involves community consultation.	No impact on significant recreation areas to the north of the Oakajee River or at Buller River. Potential permanent exclusion of recreation usage for 2.0km of coastline between the Oakajee and Buller Rivers. Present informal recreation at Spot "X" may be affected.
OTHER ISSUES					
Fishing		The area is utilised by professional fishermen for western rock lobster. Some recreational fishing takes place on beaches, particularly north of Oakajee River.	Potential reduction in the commercial catch of rock lobster by the permanent removal of habitat. The inshore option may result in a greater affect on the rock lobster fishery. Potential contamination from port activities.	Breakwater or stabilised beach may provide habitat. Develop a procedure to address impact on commercial rock lobster fishery. Monitoring of western rock lobster stocks for contamination.	Minor impact on rock lobster . Risk of significant contamination is minimal. No significant impact on recreational fishing.
Visual		Coronation Beach is to the north and the residential area of Drummonds Cove is to the south.	Port development is likely to be visible from Drummond Cove.	The port will be a low profile construction.	Port will be visible from Drummond Cove but it is unlikely that the development will be visible from Coronation Beach.

The potential regional impact on the deepwater port on specific components of the marine environment is considered to be the same irrespective of the sector in which the port is located, and may be summarised as follows:

- Seagrass - no seagrass meadows are present. Therefore the impact will be minor in regional terms.

- Marine Vegetation - the marine vegetation is typical of the region and of the south-west coast generally. Therefore the impact will be minor in regional terms and it is unlikely that there will be any impact on any significant marine flora.

- Fauna - the marine fauna habitats are typical of the region and the site has not been identified by the Department of Conservation & Land Management (CALM) as having high conservation value. The impact is considered to be minor.

- Threatened and Priority Fauna - the site is not likely to be significant to any Threatened and Priority Fauna species.

Construction of the port will involve the placement of rock and fill materials to create the breakwaters and possibly dredging of the harbour basin. These activities may cause a short-term increase in turbidity due to suspended sediment.

The marine biota in this area also are subjected to high natural turbidity levels due to wave action along the coast and are therefore not likely to be affected by any temporary turbidity generated by construction or dredging.

Potential operational impacts on the environment will be managed effectively by procedures which are routine for all ports in Western Australia and Australia generally. These will include management of construction and dredging operations, compliance with the guidelines for management of ballast water which are designed to limit the potential for introduction of exotic marine organisms, regulations to protect marine water quality, an oil spill contingency plan, and a general accidental spill management plan.

2.3 Shoreline

An initial assessment of coastal sand movement has been made for this PER and further information will be available prior to the completion of the EPA Assessment Report on the port proposal. The main conclusions of the initial assessment are that there will be little movement of sand from south of the Buller River, with the total nett transport of sand each year being in the order of approximately 5,000m^3. Nett transport will be to the north.

Larger scale movement of sand may occur during winter and summer storms, which may generate sediment movement in the order of 10,000m^3 to 50,000m^3/yr. However, this movement of sand is likely to be in both northerly and southerly directions, and there will be effectively no nett annual transport in a yearly context.

The port structures are likely to form a very effective barrier to this longshore sediment movement. Sediment is expected to accumulate on the coast adjacent to both sides of the structure and, in the absence of remedial action, the coastline further to the north and south of the port would be expected to erode.

Sand bypassing therefore, may be required to mitigate these impacts. In addition to this, it may be necessary to construct coastal structures either side of the port's wave shadow to prevent sediment becoming trapped in this region and removed from the active littoral system.

The impact of the port on the shoreline and sediment movement along the coast will be the same irrespective of which sector the port is established in.

2.4 Onshore Facilities

It is expected that the onshore facilities for the deepwater port will affect a maximum area of approximately 50ha in area. An additional area associated with the service corridor will also be affected, however the size of this area will be determined by the location of the port. The greatest impact on vegetation communities will occur in the southern sector, whilst the least impact will occur in the central sector where the opportunity exists to locate the majority of the onshore structures on the mobile dune area.

Generally, the regional implications on specific components of the onshore environment will be the same for the establishment of the port in each sector, and may be summarised as follows:

- Regionally Significant Vegetation - the proposal will have minimal effect on the well vegetated coastal dunes between the Buller and Oakajee Rivers. Therefore the impact on vegetation is considered to be minor in regional terms.

- Declared Rare Flora - no species of Declared Rare Flora are known to be present based on specific surveys. A spring flora survey will be undertaken in spring of 1997.

- Regional Significant Fauna - the area which will be affected is most unlikely to provide significant fauna habitat as it mainly comprises bare sand. The potential impact is considered to be negligible.

- Declared Rare Fauna - no species of Declared Rare Fauna are likely to be present in the potential impact area.

2.5 Pollution

The pollution impacts of the proposal are similar for each sector of the Port Location Area, and may be summarised as follows:

- Dust - the construction and operation of the port will not cause a dust nuisance to any residents in the Oakajee area or any important

recreation areas. This is because the port site is distant from the closest houses and the important recreation area of Coronation Beach. Dust generation will also be managed in accordance with national and international health and environmental guidelines.

- Noise and Vibration - noise and vibration associated with construction or operation of the port is unlikely to cause annoyance to any members of the public as the nearest houses are a considerable distance away as is the nearest important recreation area at Coronation Beach. The relevant noise regulations will be complied with.

2.6 Social Surroundings

The potential impacts of the proposal on the social surroundings may be summarised as follows:

- Public Health and Safety - the port operator will have statutory control over the coastal and offshore area between the Buller and Oakajee Rivers, and potentially an area north of the Oakajee River if the port is located in the northern sector. The port operator will be able to regulate all public activity in this area should this be required for risk mitigation purposes during the handling of any hazardous cargoes in the long term.

- Aboriginal Sites - one Aboriginal site is known to occur within an area which may be impacted by the port. This site will be protected in accordance with the requirements of the Minister for Aboriginal Affairs.

- Post Colonisation Heritage Sites - no heritage sites are known in the vicinity of the Port Location Area.

- Recreation - The central and southern sectors of the Port Location Area are not used regularly for any recreational activities apart from fishing and diving. However, the northern sector contains a popular windsurfing location, known as Spot 'X'. This location will be significantly affected if the port was established in this sector. It is not anticipated that windsurfing activities further to the north at Coronation Beach will be significantly impacted by the location of a port in any of the sectors.

- Visibility - the port will be located at relatively large distances from Coronation Beach which is the primary local coastal recreation site, from Drummond Cove which is the nearest coastal residential area, and from the City of Geraldton. It is anticipated that even if the port were to be located in the northern sector, that the visual impact from Coronation Beach would be screened by a coastal promontory. The port is also not visible from the North West Coastal Highway, which runs to the east of the port site. The visual impact therefore will be minor.

2.7 Other Issues

Other issues associated with the establishment of a deepwater port at Oakajee may be summarised as follows:

- Rock Lobster Fishing - the maximum area of impact of the deepwater port comprises approximately 5% of the near shore area which is the principal focus of the rock lobster fishery in the Oakajee block as defined by the Department of Fisheries. The annual catch in the area of impact is estimated at approximately 2590kg which has a value of approximately $46,000. It is unlikely however, that the loss of habitat will be this extensive and it is also probable that the submerged rock in the breakwaters will provide additional artificial rock lobster habitat.

  Local professional fishing representatives have expressed concern about market perceptions of potential contamination of rock lobster by industrial and port activities at Oakajee. This will be managed by strict management of any industrial discharges to the marine environment, strict controls on industrial wastewater disposal within the industrial estate, and the operational management procedures which will apply at the port.

- Other Commercial Fishing - no other significant commercial fishing is known to occur in the potential impact area.

- Recreational Fishing - fishing from the beach and near shore will not be affected for the majority of coastline between the Buller and Oakajee Rivers. The potential impact of the proposal on recreational fishing is therefore considered to be minor.

3. Environmental Management and Monitoring

The operators of the deepwater port will implement management and monitoring programs designed to prevent or limit environmental impacts to acceptable levels and to provide information on environmental variables which may be affected by port operations. The monitoring programs will be implemented prior to the commencement of construction of the port to provide baseline data and information collected during these research programs will be supplied to all relevant Government Agencies and will be made available to the general public. The monitoring programs will include:

- Assessments of water and sediment quality.

- Surveys for the presence of introduced organisms.

- Regular surveys of marine habitats in the vicinity of the port.

- Establishment and monitoring of beach profiles to the north and south of the port in order to assess coastal sand movement.

In addition to the implementation of the above programs, the port operator will manage the port in accordance with the principles of AS/NZS ISO 14001:1996, the national environmental management standard.

4. Commitments

The proponent has made a series of commitments in this PER relating to environmental management and monitoring. A summary is provided in Table B. These commitments will be implemented by the port operators and it is expected that they will become binding conditions as part of the environmental approval from the Minister for the Environment.

5. Conclusions

On the basis of the specialist studies and other work associated with the preparation of this PER and the previous PER for the Oakajee Industrial Estate, it is concluded that the deepwater port proposal involves minimal environmental and social costs. The proposal is able to meet all of the EPA objectives as specified in this document.

The Oakajee Deepwater Port will be a vital strategic component in the future economic development of the Mid West region. The port will provide the necessary capacity for large ships and this will benefit the agricultural, mining and industrial sectors of the region.

TABLE B

OAKAJEE DEEPWATER PORT
SUMMARY OF COMMITMENTS

Issue	Objective	Commitment	Timing	To Whose Requirements	Performance Indicator
Macroalgae	To minimise interference with the process of nutrient and carbon cycling from beach cast seaweed.	1) Port operator will monitor accumulation on ongoing basis and will manage any large accumulation by collection and re-distribution	During life of port	CALM	Development and implementation of the management and monitoring programme.
Introduced Marine Organisms	Minimise the risk of introduction of unwanted, non-indigenous marine organisms	2) Port operator will require the Master of any ship seeking to discharge ballast water into the harbour to confirm compliance with the Australian Ballast Water Management Strategy. 3) Port operator will implement a monitoring program for toxic dinoflagellates	2) During life of port 3) Prior to and during operation	DEP	Development and implementation of the management and monitoring programme.
Marine Water Quality	To maintain water quality to accepted criteria to protect the environmental values of recreation, aesthetics, aquatic life for human consumption and maintenance of aquatic ecosystems in agreed areas.	4) The port operator will prepare and implement a Marine Management Plan that will include the following: - a Construction Management Plan - a Dredging and Dredge Spoil Disposal Management Plan (DDSDMP)	4) Prior to and during construction	- DEP - DEP	Development and implementation of the specified plans.

		- an Oil Spill Contingency Plan		- DME, DEP and State Committee for Combating Oil Pollution at Sea	
		- a Wastewater Management Plan		- DEP	
		- an Accidental Spillage Management Plan		- DEP/DME	
		- a Water Quality Monitoring and Management Program		- DEP	
		- a Sediment Monitoring and Management Program.		- DEP	
		5) The port operator will commission a detailed study of water circulation and water exchange in the port following the adoption of a final design.	5) During detailed design	5) DEP	
Sediment Quality	To maintain sediment quality to accepted criteria to protect the environmental values of recreation, aesthetics, aquatic life for human consumption and maintenance of aquatic ecosystems in agreed areas.	6) Port operator will conduct a sediment monitoring program	6) Prior to and during construction, and throughout life of the port	DEP	Development and implementation of the management and monitoring programme.

Shoreline	To maintain the stability of beaches	7) Port operator will monitor coastal sand movement between Buller and Oakajee Rivers and possibly north of the Oakajee River if the port is developed in the northern sector. 8) Port operator will remove significant accumulations of sand from breakwater and redistribute to beaches as required.	7) Prior to and during operation 8) Throughout life of the port	DEP	Development and implementation of the management and monitoring programme.
Vegetation Communities	To maintain the abundance, diversity, geographic distribution and productivity of vegetation communities.	9) Port operator will implement a rehabilitation plan for all areas disturbed by construction activities which are not required for port structures and facilities	9) Plan - prior to construction. Implementation - following completion of construction activities	CALM	Development and implementation of the rehabilitation plan.
Declared Rare Flora	Protect rare and priority flora consistent with the provisions of the Wildlife Conservation Act, 1950.	10) Proponent will commission an additional survey for Declared Rare Flora	10) Spring 1997	CALM	Report submitted
Dust	To protect the surrounding land users such that dust emissions will not adversely impact upon their welfare and amenity or cause health problems and meet EPA Guidelines for Assessment and Control of Dust and Windborne Material from Land Development Sites (updated 1995) and the Environmental Protection Policy (Atmospheric Wastes) (Kwinana).	11) Port operator will ensure that contractors associated with construction of the port, and all port users comply with EPA guidelines 12) Port operator will ensure that all operations comply with the air quality criteria specified by the EPA. 13) Port operator will prepare an Air Quality Management Plan.	11 & 12) During construction and operational activities 13) Prior to construction	11) DEP 12) DEP 13) DEP	11 & 12) - Contract specifications - Regular monitoring reports submitted 13) Submission of the plan to the DEP

Noise and Vibration	Protect the amenity of nearby residents from noise and vibration impacts by ensuring that noise and vibration meet criteria in the Noise Abatement (Neighbourhood Annoyance) Regulations 1979, and the proposed new Environmental Protection (Noise) Regulations (when promulgated).	14) Port operator will ensure that all contractors and port users comply with relevant noise and vibration criteria. 15) Port operator will conduct regular noise monitoring, as necessary.	14) During construction and operation activities. 15) During construction and operation	14) DEP 15) DEP	14) Contract specifications 15) Regular monitoring reports submitted
Public Health and Safety	Risk is as low as reasonably achievable and complies with acceptable standards. The EPA's criteria for the assessment of the fatality risk of proposed hazardous and industrial developments are outlined in Bulletins 611 and 627.	16) All proposals for handling of hazardous cargoes will be referred to DEP and DME 17) The port operator will prepare a Port Safety Plan	16) Prior to handling of any hazardous cargoes 17) Prior to operation	16) DEP and DME 17) DEP and DME	16)Referrals received by DEP/DME 17) Report approved by DEP/DME
Aboriginal & Post-Colonisation Heritage Sites	Comply with statutory requirements in relation to areas of cultural or historical significance.	18) Proponent will prepare a Heritage Management Plan to ensure discovered sites are managed according to statutory requirements.	18) Prior to construction	Aboriginal Affairs Department	Development and implementation of the Heritage Management Plan.
Recreation	The concept should not compromise recreational uses of the area, as developed by planning agencies.	19) Port operator will prepare a Coastal Management Plan which will include provision for continued recreational activities 20) Proponent will undertake detailed assessment of impact of port structures on wave breaks to the north of the port.	19) Prior to construction 20) Prior to construction	19) MFP 20) DEP	19) Coastal Management Plan completed and implemented 20) Submission of specialist report to the DEP.

		21) The proponent will undertake a study to determine the significance of the Oakajee area to windsurfing.	21) Prior to construction	21) EPA	21) Submission of specialist report to the EPA.
Professional Fishing	Minimise the impact of the port on professional rock lobster fishing in the area	22) Port operator will manage construction so as to limit the potential for incidental damage to rock lobster habitat. 23) Port operator will liaise with Dept. of Fisheries and Fishing Industry representatives with respect to port operations.	22) During construction 23) Throughout life of port	22) DEP 23) Dept. of Fisheries	(22), & (23) Monitoring results submitted to DEP and Dept. of Fisheries

1. INTRODUCTION

1.1 Background

This Public Environmental Review (PER) describes the environmental implications of a proposal to establish a deepwater port at Oakajee, north-west of the City of Geraldton in Western Australia. The port will be adjacent to a proposed industrial estate and close to the site of the proposed Geraldton Steel Plant (GSP).

The deepwater port is considered to be an essential adjunct to the industrial estate as it will provide for large scale exports of minerals and mineral-based products associated with future mining and industrial development of the Mid West Region. The first of these industries will be the GSP, which is a component of the Mid West Iron and Steel (MWIS) Project. This is currently scheduled to commence production in the year 2000 with an annual output of 2.4 million tonnes of slab and billet steel. The GSP is the subject of a separate environmental impact study (Consultative Environmental Review) which is being assessed simultaneously by the Environmental Protection Authority (EPA). The intention is that the port will be operational more than five years after commencement of construction of the GSP (about 2002).

The GSP originally was planned to be located in the Narngulu Industrial Estate south-east of Geraldton and to export steel through the existing port on Point Moore. This port however, is restricted in depth and as a result can only accommodate fully-loaded ships in the order of 30,000 - 35,000 DWT.

The proposed deepwater port at Oakajee offers the MWIS Project the potential to export steel using Panamax ships in the order of 65,000 DWT. This represents a significant operational and economic advantage to the project. The initiative of the Government of Western Australia in proposing an industrial estate at Oakajee also means that the GSP can be located in proximity to the port. This eliminates the need for transport of products on public roads and very substantially reduces the transport distance to the port compared to that which would be involved if the plant were to be located at Narngulu.

A hot briquetted iron plant also may be established in the short term at Oakajee. The scale of production being considered by Mt Gibson Iron Pty Ltd (formerly Asia Iron Pty Ltd) in the feasibility studies for this project is in the order of 2.1 million tonnes each year. It would be difficult to handle this volume of exports through the existing Port of Geraldton in addition to the 2.4 million tonnes of steel.

1.2 EPA Section 16(e) Advice on Oakajee Port Concept

During the preparation of this PER, the Minister for the Environment sought early environmental advice from the Environmental Protection Authority (EPA) pursuant to Section 16(e) of the Environmental Protection Act, 1986 on the development of a port at Oakajee. As this advice was required prior to the finalisation of the formal approval process for this PER, the Department of

Resources Development (DRD) commissioned the preparation of a separate environmental document on the port proposal.

The initial environmental review was a strategic assessment based on existing information and did not necessarily detail environmental management strategies which are addressed fully in this PER.

The EPA has recently considered the initial environmental review under Section 16(e) of the Environmental Protection Act, 1986 (as amended). This advice, which has recently been published (EPA, 1997), advised that "The EPA has made a number of recommendations for management and further studies... If these measures are implemented, and subject to study results, implementation of the port concept is capable of being managed so as not to compromise the EPA's objectives." This PER takes into consideration the recommendations of the EPA's Section 16(e) assessment.

1.3 The Proponent

The proponent of the Oakajee Deepwater Port on behalf of the Government of Western Australia is the Minister for Resources Development. The Department of Resources Development (DRD) and the Department of Transport (DOT) are jointly co-ordinating technical studies associated with the design of the deepwater port and the DRD is also co-ordinating the establishment of the Oakajee Industrial Estate together with LandCorp.

The Minister for Transport also has responsibility to the Geraldton Port Authority (GPA) whose area of jurisdiction under the Geraldton Port Authority Act, 1968 includes the Oakajee port site. The Government of Western Australia has announced an intention to seek a private operator for the Oakajee Deepwater Port in which case the environmental approval and environmental conditions will transfer to that owner. Should this not eventuate however, it is most likely that the port will be operated by the GPA.

1.4 Purpose of the PER

The environmental impact assessment process in Western Australia is specified by the Environmental Protection Act (1986) and is illustrated in the flow chart presented in Figure 1. The Act requires a proponent to notify the EPA of any proposal which may have significant environmental implications. The EPA then determines whether the proposal should be formally assessed. If a decision is made for a formal assessment, the EPA requires the proponent to prepare a detailed account of the environmental implications in a report such as the present PER.

After the PER has been prepared, it is reviewed by the Department of Environmental Protection (DEP) to ensure that it provides sufficient detail and a comprehensive coverage of issues. When this has been established, the PER is released for a public review period. During this period any person may make a written submission to the EPA on any aspect of the project. At the end of the

public review period, a summary of submissions is supplied to the proponent by the EPA and a response is sought.

The EPA then begins its assessment of the development proposal taking into account the PER, the public submissions, the proponent's response to the submissions, and any other relevant information.

The results of the EPA assessment are published in the form of an Assessment Report which includes recommendations made to the Minister for Environment. Interested parties can appeal to the Minister about the content of the EPA Assessment Report, or any of its recommendations. Ultimately the Minister for the Environment in consultation with Decision Making Authorities decides whether the proposal may proceed and what conditions will be imposed upon it.

The environmental assessment process is designed to enable State authorities to consider in detail the environmental and social implications of development proposals. These considerations are based on technical assessments of the nature and extent of changes to the existing biophysical and social environments, on proposed management strategies designed to control or limit adverse changes, and on monitoring programs designed to document and analyse the effectiveness of such strategies.

The environmental assessment process also enables members of the public to obtain details of the proposal and to formally comment on any matters of interest to them. These inputs are required within a specified public review period and are considered by the EPA together with the technical assessments. The public is encouraged to provide written comments to the EPA as part of the environmental review process. Details of the public review period for the deepwater port proposal at Oakajee and advice on how to make a submission are provided at the beginning of this PER.

1.5 Scope and Structure of the PER

This PER has been prepared to comply with guidelines issued by the EPA. The guidelines, which specify the information required for assessment purposes, are provided in Appendix 1.

In summary, the PER provides:

- Background information about the environmental impact assessment process, the proponents, public consultation associated with the proposal, a summary of alternative sites in the Geraldton region which have been considered as locations for a deepwater port.

- A general description of the area in which the Oakajee Deepwater Port will be located, the possible scale of the Port and broad design options currently being considered.

- A review of the existing, biophysical and social environment in the general port area including marine habitats, ocean conditions, fishery resources, coastal sand movements, and adjacent onshore environment.

- An analysis of the implications of the deepwater port proposal in terms of the existing biophysical and social environment.

- A description of the approach to environmental management which aims to provide regular information on water quality, potential introduced organisms, marine habitats and coastal sand movement in the vicinity of the port.

- A series of commitments by the proponent which are intended to ensure that the proposal will be implemented consistent with the EPA objectives for relevant environmental factors. These commitments will become conditions associated with the environmental approval from the Minister for the Environment and will be binding.

1.6 Relevant Legislation

The Oakajee Port project will be subject to a number of Acts of Parliament and regulations at State and Commonwealth levels. A selection of key legislation is listed below.

- Aboriginal Heritage Act 1972.
- Australian Heritage Commission Act 1975.
- Conservation and Land Management Act 1984.
- Dangerous Goods Regulations 1992.
- Endangered Species Protection Act 1992.
- Environmental Protection Act 1986 as amended.
- Environmental Protection (Sea Dumping) Act 1981
- Explosive and Dangerous Goods Act 1961.
- Fish Resources Management Act 1994.
- Geraldton Port Authority Act 1968
- Hazardous and Toxic Substances Regulation.
- Health Act 1911 - 1979 and Regulations.
- Heritage of Western Australia Act 1990.
- Noise Abatement (Neighbourhood Annoyance) Regulations 1979.
- Occupational Health, Safety and Health Act 1984.
- Pollution of Waters by Oil and Noxious Substances Act 1987.
- Protection of the Sea (Prevention of Pollution from Ships) Act 1983
- Shipping and Pilotage Act 1967.
- Marine and Harbours Act 1981.
- Western Australian Marine Act 1982.
- Western Australian Marine (Sea Dumping) Act 1981
- Wildlife Conservation Act 1950.

International agreements or treaties and national agreements and State policies that may directly or indirectly affect this project include:

- Convention on Biodiversity.
- International Convention for the Prevention of Pollution from Ships (MARPOL, 73/78).
- Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter (The London Convention 1972).
- National Strategy for Ecologically Sustainable Development.
- Australian Dangerous Goods Code: Australian Code for the Transport of Dangerous Goods by Road and Rail.

1.7 Decision Making Authorities and Involved Authorities

The decision-making authorities (DMAs) and other authorities which have provided input to this formal environmental assessment and which will be involved in ongoing environmental management of the Oakajee Port include:

- Environmental Protection Authority (EPA)
  The EPA will provide recommendations to the Minister for the Environment on the proposal.
- Department of Environmental Protection (DEP)
  The DEP will facilitate the assessment of this PER and will be the key agency for ensuring that the port operator complies with environmental conditions.
- Department for Resources Development (DRD)
  The DRD is responsible for the co-ordination of the Government's initiative with respect to the port.
- Department of Fisheries
  The Department of Fisheries is responsible for the management and regulation of fisheries in Western Australia.
- Department of Conservation and Land Management (CALM)
  CALM protects and manages native flora and fauna and their ecosystems through the provisions of the Conservation and Land Management Act (1984) and the Wildlife Conservation Act (1950). CALM will provide advice on the management of marine and onshore flora and fauna.
- The Department of Transport
  The Department of Transport is responsible for maritime transportation policy development, strategic planning for the development and

management of new ports and regulation of maritime activities in Western Australia.

- Department of Minerals and Energy (DME)
  The DME controls the activities of extractive industries through several Acts, including the Mining Act 1978, the Mines Safety and Inspection Act 1994 previously the Mines Regulation Act 1946-1974, Petroleum Act 1967 and the Explosives and Dangerous Goods Act 1961. Additionally, the DME also administers mining operations disturbance of land through the Soil and Land Conservation Act 1945 on behalf of the Department of Agriculture. The DME will provide advice to the EPA/DEP on environmental and mining procedures associated with quarry operations.

- Worksafe Australia
  Worksafe Australia has primary responsibility, under the Occupational Health, Safety and Welfare Act 1984, for the regulation of occupational health and safety issues.

- Shire of Chapman Valley
  The deepwater port will be constructed within the Shire of Chapman Valley. Under the Local Government Act 1960, municipal authorities have the power to make by-laws with respect to such matters as planning, zoning and land use or environmental controls to the extent that such by laws are not inconsistent with Commonwealth or State laws. The local authority's approval for any quarry proposal is also required.

1.8 Public Consultation

The possibility of a deepwater port at Oakajee has been discussed with interest groups in the Mid West Region by a number of State Government Agencies over several years. These have included the GPA in the context of the alternative proposed deepwater port at Point Moore, and more specifically by LandCorp and the DRD as part of studies to identify an industrial port site near Geraldton.

The DRD, LandCorp and their consultants have also discussed the present proposal with Local Authorities (City of Geraldton, Shire Councils of Chapman Valley, Greenough, Mullewa, Mingenew and Irwin) with regular updates to the Shire Councils of Chapman Valley and Greenough and staff at the City of Geraldton. These updates have generally been fortnightly since early January 1997.

Other interest groups which have been directly consulted include:

- The Western Australian Fishing Industry Council and several locally based Professional Fishermen's Associations (Geraldton, Leeman, Dongara, Mid West).

- The Amateur Fishermen's Advisory Committee.

- Farmer groups including the Mendel/Wongoondy, Pindar, and Tardun Progress Associations.
- Progress Associations closer to the proposed port including the Drummond Cove and the Waggrakine/Glenfield Progress Associations.
- Chapman Valley LandCare Group.
- Co-operative Bulk Handling (CBH).
- Aboriginal community representatives.
- Friends of the Batavia Coast.
- Active Community Environmentalists.
- Geraldton Chamber of Commerce.
- Geraldton Windsurfers

Consultation with these and other interest groups has continued during the environmental assessment process.

Further consultation will occur during the Public Review period with "open days" and displays in shopping centres and preparation of a public information brochure.

1.9 Need for a Deepwater Port

For many years various Government agencies have carried out studies with the objective of establishing a deepwater port at or near the City of Geraldton. It is generally considered that such a port is necessary if trade and economic development in the Mid West Region is to reach its full potential. Most of these studies have been co-ordinated by the GPA but the DRD has also evaluated options in association with studies which sought to identify a suitable location for a new industrial estate in the region, and the Ministry for Planning has considered sites in the context of the preparation of successive Geraldton Region Plans.

The existing Port of Geraldton currently has a draft limit of about 9.1m which means that only relatively small ships of up to about 30,000 to 35,000 DWT are able to enter or leave the port when fully loaded. In contrast, ships which are generally involved in international sea trade are in the range of 35,000 DWT to 50,000 DWT with drafts of between 11m to 12m (Handymax ships) or in the range 50,000 DWT to 80,000 DWT (Panamax ships) with drafts of about 14m. A further minimum of 2m of water is required for underkeel clearance in all operational areas.

A specific study of shipping requirements at the Port of Geraldton found that the average size of ships loading grains during the 1980s was 33,620 DWT while for minerals it was 24,000 DWT (Halpern Glick Maunsell, 1991a). This means that

many of the ships visiting Geraldton could not be fully loaded there. This study concluded that there was an immediate and essential need for ships up to 55,000 DWT to be fully loaded at Geraldton and that it would be desirable to be able to fully load ships up to 80,000 DWT.

The study also recommended that any deepwater port should be capable of subsequent development to enable the full loading of ships in the range of 150,000 DWT (Cape ships) as these may be required by large scale mineral export projects. Such ships have drafts of about 17m and require a further minimum of 2m of water for underkeel clearance, i.e. a total water depth in the order of 19m.

1.10 Alternative Locations for a Deepwater Port in the Geraldton Region

A number of options for providing a deepwater port in the Geraldton region have been considered by various Government agencies and others. The GPA investigated the feasibility of dredging the approach channel and existing harbour basin (Maunsell-Nedeco, 1983, 1985) and has made a number of assessments of deepwater port options (Port & Harbour Consultants, 1989; Halpern Glick Maunsell, 1991a, 1991b; Alan Tingay & Associates, 1994a).

The deepening of the approach channel and the existing harbour so that these could accommodate large ships would involve very substantial costs. This is due primarily to the difficulty of dredging the hard seabed which occurs in parts of Champion Bay and the fact that a dredge would not be able to operate in the outer section of the approach channel during adverse sea conditions but would have to be maintained on standby. Despite the costs and difficulties, some limited dredging of the approach channel occurred in the mid-1970s with the use of a jack-up dredge together with blasting. The blasting was required to deal with the harder sections of seabed but gave rise to numerous complaints from people in Geraldton due to noise and other disturbance.

Consideration has also been given to expanding the existing harbour northwards out to a sufficient depth for Panamax size ships, together with dredging of the approach channel. This option however, would involve substantial port structures immediately in front of the City of Geraldton and would not provide the shipping capacity offered by other options.

As dredging presents particular difficulties in the Geraldton region, the possibility of building a port in sufficiently deep water to enable large ships to be handled has been examined in detail. This option involves the construction of long breakwaters from the shore out to depths of at least 16m for Panamax ships or 19m for Cape ships. An additional outer breakwater is then required roughly parallel to the coastline to form a protected harbour.

These depths of water must extend throughout the area in which the ships are handled including the channel entrance, turning basin and berths. This means that the breakwater may need to extend further than the 16m or 19m contours or that dredging may be required in the port itself.

The potential for a deepwater port of this type in the Geraldton region was first examined by Mitchell Plateau Bauxite Pty Ltd in 1981. This company considered a number of sites including a location to the north of the Oakajee River; at Georgina, Bradley and Bookara to the south of the Greenough River; and Bonnifield to the north of Dongara. The potential locations at Oakajee and Georgina were also investigated by the GPA in 1988 together with a further site off the western end of Point Moore near the existing port.

The Georgina site is a few kilometres south of the mouth of the Greenough River. The location is backed by high coastal dunes and the Greenough Rivers flats further inland. Subdivisions have recently occurred in the vicinity of this site and further inland there are an increasing number of smaller hobby farms and a large heritage zone associated with the old settlement of Greenough.

The Point Moore site is described in detail in Alan Tingay & Associates (1994). This site was favoured by the GPA at the time because it offered the best potential for integration with the existing port and with the storage and other infrastructure of current port users.

The original port site at Oakajee considered by Mitchell Plateau Bauxite Pty Ltd was in the vicinity of Coronation Beach north of the Oakajee River. More recently however, LandCorp, in association with the DRD, has proposed an industrial estate south of the Oakajee River. As a consequence a site for the port adjacent to the estate is now favoured.

In late 1996, the Minister for Resources Development announced that Oakajee was the preferred site of the Government of Western Australia for a deepwater port and that it intended to initiate design and cost evaluation studies for that location. It is also seeking environmental approval through the present PER. Simultaneously, the Government requested the MWIS Project to evaluate the potential for relocating the GSP to a site adjacent to the proposed port and to seek environmental approval for the plant at that location.

The Government believes that the GSP will provide sufficient justification for the construction of the deepwater port and that the two combined will provide a focus for further industrial and economic development of the region. It also considers that the site is appropriately located at some distance from the City of Geraldton and that as a consequence, transport and other activities associated with industries and the deepwater port will not cause significant social impact to residents.

As a result of the Government policy, the GPA has decided to place the deepwater proposal for Point Moore on hold pending the outcome of the assessments of the Oakajee proposal which are currently in progress.

1.11 Potential Cargoes

At this stage the potential cargoes through the Oakajee port comprise exports and imports associated with the proposed Geraldton Steel Plant of An Feng Kingstream Steel and the hot briquetted iron (HBI) plant of Mount Gibson Iron Pty Ltd. The materials and quantities involved with these projects are as follows:

- GSP - export of 2.4Mtpa slab and billet steel, import of 50,000tpa scrap steel.
- HBI - export of 2.1Mtpa hot briquetted iron. 4.5Mtpa

Additional exports/imports are expected from new industries which choose to establish in the Oakajee industrial estate and possibly large volume mineral exports from future mines, such as iron ore and alumina, in the Mid West Region. There also is a possibility that hazardous cargoes may be handled through the port. Due to its isolation the port is considered to be suitable for such cargoes although any future proposals for the import or export of hazardous materials will be subject to EPA review. Predictions of the nature and scale of these cargoes at this time however, would be speculative and is not necessary for the present environmental assessment.

2. THE OAKAJEE DEEPWATER PORT PROPOSAL

2.1 Location

The precise site of the deepwater port at Oakajee is not known at this stage as the location will be determined by the concept design studies which are currently in progress.

As the exact location of the port is yet to be established, this assessment examines the potential impact of the port within a defined area. This area is referred to as the Port Location Area, and extends from approximately 1km north of the Buller River to just north of the Oakajee River, and approximately 3km off the coast. The regional location and the boundaries of the Port Location Area are provided in Figures 2 and 3.

To enable the consideration of the environmental impacts of the port as accurately as possible in the absence of a decision on the preferred location, the Port Location Area has been divided into three equal sectors; central, northern and southern (Figure 3). Each of these sectors occupies approximately one third of the Port Location Area. A port may be located in any one of these sectors, or may overlap the boundaries of two sectors. The sectors referred to throughout the document therefore are for convenience only and are used to illustrate impacts which may vary according to the location of the port within the Port Location Area.

It is also assumed that the final port design may affect an offshore area of up to approximately 170ha and an onshore area of up to 50ha plus a service corridor connecting to the Industrial Estate.

2.2 Port Design

A preferred design for the deepwater port is yet to be selected. However, it is considered that the final plan is most likely to be an "inshore" option as described in the strategic environmental assessment (Welker Environmental Consultancy, 1997) and recently assessed by the EPA (EPA, 1997). The general features of this design are breakwaters extending out to the 5m water depth contour. The harbour basin and the approach channel would be dredged to 16.5m depth to accommodate fully loaded Panamax size ships in the order of 65,000DWT, both entering and leaving.

A representative diagram of this option is provided in Figure 4. The design in this figure is indicative only and the final detailed design of the preferred offshore option may vary. However, the amount of offshore area affected by this final design is very unlikely to be greater than that indicated in Figure 4.

2.3 Port Management Areas

It is envisaged that three management areas will be defined around the Oakajee port:

- a Statutory Control Area,
- a Special Management Area, and
- a main Port Operations Area.

These three areas are described below.

Statutory Control Area

It is usual for port operators to be given statutory authority over large areas of ocean surrounding the particular port under their control. This enables the operators to manage activities in the vicinity of the port in a manner which ensures that shipping operations are not constrained and so that ship movements do not pose an unnecessary risk to others such as professional fishermen and private craft.

For example, the area under the jurisdiction of the Geraldton Port Authority through powers conferred by the Geraldton Port Authority Act, 1968, currently extends from Point Moore to beyond the proposed site of the port at Oakajee. It is envisaged similarly that a relevant area around the Oakajee port will be defined.

Under existing state legislation, statutory control of the entire port, including the Statutory Control Area must be vested in either a public port authority formed under a separate Act of Parliament or in the Minister for Transport. There are currently no provisions under Western Australian legislation for a private port operator to have statutory control of a port area. However, it may be possible for a private port operator to obtain a lease or jetty license from the Minister for Transport to cover its requirements. It is understood that the Government has agreed to divest control of other port areas to private operators, and the arrangements for this delegation will be included in new legislation to be considered by Parliament during Spring 1997.

It is therefore anticipated that by the time the Oakajee port is operational, statutory control over this area will be vested in the port operator. This may be achieved by an extension of the area under the control of the GPA, or by definition of two separate areas under the separate control of the operators of each of the two ports.

Special Management Area

An area around the general location of the Oakajee port will be defined as a special management area for the purposes of port management. The location of the special management area will be determined following a final decision on the port location. However, the area is likely to include all of the land between the Industrial Estate and the coast, extending between the Oakajee and Buller Rivers, and possibly the coastal sector for a distance of up to 1km north of the

Oakajee River. The area will also extend offshore for a distance of 3km around the port structures; that is north, south and west. Within this area, non-port related activities may need to be restricted in order to ensure public in the vicnity of the harbour and shipping channels safety with respect to ship movements. This area also will be used for environmental monitoring associated with port operations.

Port Operations Area

A main port operations area will be defined to include the port itself, and defined shipping channels approaching the port. In this area, non port activities will be restricted due to the need to give priority to ship operations. It is also expected that the marine environment in this main port operations area may be affected by shipping operations and harbour construction and maintenance activities. These activities include the construction of the port, and any maintenance dredging, disturbance of seabed sediments due to ship propellers, incidental and potentially accidental spillage of materials during port operations, and other factors.

The Port Operations Area will also comprise a limited area adjacent to and outside of the port breakwaters. While it is not considered that this area will be directly impacted by port operations, the area will be considered in water quality monitoring programs as a transition zone to the Special Management Area.

Potential Uses of the Port

The Mid West Iron and Steel Project and the Hot Briquetted Iron (HBI) project proposed by Mt Gibson are the most likely users of the port over the short to medium term. The Mid West Iron and Steel Project proposes to produce up to 2.4Mtpa of steel slab (each slab is approximately 19.6 tonnes) for export through the Oakajee port. In association with the production of steel slab the importation of approximately 50,000tpa of steel scrap will be required.

The Mt Gibson project will involve the production and export of 2.1Mtpa of hot briquetted iron. Raw materials for this project are expected to be sourced from within WA.

In the long term the export or importation of the following products and raw materials is possible:

- import of additional iron ore pellets (assuming future expansion of the Mt Gibson project);
- other non-hazardous materials; and
- hazardous materials depending on the type of industries that establish in the Oakajee Industrial Park and the Mid West Region.

At this stage it is difficult to estimate hazardous material shipments through the port. Given this uncertainty a full assessment of potentially hazardous shipments

will be undertaken when better information is available on potential industrial developments in the Mid West Region.

2.4 Breakwater Construction

It is anticipated that the final port design will incorporate conventional breakwaters closer to the shore. These comprise a mound of large-sized rocks dumped in place and of sufficient size to resist movement by wave energy.

The possibility of including culverts or similar structures in these breakwaters to promote water circulation within the harbour basin will be investigated in the port design study currently in progress. It is likely however, that the water flow through culverts would have an insignificant impact on water circulation unless the culverts were very large and that this is likely to be impractical.

The outer breakwaters of the port in deeper water will be mass-armoured. This type of breakwater has two components; a core and the armour. The core may be made of a mixture of different types of material including sand and rock of varying sizes (Port & Harbour Consultants Pty Ltd, 1989; Foster, 1990). The selection of materials depends on their availability close to the port site and the sea conditions which determine the stability of materials during construction.

The armour components of the breakwaters comprise a layer of rock placed on the outer slope which is most exposed to incoming wave action. The size of the rock in the armour is smaller than that used in conventional breakwaters and is selected so that wave action will mould or shape the profile of the slope. Over time, the slope becomes stable and is highly efficient in absorbing wave energy. Typically a minimum of three layers of armour are placed on the seaward side with the individual blocks ranging from 3 to 5 tonnes for granite or 5 to 9 tonnes for limestone. It is considered that granite or an equivalent dense rock will be required at Oakajee due to the local wave climate.

The breakwaters will be constructed progressively out from the shore with the rock dumped from trucks and placed by cranes, excavators or other large earthmoving machinery. In the deeper water areas, some of the armour and core material may be placed by bottom dump barge.

The mass-armoured breakwater proposed for the outer sections of the deepwater port has various advantages compared to a conventional breakwater. The most important of these are:

- The ability to use 100% of the rock quarried as different sizes of rock can be used in different sections of the breakwater.
- Reduced constraints on necessary rock quality for construction purposes.
- Cost savings resulting from the use of smaller armour stones.
- Resistance to sudden failure if design waves are exceeded.

Mass-armoured breakwaters have been built in a number of locations around the world because of these advantages. An Australian example is the breakwater of the harbour at King Island, Tasmania. This harbour is fully exposed to south-west seas from the Southern Ocean and is also subject to occasional severe storms from the east. The main breakwater is 600m long, has a top width of 63m, and extends to 18m water depth. Ninety-five percent of the rock used in this breakwater weighed less than two tonnes and all of the material used was overburden or waste rock from a nearby schaelite mine. The maximum design wave height was 5.7m with a 10 second return period but the breakwater is considered to be fully resistant to waves up to 7.6m in height.

Mass-armoured breakwaters have also been built at various locations in Canada, the Faroe Islands, and Iceland. Some of the examples in Iceland are in deeper water than at Oakajee and have to withstand considerably more extreme ocean conditions. Fifteen such structures have been built in Iceland since 1983 and the information on these is provided by Sigurdarson (1994). The largest of these, which is at Helguvik, extends into 24m of water and is designed to withstand 50 year storms with maximum wave heights of 5.8m and a frequency of 9.6 seconds.

The inshore port is likely to require in the order of 4 million tonnes of breakwater material.

8 in Bulletin

2.5 Source and Transport of Construction Materials

Breakwaters incorporated into the design of the port will be constructed from limestone and/or granite rock. The sources of these materials have not been identified to date, and specification of the types of materials required and the identification of suitable existing or potential quarries is part of the concept design study currently in progress.

Extensive deposits of limestone and granite occur in the Geraldton region, and in the local area close to the proposed port site, including within the Oakajee Industrial Estate area. For example, there is a former granite quarry on the east side of the North-West Coastal Highway adjacent to the Oakajee Industrial Estate which supplied rock for the construction of breakwaters at the existing Port of Geraldton.

Therefore, it is considered that suitable materials for the breakwaters will be located within 25km of the proposed port site. The construction materials will be transported to the port site in trucks but the specific routes which will be used cannot be specified until the source of the materials is identified.

Separate environmental approvals will be sought for any new rock quarries and for the transport of construction materials to the site. These applications will specify buffer distances from the quarries to any nearby residences, existing vegetation, flora and fauna at the quarry site, operational procedures, rehabilitation plans, transport routes and vehicle types and numbers.

The operating hours for transport of rock to the port site, trucking routes and road crossings will be in accordance with the requirements of the relevant Local Authorities and Main Roads Western Australia.

2.6 Dredging

Geotechnical information relating to the seabed at Oakajee is very limited but at this stage it is assumed that the conditions are equivalent to those in Champion Bay near the Port of Geraldton. In this area there are deposits of very hard calcarenite caprock with compressive strengths up to and exceeding 50Mpa which is underlain by softer limestone and sedimentary materials. This material is likely to be very difficult to dredge, and the dredging operations would be further complicated by the relatively severe wave climate at the site which is likely to frequently create conditions when dredges will not be able to operate.

Dredging operations are likely to be carried out by a large cutter-suction dredge or a jack-up dredge. Drilling and blasting may also be required to break up the seabed. The dredging operations would be carried out after construction of the breakwaters, which would provide some protection for the dredge.

The volume of dredge spoil is not anticipated to exceed approximately 8Mm^3.

A cutter-suction dredge has a cutting device to break up the seabed and the loose material (spoil) is then sucked to the surface through a pipe, and then pumped through a further pipe to a spoil dump area.

2.7 Reclamation Area

Under the preferred inshore option dredge spoil will be dumped directly adjacent to and inshore from the breakwaters to form a reclaimed area of land which can be used for the storage and handling of commodities shipped through the port. This reclamation area will be made by firstly constructing a rock breakwater to provide containment for the spoil and then filling this area with the dredged spoil material.

The size of the reclamation area will be determined by the amount of spoil recovered by dredging operations.

2.8 Onshore Storage Facilities

Storage facilities for commodities awaiting export or for imported materials also may be located on the near-coastal dunes immediately adjacent to the port. It is anticipated that the onshore storage area will cover an area of up to approximately 50ha and be approximately 1.5km in length (south to north) and 400m wide (west to east).

Storage will also occur on the sites of the individual industries within the industrial estate itself.

2.9 Service Corridor

The service corridor between the deepwater port and the industrial estate, which is about 1km inland, will comprise a ramp constructed the same materials as the offshore breakwaters. This ramp will extend across and up the nearshore Quindalup Dunes to the design level of the industrial estate. The minimum elevation of the ramp at the shore will be 7m, while the design level for the western part of the industrial estate will be 83m. The length of the corridor will be determined by the final location of the port, ie. the corridor will be shorter if the port was to be located in the central sector as opposed to the northern and southern sectors.

The service corridor will provide for two two-way roads, conveyor belts, pipe racks, and other facilities. The corridor is expected to be not more than 100m wide.

2.10 Water Requirements

It is envisaged that the pipeline constructed to service the Oakajee Industrial Estate and the Geraldton Steel Plant also will supply water for port requirements. Pipelines for the port will be incorporated into the services corridor. The water demand from the port will not be large, particularly in comparison to industrial requirements.

2.11 External Services Corridors

The rail corridor to the Industrial Estate is currently being investigated by Westrail, DRD and Landcorp. It is likely that the rail corridor will, at least in part, be the alignment for a general services corridor to cater for rail transport, gas and water supplies and power transmission. It is anticipated that this proposal will be referred to the EPA in due course for separate assessment.

The transport of materials to the port along existing road routes will also be separately referred to the EPA as proposals are developed to ensure that the cumulative impacts of traffic associated with the port can be assessed.

3. EXISTING ENVIRONMENT

3.1 Introduction

This section of the PER provides a description of the existing environment in the general vicinity of the Oakajee Deepwater Port. The information presented forms the basis for an analysis of the environmental and social implications of the port, which is presented in Sections 4 to 6.

The environmental and social features at Oakajee which are relevant to this analysis comprise the marine, coastal, and near-coastal onshore physical and biophysical features, and the social setting. In particular, these include:

- Near-coastal ocean conditions,
- Offshore marine habitats and biota,
- Coastal sand movement,
- Onshore biophysical features, and
- The proximity of houses and the use of the coastal area for fishing, recreation, and other purposes.

The discussion presented below is based on specialist assessments and technical reports which have been prepared specifically for this PER, together with information from other earlier and more general studies.

An aerial photograph, which provides a general overview of the area is included in Figure 5.

3.2 Climate

The climate at Geraldton is classified as extra dry Mediterranean because the region has seven or eight dry months each year. Maximum temperatures near the coast are mild, with monthly averages rarely rising above 30°C. The area experiences cool winter conditions, with monthly minimal as low as 8°C.

Rainfall is low (average 469mm per year) with most falling between May and August. There are long periods without rain during the summer (during which there is an average of two rain days per month) although thunderstorms sometimes cause heavy falls in local areas, and tropical cyclones occasionally bring heavy rain to the general region.

Geraldton has an annual evaporation rate of 2464mm, and evaporation exceeds rainfall every month except June and July. Net evaporation is 1995mm.

3.3 Marine Environment

3.3.1 Bathymetry and Ocean Conditions

The bathymetry of the Oakajee area is shown in Figure 6. The seafloor drops from the shoreline to a depth of 5m at approximately 900m offshore, then to 10m at 1.4km and 20m at approximately 2km offshore. From this point the gradient is more gentle and the seabed is at -30m AHD at approximately 7km offshore. The seabed contours are aligned in a south-south-east to north-north-west direction roughly parallel to the coast.

The site, and the coastal area of the Geraldton region in general, experiences high wave energy. In June 1982, a Waverider buoy was deployed at Oakajee for one year in 15m to 20m of water approximately 1km offshore (Steedman Science & Engineering, 1983). The purpose of these measurements was to determine the wave climate for ship operations and breakwater design associated with the proposed port at that time. The location of the buoy was chosen to correspond with the head of the proposed breakwater.

These measurements showed that the mean significant wave height over the year's duration was 1.2m, with a large proportion of the wave energy of periods ranging from 12 to 16 seconds. The calmest months of the year were October, November, March and April.

Other direct measurements by Steedman Science and Engineering (1991) indicate that in 20m of water off Point Moore the significant wave height exceeds 0.5m for 99% of the time. The main elements of the offshore wave climate are:

- Locally generated seas resulting from sea breeze conditions with waves typically 0.5m to 1.5m high and with periods of 3 to 6 seconds generally from the south-west to south.

- Seas generated locally by the passage of cold fronts during winter with highly variable wave heights which often exceed 2m and periods of 6 to 10 seconds. The direction of these waves may vary from west to south-west during the passage of each storm.

- Swell waves generated by storms in the southern Indian Ocean which approach the coast continually, generally from the south-west. These waves often exceed 2m and have typical periods of between 8 and 16 seconds.

- Severe waves caused by dissipating tropical cyclones.

The general wave patterns described above will occur around the outer sections of the deepwater port.

Offshore waves are greatly affected by the various reefs and the gaps between the reefs as they travel toward the shore. The reefs and adjacent areas modify the waves by the following physical processes.

- Reflection off the reef faces.
- Depth limited breaking on the reef tops.
- Diffraction through the gaps in the reefs.
- Attenuation due to hydraulic turbulence as the waves travel over the reefs.
- Refraction and shoaling due to variability in the seabed topography.

All of these processes act in varying degrees and significantly attenuate the waves as they approach the beaches. This is particularly relevant to the Oakajee site which is characterised by large amounts of nearshore reef, spread in patches from the coast out to several hundred metres offshore. The resultant waves that break on the beaches are believed to be very important in the transport of sand in the littoral zone.

The astronomical tides at Geraldton are predominantly diurnal (i.e. with one tidal cycle each day) and have a relatively limited daily range of about 0.7m during spring tides and less than 0.5m during neap tides. Tidal statistics derived from the Australian National Tide Tables (1988) are as follows:

• Highest Astronomical Tide (HAT)	1.5m+ Chart Datum (CD)
• Mean Higher High Water (MHHW)	1.1m+ CD
• Mean Sea Level (MSL)	0.8m+ CD
• Mean Lower Low Water (MLLW)	0.6m+ CD
• Lowest Astronomical Tide (LAT)	0.2m+ CD

The maximum astronomical tide range is therefore 1.3m (difference between the lowest and highest astronomical tides).

Seasonal shifts in the sea level occur due to meteorological conditions. Typically the MSL at Geraldton rises 0.1m during winter and falls 0.1m during summer. During storm events (both winter storms and summer cyclones) barometric and wind effects can cause significant storm surges which may exceed 1m above the astronomical tide level. The highest water level recorded at Geraldton was 2.1m+ CD in 1970 and was probably associated with tropical cyclone Glynis.

There is virtually no data on ocean currents in the Geraldton region.

3.3.2 Wind Regime

Annual and seasonal wind roses at Oakajee are shown in Figure 7.

The seasonal weather pattern and general wind regime is largely controlled by the north-south movement of the anti-cyclonic belt (or sub tropical high pressure belt). This belt is made up of a series of discrete anti-cyclones or high pressure cells that encircle the earth at mid-latitudes between 20° and 40°S. A notional line joining the centres of these cells is known as the high pressure ridge.

In winter this high pressure ridge lies across Australia typically between 25° to 30°S and it straddles Geraldton which is at 28° 47'S. During summer the ridge moves south of Geraldton and lies between 35° and 40°S. This shift in the position of the high pressure ridge is fundamental to the seasonal wind patterns at Geraldton where easterlies predominate in winter and southerlies in summer.

However, the general seasonal wind pattern is complicated by a land/sea breeze system which affects coastal regions and causes variations on a daily time scale. These breezes are easterlies coming from the land in the morning and swing around to south-westerlies coming from the sea in the afternoon.

During winter the morning winds are predominantly from the north-east whereas the afternoon winds usually come from the north-west through to the south. In summer the morning winds mainly come from the east through to the south. During summer afternoons, the common wind directions are south and south-west.

The wind conditions for winter and summer during both the morning and afternoon are shown in the wind roses in Figure 7. These wind roses are based on data collected by the Bureau of Meteorology over many years at the Geraldton Airport and, while they do not provide a precise indication of coastal wind conditions, they indicate the general regional conditions. A feature of the wind patterns is the predominance of strong winds with speeds often more than 40kph. There is also a predominant wind direction from the south.

Extreme winds occur in summer mainly from the north-east to east, and generally are isolated events which are associated with tropical cyclones, thunderstorms, and other unusual conditions. The dominant winds during summer however, blow from the south and south-west at 20kph to 30kph. December is the windiest month of the year, with 99% of days having wind speeds in excess of 10kph.

In mid-winter, the northern fringe of the Roaring 40s extends over the southern area of Australia and results in frequent west to south-west gales along the coast. Strong winter winds also at times blow from the north-west. July is the least windy month of the year but for 75% of the days in this month the wind still exceeds 10kph.

The autumn and spring wind conditions are transitional phases between winter and summer with fewer extreme events.

3.3.3 Seafloor Substrates and Habitats

The marine environment off Oakajee has been specifically surveyed as part of the studies associated with this PER (Alan Tingay & Associates, 1997; see Appendix 2). The area has six distinct habitat types with associated flora and fauna as shown in Figure 8, which are as follows:

- Sandy beaches which extend along the length of the shoreline adjacent to the industrial estate. Biota in the beach sand probably consist of burrowing fauna such as polychaete and bi-valve molluscs, and ghost

crabs. In a few places limestone reefs are very close to the shoreline and are partially covered by sand.

- Shallow sandy seafloor which extends offshore between raised limestone reef blocks. The biota consist of fauna such as polychaete worms, bivalve molluscs and small crustaceans, with some bottom-dwelling fish such as dragonets and whiting. The water column above this type of habitat is also used by nomadic and migrating fish such as mullet, tailor, and mulloway.

- An extensive area of high reef which occurs from the beach offshore to about the 5m depth contour. This reef is fragmented and dissected with small pockets of sandy seafloor or areas of limestone pavement in between the raised blocks. The reef presents a diverse array of microhabitats for marine life and features kelp on the reef tops and an understorey of encrusting and coralline red algae. The vertical walls, underhanging surfaces and caves in the reef blocks are colonised by encrusting fauna such as sponges and solitary and colonial ascidians. This habitat also provides a refuge for a large range of reef fish and for juvenile and adult rock lobsters. Some abalone may also be present.

- Flat limestone pavement which occurs between the reef blocks and offshore from the high reef to a depth of about 15m. A veneer of sand occurs over some of the surface particularly in depressions while elevated areas of this habitat tend to graduate into low reef. The pavement is colonised by algae (*Sargassum* species) and seagrass (*Amphibolus* species) with small patches of kelp (*Ecklonia*) on higher areas.

- Low reef ridges which run parallel to the coast which are elevated about 1.5m above the surrounding limestone pavement, and which are located further offshore than the high reef. The upper surfaces of these reefs are colonised by the kelp *Ecklonia*, while other surfaces are covered by *Sargassum*, a range of red algal species and seagrasses (*Thalassodendrum*). Crevices, vertical surfaces and overhangs are covered by encrusting biota such as sponges and ascidians, and are used extensively by reef fish and rock lobsters.

- Limestone pavement which occurs over much of the seafloor in water depths greater than 10m. Much of this pavement is covered by a veneer of sand ranging from a few millimetres to 10cm to 20cm thick. This habitat is colonised by low density algae which attach to raised pieces of limestone, or bare areas that are temporarily exposed following storm activity before being re-covered. As the thickness of the sand veneer increases, the density of algae decreases. Red and brown algae including *Sargassum* species and seagrass (*Thalassodendrum*) occur where the sand veneer is thinnest, and a suite of red algal species occurs where the sand is deeper over the limestone pavement.

- Further again offshore and in depressions, the sand veneer overlying the pavement becomes thicker and a sandy seafloor habitat occurs. This habitat appears to be virtually devoid of marine life with no algae,

seagrasses, or fauna evident. Some burrowing fauna however, are likely to be present, as are bottom-dwelling fish such as dragonets, whiting and rays.

3.3.4 Ecology of the Marine Environment

The marine ecosystem at Oakajee is in near pristine condition. The shallow water habitats, those areas in less than 15m of water, such as the high reef, low reef and shallow limestone pavement, are important areas of primary productivity in the Oakajee area.

The process of primary production and nutrient flows in coastal marine waters is illustrated in Figure 9. Nutrient cycling occurs through either the consumption of organic material by grazers and herbivores in situ or by the detachment of plant material from the reef area. Consumed material is eventually released back into the ecosystem. Large volumes of seagrass and algae may also be detached by autumn and early winter storms. A proportion of this material accumulates on beaches and decomposes, providing nutrients and carbon to the near shore and offshore components of the coastal ecosystem. Fauna that inhabit the decomposing material, and which assist in the breakdown of the seaweed are a food source for juvenile and adult fish in the vicinity of the beaches.

The shallow habitats also form a refuge for marine fauna by providing crevices or caves in reefs, or shelter within algal and mixed algal seagrass communities. The marine fauna that utilise these areas include a wide range of reef fish and a large number of invertebrates including puerulis, juvenile and adult rock lobsters.

Other habitats, those areas in more than 15m of water, support a much lower biomass and are areas of lower productivity. Nevertheless, these habitats are colonised by benthic in-fauna and are a feeding ground for some fish species and also rock lobsters during their offshore migration.

Nutrient levels in south-western Australian coastal waters are generally low. The nutrients in the coastal ecosystem are tied up in the living biomass of the plants and animals in the system. In the Oakajee area, the Oakajee and Buller Rivers may contribute additional sources of nutrients to the ecosystem through sediment collected by runoff from agricultural areas. Nutrients may also be sourced from groundwater flows under these areas. There is no offshore upwelling of nutrients from deep oceanic waters to provide additional external nutrient sources. Without major external nutrient sources, internal recycling of nutrients assumes additional importance in the functioning of the coastal ecosystem.

3.3.5 Coastal Sand Movement

An understanding of sand or sediment movement along the coast at Oakajee is necessary, as the breakwater structures for the port will block this movement and therefore have the potential to cause beach erosion, particularly to the north of the port. Therefore, an assessment of accretion/erosion, and estimates of sediment transport rates along the coast at Oakajee were made for this PER using information gathered during a site inspection, empirical modelling

techniques, and from visual analysis of aerial photographs (MP Rogers & Associates, 1996 - report provided in Appendix 3). Shoreline movement plans are also being prepared and will be available prior to the EPA assessment of this PER. These plans are based on aerial photography and show changes in the shoreline over long time intervals which will enable verification of the predictions presented here. Detailed studies including modelling the impact of the port will be made when a preferred port design has been selected.

The general conclusions of the initial assessment are that:

- There is little movement of sand from south of the Buller River.
- There is little nett longshore transport of sediment at Oakajee by background swell conditions because of the presence of an extensive nearshore reef.
- The total nett transport of sand to the north each year is likely to be very small and in the order of approximately 5000m^3.
- Sea breeze conditions are liable to generate more sediment transport than swell conditions, with a nett northward sediment movement in the order of 10,000 to 20,000m^3/yr.
- Winter and summer storms also may generate longshore sediment movement in the order of 10,000 to 50,000m^3/yr but this is likely to be both to the north and south and there will be effectively no nett transport.

A summary of the estimated sediment transport due to wave and climate conditions is presented in Table 3.1.

TABLE 3.1

ESTIMATED LONGSHORE SEDIMENT TRANSPORT FLUXES AT OAKAJEE

Dominant Conditions	Longshore Sediment Transport		
	Magnitude (m^3/yr)	Direction	Zone
Background Swell	Minor	-	Beach
Sea-Breeze	10,000 - 20,000	Northwards	Beach
Storms	10,000 - 50,000 10,000 - 50,000	Northwards Southwards	Beach Beach
All of the Above	5,000	Northwards	Nearshore reef

To put this in perspective, on an exposed stretch of sandy coastline (devoid of any nearshore reef) experiencing similar meteorological and oceanographic conditions to those of the Oakajee coast, net longshore sediment transport in the order of 100,000 m^3/yr would typically be expected. Therefore, the nett longshore sediment transport at Oakajee can be expected to be less than 10% of the anticipated nett movement at a similar location with no nearshore reefs.

3.4 Terrestrial (Onshore) Environment

3.4.1 The Quindalup Dunes

The major land systems at Oakajee are illustrated in Figure 10.

The coastline is backed by a strip of sand dunes which were formed by wind action in the relatively recent geological past. These are part of the Quindalup Dune System which extends along much of the southern sector of the west coast of Western Australia.

The Quindalup Dunes near the coast comprise a low narrow foredune immediately behind the beach and then a series of large blowouts (or mobile dunes) and stable parabolic dunes and chaots as shown in the aerial photograph in Figure 5.

The dunes rise from the beachline to a height of about 85m AHD approximately 1km inshore where they abut a limestone plateau. The topography is shown in Figure 6. The limestone is part of an older dune system which was formed by the deposition of microscopic marine organisms in former near-coastal environments. There also may be sand deposits overlying the limestone to varying depths.

3.4.2 Vegetation and Flora

A flora and fauna assessment was commissioned by LandCorp in 1993 as part of environmental investigations for the Oakajee Industrial Estate PER (Dames & Moore, 1993). This survey included the coastal dunes and escarpment which are affected by the proposed port and service corridor.

An aerial photograph of the area showing the extent of remnant vegetation is given in Figure 5 and a remnant vegetation map is shown in Figure 11. The onshore area affected by the proposal is part of the Greenough System within the Irwin District of the South-Western Botanical Province (Beard, 1980). This system is associated with the coastal limestone and extends along the coast from Kalbarri to Dongara.

Aerial photography was used to delineate types of vegetation on the site, and these areas were subsequently examined on the ground. Seven vegetation types were defined, of which four may be affected by onshore port facilities. These four are:

- plants of the foredune or beach margin,
- vegetation on the mobile dunes between the beach and the escarpment,
- vegetation communities on the stable dunes, and
- a community which occurs on the limestone ridge and escarpment.

The foredune is colonised by low vegetation with the principal plant species being *Olearia axillaris, Acanthocarpus preissii, Salsola kali, Spinifex longifolius, Rhagodia preissii, Tetragonia decumbens* and *Threkeldia diffusa.*

The mobile dunes are sparsely vegetated but there are areas of low shrub vegetation where the principal species are *Acacia rostellifera* and *Acacia xanthina*, together with *Olearia axillaris, Spinifex longifolius, Rhagodia preissii* and *Clematis pubescens.* Large areas of mobile dune are located in the central and southern sectors of the Port Location Area, and a small area is located in the southern portion of the northern sector.

Stable dunes occur in the majority of the northern sector, in the southern portion of the central sector and in the northern portion of the southern sector. These dunes are covered by heath vegetation between 1m and 2m tall which is dominated by *Acacia rostellifera* and *Olearia axillaris* with *Acanthocarpus preissii* and *Spinifex longifolius* prominent in the lower stratum. Other plant species which are common in the heath include *Acacia xanthina, Alyxia buxifolia, Anthocercis littorea, Templetonia retusa, Rhadogia preissii, Threkeldia diffusa, Salsola kali, Atriplex* sp. and *Enchylaena tomentosa.* Introduced grasses are also widespread.

The limestone ridge and scarp community is dominated by heath, although shrubland over 2m tall occurs in some locations where wind-tolerant eucalypts and melaleucas have developed. The canopy cover varies from as low as 20% to as much as 90%, reflecting the patchy distribution of individual plants. This is associated with uneven distribution of underlying soil pockets among the limestone pavement.

The dunes have low floristic diversity with only 36 plant species recorded on the stable dunes, six species on the mobile dunes and seven species on the foredunes. All of these species are typical of near-coastal areas and no declared rare flora or priority flora species were recorded.

3.4.3 Vertebrate Fauna

The fauna assessment made by Dames & Moore (1993) suggests that the low heath and vegetation is likely to provide relatively few habitats and therefore the dunes are expected to support small fauna populations. However, the available distribution data for vertebrate fauna in the Geraldton Region indicate that a diverse suite of bird species may visit the area and that a number of reptiles and native mammals may also be present. It is considered unlikely that any gazetted rare species of fauna occur in the coastal dunes.

3.4.4 Groundwater

A hydrogeological investigation of the Oakajee industrial site was carried out during 1995/96 by Rockwater Pty Ltd (1996).

The investigation found that groundwater in the area forms a veneer within and above the contact between granulite bedrock and overlying sediments. Beneath the escarpment and the adjacent coastal dunes these groundwater-

bearing sediments are variously alluvial sand and silt, Tamala sand and limestone, and the Safety Bay sand of the Quindalup Dunes.

The groundwater passing beneath the escarpment and the coastal dunes westwards to the seawater interface is recharged by rainfall over the Oakajee plateau to the east. For the northern two-thirds of the coastline adjacent to the proposed industrial estate, the aquifer beneath the coastal dunes is separated from that beneath the industrial area by a granulite bedrock ridge extending above the watertable. The granulite has an extremely low permeability such that groundwater movement through it is likely to be very limited.

For the southern one-third of this section of the coastline this separation does not apply. Rather, groundwater beneath the coastal dunes receives inflow from thin sand and siltstone aquifers beneath the Oakajee plateau to the east. It is therefore likely that the flow of groundwater from beneath the industrial estate across the escarpment to the coastal dunes and the sea beyond is concentrated in this southern one-third of the site. More specifically, the Rockwater investigation suggests groundwater flow to be concentrated in a band approximately 500m wide comprising Tamala sand beneath the escarpment and alluvial sand and silt beneath the adjacent coastal dunes. Groundwater flows beneath the site are illustrated in Figure 12.

Because of the expected concentration of groundwater discharge to the ocean in this locality, it is an appropriate area for establishing monitoring bores to maintain a check on the quality of groundwater passing from the industrial site to the ocean, and for recovery bores should any contamination of groundwater occur in the future. This is considered to be the responsibility of the operators of the industrial estate and/or of specific industries within the estate.

3.5 Social Environment

3.5.1 Land Use and Zoning

The industrial site behind the escarpment is cleared farmland used largely for cereal and lupin cropping and grazing sheep (see Figure 5). Some grazing also occurs in the remnant natural vegetation along the limestone escarpment. The coastal dunes below the escarpment are in what may be regarded as a natural state.

The industrial site, the escarpment and a portion of the coastal dunes below it are freehold land. To the west of these, following the coastline, there is an area of Vacant Crown Land controlled by the Department of Land Administration dedicated to the purpose of a foreshore reserve. This land is zoned for Recreation, while that further to the east is zoned General Farming under the Chapman Valley Town Planning Scheme.

There is also an area of about 50ha on either side of the Buller River mouth which is a "Special Zone" in the Town Planning Scheme. The uses indicated for this area are holiday and tourist settlement, including caravan park, chalets, motel and other forms of accommodation, and recreation facilities. The adoption of

these uses is subject to acceptance by the Shire Council of a development and management plan and to their adoption of detailed zoning and development standards.

3.5.2 Tourism

The Department of Resources Development previously commissioned a study to determine the tourism potential of the Oakajee area. The study, undertaken by JLW Advisory Services Pty Ltd (JLW Advisory, 1994) did not identify any sites in the area that had the potential for major tourism development.

However, the study did identify two sites, at Buller River and Coronation Beach that had the potential for minor tourism and a further three sites were identified as having enhanced day visitation potential. These sites, which would provide for site-seeing, fishing and sailboarding, were

- Oakajee River (fishing and sailboarding);
- Oakabella Creek (fishing and sailboarding); and
- Ridgeview (extensive ocean views).

3.5.3 Recreational Use

The Oakajee coastline from Buller River to Coronation Beach attracts visitors for a variety of recreational pursuits.

The coast is popular for surfing and wave skiing near the Buller River mouth, while windsurfing is popular at a location near the Oakajee River mouth (Spot "X") and at Coronation Beach. A horse riding school also is located on the Buller River and riders occasionally use tracks through the dunes in the area.

The southern section of the coast, between the Buller and Oakajee Rivers, is regarded as an attractive location for beach and reef fishing (Department of Planning & Urban Development, 1993). However, access to the area is difficult, occurring via either the Buller or the Oakajee River mouth, with four-wheel drive required to proceed from here along the beach or on a track behind the frontal dune. There are no plans to improve this access.

The more popular section of coast is that between the Oakajee River and Coronation Beach. This is accessed via a gravel road from the North-West Coastal Highway to Coronation Beach. It is a safe, protected section of the coast, offering a wide range of activities including swimming, fishing, boating, snorkelling, reef harvesting, and windsurfing. Windsurfing in the region is further considered in Section 3.5.4.

Informal short term camping is permitted at Coronation Beach, and Chapman Valley Council intends to establish a formal camp ground there in the future.

This particular section of coastline has been degraded by access tracks through the dunes and by uncontrolled camping within the camping reserve. The Chapman Valley Coastal Plan recommended active management to address this problem

and to prevent further degradation, including rehabilitation of many of the informal tracks and upgrading of the camping reserve to cater for short stay visitors.

3.5.4 Windsurfing

The coastal area north and south of Geraldton is characterised by strong onshore winds particularly in the months of October to February. The Geraldton area attracts windsurfers from overseas, eastern Australia and Perth and Coronation Beach and Oakajee (Spot "X") have become popular locations for this activity.

Spot "X" is located within the Port Location Area, and the construction of a deepwater port within the northern sector would significantly impact on the use of this area of the ocean.

Data gathered by JLW Advisory (1994) suggests that the number of overseas visitors to Oakajee and Coronation Beach is relatively small, with the number of local peoples greatly exceeding the number of overseas visitors on weekends. The JLW Advisory study reports that "An informal count of riders on Saturday 2 January (1994) was up to fifty boards in the waters off Coronation Beach with a further forty being rigged or derigged on the beach. The next day with similar wind conditions there were fifteen to twenty riders and ten to twelve on the beach. At Oakajee there were about twelve riders on the Sunday and none on the following day".

JLW Advisory Services Pty Ltd (1994) concluded that the Oakajee River site (Spot "X") offers "tourism and recreational value of mainly local interest". The location may be considered as an alternative site for holiday/recreation activities, but had insufficient attributes to support development.

The results of a four-week survey conducted during the 1993-94 summer by Alan Tingay & Associates (1994b) found similar patterns of use at Coronation Beach, with an average of 30 windsurfers per day using the beach during the survey period.

The study undertaken by Alan Tingay & Associates (1994b) found that the two primary factors that influenced the selection of a location for windsurfing were;

i) wind and swell conditions at any given location, and

ii) the convenience of the location, ie. Coronation Beach was considered to be less convenient than Point Moore Beach, St George's Beach or Sunset Beach due to it's distance from Geraldton. This appeared to be more important during the week than on weekends, particularly with local windsurfers.

The majority of windsurfers surveyed, including non-locals, were found to windsurf at more than one location within the Geraldton region.

In comparison, meetings held with windsurfers from February to April 1997 as part of the community consultation program for the present proposal indicate that the Oakajee River site (Spot "X") in particular is considered to be very significant to the local windsurfing community which claims that more than 1,000 non-local visitors per year and many local windsurfers use this location.

It is the intention to further address this issue in a Recreation Plan that will be produced as part of the Coastal Management Plan for the proposal.

3.5.5 Recreational Fishing

Recreational fishing is widespread throughout the area (W. Godenzie, pers. comm.). The following types of fishing occur:

- net fishing,
- rod fishing,
- line fishing from boats,
- diving, and
- rock lobster pots.

These fishing activities are discussed below.

Net fishing occurs along the sandy beaches. South of the Buller River, hauling of nets only is allowed. Set nets, as well as haul nets, are also allowed north of the Buller River. The target species for netting are mullet, whiting, tailor and mulloway.

Rod fishing also occurs along the beaches with the main target species being tailor, mulloway and whiting. Tailor appear in one or more 'runs' migrating north along the beaches from November to February.

Diving for rock lobsters and spear fishing occur in all the reef areas where rock lobsters and reef fish are available. Rock lobsters are also caught using pots, either placed from off the beach where the reef is close inshore, or from small boats.

3.5.6 Commercial Fishing

Western Rock Lobster Fishery

The Western Rock Lobster fishery supports 668 lobster vessels using nearly 70,000 pots (George, 1993). The resource is harvested during the legal season between November and June of each year. The fishery is managed in respect to number of boats and pots, fishing technique and catch sizes. Detailed data are collected in order to ensure the sustainability of the harvest, and the annual catch is valued at over $250 million. The principal markets are in the USA, Japan and Taiwan. Between 1983 to 1993 the catch has averaged 10 million kilograms per year (Monaghan, 1989).

At Oakajee the coastal lobster fishery is mainly concentrated in the 0m to 20m depth zone. This zone encompasses a band extending for approximately 2km offshore. Pots are set amongst reef breakers with some pots being as close as 20m from shore. This 2km wide lobster fishing zone probably holds the same or a greater density of lobsters than occurs in the more reef protected waters in the fishing grounds to the south of Geraldton (George, 1993).

The Department of Fisheries records catch statistics in 'blocks'. The Oakajee block comprises a 17km x 17km zone and is worked by eight boats, however up to another 37 work the area intermittently, particularly during the 'white' season (George, 1993). Each boat is operated by two or three people and uses about 100 pots.

The statistics on total catch, catch of white and red rock lobsters, and catch in the nearshore (0-10 fathoms or 18m) area are shown in Table 3.2. Values provided in this table and discussed below are the 1996 price of $22/kg provided by N. Caputi (pers. comm.). These data provide the annual catch for the five year period 1991 - 1996 and the average for the same year.

Table 3.2 shows that:

i) The average value of the catch from the Oakajee block is $1,128,600.

ii) Of the annual average catch of 51,300kg, 41,983kg (82%) is caught in the nearshore waters (<18m depth).

iii) The average value of the catch from the nearshore waters is $923,626.

iv) The rock lobster catch in the nearshore waters has ranged from 2975kg (valued at $65,450) to 76,099kg (valued at $1,674,178) over the five year period 1991-96.

TABLE 3.2

OAKAJEE STATISTICAL BLOCK 283$^{\nabla}$ - ROCK LOBSTER CATCHES $^{\square}$

Financial Year	0-18m depth catch (kg)			All depths catch (kg)			Total ($)
	White^{+}	Red^{x}	Total	White^{+}	Red^{x}	Total	Value* ($22/kg)
1991-92	37,735	30,898	68,654	52,082	32,053	84,135	1,850,992
1992-93	25,268	11,896	37,164	28,378	11,895	40,274	886,028
1993-94	2,112	863	2,976	3,370	863	4,233	93,126
1994-95	40,821	35,279	76,100	63,525	35,279	98,803	2,173,666
1995-96	24,424	565	25,029	28,191	871	29,016	638,352
Annual Average	26,076	15,899	41,977	35,100	16,192	51,792	1,128,433

+ white rock lobsters
x red rock lobsters
* 1996 value (on beach) $22/kg (N. Caputi pers. comm.)
∇ Excludes Abrolhos Islands
$\square$ Data supplied by Fisheries Dept of W.A.

Other Commercial Fishing

Apart from rock lobsters, little professional fishing carried is out in the nearshore (<20m) waters at Oakajee (W. Godenzie, pers. comm.). Occasionally long line fishing occurs in waters further offshore than the port site.

Abalone are fished along the shoreline north of Geraldton but while they are present in the vicinity of the port site and may be fished once every few years, the local reefs do not provide a major contribution to the local commercial fishery.

Scallops occur in the deeper waters (beyond 30m), but scallop fishing is not allowed in the nearshore waters because of potential damage to rock lobsters and their habitat. Scallops that do occur in these nearshore waters generally occur as small isolated populations which exist in an area for a couple of years following a spatfall, but then die out. While these scallops do not directly form part of the commercial fishery, they may contribute as a source of larval recruits to scallop populations that occur in other areas.

3.5.7 Aboriginal Sites

Ethnographic and archaeological surveys of the Oakajee area were carried out as part of the assessment made for the proposed industrial estate (Tamora Pty Ltd, 1993; Bavin, 1993) and some years earlier for the Mitchell Plateaux Bauxite Project (Pearce, 1982). Further specific surveys of the coastal dune areas were made in association with the present PER (Tamora Pty Ltd, 1996; Quartermaine Consultants, 1996).

The various surveys identified a number of sites along the Oakajee and Buller Rivers and sites on the fringes of the industrial estate. In addition, a single site is located in the coastal dunes which may be impacted by the present proposal. However, the potential for impact on this site cannot be determined until the port location has been identified. Details are not provided in this PER in order to better protect the site from potential disturbance.

3.5.8 Post Colonisation Heritage Sites

Advice received from the Geraldton Maritime Museum indicates that there have been three known shipwrecks in the Oakajee area. These comprise the "Flora Dora", a 28-foot single-masted fishing boat wrecked in 1924 near the mouth of the Buller River, the "Evelyn Mary", an 18-ton cutter wrecked in 1981 about 16km north of Geraldton, and the "Cock of the North", a smack wrecked in 1907 about 18km north of Geraldton. The last two may be in the vicinity of the port site, but their exact location is unknown.

A European Heritage study conducted by the Mid-West Branch of the National Trust identified two onshore European heritage sites at Oakajee. One of these is located on the northern slopes of the Oakajee River valley and comprises the ruins of a two-roomed stone cottage referred to as "Chinaman's Hut". It was originally occupied by the McDonald family and later by a Chinese tomato grower. The other site is on the northern edge of the proposed industrial estate and comprises two lime kilns which were in operation until at least the 1930s.

3.5.9 Nearby Residents

There are relatively few houses on properties within or close to the proposed industrial estate as shown in Figure 13. LandCorp is currently negotiating with the closest land owners with the intention of acquiring their properties during 1997. It is probable that LandCorp will lease the houses back to the present owners or to other parties. The lease agreements however, will contain specific provisions which will oblige the tenants to accept that a reasonable amount of road traffic and noise associated with the industrial estate and port may occur in the general vicinity.

When Landcorp has acquired the properties in close proximity to the Industrial Estate, the nearest residences will be located to the east of the North-West Coastal Highway at a minimum of about 3.5 to 4km from the area in which a port may be located. The nearest residential area is at Drummond Cove, approximately 6km south of the Port Location Area (Figure 13).

4. IMPLICATIONS OF THE PORT ON THE ENVIRONMENT

4.1 Introduction

The EPA, in its Guidelines for this PER, has defined a series of relevant factors which it considers are particularly important for its assessment of the Oakajee deepwater port proposal. Relevant environmental factors are defined as those which have the potential to have significant environmental impacts, and which the EPA therefore may be required to report on to the Minister for Environment. A summary of the relevant factors is provided in Table 4.1 below.

TABLE 4.1

RELEVANT ENVIRONMENTAL FACTORS AND CORRESPONDING EPA OBJECTIVES

FACTOR	EPA OBJECTIVE
BIOPHYSICAL	
Marine	
Marine Fauna	To maintain the abundance, species diversity and geographic distribution of fauna.
Seagrass	To maintain the abundance, species diversity and geographic distribution of seagrass.
Macroalgae	To minimise interference with the cycling of nutrient and carbon from beach-cast seaweed.
Threatened and Priority Marine Fauna	Protect threatened and priority marine fauna consistent with the provisions of the Wildlife Conservation Act 1950
Introduced Marine Organisms	To minimise the risk of introduction of unwanted, non-indigenous organisms.
Coastal	
Shoreline	To maintain the stability of beaches.
Terrestrial	
Vegetation Communities	To maintain the abundance, species diversity, geographic distribution and productivity of vegetation communities.
Rare and Priority Flora	Protect rare and priority flora consistent with the provisions of the Wildlife Conservation Act 1950.
Terrestrial Fauna	To maintain the abundance, species diversity and geographic distribution of fauna.
Threatened and Priority Fauna	Protect rare and priority fauna consistent with the provisions of the Wildlife Conservation Act 1950.
POLLUTION	
Marine Water and Sediment Quality	To maintain water and sediment quality to accepted criteria to protect the environmental values of recreation, aesthetics, aquatic life for human consumption and maintenance of ecosystems in agreed areas.
Dust	To protect the surrounding land users such that dust emissions will not adversely impact upon their welfare and amenity or cause health problems and will meet EPA Guidelines for Assessment and Control Of Dust and Windborne Material from land Development Sites (updated 1995), and the Environmental Protection Policy (Atmospheric Wastes) (Kwinana).

FACTOR	EPA OBJECTIVE
Noise and Vibration	To protect the amenity of nearby residents from noise and vibration impacts by ensuring noise and vibration meet criteria in the Noise Abatement (Neighbourhood Annoyance) Regulation 1979, and the proposed Environmental Protection (Noise) Regulations (when promulgated).
SOCIAL SURROUNDINGS	
Public Health and Safety	To ensure risk is as low as is reasonably achievable and complies with acceptable standards. The EPA's criteria for the assessment of fatality risk of proposed hazardous and industrial developments are outlined in Bulletins 611 and 627.
Heritage (Indigenous and non-indigenous)	To comply with statutory requirements in relation to areas of cultural or historical significance.
Recreation	The concept should not compromise recreational uses of the area, as developed by planning agencies.

The discussion of the environmental implications of the Oakajee deepwater port proposal, which is given in this section of the PER, addresses the relevant factors. For each factor the EPA objective and EPA policies are stated, and a discussion of the environmental implications associated with the establishment of the port in the central, northern and southern sectors with respect to that factor is then provided. This is followed by commitments for environmental management by the proponent where appropriate, and a description of the proposed monitoring program where relevant.

The EPA also has recently published advice on the Oakajee Port Proposal sought by the Minister for the Environment under the provisions of Section 16(e) of the Environmental Protection Act, 1986. A summary of this advice for each environmental factor is provided in relevant parts of this section of the PER.

4.2 The Marine Environment

4.2.1 Types of Impacts

The types of impacts that a port facility at Oakajee may have on the marine environment can be divided into the following categories:

- Permanent impacts, eg. loss or modification of habitat due to the breakwaters and other facilities.
- Construction impacts, which occur only during construction and are thus temporary eg. turbidity.
- Operating impacts which occur (or may occur) during port operations and may be ongoing, intermittent or accidental (eg. spillages or maintenance dredging).

These impacts will be the same for each of the sectors.

Habitat loss or modification will occur where the breakwaters are placed, within the harbour, those areas where land is reclaimed, and onshore where service

corridors and other facilities are sited. For the preferred inshore port design option the area that may be affected is approximately up to 170ha of marine habitat, 60ha for the onshore storage area, and 30ha to 60ha for the service corridor depending on its location.

The construction of offshore structures will involve the dumping of rock and other fill materials from the end of the advancing breakwaters and the placement of fill or dredged material in the reclamation areas. These activities are likely to generate an increase in suspended sediments and sand transported by wave action in the general vicinity of the works. The majority of the sediment can be expected to settle in the potential impact area. Therefore, there is not likely to be any additional impact on the environment.

4.2.2 Seagrass

EPA Objective

To maintain the abundance, species diversity and geographic distribution of seagrass.

Policy Context

Seagrasses are an important element of the marine environment both as a habitat for flora and fauna and because they stabilise marine sediments. In southern Western Australia, seagrass meadows extend from Eucla on the south coast and along the west coast to the northern end of Shark Bay, covering a total area of about 2 million hectares (EPA, 1996).

EPA Section 16(e) Advice

The EPA notes:

1. There are no significant seagrass meadows in the Oakajee vicinity.
2. The seagrass/algal communities are well represented elsewhere.

In considering aspects of seagrass at this locality, it appears that implementation of the port concept plan is capable of being managed so as not to compromise the EPA's objective with regard to seagrass.

Potential Impacts

The general distribution of seagrass beds in the Geraldton Region is shown in Figure 10 of Appendix 2. This figure shows that shallow coastal waters to both the north and south of Oakajee support meadows of seagrass. However, no seagrass meadows are indicated within approximately 3km of the Port Location Area. This is probably due to the lack of offshore reefs and sheltered in-shore lagoons which are a requirement for the development of extensive seagrass meadows.

The marine survey carried out for this PER confirmed that extensive meadows are not present in the Oakajee region, but some seagrasses (*Amphibolus antarctica*

and *Thalassodendrum* spp) are present on limestone pavement between the 5m and 10m depth contours on the upper surfaces of lower reefs beyond the 10m depth contour, and (at low density) on the limestone pavement in deeper water.

The permanent removal of the habitats where seagrasses grow will vary according to which sector the port is located in. A description of the marine habitat in each of the sectors is provided in Section 4.2.4. The maximum area to limestone pavement, low reef and shallow sand mixture with significant densities of seagrass that may be affected by an inshore port is 80ha. This maximum impact would most likely occur if the port was located in the southern section. The area of this habitat that is likely to be affected in the northern or central sector is approximately 30ha.

Given the above information, the greatest impact on seagrass would occur if a port was to be located within the southern sector, due to the greater occurrence of shallow limestone pavement in this area. The least impact on seagrasses would occur in the northern sector .

The seagrass and algal communities that occur at Oakajee are well represented elsewhere along the coast of Western Australia. Given the extensive regional and State distributions of known seagrass meadows, and the absence of such meadows at Oakajee, it may be concluded that the establishment of a port within each of the sectors of the Port Location Area will not result in the destruction of significant areas of seagrass.

4.2.3 Macroalgae

EPA Objective

To minimise interference with the cycling of nutrients and carbon from beach-cast seaweed.

Policy Context

The decomposition and breakdown of beach-cast macroalgae, which comprises seagrass and algae, releases nutrients and particulate carbon to the near shore environment. Beach-cast macroalgal nutrients are considered to be a vital source of recycled nutrients for the coastal ecosystem as Western Australian marine waters are generally nutrient-poor. The contribution of nutrients from groundwater and rivers to the marine environment is not known at this stage.

The particulate carbon supports detrital-based nearshore food-webs that include benthic suspension feeders, nearshore fishes and beach waders.

At present substantial amounts of macroalgae accumulate on beaches at Oakajee.

EPA Section 16(e) Advice

The EPA notes:

1. Detailed studies are being conducted into the physical characterisation of the coast, including longshore sediment transport and the studies of seaweed accumulation.

2. The additional investigations underway into the behaviour of seaweed and beach-cast to provide information to form a basis for a strategy to maintain nutrient recycling.

3. The availability of management measures for seaweed accumulation and distribution.

In considering aspects of beach-cast seaweed at this locality, any future port proponent should take account of, but not be limited to, the following:

1. Detailed studies being conducted into the physical characterisation of the coast, including longshore sediment transport and the studies of seaweed accumulation.

2. Baseline monitoring of volumes and seasonal characteristics of seaweed accumulation.

3. Investigation of the option of a trestle construction over the beach platform during the detailed engineering design.

4. Application of management measures and the development of a strategy to manage seaweed accumulation, based on the results of monitoring and circulation studies.

Should the above occur, it is likely that implementation of the port concept plan is capable of being managed so as not to compromise the EPA's objective with regard to beach-cast seaweed.

Potential Impacts

The marine survey carried out for this PER revealed that macroalgae are present at Oakajee on reef tops in the high reef area which extends from the shore to approximately the 5m depth contour, on limestone pavement which extends between the 5m and 10m depth contours, on upper surfaces of low reef ridges beyond the 10m depth contour, and (at low density) on the limestone pavement in deeper water. The macroalgae are present in these habitats along the coastline between the Buller and Oakajee Rivers, and they are also extensive in the Geraldton region, particularly in association with limestone reef areas.

Given the distribution of macroalgae in various marine habitats, and the presence of these habitats within each of the sectors of the Port Location Area,

it is considered that the port would have a similar impact on macroalgal communities in each of the sectors.

The proposed port development may lead to preferential accumulation of macroalgae on one side of the port structure as this material drifts under the influence of longshore currents. This in turn may lead to reduced deposits of wrack on beaches to the north of the port proposal.

The accumulation of macroalgae against the port structures also may cause increased productivity in areas where accumulation occurs. Redistribution of seaweed on nearby beaches will most likely occur but nutrients and carbon which derive from the decomposition of seaweed will not be removed from the local ecosystem.

The decomposition of this material can give rise to offensive odours but given the distance of the port from residential areas (a minimum of approximately 6km to Drummond Cove) and the prevailing winds, offensive situations are not expected to develop.

The accumulation and distribution of sea wrack will be monitored, and any significant build-up of sea wrack will be managed as appropriate. Accumulated material may be removed or relocated by mechanical techniques on to beaches or in the littoral stream. The water quality monitoring program also will include assessments of levels of nutrients, and this will provide an indication of any significant decrease in the marine environment.

Commitments

The following commitments are made with respect to the accumulation of sea wrack on the shoreline:

- The port operator will monitor the accumulation of sea wrack on the shoreline between the Buller and Oakajee Rivers on an ongoing basis and will take appropriate steps to overcome any adverse impacts, as required.

- The port operator will manage any large accumulation of sea wrack against the breakwaters by mechanical or other means of collection and will redistribute the wrack to other sections of the coastline in the Special Management Area or into the littoral stream where there is evidence that the sea wrack accumulation may have been reduced. Any such operations will be subject to approval by the Department of Conservation & Land Management.

- The port operator will ensure that the Water Quality Monitoring Program associated with the port is designed so that it will detect any significant variations in nutrient levels which may be attributable to changes in the distribution of sea wrack in the near-coastal marine environment.

4.2.4 Marine Fauna

EPA Objectives

To maintain the abundance, species diversity and geographic distribution of marine fauna.

To maintain the ecological integrity and biodiversity of the marine ecosystems of Western Australia.

Policy Context

The EPA has recently published a policy for the Protection of Benthic Primary Producer Habitats in the Coastal Waters of Western Australia. The primary objective of this policy is:

- To protect the environment as defined by the Environmental Protection Act, 1986 (EP Act) 1986) with focus on state coastal waters in the context of activities which may directly or indirectly affect key benthic producer habitats.

EPA Section 16(e) Advice

The EPA notes:

1. The marine environment in the Oakajee locality is similar to that elsewhere on the Mid West Coast.

2. No significant marine habitat and ecosystems is likely to be impacted.

3. The western rock lobster occurs widely in the region.

In considering aspects of marine fauna at this locality, any future port proponent should take account of, but not be limited to, the following:

1. A requirement and commitment to ongoing monitoring and management of the water body within the harbour and the port's adjacent waters.

Should the above occur, it is likely that implementation of the port concept plan is capable of being managed so as not to compromise the EPA's objective with regard to marine fauna.

Potential Impacts

A comprehensive survey of marine habitats was made for this PER (Appendix 2). This concluded that the habitats at Oakajee were similar to those recorded at Point Moore and Georgina. (Monaghan Rooke and Robinson, 1993). In addition, both Point Moore and Georgina are similar to other coastal areas surveyed on the Rottnest shelf at Cape Peron (LeProvost Semeniuk and Chalmer, 1981),

Quinns Rocks (LeProvost Semeniuk and Chalmer, 1984a) and Sorrento (LeProvost Semeniuk and Chalmer, 1984b).

Habitat loss or modification will occur where the breakwaters are placed, within the harbour, where dredging will occur, and depending on final design, in reclamation areas. For the purposes of this PER, it is assumed up to approximately 170ha of marine habitat will be affected. It is also assumed that the greater proportion of impact will occur from the shoreline out to the 10m depth contour. This would represent approximately 75% of the total impact area, or approximately 130ha of the total development.

The primary environmental impact will be between the coast and the 10m depth contour as the deep limestone pavement which occurs at greater depths is colonised by a low density of algae and small populations of seabed fauna and fish.

In contrast, the high reef out to the 5m depth contour supports a diverse range of biota including reef fish, and it is also a major habitat for juvenile and adult rock lobsters. The shallow limestone pavement further offshore out to the 10m depth contour supports less biota and is colonised by algae and kelp. The sections of low reef which rise above the limestone pavement however, provide attractive habitat for both reef fish and rock lobsters.

A discussion of the significance of the area to rock lobsters is presented in Section 5.2.

The impact of the port on the marine habitats and substrates will vary from sector to sector, but it is not possible to identify the total area of each habitat that would be affected by the construction of a port until the final design is determined. A summary of the habitats within each sector is provided below.

- ***Central Sector***

High Reef extends along the entire nearshore zone to approximately the 5m depth contour of the central sector, although there is a small area of shallow sand adjacent to the coast in the southern part of the sector. A mixture of shallow pavement, low reef and shallow sand is predominant between approximately the 5m and 12m depth contour in the northern half of the sector, whilst areas of shallow sand are predominant in the southern portion of the sector.

If a port were to be located within this sector, approximately 108ha of high reef would be directly impacted by the proposal. Approximately 4ha of shallow sand, 30ha of shallow pavement, low reef and shallow sand, and 5ha deep pavement and deep sand would also be directly impacted by the development.

- ***Northern Sector***

This sector is dominated by areas of shallow sand, extending out from the Oakajee River mouth to the 10m depth contour. In the southern portion of this sector there are areas of high reef interspersed with a mixture of shallow pavement, low reef and shallow sand. An area of high reef is also present in the northern portion of the sector above the Oakajee River. Between approximately the 5m and 12m contours there is a balance of shallow sand and a mixture of low reef and shallow pavement.

The location of a port within the northern sector would directly impact up to approximately 42ha of high reef, and 57ha of shallow sand. In addition, approximately 30 ha of shallow pavement, low reef and shallow sand and 8ha of deep pavement and deep sand would be directly impacted by the port proposal.

42
30
8
80 ha

- ***Southern Sector***

The southern sector is dominated by a mixture of low reef, shallow pavement and shallow sand. There is an area of high reef above the 5m contour, although this reef system is displaced by shallow sand, low reef and shallow pavement towards the southern portion of the sector. Areas of shallow sand predominate around the 10m depth contour.

A slightly larger area of marine habitat would be directly impacted by the port proposal if it were to be located within the southern sector as the depth contours are closer to the coast in this location. This means that a larger area has to be dredged to accommodate the approach channel for the port.

45
26
80
151

If the port were to be located in this sector, approximately 45ha of high reef and 26ha of shallow sand would be directly impacted. Approximately a further 80ha of shallow pavement, low reef and shallow sand, and 6ha of deep pavement and deep sand would also be impacted.

- ***Summary of Relative Impacts***

On the basis of the above, the least impact on highly diverse high reef habitat would occur if the port was located in the northern sector and the most impact would occur in the central sector. This impact in the central sector was described in the strategic environmental review of the port concept plan (Welker Environmental Consultancy, 1997). On the other hand, a port located in the southern sector would have the greatest impact on the least diverse shallow pavement, low reef and shallow sand habitat.

The types of habitat which will be impacted by the port structures however, occur for many kilometres along coastlines in the Geraldton region (Monaghan Rooke & Robinson, 1993; Alan Tingay & Associates, 1996). The regional implications of the deepwater port in terms of loss of marine habitats therefore is considered to be minor.

Commitment

A commitment relating to the monitoring and management of water quality is included in Section 4.2.7.

4.2.5 Threatened and Priority Marine Fauna

EPA Objective

Protect threatened and priority fauna consistent with the provisions of the Wildlife Conservation Act 1950.

Policy Context

Most marine biota produce large numbers of offspring which are widely dispersed by oceanic currents. Consequently these biota are distributed widely and occur in large numbers in comparison to their terrestrial counterparts. As a result, rare and endangered species are generally not a feature of marine fauna. Particular marine mammal and reptile species however, have been identified as in need of special protection and are listed below.

A list of specially protected fauna is published under the Wildlife Conservation (Specially Protected Fauna) Notice (1996) of the Wildlife Conservation Act (1950). These species are wholly protected through out the State at all times and include the following marine species:

- *Balaenoptera borealis*, Sei Whale
- *Balaenoptera musculis*, Blue Whale
- *Balaenoptera physalus*, Fin Whale
- *Eubalaena australis*, Southern right Whale
- *Magaptera novaeangleae*, Humpback Whale
- *Caretta caretta*, Loggerhead turtle
- *Dermochelya coriacea*, Leathery Turtle or Luth
- *Arctocephalus forsteri*, New Zealand Fur-seal
- *Neophoca cinerea*, Australian Sea-lion
- *Dugong dugon*, Dugong

Potential Impacts

Humpback, Southern Right and Blue whales migrate through the Geraldton region. Sea-lion colonies exist in the Abrolhos Islands and the Geraldton Harbour. The number of colonies and individual animals appears to be increasing (W. Godenzie, pers. comm.). Dugongs normally live in Shark Bay and further north, but have been occasionally sighted in small numbers in the Geraldton area. They appear not to be able to survive the low water temperatures and severe winter storms along this exposed coast (R. Prince, pers. comm.).

The Loggerhead and Leathery Turtles apparently do not occur in the area, but the Green Hawksbill (a non-declared species) is occasionally seen in the Geraldton region. These are essentially tropical animals which normally live further north.

The Oakajee site is not important for the survival of any of the above species.

An unusual coral has recently received attention in the Geraldton area because of its perceived rare and endangered status. Known as "black coral", this is one of a group of soft corals whose living skeleton is harvested in other parts of the world and then polished and used to make jewellery. A few specimens of black coral were observed at Point Moore in recent years and concern was raised at their presence in relation to the proposed deepwater port there. Black corals normally inhabit deep water where they occur in large numbers, but occasionally occur in low numbers in the less preferred habitat of shallow water such as at Point Moore.

There does not appear to be any suitable habitat for large populations of black coral at the Oakajee site, and this species was not located during the marine survey for the PER.

It is considered that the impact of the port on threatened and priority fauna will be the same for each sector of the Port Location Area.

4.2.6 Introduced Marine Organisms

EPA Objective

To minimise the risk of introduction of unwanted, non-indigenous marine organisms.

Policy Context

The main potential entry vector to Australia for unwanted marine flora and fauna is via the hulls and ballast water of vessels entering Australian ports. Subsequent spread of introduced flora and fauna within Australian waters occurs via natural processes and by ship movements. There are over 70 trading ports in Australia which receive international and/or coastal shipping. These ports receive over 10,000 ship visits and around 160 million tonnes of ballast water each year.

The marine environment at Oakajee is well represented elsewhere along the Western Australian coastline. However, the area is part of the important western rock lobster fishery.

The Australian Quarantine Inspection Service (AQIS) has introduced the Australian Ballast Water Management Strategy, which is designed to reduce the risk of introduction of unwanted organisms.

EPA Section 16(e) Advice

In considering aspects of introduced marine organisms at this locality, any future proponent should take account of, but not be limited to, the following:

1. Implementation within Australian ports of the Australian Ballast Water Management Strategy.

2. The development through the International Maritime Organisation of a mandatory ballast water management code.

3. Regular monitoring of the port area for introduced marine organisms.

Should the above occur, it is likely that implementation of the port concept plan is capable of being managed so as not to compromise the EPA's objective with regard to management of the risk of introduction of exotic marine organisms.

Potential Impacts and Management

The introduction of exotic species may adversely impact on natural marine ecosystems. Control of ballast water is the primary method of preventing the introduction of such species. As a result, AQIS has produced the Australian Ballast Water Management Strategy (1995). Research programs have also been initiated by the Centre for Research on Introduced Marine Organisms based in Hobart, and many ports are currently being monitored for the presence of exotic organisms.

Within the Strategy, management options involve a variety of measures designed to ensure that ballast waters are free of introduced flora and fauna. These measures include exclusion of sediment, ballast water exchanges elsewhere than in Australian waters, and treatment of ballast water onshore. Other measures used in ports include the prohibition of hull scrubbing, and regular monitoring of harbour waters for the presence of introduced organisms. The risk of introduction of unwanted marine organisms will be minimised as a result of the above latest management and monitoring measures and the prospect of continual improvement of such measures.

The implications of the port in terms of introduced marine organisms will be the same for each sector of the Port Location Area.

Commitments

The following commitments are made with respect to the management of ballast water:

- The port operator throughout the life of the port will routinely check that the Australian Ballast Water Management Strategy and/or any other management procedure for ballast water recommended by AQIS or any other Commonwealth, State or International agency which may have responsibility for the management of ballast water in the future are complied with.

- The port operator will implement a monitoring program to detect the presence of toxic dinoflagellates in the harbour of the Oakajee port. This program will be initiated prior to the commencement of shipping operations, and will occur on a bi-annual basis thereafter. The results of the monitoring program will be provided to the DEP and to any other agencies nominated by that department.

4.2.7 Marine Water and Sediment Quality

EPA Objective

To maintain water and sediment quality to accepted criteria to protect the environmental values of recreation, aesthetics, aquatic life for human consumption, and maintenance of ecosystems in agreed areas.

Policy Context

The Western Australian EPA has developed Water Quality Guidelines to protect the environmental values of marine waters (EPA, 1993).

The DEP also recently published the results of the Southern Metropolitan Coastal Waters Study (DEP, 1996) which outlines Draft Water Quality Objectives proposed by the EPA and DEP for Oakajee. Water and sediment quality criteria have been proposed for each draft objective. However, under this study, exclusions zones may be designated for harbours and also around industrial and naval wharves where certain environmental values may not be protected. The EPA also has yet to formalise its advice to Government on the recommendations of the study.

The spatial application of environmental quality guidelines or criteria will need to consider:

- The natural conditions of high turbidity to which the biota in the Oakajee area are already adapted.

- The dimensions of the port operation area which includes the harbour basin and other areas where ship movements will occur.

Western Australian Marine Legislation, administered by the Department of Transport (DOT), enables the control of marine pollution from vessels and ports. Some of the measures used to control pollution include:

- Guidelines for wastewater disposal from ships.
- Spillage Management Plans.
- Oil Spill Contingency Plans.
- Dredging and Dredge Spoil Disposal Management Plans.

Regulations under the Environmental Protection Act, 1986 control the use of Tributyltin in antifouling plants for vessels under 25m in length. The use of this substance on large vessels is not recommended under international guidelines.

EPA Section 16(e) Advice

In considering aspects of marine water and sediment quality, any future proponent should take account of, but not be limited to, the following:

1. The Port Authority should be involved in the 'National Plan to Combat Pollution of the Sea by Oil', and to prepare a 'Port Safety Plan', which incorporates risk assessment.

2. The Port Authority should provide for ships' waste.

3. The Port Authority should ensure the efficient handling of cargoes to prevent overspill.

4. The regular monitoring of the harbour and the surrounding waters in accordance with the Marine Management Plan.

5. Collection of baseline data on water and sediment quality in the port area.

Should the above occur, it is likely that implementation of the port concept plan is capable of being managed so as not to compromise the EPA's objective with regard to marine water and sediment quality.

Potential Impacts and Management

The impact of the port on marine water and sediment quality will be the same for each sector of the Port Location Area.

The marine environment outside the Port Operational Area may have the following environmental values (corresponding with the Draft Environmental Quality Objectives in DEP, 1996):

- Maintenance of aquatic ecosystems for multiple uses or as industrial buffer.
- Aquatic animals which are harvested for human consumption.
- Aesthetics.
- Recreation. (Including fishing and direct contact recreation)

Potential changes to water quality that may occur during the construction phase of the project include:

- Turbidity from breakwater construction and dredging operations.
- Accidental spillage.

The full extent of potential operating impacts will depend to some extent on the nature of industries that may use the port in future. For example, the export of bulk minerals may involve some spillages which may in turn affect water quality and sediments within the harbour. Activities or events however, that may be associated with the port operations are as follows:

- Accumulation of Tributyltin (from antifoulant paints on ships) and zinc from sacrificial anodes in the harbour.

- Accidental spillage of wastes from ships.
- Accidental oil spills.
- Unauthorised discharge of ballast water.
- Maritime accidents.
- Cargo spillages.
- Stormwater discharge.
- Maintenance dredging and breakwater reconstruction.

There is also a possibility that water circulation within the harbour will be reduced as a result of the breakwater structures and that this will contribute to a reduction in water and sediment quality.

Each of these matters is discussed below.

Dredging

Extensive dredging will be required in the construction of an inshore port option. Dredging causes sediment to be suspended in the water column and, in the absence of management control, this could add to the natural turbidity and possibly cause environmental impact. In the case of the inshore option however, turbidity associated with the extensive dredging of the harbour may be contained within the breakwaters.

Increased turbidity can reduce light penetration to photosynthetic algae and sea grasses, inhibit filter feeding animals and larval recruitment of benthic biota, cause mechanical damage to benthic fauna, deplete oxygen and cause nutrient enrichment.

The near-shore marine habitats however, are subject to relatively high wave energy under natural conditions and this leads to high natural turbidity levels and significant natural sand movement offshore (George, 1993). These natural conditions suggest that the biota are adapted to high turbidity and that it therefore will not be affected by any sediment dispersion and turbidity associated with the construction works.

It is expected that the DEP will require the preparation of a Dredging and Dredge Spoil Disposal Management Plan (DDSDMP) prior to the granting of any licence for dredging at Oakajee. A DDSDMP is generally required to specify:

- How the dredge operations will be conducted and what environmental management measures will be in place.
- Where the dredged spoil will be placed and how it will be contained to limit the dispersion of suspended sediments.

- A monitoring program designed to measure a range of water quality parameters around the dredge and spoil placement areas before, during and after the dredging operation.

It is generally required that the dispersion of suspended sediment be controlled through the use of silt curtains and through the timing of operations to coincide with months when sea conditions and water circulation conditions are less conducive to sediment dispersion. The precise measures in the management plan however, will be determined in consultation with the DEP when the construction requirements are known. It is also expected that specific boundaries will be defined for the dispersal of sediment in the Special Management Area (SMA) and that the dredge operations will be modified or temporarily suspended if sediment plumes disperse beyond these boundaries. The transport of suspended material in the SMA is likely to be complex and will depend on daily wind and tide conditions during the dredging operations and on settlement rates for the sediment.

The dispersion of sediment from reclamation areas can be limited through the use of geotech style liner covered with sand on the inside face of the containment rock bund. This system acts as a filter allowing water in the spoil slurry to drain through the bund back to the ocean while at the same time effectively containing the sediment.

Maintenance dredging may be required if sediment build up occurs in any shipping areas. It is anticipated however, that any such requirement will be very infrequent (perhaps once a decade) and relatively small scale and any impacts will be transient and localised. Nevertheless, a specific DDSDMP will be prepared for any maintenance dredging operations.

Turbidity and turbulence also will result from shipping movements. However, the area in which these effects will occur is small and restricted largely to the inner harbour and the shipping lanes approaching the port. Both of these areas largely consist of sandy seafloor which supports a low-diversity biota. The effects of shipping movements on the environment therefore will not be significant.

Spillage of Wastes

Minor sources of wastewater that may enter the harbour could include ship discharges such as condensation waters and water used for cleaning the decks of ships. Specific operational guidelines are in place in many ports to control such discharges. For instance, the GPA requires that any vessel needing to discharge wastewater must contact the Authority, which will in turn arrange for a liquid waste truck to take the waste for disposal to a suitable onshore disposal site. The GPA also prohibits wash-down of vessels in harbour. The implementation of similar methods at the proposed port will reduce the likelihood of contaminated waste entering the harbour. The treatment of liquid wastes removed from ships will be dictated by the nature of the waste.

For the export of materials, all ships entering a harbour are inspected prior to loading. If a ship's hold contains material from the previous cargo that may contaminate the export cargo, then the ship is classified as 'dirty' and must be

cleaned prior to loading. It is current practice in the existing Port of Geraldton to prohibit the removal of this material from the ship, and the waste is stored on the ship so as to minimise the potential for spillage into the harbour. It is anticipated that these management practices also will be implemented at the proposed port.

All other solid wastes removed from a vessel are subject to quarantine regulations, which are administered by the Australian Quarantine and Inspection Service. Quarantine wastes must be handled in such a manner so as to prevent the accidental discharge of material onto the berth or into the harbour.

Stormwater

Given the low rainfall of the area, and also the low incidence of storm events, only minor stormwater flows are expected from port structures at Oakajee. This, combined with good port management practices, is likely to have a negligible effect on the marine water quality.

Oil spills

Oil spills can occur during handling mishaps, bunkering accidents, and ballasting and tank cleaning operations. The risk of spillages of oil and oil derivatives is considered to be minor because:

- The operation of the port involves only refuelling of vessels which use the port.
- It is unlikely in the short to medium term that oil tankers will use the port. Any proposal to berth and unload tankers also will be subject to specific safety procedures and to the approval of the EPA and the Department of Minerals and Energy.
- All ports are required to have an oil spill contingency plan for the control and clean-up of oil spills. These plans must be approved by the Department of Minerals and Energy, and the WA State Committee for Combating Oil Pollution at Sea. If a spill were to occur then management procedures will minimise its degree and area of impact.

Whilst not all ships using the port will require refuelling, it is possible that some refuelling activities will occur. In the long term, this may require the installation of storage tanks and pipelines at the port, and the development and implementation of procedures to minimise the potential for spillage into the harbour. Accidental spillages would be managed through the implementation of the oil spill contingency plan. Any such proposals for the establishment of fuel storage and refuelling facilities at the port will be referred to the EPA and DME for consideration.

Antifoulants and Corrosion Protection

Antifouling paints on large boats may contain tributyltin which can have adverse effects on the biology of marine organisms and can be concentrated in the flesh of filter feeders such as molluscs. The use of tributyltin on small vessels less than 25m in length is controlled by regulations introduced in 1991 under the Environment Protection Act (1986) and international guidelines recommend against the use of this compound on larger ships. Nevertheless, tributyltin is still used and it is very likely to be detectable in the port at Oakajee.

The degree of contamination by tributyltin and zinc will depend on the number of ship movements and the rate of reduction in the use of the former in antifoulant paints. It is expected that detectable levels of tributyltin will be restricted to water and sediment in the harbour and in the vicinity of approach channels. The expected levels are not likely to affect biota outside of the harbour based on the results of the Southern Metropolitan Water Study.

The use of sacrificial anodes in ports to prevent corrosion may also result in the accumulation of zinc in the local marine environment, but it is most unlikely that contamination by zinc will be environmentally significant.

Accidents and Cargo Spillages

Maritime accidents where a vessel runs aground or sinks when entering or leaving a port are potential hazards that need to be considered, however unlikely. This risk is common to all ports. However, with modern navigational aids, standardised navigational procedures, seaworthiness and safety inspections, there have been very few such accidents in Western Australia over the last decade.

The approach lanes to the port for ships will be located in deep water insofar as practicable where there are no offshore reefs or other potential obstacles. This will further reduce the risk of maritime accident.

It is general practice for a Port Authority to prepare an Accidental Spillage Management Plan to minimise risks and impacts from any new cargo that could potentially be dangerous to the marine environment. Accidental spillages of materials such as fuel are possible but the likelihood of such spillage can be negligible with good management and auditing practices.

Water Circulation

Water circulation and adequate water exchange with the surrounding sea are important factors in maintaining acceptable environmental quality standards within the harbour. Preliminary advice received from MP Rogers and Associates is that the water circulation at Oakajee is likely to be significant for the port design options currently under consideration, and that water exchange between the harbour and the surrounding sea will be relatively rapid. This advice is based on existing knowledge of the direction and energy of ocean conditions in the Oakajee area.

During the conceptual design phase for the proposal, consideration was given to the use of culverts in any causeways incorporated into the port designs in an effort to facilitate flushing and therefore improve water quality in coastal areas adjacent to reclamation areas (Port and Harbour Consultants, 1996). The culverts were shown to be relatively ineffective in view of the restricted potential of coastal waters to develop through flow, resulting in negligible exchange with the large water body in the shadow of the breakwater. Jetties and bridges were also considered for the offshore harbour options to assist in the facilitation of water exchange. These structures also were not considered to significantly enhance water circulation in the vicinity of the harbour.

The assessments required to predict water circulation and exchange are relatively complex and involve the collection of physical data on wind, waves, currents and bathymetry; and computer modelling for a range of environmental conditions. This process is time-consuming and involves significant costs and cannot be completed until a final port design has been chosen. However, the necessary studies have commenced and it is expected that initial results will be available prior to the EPA assessment of this PER.

A specific assessment of water circulation and exchange will be made as part of the detailed design study for the port and the design will be modified if necessary to achieve acceptable levels.

Sediments

It is to be expected that sediments on the seabed within the harbour at Oakajee may become contaminated over time due to spillages associated with the loading of bulk cargoes such as minerals. Such spillages can be limited by appropriate design of loading systems (eg. the use of dust shrouds) and by management procedures, but cannot be eliminated entirely. There is similarly the possibility of contaminants arising from ship-cleaning activities, and from the breakdown of paint on ships' hulls.

All of these factors are likely to be minor for the cargoes which are at present predicted for export through Oakajee, as these comprise slab and billet steel, and hot briquetted iron, none of which generates significant dust or other contaminants. In the longer term however, cargoes may include iron ore and other products which may be difficult to manage comprehensively.

Given this potential, the management objective of the port operator will be to limit detectable increases of heavy metals and other contaminants in sediments to within the main Port Operations Area as defined in Section 2.2 of this PER. Elsewhere, i.e. in the Special Management Area and the Statutory Control Area relating to the port, the objective will be to maintain water and sediment quality criteria to levels within the range of those recorded during the pre-development monitoring program. A summary of the proposed sediment monitoring program is provided in Section 6 of this PER.

Commitments

The following commitments are made with respect to marine water quality:

- The port operator will, prior to construction, prepare a Marine Management Plan that will include the following;

  - a Construction Management Plan in accordance with the requirements of the DEP. All contractors will be required to comply with this plan, which will specify measures designed to prevent marine pollution and to limit the impact on the marine environment.

  - a Dredging and Dredge Spoil Disposal Management Plan (DDSDMP) in the event that the final port plan involves dredging. This Management Plan will be prepared in accordance with the requirements of the DEP and will include a monitoring program for water quality in and within a relevant distance of the works area. The DDSDMP and all results of the monitoring programs will be made available to the general public.

  - an Oil Spill Contingency Plan to the satisfaction of the Department of Minerals and Energy, the Department of Environmental Protection, and the WA State Committee for Combating Oil Pollution at Sea.

  - a Waste Management Plan of port operations prepared in accordance with the requirements of the DEP. This plan will specify management procedures for the collection and disposal of waste discharges from ships, and will regulate wash-down of ships in harbour.

  - an Accidental Spillage Management Plan to the requirements of the Department of Minerals and Energy.

  - a Water Quality Monitoring and Management Program in accordance with the requirements of the DEP. A summary of the scope this monitoring program is provided in Section 6 of this PER.

  - a Sediment Monitoring and Management Program. This program will involve bi-annual samples following construction. All samples will be analysed for a range of heavy metals and other potential contaminants. The results of the monitoring program will be provided to the DEP.

- The port operator will commission a detailed study of water circulation and water exchange in the harbour at Oakajee following the adoption of a final design for the port. The results of this study will be supplied to the DEP and other relevant government agencies, and will be used to refine the port design if necessary to achieve better performance with respect to water exchange.

Other commitments relevant to the EPA Section 16(e) advice are provided in Section 4.6.1.

4.3 The Shoreline

EPA Objective

To maintain the stability of beaches.

EPA Policy Context

The movement of sediment north and south along the coast is part of the natural physical process along the shoreline. Whilst there is a net northward movement of sediment, the movement is relatively constant and supports the ongoing erosion and accretion processes which have created physical attributes of the current coastline.

EPA Section 16(e) Advice

The EPA notes:

1. The preliminary results of the study of longshore sediment transport.

2. That detailed studies into the physical characterisation of the coast, including accretion, erosion and longshore sediment transport are underway.

3. The undertaking by the Department of Resources Development to investigate the option of a trestle construction over the beach platform during the detailed engineering design.

In considering aspects of the shoreline at this locality, any future port proponent should take account of, but not be limited to, the following:

1. Detailed studies into the physical characterisation of the coast, including accretion, erosion and longshore sediment transport, and the provision of appropriate sand by-pass, based on the results of studies.

2. Preparation of a Coastal Management Plan incorporating sand and foreshore management provisions, as part of the EMP.

Should the above occur, it is likely that implementation of the port concept plan is capable of being managed so as not to compromise the EPA's objective with regard to the maintenance of coastal stability.

Potential Impacts

The impact of a port on the shoreline will be equivalent for each sector of the Port Location Area

The port will form a very effective barrier to longshore sediment transport, both along the beach and along the nearshore reef.

The port is also expected to create a considerable wave shadow on the beach for a distance of up to 3km north from the tip of the southern breakwater and up to 1km to the south. The term "wave shadow" has been used here in a relatively loose sense. It does not mean that there will be no waves reaching this stretch of coast. Rather, under different conditions, some areas with the wave shadow will receive substantial protection from wave energy, while other areas will not.

For example, under sea breeze conditions, the stretch of coast north of the port is expected to be substantially protected from the sea breeze waves which arrive from between the south-west and southerly directions. The level of this protection will increase closer to the port structures. Under these same conditions, the coast south of the port will be fully exposed.

On the other hand, during the early stages of winter storms, when the winds and waves are arriving from the north-west, most of the coast north of the port is expected to be fully exposed. However, the port structures will offer considerable protection to the coastline to the south under these conditions, with protection increasing towards the breakwater. During the latter stages of winter storms, when the direction of the waves has swung to the south-west, the situation is reversed, and would be similar to that described for the sea breeze.

The effects of the proposed port structures on the background swell are considerably more complicated. These long period waves are substantially more affected by refraction and diffraction process, and as a result are expected to penetrate into much of the previously described wave shadow. However, as already discussed, very little longshore sediment transport is believed to be generated by the background swell, due to the high protection afforded by the nearshore reef. This is not expected to significantly change as a result of the proposed port.

The net result of these effects is that sediment accretion and erosion is expected in various areas in the vicinity of the port and adjacent coastline. Northward longshore sediment flux generated by sea breezes and winter storms will be intercepted by the port. It is expected that much of this material will be trapped in the wave shadow and accrete against the southern side of the port at a rate in the order of 20,000 to 70,000 m^3/yr. Further down-drift, and up-drift of the wave shadow, some erosion is expected to compensate for this.

The port will also intercept the longshore transport of sediment along and through the nearshore reef. The majority of this material is believed to be somewhat finer than the sediment being transported along the beach. The port structures will deflect the longshore current carrying this material westward. As it leaves the surf zone and enters deeper water, its turbulence and velocity will decrease, and the material will settle out.

This will occur along the entire length of the southern port structures and the first section of the harbour entrance. The coarser components will settle out first, closer to the reef, with the finer material deposited further offshore. Not all of the

sediment may settle out, particularly under severe south-westerly conditions. The very fine fraction of the material may be transported around the head of the southern breakwater and disperse in waters to the north. The volume of material involved in this process however is expected to be very small compared to the volumes of accretion and erosion occurring at the shore. A minor amount of erosion may occur to the north of the port as a result of this small sediment flux being intercepted.

Finally, the northern structures of the port will also intercept southward storm-driven longshore sediment movement. Most of this material is expected to accrete against the port structures and along the coast within the wave shadow, at a rate in the order of 10,000 to 50,000 m^3/yr. As a consequence of this, some erosion is expected both further down-drift and up-drift of the wave shadow.

Managing the Potential Impacts

The use of jetties and bridge approaches were considered for the offshore harbour options to facilitate longshore sediment transport. The effectiveness of such structures is considered limited due to the overriding influence of the offshore breakwaters on coastal processes. They would also allow undesirable wave penetration of the harbour.

These types of structures are considered to be impractical for the preferred inshore port options however, the port operator will manage sand movement so that there is no significant erosion of beaches either to the north or south of the port. Beach erosion to the north of the Oakajee River and south of the Buller River is considered to be very unlikely given the initial assessment of coastal sand movement.

In order to mitigate the potential impacts of the proposed deepwater port, a number of steps will be taken. These are outlined below.

Monitoring of Sediment Accumulation

The beaches either side of the port within the wave shadow will be monitored every six months, at the ends of summer and winter, using controlled surveying techniques. It is expected that sediment will accrete in these areas. Changes in beach volumes will be computed to confirm this and quantify the amount.

The accumulation of sediment along the southern side of the port in the vicinity and offshore of the nearshore reef will also be monitored. However, the amount of accumulation in this area is expected to be small and spread over a large area. Consequently it will probably be very difficult to accurately detect a change in sediment volume using conventional hydrographic surveying techniques.

Sediment By-Passing

The results of the monitoring program will provide data on the rates at which sediment accumulates either side of the port. It is unlikely that these amounts

will be equal. It is believed that there is a net movement of sediment to the north, relatively small. As a result, more sediment is expected to accrete on the southern side.

In order to minimise the impact of the port on the coastal environment, this longshore sediment movement will be maintained by regular sand bypassing. Sediment will be removed from the southern side of the port and carted a sufficient distance north of the port's wave shadow (>3km) and replaced on the beach. In view of the energetic offshore wave climate and the prevalence of nearshore reef, it is unlikely that a dredge could be used to conduct the sand bypassing. The most effective technique is likely to involve the use of loaders and trucks from the beach.

Potential Additional Measures

The sand bypassing will address the obstruction of the *net* longshore sediment movement. However, the port is likely to trap much of the sediment moved along the beach during winter storms. This is expected to be in a southward direction during the first half of each storm and later towards the north. In the absence of any obstacles on the coast, the net movement of sediment resulting from such storms throughout the year may be quite small. However, the port is likely to trap much of both the northward and southward sediment fluxes. This would permanently remove sediment from the littoral system and in the absence of management could lead to the erosion of adjacent beaches.

The volumes of sediment trapped, and the extent of any associated erosion, will depend largely on the longshore sediment fluxes generated under storm conditions and the effectiveness of the port to shelter the coast. In the assessment made for this PER, both of these factors were not known with sufficient certainty to determine whether this impact would be significant. Further investigations involving more detailed modelling and possibly some *in situ* physical experiments/studies will be required to more accurately assess this potential impact.

If it becomes apparent that significant amounts of sediment will be trapped either side of the port structures, and unacceptable coastal erosion will result, remedial action will be required. An effective means by which this impact can be limited is the construction of coastal works (e.g. groynes, artificial headlands, etc) at the edges of the breakwater's wave shadow. The structures would be designed to intercept longshore sediment movement and to trap the material before it enters the port's wave shadow, hence making it available for transportation away from the port when the direction of longshore transport reverses.

The need for and nature of such structures will be determined in the design study which has been initiated by the DRD.

Commitments

The following commitments are made with respect to protection of the shoreline between the Buller and Oakajee Rivers:

- The port operator will monitor coastal sand movements between the Buller River and Coronation Beach. The port operator will take appropriate steps to maintain the stability of the beaches in this area, as necessary. The scope and duration of this monitoring program will be determined in association with the DEP and all results will be submitted to the DEP and made available to the general public.

- The port operator will implement a program for the redistribution of sand accumulated against the breakwaters of the port if the coastal sand monitoring program indicates that such redistribution is necessary to minimise the possibility of shoreline erosion.

Other commitments relevant to the EPA Section 16(e) advice are provided in Section 4.6.3.

4.4 The Onshore Environment

4.4.1 Introduction

For the purposes of this PER it is assumed that all of the near-coastal dunes adjacent to the port will be impacted by associated developments (onshore storage facilities). The area allocated for this purpose is approximately 1500m by 400m and covers about 50ha (Figure 4). This area is required for potential storage facilities for grain, minerals, petroleum products and other commodities which may best be stored close to the port rather than in the industrial estate or offshore on the reclamation area. There also will be a service corridor linking the port to the industrial estate. This will have an area of between 30ha and 60ha depending on the location of the port.

4.4.2 Vegetation Communities

EPA Objectives

To maintain the abundance, diversity, geographic distribution and productivity of vegetation communities.

EPA Policy Context

Australia is a signatory to the International Convention on Biodiversity, and Western Australia is a signatory to the National Strategy for Conservation of Australia's Biological Diversity.

EPA Section 16(e) Advice

The EPA notes:

1. In preliminary surveys, no significant vegetation communities and no rare and priority flora were identified.

2. The vegetation communities are well represented elsewhere.

3. A full survey and mapping of vegetation communities, including a spring flora survey, will be undertaken.

In considering aspects of the vegetation communities at this locality, any future proponent should take account of, but not be limited to, the following:

1. Full survey and mapping of vegetation communities, including a spring flora survey.

2. Application to clear land would have to be made to the Commissioner for Soil and Land Conservation.

3. A foreshore landscape and rehabilitation plan, which could be integrated into a Coastal Management Plan.

4. Development and implementation of an EMP, which would include the Coastal Management Plan, as a component.

Should the above occur, it is likely that implementation of the port concept plan is capable of being managed so as not to compromise the EPA's objective with regard to vegetation communities and rare and priority flora.

Potential Impacts and Management

Up to 50ha of vegetation may be impacted by the establishment of onshore facilities associated with the port. In addition, the 100m wide services corridor may impact up to approximately 60ha. It is the intention to locate the services corridor running east-west through the middle of the industrial estate. Therefore, the impact of this corridor on vegetation communities between the industrial estate and the port will be dependant upon the distance of the port from the centre of the Industrial Estate.

Irrespective of the sector in which the port is located, four coastal vegetation communities will be impacted. These are the community on the foredunes, heathlands on mobile and stable dunes, and limestone ridge heathland and shrublands. The impact that the service corridor and onshore storage facilities will have on the vegetation communities in each of the sectors is considered below.

- ***Central Sector***

The foreshore of the central sector is dominated by a large sand blowout which is considered to have limited intrinsic biological value. If the port were located in this sector, the majority (approximately 35.5ha) of the onshore storage facilities could be located on the mobile dune. The remainder of the storage facilities would encroach upon approximately 15ha of the stable dune heathland. The central sector is also located in proximity to the central service corridor in the Industrial Estate, which would limit the area of limestone ridge vegetation that is disturbed to a minimum. It is anticipated that approximately 3ha of the mobile dune heathland and 21ha of the limestone ridge heathland and shrubland will be directly impacted by the services corridor.

- ***Northern Sector***

Approximately 40ha of stable dune vegetation would be directly impacted by the establishment of onshore storage facilities, and 10ha of mobile dune area. The distance of a port from the central services corridor of the industrial estate would also necessitate the removal of a relatively larger area of vegetation than in the central sector, with up to 5ha of stable dune heathland, 6ha of mobile dune heathland and 20ha of limestone ridge heathland and shrubland directly impacted.

40
10
5
6
20
81

- ***Southern Sector***

The location of a port in the southern sector of the Port Location Area would have the greatest impact of the three sectors on coastal vegetation communities. This is primarily due to the distance of the port from the central services corridor in the Industrial Estate. The southern portion of the foreshore of this sector is dominated by part of a large sand blowout, whilst the area north of the dune is stable dune heathland. The impact of onshore facilities on the vegetation therefore depends on the location of the port in this sector, as the opportunity may exist to establish a significant proportion of the onshore facilities on the mobile dune area. It is anticipated that up to approximately 38ha of stable dune heathland, and 6ha of mobile dune heathland will be directly impacted if a worst case impact scenario is considered. Approximately 7ha of limestone ridge heathland and shrubland would also be impacted.

38
6
7
16
245
112

The service corridor would impact on up to approximately 16ha of stable dune heathland, and 45ha of limestone ridge heathland and shrubland.

- ***Regional Impact***

The plant communities that would be impacted by the establishment of onshore storage facilities and services corridor cover extensive areas in the coastal strip between the Buller and Oakajee Rivers and beyond (see Figures 5 and 11). The removal of relatively small areas of vegetation therefore does not represent a significant impact on either a local or a regional basis.

- ***Other Considerations***

The risk of dieback spread in the dune vegetation is considered to be low owing to the well-drained nature of the soils.

The risk of weed spread in the area of the escarpment where there is a range of invasive grasses and weeds beneath the shrub overstorey will need to be considered. Limiting the area of disturbance for service corridor construction as much as possible, combined with rehabilitation of disturbed ground using endemic plant species should, however, reduce the potential for weed spread in this location.

Rehabilitation will also include the stabilisation of disturbed areas to prevent any erosion or instability of the dune systems.

Commitment

The following commitment is made with respect to the disturbance of areas of vegetation during construction of the port but which are not required for port facilities:

- The port operator will prepare and implement a rehabilitation plan (including landscape considerations) for all areas which are disturbed by construction activities but which are not required for port structures and facilities. This plan will be integrated into the Coastal Management Plan and will be prepared in consultation with CALM and the rehabilitation areas will be monitored and the monitoring results will be provided to the DEP.

Other commitments relevant to the EPA Section 16(e) advice are provided in Section 4.4.3 and 4.6.3.

4.4.3 Rare and Priority Flora

EPA Objective

Protect rare and priority flora consistent with the provisions of the Wildlife Conservation Act 1950.

EPA Policy Context

The preservation and conservation of flora and fauna is covered by three Western Australian statutes:

- Wildlife Conservation Act (1950);
- Conservation and Land Management Act (1984); and
- Environmental Protection Act (1986).

The Commonwealth Endangered Species Protection Act (1992) also enables the Federal Government to be involved in the protection of endangered or vulnerable species.

EPA Section 16(e) Advice

Refer Section 4.4.2

Potential Impacts

No plant species listed as Declared Rare Flora under the Western Australian Wildlife Conservation Act (1950), or the Commonwealth Endangered Species Protection Act (1992) have been located in the areas proposed to be cleared, or within the coastal strip between the Buller and Oakajee Rivers. Therefore, there is not likely to be any impact on declared rare flora, and it is considered that the impact of a port on rare and priority flora will be the same for each sector of the Port Location Area.

Commitment

The following commitment is made with respect to declared rare flora:

- The proponent will commission a follow-up survey for declared rare or priority flora in any areas of vegetation which might be disturbed by future development. This survey will be made in spring 1997. The results of this survey will be provided to CALM and the DEP.

4.4.4 Terrestrial Fauna

EPA Objective

To maintain the abundance, diversity and geographic distribution of fauna.

EPA Policy Context

Refer to Section 4.4.2 above.

Potential Impacts

The impact on remnant vegetation which provides the main habitats for fauna within the Oakajee project area will be relatively minor in both local and regional terms, and it is considered that faunal habitats are well represented elsewhere. The rehabilitation of disturbed areas with endemic flora species wherever possible, along with weed control, should minimise the impact of any clearing on faunal habitats.

The service corridor may present an obstruction to the passage of some faunal species through the area. However, the impact of the service corridor on faunal movement should not be significant given the occurrence of similar habitats along the limestone escarpment and within the dune system.

The impact of the port on terrestrial fauna is considered to be equivalent for each sector of the Port Location Area.

4.4.5 Threatened and Priority Fauna

EPA Objective

Protect rare and priority fauna consistent with the provisions of the Wildlife Conservation Act (1950).

EPA Policy Context

Refer to Section 4.4.3 above.

Potential Impacts and Management

No rare or endangered fauna species are likely to occur within the project area. Therefore no impacts are anticipated on such species.

The impact on threatened and priority fauna is considered to be the same for each sector of the Port Location Area.

4.5 Pollution

4.5.1 Marine Water Quality and Sediment Quality

In the EPA guidelines issued for this document, Marine Water Quality and Sediment Quality are also listed as pollution factors. However, these factors have been treated previously in Section 4.2.7, and are not considered further in this section.

4.5.2 Dust

EPA Objective

To protect the surrounding land users such that dust emission will not adversely impact upon their welfare and amenity or cause health problems, and will meet EPA Guidelines for Assessment and Control of Dust and Windborne Material from Land Development Sites (updated 1995), and the Environmental Protection Policy (Atmospheric Wastes) (Kwinana).

Policy Context

The EPA bases environmental acceptability on National Health and Medical Research Council, Victorian Environment Protection Agency, United States Environment Protection Agency, and World Health Organisation criteria.

EPA Section 16(e) Advice

In considering aspects of dust, any future proponent should take account of, but not be limited to, the following:

1. Construction and management of a port to be undertaken so as to meet EPA guidelines for dust control - management and strategies could be incorporated in an Air Quality Management Plan.

2. Determination of ambient dust levels.

3. Referral of a proposal for quarry development to the EPA for consideration of a level of assessment.

Should the above occur, it is likely that the implementation of the port concept plan is capable of being managed so as not to compromise the EPA's objective with regard to dust management.

Potential Impacts

The proposed port site is remote from residences and other locations where the public may assemble in the Oakajee region (see Figure 13). The closest residence will be approximately 3.5 to 4km from the port site following the acquisition of properties within and adjacent to the Industrial Estate. Therefore, it is considered most unlikely that there would be any social impact as a result of dust emissions associated with the construction of the port, or with port operations. Nevertheless, the port operator will ensure that the relevant EPA Guidelines, Environmental Protection Policy, and nominated criteria for dust emissions are complied with at all times.

Dust may be generated by the quarries that are to be developed to provide material for the port. However, the quarries will be the subject of separate proposals, and it is anticipated that quarry operators will be required to address dust impacts as part of their proposal.

The impact of the port in relation to the generation of dust is considered to be the same in each sector of the Port Location Area.

Commitments

The following commitments are made with respect to the management of dust emissions:

- The port operator will ensure that all contractors associated with the construction of the deepwater port comply with the EPA Guidelines for Assessment and Control of Dust and Windborne Material from Land Development Sites (updated 1995) and the Environmental Protection Policy (Atmospheric Waste) (Kwinana).

- The port operator will ensure that all port operations comply with air quality criteria specified by the EPA.

- The port operator will prepare an Air Quality Management Plan which will detail management and strategies for dust control. The plan will be implemented prior to construction, and will incorporate ambient dust monitoring.

4.5.3 Noise and Vibration

EPA Objective

To protect the amenity of nearby residents from noise and vibrations impacts by ensuring that noise and vibration meet criteria in the Noise Abatement (Neighbourhood Annoyance) Regulations, 1979, and the proposed new Environmental Protection (Noise) Regulations when promulgated.

EPA Section 16(e) Advice

The EPA notes:

1. The proposed Oakajee port location is distant from sensitive properties.

2. The port will need to meet the requirements of the *Noise Abatement (Neighbourhood Annoyance) Regulation 1979,* and the proposed *Environmental Protection (Noise) Regulations* (when promulgated).

In considering aspects of noise and vibration, any future proposal should take account of, but not be limited to, the following:

1. Use of best practice and noise attenuation during the development and operation of the port, as appropriate and defined by industry and Government Agencies.

2. Referral of the quarry proposal to the EPA for consideration of a level of assessment.

Should the above occur, it is likely that the implementation of the port concept plan is capable of being managed so as not to compromise the EPA's objective with regard to noise and vibration.

Potential Impacts and Management

The proposed port is at a considerable distance from the nearest houses (see Figure 13). Therefore, there is little potential that noise associated with construction of the deepwater port, or with operational procedures, will cause annoyance. The port operator will ensure that the relevant noise regulations are complied with by contractors and port users.

The quarries to be developed in association with the port may be significant sources of noise and vibration. However, the degree to which residents are affected will be dependant upon the quarry locations. Any proposal to develop quarries to provide material for the port will be referred separately to the DEP/EPA for assessment.

The potential for the port to produce noise and vibration impacts is considered to be the same for each sector of the Port Location Area.

Commitments

The following commitment is made with respect to noise abatement:

- The port operator will ensure that all contractors and port users, including itself, comply with the relevant noise and vibration criteria in either the Noise Abatement (Neighbourhood Annoyance) Regulations 1979 or the Environmental Protection (Noise) Regulations when promulgated, and will adopt best practice noise attenuation measures as appropriate and defined by industry and Government Agencies.

- The port operator will conduct regular noise monitoring, as necessary.

4.6 Social Surroundings

4.6.1 Public Health and Safety

EPA Objective

To ensure that risks are as low as reasonably achievable and comply with acceptable standards. The EPA's criteria for the assessment of fatality risk of proposed hazardous and industrial developments are outlined in Bulletins 611 and 627.

Policy Context

The EPA has indicated that the following individual fatality risk levels associated with industry are acceptable (EPA, 1992; 1992a):

- One in a million per year or less in any nearby residential zones;
- Between one half and one in a million per year in any nearby sensitive developments such as hospitals, schools, child care facilities;
- Fifty in a million per year target at the boundary for each individual industry;
- One hundred in a million per year cumulative risk on any industry; and
- Ten in a million for any non-industrial activity located in buffer areas between industrial facilities and residential areas.

Public areas such as beaches are normally expected to meet an individual fatality risk level of ten in a million per year (K. Collins, DME pers. comm.). It is considered that there will be no difficulty in meeting these requirements for all cargoes handled through the deepwater port.

Specific criteria for societal risk have not been developed by the EPA but a qualitative approach will taken by the EPA in the assessment of societal risk from individual proposals. As a general rule the EPA expects that the principle of "avoidable risks should be avoided" should be applied to proposals.

EPA Section 16(e) Advice

The EPA notes:

1. A decision is yet to be made as to the operational requirements of a new port, and whether it will be available for the handling of hazardous cargoes.

2. The port will be required to meet statutory requirements for the handling of dangerous and hazardous goods and relevant criteria relating to risk.

In considering aspects of public health and safety, any future proponent should take account of, but not limited to, the following:

1. The development of a Port Safety Plan as part of the EMP, and which incorporates a risk assessment and response measures for accidents.

Should the above occur, it is likely that implementation of the port concept plan is capable of being managed so as not to compromise the EPA's objective with regard to public health and safety.

Potential Impacts and Management

All port operators in Australia have emergency procedures which are designed to provide a co-ordinated and comprehensive response to all pollution, fire, and accident events. The operators of the Oakajee Deepwater Port similarly will develop a comprehensive Emergency Response Plan. This plan will specify actions to be taken by nominated personnel in the event of an emergency and the necessary response. In addition, emergency response equipment will include fire hydrants at all wharves, and a self-inflatable containment boom and skimmer for the treatment of any oil spills.

Public risks associated with hazardous cargoes which may in the future be handled at Oakajee may involve the restriction within the vicinity of the port of public activities. It is anticipated that this will not have any implications on current or future recreational activities if the port is located in the central sector. A port located in this sector would be at least 3km from the nearest public area which is not under the control of the port operator. This distance is likely to be adequate for risk management purposes, and should ensure that the EPA risk criteria are easily met by any proposal involving hazardous goods.

If a port were to be located within the northern and southern sectors, the restriction that may apply to recreational use of the area will be determined following a detailed risk assessment when specific proposals for hazardous shipments are known. Notwithstanding the outcome of this risk assessment it is highly unlikely that any restriction will apply to the use of Coronation Beach.

The necessity for the restriction of activities will depend on the nature, quantity, and timing of any hazardous cargoes which may be handled. The methods used for handling such cargoes will be subject to the requirements of the DME and the EPA , which will have the option of assessing any proposal which involves hazardous cargoes in significant quantities.

It is probable that any such constraints on public activity near the port would be temporary in nature, and would apply only when hazardous cargoes are actually being unloaded, or in relatively close proximity of large-volume onshore storage facilities for hazardous chemicals.

Commitments

The following commitments are made with respect to the management of hazardous cargoes:

- The port operator will ensure that all proposals for the handling of potentially hazardous cargoes through the deepwater port are referred to the DEP and the Department of Minerals and Energy for their consideration. All requirements of these departments with respect to quantitative risk assessments and procedures for the safe handling of hazardous cargoes will be met.

- The port operator will prepare a Port Safety Plan which will incorporate a risk assessment and response measures for incidents, and will be subject to community consultation.

4.6.2 Aboriginal and Post-Colonisation Heritage Sites

EPA Objective

Comply with statutory requirements in relation to areas of cultural or historical significance.

EPA Section 16(e) Advice

The EPA notes:

1. The Commitment by the DRD to resolution of any Aboriginal heritage issues.

2. The need for any future port development to comply with relevant statutory requirements for significant sites.

In considering aspects of heritage, any future proponent should take account of, but not be limited to, the following:

1. Consultation with the AAD on Aboriginal heritage matters.

2. The need for any future port development to comply with relevant statutory requirements for significant sites.
3. The development of a Heritage Management Plan, as required.

Should the above occur, it is likely that implementation of the port concept plan is capable of being managed so as not to compromise the EPA's objective with regard to heritage.

Potential Impacts

There are no Post-Colonisation heritage sites in proximity to the Port Location Area, therefore there is no potential for the port to impact on these sites.

There is a single Aboriginal site recorded in the potential impact area in the central sector on the coastal dunes. This site will be managed in accordance with the requirements of the Minister for Aboriginal Affairs. If the port is located in this sector.

Archaeological surveys have indicated that there is potential for further sites to be located in the dune system during construction activities. An archaeological management plan will be prepared to address this possibility.

Commitment

The following commitment is made with respect to the management of Aboriginal Heritage Sites:

- The proponent will prepare a Heritage Management Plan prior to construction to ensure that any sites discovered during construction activities are managed in accordance with statutory requirements.

4.6.3 Recreation

EPA Objective

The concept should not compromise recreational uses of the area, as developed by planning agencies.

EPA Policy Context

Recreational opportunities on the coastline in the Geraldton region are important to the local community and attract tourists to the area. The Shire of Chapman Valley intends to formalise camping facilities at Coronation Beach which is a major coastal recreational location north of Geraldton.

EPA Section 16(e) Advice

The EPA notes:

1. The remoteness of current recreational areas from the general port site, but that there is likely to be the prospect that the community may seek some additional recreational opportunities.

2. That there are no recreational plans currently developed by planning agencies for the proposed port area.

3. That a recreational plan is proposed to be developed for an area 3km north and south of the proposed port area.

In considering aspects of recreation, any future proponent should take account of, but not be limited to, the following:

1. The Port Authority to determine demand for access to areas of the port for recreational pursuits.

2. The Port Authority, and other relevant agencies, to develop a recreational plan for the area which considers public safety issues and involves community consultation.

Should the above occur, it is likely that implementation of the port concept plan is capable of being managed so as not to compromise the EPA's objective with regard to recreation.

Potential Impacts

Potential risks and hazards associated with the long term development of the port may restrict development of formal recreation facilities around the Oakajee River and north of the Buller River. However, informal or limited access for surfing, windsurfing and fishing between the Buller and Oakajee Rivers, and further north to Coronation Beach, may continue provided risk criteria are not breached and port operations are not adversely impacted.

It is not anticipated that the establishment of a service corridor will impact on existing recreation, although it will prevent continuous access along the beach.

Areas within, and to the north of, the Port Location Zone such as Oakabella, Coronation Beach and Spot "X", are considered to be significant windsurfing locations. Concerns have been raised during public consultation with respect to the impact of port structures on wave breaks at these windsurfing locations. It is considered that the location of a port within the central and southern sectors will not interfere with windsurfing activities.

However, Spot "X" would not be available as a windsurfing location if the port were to be located in the northern sector of the Port Location Area but windsurfing breaks further north at Coronation Beach would not be affected. A risk assessment will be undertaken to determine any restrictions on recreational usage within the vicinity of the port when specific proposals for hazardous cargoes are known.

A detailed assessment of the impact of the port on wave breaks will be made when the location and design of the port is finalised.

In addition, there is an apparent conflict between the findings of JLW Advisory Services (1994) and Alan Tingay & Associates (1994b) and the anecdotal evidence of windsurfers in the region regarding the volume of use of different locations by windsurfers. Therefore, a Recreation Plan will be prepared which will include a study to further determine the significance of the Oakajee area to windsurfing, and the potential impact that the construction of the port would have on the sport.

Recreational fishers may lose access to approximately 1.5km of shoreline irrespective of the port location. This is not considered to be significant given the extent of accessible shoreline in the Geraldton region.

In summary, the following restrictions may apply to recreational access and development as a result of the port:

- The development of any formal or intensive recreation facilities or activities north of the Buller River and south of the Oakajee River will be prohibited by the port operator who will have statutory authority over the Special Management Area which includes this section of the coast.

- Depending on the requirements of the DME with respect to the handling of any hazardous cargoes, access to beaches to the north and south of the port may be temporarily restricted when hazardous materials are being handled.

- Access to the port by the public in accordance with safety requirements.

Commitments

The following commitments are made with respect to the management of recreational activities:

- The port operator will prepare a Coastal Management Plan (CMP) for the coastal area under its control between the Buller and Oakajee Rivers. The CMP, which will include a Recreation Plan, will be prepared prior to the commencement of construction of the port, in accordance with the requirements of the Ministry for Planning, and in consultation with the Shire of Chapman Valley.

- The proponent will complete a detailed assessment of the impact of port structures on wave breaks to the north of the proposed port when the final design and location of the port is selected.

- The proponent will undertake a study, as part of the Recreation Plan, to determine the significance of the Oakajee area to windsurfing. This study will also consider the potential impact of the construction of the port on the sport.

5. OTHER ISSUES

5.1 Introduction

This section of the PER provides information on some issues which have not been identified by the EPA as relevant factors, but which are likely to be of interest to some sectors of the community and some government agencies. These issues are the implications of the port on fishing and the visual environment.

5.2 Professional Fishing

The potential impacts that the port proposal will have on professional fishing in the Oakajee area are considered below.

Habitat Loss

For the purposes of this PER, it is assumed that up to approximately 170ha of marine habitat will be removed by the port as rock lobster habitat. Assuming that the catch is evenly distributed along the coastline of the Oakajee block, the marine habitat close to the shoreline (which would be affected by an inshore deepwater port) in the central sector produces approximately 8% of the annual average catch (or 4,144kg) valued at $73,600.

The northern location for a port would have the least impact on professional fishing because of the lower impact on high reef and shallow limestone pavement habitat of crayfish. For this location impact may be reduced by up to approximately 50% to 60%. The impact of a port in the southern sector would be intermediate between that in the central and northern sectors.

It is likely however, that the rock-armoured breakwaters will, to some extent, replace some of the lost habitat.

Fishing Ground Loss

An area of seafloor occupied by the approach lane to the deepwater port, the port structures and harbour, and an offshore mooring area will be lost as a fishing ground for rock lobsters. As large ships will be moving through these areas, use of lobster pots and their attached lines and floats will be restricted.

But rock lobsters will continue to use these areas as they do at present. However, as most (78%) of the rock lobster catch in the Oakajee statistical block occurs in the nearshore to 18m depth zone, while the ship movement areas are in deeper water, the restriction of fishing in these areas will have a minor effect on the total catch.

In addition, as the catch in these deeper waters tends to be dominated by the migratory "white" rock lobsters, it is likely these will be accessible to fishing activities as they migrate into other unrestricted areas.

Potential for Rock Lobster Contamination

The potential for contamination of the marine environment has been discussed in Section 4.2.7. The same comments also apply to contamination of rock lobsters. Emphasis will be placed on procedures to prevent contamination, and audits to ensure that appropriate procedures are being carried out.

Market Perceptions of Contamination

One of the marketing advantages enjoyed by rock lobster industry in Western Australia is the perception that the product comes from a pristine environment and is free of any contamination. While actual contamination of rock lobsters may never occur, fishermen are concerned that there may be market perception that contamination from industrial or port activity is possible, and that this may have an effect on product price. Although the perceived threat of contamination may be restricted to a small and localised area, the concern is that the market reaction may affect the whole industry.

The problem of market perception is best overcome by installing good management systems to ensure that contamination never occurs, conducting audits to ensure that the systems are being followed, putting contingency plans in place in case accidents should occur, and finally, conducting monitoring to ensure that contamination is not occurring.

It should also be noted that there have been no difficulties in terms of market perceptions as a result of the existing Port of Geraldton.

Commitments

The following commitments are made with respect to rock lobsters in the vicinity of the port:

- The port operator through a Construction Management Plan will take steps to ensure that construction of the port is managed so as to limit the potential for incidental damage to rock lobster habitat. The Construction Management Plan will be prepared to the requirements of the DEP.

- The port operator will liaise with the Department of Fisheries and rock lobster fishing industry representatives on a continuing basis regarding port operations and their implications for rock lobsters and to provide information on the results of the Water Quality Monitoring Program.

5.3 Visual Impact

The port itself will affect the landscape of the coast where it is located. Visibility of the main breakwater structures however, should be low from distant viewing points at Drummond Cove and Coronation Beach. Large ships berthed within the port, and cranes and buildings on shipping berths and reclaim areas will be more visible due to their size.

From the more popular section of coastline at Coronation Beach the landscape impact should be minor because of screening afforded by a shoreline protrusion south of this beach, particularly if the port is located in the central and southern sectors. A port in the northern sector would be more visible, but should to some extent still be screened from Coronation Beach by the coastal protrusion.

For viewers in populated areas to the south - Drummond Cove and the Geraldton foreshore - the natural character of this section of coastline will be modified, but the separation distance of approximately 6km from Drummond Cove and 17km from the Geraldton City foreshore will minimise the visual impact. The port will also not be visible from the North West Coastal Highway, which runs approximately 4km to the east of the Port Location Area.

6. ENVIRONMENTAL MANAGEMENT APPROACH

6.1 Introduction

The proponents will ensure that a range of environmental management and monitoring programs are prepared and implemented with respect to the Oakajee Deepwater Port. These programs, which will be included in an Environmental Management Plan for the port, include the following:

- Coastal Management Plan (including a Recreation Management Plan)
- Marine Management Plan
- Port Safety Plan
- Air Quality Plan, and
- Heritage Management Plan

The monitoring programs will be initiated either prior to the commencement of construction or during construction, and the majority will continue during the operational life of the port. The scope of the various management and monitoring programs is summarised in this section of the PER, and the complete plans will be prepared following the granting of environmental approval for the deepwater port. The plans will be submitted to the EPA for evaluation and approval prior to implementation.

6.2 Management of Construction

All contractors and others involved in the construction of the port will be required to comply with a Construction Management Plan (see Commitment in Section 4.2.7). This plan will specify requirements for limiting dispersion of suspended sediments, and the control of dust, noise and vibration. In particular, the contractors will be required to comply with the following:

- The Dredging and Dredge Spoil Disposal Management Plan.
- EPA Guidelines for the Assessment and Control of Dust and Windborne Material from Land Development Sites (as updated in 1995) and the Environmental Protection Policy (Atmospheric Waste) (Kwinana).
- The Noise Abatement (Neighbourhood Annoyance) Regulations, 1979 and, the proposed new Environmental Protection (Noise) Regulations when promulgated.

The port operator will prepare and implement a water quality monitoring program which will include assessment of construction activities (see Section 6.10 below) and will regularly monitor noise during construction.

6.3 Dredging

All dredging operations will be required to conform with a Dredging and Dredge Spoil Disposal Management Plan prepared by the port operator to the requirements of the DEP. The port operator will also prepare and implement a water quality monitoring program which will include assessment of all dredging operations (see Section 6.10).

6.4 Onshore Rehabilitation

The port operator will prepare a rehabilitation plan in consultation with CALM for all onshore areas which are disturbed by construction activities but which are not required for permanent facilities. This rehabilitation plan will specify the types of plant species to be used, soil treatments and timing of plantings, water regimes, and regular monitoring of the health and condition of rehabilitation areas.

6.5 General Port Management

The port operator will manage the port in accordance with the principles of environmental management standard AS/NZS ISO 14001:1996. This standard requires a comprehensive approach to the environmental management of all port operations as an integral part of general port management. This includes regular checks of key factors by management personnel, routine documentation of those inspections and checks, and regular audits of environmental performance.

6.6 Discharge of Wastes from Ships

Masters of all ships in the harbour will be required to comply with the requirements of a solid and liquid waste management plan which will specify procedures for the collection and disposal of waste discharges from ships and procedures for the washdown of ships in harbour (see Commitment in Section 4.2.6).

6.7 Accidental Spills

The port operator will manage any accidental spills associated with port operations in accordance with either the Oil Spill Contingency Plan or the Accidental Spillage Management Plan (see Commitment in Section 4.2.7). These plans will specify containment, treatment and collection procedures.

6.8 Monitoring and Management of Coastal Sand Movement

Coastal sand movement before and after the construction of the deepwater port will be monitored through the establishment of a series of surveyed transects across the beach profile along a section of the coastline from south of the deepwater port to the mouth of the Oakajee River. Coastal movement plans will also be prepared using aerial photography taken at no more than five-year intervals.

The information collected from these assessments will be used to gauge the effectiveness of sand bypassing from the south to the north of the port and to indicate whether additional sand replenishment measures are required.

6.9 Monitoring and Management of Macroalgae

The accumulation and distribution of macroalgae on the shoreline between the Buller and Oakajee Rivers will be routinely assessed by the port operator to determine whether the deposits adjacent to the approach breakwater are larger than would be expected in natural conditions, and whether there are any signs of depletion of macroalgae on other sectors of the coast.

Any significant accumulation of macroalgae which is considered to be abnormal will be managed by mechanical collection and transported to areas where it appears that the macroalgae may be at lower than normal levels. The water quality monitoring program outlined in Section 6.10 will also be designed to assess nutrient levels in seawater and this will provide an indication of whether there are any significant changes which may be attributable to changes in the distribution of macroalgae.

6.10 Monitoring and Management of Water Quality

6.10.1 Objectives

The objectives of the water quality monitoring program are to:

- Establish a baseline for existing water quality within and adjacent to the proposed deepwater port.
- Determine whether construction of the port has an effect on water quality within and adjacent to the port area.
- Determine whether any changes in water quality, if they occur, are likely to have an adverse impact on the existing marine environment.
- Determine if any changes in water quality, if they occur, have any implications for beneficial uses in the Special Management Area.

6.10.2 Parameters and Environmental Criteria

The water quality parameters and environmental criteria which will be used in the water quality monitoring program will be as follows:

- Within the Port Operations Area - to be determined in consultation with the EPA with recognition of the fact that the primary beneficial use in this area is port operations. This area will also include a small area around the port boundary (Section 2.2).

- Within the Special Management Area - in accordance with those described in Bulletin 711 of the EPA (1993) using the categories of "Protection of Aquatic Ecosystems" and "Recreational Water Quality and Aesthetics".

- During dredging operations - in accordance with the "Guidelines for the Preparation of a Dredging and Dredge Spoil Disposal Management Plan" of the Waterways Commission (1995).

It is proposed to use the parameters and criteria listed in Table 6.1 for water quality monitoring following the establishment of the port. However, the final parameters and criteria will be determined in consultation with the DEP.

TABLE 6.1

WATER QUALITY MONITORING PROGRAM - OAKAJEE DEEPWATER PORT
PORT OPERATION PARAMETERS AND CRITERIA

Parameter	Environmental Criteria [1]
pH	<0.2 pH unit change
Dissolved Oxygen	>6 mg/L (>80-90% saturation)
Turbidity	<10% change seasonal mean concentration
Orthophosphate (PO4-P)	1-10 µg/L
Nitrate (NO3-N)	10-60 µg/L
Ammonium (NH4-N)	<5 µg/L
Chlorophyll-a	<1 µg/L
Copper	5 µg/L
Iron	NR
Nickel	15µg/L
Tin (Tributyltin)	0.002 µg/L
Zinc	20 µg/L
Total Hydrocarbons	10 µg/L*
Faecal Coliforms	150 organisms/100ml
Enterococci	35 organisms/100ml

1 - Environmental Protection Authority, Bulletin 711, 1993.
NR - No recommendations made at this time.
* - Interim guideline only. Bulletin 103, Department of Conservation & Environment (1981).

The parameters and guidelines proposed for any dredging activities undertaken during port construction are listed in Table 6.2. However, the final parameters and guidelines to be used will be determined in consultation with the DEP.

TABLE 6.2

WATER QUALITY MONITORING PROGRAM - OAKAJEE DEEPWATER PORT DREDGING PARAMETERS AND GUIDELINES

Parameter	Waterways Guidelines [1]
pH	Range 5-9; <1.0 unit change
Dissolved Oxygen	>5.0mg/L or >60% saturation
Temperature	Return water discharges shall not cause the water temperature in the receiving waters to vary by more than 2°C from background temperatures in the receiving waters.
Nutrients	The concentration of nutrients in the return waters shall not exceed the background concentration in receiving waters.
Suspended Solids	The suspended solids concentration of the return water shall not exceed the higher of the background concentration in the receiving waters or 80mg/L.
Odours and Colours	Return water discharges shall not produce objectionable odours or colours in the receiving waters.
Floatable Matter	Return water discharges shall not cause visible floating oil, foam, grease, scum, litter or other objectionable matter in the receiving waters.
Settleable Matter	Return water discharges shall not cause the deposition of settleable matter which may adversely affect the visual, recreational and ecological values of the receiving waters.
Salinity	The return water salinity shall not vary by more than 10% from the background salinity levels in the receiving water.
Toxicants	The operator may be required to undertake toxicity analysis of the return water discharge. The level of toxicants shall not exceed the desirable concentrations in the ANZECC Guidelines for the Protection of Aquatic Ecosystems.

1 - Waterways Commission Guidelines No 9, December 1995.

6.10.3 Timing

Water sampling to establish baseline conditions in the port area and control locations will occur following approval of the port by the Minister for Environment. It is expected that the first samples will be collected during the latter part of 1997. Further sampling will occur at regular intervals during construction and after the port has been completed. If levels of any parameter are above the criteria during a sampling period, more frequent monitoring may occur in order to identify a possible cause for the elevated levels, and also to determine the duration of the levels over time.

6.10.4 Location of Sites

The number and locations of sampling sites will be determined by the proponents in consultation with the DEP after the port has been approved by the Minister for the Environment.

6.10.5 Reporting

Written reports on the results of the monitoring program will be provided to the DEP within two months of the receipt of each set of analytical results. However, if any levels are found to exceed the environmental criteria, these results will be reported immediately to the DEP. All monitoring results will be available to the public.

6.11 Management and Monitoring of Sediment

6.11.1 Objectives

The objectives of the sediment monitoring program are to :

- Establish a baseline for existing sediments within and adjacent to the proposed deepwater port.
- Determine whether any significant changes in the composition of the sediment occur during the life of the port, and whether these are likely to have any adverse impact on the marine environment.
- Determine if any changes in sediment quality, if they occur, have any implications for the beneficial uses in the Special Management Area.

6.11.2 Parameters and Environmental Criteria

The parameters and environmental criteria which will be used in the sediment monitoring program will be developed in consultation with the EPA and will be based on a range of indicators of environmental quality and the type of commodities being handled in the port.

6.11.3 Timing

Sediment samples will be collected initially following approval of the port by the Minister for Environment in order to establish baseline conditions prior to any construction activities. The sampling locations will include control sites distant from any potential effects resulting from port operations. It is expected that the first samples will be collected during 1998. Further sampling will then occur at regular intervals to be determined in consultation with the EPA. It is envisaged that the sampling will occur at least every five years.

However, if levels of any parameter in the sediments are above the agreed criteria during the sampling period, more frequent monitoring may occur to identify a possible cause for the elevated levels.

6.11.4 Location of Sites

The numbers and locations of sample sites will be determined by the port operator in consultation with the EPA after the port has been approved by the Minister for Environment.

6.11.5 Reporting

Written reports on the results of the sediment monitoring program will be provided to the DEP within two months of receipt of each set of analytical results. However, if any levels are found to exceed the environmental criteria, these results will be reported immediately to the DEP. All monitoring results will be available to the public.

6.12 Monitoring of Introduced Organisms

Specific surveys will be made on an annual basis during the operational life of the deepwater port to determine whether any exotic dinoflagellates are present which may have been introduced through the discharge of ballast water. Routine monitoring of marine habitats will also occur and this should detect any significant occurrence of introduced larger biota.

6.13 Monitoring of Marine Habitats

Regular surveys of marine habitats in the vicinity of the port will be carried out by divers during the construction and operation of the deepwater port. The results of these surveys will be compared with the data collected by the marine survey carried out for the purposes of this PER.

7. COMMITMENTS

A summary of the commitments made in this PER is provided in the summary in Table B. The commitments are also presented in the document in the relevant sections of the main text, and are listed below for ease of reference.

Macroalgae

- The port operator will monitor the accumulation of sea wrack on the shoreline between the Buller and Oakajee Rivers on an ongoing basis and will take appropriate steps to overcome any adverse impacts, as required.

- The port operator will manage any large accumulation of sea wrack against the breakwaters by mechanical or other means of collection and will redistribute the wrack to other sections of the coastline in the Special Management Area or into the littoral stream where there is evidence that the sea wrack accumulation may have been reduced. Any such operations will be subject to approval by the Department of Conservation & Land Management.

- The port operator will ensure that the Water Quality Monitoring Program associated with the port is designed so that it will detect any significant variations in nutrient levels which may be attributable to changes in the distribution of sea wrack in the near-coastal marine environment.

Introduced Marine Organisms

- The port operator throughout the life of the port will routinely check that the Australian Ballast Water Management Strategy and/or any other management procedure for ballast water recommended by AQIS or any other Commonwealth, State or International agency which may have responsibility for the management of ballast water in the future are complied with.

- The port operator will implement a monitoring program to detect the presence of toxic dinoflagellates in the harbour of the Oakajee port. This program will be initiated prior to the commencement of shipping operations, and will occur on a bi-annual basis thereafter. The results of the monitoring program will be provided to the DEP and to any other agencies nominated by that department.

Marine Water Quality and Sediments

- The port operator will, prior to construction, prepare a Marine Management Plan that will include the following;

  - a Construction Management Plan in accordance with the requirements of the DEP. All contractors will be required to comply with this plan, which will specify measures designed to prevent

marine pollution and to limit the impact on the marine environment.

- a Dredging and Dredge Spoil Disposal Management Plan (DDSDMP) in the event that the final port plan involves dredging. This Management Plan will be prepared in accordance with the requirements of the DEP and will include a monitoring program for water quality in and within a relevant distance of the works area. The DDSDMP and all results of the monitoring programs will be made available to the general public.

- an Oil Spill Contingency Plan to the satisfaction of the Department of Minerals and Energy, the Department of Environmental Protection, and the WA State Committee for Combating Oil Pollution at Sea.

- a Waste Management Plan of port operations prepared in accordance with the requirements of the DEP. This plan will specify management procedures for the collection and disposal of waste discharges from ships, and will regulate wash-down of ships in harbour.

- an Accidental Spillage Management Plan to the requirements of the Department of Minerals and Energy.

- a Water Quality Monitoring and Management Program in accordance with the requirements of the DEP. A summary of the scope this monitoring program is provided in Section 6 of this PER.

- a Sediment Monitoring and Management Program. This program will involve bi-annual samples following construction. All samples will be analysed for a range of heavy metals and other potential contaminants. The results of the monitoring program will be provided to the DEP.

- The port operator will commission a detailed study of water circulation and water exchange in the harbour at Oakajee following the adoption of a final design for the port. The results of this study will be supplied to the DEP and other relevant government agencies, and will be used to refine the port design if necessary to achieve better performance with respect to water exchange.

The Shoreline

- The port operator will monitor coastal sand movements between the Buller River and Coronation Beach. The port operator will take appropriate steps to maintain the stability of the beaches in this area, as necessary. The scope and duration of this monitoring program will be determined in association with the DEP and all results will be submitted to the DEP and made available to the general public.

- The port operator will implement a program for the redistribution of sand accumulated against the breakwaters of the port if the coastal sand monitoring program indicates that such redistribution is necessary to minimise the possibility of shoreline erosion.

Regionally Significant Vegetation

- The port operator will prepare and implement a rehabilitation plan (including landscape considerations) for all areas which are disturbed by construction activities but which are not required for port structures and facilities. This plan will be integrated into the Coastal Management Plan and will be prepared in consultation with CALM and the rehabilitation areas will be monitored and the monitoring results will be provided to the DEP.

Declared Rare Flora

- The proponent will commission a follow-up survey for declared rare flora in any areas of vegetation which might be disturbed by future development. This survey will be made in spring 1997. The results of this survey will be provided to CALM and the DEP.

Dust

- The port operator will ensure that all contractors associated with the construction of the deepwater port comply with the EPA Guidelines for Assessment and Control of Dust and Windborne Material from Land Development Sites (updated 1995) and the Environmental Protection Policy (Atmospheric Waste) (Kwinana).

- The port operator will ensure that all port operations comply with air quality criteria specified by the EPA.

- The port operator will prepare an Air Quality Management Plan which will detail management and strategies for dust control. The plan will be implemented prior to construction, and will incorporate ambient dust monitoring.

Noise and Vibration

- The port operator will ensure that all contractors and port users, including itself, comply with the relevant noise and vibration criteria in either the Noise Abatement (Neighbourhood Annoyance) Regulations 1979 or the Environmental Protection (Noise) Regulations when promulgated, and will adopt best practice noise attenuation measures as appropriate and defined by industry and Government Agencies.

- The port operator will conduct regular noise monitoring, as necessary.

Public Health and Safety

- The port operator will ensure that all proposals for the handling of potentially hazardous cargoes through the deepwater port are referred to the DEP and the Department of Minerals and Energy for their consideration. All requirements of these departments with respect to quantitative risk assessments and procedures for the safe handling of hazardous cargoes will be met.

- The port operator will prepare a Port Safety Plan which will incorporate a risk assessment and response measures for incidents, and will be subject to community consultation.

Aboriginal and Post-Colonisation Heritage Sites

- The proponent will prepare a Heritage Management Plan prior to construction to ensure that any sites discovered during construction activities are managed accordance with statutory requirements.

Recreation

- The port operator will prepare a Coastal Management Plan (CMP) for the coastal area under its control between the Buller and Oakajee Rivers. The CMP, which will include a Recreation Plan, will be prepared prior to the commencement of construction of the port, in accordance with the requirements of the Ministry for Planning, and in consultation with the Shire of Chapman Valley.

- The proponent will complete a detailed assessment of the impact of port structures on waves breaks to the north of the proposed port when the final design of the port is selected.

- The proponent will undertake a study, as part of the Recreation Plan, to determine the significance of the Oakajee area to windsurfing. This study will also consider the potential impact of the construction of the port on the sport.

Professional Fishing

- The port operator through a Construction Management Plan will take steps to ensure that construction of the port is managed so as to limit the potential for incidental damage to rock lobster habitat. The Construction Management Plan will be prepared to the requirements of the DEP.

- The port operator will liaise with the Department of Fisheries and rock lobster fishing industry representatives on a continuing basis regarding port operations and their implications for rock lobsters and to provide information on the results of the Water Quality Monitoring Program.

8. CONCLUSIONS

The analysis presented in this PER and in the associated specialist reports indicates that the proposed deepwater port at Oakajee will have only limited environmental and social impacts. The proposal is able to meet all of the objectives for the relevant factors as established by the EPA.

The impact on the marine environment will essentially be limited to a maximum area of 170ha, with approximately 130ha of nearshore habitat primarily affected. This area contains a variety of marine habitats some of which (especially between the shore and the 5m depth contour) support diverse marine biota. The most diverse areas of marine habitats occur in the central and southern sectors of the Port Location Area, whilst there are large areas of shallow sand in the northern sector. The habitats and biota however, are typical of the near coastal zone for much of the Geraldton region.

Construction operations and possible increased turbidity associated with the dispersion of sediment either will not, or are not likely to, spread beyond this maximum defined impact area.

The impact area also comprises a relatively small proportion of the rock lobster fishing area and the value of the rock lobster catch in this area is relatively small. There should be minimal impact therefore on the commercial rock lobster industry. Other commercial fishing activity in the area is minor while recreational fishing will be able to continue unaffected along the extensive coastline to the south and north of the port site.

Onshore facilities associated with the port will impact an area of coastal dunes approximately 50ha in extent. The impact of the port on vegetation communities is dependant upon which sector the port is to be located in, with the lowest potential impact in the central sector and the highest in the northern sector. The vegetation types present in these sectors occur along the length of the coastline between the Buller and Oakajee Rivers and beyond. The loss of vegetation and fauna habitats will therefore be minor in regional terms.

Construction operations associated with the deepwater port will be carefully managed and an environmental monitoring program will be in place which will enable the extent of any construction impacts to be assessed.

The environmental management and monitoring programs will continue throughout the life of the port and will include assessment of water and sediment quality, presence of introduced marine organisms, health of marine habitats, accumulation of sea wrack against the breakwaters, and coastal sand movement.

Management procedures during the operation of the port will include an Emergency Response Plan and appropriate equipment to manage fire and oil spills, training of personnel in emergency response and environmental management, and regular environmental audits of all port operations.

The Government of Western Australia considers that the Oakajee Deepwater Port will be a vital strategic component in the future economic development of the Mid West Region. The port will provide the capacity for full loading of large ships which will benefit the agricultural, mining and industrial sectors of the region with minimal associated environmental and social costs.

REFERENCES

Alan Tingay & Associates, Halpern Glick Maunsell & Lancon Resources (1993). A Planning, Engineering, Landscape, and Environmental Study of the Narngulu Industrial Estate at Geraldton. Narngulu Industrial Committee.

Alan Tingay & Associates (1994a). Deepwater Port at Point Moore. Public Environmental Review. Geraldton Port Authority.

Alan Tingay & Associates (1994b). An Assessment of Coastal Recreation on Point Moore, Geraldton (December 1993 - January 1994). Geraldton Port Authority.

Alan Tingay & Associates (1996). Proposed Oakajee Deepwater Port Site Marine Seafloor Habitat Survey and Marine Impact Assessment.

Bavin, L. (1993). Aboriginal Archaeological Heritage Sites at the Proposed Oakajee Industrial Site. Report to LandCorp.

Beard, J.S. (1980). A New Phytogeographic Map of Western Australia. WA Herbarium Research Notes, 3, 37-58.

Conservation & Land Management (Dept of) (1994). A Representative Marine Reserve System for Western Australia. Report of the Marine Parks & Reserves Selection Working Group.

Dames & Moore Pty Ltd (1993). Flora and Fauna Assessment Oakajee Proposed Industrial Site. Report to LandCorp.

Department of Conservation & Environment (1981). Water Quality Criteria for Marine & Estuarine Water of Western Australia. Bulletin 103.

Environmental Protection Authority (1992). Criteria for the Assessment of Risk from Industry. Environmental Protection Authority Guidelines. Environmental Protection Authority, Perth, Western Australia. Bulletin 611.

Environmental Protection Authority (1993). Western Australian Water Quality Guidelines for Fresh and Marine Water. Bulletin 711.

Environmental Protection Authority. (1997). Oakajee Deepwater Port - Concept. Shire of Chapman Valley. Advice to the Minister for the Environment from the Environmental Protection Authority under Section 16(e) of the Environmental Protection Act, 1986.

Feilman Planning Consultants (1977). A Survey of Places of Historic and Landscape Value in Northampton, Dongara and Geraldton. The National Trust of Australia (WA).

Foster, D.N. (1990). Port of Geraldton Point Moore Deepwater Port Feasibility Study. Critical Review of Technical Feasibility. Unisearch Ltd, Tasmania.

George, R.W. (1993). Oakajee Rock Lobster Study - Impacts by Industry and Port. Report to LandCorp.

Granherne Pty Ltd (1994). Risk Assessment - Point Moore Deepwater Port. Geraldton Port Authority.

Halpern Glick Maunsell (1991a). Shipping Requirements at the Port of Geraldton. Technical Report E8897A. Geraldton Port Authority.

Halpern Glick Maunsell (1991b). Evaluations of Potential Deep Water Port Site near Geraldton. Report E8897 Geraldton Port Authority.

JLW Advisory. (1994). Oakajee Region Tourism Potential Study. Department of Resources Development.

LeProvost Semeniuk & Chalmer (1981). Cape Peron Ocean Outlet - Marine Environmental Study.

LeProvost Semeniuk & Chalmer (1984a). Marine Ecology & Fisheries of the Quinns Rock Area. Appendix 4 in Smith Corporation Pty Ltd - Environmental Review and Management Program for Mindarie Keys Project.

LeProvost Semeniuk & Chalmer (1984b). The Natural Environments of the Sorrento Coastal Area. Technical Appendix 2 in Public Works Department of Western Australia Environmental Review and Management Program for Sorrento Boat Harbour.

Maunsell-Nedeco (1983). Technical Feasibility Study of Dredging Outer Approach Channel. Geraldton Port Authority.

Maunsell-Nedeco (1985). Port of Geraldton Dredging Conditions for the Approach Channel and Harbour Basin for the Geraldton Port Authority. Public Works Department.

Monaghan Rooke & Robinson (1993). Marine Seafloor and Habitat Survey of Alternative Deepwater Port Sites. Geraldton Region. Geraldton Port Authority.

Monaghan Rooke & Robinson (1994). Geraldton Port Marine Environs Habitat Survey. Geraldton Port Authority.

MP Rogers & Associates (1996). Oakajee Port Coastal Engineering Study. Report R035.

Pearce, K.H. (1982). Archaeological Survey at Oakajee River. Unpublished Report to Dames & Moore for Mitchell Plateau Bauxite Co. Pty Ltd.

Port and Harbour Consultants Pty Ltd (1988). Port of Geraldton Point Moore Outline of Scheme for Deep Water Port. Geraldton Port Authority.

Port and Harbour Consultants Pty Ltd (1989). Port of Geraldton Point Moore Deep Water Port Feasibility Study. Geraldton Port Authority.

Quartermaine Consultants (1997). Report on an Archaeological Survey. Proposed Coastal Development. Oakajee River, Geraldton.

Rockwater Pty Ltd (1996). Oakajee Hydrogeological Investigation. Report to LandCorp.

Sigurdarson, S. (1994). Berm Breakwaters in Iceland, Practical Experiences. International Conference on Hydro-Technical Engineering for Port and Harbour Construction, Yokosuka, Japan.

State Planning Commission of Western Australia (1989). Geraldton Region Plan.

Steedman Science & Engineering (1983). Oakajee River Wave and Long Period Wave Measurements Geraldton Area, Western Australia. Prepared for Mitchell Plateau Bauxite Co. Pty Ltd and Clough Engineering Group.

Steedman Science and Engineering (1988). Extreme Wave Study for Proposed Deepwater Port at Point Moore Geraldton. Geraldton Port Authority.

Steedman Science and Engineering (1991). Wave Measurements off Point Moore, Geraldton. Volumes 1 & 2. Geraldton Port Authority.

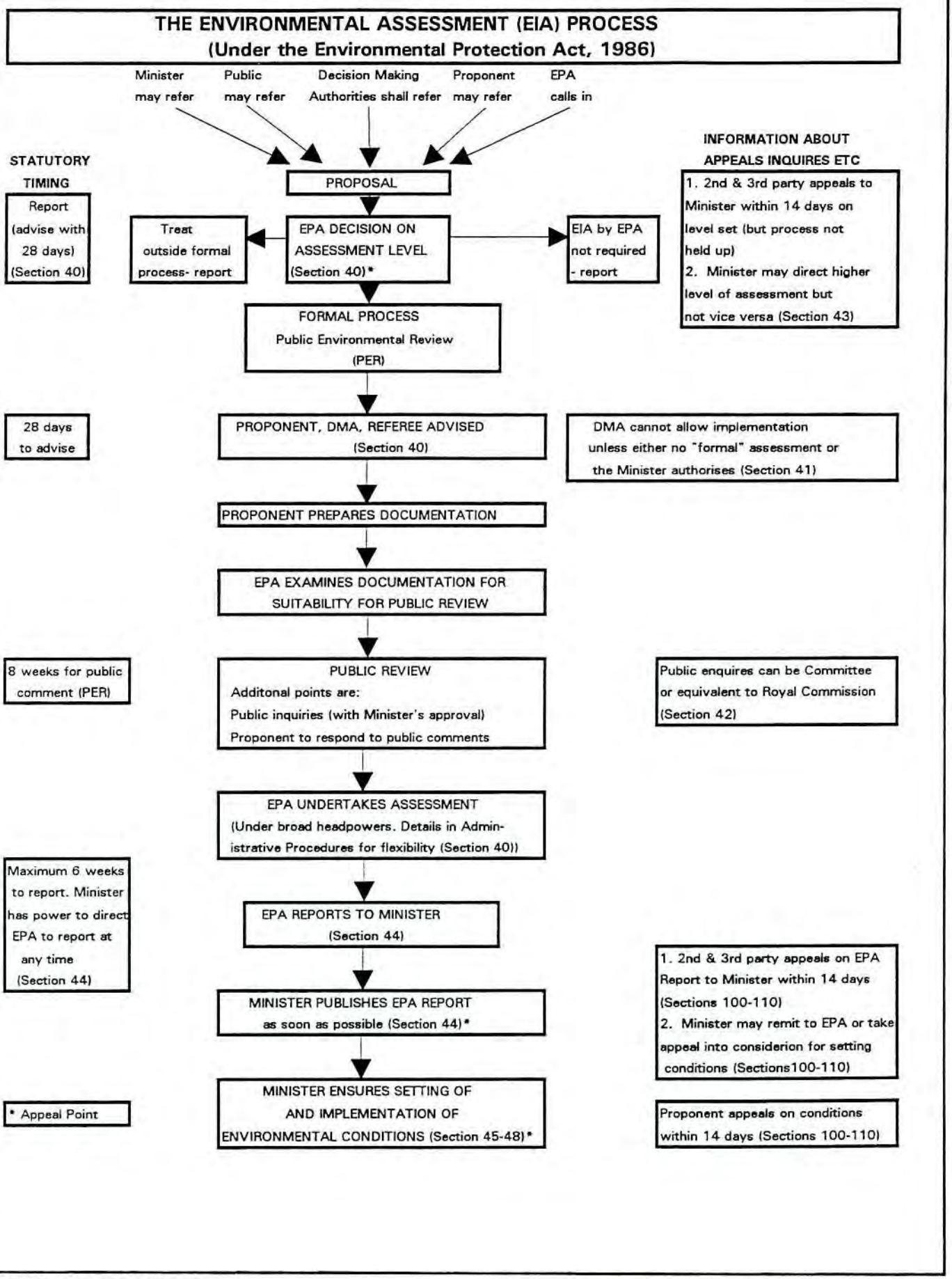
Tamora Pty Ltd (1993). Report of an Ethnographic Survey of Aboriginal Heritage for Proposed Oakajee Industrial Estate. Report to LandCorp.

Tamora Pty Ltd (1996). Aboriginal Heritage Survey, Coastal Zone, Oakajee & Buller Rivers. Report to Alan Tingay & Associates.

Waterways Commission (1995). Guidelines for the Preparation of a Dredging & Dredge Spoil Disposal Management Plan. Waterways Guidelines No. 9.

Welker Environmental Consultancy (1997). Oakajee Deepwater Port Concept Section 16(e) Strategic Environmental Review. Prepared for the Department of Resources Development.

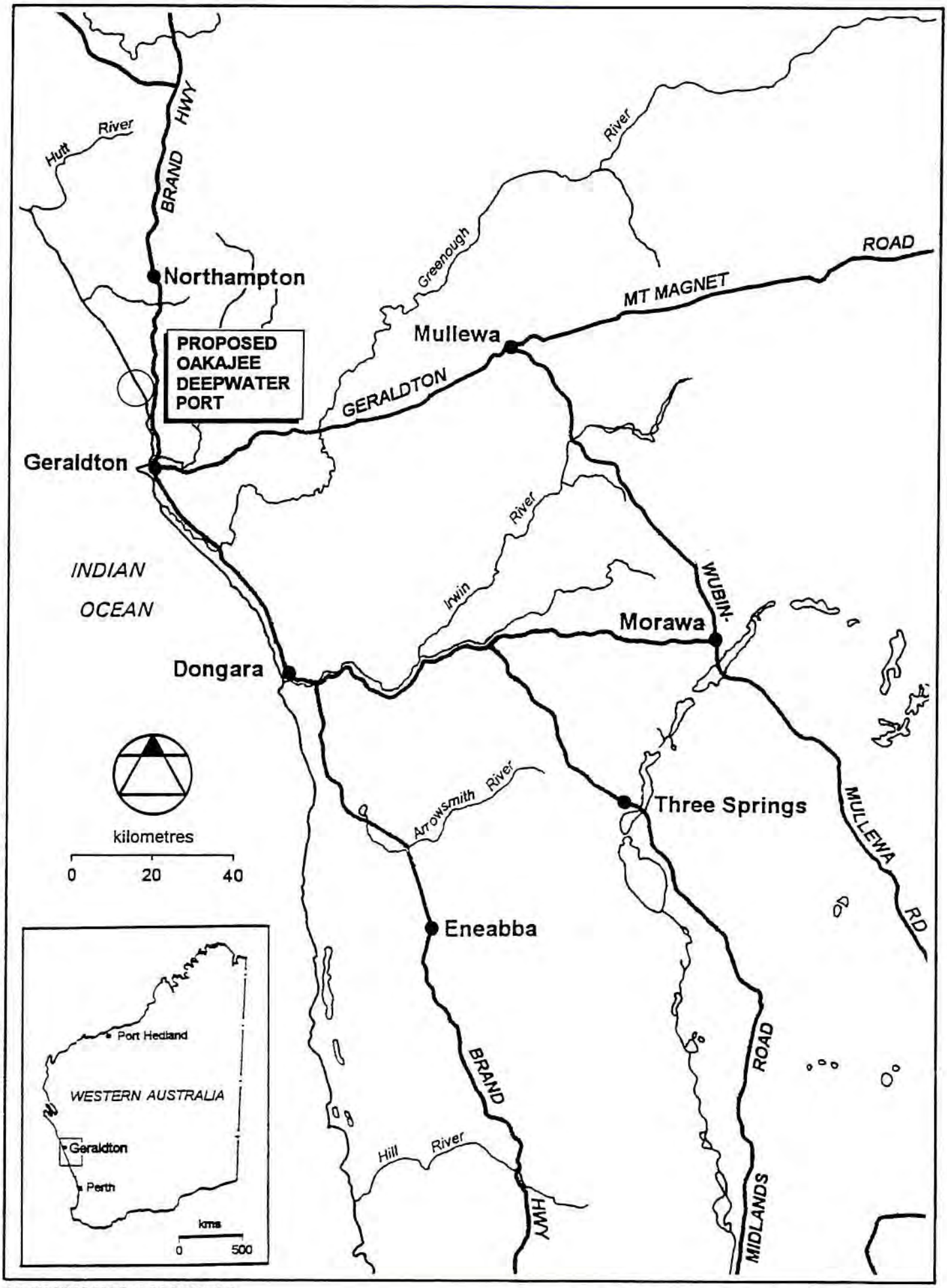
FIGURES



A96127 DRAWN BY: AT 23/12/96 CHECKED BY: AT 23/12/96

ALAN TINGAY & ASSOCIATES

OAKAJEE DEEPWATER PORT
THE PUBLIC ENVIRONMENTAL REVIEW (PER) PROCESS
FIGURE 1



A96127 DRAWN BY: ST 22-4-97 CHECKED BY: TS 23-4-97

ALAN TINGAY & ASSOCIATES

OAKAJEE DEEPWATER PORT
REGIONAL LOCATION
FIGURE 2

260 000 E
265 000 E
270 000 E
6 835 000 N
6 830 000 N

Coronation Beach
INDIAN OCEAN
19893 62
43488 12025
16200 7240
4413 CG
CG 18
CG 2914
CG 15
CG 14
CG 3150
CG 13
BUFFER
CG 7
CG 8
CG 311
OAKAJEE ROAD
CG 11
OLSEN ROAD
CG 65
CG 64
CG 538
OAKAJEE RIVER
CG 5663
CG 2202
CG 3062
CG 5620
CG 2249
BUFFER
16
15
14
13
12
11
Northern Sector
Central Sector
Southern Sector
PORT LOCATION AREA
HEAVY INDUSTRY CORE AREA
2
3
4
NORTH WEST COASTAL HIGHWAY
LACEY ROAD
CG 11692
CG 412
CG 1694
CG 1039
BUFFER
WHITE PEAK ROAD
CG 2948
6990
P15396
BULLER RIVER

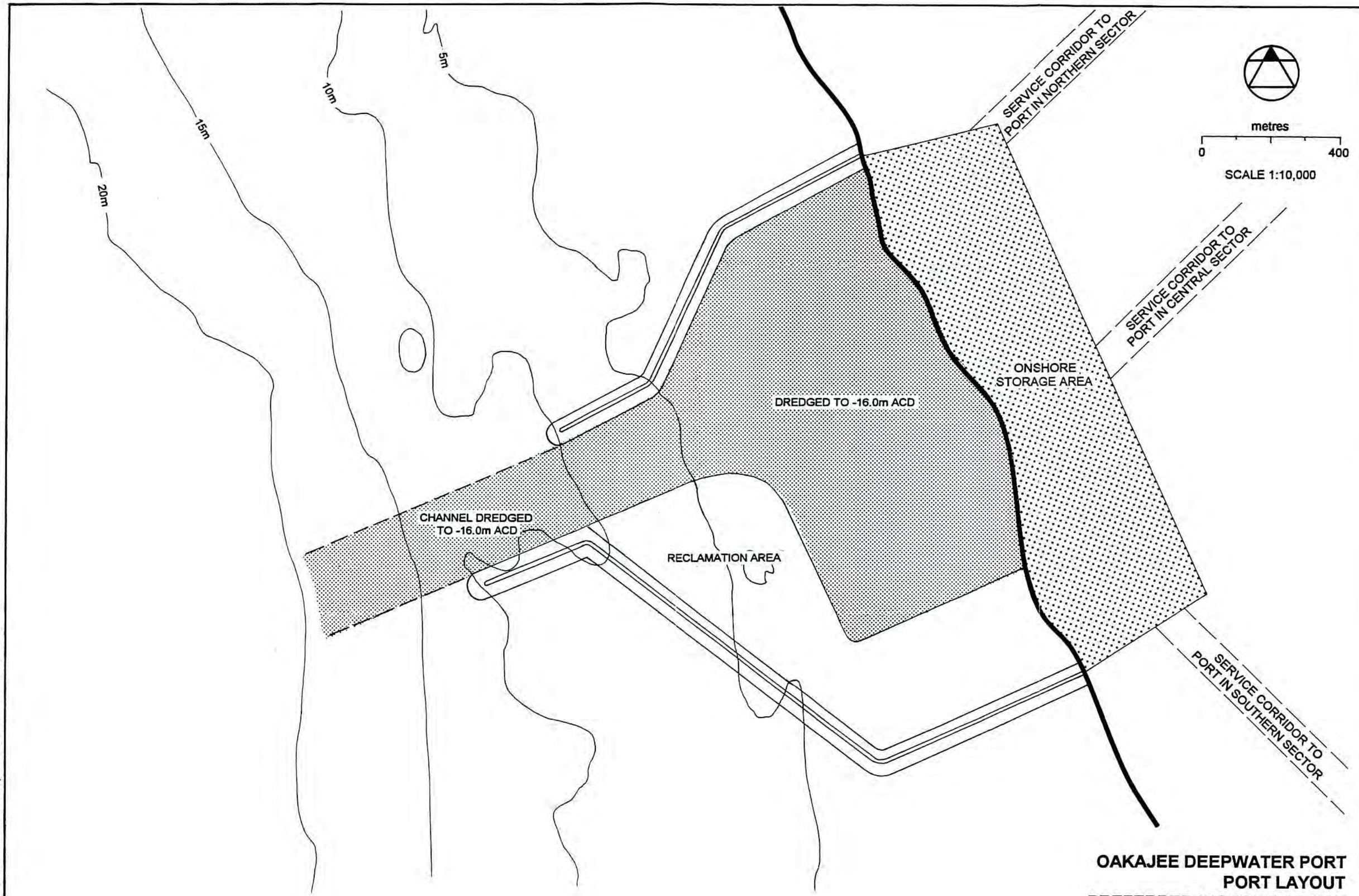
kilometres
0 1 2
SCALE 1:40,000

LEGEND

- Boundary of Heavy Industry Core Area Oakajee Industrial Estate
- Boundary of Buffer Area for Oakajee Industrial Estate
- Boundary of Port Location Area -area in which Port Site will be located

OAKAJEE DEEPWATER PORT
PROPOSED LOCATION IN RELATION TO OAKAJEE INDUSTRIAL ESTATE
FIGURE 3

ALAN TINGAY & ASSOCIATES



OAKAJEE DEEPWATER PORT
PORT LAYOUT
PREFERRED INSHORE OPTION
FIGURE 4

A96127 DRAWN BY: ST 11.3.97 CHECKED BY: AT 12.3.97

ALAN TINGAY & ASSOCIATES

kilometres

0 1

SCALE approx 1:28,000

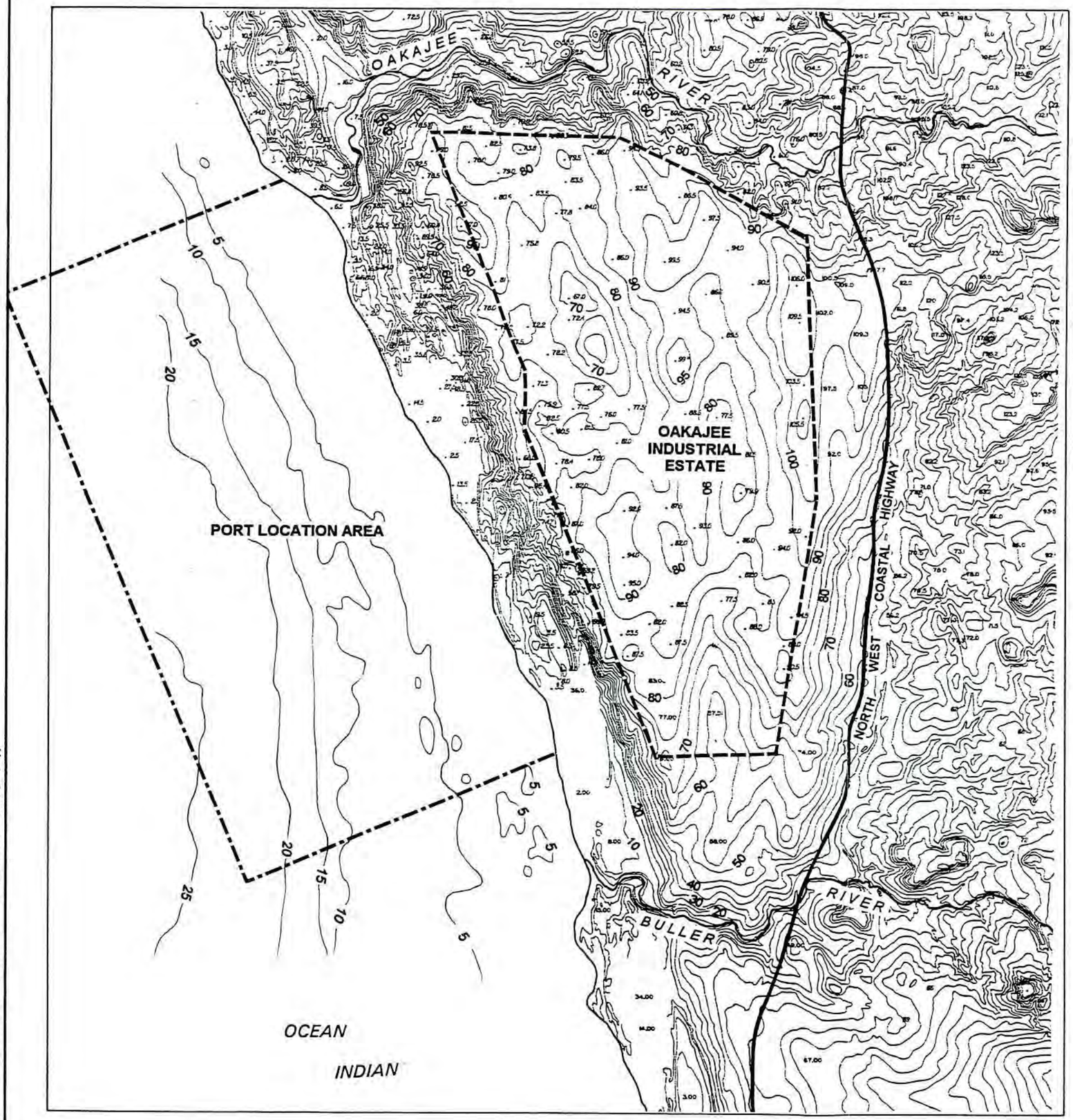
LEGEND

- Boundary of Oakajee Industrial Estate
- Boundary of Port Location Area
  -area in which Port Site will be located
- Boundary of Industrial Estate
  Buffer Area

OAKAJEE DEEPWATER PORT
AERIAL PHOTOGRAPH
FIGURE 5

A96127 DRAWN BY: ST 22-4-97 CHECKED BY: TS 23-4-97

ALAN TINGAY & ASSOCIATES



kilometres

0 1 2

SCALE 1:40,000

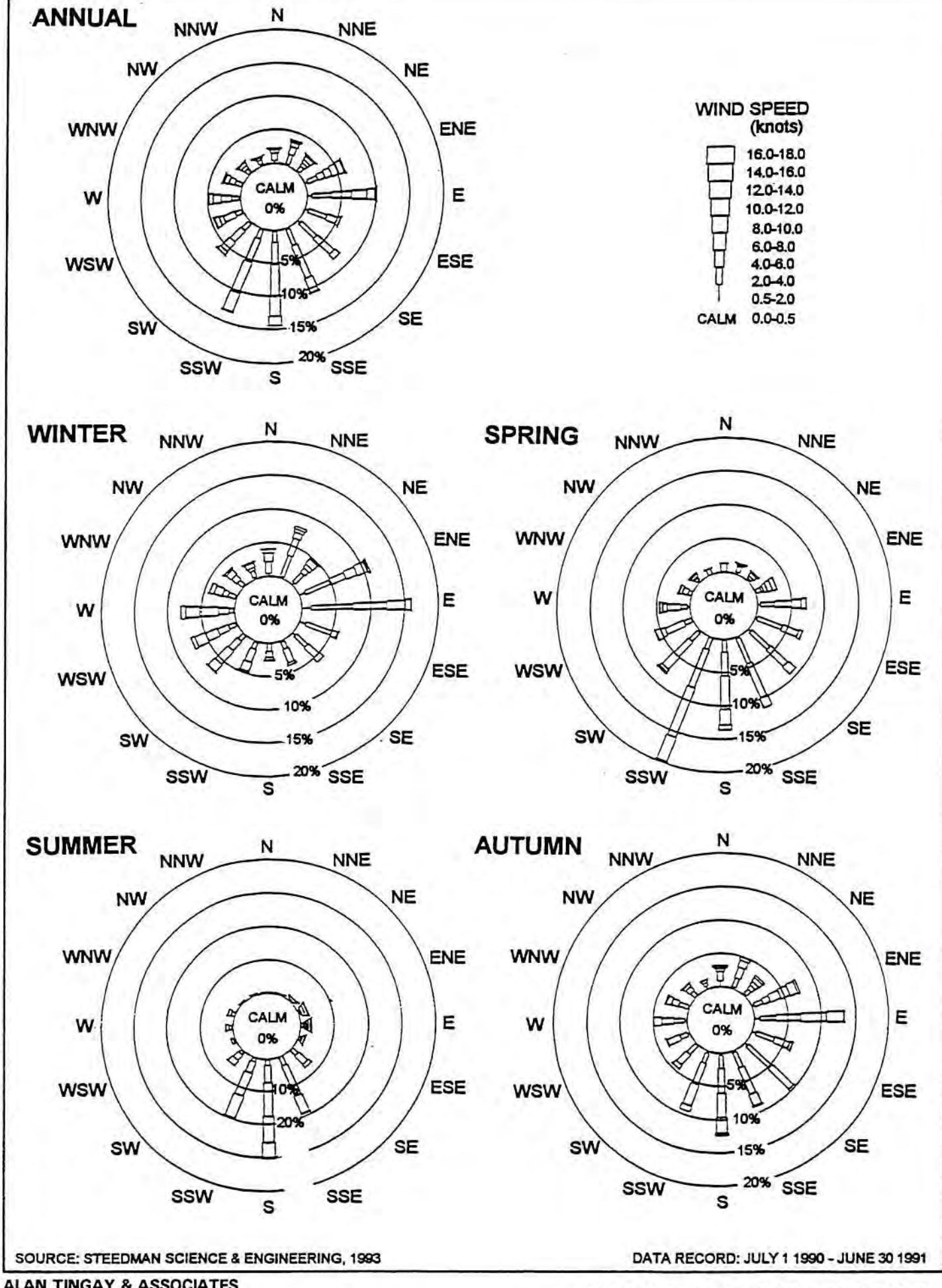
LEGEND

- 70 — Topographic Contours in metres AHD
- 20 — Bathymetric Contours in metres AHD below surface
- Boundary of Heavy Industry Core Area, Oakajee Industrial Estate
- Boundary of Port Location Area -area in which Port Site will be located

OAKAJEE DEEPWATER PORT
TOPOGRAPHY & BATHYMETRY
FIGURE 6

A96127 DRAWN BY: ST 22-4-97 CHECKED BY: TS 23-4-97

ALAN TINGAY & ASSOCIATES



SOURCE: STEEDMAN SCIENCE & ENGINEERING, 1993

DATA RECORD: JULY 1 1990 - JUNE 30 1991

A96127 DRAWN BY: ST 23/12/96 CHECKED BY: AT 23/12/96

ALAN TINGAY & ASSOCIATES

OAKAJEE DEEPWATER PORT
ANNUAL & SEASONAL WIND ROSES FOR OAKAJEE
FIGURE 7

Oakajee River

INDIAN OCEAN

PORT LOCATION AREA

5
10
15
20
25

6 836 000mN
6 835 000mN
6 834 000mN
6 833 000mN
6 832 000mN
6 831 000mN
6 830 000mN

259 000mE
260 000mE
261 000mE
262 000mE
263 000mE
264 000mE
265 000mE

Buller River

Kilometres
0 1
SCALE 1: 25,000

LEGEND

- Marine Survey Study Area
- Beach
- Shallow Sand
- High Reef
- Mixture of Shallow Pavement, Low Reef & Shallow Sand
- Mixture of Deep Pavement & Deep Sand
- Limit of Discernible Seafloor
- Boundary of Port Location Area -area in which Port Site will be located

OAKAJEE DEEPWATER PORT
MARINE SUBSTRATES & HABITATS
FIGURE 8

A96127 DRAWN BY: S.T 22-4-97 CHECKED BY: T.S 23-4-97

ALAN TINGAY & ASSOCIATES

REFERENCE

Movement of primary productivity materials

Nutrient flow

Riverine nutrient input

Seagrass and algal wrack bank

To onshore banks of wrack (17% of total productivity)

Offshore loss ?

Nutrient return from wrack

Recycled in coastal waters

Detached algae

Groundwater nutrient input

Recycled *insitu* by grazers and herbivores

Total benthic primary productivity

Offshore nutrient loss

Offshore nutrient input

High primary productivity (algae and seagrasses)

15 - 20m depth

Low primary productivity

OAKAJEE DEEPWATER PORT
COASTAL WATERS
PRIMARY PRODUCTION
& NUTRIENT FLOW DIAGRAM
FIGURE 9

SOURCE: WELKER ENVIRONMENTAL CONSULTANCY, 1997

A96127 DRAWN BY: ST 11·3·97 CHECKED BY: AT 11·3·97

ALAN TINGAY & ASSOCIATES

Coronation Beach

INDIAN

OCEAN

PORT LOCATION AREA

OAKAJEE INDUSTRIAL ESTATE

Oakajee River

HIGHWAY

COASTAL

WEST

NORTH

Buller River

Ta

Qu

No

Mo

kilometres

0 1 2

SCALE 1:40,000

LEGEND

COASTAL SANDPLAIN & DUNE SYSTEMS

Qu — QUINDALUP-Calcareous dune sands

Ta — TAMALA -Yellow, red & black sands

SYSTEMS ON GRANITIC ROCKS

No — NORTHAMPTON- Undulating: red loams & clays

SYSTEMS ON SEDIMENTARY ROCKS

Mo — MORSEBY-Low hilly: clays, loams & sands on clay

Boundary of Heavy Industry Core Area, Oakajee Industrial Estate

Boundary of Port Location Area -area in which Port Site will be located

OAKAJEE DEEPWATER PORT
LAND SYSTEMS
FIGURE 10

DRAWN BY: S.T. 22-4-97 CHECKED BY: TS 23-4-97

A96127

SOURCE: L. ROGERS, 1995

ALAN TINGAY & ASSOCIATES

INDIAN OCEAN

Oakajee River

OAKAJEE INDUSTRIAL ESTATE

PORT LOCATION AREA

HIGHWAY

COASTAL

WEST

NORTH

Buller River

A B C D E F

kilometres

0 1 2

SCALE 1:40,000

LEGEND

- A — Mobile Dune Heathland
  Olearia axillaris/Acacia rostellifera
- B — Stable Dune Heathland
  Olearia axillaris/Acacia rostellifera/ Anthoceris littorea
- C — Limestone Ridge Heathland & Shrubland
  Melaleuca cardiophylla/Acacia xanthina/ A.rostellifera/Eucalyptus eudesmoides/ Hakea obliqua
- D — Sandplain Shrubland to Low Woodland
  Banksia prionotes/Acacia rostellifera/ Acacia cyclops/Acacia saligna/ Casuarina campestris
- E — River Margin Open Woodland to Woodland
  Eucalyptus camaldulensis/ Casuarina obesa/ Melaleuca rhaphiophylla/Acacia saligna/ Acacia acuminata/Tamarix sp
- F — Valley Slopes of Heathland (*Allocasuarina campestris*) & Woodland (*Acacia saligna*)
- Cleared
- Boundary of Heavy Industry Core Area Oakajee Industrial Estate
- Boundary of Port Location Area -area in which Port Site will be located

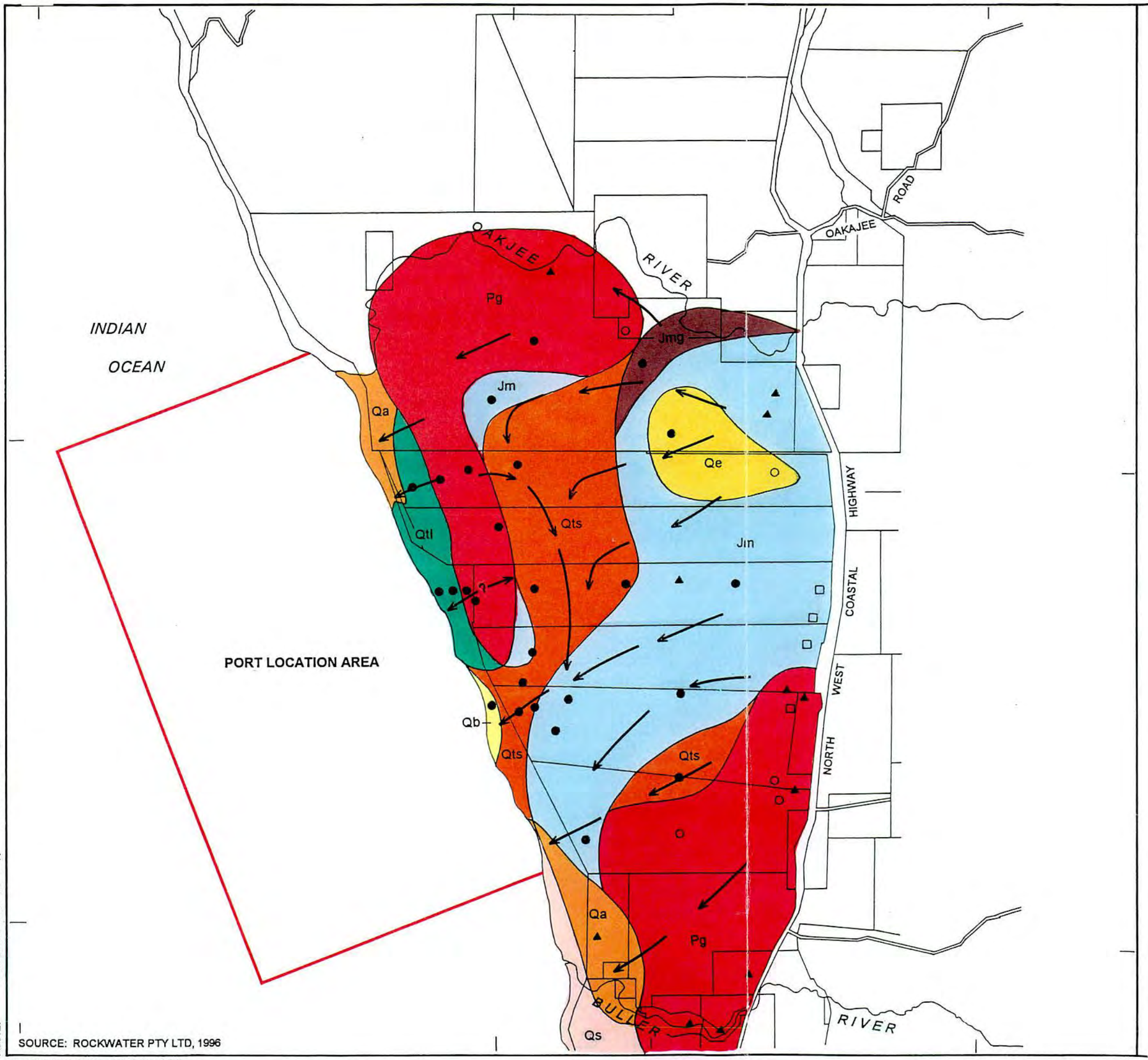
OAKAJEE DEEPWATER PORT
REMNANT VEGETATION
FIGURE 11

SOURCE: DAMES & MOORE, 1993

DRAWN BY: ST 22-4-97 CHECKED BY: TS 23-4-97

A96127

ALAN TINGAY & ASSOCIATES



kilometres

0 1 2

SCALE 1:40,000

LEGEND

- Direction of Groundwater Flow
- Qs — Safety Bay Sand
- Qa — Quaternary Alluvium
- Qb — Quaternary Silt (calcareous)
- Qe — Quaternary Superficial Sand (yellow)
- Qtl — Tamala Limestone (limestone)
- Qts — Tamala Limestone (sand)
- Jm — Chapman Group (siltstone)
- Jmg — Chapman Group (sandstone)
- Pg — Granulite
- Private Bore/Windmill
- Abandoned Private Bore
- Soak
- Monitoring Bore
- Boundary of Port Location Area- area in which Port Site will be located

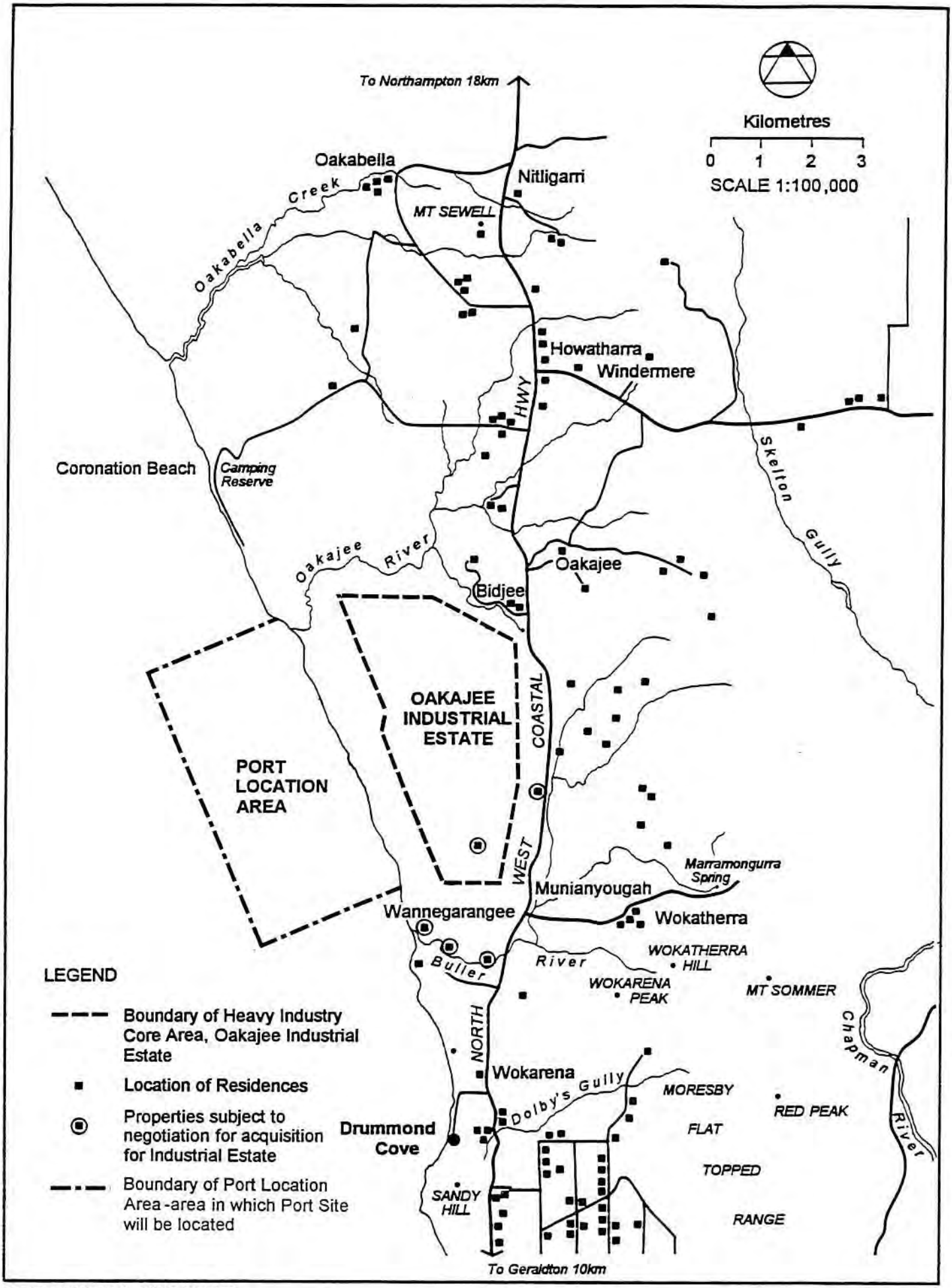
OAKAJEE DEEPWATER PORT GROUNDWATER FLOW DIRECTIONS FIGURE 12

SOURCE: ROCKWATER PTY LTD, 1996

DRAWN BY: S.T 22-4-97 CHECKED BY: T.S 23-4-97

A96127

ALAN TINGAY & ASSOCIATES



A96127 DRAWN BY: S.T 22-4-97 CHECKED BY: T.S 23-4-97

ALAN TINGAY & ASSOCIATES

OAKAJEE DEEPWATER PORT
LOCATION OF NEARBY RESIDENCES
FIGURE 13

APPENDICES

APPENDIX 1

EPA GUIDELINES

Environmental Protection Authority

OAKAJEE DEEPWATER PORT, OAKAJEE, CHAPMAN VALLEY, MINISTER FOR RESOURCES DEVELOPMENT, (ASSESSMENT NO.1074)

PUBLIC ENVIRONMENTAL REVIEW GUIDELINES

Overview

The Minister for Resources Development has referred to the Environmental Protection Authority (EPA) a proposal for a port development to be located adjacent to the Oakjee Industrial Estate, north of Geraldton.

All environmental reviews have the objective of protecting the environment, and environmental impact assessment is deliberately a public process in order to obtain broad ranging advice. The review requires the proponent to describe the proposal, receiving environment, potential environmental impacts and the management of the issues arising from the environmental impacts, so that the environment is protected to an acceptable level.

Throughout the assessment process it is the objective of the Environmental Protection Authority (EPA) to assist the proponent to improve the proposal such that the environment is protected in the best manner possible. The DEP will co-ordinate, on behalf of the EPA, relevant government agencies and the public in providing advice about environmental matters during the assessment of the Public Environmental Review (PER) for this proposal.

The primary purpose of the PER is to provide information on the proposal to the EPA within the regional framework. The aim of the document is to emphasise those relevant environmental factors which have the potential to impact on the physical and biological environment of Oakajee.

Objectives of the PER

The objectives of the PER are to:

- place this proposal in the context of the regional environment;
- adequately describe all components of the proposal, so that the Minister for the Environment can consider approval of a well-defined project; and
- provide the basis of the proponent's environmental management program, which shows that the environmental issues resulting from the proposal can be acceptably managed;
- communicate clearly with the public (including government agencies), so that the EPA can obtain informed public comment to assist in providing advice to government.

Contents of the PER

The fundamental contents of the PER should include:

- a brief introduction of the proponent, the project and location. A map/plan, which both clearly indicates the nature and extent of the initial project and the works proposed, and a regional map should also be included which identifies the proposal within a social and regional setting;

- a summary table which clearly presents the characteristics of the proposal, to include but not be limited to a description of the components of the proposal such as the port including the breakwater, causeway, berths, reclaim areas, service corridor(s) to the industrial site, quarry, and associated infrastructure including details of their potential impacts;
- details of decision making authorities and involved agencies;
- reference to the description of the receiving environment which may be impacted;
- discussion of the relevant environmental factors, including an assessment of the significance as related to objectives or standards which may apply, for example air quality guidelines;
- discussion of the management of the factors raised including commitments to appropriate action;
- a description of and summary of an environmental management program, including the key commitments, monitoring work and the auditing of the program which will provide the basis for the operation of the port in an acceptable manner.

For this proposal, the environmental review would focus on protecting the environmental values of the area directly affected by the port and its associated infrastructure.

The language used in the body of the PER should be kept simple and concise, considering the audience includes non-technical people, and any extensive, technical detail should either be referenced or appended to the PER. The PER will form the legal basis of the Minister for the Environment's approval of the proposal and, hence, should include a description of all the main and ancillary components of the proposal, including options if necessary.

Environmental Management

The EPA considers that the proponent should approach environmental management of the proposal in terms of best practice. Best practice environmental management includes:

- an overall objective to reduce as far as practicable potential impacts on the environment;
- development of an environmental policy;
- agreed environmental objectives;
- management of environmental objectives;
- involving the public as appropriate;
- audit performance against agreed indicators;
- regular reporting to the EPA (or nominated agency);
- commitment to a quality assured management system and continuous improvement;
- periodic (for example 5 yearly) review in conjunction with the EPA (or nominated agency).

Factors

Factors can be determined from a consideration, called scoping, of the potential impacts from the various components of the proposal on a receiving environment, including people. Relevant environmental factors are those which have the potential to have significant environmental impacts and accordingly may require the EPA to report on to the Minister for the Environment. The PER should focus on these relevant factors for the proposal, as have been identified in consultation with the EPA and relevant public and government agencies.

A description of the project component and the receiving environment should be referenced to the discussion of the factor. The technical basis for measuring the impact and any objectives or standards for assessing and managing each factor should be provided.

The EPA considers that the proponent should provide, within the body of the document, a table which describes, with regards to the relevant environmental factors (those upon which the EPA is likely to report on to the Minister for the Environment). The following elements should be addressed in the table:

(a) identification of the characteristics of the proposal;

(b) nominated environmental management objectives(s) for those aspects which require management;

(c) description of the existing environment;

(d) potential impacts of the proposal on the environment;

(e) environmental management response or commitment to manage impacts to meet the above objective(s); and

(f) likely impact of application of this response.

The factors from which the key environmental factors are derived (and their corresponding objectives) at this stage should be set out under the following categories :

- **biophysical;**
- **pollution; and**
- **social surroundings.**

A range of factors identified and the EPA's management objective for these factors have been listed in Attachment 1. The following are the key factors in this assessment:

- **Vegetation Communities;**
- **Declared Rare and Priority Flora;**
- **Terrestrial Fauna;**
- **Threatened and Priority Fauna;**
- **Marine Fauna;**
- **Seagrass;**
- **Macroalgae;**
- **Threatened and Priority Marine Fauna;**
- **Introduced Marine Organisms;**
- **Shoreline;**
- **Marine Water Quality;**
- **Sediment Quality;**
- **Dust;**
- **Noise and Vibration;**
- **Public Health and Safety;**
- **Heritage;**
- **Recreation.**

Further key issues may be raised during the preparation of the PER, and on-going consultation with the EPA and relevant agencies is recommended. Minor issues which can be readily managed as part of normal operations for similar projects may be briefly described. Information used to reach conclusions should be properly referenced, including personal communications. Assessments of the significance of an impact should be soundly based and the assessment should lead to a discussion of the management of the issue.

Specific Issues

In discussing the environmental factors identified above, the PER should cover the specific issues listed below:

Port and Quarry Sites

Impact on:

- **off-shore reef and near-shore marine habitats both during construction and operation;**
- **off-shore sand movement through the breakwater and causeway;**
- **accumulation of algal and seagrass wrack on the breakwater;**
- **local professional and amateur fishing and rock lobster fishing operations;**
- **existing recreational use of beach and off-shore reef areas;**
- **impact on groundwater resources;**
- **coastal foreshore/dunes;**
- **marine water quality;**
- **sediment quality - potential contamination (heavy metals, TBT);**
- **ballast water management - treatment and disposal;**
- **dust - during construction and operation;**
- **existing local residents and communities including the impact of traffic and noise associated with port construction and operation, air emissions, dust, odour, noise, and consideration of the retention and management of appropriate buffer zones.**
- **land within the proposed access corridor(s) to the port;**
- **any identified areas of Aboriginal and European heritage.**
- **flora, fauna, and vegetation at the quarry site;**
- **impacts of the quarry on the local communities in terms of air emissions, noise and vibration, dust, traffic.**
- **infrastructure servicing the port - roads, rail, conveyor belts, etc.**
- **potential impacts associated with the handling and transport of hazardous materials from the proposed port to the industrial estate, or from the industrial estate to the port (risk);**

Commonwealth Requirements

The following specific Commonwealth requirements need to be addressed:

- the requirements of the Commonwealth *Endangered Species Protection Act 1992*;
- the requirements of the *Australian Heritage Commission Act 1975*, if the proposal is likely to directly or indirectly effect any places listed on the Register of the National Estate;
- if there are indigenous issues associated with the proposal, issues relating to potentially affected resident indigenous communities and traditional owners should be examined.

Public Consultation

A description should be provided of the public participation and consultation activities undertaken by the proponent in preparing the PER. It should describe the activities undertaken, the dates, the groups/individuals involved and the objectives of the activities. Cross reference should be made with the description of environmental management of the issues which should clearly indicate how community concerns have been addressed. Those concerns which are dealt with outside the EPA process can be noted and referenced.

If additional information (eg project design, field surveys) is to be provided at a later date, the process by which the public review of this information will be facilitated, should be documented.

Environmental Management Commitments

The method of implementation of the proposal and all commitments made by the proponent in the PER will become *legally enforceable* under the environmental conditions of the Minister for the Environment's approval. Specific commitments to protect the environment, typically related to the key issues, should be separately listed, numbered and take the form of:

- who would do the work;
- what the work is;
- when the work would be carried out; and
- what agencies would be involved.

These key commitments show that the proponent is committed to actionable and auditable management of the environmental issues.

Other commitments show that the proponent is dedicated to good environmental management of the project, and the EPA expects that the proponent will audit these commitments by internal processes under an Environmental Management System. The commitments define the goals/objectives for the environmental management program and procedures (the details of how the commitment will be met), which should be described in as much detail as possible. The EPA acknowledges that, with the implementation of best practice and continuous improvement for the project, the procedures may need to be modified, or added to, in regular updates to the environmental management program.

An example of a typical commitment is:

Issue	Objective	Commitment	Timing (Phase)	Whose requirements	Specification (Performance Indicator)
EMP	Implement effective EMP	Develop and implement an effective EMP	Pre-construction and on-going	EPA	EMP developed and implemented to requirements of EPA.

OAKAJEE DEEPWATER PORT PROPOSAL

PUBLIC ENVIRONMENTAL REVIEW

GUIDELINES

PRELIMINARY ENVIRONMENTAL FACTORS	RELEVANT ENVIRONMENT	EPA OBJECTIVE(S)	EPA POLICY / POSITION AND ADDITIONAL COMMENTS
BIOPHYSICAL			
Vegetation Communities Rare and Priority Flora	Primary and secondary dune areas adjacent to the port and port services area.	To maintain the abundance, diversity, geographic distribution and productivity of vegetation communities. Protect rare and priority flora consistent with the provisions of the *Wildlife Conservation Act 1950.*	
Terrestrial Fauna Threatened and Priority Fauna	Primary and secondary dune areas.	To maintain the abundance, diversity and geographic distribution of fauna. Protect threatened and priority fauna consistent with the provisions of the *Wildlife Conservation Act 1950.*	
Seagrass Macroalgae	Extent of port area and approach channel(s) and surrounding marine environment.	Maintain the abundance, species diversity and geographic distribution of seagrass. To minimise interference with the process of nutrient and carbon cycling from beach cast seaweed.	

Marine Fauna Threatened and Priority Marine Fauna Introduced Marine Organisms	Extent of port area and approach channel(s) and surrounding marine environment.	To maintain the abundance, species diversity and geographic distribution of marine fauna. Protect threatened and priority fauna consistent with the provisions of the *Wildlife Conservation Act 1950.* Minimise the risk of introduction of unwanted, non-indigenous marine organisms.	
Shoreline	Foreshore area and adjacent marine area.	To maintain the stability of beaches.	
POLLUTION			
Marine Water Quality	Extent of port area, approach channel(s) and surrounding marine environment.	To maintain water quality to accepted criteria to protect the environmental values of recreation, aesthetics, aquatic life for human consumption and maintenance of aquatic ecosystems in agreed areas. (Southern Metropolitan Coastal Water Study, 1996)	
Sediment Quality	Extent of port area, approach channels and surrounding areas.	To maintain sediment quality to accepted criteria to protect the environmental values of recreation, aesthetics, aquatic life for human consumption and maintenance of aquatic ecosystems in agreed areas. (Southern Metropolitan Coastal Water Study, 1996)	

Dust	Port and quarry sites.	To protect the surrounding land users such that dust emissions will not adversely impact upon their welfare and amenity or cause health problems and meet EPA Guidelines for Assessment and Control of Dust and Windborne Material from Land Development Sites (updated 1995), and the Environmental Protection Policy (Atmospheric Wastes) (Kwinana).	The EPA base environmental acceptability on NH&MRC, VEPA, USEPA, and WHO criteria.
Noise and Vibration	Port and quarry sites.	Protect the amenity of nearby residents from noise and vibration impacts by ensuring that noise and vibration meet criteria in the Noise Abatement (Neighbourhood Annoyance) Regulations 1979, and the proposed new Environmental Protection (Noise) Regulations (when promulgated).	
SOCIAL SURROUNDINGS			
Public health and safety	Port area and transport corridor to industrial site, adjacent recreational beach areas.	Risk is as low as reasonably achievable and complies with acceptable standards. The EPA's criteria for the assessment of the fatality risk of proposed hazardous and industrial developments are outlined in Bulletins 611 and 627.	DOME's Explosive and Dangerous Goods Division provide advice in relation to risks and hazards.
Heritage (indigenous and non-indigenous cultures)	Marine and foreshore areas.	Comply with statutory requirements in relation to areas of cultural or historical significance.	To comply with the appropriate Acts.
Recreation	Coastal strip from the Buller to Oakajee Rivers.	The concept should not compromise recreational uses of the area, as developed by planning agencies.	

APPENDIX 2

MARINE SURVEY REPORT

MINISTER FOR RESOURCES DEVELOPMENT

PROPOSED
OAKAJEE DEEP WATER PORT SITE
MARINE SEAFLOOR HABITAT SURVEY
MARINE IMPACT ASSESSMENT AND
FISHERIES ASSESSMENT

ALAN TINGAY & ASSOCIATES

APRIL 1997

REPORT NO: 97/25

DISCLAIMER

This report has been prepared on behalf of and for the exclusive use of the client, and is subject to and issued in accordance with the agreement between the Client and Alan Tingay & Associates. Alan Tingay & Associates accepts no liability or responsibility whatsoever for it in respect of any use of or reliance upon this report by any third party.

As part of our Quality System, documents are checked then approved prior to distribution.

Document Reference:	PC001 - Report No. 97/25
Project Number:	A96127
Draft:	Final
Checked:	TS
Approved:	AT
Date:	5/05/97

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

APPENDICES

SUMMARY

It is proposed to develop a deep water point facility at Oakajee, 18km north of Geraldton. The port is initially intended to export products in the form of slab and billet steel from a steel plant although other industries may subsequently use the port. The exact location and design of the port has not yet been finalised. However, the port will be constructed within a Port Location Area as indicated in Figure 1. This report documents the marine environment and fisheries at Oakajee, identifies potential impacts of the port develcpment, and suggests management strategies to minimise these impacts.

The seafloor at Oakajee consists of limestone reefs and pavement and slopes from the shoreline offshore to a depth of 20m from where it slopes more gently to greater depths further offshore. A veneer of sand covers the depressions in the seafloor and much of the offshore area. A marine habitat survey of the seafloor was conducted in December 1996 which covered an area extending along 6km of shoreline and up to 5km offshore. This survey identified the following major habitats:

i) Sandy beaches - these form most of the shoreline in the Oakajee area and act as a site recycling of nutrients from stranded algal and seagrass wrack.

ii) Shallow sandy seafloor - a habitat of low biomass and productivity occurring in patches amongst limestone reef and pavement.

iii) High reef - an extensive shallow water area colonised by dense algal meadows and reef biota forming a band parallel, and close to, the shoreline. This is an area of extremely high biomass, productivity and biological diversity.

iv) Shallow limestone pavement - flat areas of limestone colonised by dense, mixed algal and seagrass meadows and an area of high biomass and productivity.

v) Low reef - low ridges of limestone in less than 15m depth colonised by dense algae and seagrass as well as other reef biota. An area of high biomass, productivity and biological diversity.

vi) Deep limestone pavement - in water depths greater than 15m by algae and sessile invertebrates at low density.

vii) Deep sandy seafloor - major component of the seafloor in water depths greater than 15m consisting of bare sand and of relatively low biological importance.

The Oakajee area is used by both commercial and recreational fisheries. Commercial fishing is largely limited to the important rock lobster fishery with eight boats using the Oakajee coastline continuously and up to 37 boats using it on a seasonal basis. The average annual catch of rock lobsters in the Oakajee statistical fishing block is valued at $1.2m. The rock lobster fishery is located

mainly in the shallow (0-18m depth) waters and includes both white and red rock lobsters. In comparison to adjoining fishing areas, the annual catch of rock lobsters is lower at Oakajee. There is no evidence that the Oakajee area supports more juvenile (undersize) rock lobsters than the adjoining areas.

While the port design is not yet finalised and other industries are likely to use the port in the future, an outline of the potential impacts of the port development on the natural marine environment is provided. These impacts can be divided into permanent, construction and operating effects. Permanent impacts include loss of marine habitat, buildup of sand and algal and seagrass wrack on the shoreline, and local modification of water circulation. Construction impacts are limited to the construction phone of the project and include increased turbidity, dredging and potential for accidental spillage. Operating impacts may occur once the port is in use and potentially include maintenance dredging, wastewater discharge, oil spills, ballast water discharge, anti-fouling paints, maritime accidents, cargo spillages, stormwater discharge and turbidity and turbulence caused by shipping movements. The importance and likelihood of the above impacts are discussed together with means to prevent or limit their occurrence. There is also a potential environmental benefit in building the new port in that the breakwaters will provide an extra area of reef-type habitat.

The impact of the port development on marine conservation at Oakajee is discussed. The marine habitats and biotic assemblages at Oakajee also occur extensively elsewhere along the south-west coast of Western Australia. There are no high conservation marine reserves in the Oakajee region. Similarly the Oakajee region does not provide a significant resource for any declared rare or endangered marine biota and the port development will not have a substantial effect on seagrass.

The Oakajee port development will remove a limited area of habitat for rock lobsters and thus have a small effect on the local fishery. Rock lobster fishing will also be restricted in a limited area for shipping approach channel to the port, and perhaps in a more extensive offshore mooring area.

A management strategy is proposed to minimise the environmental impact of the port development. The management strategy includes monitoring of environmental parameters to confirm that the effects of the port development do not exceed acceptable levels. If these levels are exceeded, then an appropriate management strategy should be adopted to overcome the problem.

1. INTRODUCTION

1.1 Background

It is proposed to develop an industrial estate and related port facilities at Oakajee, 18km north of Geraldton (Figure 1). The industrial area is located 1km inland from the coast and is situated behind a coastal escarpment. At present, the intended users of the industrial estate are the proposed Geraldton Steel Plant (GSP) and a proposed hot briquetted iron plant, although other industries may subsequently become established in the estate. The development of the GSP at Oakajee is the subject of a separate environmental assessment (Alan Tingay & Associates, 1997), and any future users of the Oakajee Estate will also be subjected to environmental assessment by the Environmental Protection Authority, prior to approval for them to establish at Oakajee.

The exact location and design of the breakwaters have yet to be finalised. This will occur following more detailed engineering feasibility studies of the Oakajee site. However, the area in which the port facilities will be located is shown in Figure 1. The exact location of the port will not be established until further geotechnical work is completed.

This report is concerned with the impact of the proposed port facilities, and their construction and operation, on the marine habitats and biota, and the fisheries in the area. As such, it documents the marine habitats, biota and fisheries in the Oakajee area and then assesses the impact of the proposed port on these resources.

1.2 Acknowledgements

The following individuals provided information relevant to this project and we would like to thank them for their assistance.

- Dr Bob Prince of the Department of Conservation and Land Management (CALM) for information on dugongs.
- Mr Wayne Godenzie of the Fisheries Department for background information on recreational and commercial fisheries.
- Mr Nick Caputi of the Fisheries Department for providing statistics on the rock lobster fishing industry at Oakajee and adjacent areas.
- Dr Howard Jones of the Fisheries Department for useful discussion and access to the Fisheries Resource Maps.

2. MARINE ENVIRONMENT DESCRIPTION

2.1 Physical Environment

2.1.1 Regional Geomorphology

The coastline of Western Australia between Cape Naturaliste in the south and North West Cape in the north is comprised predominantly of relatively young sedimentary (Quaternary) geology with generally low relief. The coastline is dominated in the south by limestone headlands and broad sandy beaches. The coastal limestone, which extends offshore many kilometres and occasionally forms islands, is believed to be have resulted from calcareous dunes of the late Quaternary period which have lithified to aeolianite (Seddon, 1972). The more prominent of these ridges have formed islands.

Much of the shoreline where limestone is present displays a current wave cut platform just below the high water line, and often evidence of other older platforms which have resulted from historical changes in sea level over the last 10,000 years. Wave cut platforms often extend many hundreds of metres offshore.

The offshore islands which extend from the Perth area to Geraldton also exhibit multiple wave cut platforms similar to those on the shoreline. Where the limestone formations are below water level or where wave action has removed the upper portions of islands there are reef formations which typically form in roughly parallel lines to the beach. These create barriers to swell and currents thereby producing protected inshore areas.

This coastal and marine limestone formation extends up to and including Port Gregory. From Port Gregory north to Kalbarri the coastline is dominated by extensive and high abuttments and sea cliffs (predominantly sandstone) of the older Silurian age. From Kalbarri to Shark Bay the coastline is characterised by similar high limestone/sandstone sea cliffs but of the younger Quarternary age. This area contains fewer offshore reefs and generally deeper water closer inshore. Good examples of these formations can be seen in the area north of Kalbarri and at Dirk Hartog Island.

2.1.2 Bathymetry

The bathymetry of the area south of Geraldton and extending 30km to the north is characterised by an extensive offshore shelf with a relatively consistent depth of between 35m - 45m (the continental shelf). This extends offshore for a distance of approximately 80km before rapidly dropping off into the deep water. On the outer edge of the shelf opposite the Oakajee site is a series of small islands (Houtman Abrolhos Islands) with very shallow and extensive wave cut reef platforms. These islands and reefs extend from 70-80km almost directly west of Geraldton in a north north westerly direction parallel to the coast for approximately 80km.

Closer inshore the 30m bathymetric displays an unusual local configuration. Whereas it is 15km offshore at Port Gregory and 8km offshore at Geraldton, it

comes very close to the coastline (3km) in the Oakabella River area just north of Oakajee.

The Houtman Abrolhos Islands act to a minor degree to break down ocean swells and general oceanic energy, however the intervening distance of relatively deep water allows for further build up of wind driven and ground swells. As a consequence ocean swells and currents at Geraldton and Oakajee, where there are no fringing inshore reefs, are considered to be of relatively high energy.

The bathymetry of the Oakajee area is shown on Chart AUS 751 and in Figure 2. The seafloor drops from the shoreline to a depth of 5m at approximately 900m then to 10m at 1.4km and down to a depth of 20m at approximately 2.2.km. From here the gradient is more gentle reaching 30m at approximately 7km offshore.

2.1.3 Oceanography

The oceanography including the wind, wave and tidal regime have been described in other reports associated with this document (Welker Environmental Consultancy, 1997; Alan Tingay & Associates, 1997). For this report, the important points to note are:

i) Wind

- The Geraldton area is usually subject to strong winds during summer.
- Summer winds tend to be from the south-east to south-west.
- Winter winds are more variable in direction and tend to be lower in strength (with the exception of winter storms).
- There is a strong diurnal land breeze/seabreeze system, particularly during summer when the breeze swings from the south-east to the south-west.

ii) Waves

- Locally generated waves result from the strong winds in the area, particularly from the south-west sea breeze.
- Passing cold fronts in winter generate storm conditions.
- Swell waves are generated by storms in the Southern Ocean.

iii) Tides

- Predominantly diurnal (one cycle per day).
- Small daily range of 0.7m during spring tides.
- Tidal levels are also affected by winter cold fronts and summer cyclones.

Oceanic currents in the vicinity of the Oakajee area are not well known at present. However, information on currents on the continental shelf in the vicinity of the Abrolhos Islands suggests that currents in summer are driven by the southerly winds and are likely to flow to the north (Cresswell, 1989). These currents occur in pulses and are linked to the eastward passage of high pressure systems. In winter, current flow tends to be southward and also in pulses, as a result of the passage of north-westerly winds produced by low pressure systems, and possibly also due to the spread of the Leeuwin Current onto the continental shelf. In general, though, the Leeuwin current occurs off the continental shelf and to the west of the Abrolhos Islands, and is not relevant to the situation at Oakajee.

Seawater characteristics at Oakajee have been discussed by George (1993). While there is little direct information from the Oakajee site, it is expected that conditions are typically oceanic with oxygen levels close to saturation and seawater temperatures in the range 18.9°C to 24.1°C. Salinity levels are likely to be in the vicinity of 35.0% to 35.5%, but perhaps occasionally ranging down to 34.4% after freshwater inflow from thte local rivers and up to 37.7% after periods of extreme evaporation.

Seawater turbidity appears to be unusually high at Oakajee. George (1993) noted that it was impossible to see the seafloor at 6m depth even on a calm day. Field surveys for this report in November and December 1996 similarly revealed high turbidity during conditions of normal to high wind strength (easterly to south-westerly), but with turbidity decreasing during a day of low wind and low swell. At the same time, south of the Oakajee site (Drummond Cove southwards), turbidity was much lower and the seafloor was clearly visible at 6m depth.

High turbidity at Oakajee probably results from the continual re-suspension of fine sediments there through wave and swell activity. The absence of offshore reef lines at Oakajee means that these forces are active closer to the shoreline and in shallower water depths. The source of the fine sediments is probably from the local small rivers (the Oakabella, the Oakajee and the Buller), as well as the larger Chapman River and possibly rivers south of Geraldton. All of these rivers flow intermittently following periods of heavy rain and sediment plumes are visible extending out to sea. In 1996, winter rainfall in the Geraldton area was particularly high, with the result that turbid water was observed to persist along the Geraldton coastline throughout much of the spring and early summer.

2.2 Marine Biological Environment

2.2.1 Regional Biota

The south-west coast of Western Australia is a zone of overlap between the temperate biota of southern Australia and the tropical biota of northern Australia (Wilson et al, 1979). As such it contains elements of biota from both the temperate areas and the tropical areas. In addition, there is a suite of species which are endemic to the south-west coast (e.g. West Australian Jewfish, Western Rock Lobster).

The Geraldton coastline probably contains more tropical species than areas further south around Perth, but it is dominated by the temperate kelps (*Ecklonia*), brown algae (*Sargassum*) and seagrasses (*Posidonia*, *Amphibolus* and *Thalassodendrum*) (Monaghan, Rooke & Robinson, 1993; 1994) of southern waters. Tropical species such as corals occur in abundance on the offshore Abrolhos Islands, but only sporadically in the nearshore Geraldton waters.

2.2.2 Marine Habitats and Biotic Assemblage

The biota of the Oakajee area are described in terms of either the habitat they occupy, or as biological assemblages if they form distinct assemblages (e.g. seagrass meadows). This split descriptive system has previously been used for the Geraldton area (Monaghan, Rooke & Robinson, 1993; 1994) and has been adopted on a statewide basis for marine environments (CALM, 1994).

A description of the major biological assemblages, the habitats they occupy, and the distribution of the habitats in the Oakajee area is provided in the following section. This information is based on:

- Aerial photographs

  Aerial photographs taken of the Oakajee coastline were examined to identify any that provided good penetration to the seafloor. The best set of photographs were taken in October 1994 when water clarity and weather conditions were ideal and seafloor characteristics were readily discernible to depths of up to 20m (Figure 3).

  Mapping of the seafloor characteristics was based on the following photographs: WA 3453(c) Cape Leeuwin-Kalbarri Run 22 No's 5007-5010 at 1:20,000, 29.10.94, 940590.

- Bathymetric charts

  Existing bathymetric charts of the seafloor were examined to describe the seafloor depth and topography and to identify features of interest such as reef areas.

- Detailed Site Survey

A seafloor survey of the Oakajee area was undertaken on 26 November and 17-20 December 1996. A total of 79 sites were surveyed extending 3km north and 3km south of the Oakajee site and up to 5km offshore. The survey was based primarily on videotape coverage of the seafloor and supplemented by diving at a few sites. For the video survey, a video camera was suspended approximately 600mm above the seafloor while the boat drifted for approximately 50m - 100m at each site. The main habitat types and biota were recorded directly from the live video images while more detail was provided from a subsequent examination of the videotape. This survey was conducted by two marine biologists (P. Chalmer and K. Grey) who were familiar with the area and had conducted similar habitat and biota surveys using both diving and video survey in the region at Pt Moore, Georgina and Champion Bay.

Survey sites were located throughout the project area to cover the range of habitat types, however access to the reef areas along the shore was extremely difficult because of wave conditions and thus seafloor inspection was limited in this area. However, interpretation of the nearshore reef areas was relatively easy because of the good water penetration of the aerial photograph.

Information from the aerial photographs, bathymetric charts and the site survey were integrated to describe the major habitats/biotic assemblages and map their distribution. The major habitats/biotic assemblages identified were:

- Sandy beaches
- Shallow sandy seafloor (< 15m deep)
- High reef
- Shallow limestone pavement (< 15m deep)
- Low reef
- Deep limestone pavement (> 15m deep)
- Deep sandy seafloor (> 15m deep)

The 15m depth contour was selected to separate the shallow and deep limestone pavement and sandy seafloor habitats because close to this depth the:

i) slope of the seafloor changed from relatively steep at less than 15m depth to a very gentle slope beyond 20m depth.

ii) biota on the limestone pavement changed, with all seagrass and dense algae restricted to the shallow depths (<15m), and low density algae, or no algae, or sponges only occurring in deeper waters (>15m).

However, in reality, there was a continuum in sand and limestone pavement habitats across the 15m contour, and the exact boundary between the shallow and deep habitats is blurred to some extent. The occurrence of these habitats at each of the survey sites is shown in Figure 4.

A difficulty in mapping the distribution of habitats arose when the habitats occurred as a series of small patches forming a mosaic across the seafloor. In addition, some of these habitats could not be distinguished using the aerial photograph either because they occurred in waters that were too deep for the photographs to penetrate or the colours of the different habitats could not be distinguished on the aerial photograph. These difficulties arose in two situations:

i) Deep Sand Seafloor and Deep Limestone Pavement - These two habitats co-occurred, with gradients between the two, and the depth of water was too great for aerial photographic penetration. Consequently, the habitat distribution (Figure 4) map shows a seafloor category containing a mixture of these two habitats. The seafloor survey suggested that the sand habitat predominated in this area with limestone pavement forming less than approximately 20% of the seafloor.

ii) Shallow Limestone Pavement - Low reef and small patches of sand seafloor also occurred with shallow limestone pavement as a mosaic in

some of the shallower water. The sand patches were too small to be mapped individually and colour differences between limestone pavement and low reef could not be discerned from the aerial photograph. As a result, these habitats are also shown as an area of mixed habitats in the distribution map (Figure 4). This area of mixed habitat appeared to contain more limestone pavement than sandy seafloor or low reef based on the seafloor survey.

Each of the seafloor habitats, the characteristic biota of each habitat, and the distribution of each habitat, is discussed below:

i) Sandy Beaches

The shoreline in the vicinity of the Oakajee project consists largely of a narrow sandy beach. In a few places, limestone reefs are very close to the shoreline and are partially covered by sand. Biota on the beaches consist of burrowing infauna such as polychaete worms and bivalve molluscs, and ghost crabs. In some areas (for example south of Coronation Beach) algal and seagrass wrack accumulates on the beaches where it breaks down releasing nutrients back into the marine environment. Wrack accumulations on the beaches also provide a nursery environment for juvenile fish of some species by providing both shelter and a food source.

ii) Shallow Sandy Seafloor

This habitat extends offshore from the beaches into the areas between the reef blocks and between low ridges of limestone pavement. Biota such as polychaete worms, bivalve molluscs and small crustaceans, and some bottom dwelling fish such as dragonets and whiting occur in this habitat. The water column above this habitat is also used by nomadic and migratory fish such as mullet, tailor and mulloway along the beach.

iii) High Reef

An extensive area of high reef occurs from the beach offshore to the five metre contour. The reef is fragmented and dissected providing a diverse array of micro habitats for marine life. Between the reef blocks are small pockets of sandy seafloor or areas of limestone pavement. This is an area of extreme wave energy and inspection was limited during the November/December 1996 survey because of weather conditions. However, based on the sites visited during this survey plus other inspections of similar areas in the region, this habitat contains a diverse range of biota with kelp (*Ecklonia radiata*), *Sargassum* and other brown algae on the reef tops and an understorey of foliose and encrusting coralline red algae. The vertical walls, underhanging surfaces and caves in the reef are colonised by encrusting fauna such as sponges, and solitary and colonial ascidians. This habitat also provides a refuge for a large range of reef fish and is a major habitat for juvenile and adult rock lobsters. Some abalone may also be present on, or close to, the upper reef surfaces.

High reef is classed as reef greater than 1.5m high and generally consists of blocks of relict limestone from around which the surrounding limestone has

previously been eroded. While this form of high reef is extensive at Oakajee, another form, earlier in the erosional sequence, also occurs. In this form of high reef, there is a flat pavement surface with crevices and holes 2-3m wide in the seafloor. These crevices and holes were linked together approximately 2-2.5m below the seafloor where the presumably softer limestone was eroding away faster than the limestone forming the seafloor. While this structure is not a "reef" in the normal sense, it provides equivalent niches in the forms of crevices, caves, complex structure and lack of light, and it supports the same biotic assemblage normally seen on high reef blocks.

The high reef habitat occurs as a broad band along the shoreline, some of which is in the form of reef blocks which are almost intertidal, while other areas are deeper and occur as subtidal reefs or as creviced and undercut limestone seafloor.

iv) Shallow Limestone Pavement

Flat limestone pavement occurs between reef blocks, and offshore from the reef blocks to a depth of 15m. A veneer of sand may occur over some of the surface particularly in the depressions. Elevated areas of this habitat tend to graduate into low reef habitat whereas low areas are covered by an increasing thickness of sand and merge into sandy seafloor. This habitat is colonised by dense mixed meadows of algae (*Sargassum* species and other red and brown algae) and seagrasses (*Amphibolus* spp and *Thalassodendrum*). Overall, algae dominate these meadows, but the proportion of algae and seagrass are extremely patchy and in places the seagrasses form pure stands. Small patches of kelp (*Ecklonia*) occur on high areas such as sloping and slightly raised limestone pavement. Where ledges and crevices occur in the pavement, the biota of the low reef habitat colonise the area.

v) Low Reef

Low reef occurs where the offshore ridges run parallel to the coast and are raised above the surrounding pavement. Low reef is less than approximately 1.5m in height and occurs farther offshore than the high reef. The upper surfaces of elevated pieces of the reef are colonised by the kelp *Ecklonia.* Elsewhere the low reef is covered by *Sargassum,* a range of red and brown algal species and seagrasses (*Thalassodendrum* and *Amphibolus antarctica*). Crevices, vertical surfaces and overhangs are covered by encrusting biota such as sponges and ascidians, and are used extensively by reef fish and rock lobsters.

The low reef habitat principally occurs in waters of less than 15m depth and usually merges into shallow limestone pavement.

vi) Deep Limestone Pavement

Patches of limestone pavement occur on the seafloor in water depths ranging from 15m to 30m. In deeper waters, the limestone patches are colonised by sponges and similar forms of sessile fauna. White rock lobsters were observed sheltering in ledges in deep waters in this habitat as part of their offshore migration. In shallower waters (less than about 20m), algae, including

Sargassum, Osmundaria and other red and brown algae, and seagrass (*Thalassodendrum*) occur on the pavement. Where a veneer of sand up to 10-20cm thick covers the pavement, the algae are attached to the pavement beneath the sand, or to raised pieces of limestone. In these areas the algae give the false appearance of growing out of a sandy seafloor. As the thickness of the sand veneer increases, the density of algae decreases.

vii) Deep Sand Seafloor

Further offshore and in depressions in the limestone pavement, the sand veneer overlying the limestone pavement described in vi) above, becomes thicker and a sand seafloor habitat is formed. This habitat has no algae, seagrasses or fauna evident. The only fauna which occur in the habitat are burrowing infauna such as bivalve molluscs, polychaete worms and small crustaceans, and bottom dwelling fish such as dragonets, whiting and rays.

2.2.3 Habitat Productivity

The shallow water habitats referred to as high reef, low reef and shallow limestone pavement are the important areas of primary productivity in the Oakajee area. These habitats all support either a dense assemblage of algae or algae and seagrass and are considered areas of high productivity in South-Western Australian (Cambridge, 1979; Kirkman, 1984). These habitats all occur in less than 15m depth and form a large proportion of the shallow inshore waters. In addition to being the main source of primary productivity, these habitats also form a refuge for marine fauna either because of the crevices and caves in the reef areas or the shelter within the algal and mixed algal seagrass meadows. The marine fauna that utilise these areas include a diverse range of reef fish as well as a multitude of invertebrates including adult and juvenile rock lobsters.

In contrast, the other habitats support a much lower biomass and are areas of lower productivity. The sandy seafloor (both deep and shallow is largely devoid of both algae and seagrass. Deep limestone pavement is colonised by sponges and other sessile invertebrates at low density in deepwater, and some algal species closer inshore. Nevertheless, these habitats are colonised by benthic in-fauna, and are a feeding ground for some fish species and for rock lobsters during their offshore migrations.

The sandy beaches are also bare of vegetation. However, seagrass and algal wrack accumulates and breaks down on the beaches and is then recycled as a nutrient source back into the marine environment. Juvenile fish of species such as cobbler, herring, whiting and mullet also use these banks of decomposing material as a nursery area which provides both shelter and a food source (amphipods and other small invertebrates which break down the seagrass) (Lenanton et al, 1982; Robertson and Lenanton, 1984).

The water column above the seafloor is also an area of primary productivity by phytoplankton which drifts with the ocean currents.

2.2.4 Nutrient Recycling and Algal and Seagrass Wrack

Nutrient levels in South-Western Australian coastal waters are generally low (Pearce et al, 1984). The nutrients that are in the coastal ecosystem are tied up in the living biomass of the plants and animals in the system. There is no offshore upwelling of nutrients from deep oceanic waters to provide an external source of nutrients, although some nutrients enter the coastal ecosystem from seasonal river flow and, perhaps, from groundwater input. Thus without major external nutrient sources, internal recycling of nutrients assumes an additional importance in the functioning of the coastal ecosystem (Robertson and Hansen, 1982).

Nutrient cycling within the coastal ecosystem is conceptually understood (Figure 5), but the importance of the nutrient pathways is largely unknown and are not yet quantified (e.g. Kirkman and Kendrick, in press.) Primary productivity (production by plants) is carried out in the shallow (<15m to 20m) nearshore waters where sufficient sunlight penetrates to the seafloor. Of the total benthic primary productivity, some is consumed by grazers and herbivores in situ and eventually released back into the ecosystem as nutrients through the local food chain. A large volume of algae and seagrass is detached by autumn and early winter storms. A proportion of this material is broken down offshore and released back into the coastal waters as nutrients. The remainder is washed ashore onto the beaches where it may accumulate into large beds of wrack or be stranded in smaller quantities along the beaches.

At Marmion, near Perth, the wrack has been estimated to form 17% of the total primary productivity in the nearshore coastal environment (Robertson and Hansen, 1982; Hansen, 1984) and thus is a significant component of total productivity. After becoming detached, kelps drift along the seafloor and are generally washed ashore within a few kilometres of where they originate (Kirkman and Kendrick, in press). Seagrasses and floating algae such as sargassum drift on the surface and tend to travel further, possibly 10km from their origin, and perhaps up to 40km.

On the shoreline, the wrack is broken down into smaller particles by detritivores and physical processes biodegraded by bacteria and leached. Detritvores are small animals such as amphipods which eat wrack. The wrack is also periodically washed back into the sea, redistributed along the coast, and then washed back onto the shore elsewhere. In the case of kelp and other algae, breakdown may occur within three weeks, but seagrasses may take over one year to breakdown (Hansen, 1984). Eventually, the decomposition products of the wrack are washed back into the sea where they locally elevate nutrient levels and provide a food source for benthic filter animals.

2.2.5 Condition of the Oakajee Ecosystem

The ecosystem at Oakajee at present is in a condition close to pristine. There is no industry in the area apart from fishing and the industry based at the Geraldton Port 18km away. Residential areas are also distant from the site. The fishing industry is concentrated primarily on rock lobsters, one of the main predators in the ecosystem, the effects on the rest of the ecosystem of fishing rock lobsters are unknown.

The only other non-natural component of this ecosystem is the possible extra riverine discharge and nutrient addition from the nearby small rivers which pass through agricultural areas.

3. FISHERIES ACTIVITIES

Both commercial and recreational fishing occur in the vicinity of the proposed Oakajee port site. These are discussed separately below.

3.1 Commercial Fishing

Other than the Western Rock Lobster, the west coast of Western Australia is generally poor in fish resources in comparison with South America and Southern Africa (N. Caputi pers comm). However it supports a large variety of relatively small professional fisheries including fin fish (eg. tuna, snapper, jewfish, tailer, bream, whiting, herring, trevally, mulloway, samson fish and sharks) and others (prawns, crabs, scallops, abalone, squid and octopus). In contrast, the Western Rock Lobster fishery is the most valuable single species fishery in Western Australia and Australia (George 1993).

Within the Oakajee area the rock lobster fishery is also the most valuable, but other fisheries occur within the region, although not generally at the Oakajee site.

3.1.1 Western Rock Lobster Fishing

The Western Rock Lobster fishery along the Western Australian coast supports 668 lobster vessels using nearly 70,000 pots (George 1993). The resource is harvested during the legal season between November and June of each year. Fishing is closely managed with respect to the number of boats and pots, fishing technique and catch sizes. Detailed data is collected in order to ensure the sustainability of the harvest. The 1992-93 catch was valued at over $250 million and the 1995-96 catch at $223 million (N. Caputi pers. comm.) and consisted of live, whole cooked, whole raw frozen and frozen tails. The principal markets are in USA, Japan and Taiwan. Between 1983 to 1993 the catch has averaged 10 million kilograms per year (Monaghan 1989).

At Oakajee the coastal lobster fishery is mainly concentrated in the 0-18m (0-10 fathom) depth zone. This zone encompasses a band extending for approximately 2km offshore. Pots are set amongst reef breakers with some pots being as close as 20m from shore. This 2km wide lobster fishing zone is believed to hold the same or a greater density of lobsters than occur in the more reef protected waters in the fishing grounds to the south of Geraldton (George 1993).

Catch statistics are recorded for blocks of coastline with each block covering approximately 17km of coastline (Figure 6). The Oakajee fisheries block is worked by eight boats, however up to another 37 work the area intermittently, particularly during the 'white' season (George 1993). Each boat is operated by 2-3 people and uses about 100 pots.

The catch statistics for the Oakajee block, and for the two blocks to the north and to the south of Oakajee for the five years 1991-1996 have been provided by the Department of Fisheries and are included in Appendix 1 of this report. Block 282 has Port Gregory close to its northern boundary. Block 283 has Horrocks

close to its northern boundary, Block 284 extends from the Oakabella River to the Buller River and contains Oakajee, Block 285 extends from Drummond Cove to Geraldton, and Block 286 extends from the Greenough River mouth to African Reef.

The annual and average statistics on total catch, catch of white and red rock lobsters, and catch in the near-shore (0-10 fathoms or 18m) area of the Oakajee block are shown in Table 3. Values provided in Table 3 and discussed below are based on the 1996 price of $22/kg provided by N. Caputi (pers. comm.).

- The average rock lobster catch from the Oakajee block is 51,300kg valued at $1,128,433 (Table 3).

- Of the total average catch of 51,292kg, 41,977kg (or 82%) is caught in the nearshore waters (<18m depth) (Table 3, Figure 7A). The percentage of the catch caught in the nearshore waters ranged from 70% to 92%.

- The rock lobster catch in the nearshore waters has ranged from 2,975kg (valued at $65,450) to 76,099kg (valued at $1,674,178) over the five year period 1991 -96. (Table 3, Figure 7B, C.)

- The average catch from the nearshore waters is 41,977kg valued at $923,494.

Rock lobster catches, fishing effort and catch rate in the 0-18m depth zone of the Oakajee statistical block are compared in Figure 8 with two adjoining blocks both to the north and to the south of Oakajee.

Average annual catch over the period 1991-92 to 1995-96 is shown in Figure 8A. This figure shows that the catch is lowest in the Oakajee block, slightly higher in the Horrocks block and 4-5 times higher in the other three blocks.
Average fishing effort in each of the five blocks is shown in Figure 8B. This figure shows that the fishing effort is lowest in the Oakajee block, slightly higher in the Horrocks block, and much higher in the other three blocks. Fishing effort and the catch are obviously highly correlated, probably because the fishermen adjust their fishing effort between blocks to fish the areas where most lobsters occur.

Annual catch rate is shown in Figure 8C. The catch rate is similar between blocks, probably because, as mentioned above, the fishermen probably adjust their effort between the blocks to fish those areas where their returns are the highest. Catch rates in the Oakajee block may be marginally higher than in the surrounding blocks, but this difference is minimal when compared to the large differences in catch and effort described above.

The importance of the Oakajee block as a habitat for juvenile and undersize rock lobsters was evaluated by examining the fisheries data for undersize rock lobsters from Oakajee and comparing it to the adjoining blocks (Figure 9 and Appendix 1). Complete data on undersize rock lobsters are not available as this information is a voluntary statistic which is only returned by a proportion of the fishermen. It is assumed that these data reflect the total fishery in the area.

Figure 9 provides a comparison between Oakajee and the adjoining blocks for number of undersize rock lobsters caught, the number per potlift, and the number per kilogram of catch caught. According to the data, the Oakajee block provides the lowest number of undersize rock lobsters caught (Figure 9A). When compared on the basis of number of undersize rock lobsters per pot lift or per kilogram of catch (Figure 9B, C), the Oakajee block provides the second lowest, and very close to the lowest, number of undersize rock lobsters. Therefore, the data do not provide any evidence that the Oakajee block is of any greater importance to juvenile and undersize rock lobsters than the adjoining blocks.

3.1.2 Other Commercial Fishing

Apart from rock lobsters, little professional fishing carried out in the nearshore (<20m) waters (W. Godenzie, pers comm). Occasionally long line fishing occurs in waters further offshore than the port site and deeper than 20m.

Abalone (Roe's Abalone) are fished along the shoreline north of Geraldton, but while they are present on the reefs in the vicinity of the port site and may be fished once every few years, these reefs do not provide a major contribution to the local commercial fishery.

Scallops occur in the deeper waters (beyond 30m), but scallop fishing is not allowed in the nearshore waters because of potential damage to rock lobsters and their habitat. In the near-shore waters, scallops generally occur as small isolated populations which exist in an area for a couple of years following a spatfall, but then die out. While these scallops do not directly form part of the commercial fishery, they may contribute as a source of larval recruits to scallop populations that occur in other areas.

3.2 Recreational Fishing

Recreational fishing is widespread throughout the area (W. Godenzie, pers comm). The following types of fishing occur:

- Net fishing
- Rod fishing
- Line fishing from boats
- Diving
- Rock lobster pots

These fishing activities are discussed below.

Net fishing occurs along the sandy beaches. South of the Buller River, hauling of nets only is allowed. Set nets, as well as haul nets, are also allowed north of the Buller River. The target species for netting are mullet, whiting, tailor and mulloway.

Rod fishing also occurs along the beaches with the main target species being tailor, mulloway and whiting. Tailor appear in one or more 'runs' along the beaches migrating north from November to February.

Diving for rock lobsters and spear fishing occur in all the reef areas where rock lobsters and reef fish are available. Rock lobsters are also caught using pots, either placed from off the beach where the reef is close inshore, or from small boats.

Reefs close to the beach adjacent to the site of the proposed breakwater are also popular with divers because of both the nature of the fragmented reef blocks and their proximity to the beach.

4. ASSESSMENT OF POTENTIAL MARINE IMPACTS

4.1 Project Description

The location and design of the port has not yet formalised, but the port structures will be located within the area shown in Figure 1.

4.2 Potential Impacts

The types of impacts that the construction of a port facility at Oakajee may have can be divided into the following categories:

- Permanent impacts eg. loss or modification of habitat
- Construction impacts which occur only during construction and are thus temporary
- Operating impacts which occur (or may occur) during port operations and may be ongoing, intermittent or accidental and rare (eg. spillages)

Whilst most of the impacts may cause adverse effects on the immediate marine habitats there are likely to be some benefits to the marine environment as a result of the construction. These benefits relate to the creation of further habitat (breakwaters), and provision of sheltered water zones which may create favourable conditions for some species.

Each of the above types of impacts is discussed in more detail in the subsequent sections.

4.2.1 Permanent Impacts

The major permanent impacts that will occur at Oakajee are:

- Loss of natural habitat,
- Possible buildup of sand and algal and seagrass wrack adjacent to the approach breakwater near the shoreline, and
- Modification of the water circulation around the groyne.

Habitat loss or modification will occur where the breakwaters are placed, within the harbour, where dredging will occur, and depending on final design, those areas that are used for land reclamation. For the purposes of this report, it is assumed that the entire block of marine habitat encompassed by the breakwater structures could be altered or modified. This block has a total seafloor area of approximately 400ha.

4.2.2 Construction Impacts

The major impacts that may occur during the construction phase of the project include:

- Increased turbidity,
- Potential for accidental spillage, and
- Dredging.

These effects, will be limited to the construction phase and thus will be temporary:

Increased turbidity will result from dumping of rocks to form breakwaters, dredging activities in the inner harbour and possibly the approach channel, and from land reclamation. Fine material dumped with the rocks during formation of breakwaters will result in increased sediment suspended in the water column. Similarly, dredging of the limestone and sand seafloor will release fine sediments into the water column. The amount of dredging required for the harbour and approach channel is dependent on the final design for the port facilities and is not yet known. During land reclamation, fine sediments also will find their way back into the water column.

Increased turbidity can reduce light penetration to photosynthetic algae and seagrasses, inhibit filter feeding animals and larval recruitment of benthic biota, cause mechanical damage to benthic fauna, deplete oxygen and cause nutrient enrichment. However, the Oakajee site is presently noted for its high natural turbidity (George, 1993) and the biota in the area are already adapted to handle conditions of high turbidity. Thus the biota at Oakajee are likely to be tolerant to some degree of the additional turbidity generated by the port construction activities. Sediment loss from the land reclamation can be minimised by good management practices (including the preparation of a Dredging and Dredge Spoil Disposal Management Plan - DDSDMP) during construction. Finally, the sediments at Oakajee are largely sand and limestone, and low in nutrients.

Blasting of hollow areas of the seafloor may be required prior to formation of the breakwaters. Subsequent studies will identify whether this is necessary and to what extent. However, the amount of blasting will be limited to small areas beneath the breakwaters.

Accidental spillages of materials such as fuel are possible but the likelihood of such spillage can be reduced to negligible with good management and reporting practices.

4.2.3 Operating Impacts

At present, the GSP and a proposed hot briquetted iroin (HBI) plant are the only industries that are intending to use the Oakajee port. Operation of the port for these projects will require transport of steel and conveying of HBI onto the wharves, loading of the commodities, and vessel movements in and out of the port.

In the future, the Oakajee port is likely to be used by other industries, but until the identities of those industries are known, it is not possible to predict the potential operating effects. However, the operational impacts of any additional industries proposing to use the port will be subject to separate environmental impact assessment prior to gaining approval to use the port.

Some of the operating impacts are common to all industries and to port operations and can be identified at this time. These include:

- Maintenance dredging,
- Wastewater discharge,
- Oil spills,
- Ballast water discharge,
- Anti fouling paints,
- Maritime accidents,
- Cargo spillages,
- Stormwater discharge, and
- Turbidity and turbulence caused by shipping movement.

Maintenance dredging may be required if sediment buildup around the inner harbour occurs. This is anticipated to be very infrequent, perhaps once a decade, and the volume of material removed is not likely to be substantial.

Wastewater discharge can take place from a number of sources in a port. The volumes of wastewater are however, minor and any significant discharge volume requires licensing with the DEP under the Environmental Protection Act, 1986. In addition, the EPA has powers to prevent any pollution which may result from wastewater of unacceptable quality.

Minor sources of wastewater which may enter the port include ship discharges such as condensation waters and water used for cleaning the decks. Specific operational guidelines are in place in many ports to control such discharges. For example, Geraldton Port Authority requires that any vessel needing to discharge wastewater must contact the Authority, which will in turn arrange for a liquid waste disposal truck to load the liquid for disposal to a suitable on-shore disposal site. They also prohibit washdown of vessels in harbour.

Oil spills are a potential hazard which must be dealt with in any port. Spills can occur during handling mishaps, bunkering accidents, and ballasting and tank cleaning operations. The risk of spillages of oil and oil derivatives is considered to be minor however, as a result of the following:

- Ships will only refuel at the port and no discharge of bulk petroleum produced is proposed at this stage. Any such proposal would be subject to a separate environmental assessment and would have to comply with the requirements of the Department of Mineral & Energy.

- All ports are required to have a oil spill contingency plan for the control and cleanup of oil spills. These plans must be approved by the Dept. of Mines, the DEP, and the W.A. State Committee for Combating Oil Pollution

at Sea. If a spill were to occur then management procedures will minimise its degree and area of impact.

Ballast water discharge in coastal waters is a potential source of introduction for exotic organisms or contamination. In 1989 AQIS developed a set of voluntary guidelines for ships entering Australian waters and in 1994 a draft Australian Ballast Water Management Strategy was released. AQIS requests ships' masters to make every effort to minimise sediment discharge when ballast is released. Vessels entering ports are boarded by harbour masters and each ship's Master is questioned as to whether AQIS requirements have been complied with.

Antifouling paints on large boats contain tributyl tin which can have adverse effects on the biology of marine organisms and can be concentrated in the flesh of filter feeders such as molluscs. In recent years, use of tributyl tin has been modified through Amendment Regulations to the Environmental Protection Act, 1986 introduced in 1991. These regulations control the use of paints and the levels of allowable release of tributyl tin from the paints.

Maritime accidents where a vessel runs aground or sinks when entering or leaving a port are a potential hazard that needs to be considered, however unlikely. This risk is common to all ports, but with modern navigational aids, standardised navigational procedures, sea worthiness and safety inspections, there have been very few such accidents in Western Australia over the last decade. Additionally, the approach channel for ships to Oakajee is straightforward with deep water all the way to the harbour entrance and no offshore reefs. These factors will also act to reduce the risk of a maritime accident occurring.

Cargo spillages during handling can range from minor (eg small quantities of lime, salt, coal etc) to very significant (eg toxic chemicals, heavy metal concentrates) depending on the type of cargo being handled. Each port should have a hazardous cargo handling plan. When a new cargo that could potentially be dangerous to the marine environment is considered for handling by the Port Authority, an accidental spillage management plan also should be drawn up to minimise risks and impacts.

Stormwater is derived from runoff from sealed on impervious surfaces. The port at Oakajee however, is expected to involve only minor stormwater flows due to the generally low rainfall and having a low incidence of storm events which, combined with good port management practices, will have a negligible effect on the marine environment.

Turbidity and turbulence will result from shipping movements. However the area in which these effects will occur is small and restricted largely to the inner harbour and the inshore part of the approach lane. The approach lane is largely through a sandy seafloor supporting a low biomass and any effects therefore will not be significant.

4.2.4 Potential Environmental Benefits.

Additional reef-type habitat will be provided by the breakwaters of the port. This rock armouring of the breakwaters will provide a habitat which will be colonised by a large variety of marine life which require shelter, a place to settle and a food source. Eventually, the marine life on the breakwaters will probably resemble that occurring on the natural reefs in the area and it is likely that the breakwaters will be used as a refuge habitat by rock lobsters. The addition of this habitat will to some extent offset the loss of natural reef in the area due to the port project.

5. REGIONAL AND LOCAL CONSERVATION ISSUES

5.1 Regional Significance

The survey of the marine habitats and main biotic assemblages at Oakajee showed that they were similar to those recorded at Point Moore and Georgina. (Monaghan Rooke and Robinson 1993). Both Point Moore and Georgina are similar to other coastal areas in terms of habitat and biota communities surveyed on the Rottnest shelf at Cape Peron (LeProvost Seminiuk and Chalmer, 1981) Quinns Rock (LeProvost Seminiuk and Chalmer, 1984a) and Sorrento (LeProvost Seminiuk and Chalmer,1984b).

The similarity of the biota along the south-west coast of Western Australia is not surprising given:

i) the broad similarity in geomorphology of the coastline between Bunbury in the south and Port Gregory in the north.

ii) the similarity in substrates and habitats along this section of the coast.

iii) the similarity in oceanographic conditions (wave, wind, tide, salinity and temperature) along the coast.

v) that marine flora and fauna generally produce large numbers of offspring which are widely dispersed by ocean currents, so that the some species are available to colonise all of this coastline.

5.2 Marine Reserves and Conservation

A review of the marine environments along the Western Australian coastline has recently been conducted to identify areas which are representative of the coastline and hence have high conservation value (CALM, 1994) The Oakajee area, and indeed the coastline between Port Gregory and Port Denison, was not identified containing any special areas which were sufficiently representative to warrant reservation.

5.3 Rare and Endangered Biota

Marine Flora

Under the Wildlife Conservation Act (1950) the Department of Conservation and Land Management (CALM) is responsible for wildlife conservation matters in both the marine and terrestrial environments. The Wildlife Conservation (Rare Flora) Notice (1996) associated with this Act sets out the current schedule of Declared Rare Flora. This list does not include any marine flora and hence is not applicable to the marine environment at Oakajee.

Marine Fauna

Under the Wildlife Conservation (Specially Protected Fauna) Notice 1996 of the Wildlife Conservation Act (1950) there is a published list of specially protected fauna. These species are totally protected throughout the whole State at all times and fauna include the following marine species:

- *Balaenoptera borealis*, Sei Whale
- *Balaenoptera musculus*, Blue Whale
- *Balaenoptera physalus*, Fin Whale
- *Eubalaena australia*, Southern right Whale
- *Megaptera novaeangline*, Humpback Whale
- *Caretta caretta*, Loggerhead turtle
- *Dermochelya coriacea*, Leathery Turtle or Luth
- *Arctocephalus forsteri*, New Zealand Fur-seal
- *Dugong dugon*, Dugong
- *Neophoca cinerea*, Australian Sealion
- *Crocodylus porosus* Salt water Crocodile

Humpback, Southern Right and Blue whales migrate through the Geraldton region in increasing numbers as they recover from depletion by whaling. The Oakajee port structure will not affect this migration. Southern Right Whales breed on the south coast of Western Australia and Humpback Whales breed on the North-West Shelf (CALM, 1994). The Geraldton coast is not important to either species as a breeding area.

Sea Lion colonies exist in the Abrolhos Islands and on an isolated breakwater in the Geraldton Harbour. The number of Sea Lion colonies and individual animals appears to be increasing (W. Godenzie, pers comm) following cessation of hunting in earlier years. The Oakajee area is not used extensively by sea lions at present.

Dugongs are normally resident in Shark Bay and areas further north, but some have occasionally been sighted in the Geraldton area. These animals generally appear in late summer when local food resources and water temperatures are adequate for their survival, but have been found dead on the beaches in winter when temperatures are below optimium for dugongs (R. Prince, pers comm). Thus it appears that dugongs are not able to survive the full year in the Geraldton area.

Green Turtles (non-declared species) and Loggerhead Turtles are occasionally seen throughout the Geraldton region, but these sea turtles are essentially tropical animals which normally live further north where waters temperatures are higher. The Oakajee site is not important for the survival of any of the sea turtle species.

Black Coral

An unusual coral has recently received attention in the Geraldton area because of its perceived rare and endangered status. This coral, known as the 'black coral', is one of a group of soft corals whose living skeleton is harvested in other

parts of the world and then polished and used to make jewelry. A few specimens of black coral were observed at Point Moore in recent years and concern was raised at their presence in relation to the proposed deepwater port there. Investigations of the biology of black corals (John Monaghan & Associates, 1995) revealed that they are normally deep water inhabitants where they occur in large numbers, but occasionally occur in low numbers in the less preferred habitat of shallow water such as at Point Moore.

Black corals were not observed at Oakajee during the survey for the present report, but could possibly occur there in very low numbers. For example, two days of underwater searching at Point Moore were required to locate a specimen of black coral when the location of that specimen was already known and a person who knew the location was assisting in the search (John Monaghan & Associates, 1995). However, the black corals which are occasionally observed in shallow waters by divers are outlying individuals from populations in deep water further offshore. These outlying individuals are transported to shallow water areas during their planktonic larval phase when they are dispersed widely by ocean currents. The scarcity of black corals is a reflection of the limited access that divers have to deep water rather than to actual rarity.

Water Quality

The EPA has established guidelines for the maintenance of water quality in marine environments based on the perceived environmental values for each locality (EPA, 1993). For Oakajee, the following three environmental values apply:

- Ecosystem protection,
- Recreation and aesthetics, and
- Industrial water.

The ecosystem protection value applies because the Oakajee coast supports an extensive, highly productive ecosystem which is in a largely natural state. Additionally, the ecosystem protection value is also intended to cover those ecosystems which support fishing (both commercial and recreational).

The recreation and aesthetics protection value is also applicable because there is significant primary contact (swimming, scuba diving and snorkelling, sailboarding), secondary contact (recreational and commercial fishing) and visual use (tourism) in the coastal waters.

The only industrial use for water in this area is for shipping and navigation which was one of the beneficial uses previously identified by the Department of Conservation and Environment in their earlier version of water quality guidelines (DCE, 1981).

For each of the above environmental values, there is a specified set of water quality criteria. These criteria are listed and discussed in the main report to which this appendix is attached.

5.4 Seagrasses

Seagrasses, and particularly seagrass meadows have been identified as important for their role in marine ecosystems and the long term stabilisation of sandy or silty seafloors. Information is available on the distribution of seagrass meadows in Western Australia from:

i) The CSIRO which is currently mapping the distribution of seagrasses in Western Australia. However, the CSIRO maps at present do not extend north of Dongara.

ii) Fisheries Department Resource Maps 1986. These maps show the distribution of fisheries resources, including the distribution of seagrass meadows from Dongara to Kalbarri.

Mapping of seagrass meadows contained in the Fisheries Department Resource Maps (1986) (Figure 10) shows that the shallow coastal waters to both the north and south of Oakajee support extensive meadows of seagrass, but no seagrass meadows are indicated within approximately three kilometres of the project site. This is probably due to the lack of offshore reefs and sheltered in-shore lagoons which are a requirement for development of extensive seagrass meadows. However, the marine survey of the Oakajee site has indicated that while extensive seagrass meadows may not occur there, the seagrasses *Amphibolus antarctica* and *Thalassodendrum* spp are present within the algal community on limestone pavement and low reef.

Given the extensive nature of known seagrass meadows both in the Geraldton area and along the south-western Australian coast, the Oakajee port will not result in the destruction of significant areas of seagrass.

6. ASSESSMENT OF POTENTIAL IMPACTS ON FISHING

6.1 Overview

Fishing activities in the waters in the project area at Oakajee are dominated by the Western Rock Lobster. Other commercial fishing in the area is of relatively minor importance compared to the lobster fishery. The scallop fishery operates in deeper waters than those in which the port is proposed to be constructed so will therefore not be affected. It is unlikely also that there will be any significant impact on the occasional net or line fishing undertaken in the general area. Access to waters will still be available north and south of the breakwaters once constructed.

Recreational fishing will possible be excluded from approximately 2km of shoreline. This is not significant given the extent of accessible shoreline in the Geraldton region. As a consequence the following sections will deal with the rock lobster industry only.

6.2 Western Rock Lobster

6.2.1 Value

Within the Oakajee block the Western Rock Lobster industry produces $1,128,433 of product of which $923,494 is from the 0-18m depth zone along the 17km of coastline (see Table 1 and Section 6.1). Assuming that the catch is evenly distributed along the coastline of the Oakajee block, the marine habitat close to the shoreline (which would be affected by an inshore deepwater port) in the central sector produces approximately 8% of the annual average catch (or 4,144kg) valued at $73,600.

6.2.2 Potential Impacts

The construction and operation of a deep water port facility at Oakajee has the potential to have the following impacts on the rock lobster fishery:

- Habitat loss,
- Fishing ground loss,
- Potential for rock lobster contamination, and
- Market perceptions of contamination.

There are other minor potential effects that relate to the biology of rock lobsters and their growth and development. Those minor effects have been discussed for the marine environment in general (Section 4.1), and the comments apply equally to rock lobsters as part of the marine ecosystem.

The four major potential impacts listed above are described in detail below.

Habitat Loss

The maximum area of habitat important to rock lobsters that may be affected by the inshore port proposal is approximately 170ha and corresponds to the location of the port in the southern sector. The northern location for a port would have the least impact on professional fishing because of the lower impact on high reef and shallow limestone pavement which are the preferred habitat of crayfish. For this location impact may be reduced by up to approximately 50% to 60%. The impact of a port in the southern sector would be intermediate between that in the central and northern sectors.

It is likely that the rock armoured breakwaters will, to some extent, replace some of the lost habitat. If this occurs, then the potential habitat loss may be reduced by a further 30-50%.

Fishing Ground Loss

An area of seafloor occupied by the approach lane to the deepwater port, the port itself and perhaps an offshore mooring area will be lost as a fishing ground for rock lobsters. As large ships will be moving through the approach lane, use of lobster pots and their attached lines and floats will be restricted.

Until further studies are completed, the location and design of the approach lane into the harbour are unknown. Similarly, the amount of area required as an offshore mooring ground is presently unknown. As an indication, at Geraldton up to twelve ships can be moored offshore at one time although there is no designated mooring area. A relatively large area is required for each ship as the seafloor there (and probably also at Oakajee) has poor holding ability. Fishermen at Geraldton presently may set pots in the area known to be used for offshore mooring, but do so at their own risk of loosing the pots. The effect on the loss of fishing ground will be one of the considerations when the location and extent of the offshore mooring area are being decided.

While fishing activity will not be allowed in the approach channel and may not be allowed in the offshore mooring area, rock lobsters will continue to use these areas as they have in the past. Both the approach lane and the offshore mooring area will be in waters greater than 18m deep. As most (82%, Table 3) of the rock lobster catch in the Oakajee statistical block occurs in the nearshore 0m-18m depth zone, the restriction on fishing part of the offshore area is not likely to have a major effect on the total catch.

In addition, 97% of the catch in these deeper waters are migratory white rock lobsters and it is likely that these will be accessible to fishing activities as they migrate into other unrestricted areas.

Potential for Rock Lobster Contamination

The potential for contamination of the marine environment has been discussed in Section 4.1.2. The comments in Section 4.1.2.3 also apply to contamination of rock lobsters. The post port operators will adopt management procedures to

prevent contamination, and checks to ensure that procedures are being carried out.

Market Perceptions of Contamination

One of the advantages enjoyed by rock lobster industry in Western Australia is the market perception that the product comes from a pristine environment and is free of any contamination. While actual contamination of rock lobsters may never occur, there is a concern by fishermen that their markets may perceive that contamination from some form of industrial or port activity could occur, and that this may have an effect on product price. Importantly, while the perceived threat of contamination may be restricted to a small and extremely localised area, the market reaction could involve the whole industry.

In response to this concern, the port operator will adopt management systems designed to minimise the possibility of contamination, conduct audits to ensure that the systems are being followed, put contingency plans in place in case accidents should occur, and finally, will conduct monitoring to ensure that any contamination is detected.

7. MANAGEMENT STRATEGIES AND PROPOSED MONITORING

Appropriate management strategies can minimise the environmental impact of the Oakajee port, or minimise the risk of accidents occurring. The management strategies include:

i) An oil spill contingency plan.

ii) A spillage management plan for any hazardous chemicals.

iii) The Australian Ballast Water Management Strategy developed by AQIS.

iv) Regular environmental audits of the port to identify problem areas.

v) Monitoring and management of sand and sea wrack accumulation resulting from longshore drift at the base of the breakwater.

In addition, monitoring will be carried out to confirm that environmental parameters are within acceptable limits. If a problem occurs and environmental parameters exceed the acceptable levels, then the consequences and seriousness of the problem will be evaluated and a management strategy put in place by the port operator to overcome the problem.

The monitoring program will include:

i) beach profile - accumulation of sand and sea wrack at the base of the breakwater.

ii) water quality - including during port construction, for heavy metals, hydrocarbons, bacteria and turbidity.

iii) port sediments - for presence of heavy metals and hydrocarbons.

iv) introduced marine organisms - to confirm that AQIS guidelines are preventing the introduction of exotic species.

v) marine habitats - to ensure that the effects of port construction are limited to the port area.

vi) rock lobsters
- to confirm that rock lobsters are utilising breakwaters as a habitat
- annual catch statistics for the Oakajee block, and
- heavy metal, hydrocarbon and bacteria, levels in rock lobsters both from within the port and in adjacent areas.

REFERENCES

Alan Tingay & Associates (1996). Oakajee Deepwater Port Public Environmental Review.

Cambridge, M.L. (1979). Technical Report on Seagrass. Cockburn Sound Environmental Study. Department of Conservation and Environment, Western Australia. Report No 7, 100p.

Conservation and Land Management (Dept of) (1994) A Representative Marine Reserve System for W.A. Report of the Marine Parks and Reserves Selection Working Group. pub. Dept CALM June 1994.

Cresswell, G.R., Boland, F.M., Peterson, J.L. and Wells, G.S. (1989). Continental Shelf Currents near the Abrolhos Islands, Western Australia. Aust. J. Mar. Freshwater. Res. 40: 113-128.

Department of Conservation and Environment (1981) Water Quality Criteria for Marine and Estuarine Waters of Western Australia EPA Bulletin 103

Environmental Protection Authority (1993) Western Australian Water Quality Guidelines for Fresh and Marine Waters Report of the Environmental Protection Authority, EPA Bulletin No 711.

George R. W. (1993) Oakajee Rock Lobster Study - Impacts by Industry and Port Report to LandCorp.

Hansen, J.A. (1984). Accumulations of Macrophyte Wrack Along Sandy Beaches in Western Australia: Biomass, Decomposition Rate and Significance in Supporting Nearshore Production. Unpublished Ph.D. Thesis, University of Western Australia.

Hutchins B. & Swainston R. (1986) Sea fishes of Southern Australia.Swainston Publishing

John Monaghan and Associates (1995) Investigation of Black Coral at Point Moore, Geraldton. Unpublished report to the Geraldton Port Authority.

Kirkman, H. and Kendrick, G.A. (in press). Review of the Ecological Significance and Commercial Harvesting of Beach-Cast Seaweeds and Seagrasses in Australia.

Kirkman, H. (1984). Standing Stock and Production of *Ecklonia radiata* (C. Ag.). J. Agardh. J. Exp. Mar. Biol. Ecol. 76:119-130.

Lenanton, R.C.J., Robertson, A.I. and Hansen, J.A. (1982). Nearshore Accumulations of Detailed Macrophytes as Nursery Areas for Fish. Mar. Ecol. Prog. Ser. 9:51-57.

LeProvost Environmental Consultants (1991) Construction and Operation of a Heavy Industry Port Facility on the Coast North of Perth: Concerns with Respect to the Marine Environment Report to Halpern Glick and Maunsell

LeProvost Seminiuk and Chalmer, 1981, Cape Peron Ocean Outlet - Marine Environmental Study, report to Binnie and Partners Pty Ltd.

LeProvost Semeniuk and Chalmer (1982) MPBC Geraldton Refinery Marine Environmental Study Phase 1 Report. Unpublished report to Dames and Moore, Consulting Engineers Perth Western Australia.

LeProvost Seminiuk and Chalmer, 1984a, Marine Ecology and Fisheries of the Quinns Rocks Area, Appendix 4 in Smith Corporation Pty Ltd - Environmental Review and Management Program for Mindarie Keys Project.

LeProvost Seminiuk and Chalmer, 1984b, The Natural Environments of the Sorrento Coastal Area, Technical Appendix 2 in Public Works Dept. of Western Australia. Environmental Review and Management Program for Sorrento boat harbour.

Monaghan P. (1989) Distribution and Marketing of Western Rock Lobster, Fisheries Management Paper No. 29 1-125.

Monaghan Rooke and Robinson (1993) Marine Seafloor and Habitat Survey - Alternative Deep Water Port Sites - Geraldton Region, unpublished report to Geraldton Port Authority.

Monaghan Rooke and Robinson (1994) Geraldton Port - Marine Environs Habitat Survey, unpublished report to Geraldton Port Authority.

Pearce, A.F., Johannes, R.E., Manning, D., Rimmer, D.W. and Smith, D.R. (1984). Hydrology and Nutrient Data Off Marmion Perth, 197901982. CSIRO Marine Laboratories Report, 1984.

Robertson, A.I. and Hansen, J.A. (1982). Decomposing Seaweed: A Nuisance or a Vital Link in Coastal Food Chains? CSIRO Marmion Laboratories Research Report 75-83.

Robertson, A.I. and Lenanton, R.C.J. (1984). Fish Community Structure and Food Chain Dynamics In the Surf Zone of Sandy Beaches: The Role of Detached Macrophyte Detritus. J. Exp. Mar. Biol. Ecol. 84:265-283.

Seddon. G. (1972) A Sense of Place, UWA Press

Welker Environmental Consultancy (1997). Oakajee Deepwater Port Concept. Section 16(e) Strategic Environmental Review for Department of Resources Development.

Wilson, B.R., Hancock, D.A. and Chittleborough, R.G. (1979). The Sea in O'Brien, B.J. (ed) Environmental Science: 146-182. University of Western Australia Press, Nedlands.

TABLES

TABLE 1

PHYSICAL DESCRIPTION OF SURVEY SITES
OAKAJEE DEEP WATER PORT SITE

Survey Site No.	Sand	Limestone Pavement Sand Veneer	Limestone Pavement	Low reef	High reef
1	+	+	+	•	•
2	+	•	•	•	•
3	+	+	•	•	•
4	+	+	+	•	•
5	•	+	+	•	•
6	•	•	+	+	•
7	•	•	+	•	•
8	+	•	•	•	•
9	+	•	•	•	•
10	+	•	•	•	•
11	+	•	•	+	•
12	+	•	+	+	•
13	+	•	•	•	•
14	+	•	•	•	•
15	+	•	•	•	•
16	•	+	+	•	•
17	+	•	+	+	•
18	+	+	+	+	•
19	+	+	+	•	•
20	+	+	+	+	•
21	•	+	•	•	•
22	•	+	•	•	•
23	•	+	+	+	•
24	•	+	+	•	•
25	•	•	+	•	•
26	+	•	•	•	•
27	+	+	+	•	•
28	+	+	•	•	•
29	•	+	+	•	•
30	+	•	•	•	•
31	+	•	•	•	•
32	+	•	•	•	•
33	+	•	•	•	•
34	+	•	•	•	•
35	+	•	•	•	•
36	+	•	+	•	•
37	+	+	•	•	•
39	+	•	•	•	•
41	+	•	•	•	•
43	+	•	•	•	•
45	+	•	+	+	•
47a	•	•	+	+	•
47b	•	•	+	+	•
49	+	•	•	•	•
51	+	•	•	•	•
53	+	•	•	•	•

Survey Site No.	Sand	Limestone Pavement Sand Veneer	Limestone Pavement	Low reef	High reef
55	+	•	•	•	•
57	+	•	•	•	+
58	•	•	•	•	+
59	+	•	•	•	•
61	+	•	•	•	•
63	+	•	•	•	•
65	•	+	+	+	•
67	•	•	•	•	+
71	+	•	•	•	•
73	+	•	•	•	•
75	+	+	+	•	•
77	+	•	•	•	•
79	•	•	•	•	+
80	•	•	•	•	+
81	+	•	•	•	•
83	+	•	•	•	•
85	+	•	•	•	•
87	+	•	+	•	•
89	+	•	+	•	•
91	+	•	+	•	•
93	+	•	•	•	•
95	+	•	•	•	•
97	+	+	•	•	•
99	+	+	+	+	•
101	•	•	•	•	+
102	+	•	•	•	•
103	+	+	•	•	•
104	•	•	+	•	•
105	•	+	+	+	•
106	•	•	•	•	+
107	+	•	•	•	•
108	•	•	+	•	•
109	•	•	+	•	•
110	+	+	•	•	•
111	+	•	+	+	•

+ present
• absent

TABLE 2

BIOLOGICAL DESCRIPTION OF SURVEY SITES - OAKAJEE DEEP WATER PORT SITE

Survey Site No	Site Depth (m)	Marine Habitat *						Algae Species	Seagrass Species	Benthic Fauna, Fish and Crustaceans Species
		DS	DP	SP	LR	HR	SS			
1	10	•	•	+	•	•	+	Some kelps	•	•
2	20	+	•	•	•	•	•	•	•	•
3	20	+	+	•	•	•	•	Sparse algae	•	•
4	15	+	+	•	•	•	•	*Sargassum* spp; foliose red and brown algae	*Thalassodendrum*	•
5	11	•	•	+	•	•	•	*Ecklonia radiata, Sargassum* spp, brown algae abundant	•	•
6	9-10	•	•	+	+	•	•	Sparse brown algae on pavement. *Ecklonia radiata* on low reef with foliose red & brown algae, and coralline red algae present	Sponges	•
7	8	•	•	+	•	•	•	-	-	-
8	21	+	•	•	•	•	•	•	•	•
9	19	+	•	•	•	•	•	•	•	•
10	15	+	•	•	•	•	•	•	•	•
11	10-11	+	•	•	+	•	•	-	-	-
12	9-10	•	•	+	+	•	+	-	-	-
13	21	+	•	•	•	•	•	•	•	•
14	18	+	•	•	•	•	•	•	•	•
15	14	+	•	•	•	•	•	•	•	•
16	11-12	•	•	+	•	•	•	Sparse algae present on sand veneered pavement	•	•
17	10-11	•	•	+	+	•	+	*Ecklonia radiata*, foliose red and brown algae and coralline algae all abundant	•	•
18	9-10	•	•	+	+	•	+	*Ecklonia radiata* present on low reef. *Sargassum* spp and foliose red and brown algae abundant	*Thalassodendrum* spp abundant on pavement	•

Survey Site No	Site Depth (m)	Marine Habitat *						Algae Species	Seagrass Species	Benthic Fauna, Fish and Crustaceans Species
		DS	DP	SP	LR	HR	SS			
19	10-11	•	•	+	•	•	+	Foliose red and brown algae and *Sargassum* spp abundant on pavement	*Thalassodendrum* spp abundant on pavement	•
20	8	•	•	+	+	•	+	*Ecklonia radiata* abundant on reef. Foliose red and brown algae abundant, and *Sargassum* spp present on pavement	*Thalassodendrum* spp abundant on pavement, and *Amphibolus antarctica* present	•
21	-	•	•	+	•	•	•	•	•	•
22	10	•	•	+	•	•	•	-	-	-
23	9	•	•	+	+	•	•	-	-	-
24	9	•	•	+	•	•	•	-	-	-
25	9	•	•	+	•	•	•	-	-	-
26	27	+	•	•	•	•	•	•	•	•
27	30	+	+	•	•	•	•	•	•	•
28	30	+	+	•	•	•	•	•	•	•
29	26	•	+	•	•	•	•	•	•	Some sponges on pavement
30	26	+	•	•	•	•	•	•	•	•
31	26	+	•	•	•	•	•	•	•	•
32	-	+	•	•	•	•	•	•	•	•
33	21	+	•	•	•	•	•	•	•	•
34	-	+	•	•	•	•	•	•	•	•
35	6	•	•	•	•	•	+	•	•	•
36	5	•	•	+	•	•	+	Patches of brown algae	Patches to dense meadows of *Amphibolus antarctica*, particularly on ridge tops, epiphytic red and brown algae	•
37	25	+	+	•	•	•	•	Algal turf on rocks	•	Sponges on pavement. White rock lobsters sheltering under low pavement ledges

39	22	+	•	•	•	•	•	•	•	•
41	20	+	•	•	•	•	•	•	•	•
43	12	•	•	•	•	•	+	•	•	•
45	7	•	•	+	+	•	+	Mixed meadow of *Ecklonia*, *Sargassum* and *Amphibolus antarctica* with red and brown algae abundant	see algal comments	•
47a	5	•	•	+	+	•	•	Mixed dense meadow of kelps, *Sargassum*, *Amphibolus* and *Thalassodendrum*	see algal comments	•
47b	5	•	•	+	+	•	•	Mixed dense meadow of kelps, *Sargassum*, *Amphibolus* and *Thalassodendrum*	see algal comments	•
49	21	+	•	•	•	•	•	•	•	•
51	20	+	•	•	•	•	•	•	•	•
53	15	+	•	•	•	•	•	•	•	•
55	11	•	•	•	•	•	+	•	•	•
57	5	•	•	•	•	+	+	Dense mixed meadow of brown algae, *Sargassum*, red algae, *Amphibolus antarctica* and *Thalassodendrum*	see algal comments	King wrasse present
58	4	•	•	•	•	+	•	Dense meadow of brown algae and kelps with *Amphibolus antarctica*	see algal comments	•
59	22	+	•	•	•	•	•	•	•	•
61	21	+	•	•	•	•	•	•	•	•
63	20	+	•	•	•	•	•	•	•	•
65	11	•	•	+	+	•	•	*Ecklonia radiata*, patches of dense *Amphibolus antarctica* mixed with *Sargassum* and foliose red algae	see algal comments	•
67	9	•	•	•	•	+	•	*Ecklonia radiata* with understorey of foliose and encrusting red algae. *Caulerpa/Halimeda* on reef	•	•
71	21	+	•	•	•	•	•	•	•	•

73	20	+	•	•	•	•	•	•	•	•
75	15	•	•	+	•	•	+	Mixture of brown algae, *Sargassum*, *Osmundaria* and foliose red algae	*Amphibolus antarctica* and *Thalassodendrum* present	•
77	10	•	•	•	•	•	+	•	•	•
79	-	•	•	•	•	+	•	Mixed diverse meadow of kelps, *Sargassum*, coralline reds, and foliose red and brown algae	•	•
80	5	•	•	•	•	+	•	Mixed diverse meadow of kelps, *Sargassum*, coralline reds, and foliose red and brown algae	*Thalassodendrum* present	•
81	25	+	•	•	•	•	•	•	•	•
83	22	+	•	•	•	•	•	•	•	•
85	19	+	•	•	•	•	•	•	•	•
87	-	•	•	+	•	•	+	Foliose red and brown algae	Thick meadow of *Thalassodendrum* and *Amphibolus antarctica*	•
89	8-9	•	•	+	•	•	+	Mixed meadow of seagrass and algae	see algal comments	•
91	-	•	•	+	•	•	+	Mixed meadow of *Amphibolus antarctica* and red and brown algae	see algal comments	•
93	22	+	•	•	•	•	•	•	•	•
95	18	+	•	•	•	•	•	•	•	•
97	12	•	•	+	•	•	+	Sparse meadow of red and brown algae with *Osmundaria*	*Amphibolus* present	King wrasse present
99	9	•	•	+	+	•	+	Mixture of large kelps, red algae, *Osmundaria*, *Amphibolus antarctica* with an understorey of red and brown algae	see algal comments	•
101	6	•	•	•	•	•	+	Heavy *Ecklonia* and *Sargassum* meadow with encrusting red algae, some *Halimoda* and *Cladophora*	Trace of *Amphibolus antarctica*	Banded sweep, Cleaner wrasse, Damsel Fish, Gold Spotted morwong, rock lobsters abundant, sponges and colonial and solitary ascidians

										abundant in crevices and caves
102	20	+	•	•	•	•	•	•	•	•
103	16	+	+	•	•	•	•	*Osmundaria* and foliose red algae	*Thalassodendrum* present	•
104	9-10	•	•	+	•	•	•	Understorey of small kelps and foliose red and brown algae	*Amphibolus* and *Thalassodendrum* present	•
105	6	•	•	+	+	•	•	Understorey of small kelps and foliose red and brown algae	*Amphibolus* and *Thalassodendrum* present	•
106	5	•	•	•	+	•	•	Dense *Sargassum* and foliose red algae	Some *Thalassodendrum* present	•
107	18	+	•	•	•	•	•	•	•	•
108	10	•	•	+	•	•	•	Mixed meadow of foliose red algae, Sargassum, kelps and brown algae	Amphibolus anarctica and Thalassodendrum present	Sponges present
109	10	•	•	+	•	•	•	Mixed kelp and foliose red and brown algae	Amphibolus anarctica and Thalassodendrum present	Sponges present
110	8	•	•	+	•	•	+	Filamentous red and brown algae	•	•
111	3	•	•	+	+	•	+	Kelps and large brown algae. Understorey of foliose red and small brown algae	*Amphibolus antarctica* on pavement and on top of reef blocks	•

* DS = Deep Sandy Seafloor; DP = Deep Pavement; SP = Shallow Pavement; LR = Low Reef; HR = High Reef; SS = Shallow Sandy Seafloor

+ = Present; • = Absent; - = not recorded (depth) or videotape data destroyed by on board power failure.

TABLE 3

OAKAJEE STATISTICAL BLOCK 283 - ROCK LOBSTER CATCHES

Financial Year	0-18m depth catch (kg)			All depths catch (kg)			Total ($) Value *
	White+	Red^x	Total	White+	Red^x	Total	
1991-92	37,735	30,898	68,654	52,082	32,053	84,135	**1,850,992**
1992-93	25,268	11,896	37,164	28,378	11,895	40,274	**886,028**
1993-94	2,112	863	2,976	3,370	863	4,233	**93,126**
1994-95	40,821	35,279	76,100	63,525	35,279	98,803	**2,173,666**
1995-96	24,424	565	25,029	28,191	871	29,016	**638,352**
Annual Average	**26,076**	**15,899**	**41,977**	**35,100**	**16,192**	**51,792**	**1,128,433**

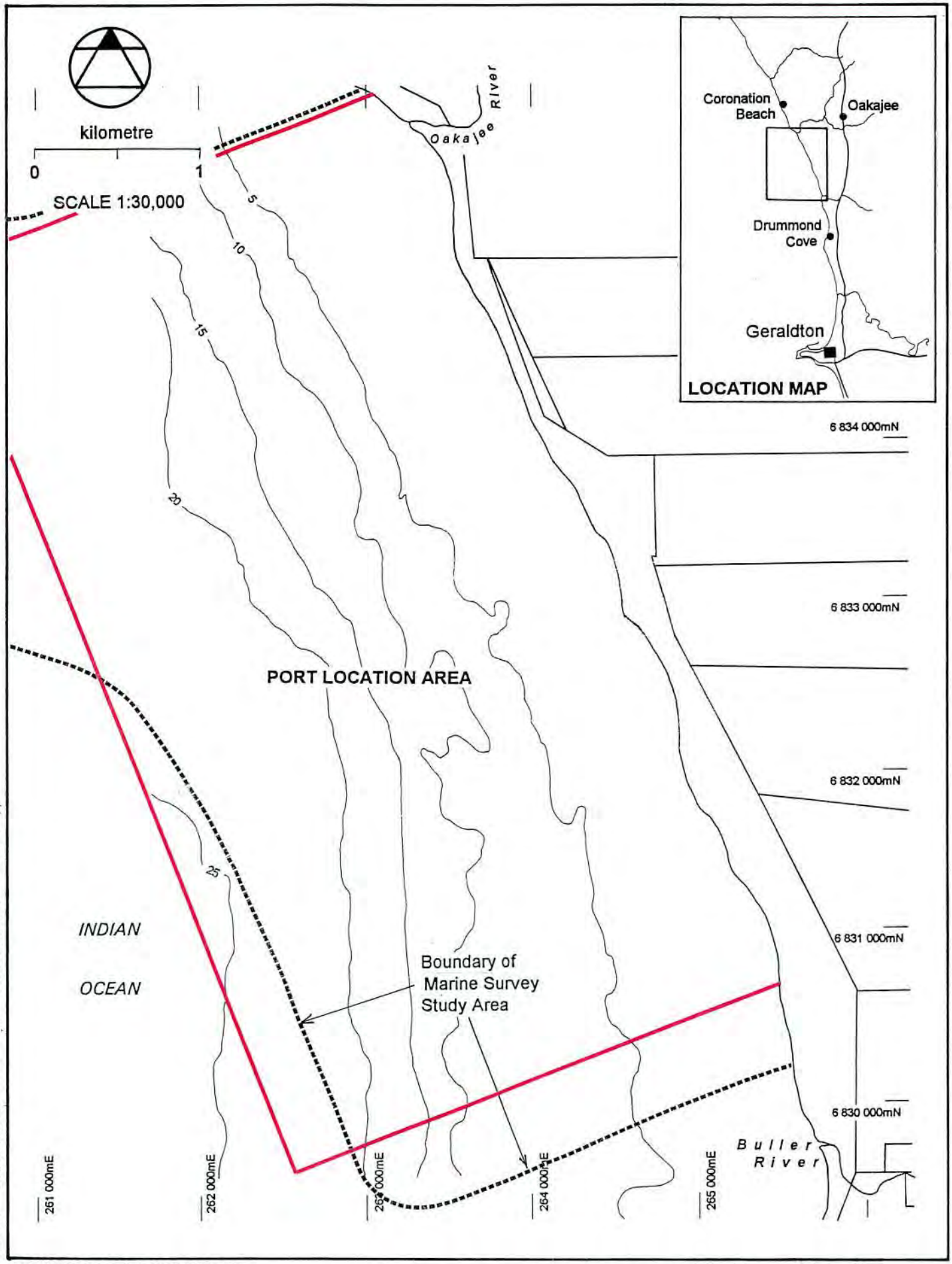
Note: Excludes Abrolhos Islands. Data supplied by Fisheries Dept of W.A.

+ White rock lobsters

x Red rock lobsters

* 1996 value (on beach) $22/kg (N. Caputi pers. comm.)

FIGURES



A96127 DRAWN BY: ST 22-4-97 CHECKED BY: TS 24-4-97

ALAN TINGAY & ASSOCIATES

APPENDIX 2 - OAKAJEE DEEPWATER PORT
LOCATION OF MARINE SURVEY
FIGURE 1

Oakajee River

INDIAN OCEAN

PORT LOCATION AREA

Buller River

CG 2249

6 836 000mN
6 835 000mN
6 834 000mN
6 833 000mN
6 832 000mN
6 831 000mN
6 830 000mN

259 000mE
260 000mE
261 000mE
262 000mE
263 000mE
264 000mE
265 000mE

16
15
14
13
12
11

Kilometre
0 1
SCALE 1:25,000

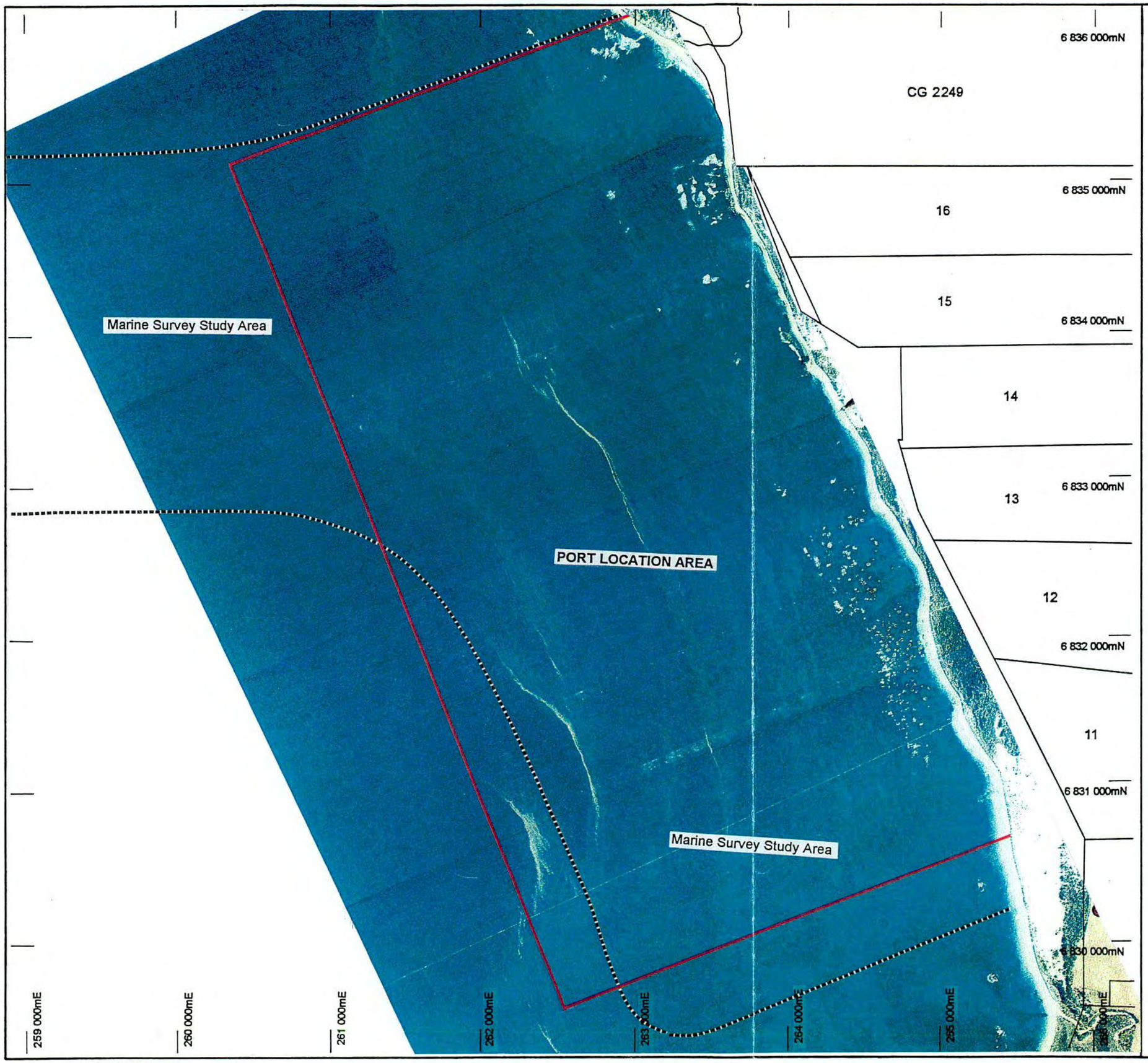
LEGEND

- 20 Indicates Marine Survey Site, Number & Location
- Deep Limestone Pavement
- Deep Sandy Seafloor
- Shallow Pavement
- Shallow Sand
- Low Reef
- High Reef
- 5 Bathymetric Contours at 5m Intervals (ACD)
- Boundary of Port Location Area -area in which Port Site will be located

APPENDIX 2
OAKAJEE DEEPWATER PORT
SEAFLOOR SUBSTRATES
FIGURE 2

A96127 DRAWN BY: ST 22-4-97 CHECKED BY: TS 24-4-97

ALAN TINGAY & ASSOCIATES



Kilometre

0 1

SCALE 1:25,000

LEGEND

Boundary of Port Location Area -area in which Port Site will be located

Extent of Marine Survey

APPENDIX 2
OAKAJEE DEEPWATER PORT
AERIAL PHOTOGRAPH OF MARINE SURVEY AREA
FIGURE 3

A96127 DRAWN BY: ST 22-4-97 CHECKED BY: TS 24-4-97

ALAN TINGAY & ASSOCIATES

Oakajee River

6 836 000mN

6 835 000mN

6 834 000mN

6 833 000mN

6 832 000mN

6 831 000mN

6 830 000mN

5

10

15

20

25

PORT LOCATION AREA

INDIAN

OCEAN

259 000mE

260 000mE

261 000mE

262 000mE

263 000mE

264 000mE

265 000mE

Buller River

Kilometres

0 1

SCALE 1:25,000

LEGEND

- Marine Survey Study Area
- Beach
- Shallow Sand
- High Reef
- Mixture of Shallow Pavement, Low Reef & Shallow Sand
- Mixture of Deep Pavement & Deep Sand
- Limit of Discernible Seafloor
- Boundary of Port Location Area -area in which Port Site will be located

APPENDIX 2
OAKAJEE DEEPWATER PORT
SEAFLOOR HABITATS
FIGURE 4

A96127 DRAWN BY: ST 22-4-97 CHECKED BY: TS 24-4-97

ALAN TINGAY & ASSOCIATES

REFERENCE

Movement of primary productivity materials

Nutrient flow

Riverine nutrient input

Seagrass and algal wrack bank

To onshore banks of wrack (17% of total productivity)

Offshore loss ?

Nutrient return from wrack

Recycled in coastal waters

Detached algae

Groundwater nutrient input

Recycled *insitu* by grazers and herbivores

Total benthic primary productivity

Offshore nutrient loss

Offshore nutrient input

High primary productivity (algae and seagrasses)

15 - 20m depth

Low primary productivity

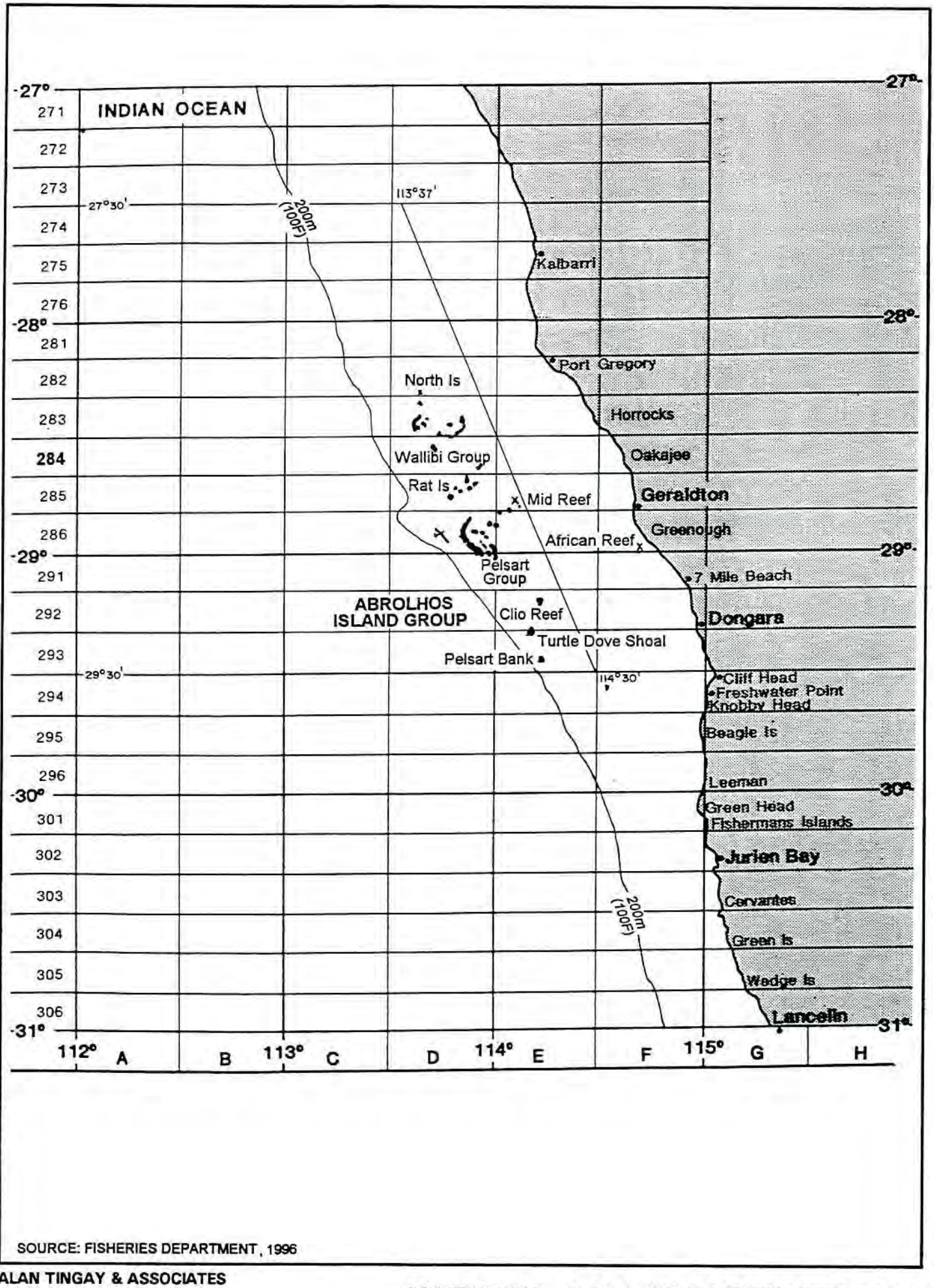
APPENDIX 2
OAKAJEE DEEPWATER PORT
COASTAL WATERS
PRIMARY PRODUCTION
& NUTRIENT FLOW DIAGRAM
FIGURE 5

SOURCE: WELKER ENVIRONMENTAL CONSULTANCY, 1997

DRAWN BY: ST 11.5.97 CHECKED BY: AT 11.5.97

A3d127

ALAN TINGAY & ASSOCIATES



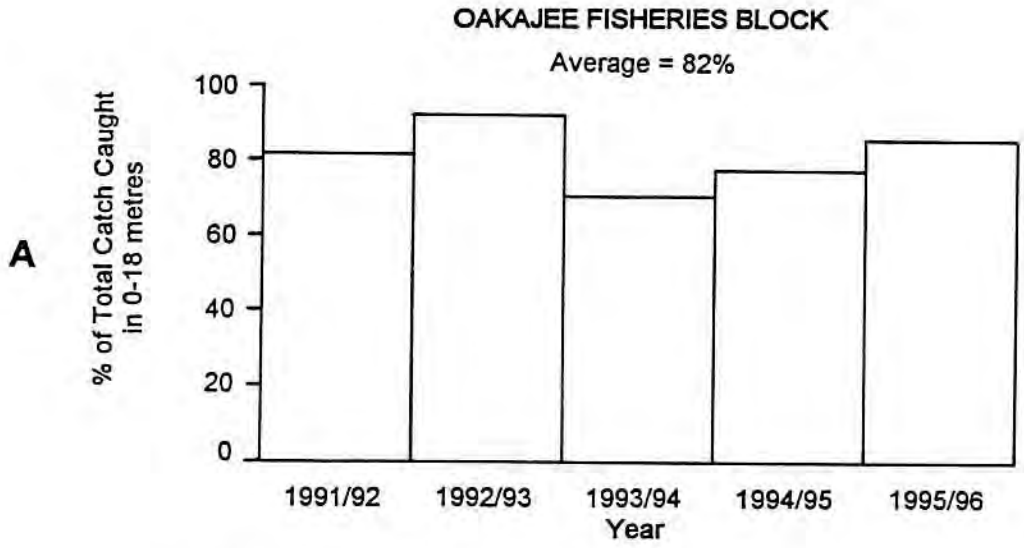
SOURCE: FISHERIES DEPARTMENT, 1996

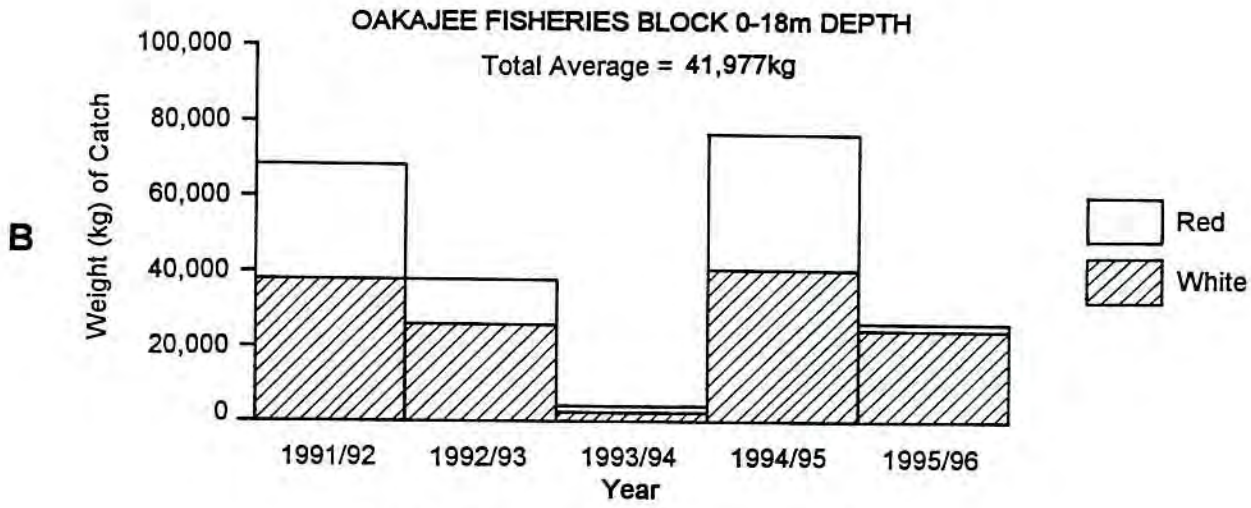
DRAWN BY: ST 16.2.97 CHECKED BY: AT 18.2.97

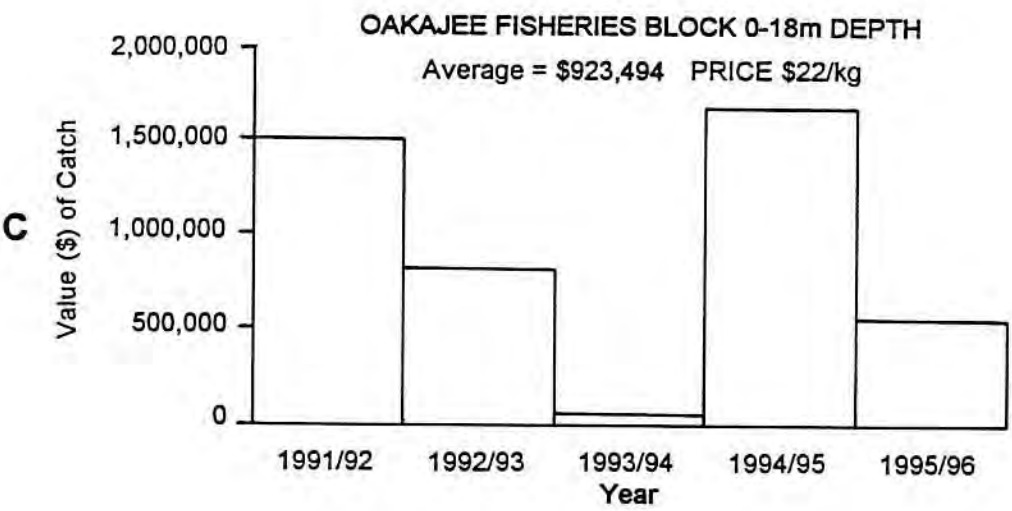
A96127

ALAN TINGAY & ASSOCIATES

APPENDIX 2 - OAKAJEE DEEPWATER PORT
ROCK LOBSTER STATISTICAL BLOCK 284
FIGURE 6





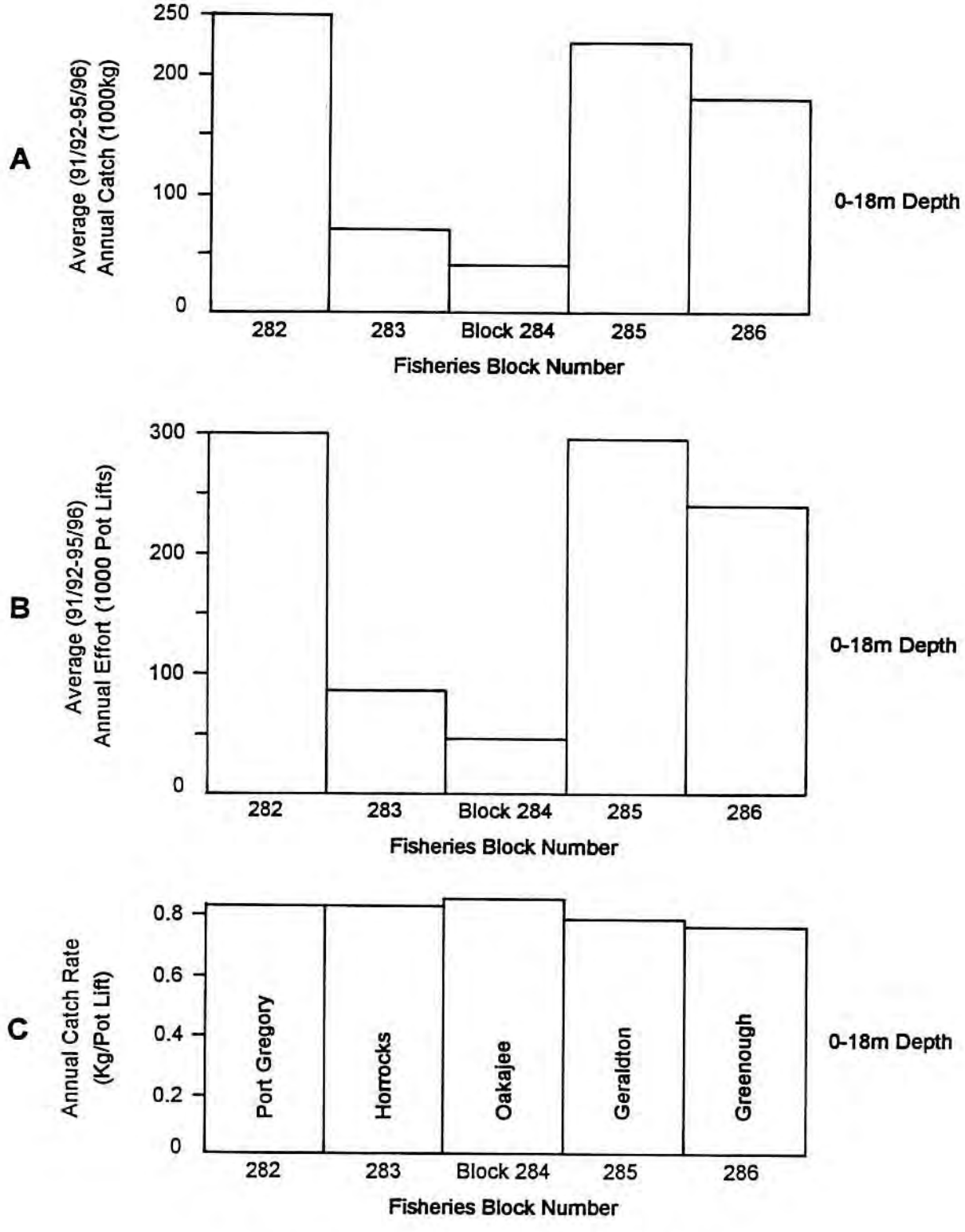


SOURCE: APPENDIX 1, FISHERIES DEPARTMENT, 1996

A96127 DRAWN BY: ST 16.2.97 CHECKED BY: AT 18.2.97

ALAN TINGAY & ASSOCIATES

APPENDIX 2 - OAKAJEE DEEPWATER PORT
ROCK LOBSTER CATCH DATA, OAKAJEE BLOCK
FIGURE 7



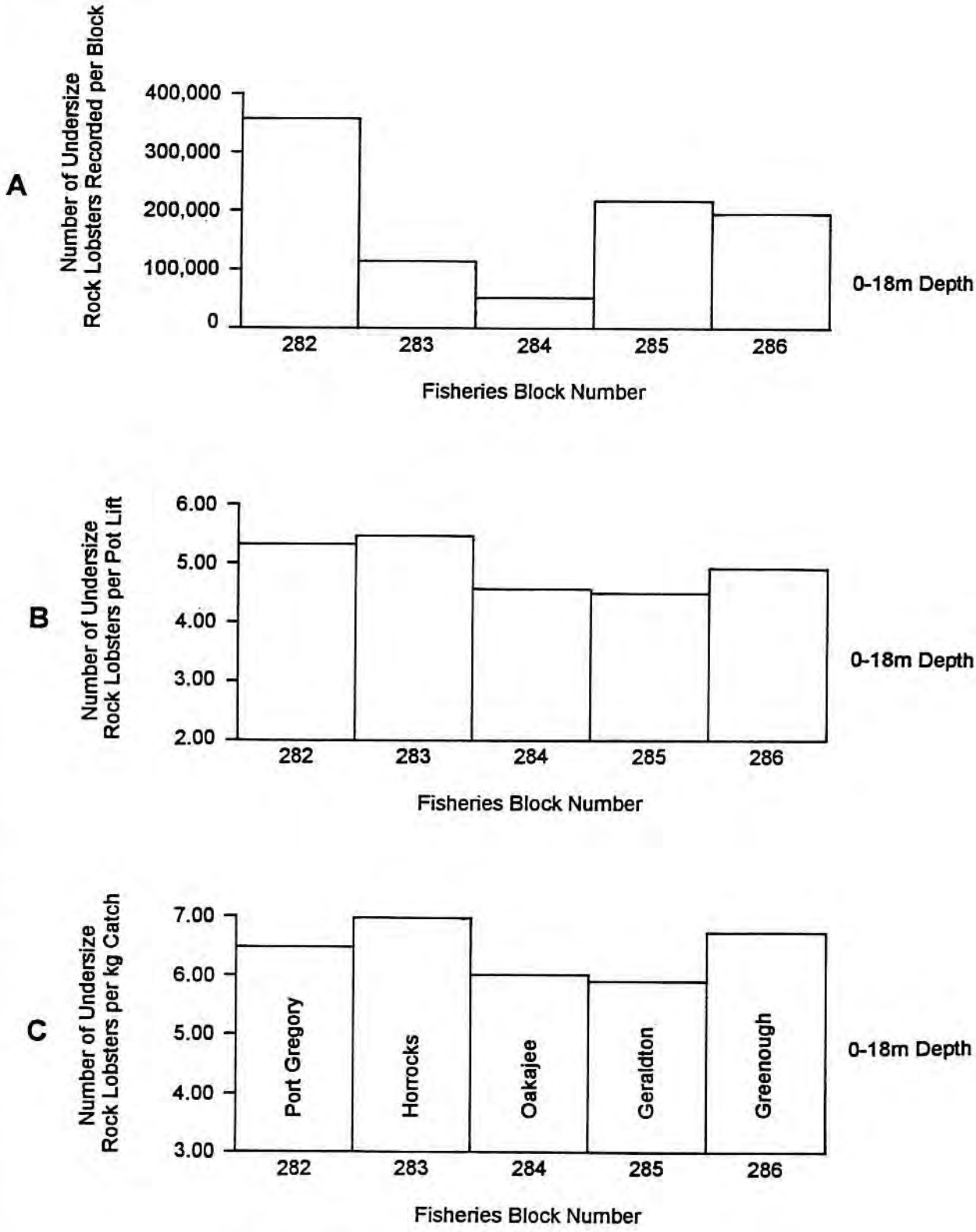
SEE FIGURE 5 FOR LOCATIONS OF BLOCKS

SOURCE: APPENDIX 1, FISHERIES DEPARTMENT, 1996

A96127 DRAWN BY: ST 16.2.97 CHECKED BY:

ALAN TINGAY & ASSOCIATES

APPENDIX 2 - OAKAJEE DEEPWATER PORT
ROCK LOBSTER FISHERIES DATA, OAKAJEE & ADJOINING BLOCKS
FIGURE 8



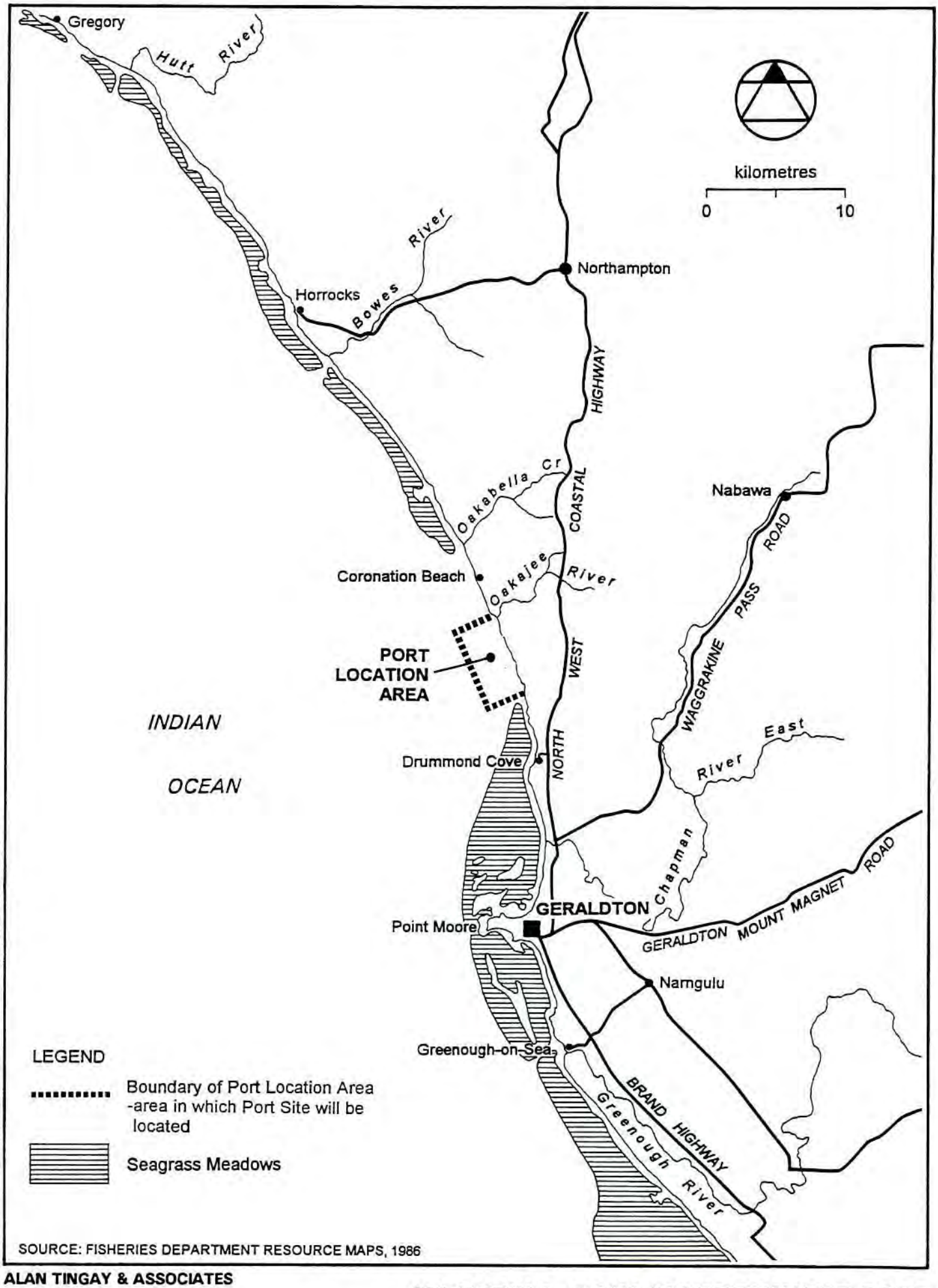
OAKAJEE IS LOCATED IN BLOCK N0: 284. SEE FIGURE 5
FOR LOCATIONS OF BLOCKS

SOURCE: APPENDIX 1, FISHERIES DEPARTMENT, 1996

A96127 DRAWN BY: ST 16.2.97 CHECKED BY: AT 18.2.97

ALAN TINGAY & ASSOCIATES

APPENDIX 2 - OAKAJEE DEEPWATER PORT
UNDERSIZE ROCK LOBSTER DATA, OAKAJEE & ADJOINING BLOCKS
FIGURE 9



A96127 DRAWN BY: ST 22-4-97 CHECKED BY: TS 24-4-97

ALAN TINGAY & ASSOCIATES

APPENDIX 2 - OAKAJEE DEEPWATER PORT
GERALDTON COAST SEAGRASS MEADOWS
FIGURE 10

APPENDIX 1

ROCK LOBSTER FISHERIES STATISTICS
OAKAJEE REGION
1991 - 1996

FINANCIAL YEAR 1991 - 1992

Block	Depth	Catch (kg)			Pot Lifts			Catch Rate		
	(ftm)	White	Red	Total	White	Red	Total	White	Red	Total
282	all	162538	137227	299765	184881	174374	359254	0.87915	0.78697	0.83441
282	0-10	148545	122292	270836	171373	158600	329973	0.86679	0.77107	0.82078
283	all	83866	38204	122070	83811	44353	128164	1.00065	0.86138	0.95245
283	0-10	57532	37877	95409	68806	43541	112347	0.83615	0.86991	0.84923
284	all	52082	32053	84136	49643	28671	78314	1.04914	1.11797	1.07434
284	0-10	37756	30898	68654	38864	27894	66758	0.97148	1.10772	1.02841
285	all	202698	95910	298608	268277	108787	377063	0.75556	0.88163	0.79193
285	0-10	133010	83063	216074	197572	96364	293937	0.67322	0.86198	0.73510
286	all	272930	142104	415034	340490	151937	492427	0.80158	0.93528	0.84283
286	0-10	78653	95623	174277	136801	102357	239158	0.57495	0.93421	0.72871

FINANCIAL YEAR 1992 - 1993

Block	Depth	Catch (kg)			Pot Lifts			Catch Rate		
	(ftm)	White	Red	Total	White	Red	Total	White	Red	Total
282	all	128189	153136	281325	135924	181424	317347	0.94309	0.84408	0.88649
282	0-10	115541	138183	253723	126368	171663	298030	0.91432	0.80497	0.85133
283	all	68302	40396	108699	64243	36363	100606	1.06318	1.11092	1.08044
283	0-10	56375	39842	96217	57817	35696	93513	0.97505	1.11614	1.02891
284	all	28378	11896	40274	29809	9007	38816	0.95201	1.32066	1.03756
284	0-10	25268	11896	37164	26759	9007	35767	0.94428	1.32066	1.03906
285	all	173354	84602	257956	216109	98957	315166	0.80216	0.85494	0.81874
285	0-10	140821	79818	220639	186923	92874	279797	0.75336	0.85943	0.78857
286	all	163160	124147	287306	167176	159060	326236	0.97598	0.78050	0.88067
286	0-10	78677	88914	167591	108978	123343	232322	0.72195	0.72086	0.72137

FINANCIAL YEAR 1993 - 1994

Block	Depth	Catch (kg)			Pot Lifts			Catch Rate		
	(ftm)	White	Red	Total	White	Red	Total	White	Red	Total
282	all	148591	167309	315900	173923	200419	374342	0.85435	0.83479	0.84388
282	0-10	148209	149998	298207	172554	181253	353806	0.85892	0.82756	0.84285
283	all	36467	41834	78301	40685	39206	79891	0.89633	1.06703	0.98010
283	0-10	26935	41834	68769	32050	39206	71256	0.84040	1.06703	0.96509
284	all	3370	863	4233	6873	1477	8350	0.49036	0.58452	0.50702
284	0-10	2112	863	2976	4824	1477	6301	0.43786	0.58452	0.47223
285	all	214170	86183	300353	254598	91944	346542	0.84121	0.93734	0.86671
285	0-10	151643	67841	219484	191994	72214	264208	0.78983	0.93945	0.83073
286	all	178058	86218	264276	226231	97728	323959	0.78706	0.88223	0.81577
286	0-10	95958	59662	155620	138237	74453	212690	0.69415	0.80135	0.73168

FINANCIAL YEAR 1994 - 1995

Block	Depth	Catch (kg)			Pot Lifts			Catch Rate		
	(ftm)	White	Red	Total	White	Red	Total	White	Red	Total
282	all	169387	191435	360822	196956	211447	411103	0.84839	0.90536	0.87769
282	0-10	149174	127926	277100	181792	154762	336554	0.82058	0.82660	0.82334
283	all	27221	2423	29645	34200	5523	39722	0.79595	0.43881	0.74629
283	0-10	15091	2382	17473	25308	5174	30482	0.59628	0.46042	0.57322
284	all	63525	35279	98803	65431	34946	100377	0.97087	1.00951	0.98432
284	0-10	40821	35279	76100	48977	34946	83924	0.83347	1.00951	0.90677
285	all	206683	68775	275458	250169	87304	337473	0.82617	0.78776	0.81624
285	0-10	149673	57007	206680	198847	76177	275024	0.75270	0.74825	0.75150
286	all	173227	110527	283754	237068	103321	340390	0.73071	1.06974	0.83362
286	0-10	102981	89156	192137	152725	83106	235831	0.67429	1.07280	0.81473

FINANCIAL YEAR 1995 - 1996

Block	Depth	Catch (kg)			Pot Lifts			Catch Rate		
	(ftm)	White	Red	Total	White	Red	TotaL	White	Red	Total
282	all	89681	103853	193534	101346	120727	222074	0.88489	0.86023	0.87149
282	0-10	80405	75015	155421	91850	98448	190298	0.87539	0.76198	0.81672
283	all	62596	41460	104056	88209	48099	136308	0.70963	0.86198	0.76339
283	0-10	47613	40547	88160	74495	46928	121423	0.63915	0.86402	0.72606
284	all	28145	871	29016	36706	2095	38802	0.76676	0.41566	0.74780
284	0-10	24424	565	24989	31082	1079	32160	0.78580	0.52383	0.77701
285	all	240759	86150	326910	295760	118535	414295	0.81404	0.72679	0.78907
285	0-10	193589	80708	274296	243699	112993	356692	0.79438	0.71427	0.76900
286	all	189617	112606	302223	252753	135523	388277	0.75021	0.83089	0.77837
286	0-10	122965	89069	212034	162228	106521	268749	0.75797	0.83616	0.78897

Source: Fisheries Department

For statistical block locations, see Figure 5 of this report. Oakajee is located in Block 284

Subset of Rock Lobster Logbook Data
(Total Catch from 0-10 fathom with undersized provided)

FINANCIAL YEAR 1991 - 1992

Transect	Catch (kg)	Potlifts	Undersize	Undersize (n) per potlift	Undersize (n) kg of catch
282	65679	81365	460580	5.66066	7.01259
283	20989	26226	126298	4.81576	6.01734
284	17148	16639	61530	3.69794	3.58817
285	21073	31480	96921	3.07881	4.59930
286	35483	51274	212446	4.14335	5.98726

FINANCIAL YEAR 1992 - 1993

Transect	Catch (kg)	Potlifts	Undersize	Undersize (n) per potlift	Undersize (n) kg of catch
282	54183	67963	340145	5.00486	6.27771
283	22388	22574	141900	6.28599	6.33822
284	8284	8058	37030	4.59543	4.47006
285	27991	39966	164020	4.10399	5.85974
286	29803	45533	179404	3.94009	6.01966

FINANCIAL YEAR 1993 - 1994

Transect	Catch (kg)	Potlifts	Undersize	Undersize (n) per potlift	Undersize (n) kg of catch
282	57541	68795	345332	5.01973	6.00149
283	14663	14819	90900	6.13402	6.19928
284	481	1017	3030	2.97935	6.29938
285	34707	39002	174527	4.47482	5.02858
286	22407	30252	177032	5.85191	7.90075

FINANCIAL YEAR 1994 - 1995

Transect	Catch (kg)	Potlifts	Undersize	Undersize (n) per potlift	Undersize (n) kg of catch
282	67962	80646	427953	5.30656	6.29695
283	3392	6653	24795	3.72689	7.30985
284	17817	19439	125440	6.45301	7.04047
285	38426	49403	223989	4.53391	5.82910
286	31622	38183	206562	5.40979	6.53222

FINANCIAL YEAR 1995 - 1996

Transect	Catch (kg)	Potlifts	Undersize	Undersize (n) per potlift	Undersize (n) kg of catch
282	29628	38214	201476	5.27231	6.80019
283	18423	26870	163387	6.08065	8.86864
284	2057	3566	17470	4.89905	8.49295
285	51594	68221	422206	6.18880	8.18324
286	28586	39120	204397	5.22487	7.15025

Source: Fisheries Department

For statistical block locations, see Figure 5 of this report. Oakajee is located in Block 284

APPENDIX 3

COASTAL PROCESSES REPORT

Limitations of Report

This report has been prepared for use by the Client with the degree of skill, care and diligence normally exercised by members of the engineering profession performing services of a similar nature, and in accordance with the ethics of the engineering profession. No other warranty, expressed or implied, is made as to the accuracy of the data and professional advice included in this report. This report has not been prepared for use by parties other than the Client and its consulting advisers. It may not contain sufficient information for the purposes of other parties or for other uses.

M P Rogers & Associates Pty Ltd (ACN 062 681 252) takes no responsibility for the completeness or form of any subsequent copies of this report. Copying this report without the permission of the Client or M P Rogers & Associates is not permitted.

Contents

1. Introduction

The Department of Resource Development (DRD) and Kingstream Resources (Kingstream) are examining the development of a deepwater port approximately 20 km north of Geraldton near the mouth of the Oakajee River. Deepwater port facilities would be required to cater for larger, deeper draught vessels that can not use the existing port at Geraldton. Kingstream would use the facilities for the export of the steel produced in its proposed steel mill at Oakajee. It is also envisaged that the proposed port could also be used by other operators with requirements for deep-draught vessels.

The project is currently at the stage where the financial viabiliity is being assessed and environmental approvals are being sought. As part of this process, a variety of environmental and engineering investigations have been commissioned by DRD and Kingstream. M P Rogers & Associates (MRA) has been engaged through Alan Tingay & Associates to provide an expert assessment of the potential impacts of the proposed port on the coastal dynamics of the area.

This coastal engineering investigation involved the following work:

- review of relevant available reports and data, including the analysis of wind and wave records,
- review of recent aerial photography,
- a site inspection in which the whole coastline, from a couple of kilometres south of the Buller River north to Coronation Beach, was examined,
- assessment of the coastal processes and sediment transport in the area, and
- prediction of teh impacts of the port development on the coastal processes.

This report presents the findings of this investigation. In some aspects of the work, particularly with respect to the assessment of longshore sediment transport, the techniques used were empirical and only approximate. In view of this, further work which would yield more definitive answers, to confirm the initial predictions, has also been outlined.

2. Meteorological & Oceanographic Conditions

Any comprehensive study of coastal processes must be done with a knowledge of the fundamental driving forces. Consequently, an understanding of the magnitude and variation in the winds, waves, tides and currents are important in assessing the coastal processes.

2.1 Wind Regime

The wind regime influences coastal processes through the generation of ocean waves and currents as well as feeding dune systems with wind blown beach sand.

The seasonal weather patterns in the vicinity of the Oakajee site are largely controlled by the position of the so called Subtropical High Pressure Belt. This is a series of discrete anticyclones that encircle the earth at the mid-latitudes (20° to 40°). These high pressure cells are continuously moving from west to east across the southern portion of the Australian continent. A notional line joining the centres of these cells is known as the High Pressure Ridge.

In winter this ridge lies across Australia typically between 25° to 30° S and straddles Oakajee at 28° 35' S. During summer, the ridge moves south of Oakajee and lies between 35° and 40° S. This latitudinal shift in the position of the High Pressure Ridge is fundamental to the seasonal wind patterns experienced in the region.

In addition to these regional scale effects which cause seasonal variations, the meso-scale phenomenon of a land-sea breeze system is commonly experienced at Oakajee and adjacent coastal regions, causing wind variations on a daily time scale. Offshore breezes are experienced in the morning which swing around to the southwest and south in the afternoon.

The Bureau of Meteorology has measured the wind speed and direction at Geraldton Airport for many decades. This location is approximately 25 km south and 9 km inland from the proposed port site. None the less, it is still believed to provide an accurate indication of the winds experienced at Oakajee.

The wind record at Geraldton Airport extends from 1941 to 1993. Roses of the 9:00 am and 3:00 pm winds for spring and summer are shown in Figure 2.1. Similar information for autumn and winter is displayed in Figure 2.2.

In spring, and particularly summer, the morning winds are typically light (<20 km/h) to moderate (20-40 km/h) in strength and blow from northeasterly through to southerly directions. The afternoons of these seasons are usually dominated by moderate to strong (>40 km/h) southwest and southerly winds. It is believed that this is a reflection of the dominant afternoon sea-breeze experienced in the region.

The autumn wind characteristics are similar to those experienced during summer. Light to moderate northeast to southeasterly winds are usually experienced in the morning, and light to moderate southwest to southerly winds typically blow during the afternoon.

Winter meteorology is characterised by storms associated with the passage of low pressure systems and intervening periods of generally light and variable winds. Moderate to strong north to northwesterly winds usually signify the onset of a winter storm. As the low pressure system passes over the site, the winds swing through west, and around to the southwest and south during the tail of the storm. Winds during winter storms are generally strong, in excess of 40 km/h.

As a result of these meteorological patterns, the winter wind roses for Geraldton show winds of variable speed and direction in both the morning and afternoon. The dominance of northeasterly winds during the morning may be due to a land-breeze effect - during the night and early morning, relatively warm air over the ocean rises and draws in the cooler air overlying the land. This is essentially the reverse of the afternoon sea-breeze effect and generates winds in the opposite direction.

2.2 Wave Climate

The waters in the vicinity of the Oakajee site experience high wave energy. In June 1982, a Waverider buoy was deployed at Oakajee for one year in 15-20 metres of water approximately 1 km offshore (Steedman & Associates, 1983). The purpose of these measurements was to determine the wave climate for ship operations and breakwater design associated with the proposed port. The location of the buoy was chosen to correspond to the head of the proposed breakwater (refer to Figure 2.3).

These measurements show that the mean significant wave height over the year's duration was 1.2 metres, with a large proportion of the wave energy of periods ranging from 12 to 16 seconds. The calmest months of the year were October and November, and March and April.

Other wave measurements, made over a 6 month duration in 20 metres of water off Point Moore (Geraldton), showed the significant wave height exceeding 0.5 metre for 99% of the time (Steedman Science & Engineering, 1991).

The main elements of the wave climate experienced at the Oakajee site are:

- Locally generated seas which are fetch limited by the extent of the sea breeze system. These waves are typically 0.5 metre to 1.5 metres high with periods of 3 to 6 seconds and are generally from the southwest to south.

- Seas generated locally by the passage of cold fronts during winter. The wave heights and periods vary markedly from storm to storm. Often the wave heights exceed 4 metres and the wave periods reach 6 to 10 seconds. The direction from which the waves approach can range from west to southwest during the passage of the storm.

- Swell waves from distant storms in the Southern Indian Ocean continually reach the offshore area. These swell waves often exceed 2 metres and typical periods are between 8 and 16 seconds. These swell waves commonly approach from the southwest.

- Severe waves caused by dissipating tropical cyclones. These storms are infrequent at Oakajee however when they do occur they cause severe conditions for short periods of time.

Offshore waves are greatly affected by the various reefs and the gaps between the reefs as they travel toward the shore. The reefs and adjacent areas modify the waves by the following physical processes.

- Reflection off the reef faces.

- Depth limited breaking on the reef tops.

- Diffraction through the gaps in the reefs.

- Attenuation due to hydraulic turbulence as the waves travel over the reefs.

- Refraction and shoaling due to variability in the seabed topography.

All of these processes act in varying degrees and significantly attenuate the waves as they approach the beaches. This is particularly relevant to the Oakajee site which is characterised by large amounts of nearshore reef, spread in patches from the coast out to several hundred metres offshore. The resultant waves that break on the beaches are believed to be very important in the transport of sand in the littoral zone.

During the site inspection, the nearshore conditions were observed during a strong sea-breeze. In the afternoon, about 4-5 hours after the sea-breeze had commenced, waves about 1 metre high and 3-4 seconds' period were observed breaking on the nearshore reefs under 20 to 25 knot south-southwesterly winds. Depending on the amount of nearshore reef protection, waves in the order of 0.2 to 0.4 metres' height would eventually break on the beach. Under these conditions, little sediment was suspended in the waters adjacent to the beach, and hence it was concluded that only a small amount of longshore sediment transport was occurring in the inshore zone.

Similar attenuation of wave energy by the nearshore reef is also expected during times when the background swell dominates the wave climate. However, during storm events the situation is expected to be quite different. This covers both winter storms and dissipating tropical cyclones, although the former is experienced far more frequently. The elevated water levels experienced under these conditions would allow larger waves to pass over the reefs without breaking. During storms, the offshore wave climate is generally very energetic. Hence it is likely that substantially more wave energy will arrive at the shore during these events than any other time of the year.

2.3 Tides

The astronomical tides in the Geraldton region are predominantly diurnal, namely one tidal cycle each day, and relatively limited in range (Department of Defence, 1995). The range of diurnal tides generally varies over about a 4 week cycle. Periods or relatively large tide ranges, referred to as "spring tides", occur for a few days every 2 weeks. Separating these are periods of relatively small tide ranges, "neap tides", which last a few days and occur every 2 weeks. The few days between spring and neap tides are referred to as transition periods.

There are no extensive tide records specifically for the Oakajee port site. However, these do exist for the Port of Geraldton which is only about

22 km south of Oakajee. The two locations are believed to experience very similar tides.

At Geraldton, the daily range is typically about 0.7 metres during spring tides and less than 0.5 metres during neap tides. The Mean High High Water (MHHW), indicative of a typical high tide, is about 0.4 metres above Mean Sea Level (MSL). The Highest Astronomical Tide (HAT) is about 0.7 metres above MSL.

Seasonal shifts in the sea level occur due to meteorological effects. Typically, the mean sea level at Geraldton rises 0.1 metre during winter and falls 0.1 metre during summer.

During storm events, barometric and wind effects can cause significant storm surges. In extreme storms the surge can exceed 1 metre above the astronomical tide level, (Port & Harbour Consultants, 1989). The highest water level recorded at Geraldton was 1.5 metres above MSL in 1970 and was probably associated with Tropical Cyclone Glynis.

Given the small astronomical tides, the level of the sea would generally have a secondary effect on the sand transport along the beaches. The exception to this, as previously identified, is during storm events when high water levels would enable substantially more wave energy to pass over the reefs and attack the rear of the sandy beaches.

2.4 Nearshore Currents

A brief literature search uncovered little data on the ocean currents near Geraldton. In the deeper water of the continental shelf, the warm Leeuwin current has been observed in various satellite images. However, no data on the nearshore currents around Geraldton were found.

During the site inspection, strong northerly nearshore currents were observed under sea-breeze conditions. The winds were 20 to 25 knots from the south-southwest, and had been blowing with comparable strength and direction for several hours. The nearshore currents are believed to be the product of both wind shear and wave pumping, and were estimated to have magnitudes at the surface in the order of 0.1 to 0.3 m/s.

3. Coastal Processes

3.1 Background

From a coastal engineering perspective, the most important of coastal processes is generally the interaction of waves, currents and beaches to generate sediment transport. When waves break obliquely on a beach, a current will form that moves along the beach. This *longshore current* can carry sediment suspended in the water by the wave action. Such sediment movement is termed *longshore sediment transport* as the material is moved in a direction parallel to the shoreline, or along the shore.

Alternatively, during storms, elevated water levels allow waves to attack the rear of beaches, which would otherwise be "high and dry". As a result, sediment is eroded from these areas and deposited in an offshore bar. During intervening periods between the storms, sediment will generally be moved back onto the beach by the background swell. Storm erosion and recovery are the two most common forms of *cross-shore sediment transport*.

Sediment transport processes are important from a coastal engineering point of view because they are responsible for the erosion or accretion of beaches. Depending on the nature of the driving force, shoreline recession or progradation may occur over a variety of different time scales. For example, winter storm erosion may cause a substantial recession ($\sim$10 to 20 metres) of the shoreline over the course of a day or so. On the other hand, it may take several months, or even years, for the background swell to redeposit the sediment on the beach and return the shoreline to its former position.

On an even larger time scale, natural variations in the longshore sediment transport rates along the coast result in different areas experiencing long-term erosion or accretion. These processes may be quite slow, for example the shoreline recession / progradation may be in the order of 0.5 to 1 m/yr. However, if persistent, they can result in large-scale changes to the coastal morphology over time-scales in the order of decades. Such changes are usually of great interest to coastal developments.

So far, only natural phenomena have been exemplified, however human interference with sediment fluxes can also result in significant accretion or erosion of sediment over a variety of time-scales. For example, the construction of a groyne is likely to immediately cause sediment to be trapped on its up-drift side and eroded from some areas on its down-drift side. As this continues over time, the up-drift side of the groyne may

become saturated, leading to a longshore sediment flux bypassing the groyne and the possible formation of an offshore bar at its head. Depending on the size and shape of the structure, and the nature of the coastal environment, the accretion and erosion associated with these processes may occur over days, weeks or decades. Because of the great variability in the manner and rate at which coastal systems adjust to external influences, each modification to the natural environment must be carefully assessed in order to estimate the effects it could have on the environment and vice versa.

3.2 Coastal Dynamics near the Oakajee Port Site

A good technique of assessing long-term accretion / erosion trends and estimating sediment fluxes is through the analysis of aerial photographs using controlled photogrammetry to produce shoreline movement plans. Unfortunately, various constraints precluded the use of this form of analysis from the present investigation. Instead, assessments of accretion / erosion and estimates of sediment transport rates were made using information gathered during the site inspection, empirical modelling techniques, and from visual analysis of the aerial photographs.

The presence of two large *cuspate forelands* immediately to the south of the Buller River (see Figure 1.1) suggests that there is little sediment arriving from the south. These features, also known as *salients*, typically form in the lee of offshore obstructions, such as islands or reefs. The effects of wave refraction, diffraction and sheltering combine to accumulate sediment behind these obstacles. As a result, there is generally little longshore sediment transport past these coastal features.

The aerial photography taken in late spring of 1996 clearly illustrates this process under conditions dominated by the background swell (see Figure 3.1). Substantial wave breaking is evident over the reefs opposite the heads of the forelands. Furthermore, the effects of refraction and diffraction can be clearly seen by the bent nature of the crests of the waves passing through gaps in the reefs and wrapping around the sides of the salients. The presence of cusps on the beach immediately north of these features confirms that there is little sediment transport under these conditions. Beach cusps generally only form when waves break square onto the beach. Under these conditions, typically little longshore sediment transport will result since obliquely incident waves are usually required to generate a longshore current.

The extensive nearshore reef present along the coastline in the vicinity of the Oakajee site was identified earlier in Section 2.2. A description of the effect this is believed to have on the nearshore wave climate was also given in that section. In summary, it is expected that the reefs will greatly attenuate incoming waves under conditions dominated by afternoon sea-breeze seas or background swell. However, substantially more wave energy is expected to reach the shore during storms when elevated water levels allow larger waves to pass over the reefs after breaking. In addition to greatly attenuating wave energy, through diffraction and erosion, and later refraction effects, the nearshore reef causes the transmitted swell waves to line up generally square to the shore.

Given this scenario, it is expected that very little net longshore sediment transport is generated along the beaches by the background swell. However, it is also believed that there may be significant amounts of sediment transport occurring within the nearshore reef system. This would be driven predominantly by swell waves breaking obliquely on the edges of the reef, suspending sediment and creating currents which would advect the material. Sea-breeze and storm waves are also believed to contribute to this process, although the larger and longer period the waves would have the greatest effect. It is possible that much of this sediment movement consists of circulation in localised littoral cells. It is very difficult to assess the sediment fluxes occurring within such cells, let alone deducing the net movement in the longshore direction. An estimate in the order of 5,000 m^3/yr northward has been made to account for the net longshore sediment flux within the nearshore reef system.

Somewhat more longshore sediment transport is believed to occur along the beaches under sea-breeze conditions. This is primarily due to the fact that the sea-breeze waves break on the beach at a consistently more oblique angle than do the swell waves. Reasons for this include the following:

- Sea-breeze waves are significantly more oblique (typically travelling from the south-southwest) to the general alignment of the Oakajee coastline prior to encountering the nearshore reefs.

- Sea-breeze waves are of shorter period than the background swell and hence less influenced by the refractive effects of the nearshore zone, which will tend to align wave crests parallel to the shore.

- After breaking on the nearshore reef, sea-breeze waves are regenerated to some extent by the wind over the fetch between the reef and the shore. The swell waves do not receive this ehancement.

The sea-breezes in the vicinity of the Oakajee Port Site consistently blow from directions ranging between southwest and south. Longshore sediment transport generated by these waves will therefore be to the north. Initial and approximate empirical modelling suggests that a net northward sediment movement of 10,000 to 20,000 m^3/yr may be generated under the sea-breeze conditions in the vicinity of the proposed port site.

In contrast to the background swell and sea-breeze conditions, it is believed that storms (both winter storms and dissipating tropical cyclones) would generate substantially higher rates of longshore sediment transport. However, it must be remembered that the cumulative duration of these events throughout the year is likely to be much shorter than that of either sea-breeze or background swell conditions. Therefore the total longshore sediment movement effected by storms over the course of a year may not necessarily be large.

The passage of winter storms and dissipating tropical cyclones through the Oakajee area will be characterised by large swings in the direction of both the wind and the seas they generate. For winter storms, the winds and waves would initially arrive from the northwest, and then swing through west to the southwest as the low pressure system passes over the site. As a result, significant longshore sediment transport to the south is expected during the early stages of such events. When the winds and waves arrive from predominantly westerly directions, longshore sediment transport is expected to be greatly reduced. However, during the latter stages of winter storms, substantial sediment transport to the north would be expected.

Dissipating tropical cyclones are also expected to exhibit similarly large swings in wind and wave directions. Once again this would result in both the northward and southward movement of sediment along the shore at different stages throughout the storm.

Initial and approximate empirical calculations suggest that the overall longshore sediment transport resulting from storms throughout a year is in the order of 10,000 to 50,000 m^3/yr each way. That is a *gross* northward movement of 10,000 to 50,000 m^3/yr and a similar gross movement to the

south. The *net* movement that results from these two fluxes may be quite small.

The picture developed thus far is that of relatively small amounts of longshore sediment transport, as summarised below in Table 3.1.

Table 3.1 Estimated Longshore Sediment Transport Fluxes

Dominant Conditions	Longshore Sediment Transport		
	Magnitude (m^3/yr)	Direction	Zone
Background Swell	Minor	-	Beach
Sea-Breeze	10,000 - 20,000	Northwards	Beach
Storms	10,000 - 50,000 10,000 - 50,000	Northwards Southwards	Beach Beach
All of the Above	5,000	Northwards	Nearshore reef

To put this in perspective, on an exposed stretch of sandy coastline (devoid of any nearshore reef) experiencing similar meteorological and oceanographic conditions to those of the Oakajee coast, net longshore sediment transport in the order of 100,000 m^3/yr would typically be expected.

During the site inspection, a number of observations were made that supported the notion that the Oakajee coast experiences relatively small amounts of longshore sediment transport. In the first instance, an isolated pocket of coarse quartz sand was discovered on the beach near the mouth of the Oakajee River. This was surrounded on both sides by the fine to medium calcium carbonate sand which is common to most of the beaches in this area. The coarse sand is likely to be of alluvial origin and its presence in a discrete mass suggests little mixing of the beach sands. This supports the notion that only small sediment fluxes are experienced along the beach Oakajee beaches.

In addition to this, recent accretion, namely that which has occurred over the last few years, was observed in only a few areas of the coastline that was examined during the field inspection. If a coastline such as this, which exhibits a number of irregular shoreline features, (eg. cuspate forelands, bays, etc.) experienced large sediment fluxes, substantial long-term sediment erosion and accretion would be expected in some areas. This was not observed, although it is conceded that it is very difficult to

discern between recent storm erosion, of which much was evident, and long-term erosion from a single site inspection. The lack of large volumes of recent accretion suggests that longshore sediment fluxes along the Oakajee shoreline are small.

3.3 Potential Impacts of the Proposed Port

Three different locations within the area shown in Figure 1.1 have been identified as possible port sites. A brief outline of each of these is given below, with their location shown in Figure 3.3.

- **Northern Port Option**
  - Similar location to sites historically earmarked for the deepwater port.
  - Located north of the Oakajee River, adjacent to Coronation Beach.

- **Middle Port Option**
  - Located south of the Oakajee River.
  - Aligned with a potential access corridor, although rail access is still difficult to the site.
  - Would be built over a popular windsurfing location known as "Spot X".

- **Southern Port Option**
  - Located midway between the Oakajee and Buller Rivers.
  - Aligned with a potential access corridor.
  - Rail access possible to this site.

Of the three sites, the Southern Option is currently viewed as the preferred location, as it allows the most flexible linkage with proposed onshore developments. All three sites lie within the stretch of coast covered by this investigation, and are within close proximity to each other (see Figure 3.2).

The potential results of the interaction between the proposed port structure and the coastal processes described in Section 3.2 will now be discussed. As far as this is concerned, the most important factor is the size and layout of the breakwater and groyne structures associated with the proposed port. The concept design of this has not yet been finalised, however it is expected that the basic size and shape of the breakwaters will be similar to that illustrated in Figure 3.3. The main breakwater extends directly offshore approximately 1.5 km, which is well clear of the nearshore reef.

The structure then continues in an approximately northwesterly direction for about another 1.3 km, terminating in just over 20 metres of water.

In addition to the main breakwater, it is likely that the port will involve additional secondary structures and some reclamation over the nearshore reef. These features have not been shown in any of the figures. It is believed that they would have only a very minor contribution to the overall impact of the port.

In order to assess the potential interactions between the main breakwater and the longshore sediment transport regime, the two need to be superimposed. This has been done in Figure 3.4. The shear size of the breakwater means that is will form a very effective barrier to longshore sediment transport, both along the beach and along the nearshore reef.

The main breakwater is also expected to create a considerable wave shadow on the beach. The extend of this has been notionally indicated by A-C in Figure 3.4. The term *wave shadow* has been used here in a relatively loose sense. It does not mean that there will be no waves reaching this stretch of coast. Rather, under different conditions, some areas with the wave shadow will receive substantial protection from wave energy, while other areas will not.

For example, under sea-breeze conditions, the stretch of coast denoted by B-C (see Figure 3.4) is expected to be substantially protected from the sea-breeze waves which arrive from between southwest and southerly directions. The level of this protection would increase moving from C to B. Under these same conditions, A-B would be fully exposed.

On the other hand, during the early stages of winter storms, when the winds and waves are arriving from the northwest, most of B-C is expected to be fully exposed. However, the main breakwater would offer considerable protection to the coastline between A and B under these conditions, with protection increasing towards the breakwater (B). During the latter stages of winter storms, when the direction of the waves has swung to the southwest, the situation is reversed, and similar to that described for the sea-breeze.

The effects of the proposed port structures on the background swell is considerably more complicated. These long period waves are substantially more affected by refraction and diffraction process, and as a result are expected to penetrate into much of the previously described wave shadow.

However, as already discussed, very little longshore sediment transport is believed to be generated by the background swell, due to the high protection afforded by the nearshore reef. This is not expected to significantly change should the proposed port be constructed.

The net result of these effects is that sediment accretion and erosion is expected in various areas in the vicinity of the port and adjacent coastline, as illustrated in Figure 3.4. Northward longshore sediment flux generated by sea-breezes and winter storms would be intercepted by the breakwater. It is expected that much of tis material would be trapped in the wave shadow and accrete against the southern side of the breakwater at a rate in the order of 20,000 to 70,000 m^3/yr. Further down-drift, to the south of A, and up-drift of the wave shadow, to the north of C, some erosion should be expected to compensate for this.

The breakwater would also intercept the longshore transport of sediment along and through the nearshore reef. The majority of this material is believed to be somewhat finer than the sediment being transported along the beach. The breakwater would deflect the longshore current carrying this material westward. As it leaves the surf zone and enters deeper water, its turbulence and velocity would decrease, and the material would settle out. The area over which this would occur would be quite extensive, as indicated in Figure 3.4. The coarser components would settle out first, closer to the reef, with the finer material deposited further offshore. Not all of the sediment may settle out, particularly under sever southwesterly conditions. The very fine fraction of the material may be transported around the head of the breakwater and disperse in waters to the north. The volume of material involved in this process is expected to be very small compared to the volumes of accretion and erosion occurring at the shore. A minor amount of erosion may occur to the north of the port as a result of this small sediment flux being intercepted.

Finally, the proposed port breakwater would also intercept southward storm driven longshore sediment movement. Most of this material is expected to accrete against the breakwater and along the coast within the wave shadow, at a rate in the order of 10,000 to 50,000 m^3/yr. As a consequence of this, some erosion is expected both further down-drift and up-drift of the wave shadow.

3.4 Minimising the Potential Impacts

In order to mitigate the potential impacts of the proposed deepwater port, a number of steps should be taken. These are outlined below.

3.4.1 Monitoring of Sediment Accumulation

The beaches either side of the main breakwater within the wave shadow should be monitored every six months, at the ends of summer and winter, using controlled surveying techniques. It is expected that sediment would accrete in these areas. Changes in beach volumes should be computed to confirm this and quantify the amount.

Ideally, the accumulation of sediment along the southern side of the breakwater in the vicinity and offshore of the nearshore reef should also be monitored. However, the amount of accumulation in this area is expected to be small and spread over a large area. Consequently it would probably be very difficult to accurately detect a change in sediment volume using conventional hydrographic surveying techniques.

3.4.2 Sediment By-Passing

The results of the monitoring program should the rates at which sediment accumulates either side of the breakwater. As identified earlier, it is unlikely that these amounts will be equal. It is believed that there is a net movement of sediment to the north, possibly in the order of 10,000 to 20,000 m^3/yr. As a result, more sediment is expected to accrete on the southern side of the breakwater.

In order to minimise the impact of the port on the coastal environment, this longshore sediment movement should be maintained by regular sand bypassing. In view of the energetic offshore wave climate and the prevalence of nearshore reef, it is unlikely that a dredge could be used to conduct the sand bypassing. The most effective technique is likely to involve the use of loaders and trucks. Sediment would be removed from the southern side of the main breakwater and carted a sufficient distance north of the port's wave shadow (refer to Figure 3.4) and replaced on the beach.

To be effective at mimicking the natural processes, sand bypassing should be done as regularly as practical. Annually would be ideal, however, depending on the actual volumes of sediment to be moved, and the severity of the response of the adjacent coast, it may be possible to reduce the frequency of the bypassing to every couple of years or so.

3.4.3 Coastal Works

The sand bypassing only addresses the obstruction of the *net* longshore sediment movement. However, it has already been identified that the port is likely to trap much of the sediment moved along the beach during winter storms. This is expected to be in a southward direction during the first half of each storm and later towards the north. In the absence of any obstacles on the coast, the net movement of sediment resulting from such storms throughout the year may be quite small. However, the imposition of the large breakwater associated with the proposed port is likely to trap much of both the northward and southward sediment fluxes (refer to section 3.3). This would permanently remove sediment from the littoral system and probably lead to the erosion of adjacent beaches outside of the port's wave shadow.

The volumes of sediment trapped, and the extent of any associated erosion, would depend largely on the longshore sediment fluxes generated under storm conditions and the effectiveness of the breakwater to shelter the coast. In this initial and approximate assessment, both of these factors are not known with sufficient certainty to determine whether this impact would be significant. Further investigations involving more detailed modelling and possibly some *in situ* physical experiments / studies would be required to more accurately assess this potential impact.

If it becomes apparent that significant amounts of sediment will be trapped either side of the main breakwater, and unacceptable coastal erosion will result, remedial action will be required. An effective means by which this impact can be limited is the construction of coastal works (eg. groynes, artificial headlands, etc) at the edges of the breakwater's wave shadow (sites A and C in Figure 3.4) designed to intercept longshore sediment movement. The aim of these structures would be to trap the material before it enters the port's wave shadow, hence making it available for transportation away from the port when the direction of longshore transport reverses.

These coastal works would be important components of the port development. Considerable effort would be required to optimise their design so that they function effectively in the manner envisaged.

4. Conclusions & Recommendations

The following conclusions and recommendations have been drawn from this investigation:

- The proposed deepwater port at Oakajee is located on a stretch of coast that is afforded substantial protection from the offshore wave climate by nearshore reef.

- Initial and approximate estimates suggest the following longshore sediment transport rates occur along this coastline:

    1) 10,000 to 20,000 m^3/yr north along the beaches generated by afternoon sea-breeze waves.

    2) 10,000 to 50,000 m^3/yr north and a similar quantity south along the beach under the influence of winter storm conditions.

    3) Notionally 5,000 m^3/yr north along the nearshore reef line under the combined influences of background swell, sea-breeze waves and winter storms.

- Longshore sediment transport along the Oakajee coastline under other conditions, including those dominated by the background swell, is believed to be minor.

- The main breakwater associated with the proposed port facility is likely to form a very effective barrier to this longshore sediment movement.

- Sediment is expected to accumulate on the coast adjacent to both sides of the structure. A small amount of material may be trapped on the southern side of the breakwater in the vicinity of the nearshore reef.

- In the absence of remedial action, erosion of the coastline further to the north and south of the port would be expected to compensate for the accretion at the breakwater.

- Sand bypassing is likely to be required to mitigate these impacts. In addition to this, it may be necessary to construct coastal structures either side of the port's wave shadow to prevent sediment becoming trapped in this region and removed from the active littoral system.

- The accuracy of many of the sediment transport estimates, as well as the overall understanding of the coastal processes, would be greatly improved by completing a proper shoreline movement analysis of the area.

5. References

Department of Defence, 1995. *Australian National Tide Tables,* published by the Australian Government Publishing Service, Canberra.

Port & Harbour Consultants, 1989. *Port of Geraldton, Point Moore Deepwater Port Feasibility Study*. Prepared for the Geraldton Port Authority.

Steedman Science & Engineering, 1991. *Wave Measurements off Point Moore, Geraldton.* Prepared for the Geraldton Port Authority.

Steedman Science & Engineering, 1983. *Oakajee River Wave and Long Period Wave Measurements, Geraldton Area, Western Australia.* Prepared for Mitchell Plateau Bauxite Company Pty. Ltd. and Clough Engineering Group.

Figures

Figure 1.1 - Location Diagram

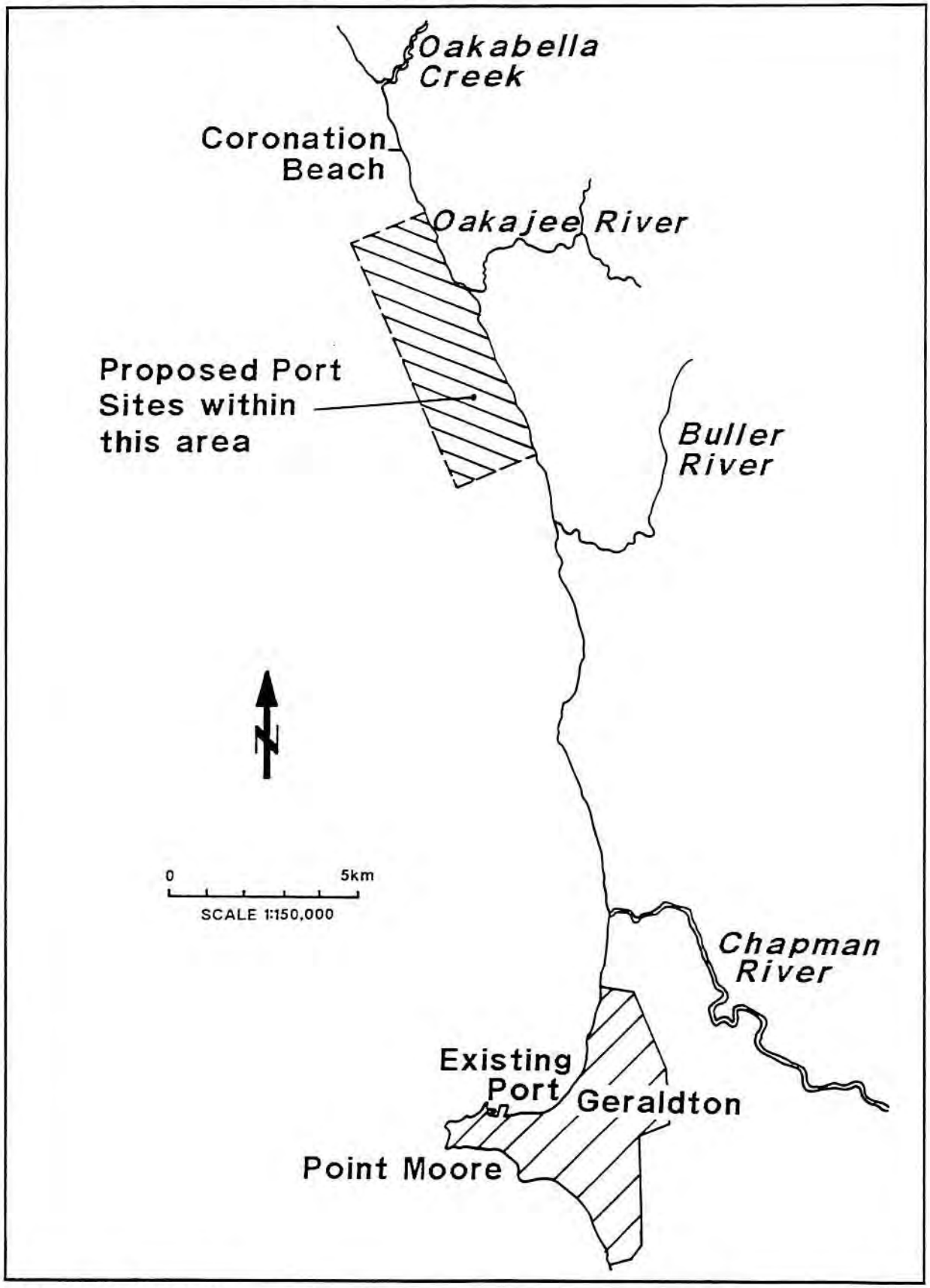


Figure 2.1 - Geraldton Wind Roses - Spring and Summer

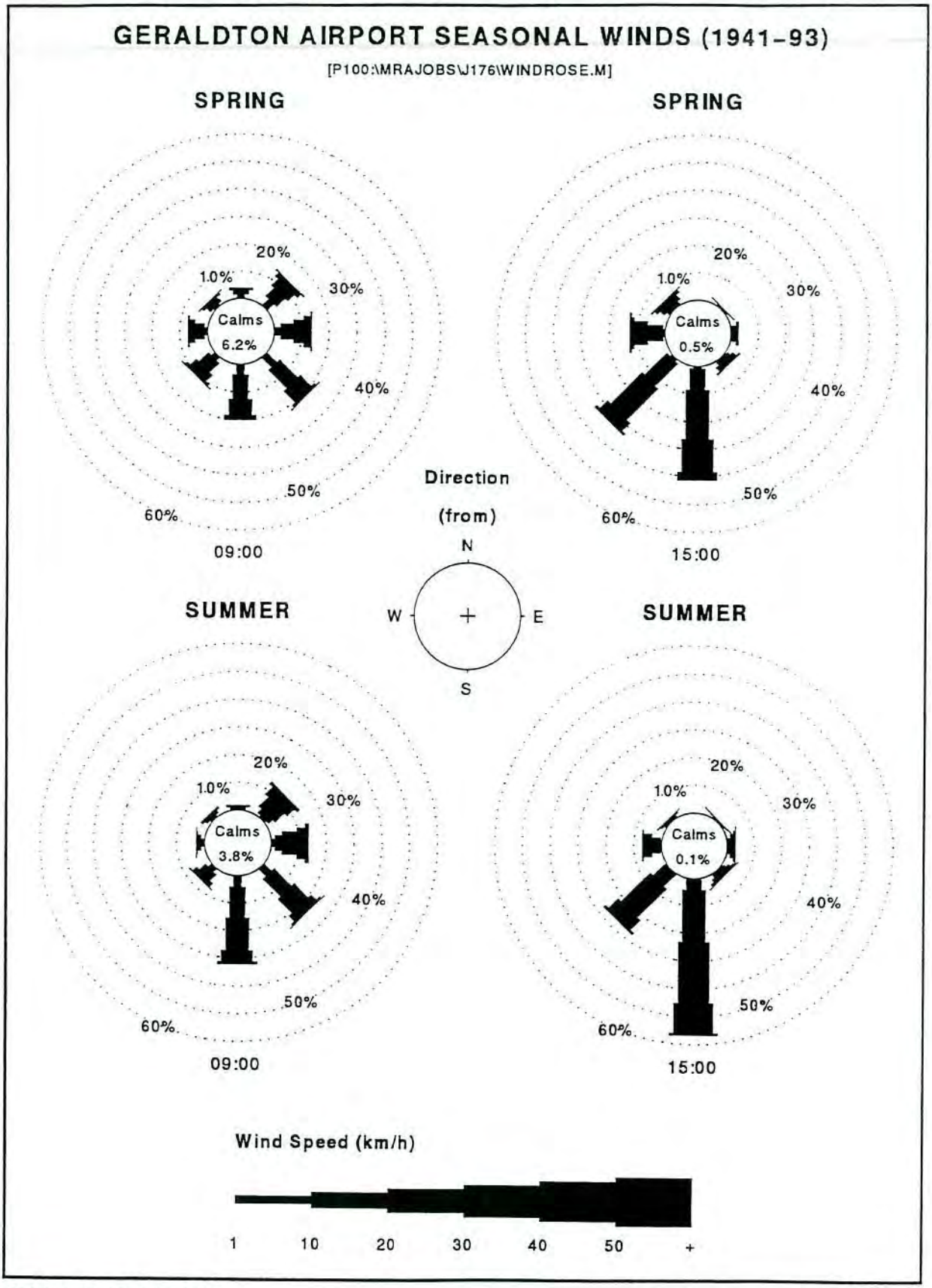


Figure 2.2 - Geraldton Wind Roses - Autumn and Winter

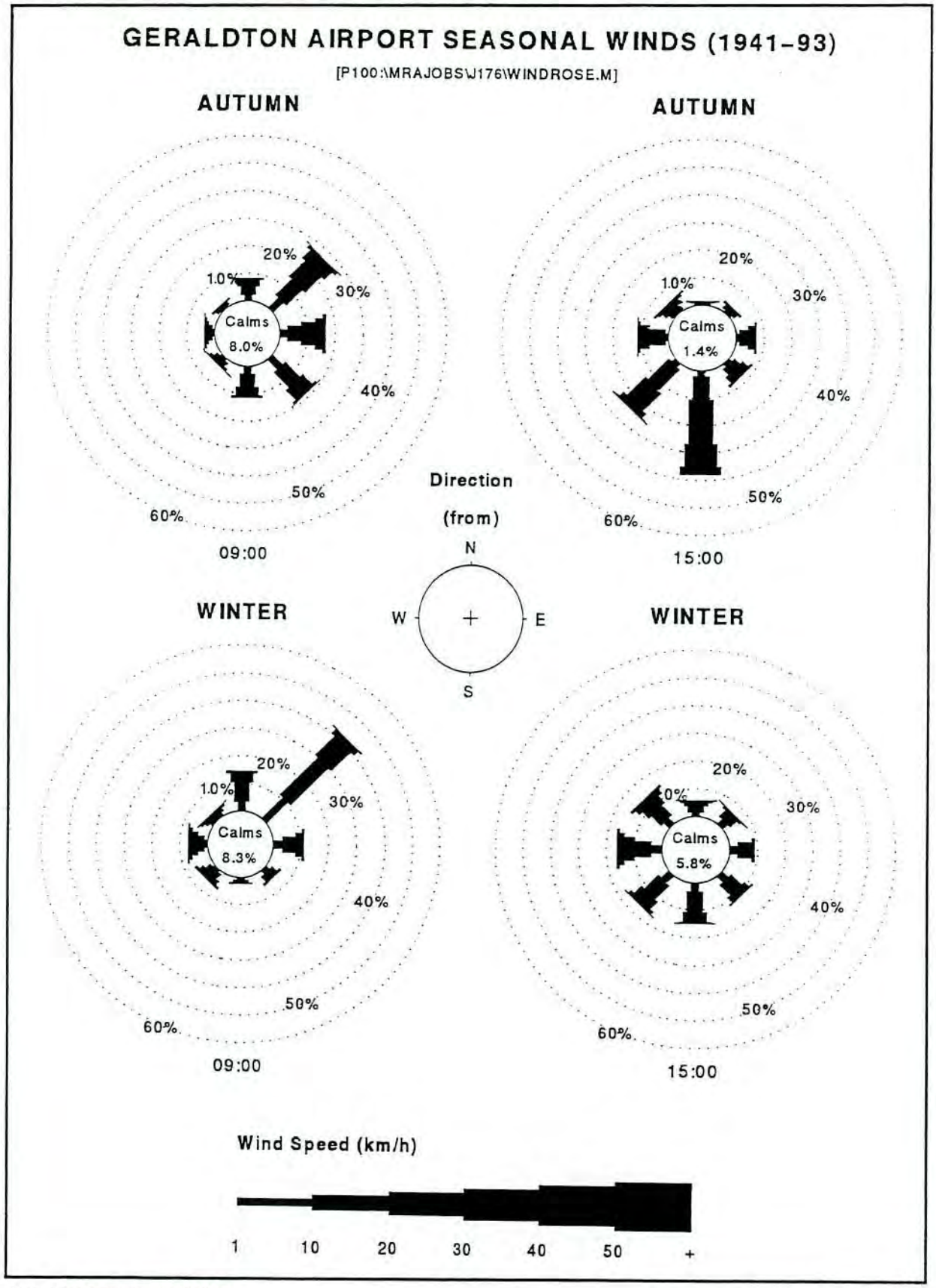


Figure 3.1 - Cuspate Forelands Near Buller River

Figure 3.2 - Proposed Port Sites

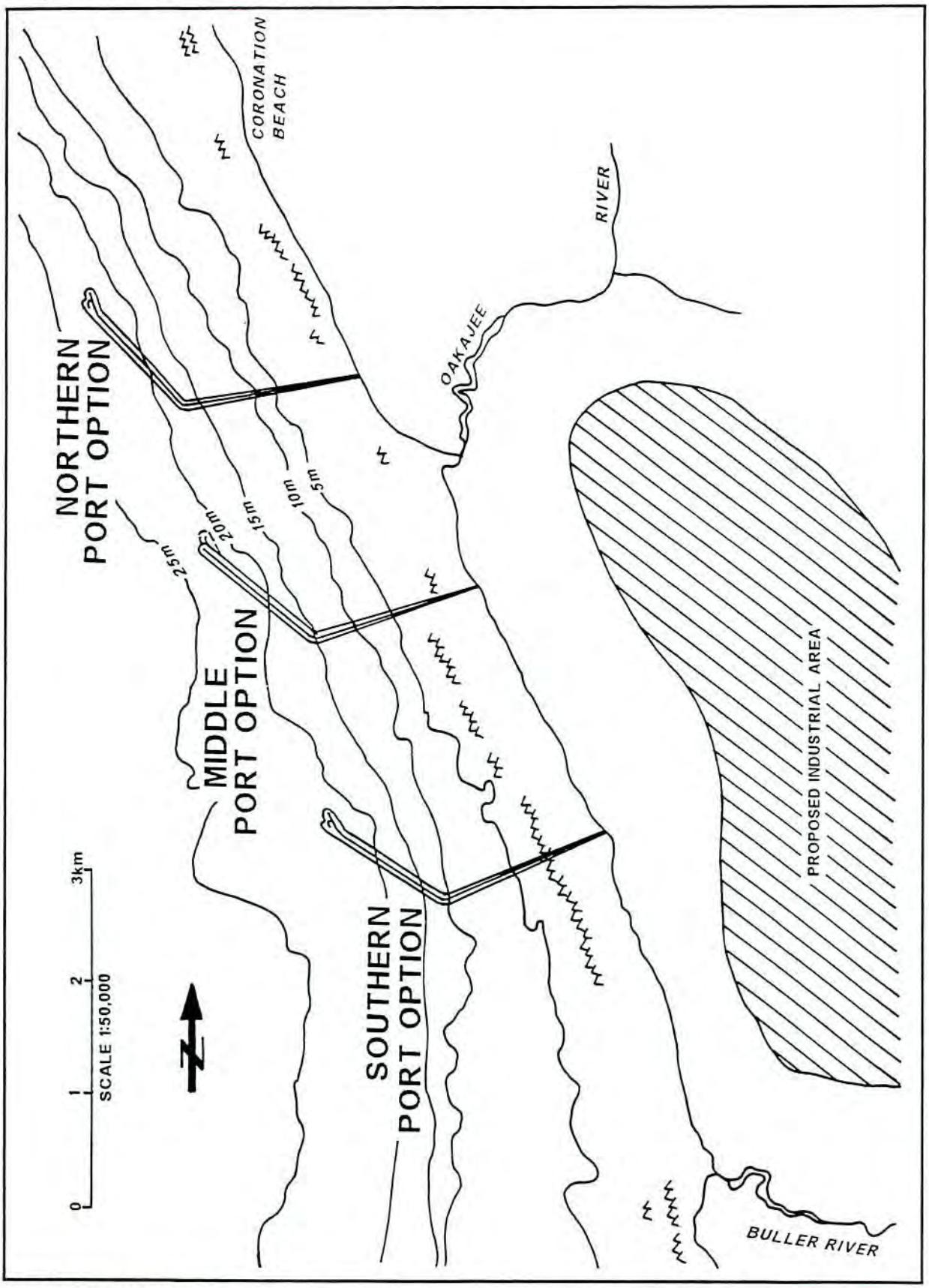


Figure 3.3 - Main Breakwater of Porposed Port

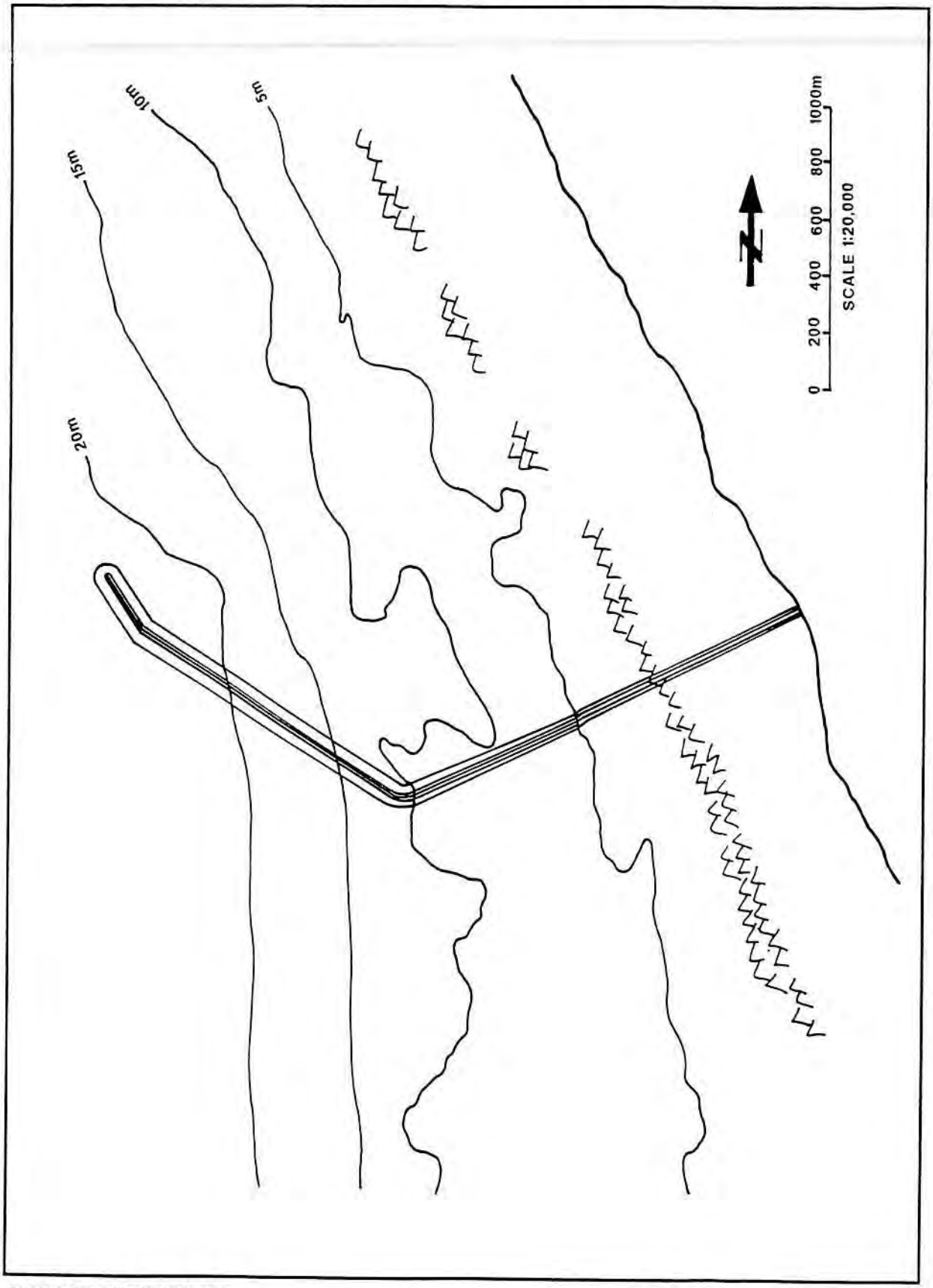


Figure 3.4 - Sediment Fluxes and Potential Impacts on Sediment Movement