



BROOME COASTAL MANAGEMENT PLAN

Environmental Protection Authority
Perth, Western Australia
Bulletin 252 June 1987

BROOME COASTAL MANAGEMENT PLAN

C E Chalmers and P J Woods

with contributions by

Department of Aboriginal Sites, WA Museum
G Pearson, Fisheries and Wildlife Department
J R H Riches, Department of Agriculture
R W George and D S Jones, WA Museum
T Willing, Shire of Broome

Environmental Protection Authority
Perth, Western Australia

Bulletin 252 June 1987

ISBN 0 7309 0507 1
ISSN 0156-2983

CONTENTS

		Page
i	ACKNOWLEDGEMENTS	vi
ii	COASTAL PLANNING IN WESTERN AUSTRALIA	vii
iii	SUMMARY	vii
1.	INTRODUCTION	1
1.1	<u>LOCATION</u>	1
1.2	<u>BACKGROUND</u>	1
1.3	<u>PLAN REVIEWAL</u>	4
1.4	<u>EXTENT AND PRESENT STATUS OF THE STUDY AREA</u>	4
1.5	<u>PURPOSE AND AIMS OF THE PLAN</u>	6
2.	THE BROOME ENVIRONMENT	6
2.1	<u>PHYSICAL ENVIRONMENT</u>	7
2.1.1	GEOLOGY	7
2.1.1.1	<u>Geological History</u>	11
2.1.2	GEOMORPHOLOGY/BATHYMETRY	12
2.1.3	LANDSCAPE	13
2.1.4	SOILS	15
2.2	<u>CLIMATE AND OCEANOGRAPHY</u>	17
2.2.1	CLIMATE	17
2.2.2	WINDS AND WEATHER	17
2.2.3	RAINFALL AND TEMPERATURE	18
2.2.4	CYCLONES AND STORMS	18
2.2.5	SEAS (WAVES AND SWELL)	19
2.2.6	TIDES AND CURRENTS	19
2.2.7	COASTAL PROCESSES	20
2.2.7.1	<u>Sediment Transport Regime</u>	20
2.3	<u>TERRESTRIAL BIOTA</u>	22
2.3.1	VEGETATION	22
2.3.1.1	<u>Mangroves</u>	22
2.3.1.2	<u>Samphire Flats</u>	23
2.3.1.3	<u>Saline Grasslands</u>	23
2.3.1.4	<u>Paperbark Thickets</u>	23
2.3.1.5	<u>Seepage Areas and Wetlands</u>	24
2.3.1.6	<u>Coastal Dunes</u>	25
2.3.1.7	<u>Limestone Outcrops</u>	26
2.3.1.8	<u>Vine Thickets</u>	26
2.3.1.9	<u>Pindan</u>	27
2.3.2	MAMMALS AND BIRDS	29

CONTENTS (contd)

	Page
2.3.2.1 <u>Migrant Holarctic Wading Birds</u>	29
2.4 <u>MARINE BIOTA</u>	33
2.4.1 MANGROVES	33
2.4.2 INVERTEBRATE WILDLIFE	36
2.4.2.1 <u>Shellfish</u>	36
2.4.2.2 <u>Crabs</u>	36
2.4.3 DUGONGS	37
2.5 <u>CULTURE AND HERITAGE</u>	37
2.5.1 THE BROOME "ATMOSPHERE"	37
2.5.2 ABORIGINAL SITES	37
2.5.3 HISTORIC SITES - NON-ABORIGINAL	38
3. <u>EXISTING PLANNING AND MANAGEMENT CONTROLS</u>	39
3.1 <u>EXISTING TENURE</u>	39
3.2 <u>EXISTING ZONING</u>	39
3.3 <u>EXISTING MANAGEMENT</u>	39
3.4 <u>EXISTING FACILITIES</u>	39
3.4.1 ROADS	39
3.4.2 CAR AND TRAILER PARKING	39
3.4.3 BOAT LAUNCHING FACILITIES	39
3.4.4 BEACH ACCESS FOR PEDESTRIANS	39
3.4.5 JETTIES	44
3.4.6 PARKS AND TOILET FACILITIES	45
3.4.7 TOURIST FACILITIES AND ACCOMMODATION	45
3.5 <u>USE PRESSURES</u>	45
3.5.1 POPULATION GROWTH	45
3.5.2 TOURISM	45
3.5.3 HOLIDAY ACCOMMODATION	46
3.5.4 ACCESS	46
3.5.5 SMALL BOAT LAUNCHING	47
3.5.6 SHELL COLLECTING	47
3.5.7 ABORIGINAL FOOD GATHERING	47
3.5.8 BOTANICAL GARDENS	47
3.5.9 COMMERCIAL FISHING	50
3.5.10 MINING AND QUARRYING	50
3.5.11 PORT DEVELOPMENT	50
3.5.12 URBAN DRAINAGE	50
3.5.13 RUBBISH DUMPING AND LITTERING	50
3.5.14 SHACK CONSTRUCTION AND ILLEGAL CAMPING	50
3.5.15 HORSE TRAINING	50
3.5.16 BIRD OBSERVATORY AND FIELD STATION	50
3.6 <u>ASSESSMENT OF MANAGEMENT NEEDS</u>	51
3.7 <u>MANAGEMENT ISSUES</u>	51

CONTENTS (contd)

	Page	
3.7.1	MANGROVES	51
3.7.2	QUARRYING	52
3.7.3	COASTAL PROCESSES	52
3.7.4	MIGRATORY WADING BIRDS	53
3.7.5	CULTURE AND HERITAGE	53
3.7.6	ABORIGINAL SITES	53
3.8	<u>OPPORTUNITIES AND CONSTRAINTS</u>	53
3.8.1	RESOURCES (OPPORTUNITIES)	53
3.8.2	CONSTRAINTS	54
4.	<u>PLANNING AND MANAGEMENT GOALS, OBJECTIVES AND POLICIES</u>	55
4.1	<u>PLANNING AND MANAGEMENT GOALS</u>	55
4.2	<u>OBJECTIVES</u>	55
4.3	<u>PLANNING AND MANAGEMENT POLICIES</u>	55
4.3.1	ALLOCATION OF COASTAL AREAS FOR USE	55
4.3.2	RESOURCE UNITS	56
4.3.2.1	<u>Development Unit</u>	57
4.3.2.2	<u>Management Unit</u>	57
4.3.2.3	<u>Preservation Unit</u>	57
4.3.3	PRIORITIES	57
4.3.4	FUNDING	57
4.3.5	SUPERVISION AND POLICING	57
4.3.6	LAND USE ZONING	57
4.4	<u>ACCESS</u>	57
4.4.1	OFF-ROAD VEHICLES	58
4.4.2	CARPARKS	58
4.4.3	PEDESTRIAN ACCESS	58
4.4.4	LAUNCHING FACILITIES	59
4.5	<u>DEVELOPMENTS</u>	59
4.6	<u>TOURISM</u>	59
4.7	<u>URBAN DEVELOPMENT</u>	62
4.8	<u>INDUSTRIAL AND COMMERCIAL DEVELOPMENT</u>	62
4.9	<u>PICNIC AREAS</u>	62
4.10	<u>RECREATIONAL USE</u>	63
4.11	<u>LANDSCAPE MANAGEMENT</u>	63
4.12	<u>SOIL CONSERVATION</u>	63
4.13	<u>FIRE MANAGEMENT</u>	64
4.14	<u>WILDLIFE MANAGEMENT AND RESEARCH</u>	65
4.15	<u>SHELLFISH</u>	65
4.16	<u>WASTE AND GARBAGE DISPOSAL</u>	66
4.17	<u>EFFLUENT DISPOSAL</u>	66
4.18	<u>STORM WATER DRAINAGE</u>	66

CONTENTS (contd)

	Page
4.19	<u>CONSERVATION</u> 66
4.20	<u>PUBLIC EDUCATION</u> 67
4.21	<u>MANGROVES</u> 67
4.22	<u>BROOME TOWNSITE, OFF-SHORE WATERS MANAGEMENT</u> 67
5.	<u>COASTAL MANAGEMENT AREAS</u> 67
5.1	<u>COASTAL MANAGEMENT AREA 1</u> 68
5.2	<u>COASTAL MANAGEMENT AREA 2</u> 69
5.3	<u>COASTAL MANAGEMENT AREA 3</u> 70
5.4	<u>COASTAL MANAGEMENT AREA 4</u> 74
5.5	<u>COASTAL MANAGEMENT AREA 5</u> 74
5.6	<u>COASTAL MANAGEMENT AREA 6</u> 75
5.7	<u>COASTAL MANAGEMENT AREA 7</u> 77
5.8	<u>PORT AREA</u> 78
6.	<u>PROPOSED RESEARCH</u> 78
7.	<u>IMPLEMENTATION</u> 79
7.1	<u>ROLES OF STATE AND LOCAL GOVERNMENT</u> 79
7.2	<u>FUNDING</u> 79
7.3	<u>CROWN LAND VESTING</u> 80
7.4	<u>TOWN PLANNING SCHEME AMENDMENTS</u> 80
8.	<u>REFERENCES</u> 81

APPENDICES

1	PLANTS SUITABLE FOR ORNAMENTAL PLANTING IN BROOME 84
2	WILDLIFE FOUND ON MUDFLATS AND REEFS, AND MANGROVES 85
3	FIDDLER CRABS, <i>UCA</i> SPECIES, FOUND IN ROEBUCK BAY 85
4	TYPICAL CARPARK DESIGN 86

MAPS

		Page
1.	Areas covered by coastal management plans	vii
2.	Broome - Location	1
3.	Coastal management areas	3
4.	Geology	8
5.	Breeding habitat and migratory pathways of Holarctic Waders	30
6.	Marine resources	35
7.	Existing land tenure	40
8.	Town Planning Scheme No 2	41
9.	Town Planning Scheme No 3	42
10.	Capability units, roads, boat launching areas and tourist accommodation	43
11.	Proposed developments	48
12.	Aerial photograph - Broome town foreshore	72

FIGURES

1.	Wind roses, temperature and rainfall graphs	18
2.	Dune transect - Kavite Road	25
3.	Dune transect - Gupungi Road	25
4.	Dune transect - Upper Cable Beach	25
5.	Pied oyster catcher	31
6.	Greenshank	32
7.	Supply of mangrove material to the food chain	34
8.	<i>Ocypode fabrici</i> (ghost crab)	37
9.	Streeters Jetty	44
10.	Typical diagram - tourist development node	61
11.	Geology and topography - Upper Cable Beach area	62
12.	Recommendations for the town foreshore	71

PHOTOGRAPHS

1.	Gantheaume Point	7
2.	Willies Creek	9
3.	East of Dampier Creek	9
4.	Cable Beach near Bali Hai	10
5.	North Cable Beach	11
6.	Cable Beach and hinterland	12
7.	Broome townscape - courthouse and gardens	13
8.	Gully erosion near Gantheaume Point	16
9.	Marine erosion of pindan cliffs	17
10.	Crab Creek at low tide	19
11.	The crescent shaped bay north of the jetty	21
12.	Pindan vegetation	28
13.	Carnarvon Street - Chinatown	38
14.	Anglers on the main jetty	44
15.	Bali Hai caravan park	46
16.	Off-road vehicle tracks - Cable Beach	75
17.	Hidden Valley	76

TABLE

1.	Crown reserves in coastal management areas	5
----	--	---

Information and criticism have been provided from a number of sources during preparation of this plan, which must be acknowledged.

Russell Taylor and Shelley Cook of Taylor and Burrell provided advice about the town planning scheme as did the councillors and officers of the Shire of Broome. Numerous members of the public made written and informal submissions.

Members of the WA Heritage Committee and officers of the WA Tourism and State Planning Commissions made their research available and provided valuable advice about the Broome area. Officers of WA Branch of the Fishing Industry Council and the Departments of Resources Development, Marine and Harbours, Mines, Sport and Recreation also provided advice.

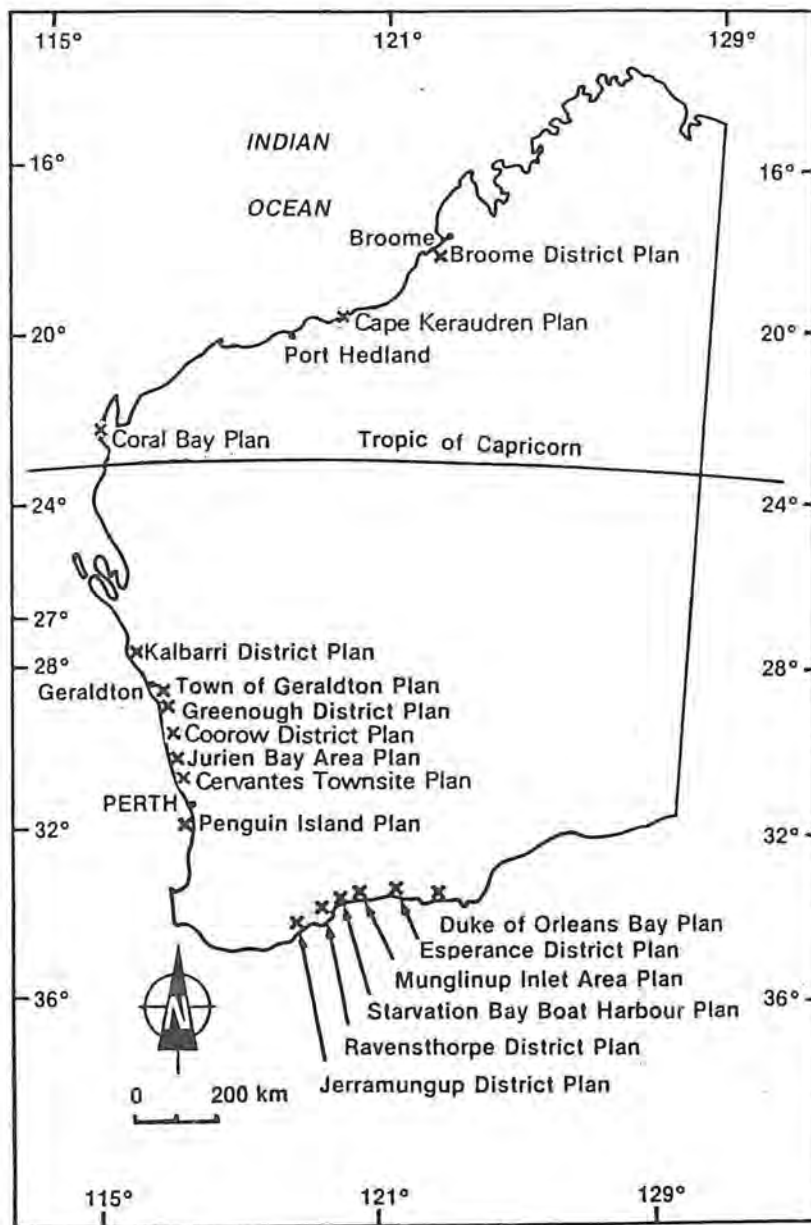
June Hutchison and Ilona D'Souza provided valuable assistance in proof reading and editing, Brian Stewart, prepared the report for publication, and Stuart Chape provided some photographs. Mike Rigoll and Steven Davies prepared the illustrations.

Thanks are also due to the Word Processing Section of the Environmental Protection Authority.

In 1982 the Western Australian Government established a Coastal Management Coordinating Committee (CMCC) comprising representatives from a number of State authorities to:

- . advise government about coastal management policies, legislation and administration arrangements;
- . coordinate departmental activities on the coast through the exchange of information and views, and review expenditure programmes and priorities;
- . overview the preparation and implementation of coastal management plans at regional and local levels for various locations on the coast of WA.

This is the fifth final plan prepared under this programme and the locations covered by other plans are shown on Map 1.



Map 1. Areas covered by coastal management plans.

In 1980 Broome Shire Council approached the Department of Conservation and Environment (DCE) seeking assistance with the preparation of a Coastal Management Plan for the Cable Beach area. However, it was agreed to delay the plan until it could be prepared in the context of an overall town planning scheme to be undertaken by Taylor and Burrell, Consultants in Town Planning and Urban Design.

Preliminary Town Planning Schemes 2 and 3 were released for comment in November 1983; they identified seven coastal management areas for each of which the Council should prepare development and management policies. In April 1984 DCE published a Draft Coastal Management Plan for the Shire of Broome and that plan was made available for public comment for a period of six months. In September and October 1985 Town Planning Schemes 2 and 3 were gazetted and they stated that Council shall prepare or cause to be prepared policies for the coastline around Broome.

This plan has been prepared to describe and assist in the protection of the coastal environment, coordinate those developments which occur in or influence the coastal zone, and provide a framework in which to prepare policies for the coastline. It contains the results of an investigation of the natural and man-made resources of the area, and use pressures which are likely to be placed on them. It then determines development and management aims which are to:

- limit use of coastal areas to activities requiring locations;
- protect natural systems and cultural assets;
- protect ground and seawater quality;
- provide for a wide range of recreational uses;
- protect sites of concern to Aboriginal people;
- encourage and cater for tourism;
- provide for appropriate industrial and commercial activities;
- develop a public education programme relating to coastal areas.

Management units are described which identify areas capable of sustaining varying levels of development and use, and locations are nominated for particular activities.

A number of processes which may create environmental problems are identified and strategies are defined to overcome, manage or monitor losses. In addition, operations are recommended to repair damage which has occurred because of past careless or unplanned use.

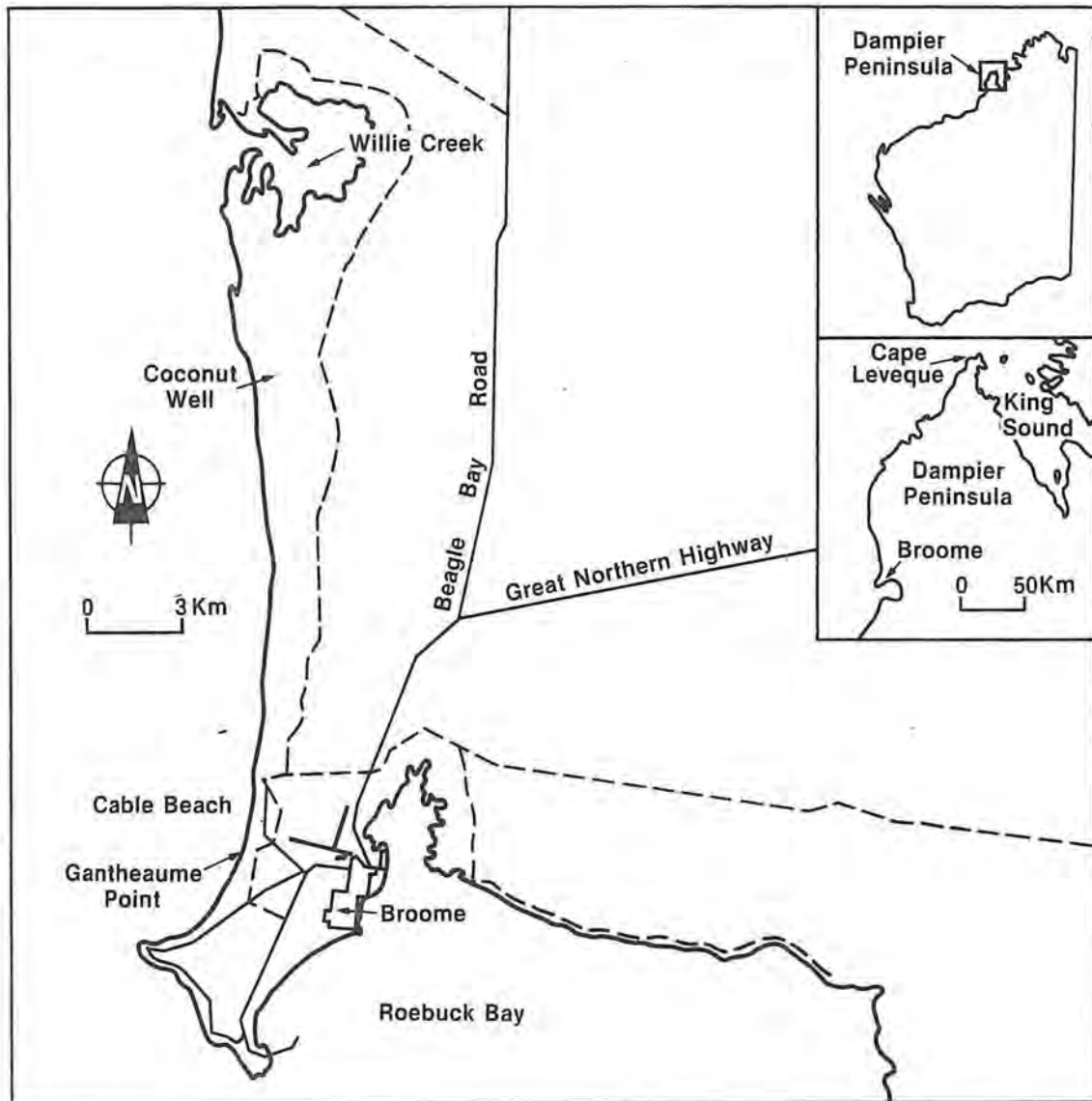
Finally, a chapter describes how the plan may be implemented identifying alterations which will be required to existing Crown land vestings, amendments to the Town Planning Scheme, government agencies which may provide assistance and possible sources of funding.

This plan will be subject to complete review in December 1991, but if alterations are required before, they can be made after discussions between Council, DCE and other interested bodies or members of the public.

1. INTRODUCTION

1.1 LOCATION

Broome is a major town on the coast of the Kimberley Region of Western Australia. It is situated on the north-west corner of Roebuck Bay at 17°58' south and 122°14' east, 2 365 kilometres by road north-east of Perth (Map 2).



Map 2. Broome - Location.

1.2 BACKGROUND

In October 1980 Council approached the Department of Conservation and Environment (DCE) (now called the Environmental Protection Authority) seeking assistance in the preparation of a development plan for Cable Beach between Gantheaume Point and Bali Hai. At that time it was agreed to delay the plan until it could be prepared in the context of an overall town planning scheme which was to be undertaken by Taylor and Burrell, Consultants in Town Planning and Urban Design. Subsequently, Taylor and Burrell prepared the Shire of Broome Town Preliminary Planning Scheme No 2⁽¹⁾, which covers the townsite, and Preliminary Scheme No 3⁽²⁾, which covers the rural areas in the Shire.

Preliminary Town Planning Schemes Nos 2 and 3 were released for comment in November 1983, and they identified seven coastal management areas (Figure 3) stating that Council should prepare development and management policies for each area. In April 1984, DCE released the Draft Coastal Management Plan for the Shire of Broome and made it available for public comment for six months. (3)

The Minister for Planning's approval of the Shire of Broome Town Planning Schemes, Nos 2⁽⁴⁾ and 3⁽⁵⁾ was notified in the Government Gazette of WA on 20 September and 18 October 1985, respectively. Part 1, the Introduction of Scheme 3 contains a statement that it provides a framework in which Council would develop a management strategy for the protection of the coastline. In addition, Part VI, the general provisions of both Schemes contain a statement that Council will prepare or cause to be prepared policies for each of the coastal areas shown on the scheme map. The text is as follows:

PART VI - General Provisions

6.1 Coastal Policy.

6.1.1 The Council shall prepare, or cause to be prepared, policies for each of the seven coastal management areas as shown on the Policy Map attached to the Scheme.

6.1.2 During preparation of the policies and prior to adoption thereof Council will seek comment on the policies and any development proposals from:

- (a) Coastal Management Coordinating Committee,
- (b) Registrar of Aboriginal Sites.

6.1.3 Following preparation of the policies Council shall advertise a summary of the policy once a week for two consecutive weeks in a newspaper circulating in the area giving details of where the full policy may be inspected and where, in what form and during what period (not being less than 21 days) representations may be made to Council.

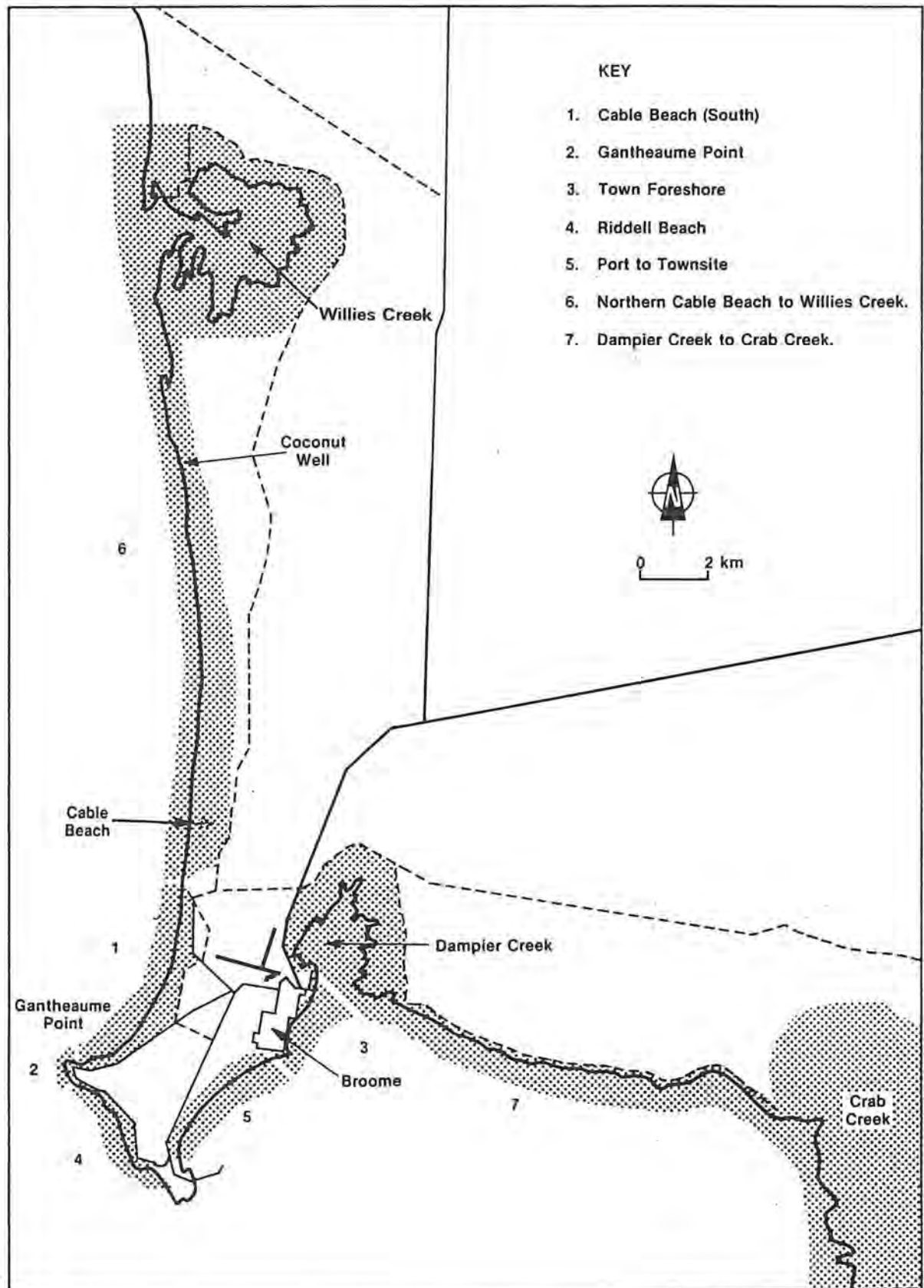
6.1.4 Having considered the submissions made under the provisions of Clause 6.1.3, Council may resolve to adopt a policy for an area and may adopt management strategies in accordance with the recommendations of the policy and will thereafter determine development in accordance with the strategy.

6.1.5 Prior to adoption of coastal policies and the strategies resulting therefrom Council will refer any development proposals falling within a policy area to the bodies referred to in Clause 6.1.2 and request that they advise on the proposal and any requirements recommended by any one of the bodies.

6.1.6 After receipt of the advice or recommendations from the Coastal Management Coordinating Committee, Council may use the advice or recommendations to either -

- (i) approve the development proposal;
- (ii) refuse the proposal;
- (iii) grant approval subject to conditions which may include a requirement to prepare an Environmental Review and Management Programme."

The Coastal Management Areas as described in the Scheme are shown on Map 3 and scheme maps are shown on Maps 8 and 9.



Map 3. Coastal management areas.

In 1981 the Western Australian Tourism Commission (WATC) published the Kimberley Regional Tourism Survey which amongst other things concluded that the tourist industry will be favourably affected by the recent sealing of the Great Northern Highway, between Broome and Port Hedland, and the increasing importance of Darwin as an international gateway to Australia.

The Survey noted that although the "majority of residents in all towns surveyed recognised tourism as being important to their town's economic and social development", it appears that the "ensuing competition between residents and visitors for scarce facilities has precipitated some negative feelings. Although this attitude is not prevalent it should be treated seriously as 'local atmosphere' is important to visitor satisfaction".

A visitor survey conducted at Broome showed that approximately 60% of attractions visited were coast oriented (ie lay in the coastal zone), highlighting the importance of the coast as a resource of Broome.

In 1982 the WATC published the Caravan Parks Survey of Northern Western Australia that showed the number of visitor arrivals in the Kimberley had increased 10% per year over the previous five years.

These findings suggest that there will be increasing pressure on both the resources and residents at Broome and that careful planning and management are required to avoid:

- . continuing "competition" between residents and visitors for facilities and resources;
- . degradation of coastal resources already in demand; and
- . unwise allocation and use of scarce coastal resources; while providing for:
- . increased tourist and residential use of the coast; and
- . preservation of the environmental quality and "atmosphere".

Following receipt in 1982 of the Preliminary Town Planning Scheme recommendations for the coast, DCE prepared a draft management plan after considering comments made by Council, the Departments of Agriculture, Fisheries, Conservation and Land Management (CALM), Marine and Harbours, Lands Administration, Mines, Sport and Recreation, as well as the State Planning Commission (SPC), WA Museum, WATC, WA Heritage Committee, National Trust, Australian Fishing Industry Council, and members of the public.

The draft plan⁽⁸⁾ was made available for public comment for a period of six months and those comments were considered during the preparation of this plan.

1.3 PLAN REVIEWAL

This plan will be subject to review in December 1991. Any alterations to the plan before this will be undertaken after consultation between EPA, SPC, Council, and other interested bodies and people.

1.4 EXTENT AND PRESENT STATUS OF THE STUDY AREA

The areas under consideration in this plan, which have been defined in Town Planning Schemes Nos 2⁽⁹⁾ and 3⁽¹⁰⁾, are outlined on Map 3, and involve areas of vacant Crown land and Crown reserves, as shown in Table 1.

Table 1. Crown reserves in coastal management areas.

RESERVE	PURPOSE	APPROX AREA (ha)	VESTED AUTHORITY	VESTING DATE	MAP NO
35494/132	Gravel		Commissioner for Main Roads and Shire of Broome	11/8/78	
30906	Use and benefit of Aborigines	121.4	Aboriginal Lands Trust	3/8/73	
631	Gravel	153.3	Shire of Broome	5/9/19	
26516	Community Welfare Purposes	20.2	Minister for Community Welfare	30/6/72	
36477/1374	Recreation	3.3	Shire of Broome	15/2/80	
33275/1195	Horse Stables	3.4315	Shire of Broome Power to lease 21 years		
35157/1231	Remote Receiver	1.1378	Not Vested		
22648/1848	Rec and Racecourse	66.4058	Shire of Broome	22/5/47	
19289/628	Recreation	5.7238	Shire of Broome	11/8/78	
30387/700	Rec Accommodation for Diocesan staff	2.0234	Crown Grant to RC Vicar		
37337/1643	Children's Hostel	0.5473	Rothhaviesthne Inc	7/8/81	
30386/699	Rec Accommodation for Sisters of St John of God	2.0234	Crown Grant to the Sisters of St John of God	5/6/70	
35828/1341	Recreation	23.5277	Shire of Broome	19/1/79	
28650	Harbour Purposes	108.3112	Minister for Transport	19/3/82	
35827/1342	Recreation	3.5900	Shire of Broome	19/1/79	
36426/1337	Pistol Club Site	4.0154	Shire of Broome with power to lease 21 years	21/12/79	
33592/1197	Club and Club's Premises	0.5016	Shire of Broome with power to lease 21 years	12/9/75	
29300	Public Rec (Golf Links)	85.3376	Shire of Broome with power to lease for 21 years	24/1/86	
17132	Rec (Bathing) and	6.1559	Shire of Broome	13/1/61	
1643/1327	Cemetery	0.1094	Unvested		
31340/838	Recreation, Bathing Caravan Park	2.6791	Not vested		
36057	Drain	0.1142	Shire of Broome	11/5/79	
34907/620	Drain	2032	Not vested		
17987	Exempted from Sale	2.0303	Not vested		
9105	Water Supply	4.4743	Not vested		
25790	Community Welfare	1.0117	Not vested		

1.5 PURPOSE AND AIMS OF THE PLAN

In the past, decisions concerning the use and management of coastal land around Broome have occurred on an uncoordinated basis. The purpose of management planning is to achieve a systematic and coordinated approach to management and development while recognising natural processes and resource characteristics as well as human needs. The aim of this plan is to:

- outline policies for the development and management of the coastal area as required in Town Planning Schemes Nos 2 and 3;
- . facilitate orderly and long-term development, conservation and management of the coastal zone;
- . identify areas suitable for particular uses that require a coastal location;
- . identify areas which should be protected and make recommendations about their management;
- . identify problem areas and recommend management strategies;
- . identify relevant authorities and people that should participate in the planning process and outline authorities which may provide a management input into the area;
- . illustrate relationships between coastal management areas and nearby land uses to define possible conflicts and suggest compatible activities; and
- . identify possible sources of financial assistance.

The allocation of compatible uses to appropriate resources is critical to successful coastal zone management. Failure to plan upon this basis may result in degradation of resources, significant increases in management costs, or loss of the resource and any improvements.

Many proposals are described in this plan and their implementation will be time consuming, expensive and in some instances require amendment to the Town Planning Scheme. However, these disadvantages will be offset by the more efficient use of land, the reduction in costs associated with continued maintenance of degrading resources, resolution of differences between conflicting land users and retention of the amenity which makes Broome an attractive place to live and visit.

Agencies which are potential sources of funds are more likely to provide financial assistance for works that are part of a long-term plan. Preparation and acceptance of this plan is a first step in this direction.

2. THE BROOME ENVIRONMENT

This section briefly describes the natural resources of the Broome coastal zone. Some of these resources have been or will be exploited by people, while others may not. However, it should be understood that together they form a changing ecosystem and that disturbance or exploitation of one resource is likely to affect others. This interrelationship has been considered during the planning process. Management strategies to safeguard the environment while allowing controlled development are detailed in Section 4.

This section describes processes that led to evolution of the Broome coastal landscape as we see it today, as well as the flora and fauna that inhabit the zone. Without an understanding of how the coastal zone evolved, or which factors are important in maintaining a stable natural system, it is difficult to predict what may happen in the future, either with or without human activity. However, if the natural system is understood, the allocation of land on the coast can be planned so disturbance and conflict are minimised and maintenance costs are reduced.

2.1 PHYSICAL ENVIRONMENT

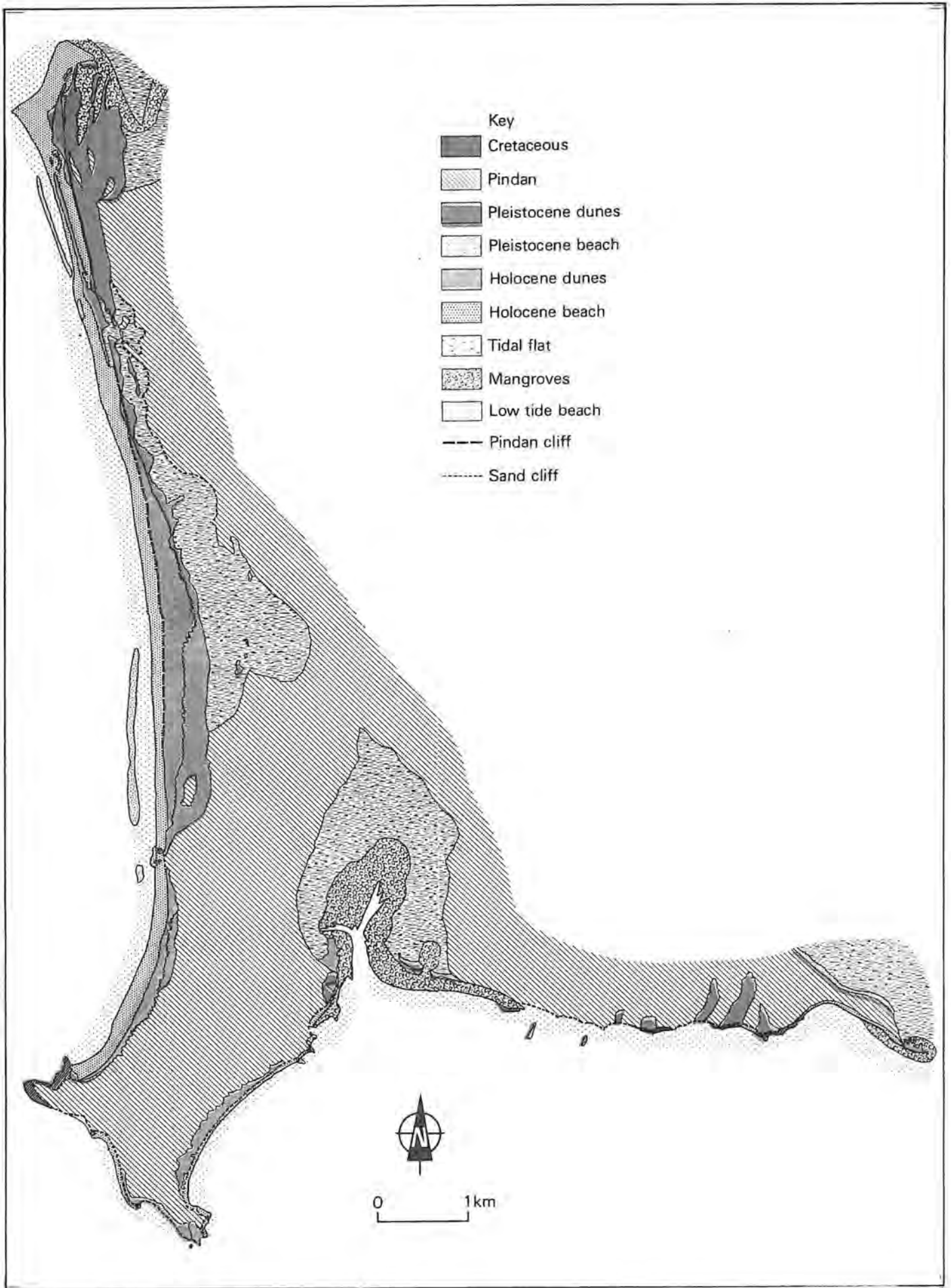
2.1.1 GEOLOGY

The distribution of sediments around Broome is shown on Map 4. The oldest sediment is the Cretaceous Broome Sandstone which outcrops at the base of coastal cliffs at Gantheaume Point and east of Dampier Creek. Overlying the Cretaceous basement is about 1 m of lateritised cobbles and pebbles, which are exposed along the coast around Gantheaume Point, at Bali Hai, east of Dampier Creek and along the abandoned sea cliff at Coconut Well. A veneer (2-6 m) of red pindan sandstone which forms a horizontal and gently undulating surface that is characteristic of the Broome area overlies the laterite (Photograph 1).



Photograph 1. Gantheaume Point. The pale Broome Sandstone, which is overlain by pindan sandstone, has been eroded to form a wave-cut platform and cliffs.

Two generations of Quaternary sediments are found around the coast. The older, or Pleistocene unit, comprises beach, dune and tidal flat deposits that are characteristically pink. Cemented beach sediments which are cross and trough-bedded form a reef which outcrops at low tide between Bali Hai and Willies Creek (Photograph 2). Leached dune sediments are found around most of the coast and extend further inland than their younger Holocene counterparts. Tidal flat sediments are found around the margins of the existing tidal flats.



Map 4. Geology.



Photograph 2. Willies Creek.

The younger, or Holocene unit, comprises sublittoral, beach, dune and tidal flat deposits that front and overlie or partially cover pre-existing sediments and coastal landforms. Beach and dune sands are typically white except where they are adjacent to an eroding pindan cliff (Photograph 2).

A veneer of sublittoral sediment exists on the seabed off Cable Beach and off the town in Roebuck Bay. There is probably abundant sand-size material north of Cable Beach, especially near Willies Creek between the Beach and beyond the offshore reef. To the south where the reef merges with the shore between Bali Hai and Gantheaume Point, there appears to be much less sand on the seabed. Between Gantheaume Point and the jetty there is little sediment in the nearshore zone. East of the jetty the coast is fronted by fine tidal flat sands and silts which contain a coarse shell fraction. (Photograph 3)



Photograph 3. East of Dampier Creek.

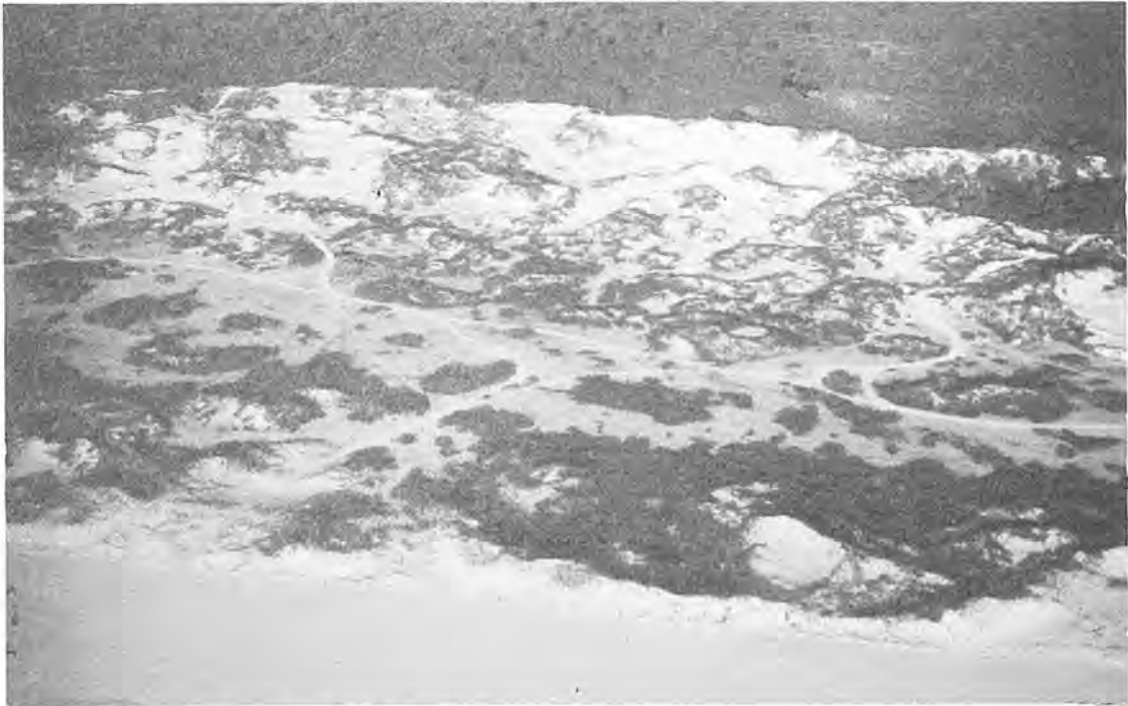
Holocene beach sediments occur along much of the coast and comprise: coarse shelly, cemented beach rock which is found between the Council caravan park and the jetty; coarse shelly sand which forms a narrow beach and recurved spit between the Council caravan park and Dampier Creek; unconsolidated quartz sand with a small percentage of shell material. In front of eroding pindan cliffs east of Dampier Creek and at Riddell Beach these quartz sands are coloured pink and overlie a rocky platform of Pleistocene and Cretaceous rocks. At Cable Beach the sands are white and front Holocene dunes though they may only form a thin veneer over older rocks. The majority of sandy beaches fronting pindan cliffs only occur between high and low water marks except at Cable Beach where a supratidal beach extends inland into beach ridges and dunes (Photograph 4).



Photograph 4. Cable Beach near Bali Hai. The presence of outcropping Cretaceous and Pleistocene rocks suggests that the Holocene beach sands may only be a thin veneer.

In most cases Holocene dunes form only a thin (1 m or less) veneer over the seaward margin of the older Pleistocene dunes, except along Cable Beach where they override and partially cover the latter. Along Cable Beach and at Coconut Well, partial cementation of the older Holocene dunes has occurred. Where ablation (wind erosion) has taken place, the cemented dune core has been exposed (Photograph 5).

Holocene tidal flat sediments are found at Willies Creek, Coconut Well, Dampier Creek and Crab Creek.



Photograph 5. North Cable Beach.

2.1.1.1 Geological History

The oldest sediment in the area, Broome Sandstone, was deposited in a shallow sea during the Cretaceous (130 million years ago). Dinosaur footprints have been recognised in the sandstone near Gantheaume Point.

During the early Tertiary the area was lateritised under conditions of a seasonally wet climate. With change to an arid climate in the late Tertiary the deposition of sand dunes commenced. A change to wetter conditions in the Quaternary has modified and subdued the dune topography and led to development of the thick red pindan soil that now mantles the landscape. Reworking of these sediments by coastal processes during the Quaternary resulted in deposition of two generations of dune, beach and tidal flat sediments around the coast.

The first occurred during the Pleistocene (1 million years ago) when a raised sea partially stripped and reworked the pindan mantle into beach and dune deposits around sweeping bays, that linked exposed bedrock headlands. Low areas were drowned and tidal flat sediments deposited.

During the last ice age about 30 000 years ago, the sea level dropped to minus 100 m and these coastal sediments were coloured pink, possibly through the addition of dust derived from inland. At the same time the deep gorges (Roebuck Deep, inner anchorage, etc) which drained Roebuck Plain were formed.

Around 6 000 years ago the sea rose again to its present level, sweeping any loose material from the drowned shelf into beaches and dunes. Reworking of Pleistocene and older sediments continued, resulting in further retreat of cliffed coasts where sediment supply was low, or deposition of dunes and beach ridges where sediment supply was greater. Low areas were again drowned and tidal flats developed (Photograph 6).



Photograph 6. Cable Beach and hinterland.

With a stable sea level and diminishing supplies of sand from offshore, growth of beaches and dunes has ceased along most of the coast with the result that the veneer of Holocene sediments has been gradually removed and the underlying Pleistocene, pindan and Cretaceous rocks increasingly exposed.

2.1.2 GEOMORPHOLOGY/BATHYMETRY

The area around Broome is characterised by a low-lying, gently undulating plain of red pindan sandstone rising to 3-8 m above Australian Height Datum (AHD). Around most of the coast the plain terminates abruptly in vertical cliffs 1-10 m high that are fronted by narrow high tide beaches, rocky outcrops or extensive tidal flats that become exposed at low tide. On west and south-east facing coasts the edge of the pindan cliff is mantled by a narrow shore-parallel belt of dunes. On south-east facing coasts erosion has exposed the underlying pindan so that the dunes are now perched on top of the cliff. Only along the west facing Cable Beach has the edge of the pindan remained covered by white beach and dune sands. Here a wide sandy beach and belt of dunes and beach ridges that increase in width to the north provide a sharp contrast to the rest of the coast. At low tide a rocky reef is exposed along this coast from Bali Hai to Willies Creek (Photograph 2).

Low-lying areas on the pindan plain which experience periodic tidal inundations, are occupied by tidal and mangrove flats. Dampier tidal flat is partially cut off from Roebuck Bay by a chain of sandy islands and spits. In contrast the flat behind Cable Beach has been almost completely separated from the sea by a sand spit. Abandoned marine pindan cliffs near Coconut Well are evidence that the eastern shore was once subject to open marine processes.

The Cable Beach coast is fronted by a seabed that slopes gently down to a wide flat plain 10-14 m deep. Approximately 6 km offshore a shore parallel

ridge rises to 4 m depth. Between Gantheaume Point and the jetty the seabed deepens rapidly to bottom in Roebuck Deep: a shore-parallel trough over 80 m deep but only 500 m offshore. East of the jetty the coast is fronted by a wide expanse of shallow water (1-2 m) that is separated from the shallow (2-7 m) waters of Roebuck Bay by the inner anchorage, a shore parallel depression 14 m deep (Map 6).

2.1.3 LANDSCAPE

The Broome landscape has three major elements including the built and modified environment of the township and port, the semi-tropical atmosphere of the plantations, and the relatively unspoilt coastal vistas of the undeveloped areas.

The town landscape is characterised by the traditional buildings, plantings of Australian and exotic species which give the semi-arid environment a sub-tropical appearance, and the old structures used in maritime industry and associated waters (Photograph 7). Some of the important vistas that exist in a number of locations are shown on Map 12.



Photograph 7. Broome townscape - courthouse and gardens.

There is a significant risk that rapidly-developing urban areas will become unattractive if appropriate plantings are not undertaken quickly. Trees and shrubs should be used in these areas purposely to soften the new urban landscape, and improve pedestrian comfort by providing shelter from the sun and wind. Eventually new areas should have a similar appearance to the established part of the town.

The plantations, camping areas, plant nurseries and homesteads at Bali Hai and Coconut Well provide another significant landscape element which enhances Broome coastal areas.

The third landscape element is the unspoilt coastline in the undeveloped portions of the study area with low headlands, beaches, creeks, mangals and

beautiful waters. The only major improvement suggested for this area involves the rehabilitation of old quarries near the Crab Creek Road. However, any development undertaken in this element could result in a loss of amenity and care is required to protect the landscape.

Ornamental planting in Broome commenced about the 1890s, when government officials and master pearlers began establishing permanent homes in shuttered bungalows of wood and iron.⁽¹¹⁾ Despite problems of water supply, voracious termites and occasional cyclones, colourful and shady gardens were created, using Aboriginal and Asian labour. Gardens helped to cool and shelter houses against the harsh, semi-arid realities of sun, glare and red dust.

The early establishment of exotic plants at Broome was facilitated by direct shipping and pearling links with Asian ports such as Singapore and Kupang. Coconuts (*Cocos nucifera*) and the evergreen frangipani (*Plumeria alba*) were imported in an era before quarantine enforcement.

A unique aspect of the Broome landscape is the scattered groups of towering *Borassus* palms (as behind Streeter & Male's, and Broome Prison). *Borassus* is evidently an early introduction, probably from Timor or neighbouring islands Roti and Savu, where it is the mainstay of a remarkable economy, founded on syrup-extraction.⁽¹²⁾

Much garden planting in Broome can be seen as an expression of the desire to create a lush tropical image: 'an illusion of Eden'. The vision varies with individual taste from the neat and orderly to the rampant jungle. The contemporary Broome landscape features a relatively rich diversity of tropical plant material, which contributes greatly to the town's character and atmosphere.

Flowering trees include the poinciana (*Delonix regia*) and golden shower (*Cassia fistula*), which make a spectacular contrast in red and yellow around November. Others include the scarlet African tulip (*Spathodea campanulata*), yellow *Peltophorum pterocarpum*, orange *Cordia sebestena* and mauve or pink *Lagerstroemia speciosa*.

The boab *Adansonia gregorii*, a symbol of the Kimberleys, with its immense trunk and striking silhouette, is well represented. Another notable curiosity is the African sausage or moon tree *Kigelia pinnata* with its strange flowers hung on rope-like stalks, followed by bizarre, sausage-like fruits.

Broome's largest trees include magnificent specimens of the slow-growing, cyclone-hardy tamarind (*Tamarindus indicus*), valued for its shade and tasty, sour pods. Popular fast-growing shade trees include the Malay almond (*Terminalia catappa*) with its striking, tiered canopy of horizontal branches as well as the African mahogany *Khaya senegalensis* and *Albizia lebbek*.

Among palms, the coconut (*Cocos nucifera*) has always been pre-eminent. Other commonly-planted species include the slender Darwin palm (*Carpentaria acuminata*) and a dwarf fan palm (*Sabal* sp). Other palm-like plants of note include the traveller's palm (*Ravenala madagascariensis*) and various *Pandanus* sp.

The most significant fruit tree in Broome is the mango (*Mangifera indica*). Large specimens with dense, shady crowns are a feature of many backyards. During the mango season (November - December), trees become a valuable

source of household income and a focus of human, parrot and flying fox activity. Other common fruit trees include pawpaw (*Carica papaya*), bananas (*Musa* sp), guava (*Psidium guajava*), cashew (*Anacardium occidentale*), the thorny tailorfruit (*Ziziphus mauritania*) and a range of *Citrus*: especially grapefruit and lime.

Establishment of a government nursery at Broome has been instrumental in promoting the horticultural use of hardy native plant species. Since the 1960s, street tree programmes have resulted in major plantings of river gums (*Eucalyptus camaldulensis*) - eg Robinson Street - as well as salmon gums (*E. bigalerita*) in Herbert Street. A list of plants suitable for ornamental planting in Broome is shown in Appendix 1.

Notable shrubs in the Broome landscape include a broad range of species with colourful flowers: *Hibiscus*, *Ixora*, *Tecoma*, *Jatropha*, *Thevetia*, frangipani (*Plumeria*), oleander (*Nerium*) and *Caesalpinia*. Shrubs with colourful, variegated foliage include croton (*Codiaeum*), *Acalypha*, *Graptophyllum* and *Manihot*. Highly regarded for their scent are frangipani (*Plumeria*), henna or Japanese boronia (*Lawsonia*) and the climber *Quisqualis*. Thevinca (*Catharanthus roseus*), both pink and white forms, is a favoured dwarf shrub. Among climbers, mention must be made of *Bougainvillea* with a range of spectacular colours and the brilliant pink Mexican rose (*Antigonon leptopus*), which often runs wild. (13)

Lawns in Broome are commonly couch (*Cynodon dactylon*) with *Paspalum* gaining in popularity.

In common with many northern towns, Broome's landscape is characterised by a vast over-provision of open space. Vacant land is abundant and often overrun with weeds, litter and degraded pindan scrub. Wide street verges, either bare and dusty or vegetated with buffel grass (*Cenchrus ciliaris*) and noxious burrs such as bindi-i (*Tribulus terrestris*) or Gallon's curse (*Cenchrus biflorus*) are all too common.

2.1.4 SOILS

Apart from the Holocene dunes, which lack a soil horizon, and the immature soils developed in the Pleistocene dunes, the major soil unit at Broome is the pindan which developed during the Quaternary on a desert dune sandstone.

As soil types are intimately associated with geological units, their distribution is identical to that shown on Map 4.

The term pindan is usually used rather loosely to describe the most common natural vegetation around Broome, which comprises a low scrubby woodland with a stunted tree layer of bloodwoods, ironwoods and paperbarks with a tall shrubby layer of *Acacia* spp. However, the term pindan is now used extensively to describe the soil type associated with the pindan vegetation. (14) The soils of the area are red earthy sands, which are of aeolian origin. They have deep uniform profiles of coherent clayey sands and have an earthy appearance apparently due to the coating and bridging of sand grains by clayey materials including iron oxides.

The pindan forms extensive undulating plains with little or no organised surface drainage, with runoff forming sheets of water in interdunal flats. (15) This structure is described as the Yeeda Land System. Around Broome the pindan is often overlain by a layer of more recent, coarser and unconsolidated sand which assists in water penetration, and plant establishment and growth.

When the pindan clays are dry they are hard and dusty, having an appearance of stability. However, when they are wet they become soft and greasy, and erode rapidly forming deep, steeply sided gullies, if changes to the land surface enable an increase in the rate of surface water runoff. This erosion can threaten engineering structures and other improvements (Photograph 8).



Photograph 8. Gully erosion near Gantheaume Point.

Where the pindan plain meets the sea undercutting of the land occurs at high tide level, which is followed by slumping, creating a pindan cliff. The above shoreline recedes at about 300 mm per year, although the rate was measured at 600-1 500 mm per day during cyclone Lindsay in February 1985 (Photograph 9).



Photograph 9. Marine erosion of pindan cliffs.

The eroding nature of the pindan plain creates a need for careful planning of structures which may be associated with an increase in the rate of surface water runoff. In addition, all developments on pindan surfaces near the sea must be planned so they are not affected by the receding shoreline.

2.2 CLIMATE AND OCEANOGRAPHY

2.2.1 CLIMATE

The Broome region experiences a tropical monsoon climate characterised by a winter (May-October) dry season and a summer (November-April) wet season (Figure 1).

2.2.2 WINDS AND WEATHER

Seasonal migration of a belt of high pressure anti-cyclonic (anti-clockwise) winds south of Broome controls the wind and weather in the region. During winter when the belt moves north, east to south-east winds (10-30 km/hr) and fine dry conditions prevail; while summer, when the belt moves south, brings a north-west monsoon with attendant westerly winds (10-20 km/hr), tropical rain and humid conditions. Between December and April tropical cyclones may affect the area bringing gale to hurricane force winds and rain. The incidence of gale force winds other than those associated with cyclones is low (less than 1% of observations) and most commonly associated with thunderstorms.

2.2.3 RAINFALL AND TEMPERATURE

Seasonal variation in rainfall and temperature is marked at Broome. In January the mean daily maximum temperature is 33°C with mean rainfall 163 mm. In contrast, in July the corresponding temperature is 28°C and rainfall 6 mm. This weather pattern results in three to four months of effective growing season. In addition, it creates a demand for water for irrigating gardens, plantations and nurseries over an extended period.

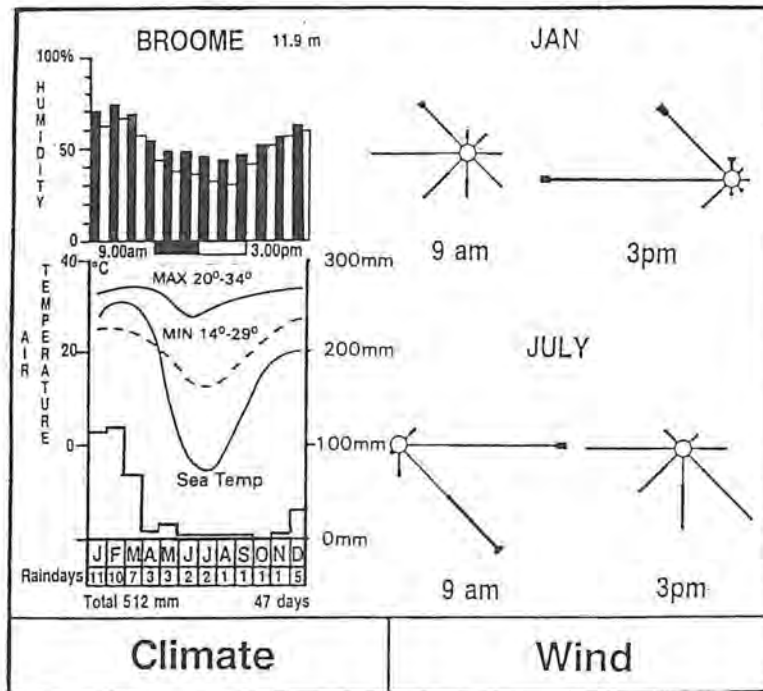


Figure 1. Wind roses, temperature, and rainfall graphs.

2.2.4 CYCLONES AND STORMS

Tropical revolving storms, or cyclones, in which winds reach hurricane force are the most violent type of storm affecting the coastline near Broome. Cyclones (clockwise winds) originate mainly in the Timor Sea between November and April and typically travel south-east. Many cross the Western Australian coast between Cape Leveque and Exmouth, though a proportion travel further west and south to cross the coast south of Carnarvon. Gale to hurricane force winds (+85 knots = 160 km/hr) are often experienced within 20 to 150 nautical miles from the centre. Since 1909, 24 cyclones have crossed the coast within 150 km of Broome and of these, eight have crossed within 50 km. A further 16 cyclones that did not cross the coast have passed within 150 km of Broome and of these, three have passed within 50 km. As the majority of cyclones pass to the north and west the major impact on the coast around Broome is the incidence of winds that swing from east through north to west, and north-west to westerly swells which impinge on west and north facing shores. However, the cyclones that pass to the east or south result in winds arriving from south-west and south-east quadrants. These generate waves and storm surge in Roebuck Bay that affect south and east facing shorelines around the townsite. Although cyclones occur relatively infrequently the forces they create can produce major threats to coastal works. Planning coastal work is complicated by the difficulty of quantifying the effect of cyclones; as the combination of onshore hurricane force winds, high tide, storm surge and very rough seas must be allowed for as a worst case.

2.2.5 SEAS (WAVES AND SWELL)

There is a dominant and a seasonal change in sea and swell conditions along the north coast of Western Australia. During most of the year, the Broome coast is subject to a refracted westerly swell that originates in the roaring 40s and south-east trade wind belt of the Indian Ocean. In winter the swell is low to moderate and in summer it is low. During winter when south-east winds dominate, south facing shores in Roebuck Bay are subject to wave activity. In summer, under the influence of the north-west monsoons and occasional thunderstorms, waves from the north and north-west are more common and affect west and north facing shores. Temporary very rough seas and heavy swell associated with cyclones which also affect the coast are probably dominant in shaping the coastline around Broome.

2.2.6 TIDES AND CURRENTS

Oceanic currents off the north coast of Australia are considerably affected by seasonal changes in the regional wind system. During winter the predominant current direction is westerly. During summer the direction is reversed with currents flowing to the north-east though weak south-west flowing counter currents may develop near the coast.

Broome tides have a large range (11 m) and regular cycles. Tidal streams over Roebuck Deep reach 4-5 knots during spring tides though at other times the rate seldom exceeds 2 knots. Tides are a major factor affecting the coastal environment in that they increase the range of wave and current action (Figure 14).

Besides being a tourist attraction in themselves, the large tides have an important influence on the species and number of plants and animals which are found in the variety of habitats provided (Photograph 10).



Photograph 10. Crab Creek at Low Tide. A wide band of mudflats and mangroves is exposed. The mangroves and mudflats in this area form an important biological system.

2.2.7 COASTAL PROCESSES

A number of coastal processes are occurring around Broome and they are still shaping the coastline. These processes which should be considered during the planning process include:

- . marine erosion and littoral transport of erosion products and sediment away from Gantheaume Point (ie northward along Cable Beach and south-east to east on coasts fronting Roebuck Bay and Roebuck Deep);
- . marine erosion of pindan cliffs around Roebuck Bay (Photograph 9);
- . swell-induced onshore transport of seabed in ebbtidal currents in Roebuck Bay;
- . onshore transport of coarse shelly material under storm conditions to beaches in Roebuck Bay; and
- . inland aeolian (wind-driven) transport of fine sand on west and south-east facing coasts (Photograph 5).

2.2.7.1 Sediment Transport Regime

Sediment transport regime: Under the influence of the wave and current regime described above, sediment in the littoral zone is transported away from Gantheaume Point.

The main process along the Roebuck Bay coast is erosion and stripping of the pindan from the Cretaceous basement leading to formation of pindan cliffs and exposure of bedrock. Erosion products are transported eastward in the littoral zone to form the spits and dunes.

At Crab Creek (Photograph 10) any fine material moved offshore is transported to the west in ebb tidal currents. There appears to be little onshore transport of material to the coast probably because there is a lack of sand-size material available, due to the rapid breakdown of shells by micro-organisms, and lack of quartz grains in the bay. The only time material is transported ashore is during storms when shells are winnowed from offshore and swept onto the beach where they are stranded. Normal tidal action then moves the sediment slowly into the mouths of Dampier and Crab Creeks. South of the Council caravan park where the pindan is eroding, movement of the sediment is slow due to the mature shape of the crescent-shaped bay north of the jetty, and sediments have consolidated into beach rock (Photograph 11).



Photograph 11. The crescent shaped bay north of the jetty.

Between the jetty and Gantheaume Point, the transport of sediment is limited by the restricted sand supply. The major activity is erosion and the cutting of two crescent-shaped bays at Riddell Beach with any swell-induced littoral transport of erosion products to the south-east.

North of Gantheaume Point, prevailing swell-induced transport is onshore and northwards. Probably during passage of cyclones to the north, when north-west winds and waves are generated, sand is temporarily transported south. The dune scarps found on Cable Beach today probably formed during such conditions, and the lack of a continuing sediment supply ensures their longevity.

The large sublittoral sand bar off Willies Creek indicates that sediment is moving both south and north. The beach ridges here indicate that this area is a sediment sink, so that sand moved north off Cable Beach is not likely to be replenished by sand moving south from north of the Creek. There is no obvious movement of sand to Cable Beach from offshore visible in the air photographs. Also, the chance of material moving from Roebuck Bay to Cable Beach is small because the swell induced transport regime is in the opposite direction. In addition, sand moving from Roebuck Bay and south of Roebuck Deep is trapped in Roebuck Deep, and it would take considerable energy to lift it from this 100 m deep channel.

Under the influence of the normal wind conditions, inland sediment movement takes place during summer on west facing shores, when west to south-west winds prevail. During winter when south-east winds are common, sediment movement takes place on shores exposed to the south and east. As most of the Roebuck Bay coast lacks an offshore sediment source no dune building has taken place and marine erosion has produced cliffs. In contrast, along Cable Beach there has been a supply of sand to the coast and dune building and inland movement of sand has occurred. However, the presence of exposed dune cores along much of Cable Beach suggests that there is now little dune sand coming ashore to form dunes or blow inland.

It is likely that wind transport occurs during cyclones when, hurricane force winds strip vegetation and sand movement takes place. The relative importance of the prevailing winds, compared to the short-lived though high energy cyclonic winds, in transporting sand is not known.

2.3 TERRESTRIAL BIOTA

2.3.1 VEGETATION

Broome's natural vegetation is essentially a mixed assembly of plants, deriving from two sources: the deserts to the south and the monsoonal Kimberley to the north. This transitional nature is further emphasised by a paucity of endemic, or strictly local species.

The interior of the Dampier Peninsula presents a relatively uniform environment, dominated by low-relief sandplains with few creeks or hills. The overwhelming vegetation is pindan, a grassland wooded by scattered trees, generally eucalypts, with a variably dense, middle layer of wattles.

The monotony of pindan country, especially inland from Broome, contrasts strongly with the diversity of coastal habitats in the vicinity of the town. No less than eight coastal plant communities are recognised here and an essentially similar pattern is evident elsewhere on the Dampier Peninsula. (15)

The plant communities outlined are:

- . Mangroves
- . Samphire flats
- . Saline grasslands
- . Paperbark thickets
- . Seepage areas and wetlands
- . Coastal dunes
- . Limestone outcrops
- . Vine thickets
- . Pindan

2.3.1.1 Mangroves

Major mangrove communities occupy sheltered tidal mudflats at the mouths of Dampier and Crab Creeks, fringing Roebuck Bay, as well as the estuary of Willies Creek. South of the entrance to Willies Creek, there is an interesting community of dead mangroves, reportedly destroyed by the 1957 cyclone, which reshaped the estuary mouth (Craig Kennedy, personal communication).

At the Coconut Well estuary, which is silted up, a remnant, stunted mangrove community persists. These examples demonstrate that mangroves occupy an inherently dynamic ecological niche, both between land and sea and the conflicting processes of erosion and sedimentation.

The commonest mangrove, *Avicennia marina*, is a tree with greenish-grey foliage. It is readily recognised by its radiating network of cable roots and projecting, pencil-like pneumatophores or "breathing roots". The scent of *Avicennia's* orange flowers sometimes permeates the town (November-January). *Avicennia* forms dense stands on both seaward and landward mangrove margins. In the latter habitat, it is joined by *Aegialitis annulata*, *Aegiceras corniculatum* and *Ceriops tagal*. *Excoecaria agallocha* and the halophytic shrub *Batis argillicola* are sometimes common on the landward fringe, as at Crab Creek. The innermost or central zones in mangrove stands generally feature *Rhizophora stylosa*, with characteristic arching stilt roots and the tall, columnar *Camptostemon schultzei*. The mistletoe *Amyema thalassium*, occurs on the latter and *Avicennia marina*. (16)

(Ecological relationships and management aspects have been discussed in Section 2.4.1).

2.3.1.2 Samphire Flats

Behind the mangroves, broad tidal flats usually occur, featuring expanses of bare mud. At the upper margins, a low saltmarsh shrub community is characteristic, dominated by succulent samphires: principally *Chenopodiaceae* such as *Halosarcia halocnemoides*, *Neobassia astrocarpa* and *Suaeda arbusculoides*, together with *Sesuvium portulacastrum*, *Hemichroa diandra* and *Limonium salicorniaceum*.

The grasses *Sporobolus virginicus* (salt water couch) and *Xerochloa imberbis* (rice grass) are often present at the landward edge, indicative of the transition to saline grasslands.

2.3.1.3 Saline Grasslands

Former tidal flats, above high water mark, are dominated by extensive pastures of Salt-water Couch (*Sporobolus virginicus*), a hardy perennial grass to 0.3 m with creeping rhizomes. This community reaches its maximum development at Roebuck Plains, inland from Crab Creek. Important grasslands also occur inland from Crab Creek. Important grasslands also occur inland from Fisherman's Bend and Dampier Creek, as well as south from Coconut Wells at Buckley Plains and behind Willy Creek. As *Sporobolus* is readily grazed by cattle at all stages, it is highly regarded by pastoralists for stock-fattening. (17) Associated grasses include *Dicanthium fecundum*, *Eragrostis falcata* and the shrub *Salsola kali* in minor depressions.

Upper margins of saline grasslands sometimes feature scattered shrubs of *Hibiscus panduriformis* together with *Xerochloa barbata* and *X imberbe*, both species of Rice grass, providing excellent fodder immediately after the wet season. However, they are vulnerable to overgrazing, subsequent erosion and scalding. (18)

Saline grasslands are subject to flooding, following heavy periods of monsoonal rain. In the late dry season, they are a favoured location for mating Brolgas, which can often be seen dancing in a shimmering heat haze.

2.3.1.4 Paperbark Thickets

Along the inner, landward margin of saline grasslands, there is a gradual or sometimes abrupt transition to seasonally-inundated, fringing stands of Paperbark, *Melaleuca acacioides*. Growing in characteristic, multi-stemmed

clumps with a dense, evergreen crown, these trees, 4-10 m high, scent the air with a pungent aroma. Occasional climbers such as *Secamone elliptica* and the parasitic *Cassytha filiformis* feature in treetops.

The width and density of the paperbark community varies greatly: from a discontinuous line of trees to closed-canopy thickets, 0.5 km in width, with a deep layer of leaf litter and minimal undergrowth. The best developed *Melaleuca* stands close to Broome occur inland of Willies Creek and south of Coconut Wells, at the northern end of Buckley Plains. Such thickets, with their shade and shelter, form an important habitat for wildlife: from clustering butterflies to nesting birds. Around September, *Melaleuca acacioides* flowering reaches its peak. The creamy, ball-like flower clusters attract numerous honeyeaters.

Paperbark thicket is also a favoured resort of cattle during midday heat. Perceived mustering difficulties have led to partial clearance and firing of thicket near Coconut Wells, creating conflict between the demands of cattle management and conservationists seeking a botanical reserve. Fire-degraded thickets have been observed to result in rapid invasion by the climbing Wild Passion Fruit, *Passiflora foetida*.

The landward margin of paperbark thicket gives way to pindan, either gradually or abruptly, depending on slope. This transition zone often includes *Atalaya hemiglaucata*, *Acacia holosericea*, *Lysiphyllum cunninghamii* and *Melaleuca nervosa*.

Several important Aboriginal sites occur in paperbark thicket, close to Broome. In the past especially, some utilisation of paperbark has occurred for fence-posts and building materials. Release of horticultural blocks, intruding into paperbark thicket, unfortunately took place at the southern end of Buckley Plains. Such development is ill-advised and should be avoided. (19)

2.3.1.5 Seepage Areas and Wetlands

Localised seepage areas, within and fringing paperbark thickets, occur infrequently but are significant: especially inland from Willies Creek. Sometimes, as at Bone's Well, these are no more than patches of damp ground with tall, emergent Corkbark trees (*Sesbania formosa*) with spectacular white flowers, to 12 m.

Nearby is a permanent, crescent-shaped, saline lake, fed by springs and popular with pelicans. The lake's inland margin features an unusual fringe of the mangrove *Lumnitzera racemosa*, as well as sedges (*Cyperus* spp and *Fimbristylis* spp). Behind lie tall stands of the evergreen tree *Timonius timon* as well as *Pandanus spiralis*, both of which are here at the southernmost limits of their Kimberley range.

A unique, permanent freshwater lake is Nimalaica Claypan. This is an important bird refuge with dense, surrounding beds of a tall, sedge-like plant, *Eleocharis* sp and also a partially-submerged forest of massive *Melaleuca leucadendron*. Associated springs are notable for *Philydrum lanuginosum* in addition to the most southerly known stands of the mangrove fern, *Acrostichum speciosum*.

These areas of seepage and shallow lakes should be designated conservation areas. The long term survival of their communities is critically-dependent on the maintenance of water-table levels. Development of landward pindan areas, eg for horticulture with bores, could jeopardize the delicate ecological balance that currently exists. (20)

2.3.1.6 Coastal Dunes

An almost unbroken chain of exposed, white, Holocene sand dunes parallels Cable Beach northwards towards Coconut Well. Foredunes are sparsely vegetated with the grass *Spinifex longifolius*, adapted to tolerate sand burial, salt spray and wind blast. Also present are the beach morning glory, *Ipomoea brasiliensis*, a creeper with long pliable stems, the hardy shrub *Salsola kali* and a prostrate herb *Euphorbia myrtilodes* (Figures 2-4).

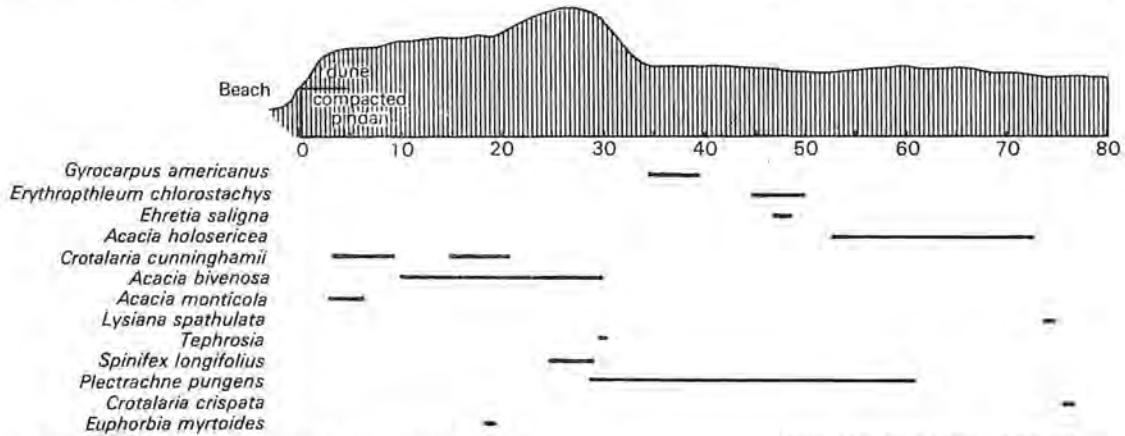


Figure 2 KAVITE ROAD Pleistocene dune transect

Note: Distances shown in metres.

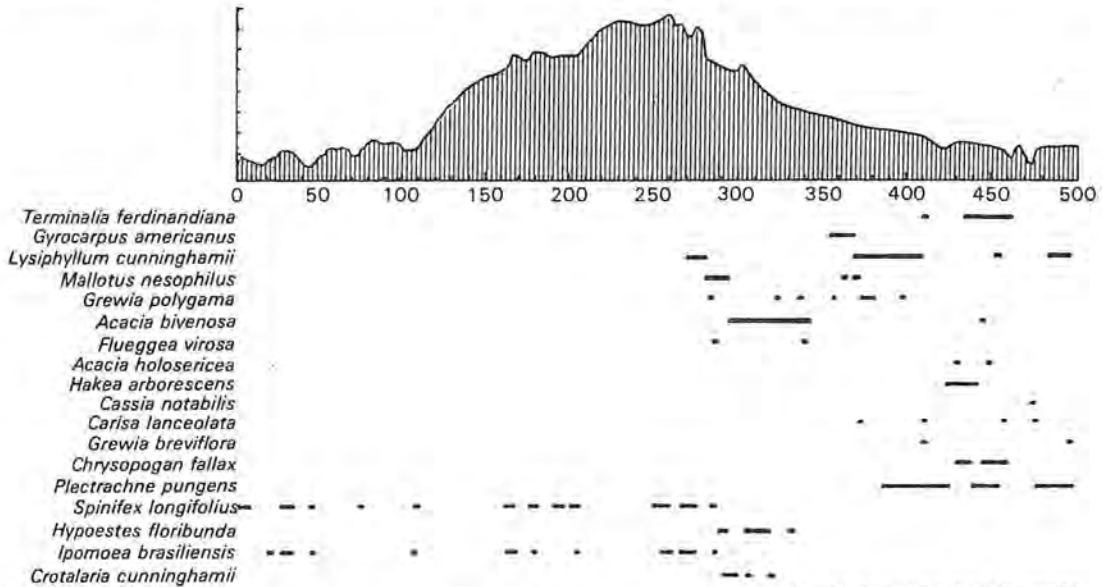


Figure 3 GUPUNGI ROAD - Holocene dune transect

Note: Distances shown in metres.

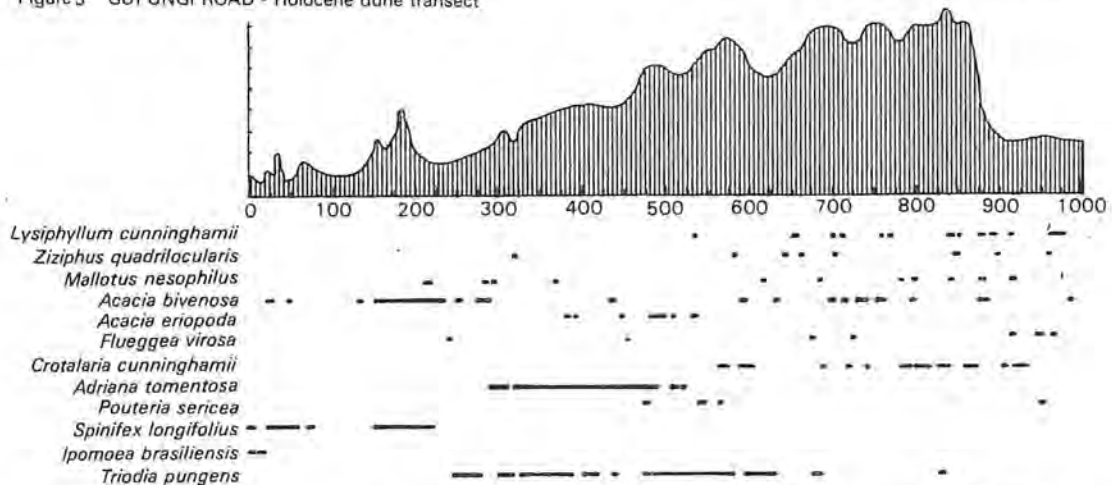


Figure 4 UPPER CABLE BEACH - Dune Transect

Note: Distances shown in metres.

On more established dunes, where pockets of vegetation have gained a hold, other hardy shrubs such as the bluish-grey *Acacia bivenosa*, stunted bauhinia (*Lysiphyllum cunninghamii*) and the beach bean creeper, *Canavalia rosea* struggle for survival between bare intervening swales and blow-outs.

Behind dune crests, on backslopes and in hollows, plant species mentioned are joined by a diverse assembly of plants climaxing in a dense shrub community. Notable species may include *Crotalaria cunninghamii*, *Mallotus nesophilus*, *Santalum lanceolatum*, *Myoporum acuminatum*, *Adriana tomentosa*, *Abutilon* sp, *Hypoestes* aff *floribunda*, *Ptilotus exaltatus* and the grass *Whiteochloa airoides*. These shrublands infrequently merge downslope into isolated pockets of taller vine thicket.

Pleistocene dunes, older and less exposed than the Holocene dunes of Cable Beach, fringe Roebuck Bay between the port and the meatworks. Pleistocene dunes are characteristically pink and relatively stable. Whilst the two dune systems have many plant species in common, the Pleistocene unit appears to have been invaded by pindan elements, giving its vegetation a more diverse aspect and some different dominant species. For example, the seaward face to the Roebuck Bay dunes has the familiar *Spinifex longifolius* and *Canavalia rosea* are joined by two notable shrubs: the woolly-leaved *Psoralea martinii* and the introduced kapokbush *Aerva javanica*.

Dune crests are dominated by *Acacia monticola* with the low shrub *Gyrostemon tepperi* and, where unburnt, large clumps of the spinifex *Triodia pungens*. An open eucalypt community with several bloodwoods (*Eucalyptus* spp) is also locally important. Sheltered dune slopes and hollows have a very mixed plant community including suckering thickets of *Atalaya hemiglauca*, *Ehretia saligna* and *Clerodendrum* sp, together with the climbing *Jasminum* sp. Species in common with Cable Beach dunes include *Crotalaria cunninghamii*, *Lysiphyllum cunninghamii*, *Santalum lanceolatum*, *Gyrocarpus americanus* and elements typically associated with vine thicket such as *Pouteria sericea*, *Grewia polygama*, *Terminalia petiolaris* and *T ferdinandianna*.

Dune vegetation on the Holocene unit is particularly vulnerable to disturbance, leading to erosion. Access tracks (for vehicles, horses and pedestrians), misuse of off-road vehicles and trailbikes, together with sand-quarrying all threaten the precarious stability of the dune system.

Planning and management strategies are imperative to minimise disturbance. (21)

2.3.1.7 Limestone Outcrops

Plate-like outcrops of beachrock occur sporadically along Cable Beach, representing exposed, cemented dune cores. Such features are poorly vegetated eg a few tiny *Euphorbia myrtoides* plants are sometimes present.

Immediately to the north of the Willies Creek estuary and extending southwards towards Coconut Well is an extensive limestone platform of coastal travertine with low cliffs, sometimes masked by drift sand. Open scrub, dominated by *Acacia bivenosa*, is characteristic with occasional stunted *Lysiphyllum cunninghamii*, *Ficus opposita*, *Mallotus nesophilus*, *Crotalaria cunninghamii* and *Flueggea virosa*. (22)

2.3.1.8 Vine Thickets

In the shelter of coastal dunes occur isolated pockets of open, deciduous vine thickets. Though small in extent, these communities are undoubtedly one of the most interesting plant formations in the area. Broome's depauperate thickets are considered by authorities such as Kenneally (23) to be the remotest western outlier derivative from Queensland's rich thickets and coastal rainforests. Insufficiently studied, vine thickets are of great biogeographical, evolutionary and ecological interest, containing plants with ancient Gondwanan affinities: linking in to the now dispersed floras of India, Madagascar, Africa and South America.

In progressing northwards from Broome towards Cape Leveque, vine thickets display an increasingly impressive magnitude, structure and diversity of species. Distinctive, localised vine thicket elements at Broome include the evergreen trees mungart (*Pouteria sericea*) and *Exocarpus latifolius*, as well as deciduous shrubs such as *Grewia breviflora*, *Grewia polygama*, *Pavetta brownii*, *Bridelia tomentosa* and *Premna acuminata*. Large emergent *Terminalia* trees also occur, principally blackberry (*T. petiolaris*) and gubinge (*T. ferdinandiana*), the latter well-regarded for its vitamin C rich fruits.

A wide range of vines occur: notably *Caesalpinia globulorum*, *Abrus precatorius*, *Capparis lasiantha*, *Jacquemontia paniculata*, *Gymnanthera nitida*, *Marsdenia* spp, *Tinospora smilacina* and, more rarely, *Opilia amentacea* and *Operculina brownii*. (24)

Vine thickets are an important habitat for birds and agile wallabies. As many of the plant species have edible fruits and berries, they represent an important traditional resource for Aboriginal people. Broome's vine thickets are threatened by increasing fire frequencies, dumping of refuse, proliferating access tracks and illicit camping. A botanical reserve, off Gupungi Road, is recommended to conserve a representative area of vine thicket, behind the Cable Beach dunes (Figures 2-4).

2.3.1.9 Pindan

Pindan, the ubiquitous inland vegetation around Broome, has been defined by Beard as "a grassland wooded by a sparse upper layer of trees and a dense, thicket-forming middle layer of unarmed, phyllodal *Acacia*". The term pindan is also applied to the red loamy soils, poor in nutrients, which support it. Fire is pindan's controlling agent; the variable appearance and density particularly of the wattles, relates directly to a fire-regeneration cycle. Stands of burnt wattle, stems exhibit a gaunt broomstick appearance but recovery is rapid through rootstock suckering and/or prolific seedling regrowth. In the absence of fire, maturing *Acacia* is often heavily infested by mistletoes (*Lysiana spathulata* and *Dendrophthoe acacioides*) (Photograph 12).



Photograph 12. Pindan vegetation. A grassland wooded by a sparse upper layer of trees and a dense thicket forming layer of Accacia Fire is the controlling agent of this vegetation association.

The wattle or *Acacia* layer, attaining circa 5 m in height, is dominated inland by the slender *Acacia eriopoda*. Disturbed areas, such as road margins, tend to be colonised by the silvery *Acacia holosericea*. Another important local community is formed by *Acacia tumida*, notably in a 2 m shrubland inland from Gantheaume Point. The densest wattle thickets are those dominated by the minnie-ritchie (*Acacia monticola*) occupying exposed, eroding clifftops at Gantheaume Point. A number of sterile *Acacia* hybrids have been identified locally.

Scattered, emergent trees (8-12 m high) are generally bloodwood eucalypts, principally *Eucalyptus polycarpa*, *E. zygomphylla*, with several undescribed taxa. Occasional majestic specimens of an undescribed white gum *E. aff. papuana* reach 15 m. Its hollow branches sometimes feature the hardy epiphytic orchid, (*Cymbidium canaliculatum*). A few isolated groves of the red-flowering woollybutt, (*Eucalyptus miniata*), occur on sand ridges immediately inland from Coconut Well. These are significant as the most southerly stand in the Kimberleys. Pindan eucalypts host several mistletoes, including *Amyema sanguineum* and *A. bifurcatum*.

A wide range of other tree and shrub species lend variety to Broome pindan, notably bauhinia (*Lysiphyllum cunninghamii*), several species of *Hakea* and *Grevillea*, *Persoonia falcata*, lemonwood (*Dolichandrone heterophylla*), ironwood (*Erythrophloeum chlorostachys*), an undescribed *Gardenia*, sandpaper fig (*Ficus opposita*), whitewood (*Atalaya hemiglauca*), medicine bark (*Ventilago viminalis*), the willowy *Ehretia saligna*, cocky apple (*Planchonia careya*), kurrajong (*Brachychiton diversifolius*), bellfruit (*Codonocarpus cotinifolius*) and conkerberry (*Carissa lanceolata*).

Important shrubs include *Gyrostemon tepperi*, *Trichodesma zeylanicum*, *Cassia notabilis*, *Solanum cunninghamii*, *Acacia adoxa*, and *Gossypium australe*.

The commonest climber is snake vine (*Tinospora smilacina*), while *Marsdenia* sp. muggabula, is a popular Aboriginal delicacy for its tasty immature seeds.

The principal pindan grass species are rhizomatous and include curly spinifex (*Plectrachne pungens*), ribbongrass (*Chrysopogon fallax*), annual canegrass (*Sorghum stipoideum*) and bunch speargrass (*Heteropogon contortus*).

Species composition in pindan communities often reflects subtle drainage patterns, despite a seemingly-uniform relief. Traces of fossil dunes, partially levelled, can sometimes be detected eg inland from Riddell Beach, which may explain the presence of desert-associated species such as *Keraudrenia integrifolia*, here at its northernmost limit. A similar desert straggler is the magnificent purple-flowering shrub *Cyanostegia cyanocalyx* and also the nut tree *Terminalia cunninghamii*, both near Coconut Well.

A poorly-drained variant of pindan, with prominent anthills, exists east of Broome, towards OTC, featuring the grey box tree, *Eucalyptus tectifera*, *Melaleuca nervosa*, the shrub *Hibiscus panduriformis* and ground plants such as *Calandrinia*, *Drosera* and *Byblis*.

The broad extent and relatively inland distribution of pindan, together with the unsuitability of other coastal vegetation communities suggest that pindan is the most expendable plant community and a logical focus for Broome's future development. Ideally, clearing should be selective, retaining scattered trees in an attractive park-like landscape. (25)

2.3.2 MAMMALS AND BIRDS

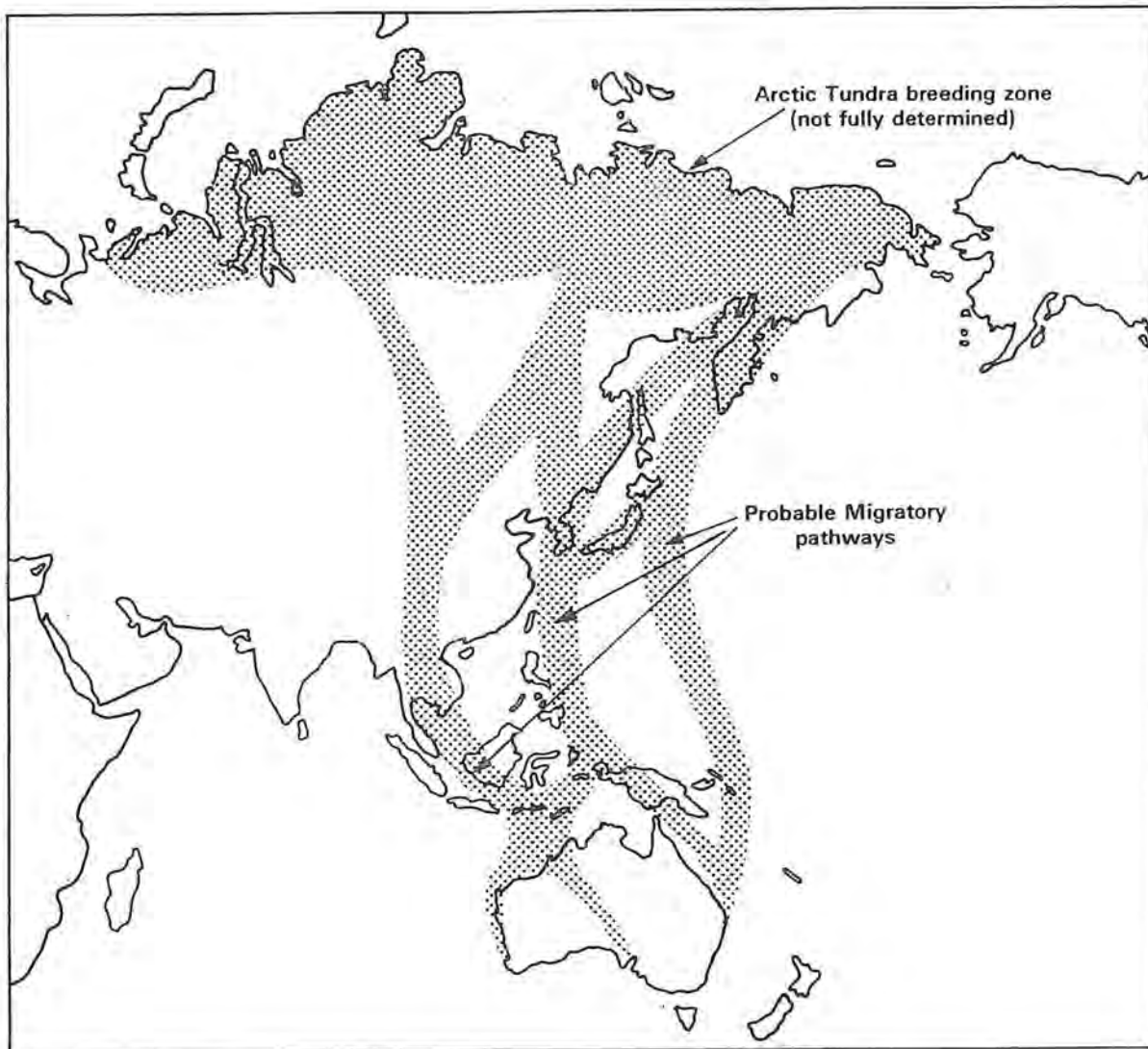
The wildlife of the Broome area was investigated as part of a study of the Dampier Peninsula. That study includes the Broome area in a wider biological district known as the Phanerozoic South West Kimberley which lies between the humid and sub-tropical areas to the north and the semi-arid and arid areas to the south. This intermediate location produces animal habitats supporting 33 species of native mammals in three major groups: sub-humid tropical, arid desert, and "more cosmopolitan" species. Since European settlement, a mere 150 years ago, a number of species have already disappeared or become rare.

The area is rich in birdlife due to the diversity of habitats especially near the coast. Of the 214 bird species recorded, 63 (29%) have been recorded in coastal habitats which account for only 15% of the total area of the peninsula. In contrast only 56 species are associated with the pindan habitat which covers about 70% of the Dampier Peninsula. The most important coastal habitats are *Tristania* swamps, samphire flats, coastal dunes, creekside vegetation, mangroves, mudflats, beaches and cliffs. While it is unlikely these areas warrant dedication as Nature Reserves, their value is recognised and they will be protected where practicable.

2.3.2.1 Migrant Holarctic Wading Birds

Of major importance in the study area are the habitats provided for migratory wading birds by the mangroves and tidal mudflats of Roebuck Bay, Crab Creek, Dampier Creek, Willies Creek and other smaller waterways.

Each year migrant wading birds, which comprise 20% of the species recorded in the Dampier Peninsula, travel along the north coast of Western Australia. Many of these species are long distance migrants travelling from southern Australia to northern Asia, Europe, Canada, the Arctic and adjacent islands, where they breed (Map 5). Australia has long been a signatory to international treaties protecting these birds and their habitats.



Map 5. Breeding habitat and migratory pathways of Holarctic Waders.

When the birds arrive on Australia's north coast they are often exhausted and rely upon the highly productive tidal flats to rehabilitate and gain strength before moving south to their summer feeding grounds. As these birds are highly stressed by the physical demands of their migratory lifestyle, a loss of habitat in any part of their route reduces their chances of survival.

The Department of Fisheries and Wildlife (now Department of Conservation and Land Management) in WA has been conducting surveys of wading birds in the area since August 1981 and considers the 700 km of coastline from Port Hedland to Broome an extremely important link in the migration of these Holarctic waders: Three areas stand out as requiring special consideration: Leslie Salt Works, Eighty Mile Beach and Roebuck Bay.

In 1982 there was an overwintering population of about 50 000 birds in proportions 10:30:10 respectively at the three locations. Birds migrating from the northern hemisphere began to arrive during the third week in August and numbers increased until mid-November when surveys on the 14th-19th recorded 654 000 birds.

By February 1983 the population had decreased slightly to 486 000. The return northern migration began in late February and continued until April.

The species composition varies at each location (see Appendix 2). A greater proportion of the larger waders occurs at Roebuck Bay than at any of the sites further south, a fact that may be attributed to the particular richness of the mangrove muds in the area. Consequently Roebuck Bay is considered to be one of the most important wader habitats in northern Australia and possibly the whole of Australia.

The combination of food-rich mangrove mudflats, sandy tidal flats at Fall and Sandy Points, and sheltered high tide roosts along the northern shore of the bay has attracted many thousands of waders with a unique variety of species. In 1981 the number of great knots at Roebuck Bay was 17 000 which, when combined with the total of 21 800 for the Eighty Mile Beach, is greater than the previous estimates of the total world population.

Similarly the populations of other species such as pied oyster catcher (Figure 5), greenshank (Figure 6), oriental plover, large sand plover, mongolian plover, godwit, eastern curlew and whimbrel indicate that Roebuck Bay is unique for species diversity and density.

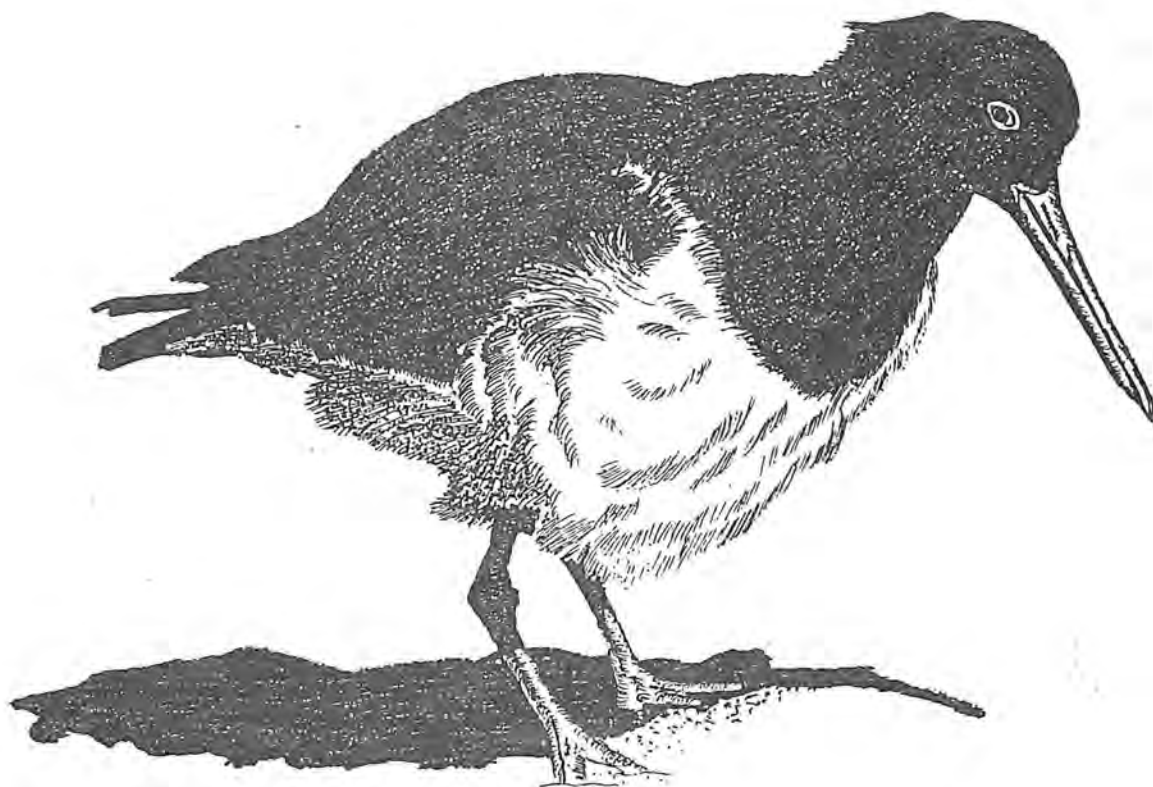


Figure 5. Pied oyster catcher.

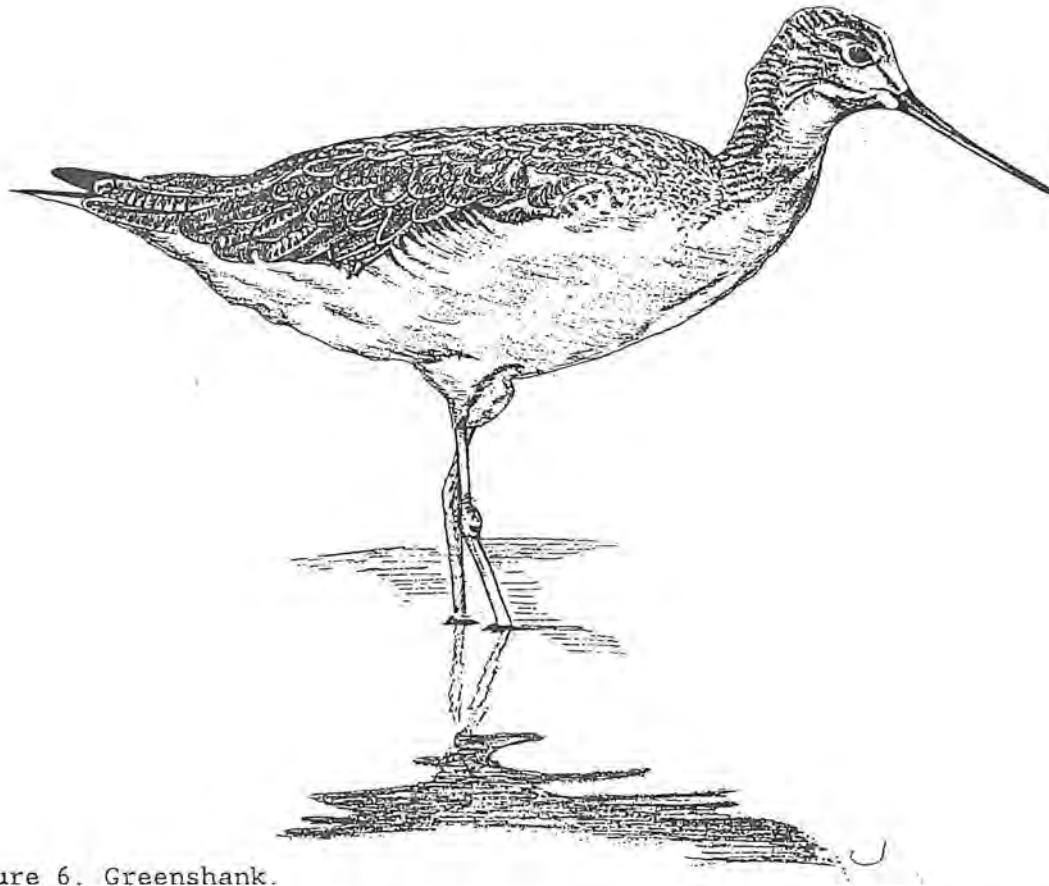


Figure 6. Greenshank.

The wader activity in Roebuck Bay is linked very closely with the tidal movements. At high tide the birds are forced off the mudflats and on to elevated beaches around the bay.

At high tides above 8.2 m the birds become nervous when roosting on the beaches below the cliffs. If disturbed they prefer to fly direct to beaches west of the town and south of Gantheaume Point. As maximum tides recede below 8.2 m the birds resume their normal roosting behaviour.

During low tide the waders appear to break into groups by species and size and feed actively until the tide begins to flood. Large waders such as eastern curlew and whimbrel are often observed feeding out from the mangroves near Crab Creek and Fall Point and around the Broome town area. As a result, large to medium waders often roost in the flooded mangroves, whereas smaller species which are less restricted in their habits prefer the exposed shallows and supratidal flats along the northern and western sides of the bay.

The reason the birds prefer the beaches around the northern side of the bay is as yet unclear but may be due to one or more of the following:

- . All other beaches within a reasonable distance of the feeding grounds in Roebuck Bay (ie less than 15 km) are flooded at tides over about 7 m. As the energy requirements of newly arrived birds are probably considerable, long distances between roosting and feeding grounds are avoided, if possible.
- . The beaches at the base of the cliffs around the northern shores provide cover and shelter (rocks), and camouflage (colour and rocks), and are close to mangroves at Crab Creek.
- . Freshwater soaks may occur there.

2.4 MARINE BIOTA

2.4.1 MANGROVES

Mangroves usually grow between high spring tide and mean sea level. The term mangrove refers to individual tree or bush species, while a mangrove plant community is called a mangal.

Mangroves belong to a variety of plant families which have common features such as pneumatophores, which are root outgrowths that function in aeration and seeds which germinate while attached to the parent plant. These features almost certainly are adaptations which assist the plants to survive in a harsh environment. (27)

Mangroves grow best in areas with warm climates, protected shores, salt water, muddy substrates and a high tidal range. All of these attributes are found in Roebuck Bay and Willies Creek. Mangroves are typically zoned (ie different species occur in various locations determined by the frequency of flooding by tidal waters, soil type, soil salinity, drainage, slope, plant interactions and animal interactions). Naturally, many of these factors are interrelated. Where environmental factors are well differentiated along a shore with a gentle gradient there will be a tendency for development of distinct broad zones as occur in Dampier and Willies Creek. (28)

At Broome the characteristic zoning sequence comprises *Avicennia*, *Rhizophora*, *Cerriops* and samphire or salt flats in a seaward landward progression. (29)

The animals that are associated with mangroves span a wide range of invertebrate and vertebrate groups. This fauna is often distributed in distinct zones related to frequency of tidal flooding, soil type, salinity, and the type of surrounding plant community. Many of the animals exploit the mangal as habitat, nursery grounds or source of food.

Fauna in mangroves may be distinguished as either resident or temporary. Resident fauna includes ground-dwelling surface animals such as hermit crabs, mud whelks and other snails; burrowing organisms such as crabs, shrimps and worms; tree-dwellers such as encrusting oysters and barnacles, wandering snails, boring *Teredo* ("ship worm"), and a host of insects, birds and bats which use mangrove foliage as habitat and derive food from leaves, flowers and fruit. Mangroves provide vital feeding grounds for the temporary fauna which is made up of free-swimming animals such as fish and crustaceans that invade the mangal environment at high tide, and of terrestrial animals such as birds, reptiles and mammals that invade the area at low tide. Additionally, numerous fish and crustacean species (notably banana prawns) use the mangrove environment as a nursery.

Thus, in terms of plant primary production, feeding grounds and nursery beds, mangroves are a vital resource. It has been shown that the destruction of mangroves can lead to a major change in near shore ecology with the subsequent decline of commercial fishing. Studies have shown that in some coastal waters 70-80% of fish caught commercially were linked to a food chain that is dependent on mangroves. Consequent on mangrove loss is the dislocation of the food chain accompanied by the inevitable loss or severe depletion of organisms within the chain. Destruction of mangroves also results in loss of habitats for a large range of terrestrial organisms such as insects, birds and bats. Removal of even part, such as a particular zone, has detrimental effects on the ecosystem since those animals that are very selective in their feeding are lost. (30)

Figure 7 is a simplified diagram illustrating the role of mangroves in the coastal ecosystem, while Map 6 shows the location of mangroves, and wading bird habitats.

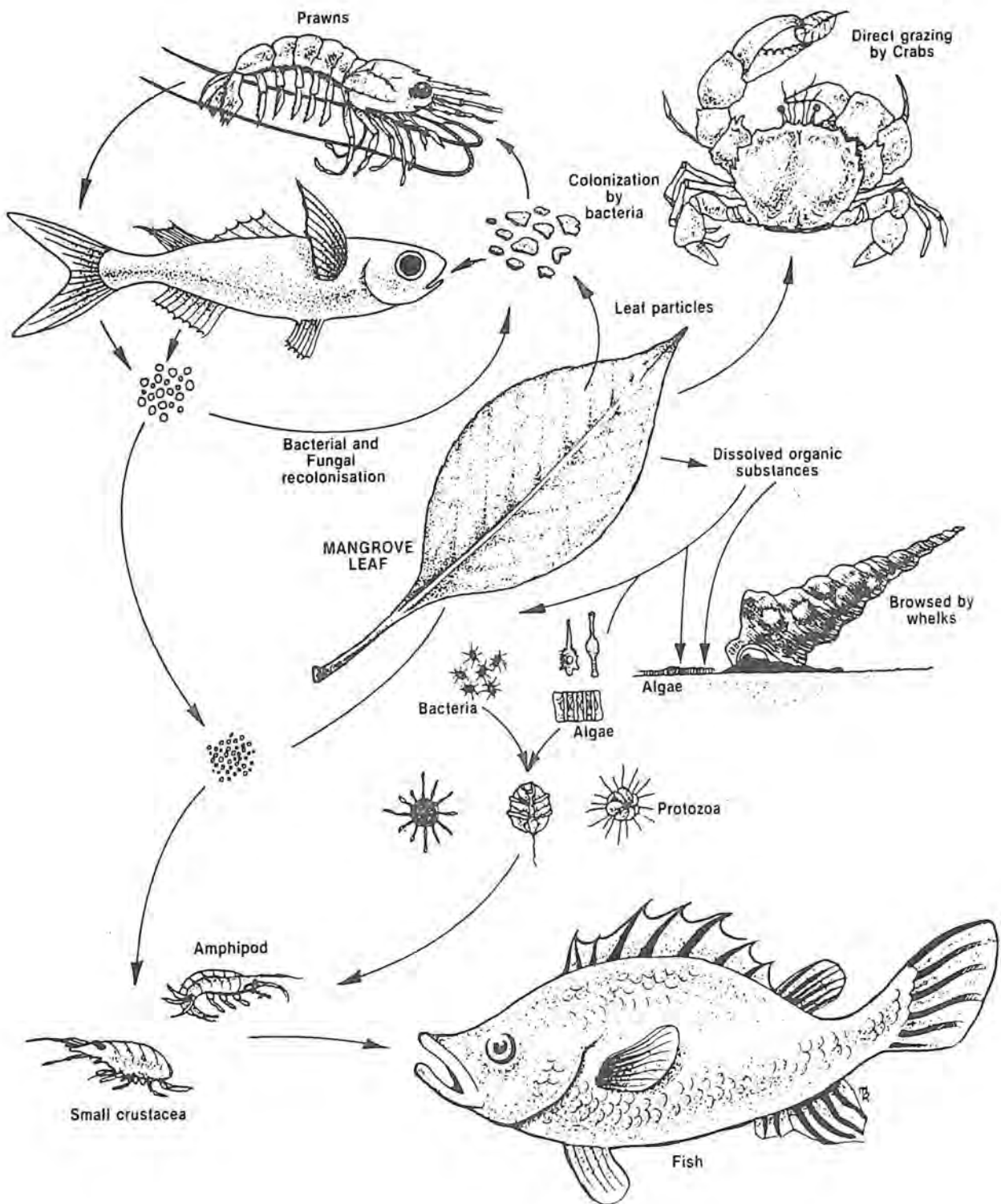
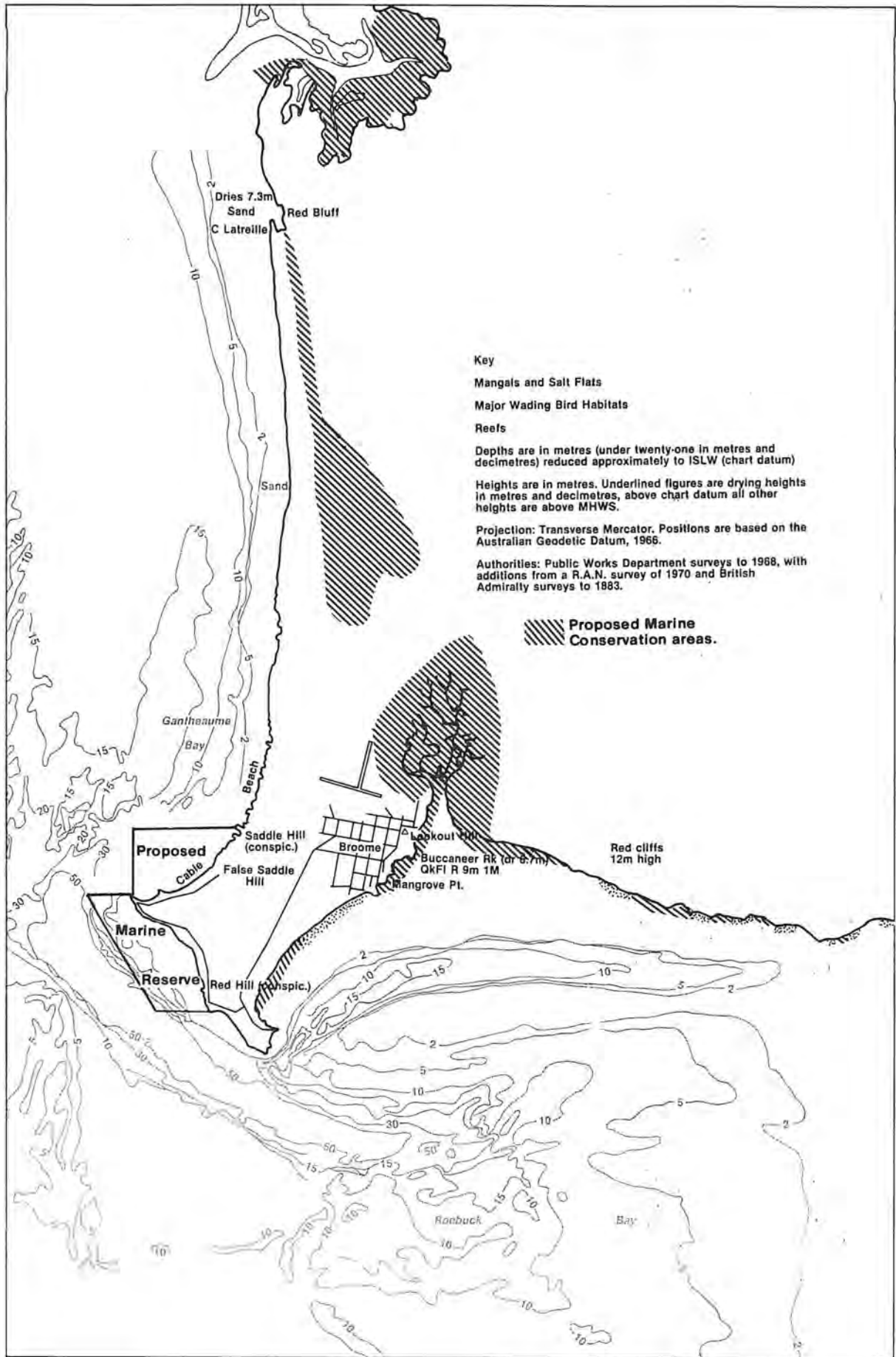


Figure 7. Supply of mangrove material to the food chain, (Adapted from Semenuik 1972.)



Map 6. Marine Resources. (Adapted from Approaches to Broome - AHQ/Navy/5783.)

2.4.2 INVERTEBRATE WILDLIFE

With the exception of some groups of crabs the ecology of the invertebrate wildlife including worms, insects, molluscs and most crustacea is not well known, although it is certain that this group has an extremely important role in the aquatic system.

2.4.2.1 Shellfish

Shellfish are found on the sandy beaches, mudflats and rocky coasts around Broome. These animals are important as a source of food and for collection. The intertidal sand bars, mudflats and rocky outcrops provide an extremely diverse range of habitats. The consequent variety of shell species found at Broome is recognised worldwide and has resulted in the area becoming a major site for shell collectors. Little research into the effects of shell collecting has been carried out though it is recognised that the shellfish resource has diminished markedly over the last 5-10 years. This is mainly attributed to increasing disturbance and destruction of habitats by a more mobile population with greater access to the coast, and increased amateur and professional as well as commercial collecting.

The Broome coast and offshore sandflats are also habitats for oysters which support an industry producing shell, meat and pearls, although commercial pearling has declined and only a few operators remain.

It is also evident from the number of middens along the cliffs and dunes of the Broome coast that shellfish have been, and still are, providing a source of food for the local inhabitants.

2.4.2.2 Crabs

The crab populations in the Broome area have been examined by staff of the WA Museum with research currently centred on the Dampier Creek tidal flat.

Crabs are found in a variety of landforms. Two ghost crabs occur in the Broome area, *Ocypode ceratophthalma* and *O fabricii*. *O ceratophthalma* is found on open, exposed seaward beaches (eg Cable Beach, Photograph 4), and at or above low water mark. *O fabricii* (Figure 8) is found lower down the beach and favours the more protected regions, deep inside bays eg the town foreshore. Rocky headlands like those at Gantheaume Point and Riddell Beach support rock crabs and marine hermit crabs.

The shores of Roebuck Bay support populations of terrestrial hermit crabs at various locations while the mangrove fringes and beaches near the town are inhabited by ghost crabs (*O fabricii*), fiddler crabs (*Uca* spp), mangrove crabs (*Macrophthalmus* spp) and mud crabs (*Scylla serrata*), the last of which is exploited as a human food source. Dampier and Crab Creeks and their associated intertidal and supratidal mudflats support a variety of fiddler crabs.

Of the 17 species of fiddler crabs present in Australia, nine are found on the tidal flats around Broome (Appendix 3).⁽³²⁾ The Dampier Creek mangrove complex has a full variety of habitats that are zoned largely according to frequency and duration of tidal inundation. The regularity and high range of the tides at Broome make this tidal flat unique in Australia as the crab habitat zones are more clearly defined than elsewhere. Apart from its worth as a mangrove habitat as discussed above (2.4.1), preservation of the tidal flat in its natural state is warranted for its scientific value alone.

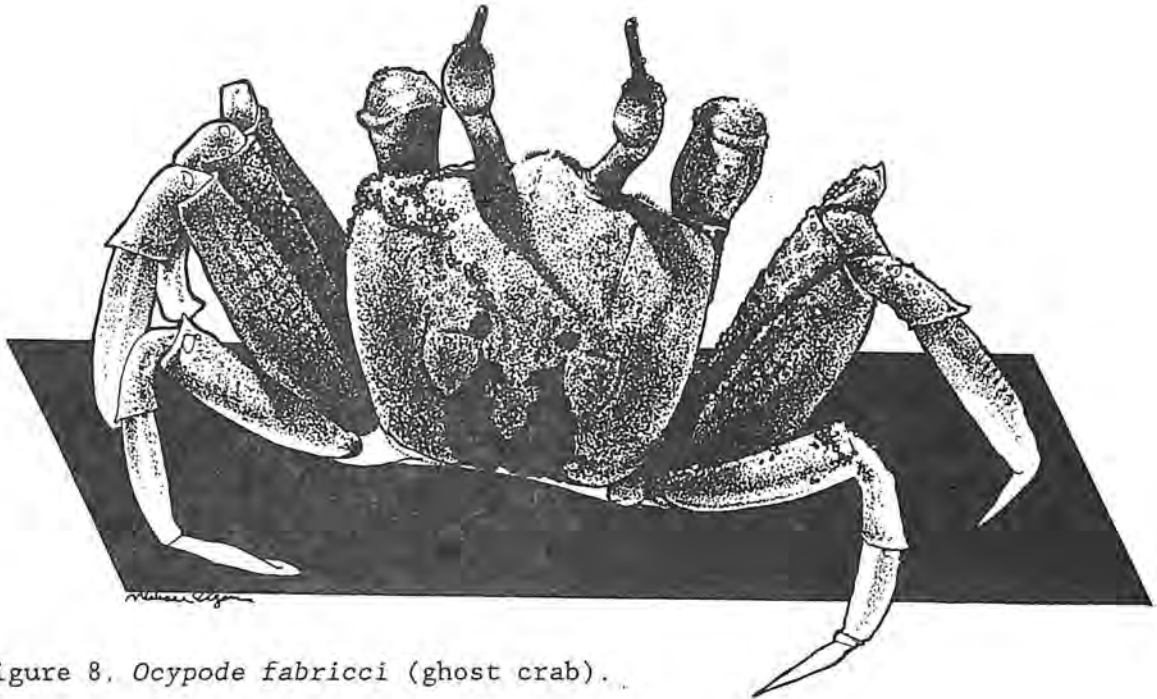


Figure 8. *Ocypode fabricci* (ghost crab).

2.4.3 DUGONGS

A number of Broome people have expressed concern about an apparent decline in the dugong population in Roebuck Bay and a possible need for more positive moves to conserve this animal. However, the issue is complex and as effective conservation measures would have to extend beyond Roebuck Bay, dugongs are considered beyond the scope of this study. However, officers from CALM are currently studying dugong populations throughout WA waters, including Roebuck Bay.

2.5 CULTURE AND HERITAGE

Planning and management strategies must take account of man-made resources as well as those of the natural environment.

2.5.1 THE BROOME "ATMOSPHERE"

Broome has a rich atmosphere deriving from its history as a pearling centre (the biggest in the world between 1880 and 1920), its cosmopolitan population, the fact that it was bombed during World War 2, and its "tropical look", which sets it apart from the more sterile mining towns and other hot and dusty coastal towns of the north-west.

2.5.2 ABORIGINAL SITES

Aboriginal people have inhabited the land within and around the town of Broome for many thousands of years. Some of their descendants still live in Broome, while others are dispersed throughout the Kimberley. They retain important links with the land and wish to see their sites protected.

Some of their sites were and some still are used as camping places. The camps which are predominantly along the coast near freshwater sources are marked by large scatters of shellfish remains, often with associated stones which were used as implements in everyday life. Certain other environments

were favoured for the collection of wild foods such as seed and fruit, and the provision of other requirements such as bark from particular types of trees. Some trees are scarred where toe holds have been cut for the collection of wild honey. Along the coast, traps were constructed of stone to harvest fish on the falling tide.

Burial sites have been found marked by bones in the sand or wedged in rocky outcrops.

There are many places in the Kimberley (often natural features in the landscape) which are associated with Aboriginal mythology and beliefs, and which still feature in the songs and stories of Broome Aborigines. Some of these stories and songs form part of the traditional exchange system, and spread from Broome throughout the Kimberley, and into the desert.

2.5.3 HISTORIC SITES - NON-ABORIGINAL

The special atmosphere of Broome is discussed in Section 2.5.1.

Many historic sites and structures remain as evidence of Broome's colourful past and some of these are within or close to the area covered by this plan. These include Bedford Park, portions of Chinatown (Photograph 13), Buccaneer Rock, Pioneer Cemetery, Customs House, the old jetty abutments at Mangrove Point and the wrecks of Dutch planes that were destroyed in 1942. These sites have been examined by the Built Environment Committee of the National Trust of Australia (WA), with respect to obtaining an assessment of their historical value and preparing recommendations about their classification and care.



Photograph 13. Carnarvon Street - Chinatown. These buildings give an indication of some of Broome's cultural origin.

3. EXISTING PLANNING AND MANAGEMENT CONTROLS

For the purposes of this plan it is necessary to examine not only land and water in the coastal strip but also adjacent and adjoining lands whose future use and management may affect the stability and quality of the coast.

3.1 EXISTING TENURE

The study area comprises unvested, vested and leased Crown land, freehold, urban, rural, commercial and industrial land and a port area (Map 7).

3.2 EXISTING ZONING

Land in the study area has been assigned a land use zone in accordance with the Broome Town Planning Schemes Nos 2 and 3 as shown on Maps 8 & 9.

3.3. EXISTING MANAGEMENT

The use of freehold land within and adjacent to the Broome townsite is controlled by Council through Town Planning Schemes 2 and 3.

There are extensive areas of vacant Crown land and Land Act reserves which are administered by the Department of Land Administration. That authority is responsible for the day-to-day management of vacant Crown land, while reserves may be vested in a variety of authorities which care for, and use them, under specified conditions.

The Department of Land Administration also provides special purpose leases for pastoral, residential, industrial, horticultural and other uses.

3.4 EXISTING FACILITIES

A number of facilities have been developed in the study area providing services for local residents, industry and tourists.

3.4.1 ROADS

Much of the area is serviced by roads, streets and informal tracks which provide access to most of the coast. Existing roads, streets and tracks are shown on Map 10.

3.4.2 CAR AND TRAILER PARKING

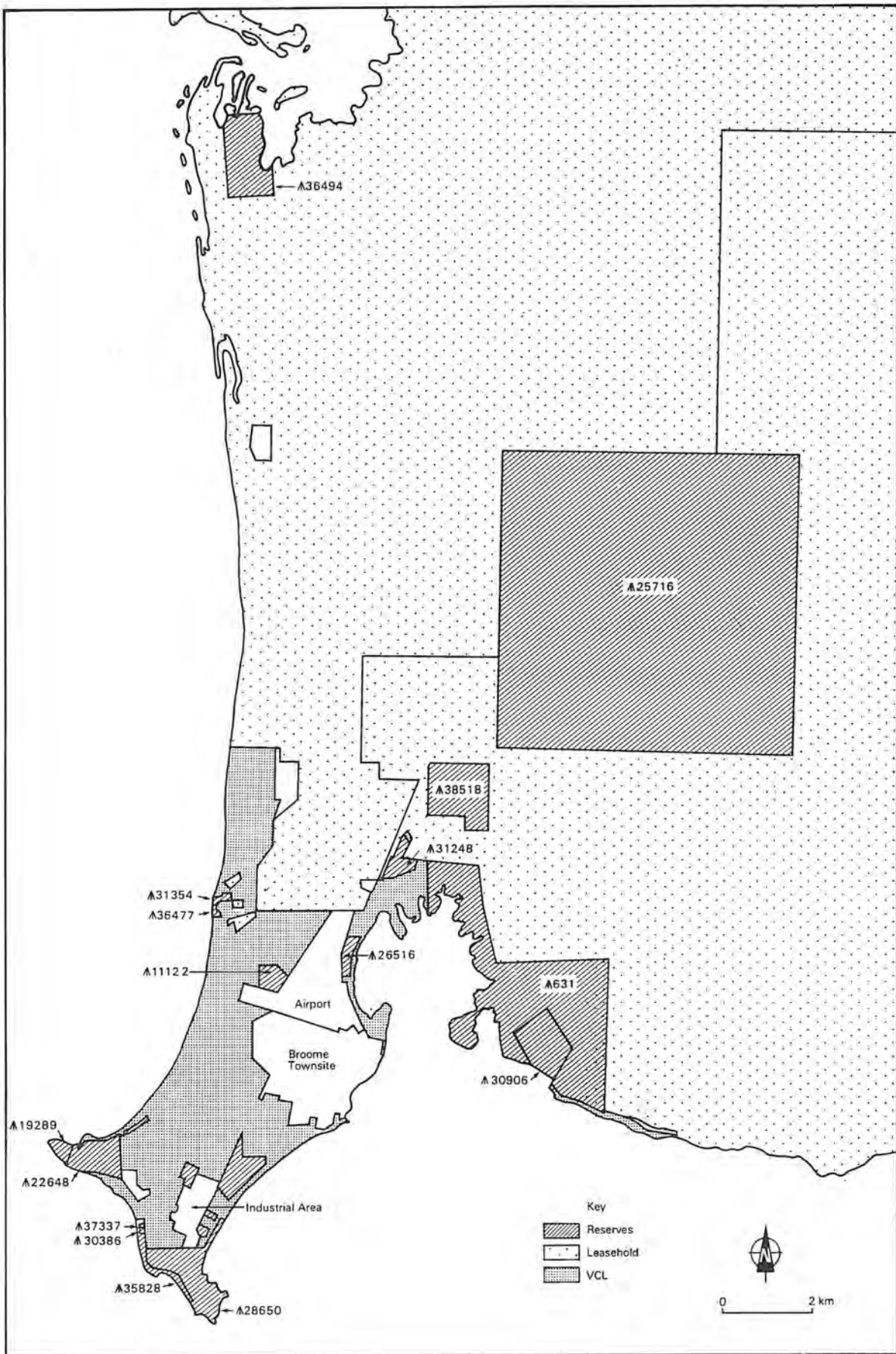
Car parking is available at several locations around the foreshore, and Council and the Department of Marine and Harbours periodically upgrade facilities. Existing parking areas are shown on Map 10.

3.4.3 BOAT LAUNCHING FACILITIES

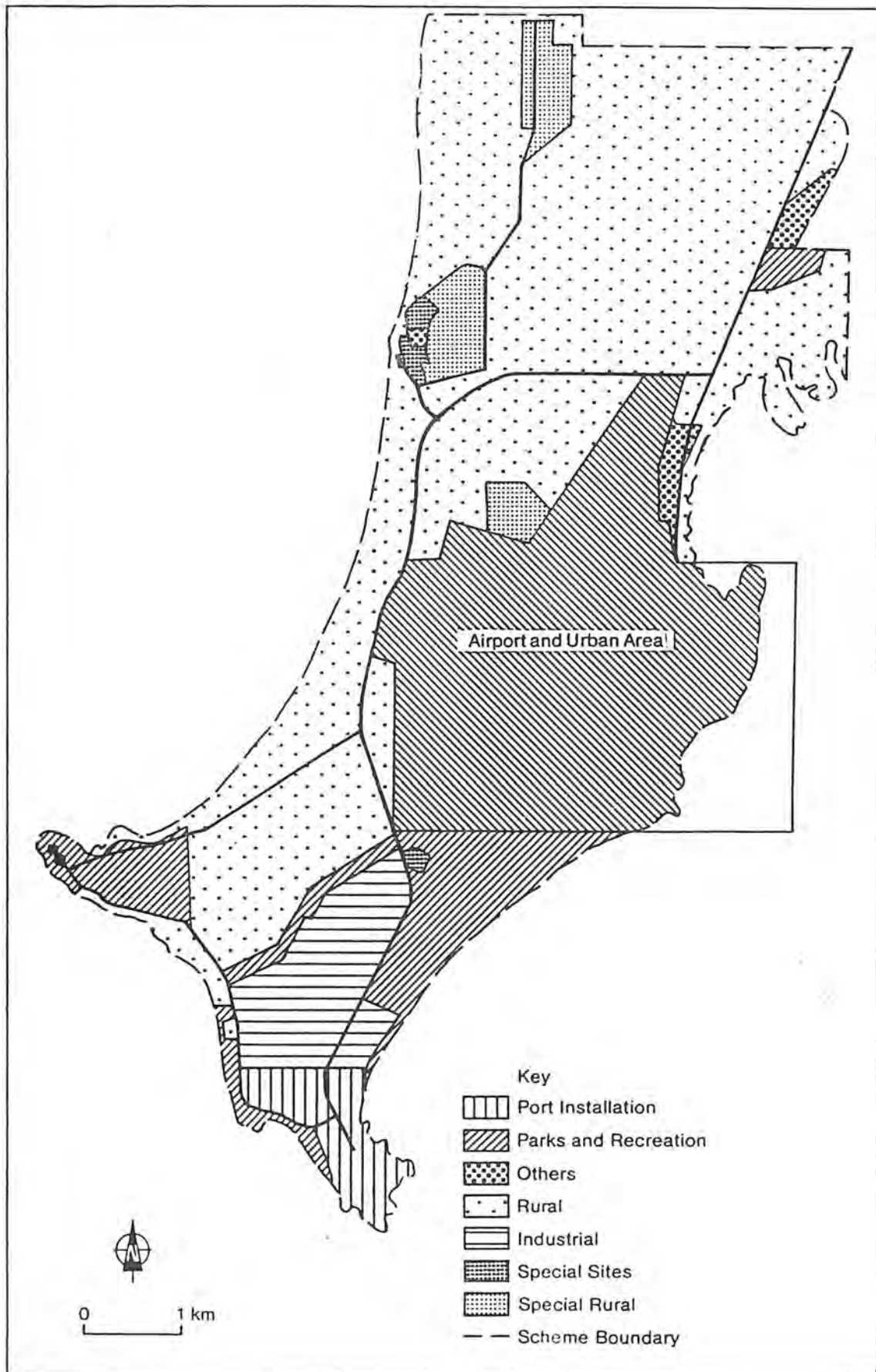
At present there are boat launching ramps near the port, Shire caravan park and at the end of Saville Street. In addition small boats are launched from a number of headlands around Roebuck Bay. The location of these facilities is shown on Map 10

3.4.4 BEACH ACCESS FOR PEDESTRIANS

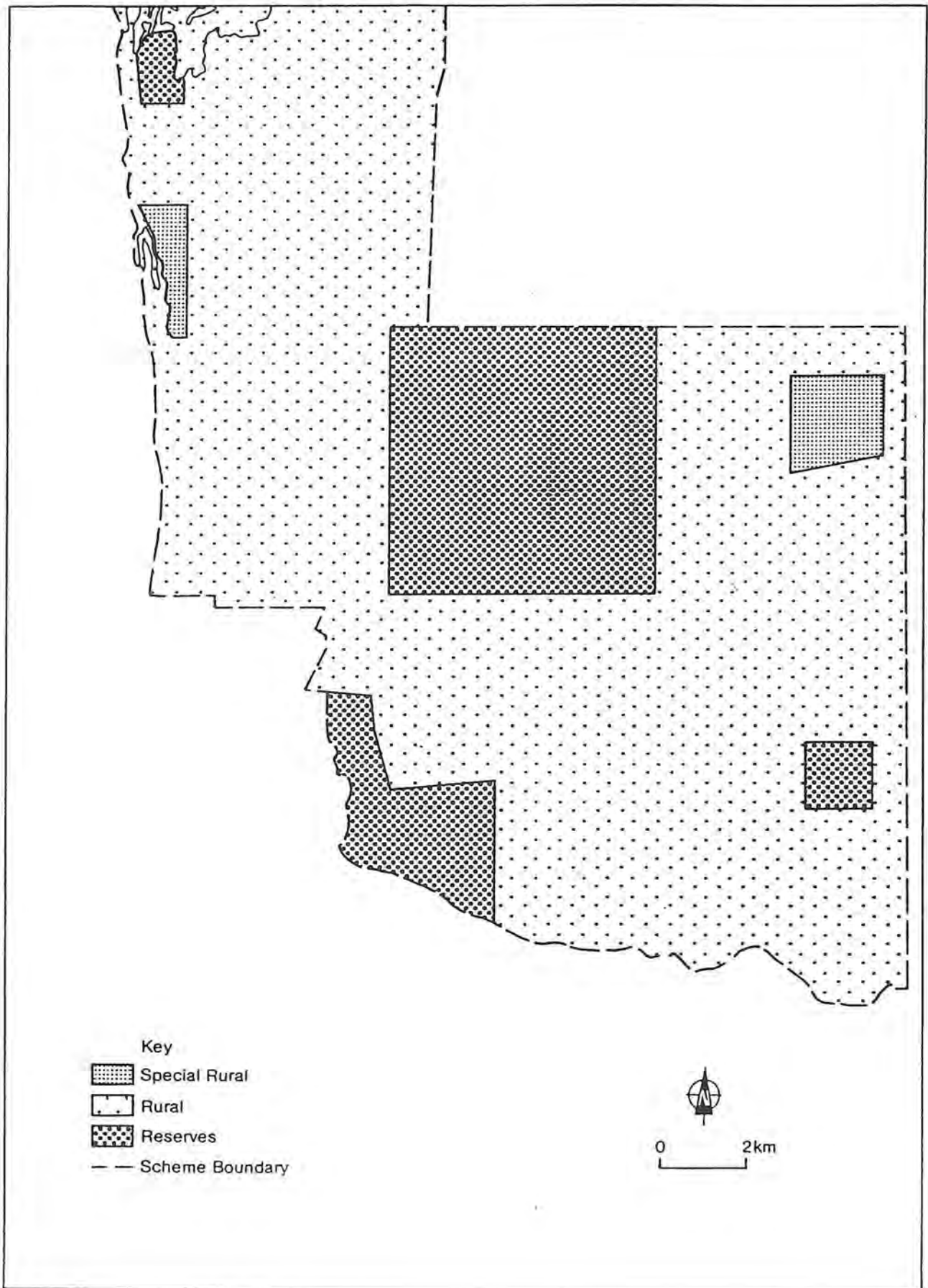
Pedestrians obtain access to the beaches of Roebuck Bay from a number of locations while steps and paths currently provide access to Cable Beach near Bali Hai. Access to Riddell Beach is restricted to a few points. The upgrading of pedestrian access to all beaches would be desirable.



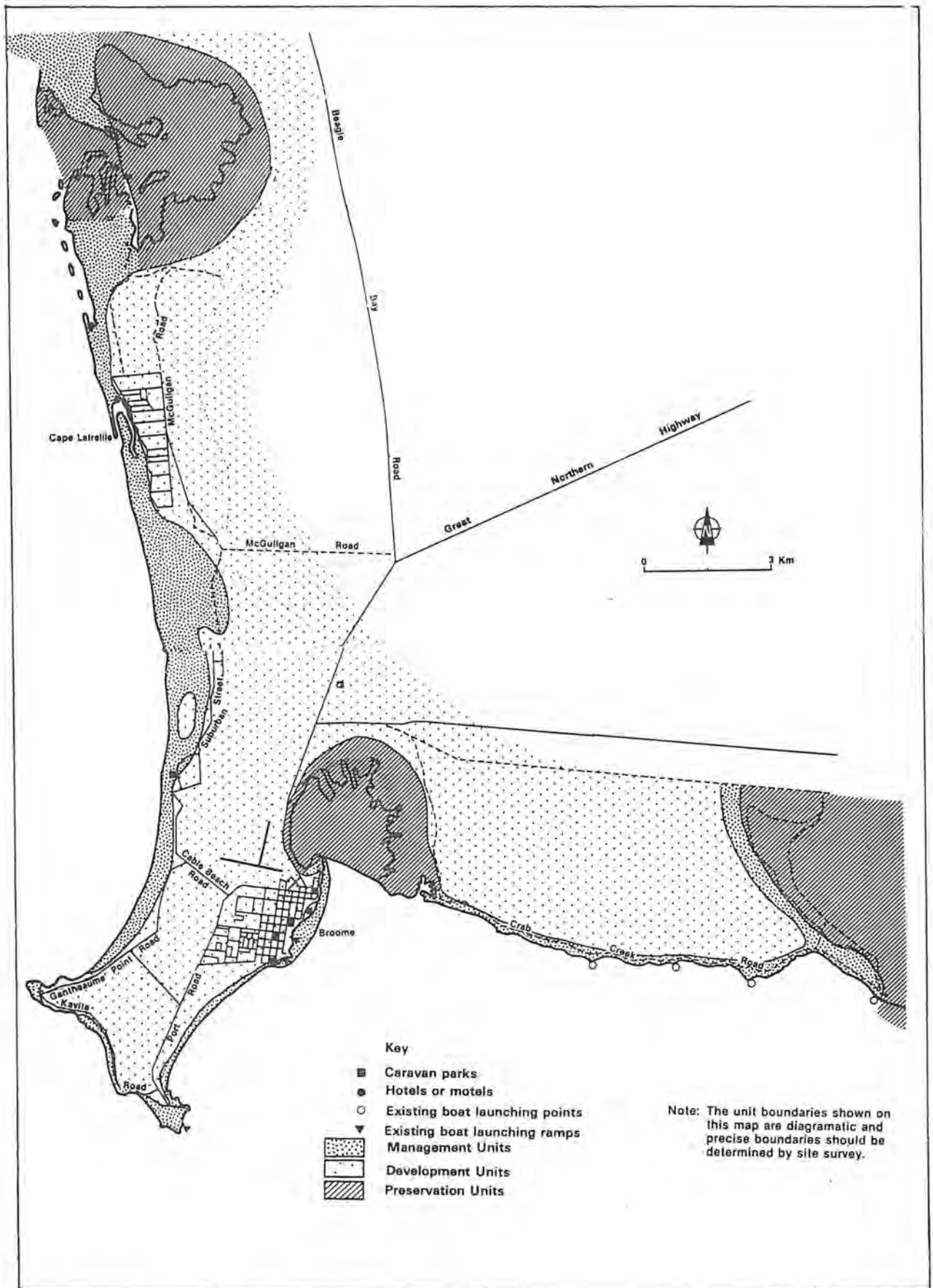
Map 7. Existing land tenure.



Map 8. Town Planning Scheme No 2.



Map 9. Town Planning Scheme No 3.



Map 10. Capability units, roads, boat launching areas and tourist accommodation.

3.4.5 JETTIES

At present there is a large jetty associated with the port facility (Photograph 14). This structure is used for port operation and provides a berth with associated loading facilities. The port jetty is also a valuable recreation resource for amateur anglers and sightseers. A private facility known as Streeters Jetty built for pearling luggers provides access to Dampier Creek in Chinatown (Figure 9).

In addition, the remains of the abutment for the original harbour jetty exist near the southern end of Robinson Street. This structure is also used by anglers and sightseers and is of historic interest.



Photograph 14. Anglers on the main jetty.

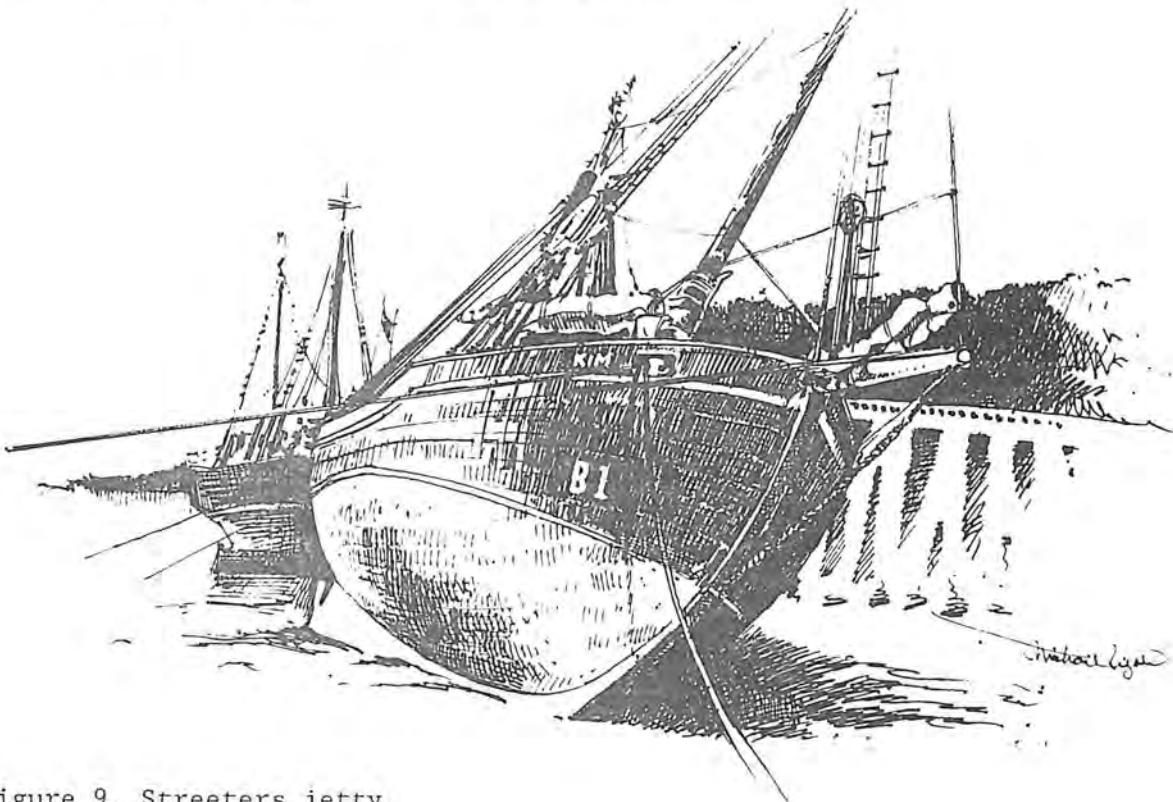


Figure 9. Streeters jetty.

3.4.6 PARKS AND TOILET FACILITIES

Formal parkland with toilets and barbecues has been developed on the foreshore near Bali Hai at Cable Beach. In addition a small parkland with playground equipment exists near the Shire caravan park at the southern end of Robinson Street.

3.4.7 TOURIST FACILITIES AND ACCOMMODATION

Tourist facilities and accommodation have been developed at a number of locations near the study area and include the Roebuck Hotel and Mangrove Hotel in Dampier Terrace, Continental Hotel in Weld Street and the Tropicana Motel in Robinson Street. Caravan parks exist at Bali Hai near Cable Beach and on Reserve 17132 at the southern end of Walcott Street.

3.5 USE PRESSURES

Coastal and adjacent areas in the Broome Shire are subject to a number of use pressures, which are increasing with the growth of the resident and tourist populations. It is important to collect information about existing and likely coastal land use pressure in order to make effective provision for these demands.

3.5.1 POPULATION GROWTH

The number of permanent residents in Broome increased from 4079 in 1976 to 4869 in 1981, an increase of 19.3%. This growth in population has increased recreational demand on the coast for bathing, surfing, fishing, boat launching and nature study as well as demand for private seaside accommodation. There are additional pressures associated with the provision of land for housing, the location of roads and the disposal of domestic waste. Any increase in industrial activity will stimulate demand for port facilities, industrial land, quarry products and waste disposal sites.

3.5.2 TOURISM

Broome is an important tourist centre and tourism is an integral part of the region's economy. The Shire has many of the attributes found in other popular coastal tourist resorts throughout the world, including a warm to hot climate and fine beaches associated with clear blue waters. In addition the environment is relatively free of natural dangers, crime, political instability, and disease which detract from other parts of the world which may otherwise be popular.

In the past Broome's relative isolation has limited growth of the tourist industry but recent upgrading of the Port Hedland-Broome road has made the town more accessible, and the upgrading of the Broome-Kununurra link will continue this trend.

The Western Australian Tourism Commission (WATC) has undertaken studies of past, existing, and projected visitor use of caravan parks, hotels, motels and guest houses, in Broome and other parts of the Kimberley.⁽³³⁾

This work predicts that there will be a steady increase (10% per annum) in the number of tourists visiting Broome and in the demand for accommodation. The coastal zone appears to be the main attraction, being used by 66% of residents and visited by 62% of tourists. While the majority (80%) of the

town's population agrees that tourism is important, a significant proportion (24%) considers that visitors lead to overcrowding and that the town's facilities cannot cope with the tourist influx (Photograph 15). For these reasons it is important that proper planning be undertaken to cater for the tourist trade while minimising the impact of tourists on the coastline and resident population.

3.5.3 HOLIDAY ACCOMMODATION

Associated with the projected growth of the tourist population is a requirement for more accommodation. The WATC survey indicates that caravan parks are preferred by non-business visitors as other forms of accommodation (hotel and motels) are too expensive; this suggests a growing demand for low to moderately priced accommodation (caravan park, chalets or flats). There have already been several applications to develop sophisticated forms of accommodation (hotel/motel) in the coastal zone, and more are likely. The WATC predicts that the number of powered caravan sites in the town will need to increase from the present 300 to 650 by 1990, requiring the development of two or three additional caravan parks. As tourism in Broome is seasonal, with 50% occupancy exceeded only between June and September, accommodation shortfall during this peak period may be met by allowing overflow onto adjacent lands that have been set aside for the purpose, rather than by increasing formal accommodation to cater for peak usage. Such management would require the approval of the Health Department.

3.5.4 ACCESS

The demand for greater access to the coast is increasing due to a growing population and availability of off-road vehicles. The consequent creation of vehicle tracks and pedestrian paths in the coastal zone has increased the likelihood of soil erosion problems.



Photograph 15. Bali Hai car park.

3.5.5 SMALL BOAT LAUNCHING

The high tidal range at Broome restricts the launching and retrieval of small boats. Three small boat launching ramps have been developed in the townsite and several natural launching areas exist on Roebuck Bay. As there is a potential conflict between boat owners using the town beach launching ramp and bathers the use of the other launching ramps should be encouraged.

3.5.6 SHELL COLLECTING

Professional and amateur shell collectors use reefs in the shallow waters around Broome as a source of live shells and fossils. The long term effect of this activity is not fully understood but it is a matter of concern, and warrants monitoring and investigation.

3.5.7 ABORIGINAL FOOD GATHERING

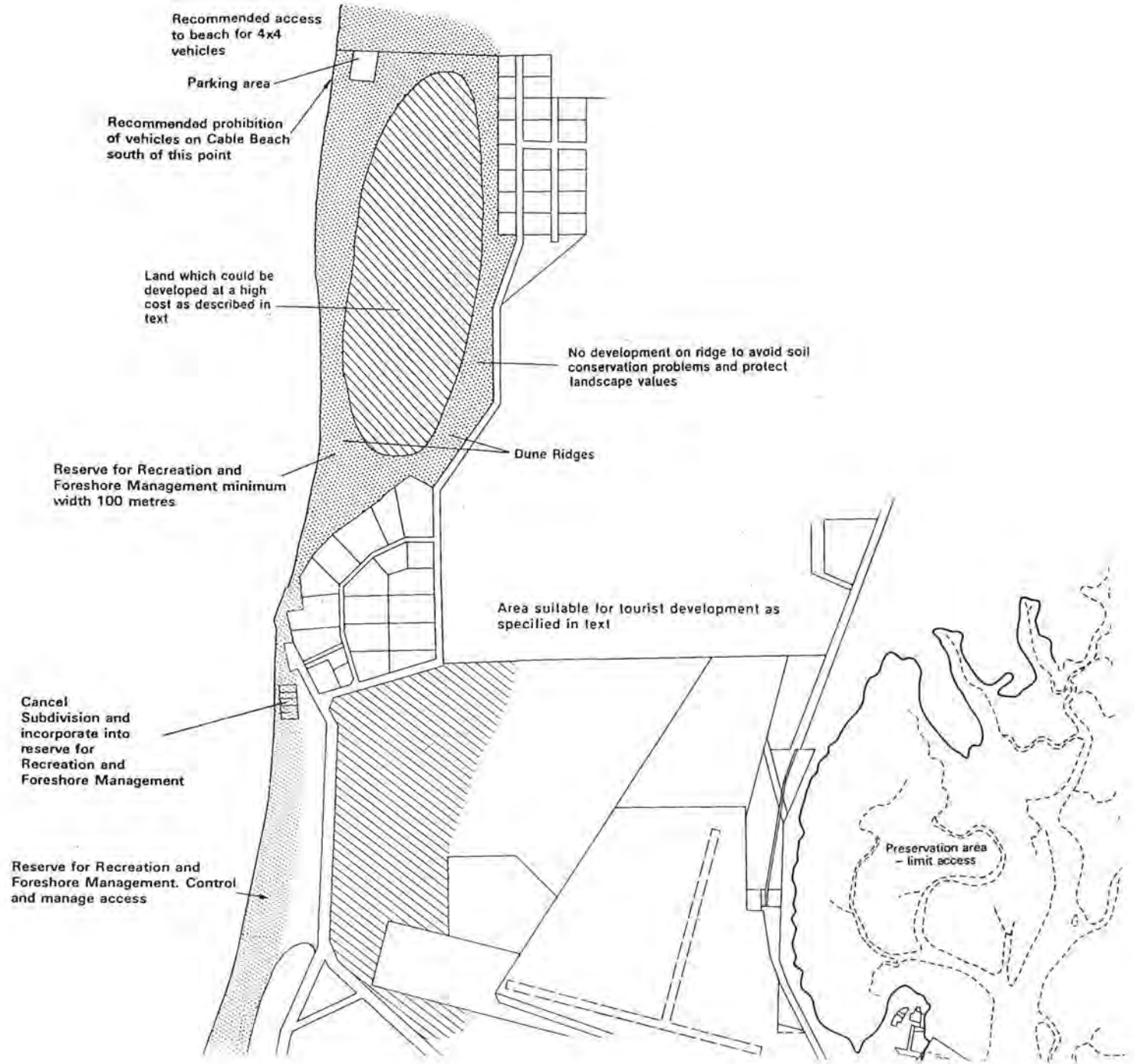
Aboriginal people continue to use the coastal environment as a source of wild foods, including fish, shellfish, native fruits and berries, and wild honey, all of which are important elements in their diet.

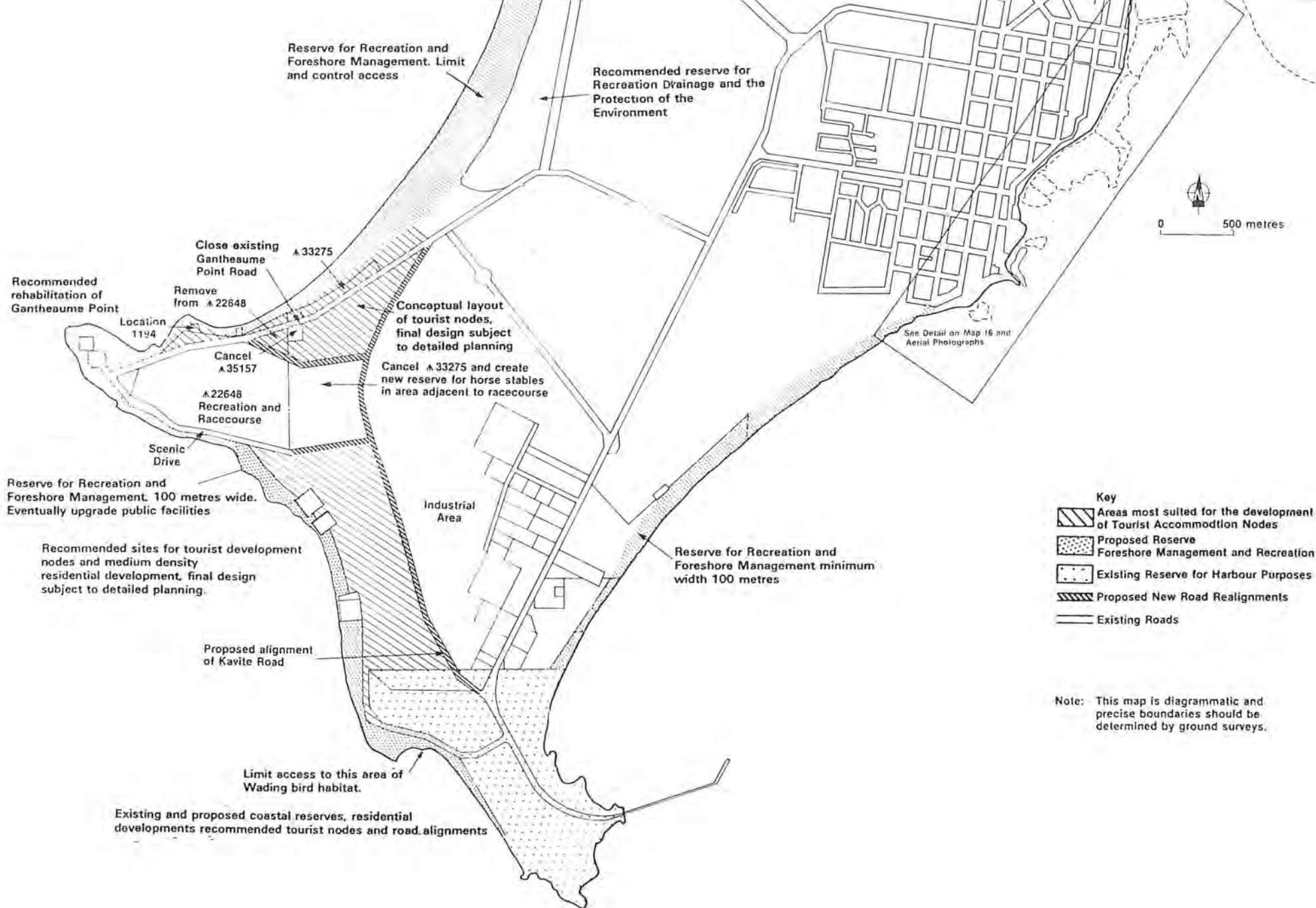
3.5.8 BOTANICAL GARDENS

The Broome Botanical Society has prepared a submission seeking approval to establish two botanical garden annexes within the study area. These include an area of remnant rain forest on vacant Crown land behind the Cable Beach sand dunes, near the intersection of Gupungi and Gantheaume Point Roads. The other site is on the Waterbank Pastoral Station near Coconut Wells.

The submission proposes that these areas of interesting vegetation be protected by an appropriate reservation as shown on Map 11. Later development of the area would include the provision of access landscaping and supplementary planting where appropriate.

Map 11. Proposed developments.





Reserve for Recreation and Foreshore Management. Limit and control access

Recommended reserve for Recreation Drainage and the Protection of the Environment

Recommended rehabilitation of Gantheume Point

Close existing Gantheume Point Road

A 33275

Remove from A 22648

Location 1194

Cancel A 35157

A 22648 Recreation and Racecourse

Scenic Drive

Conceptual layout of tourist nodes, final design subject to detailed planning

Cancel A 33275 and create new reserve for horse stables in area adjacent to racecourse

See Detail on Map 16 and Aerial Photographs

Reserve for Recreation and Foreshore Management. 100 metres wide. Eventually upgrade public facilities

Industrial Area

Reserve for Recreation and Foreshore Management minimum width 100 metres

Recommended sites for tourist development nodes and medium density residential development, final design subject to detailed planning.

Proposed alignment of Kavite Road

Limit access to this area of Wading bird habitat.

Existing and proposed coastal reserves, residential developments recommended tourist nodes and road alignments



- Key**
- Areas most suited for the development of Tourist Accommodation Nodes
 - Proposed Reserve
 - Foreshore Management and Recreation
 - Existing Reserve for Harbour Purposes
 - Proposed New Road Realignments
 - Existing Roads

Note: This map is diagrammatic and precise boundaries should be determined by ground surveys.

3.5.9 COMMERCIAL FISHING

The major commercial fisheries in the area involve the culture of pearl oysters and the capture of approximately 100 tonnes of threadfin salmon per year. These operations depend on limiting exploitation to sustainable levels and the maintenance of a balanced ecosystem.

3.5.10 MINING AND QUARRYING

Various parts of the coastline in the Broome Shire have been quarried for building gravel and road base materials and this has caused environmental problems in some locations. The areas of major concern are the old gravel pits along Crab Creek Road and the pits located on sand dunes around the coast of the Broome Peninsula. In addition, a number of other locations are covered by mining tenements and may be exploited in the future.

3.5.11 PORT DEVELOPMENT

While the port is outside the area of the Town Planning Scheme, its presence and the activities associated with it have potential for affecting coastal areas. The development and management of this area is the responsibility of the Department of Marine and Harbours.

3.5.12 URBAN DRAINAGE

The Broome urban area is expanding rapidly and this is creating problems associated with the disposal of storm water. The construction of houses, roads, parking areas and other impermeable surfaces increases surface runoff which must be removed for engineering and health reasons. Council has developed an elaborate storm water disposal system on the eastern side of the Peninsula but as the town develops toward the west another system will be required because the western side of the Peninsula drains toward Cable Beach.

3.5.13 RUBBISH DUMPING AND LITTERING

Rubbish has accumulated at various locations around the Broome Peninsula. The worst area is the foreshore between the meatworks and Napier Terrace, but a number of other locations also cause concern.

3.5.14 SHACK CONSTRUCTION AND ILLEGAL CAMPING

Shacks and illegal camps which occur at a number of locations around the foreshore could create health and social problems. These activities appear to result from a lack of public housing and the unwillingness of some visitors to pay fees at recognised camping areas.

3.5.15 HORSE TRAINING

Racehorse stables and yards occupy leases between Gantheaume Point Road and the beach. In the longer term these leases should be moved to a more permanent site immediately north of the racecourse.

3.5.16 BIRD OBSERVATORY AND FIELD STATION

As outlined in Section 2.3.2.1 the mudflats and beaches of Roebuck Bay provide wading bird habitats of international significance. The Royal Australasian Ornithologists Union (RAOU) have made application to Council and the Department of Land Administration seeking approval to establish an observatory and field station near Fall Point, to facilitate the study of these birds.

3.6 ASSESSMENT OF MANAGEMENT NEEDS

The effective management of coastal areas has not always been achieved in the past for a number of reasons. The Department of Land Administration is responsible for leased, vested and unvested Crown land but has limited resources to undertake management.

Council manages and develops a number of reserves on the foreshore but inadequate funding and limited expertise have resulted in some inappropriate works occurring in the past. If land is vested in agencies care must be taken to ensure that they have the information and resources required to care for the area adequately.

When tourist facilities are developed which utilise natural features such as attractive sections of coastline, funding for the management of the natural resources involved should be regarded as a normal management cost. Without funding and management, degradation of the resources providing the attraction may occur.

At present, access to much of the coast is informal though Council has attempted, notably behind Cable Beach, to limit access to defined paths. Rationalisation of roads and access to suitable sites needs to be undertaken in order to allow use of coastal resources while minimising environmental degradation and its associated management costs.

At present inadequate management consideration is given to quarrying works, wildlife habitat preservation, shell collecting, Aboriginal sites, waste disposal (industrial, domestic and stormwater) and underground water. To avoid problems at a later date these issues need to be considered now.

3.7 MANAGEMENT ISSUES

3.7.1 MANGROVES

As indicated in Section 2.4.1 mangroves have a vital role in the coastal ecosystem and in maintaining shoreline stability. The mangroves in the Broome area were widely exploited for firewood and building materials early this century, resulting in the clearing of large areas. More recent lifestyles have halted this sort of exploitation but now other activities threaten these important biological communities. Currently, mangroves in developing areas may be influenced by felling, rubbish dumping, dredging, and other physical changes to the system. In addition, there may be pressure to remove mangroves to reduce problems associated with pest species like biting midges and mosquitoes. Any proposal to make significant alterations to the mangrove system should be preceded by a thorough environmental investigation.

In WA protection of tidal wetlands is covered by three acts; the Fisheries Act, the CALM Act and the Rights in Water and Irrigation Act. These Acts prohibit deposition of filth and refuse, discharge of wastes into waters where fish or fishing grounds are likely to be, and removal or disturbance of the ecosystem as well as interference with water supply. At this stage rather than declare the mangroves sanctuaries or marine parks as is required under the various Acts, Council should recognise the importance of the mangroves and through planning policy implement a strategy to preserve them by avoiding incompatible land use of adjacent areas.

3.7.2 QUARRYING

As Broome has few reserves of building sand and aggregate, except along the shoreline, there is pressure to quarry in the coastal zone. The prized coarse beach sands which are not abundant are probably not critical to shoreline stability as generally the shoreline is defined by a backing pindan cliff. However, removal of beach sands will result in loss of any beach and more accelerate of the pindan.

The prized lateritic gravel with outcrops along the sea cliffs east of Dampier Creek and around Gantheaume Point is in greater supply and large scale disturbance has taken place in an effort to quarry these deposits. Apart from visual impact there is probably no harm being done. A deposit in front of the Mangrove Motel is in a more sensitive location as removal of the rocks and disturbance of the mangroves will lead to greater erosion of the shore. Again the potential rate is not known but considering the nearby developments, quarrying this limited deposit would not be wise, unless on a scale small enough to allow for natural revegetation by mangroves.

The Pleistocene dune sands which are not greatly prized as a building material are quarried at numerous locations (Riddell Beach, behind the abattoirs, and near the Mangrove Motel). As the dunes mostly lie over pindan, their removal probably does not affect shoreline erosion rates. There are numerous large deposits well away from the shore that could be quarried with no effect (eg in port area; north of Bali Hai adjacent to the northern tidal flats).

Though not highly prized the Holocene dunes are quarried south of Bali Hai. In view of the possible sensitivity of Cable Beach this should be stopped as proximity to town is the only major advantage of this deposit.

3.7.3 COASTAL PROCESSES

Unlike other sandy coasts the beaches around Broome do not seem to have a source of sand size material to replace sediment lost because of erosion. Most of the beach and dune sand is probably re-worked pindan or Pleistocene material with a small contribution of carbonate from contemporary or Holocene shells. It is also evident that little sand has come ashore during the Holocene and that there is not much sand available for transport onshore in the future. Consequently the contemporary shoreline processes tend to be erosive and most of the shoreline is receding, resulting in the formation of vertical pindan cliffs with narrow red-stained beaches punctuated by rocky outcrops. Erosion products are transported away from Gantheaume Point toward Willies and Crab Creek respectively. As this process is likely to continue, the white sandy beach along Cable Beach must be regarded as a temporary and "fragile" feature. In order to preserve this valuable resource, care must be taken to avoid exacerbating loss of sand from the area. The normal short term recycling of sand during storms and the retention of a store of sand in the dune system should be recognised. Quarrying of dune sand should not be allowed and revegetation of bare areas should be a matter of priority. Relevant government agencies can provide advice in this regard.

Coastal development should take account of the worst possible combination of cyclonic winds, storm surge and storm waves, although such events may be rare. Despite the mild prevailing conditions it should not be forgotten that it is usually the rare high energy event which shapes or destroys coastal features and developments. The possibility of a high tide with combined storm surge and storm waves must be considered if any development is to be located close to the coast.

3.7.4 MIGRATORY WADING BIRDS

As a signatory to international treaties on protection of migrant birds, Australia has an obligation to ensure careful management of habitats used by these birds. At present there is no management of these areas. With increasing tourism, management and control of access will become urgent. Advice from relevant government departments should be sought on the areas that need management and on suggested techniques.

3.7.5 CULTURE AND HERITAGE

With increasing pressure for growth, Broome is in danger of losing its "atmosphere". Already new residential developments which lack the character of the older suburbs are proliferating. Unspoilt beaches and nearby coastal lands are being developed and construction of buildings that detract from the open, clean and untouched feeling has already taken place. Valuable and scarce coastal land is being used for activities that could take place elsewhere. Rationalisation of these issues is required.

3.7.6 ABORIGINAL SITES

All sites of importance to Aboriginal people are protected under the Aboriginal Heritage Act, 1972-1980. The Act makes provision for the preservation of places and objects customarily used by, or traditional to Aborigines. Any development in Broome which is likely to disturb these sites will necessitate an application in writing to the Trustees of the WA Museum. The Trustees are responsible to the Minister for Aboriginal Affairs for the administration of the legislation.

Where tourist development will affect the natural environment it is essential to seek advice to protect sites and other places of importance to Aboriginal people. It is difficult for a developer to know whether an area of land contains significant Aboriginal sites and it is therefore most important that the relevant Aboriginal people and organisations are notified of developments well in advance. Before developments occur Council should consult with local Aboriginal communities and the Registrar of Aboriginal Sites at the WA Museum.

3.8 OPPORTUNITIES AND CONSTRAINTS

Broome has a number of resources which offer opportunities to provide for human needs while the nature of the environment limits or constrains the level of use that can occur without a loss of natural values or high management costs. Recognising constraints as well as opportunities is vital to effective resource management.

Unlike some other areas, Broome has been subject to relatively little development pressure. Although exploitation of natural resources has occurred, use patterns are not deeply entrenched. However, there is already evidence of conflict between users, and some environmental problems. This management plan will assist in guiding future use of resources and establishing appropriate use patterns.

3.8.1 RESOURCES (OPPORTUNITIES)

The study area has the following significant resources:

- . a small but prosperous town based on tourism, agriculture and commercial fishing;

- . a management infrastructure based on the Shire of Broome, and various State and Commonwealth authorities;
- . a rich history with associated sites, a cosmopolitan population and tropical easy-going atmosphere;
- . a developing system of roads and other services that provides access from the rest of the State and the Northern Territory;
- . a well developed airport;
- . an existing port, jetties and safe moorings for small boats;
- . varied coastal scenery including attractive sandy beaches and dunes, clear blue waters, tidal creeks and flats and mangroves;
- . a rich natural ecosystem which provides abundant fish and wildlife resources;
- . natural food resources which are utilised by the Aboriginal people;
- . attractive semi-arid and sub-tropical vegetation which contrasts with the arid hinterland of much of the north-west of the State; and
- . limited reserves of potable underground water are available outside the study area, however reserves within the townsite are extremely limited. The Mines Department has undertaken hydrological investigations in the area and recommended strict limits on the use of ground water for irrigation in the district.

3.8.2 CONSTRAINTS

Use constraints which influence planning and management in the Broome area include:

- . existing use patterns and planning procedures;
- . potential conflict between resident and tourist populations for local resources;
- . the great distance from other population centres with management and technical expertise;
- . a seasonal climate with occasional heavy rainfall and hurricane force winds;
- . an irregular rainfall which makes proper stormwater drainage and the establishment of vegetation difficult;
- . pindan soils and sand dune systems which depend upon vegetation for their stability;
- . a large tidal range which creates coastal engineering problems;
- . high building costs which threaten to prevent continuation of the Broome-style construction;
- . a naturally eroding coastline on which areas suitable for recreation are limited;

- . infrequent cyclonic winds and wave attack which affect coastal structures; and
- . limited development and management funding.

4. PLANNING AND MANAGEMENT GOALS, OBJECTIVES AND POLICIES

The purpose of management planning is to achieve a systematic and coordinated approach to planning, management and development that takes into account the natural environment as well as human uses and needs. The process involves consideration of an area's natural attributes and its capacity to support particular uses as well as recognising the potential impact of natural forces on man-made developments.

4.1 PLANNING AND MANAGEMENT GOALS

As the coastal zone is a limited resource and a major goal of coastal management is to protect the environment, Council should adopt the following goals:

- . Only uses that depend on a coastal location shall be permitted in the coastal zone;
- . The coastal environment will be protected and improved where possible.

4.2 OBJECTIVES

To assist in achieving the goals, Council should pursue the following objectives:

- . Maintain existing terrestrial and marine systems, coastal processes, landscapes and cultural assets.
- . Protect and maintain groundwater resources and seawater quality.
- . Provide for a wide range of appropriate recreational use.
- . Preserve the Broome atmosphere.
- . Protect Aboriginal sites.
- . Encourage and cater for tourism.
- . Provide for appropriate commercial and industrial activities.
- . Develop a public education programme.

4.3 PLANNING AND MANAGEMENT POLICIES

Council will adopt the following policies to achieve the goals and objectives outlined above.

4.3.1 ALLOCATION OF COASTAL AREAS FOR USE

Before any area in the coastal zone is allocated for a particular use the proponent must demonstrate that the use requires a coastal location. Only uses which can be accommodated without degradation or increased maintenance costs will be permitted, unless there is a benefit to be gained that overrides these costs.

4.3.2 RESOURCE UNITS

In order to provide a guide to potential uses of the coast the coastal area has been classified into three broad units based on importance to the ecosystem and its capacity to absorb development of use, which are shown on Map 10.



Streeter and Male's.

4.3.2.1 Development Unit

Areas which can be developed or used with normal levels of caution and with minimal impact.

4.3.2.2 Management Unit

Sensitive areas with particular ecological, cultural or recreational importance, the development and use of which must be strictly controlled or managed. Development is usually expensive (in both capital and maintenance) and special precautions must be taken to avoid flooding, drainage or erosion problems and to manage human use pressure. Any development or use proposals should be preceded by special planning.

4.3.2.3 Preservation Unit

Areas vital to preservation of the ecosystem, which are intolerant of development and which should be preserved and protected from most human activities.

Within this broad land use capability guide, more specific land use zoning and management strategies can be applied.

4.3.3 PRIORITIES

Any planned use of a coastal resource should take account of the long term effect on natural ecosystems, landscape, coastal processes and groundwater resources. Priorities for allocation of land uses and financial resources should be based on long term planning not on ad hoc responses to development applications.

4.3.4 FUNDING

Each year a budget item will be created providing for management of resources in the coastal zone under Council's control. Applications for grants from appropriate agencies will be made as the need arises and in the light of the long term plan.

4.3.5 SUPERVISION AND POLICING

Council shall employ rangers to investigate and report on management requirements in areas vested in Council and other areas in the coastal zone. Rangers will enforce regulations when appropriate. When appropriate Council officers will cooperate with officers from other management authorities.

4.3.6 LAND USE ZONING

Land use within the development unit in or near the coastal area will be zoned to avoid conflicts between incompatible use pressures and users. Basically the zoning recommended in the Broome Town Planning Schemes 2 and 3 is endorsed with exceptions outlined in the plans for the seven coastal management areas.

4.4 ACCESS

Through the rationalisation and upgrading of the road, track, carpark and pedestrian path systems, public access to the coast will be controlled and maintenance costs and environmental damage minimised.

Major roads will be restricted to the development unit with appropriately located minor roads providing access to or through the management unit. Tracks in appropriate locations will be upgraded, others will be closed and revegetated. Road and track access to the preservation unit will not be permitted.

Changes to the alignment of Crab Creek, Kavite and Gantheaume Point Roads will be required to allow more space along the coast for tourism and recreation, as shown on Map 11.

4.4.1 OFF-ROAD VEHICLES

Off-road vehicles are frequently used on Broome beaches. Their use may be permitted in the coastal zone providing operators use properly constructed tracks when available, keep off sand dunes and avoid conflict with other beach users. Vehicles may be used between low tide level and the foredune without environmental damage providing proper access to the beach exists. Vehicles should not be used on popular bathing beaches.

Recommended policies:

Council will

- . Provide adequate access to popular points, involving the staged development of the roads, tracks, carparks and footpaths.
- . Educate the public by providing adequate information concerning the access system and the need to conserve the coastal environment.
- . Implement the provisions of the Control of Vehicles - Off-road Areas Act 1978. The coastal management areas as defined in the Town Planning Scheme should be declared a prohibited area for all motor vehicles, with the exception of the designated vehicle access roads, tracks and carparks, and some parts of Cable Beach between low tide level and the foredune.

Four-wheel drive vehicles could obtain access to Cable Beach through the management unit immediately south of Waterback Station, without causing environmental problems. The development of this access route would avoid conflicts with beach users further south (see Map 11).

4.4.2 CARPARKS

The location and design of carparks significantly influences which areas of the coast are used by people. They can be used as an effective management tool for guiding people into areas best able to sustain use pressure.

The design of carparks will affect their construction and maintenance cost and their impact upon the landscape. Diagrams showing recommended typical design for carparks is shown in Appendix 4.

4.4.3 PEDESTRIAN ACCESS

Recommended policy:

- . Random pedestrian access will not be permitted in either management or preservation units though controlled access through management units will be permitted. Pedestrian access will be determined by carpark locations and control will be achieved by the provision of formal fenced pathways and signposting.

4.4.4 LAUNCHING FACILITIES

Recommended policy:

- . Development of boat launching facilities which will make boating safe and more enjoyable will be encouraged at suitable locations. Because of the high tidal range development of safe and adequate launching facilities needs careful consideration. Council will seek advice from the Department of Marine and Harbours.

4.5 DEVELOPMENTS

Recommended policies:

- . Tourist, urban, industrial and commercial developments will generally be restricted to the development unit. Tourist development may occur in the management area if it is preceded by proper environmental assessment and planning.
- . Development nodes rather than ribbons will be encouraged to isolate management problems in the adjacent management units. Where possible, a buffer zone will be provided between developed areas and management units where uses that do not encourage coastal access, eg playing fields, golf courses and botanical gardens.
- . Active recreation areas will be restricted to the development unit, eg race course, playing fields, ORV tracks and rifle range. Controlled passive recreation will be permitted in the management unit and facilities provided as appropriate, eg paths, seats, tables, lookouts and parkland.

4.6 TOURISM

As outlined earlier tourism is an integral part of Broome's economy. As the WATC anticipates a significant growth in tourist visits during the foreseeable future there is a need to plan for tourist facilities and accommodation. The WATC's studies indicate that more low and medium cost accommodation will be required during the next five years. While the siting of tourist accommodation is a complex issue it is possible to make a number of recommendations.

Recommended policies:

- . Tourism will be encouraged and provided for in a manner that avoids conflict with residents and environmental degradation.
- . Wherever possible facilities will be in attractive locations, with ready access to a safe swimming beach or pleasant views as this will tend to extend the average length of stay for visitors, improve the viability of the enterprise and provide extra revenue for the town.
- . Generally, holiday accommodation will be within the townsite as defined by the Town Planning Scheme, or close to it to minimise servicing costs, avoid fragmentation of the town and strengthen the overall viability of industries serving tourists. In addition, the centralisation of development will reduce its impact on the amenity of more remote areas.
- . Tourist developments near the beach will be concentrated in nodes which include:

- a foreshore reserve which will protect the beach and associated sand dune systems and allow natural coastal processes to occur without threatening developments;
- an area of public parkland which can be improved as the need arises;
- a public access system comprising roads, carparks and properly fenced paths to the beach; and
- an area for appropriate holiday accommodation.

- . The design of such tourist nodes should improve access to popular sites and ensure that people moving between the beach and the parkland, carparks and holiday accommodation do not need to cross any road. This may require the realignment of roads in some locations. Suggested typical designs for tourist development nodes are shown on Figure 10.

Location of suggested tourist developments (Map 11) shows a number of sites which are considered suitable for tourist accommodation purposes after considering sand dune stability, aesthetics, wildlife and vegetation, beach quality and the location of existing improvements. However, the cost of servicing these areas requires further consideration.

- . The existing Shire caravan park could be extended into the vacant area adjacent to the meatworks, but this will require some redevelopment of the site. This will increase the capacity and profitability of the Shire park and could provide a considerable number of additional caravan sites in the short term.
- . Reserve 31340 will be retained for recreation purposes and gradually upgraded and landscaped as the need arises.
- . Some areas near Riddell Beach will be developed for holiday accommodation while others would be more difficult because of dune stability problems.

In addition the eastern end of Riddell Beach is used by wading birds during the summer. Development of this area requires the realignment of Kavite Road. The most suitable development sites are shown on Map 11 and typical design and layout is shown on Figure 10.

- . Areas north east of Gantheaume Point have been designated for tourist development in Town Planning Scheme No 2. However, there are difficulties associated with services and tenure which must be overcome before these sites are utilised. In addition the sand dune systems on Cable Beach, which form an integral part of the coastal system, are potentially unstable and concentrations of people should be carefully located and access managed to avoid problems. The best use of the Gantheaume Point area will require the rationalisation of the road system as shown in Map 11.
- . Tourism development has already occurred at Cable Beach in the vicinity known as Bali Hai. More developments will be concentrated in this area as the town grows as shown on Map 11.

North of Bali Hai a large area of relatively flat and stable land lies within a series of dune ridges. This land is close to the beach, supports a

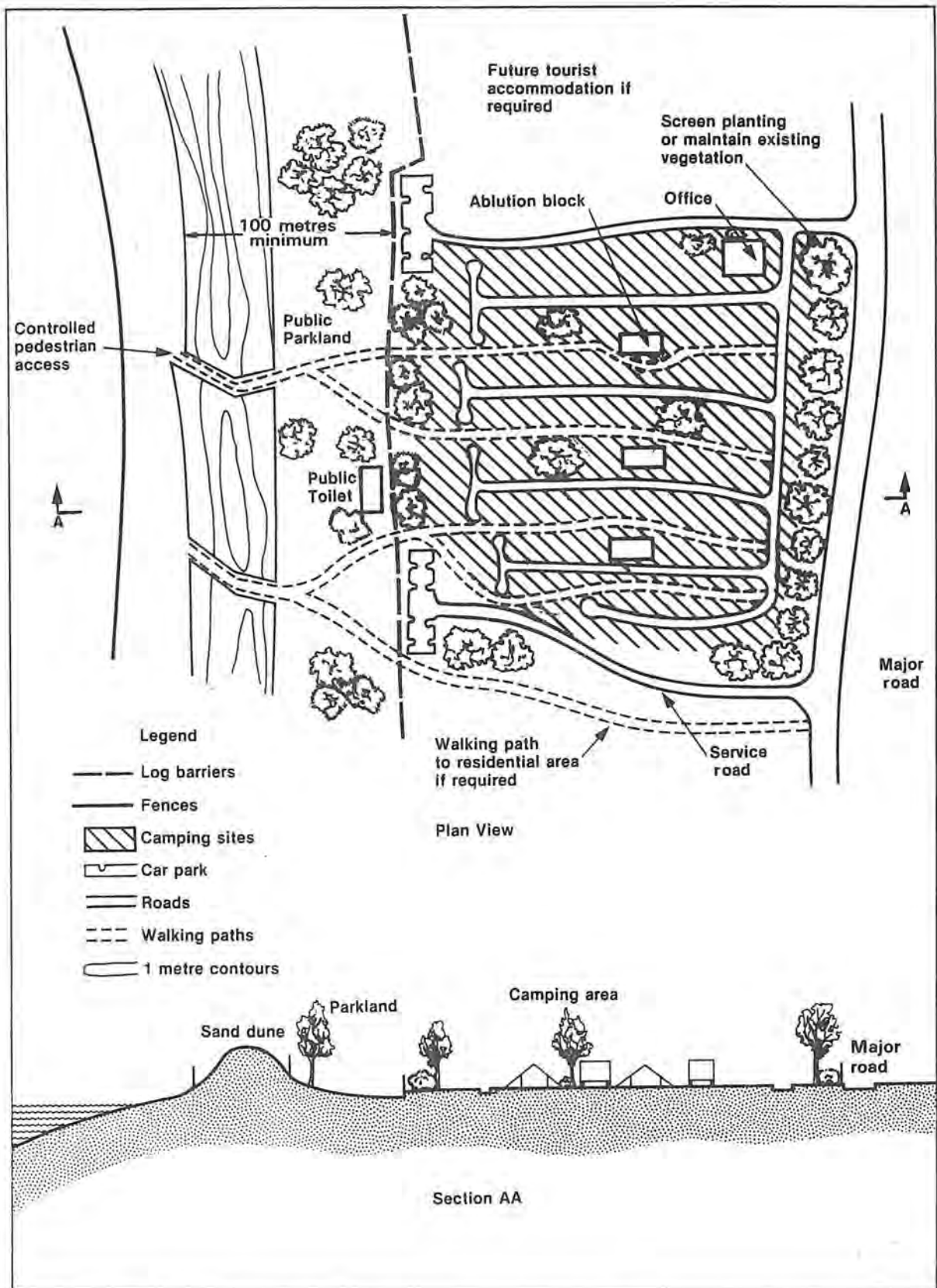


Figure 10, Typical Diagram - Tourist Development Node.

community of large trees and provides an attractive area for development (Figure 11). A detailed study is required to determine the limits of development in this area.

The stabilisation and development of the area would be relatively expensive and any proposal to use it should be accompanied by a foreshore stabilisation plan to be approved by the Commissioner of Soil Conservation and funded by the proponent.

Management Recommendations (Section A-H)

NOTE: Recommendations should be considered in context of text on pages

A-B Beach

B-C Reserve for Recreation and Foreshore Management. Should be no less than 100 metres wide. Improvements should be publicly owned and expendable because of storm damage risk. Revegetate and provide controlled access. Rebuild foredune and revegetate primary dunes and provide access to the beach.

C-D Possible development area. This area could be used for low cost expendable developments such as parking areas with tourist facilities

D-F Area suggested for high capital developments.

F-H With the exception of limited access systems development should not occur on the ridge (F-H) to avoid erosion and protect the landscape.

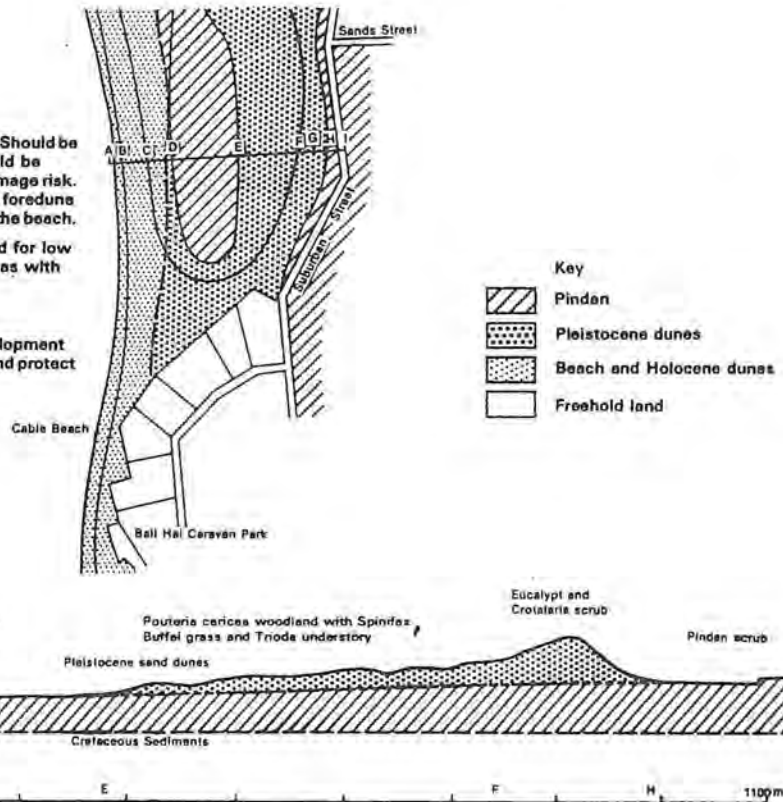


Figure 11. Geology and topography - Upper Cable Beach.

4.7 URBAN DEVELOPMENT

Recommended policy:

- Residential development of coastal land will be limited because few suitable sites are available. Areas may be found near Riddell Beach, or on and around the site of the existing meatworks if it is redeveloped.

4.8 INDUSTRIAL AND COMMERCIAL DEVELOPMENT

Recommended policy:

- Suitably designed, landscaped and located industrial and commercial developments shall only be permitted in the coastal zone if the use is appropriate to the location and if the impact on adjacent management units is acceptable.

4.9 PICNIC AREAS

Recommended policy:

- Areas of parkland and picnic areas will be upgraded or created in parts

of the study area. Such a programme would be a long term project with works occurring as demand arises and funds become available.

4.10 RECREATIONAL USE

Recommended policy:

- . Recreational activities which cause least disturbance to natural ecosystems, tourists and residents will be encouraged while more disruptive activities will not. For example swimming, bird watching, fishing and picnicking will have preference over shooting and the use of ORV's.

4.11 LANDSCAPE MANAGEMENT

The Broome coastal landscape has many valuable components including established vegetation which would be difficult to replace without considerable expense. The value of coastal vistas can be reduced by careless development, but appropriate structures may contribute to the area's character. The maintenance of landscape values will require the adoption of appropriate policies.

Recommended policy:

- . The coast is a visual resource and only developments which are in harmony with the landscape of the coastal zone will be permitted.
- . Trees and shrubs will be planted to provide shade, maintain a tropical atmosphere and improve the amenity of the area. Landscaping of newly developed areas should be in sympathy with the existing townscape.
- . The coastal landscape will be considered in planning all coastal developments. Protecting and improving the coastal landscape around Broome requires analysis of existing scenic areas and features which reduce their appeal.

4.12 SOIL CONSERVATION

Natural soil erosion caused by the wind and the sea has been a major influence in shaping the land forms which exist along the coast today. Man's activities may also produce erosion because the sandy and pindan soils of the area become mobile if the protective vegetation is removed. Erosion degrades the landscape and creates engineering problems when roads become impassable because of drift sands and gullying. When foredunes erode, beach sands become mobile and blow inland, burying the vegetation and man's improvements. In addition when sand is lost from the beach, the beach sand cycle is interrupted, increasing the risk of sea erosion and reducing the area and amenity of the beach.

Where pindan soils erode they muddy and colour the beach and nearby waters, reducing their amenity and recreational values.

Poor soil fertility, relatively low rainfall, high temperatures and the excessive drainage in drift sands makes the revegetation of eroding areas difficult and expensive, therefore the prevention of erosion is important.

Recommended policies:

- . In accordance with the recommendations of the Commissioner of Soil

Conservation, Council will adopt a long term programme to stabilise eroding areas and reduce activities which may contribute to erosion. Some elements of this programme are described below.

- The foredune stabilisation programme which has been undertaken on Cable Beach will continue. This work could be funded by the Community Employment Programme, with assistance from SPC and EPA, or Prison labour may be used.
 - The mining of foredunes will be prohibited because of possible future erosion risk. Quarries should be closed and the pits reshaped and sown with Buffel grass seed at the rate of 4 kg/ha. Seed should be allowed to mature for six months before sowing. It should be sown dry and treated with Lindane to prevent ants harvesting the seed. Fertiliser should be applied in the form of superphosphate at the rate of 100 kg/ha. The seed should be sown on the surface and lightly covered with soil by harrowing or hand raking.
 - . Gravel pits between the Crab Creek Road and Roebuck Bay result in the siltation of beaches and a loss of amenity and mangrove communities. If possible, gravel extraction should be limited to pits further from the coast and existing pits should be stabilised by the reshaping of batter slopes and erosion gullies and sown with Buffel grass as outlined above.
 - . Erosion can usually be prevented if the vegetation cover is maintained, and roads, carparks and beach access systems are well designed and carefully constructed.
 - . When vegetation is removed to allow development, areas of bare soil must be surfaced with gravel or revegetated. Where pedestrians require access from carparks or camping areas to beaches, properly designed beach access systems are required. Normally these will include clearly defined and fenced pathways which protect dune vegetation from trampling. When paths cross sandy slopes they should be surfaced with gravel or a board and chain pathway. On steep slopes steps may be required.
- Fences are best constructed of pine log rails which provide an effective but aesthetically acceptable barrier. Some situations may require a stronger barrier and agricultural type fences may be used.
- . Signs discouraging people from driving vehicles from the beach onto the sand dune system will be erected at selected points along the foreshore.
 - . When private interests develop sites near the coast for tourist purposes they will contribute to the cost of stabilising and protecting the sand dune system.

4.13 FIRE MANAGEMENT

The vegetation of Australia has evolved in the presence of fire, and plants use a variety of strategies to survive burning. Some plants regenerate vegetatively from parts of their roots and stems, while others recover by means of seeds stored on the plant or in the soil. However, sand dune communities recover slowly after fire and the erosion risk is high until the vegetation recovers, which may take several years. The danger of erosion is higher if the area is subject to intensive public use. As a result it is considered that management should attempt to exclude bushfire from the dune areas and if fire does occur it should be confined.

Recommended policies:

The following programme is recommended to reduce the risk of widespread damage by fire.

- . The lighting of fires in coastal management areas should be prohibited except in properly constructed fire places. This prohibition can be facilitated under Section 25 (1a) (1b) and (1c) of the Bush Fires Act.
- . The public education programme should include information concerning the danger of fire in the area, and the responsibilities of people in relation to the lighting of fires.
- . The roads, tracks and carparks in the area can be used as fire breaks, and the appropriate location of fire breaks should be considered when locating roads.
- . The Shire should develop its fire fighting capacity by periodically obtaining and upgrading equipment. Provision should be made for training Council staff in fire fighting techniques, and when appropriate Shire Officers may attend residential training courses provided by the Bush Fires Board.
- . A fire management plan for the Broome townsite should be prepared in cooperation with the Bush Fires Board and surrounding landholders. The plan should specifically exclude burning off in the foreshore reserves under the provisions of Section 21 of the Bush Fires Act.

4.14 WILDLIFE MANAGEMENT AND RESEARCH

As outlined in Section 3 the Broome district supports wildlife habitats of international, national and regional significance and important commercial fish stocks. Further research is required before the life history and requirements of these animals can be described adequately.

People can assist by not disturbing the important wading bird populations which use the district each year. This can be achieved by retaining natural vegetation cover between coastal roads and the beach, and by limiting public access to areas frequently inhabited by the birds.

Recommendations:

- . That Council develop a coastal access system which will minimise the disturbance of wading birds.

4.15 SHELLFISH

The status of shellfish populations is of concern, and more information is required before positive management proposals can be made.

Recommended policies:

- . Council and CALM will endeavour to arrange research to determine the number of commercial and amateur collectors, their methods and timing, location of collection sites and species involved.
- . That Council, CALM, and WA Museum investigate the impact of shell collecting on mollusc populations.

- . Advice will be sought from CALM and the WA Museum about the feasibility of establishing marine reserves as shown on Map 6.

4.16 WASTE AND GARBAGE DISPOSAL

The presence of rubbish litter and liquid wastes reduces the amenity of coastal areas. Council will continue to upgrade services required to control these problems.

Recommended policies:

- . A system of garbage collection and waste disposal will be developed to ensure that litter and pollution of resources is minimised.
- . Solid waste disposal sites should be located away from preservation and management units and away from water courses.

4.17 EFFLUENT DISPOSAL

Domestic and industrial effluents should not be discharged directly into the Preservation Unit, but collected and treated in an appropriate manner before disposal.

Recommended policies:

- . All effluent discharge points will be identified by Council and information about the volume and content of effluents collected.
- . A programme will be developed to progressively connect all effluent outfalls to the town sewerage system.

4.18 STORM WATER DRAINAGE

Careful planning will be required to dispose of the increased volume of storm water associated with new residential developments on the western and southern sides of the townsite. It is probable that given careful design, the disposal of stormwater in the vicinity of Gupungi Road can be compatible with the conservation of valuable plant associations in that area.

Recommendation policies:

- . That Council undertake thorough engineering and environmental investigations before finalising plans for the drainage of the Broome Townsite.

4.19 CONSERVATION

Preservation units will be set aside to preserve and conserve natural flora and fauna for their environmental, scientific, commercial or recreational values.

Where possible, preservation units will be set within a buffer zone or management unit. Areas warranting special preservation are shown on Map 10.

Recommended policies:

- . That Council approach the Minister for Lands seeking his approval to create reserves over areas of special value and which should then be vested in appropriate agencies.

4.20 PUBLIC EDUCATION

The Council's public education programme could be part of a wider proposal for the region, the objectives being to guide visitors, interpret the natural features and to influence the behaviour of people.

Recommended policies:

- . With assistance from SPC and EPA, Council will inform local residents and visitors about the natural and man-made attractions of the district, and how to use them in an appropriate manner.
- . With assistance from SPC and EPA, Council will prepare a pamphlet containing details of roads, paths, boat launching areas, fishing spots, caravan parks, beaches, wildlife and picnic areas, cultural and natural attractions; the pamphlet should also contain information about the proper use of vehicles and boats in the district.
- . Council will encourage the Shire Ranger to develop his interpretive skills to assist in his public education role.
- . There should be continuing contact between Shire staff and the public.

4.21 MANGROVES

The mangrove communities are recognised as important coastal resources worthy of conservation.

Recommended policies:

- . Disposal of wastes (liquid and solid), quarrying and clearing of vegetation will be avoided in the mangals and adjacent tidal flats.
- . Where possible increased discharge of stormwater into Dampier Creek tidal flat will also be avoided.
- . Care will be taken to ensure that land uses adjacent to mangrove communities will not be incompatible with the mangrove environment.

4.22 BROOME TOWNSITE, OFF-SHORE WATERS MANAGEMENT

The waters of Roebuck Bay are used by commercial and amateur fishing boat owners, yachtsmen and anglers and bathers. This multiple use can create user conflicts between boat owners and bathers at Town Beach, and use should be rationalised at that point.

Recommended policies:

- . That separate zones for swimmers and boat users be established at Town Beach, with bathers using the southern half of the beach and boat owners the northern half. This can be achieved by using the Navigable Waters Regulations, of the West Australian Marine Act.

5. COASTAL MANAGEMENT AREAS

Town planning Schemes 2⁽³⁵⁾ and 3⁽³⁶⁾ refer to coastal management areas as shown on Map 3. The scheme texts state that Council prepare or have prepared policies for each area.

5.1 COASTAL MANAGEMENT AREA 1

Coastal management area 1, which is shown on Map 3, covers Cable Beach south of Bali Hai. The major feature is a long white sandy beach which links two basement outcrops at Gantheaume Point and Bali Hai and is backed by partly vegetated and stabilised transgressive dunes. The beach is popular with residents and tourists and pressure for access to all parts of the beach is increasing. Near Bali Hai subdivision of coastal land has been allowed for a caravan park, recreation camp and for private residential and horticultural purposes. To the south legal and illegal horse-training facilities lie adjacent to the dunes. A coast-parallel road skirts the inland margin of the dunes for the length of the beach. The pindan plain, which is generally obscured beneath the dunes, protrudes at Bali Hai and near Gantheaume Point.

As Cable Beach is one of the major tourist attractions at Broome, pressure for more accommodation and access to the beach has increased. The land south of Bali Hai is suitable for carparks and beach access as is similar land at the southern extremity. The pindan adjacent and inland of the dunes is well vegetated and is suitable for camping, botanical gardens and picnic sites. Playing fields on this land would provide a buffer between the residential development and the dunes.

Maps 7 - 10 show existing roads, land tenure, use and zoning with proposed land classification, roads, tracks, carparks and pedestrian access points, land tenure and zoning.

The dune system and immediate hinterland support important vine thicket vegetation, as described in Section 2.3.1.8 which requires protection. The vine thickets in this area occur because the natural drainage system on the western side of the Peninsula concentrates water in this area. The careful design of the drainage system servicing future subdivision can ensure that storm water disposal is compatible with environmental protection.

Recommended policies:

- . Council will approach the Minister for Lands seeking the establishment of:
 - a B class reserve for Recreation and Foreshore Protection purposes as shown on Map 11;
 - a B class reserve for Recreation, Drainage and the Protection of the Environment purposes as shown on Map 11; and
 - a C class reserve for Coastal Management purposes.
- . The Department of Land Administration will consider a more appropriate alignment for Gupingi Road as town planning for the area advances.
- . The Department of Land Administration and Council will consider the relocation of Reserve 33275 for Horse Stable purposes to a site immediately north of the racecourse or within the racecourse reserve, as development of that area occurs.
- . Council and the Department of Land Administration will downgrade the Gantheaume Point loop road when developing the area.

- . Council will upgrade the drainage system which discharges onto Cable Beach near Bali Hai and rehabilitate the surrounding area, as resources become available.
- . Council will prohibit quarrying at Hill 2 and other areas in the dune system.
- . Council will consider mechanisms which may enhance the rate at which storm water infiltrates into the dune system near the corner of Cable Beach and Gupungi Roads.
- . Council will rehabilitate the foredune system as resources become available.
- . Council will provide car parking and beach access paths as the need arises.
- . Council will prohibit illegal camping and shack construction.
- . Council will prohibit rubbish dumping.
- . Council will prohibit the lighting of fires and other damage to the natural vegetation without a permit.
- . Council will control the activities of off-road vehicles.

5.2 COASTAL MANAGEMENT AREA 2

Coastal management area 2 which is shown on Map 3, covers Gantheaume Point where the coast comprises a cliffed pindan plain that is fronted by basement platforms of various widths. At high tide the red cliffs contrast with the deep turquoise waters while at spring low tide 130 million year old dinosaur footprints are exposed. The coast provides attractive lookout points. The hinterland comprises a race course reserve. The lands on either side of the loop road are a recreation reserve that has been downgraded due to quarrying for laterite and pedestrian pressure around the point. The coastal lands in this area which have access to the southern end of Cable Beach and to Riddell Beach, as well as potential for coastal walks, will come under pressure as a result of increased tourism and a requirement for new coastal accommodation. Maps 7 -10 show existing roads, tracks, tenure and zoning, as well as proposed land units, roads, tracks, carparks, pedestrian access points, foreshore reserves, tenure and zoning.

Recommended policies:

- . Council will approach the Minister for Lands seeking vesting of reserve 19289 in Council as a B class reserve for Recreation and Foreshore Protection purposes.
- . Council and the Department of Land Administration will downgrade the Gantheaume Point Loop Road to a tourist access road when the road system in the area is being developed.
- . Council will reshape and rehabilitate quarried areas as resources become available.

- . Council, the Department of Land Administration and the Broome Turf Club will consider relocating the facilities situated on the western side of the course if a major tourist development is to be constructed in the vicinity of lot 1194.
- . Council will repair the model dinosaur's footprint and arrange to develop interpretive material to improve its value for education and tourism.

5.3 COASTAL MANAGEMENT AREA 3

Coastal management area 3, which is shown on Map 3, takes in the coast around the Broome township. Major features include a belt of tidal flats and mangroves near the entrance to Dampier Creek, a coarse sandy beach that fronts a low pindan cliff along most of the coast and a large dune and lookout hill. The pindan hinterland is generally lowlying (less than 10 m) and is subject to flooding in places. The entire coastline is subject to cyclonic winds, waves and storm surge and is eroding naturally as described in Section 2.2.4. Consequently coastal management area 3 provides an important buffer zone for the town, against waves and storm surge. Most of the near coastal land has been developed for residential, commercial, industrial, quarrying, parkland, caravan park and motels purposes.

Currently the coastal strip that extends from the meat works in the south to the intersection of Napier Terrace in the north comprises freehold and vacant Crown land, and a number of reserves between Dampier Terrace and Roebuck Bay. While landscaping has occurred in some locations, this piece of foreshore, which is valuable both as a buffer against storm attack and a recreational resource, is generally neglected and detracts from the appearance of the town. The narrow, coarse sandy beach that exists at high tide level has been buried at a number of sites by earthworks and the mangroves have been cleared and degraded.

As well as providing protection the Dampier Terrace esplanade could be made much more useful to local people, including children, and more attractive to tourists by a modest programme of improvements.

Maps 7 - 10 show existing roads, land tenure, use and zoning with proposed land classification, roads, carparks, and pedestrian access points.

Recommended policies:

- . Council will approach the Minister for Lands seeking the establishment of a B class reserve for Recreation and Foreshore Protection as shown on Map 11.
- . Council will approach the Minister for Lands and request that he vest reserve 1643 in the Shire of Broome.
- . Council will continue its programme of landscaping and foreshore improvement (Figure 12 and Map 12).
- . Council will ensure that the problems associated with shoreline recession and storm surge are considered before approving any development in coastal management area 3.
- . Council will rehabilitate the sand dune quarry immediately south of the meatworks as resources become available.

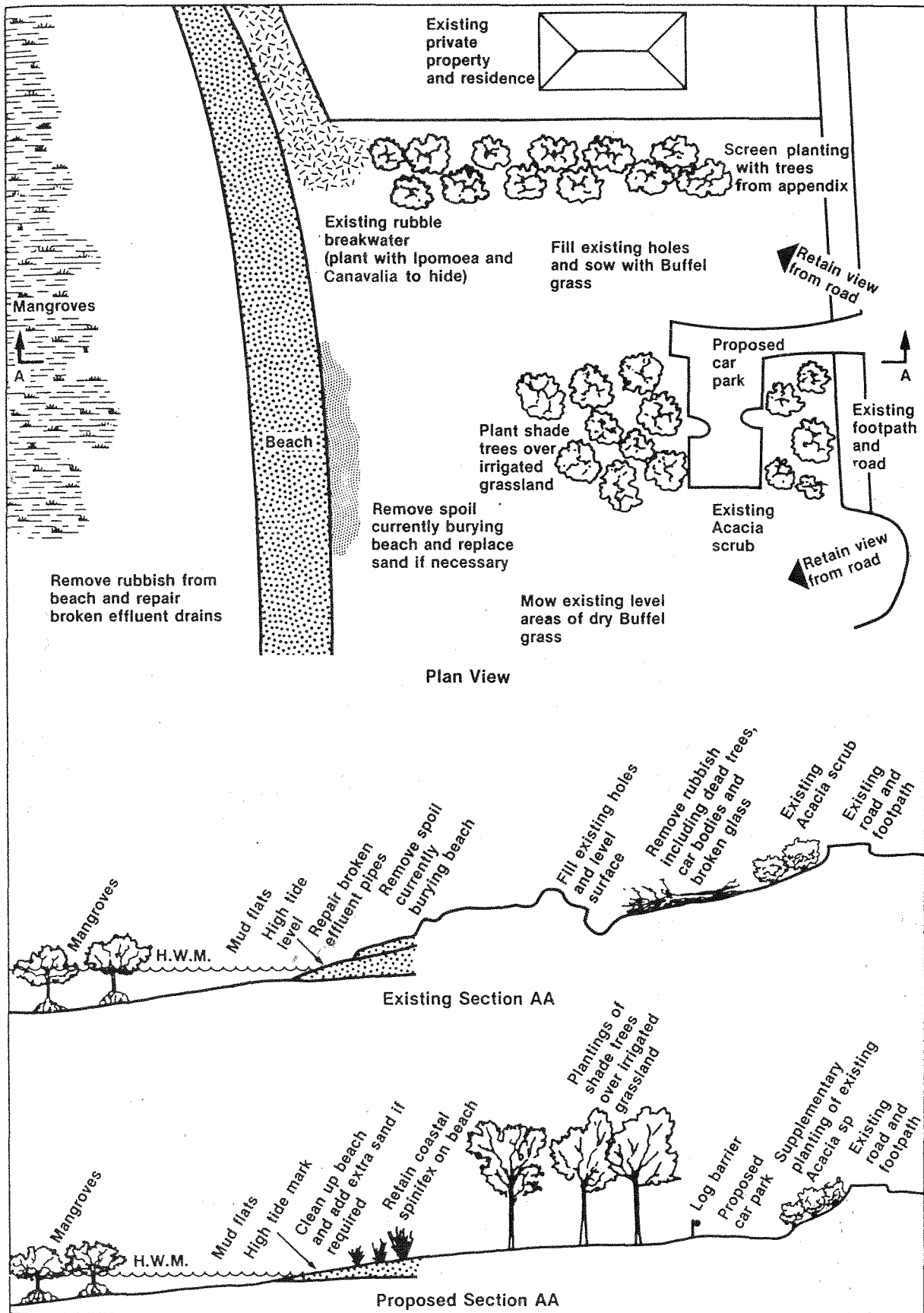
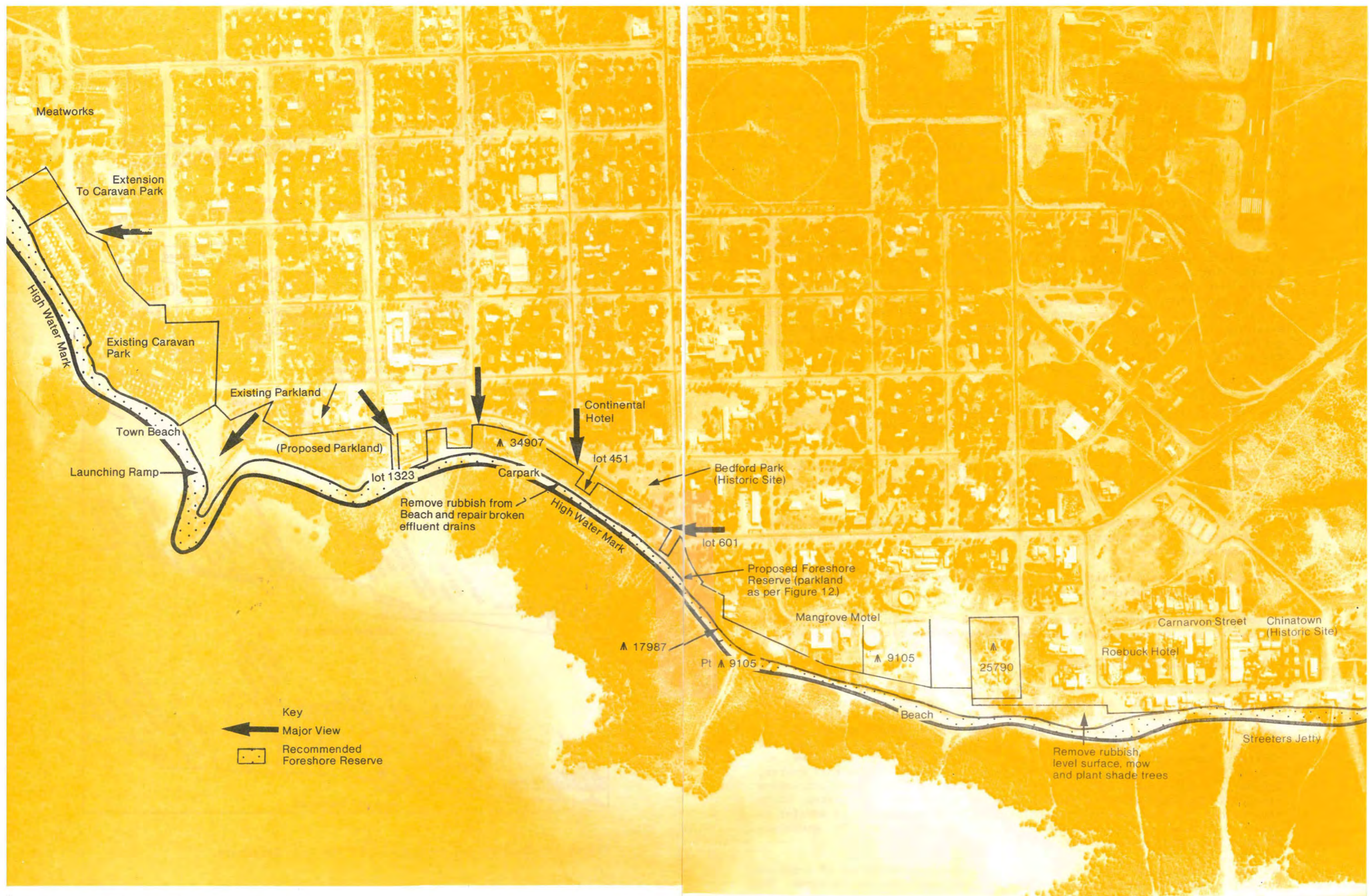


Figure 12. Recommended development of the town foreshore.



Map 12. Aerial Photograph - Broome Town Foreshore

5.4 COASTAL MANAGEMENT AREA 4

Coastal management area 4, shown on Map 3 covers Riddell Beach. The major features are red pindan coastal cliffs and two shallow bays linking basement outcrops at Gantheaume, Riddell and Entrance Points. Sandy beaches which front the pindan cliffs are generally narrow and red-stained, though a white sandy beach backed by a foredune does exist in front of the children's hostel. Dunes perched on top of the pindan cliffs south of the hostel reserve have been quarried in the past disturbing vegetation and providing random access to the beach. The beaches provide an important summertime roosting habitat for migrant waders. Near Riddell Point the coast road runs very close to a steep though stabilised dune. Further west the road runs approximately 100 m inland. The coastal strip includes vacant Crown land and several small reserves vested in charitable organisations. To the north, subdivision of the hinterland has been approved though development has not taken place as yet. Because the coast is relatively stable the area could provide opportunity for appropriate development; it is adjacent to the beach and is not far from Cable Beach. Map 11 shows existing roads, land tenure, use and zoning with proposed land classification, roads, tracks, car parks and pedestrian access points, land tenure and zoning.

Recommended policies:

- . Council will approach the Minister for Lands seeking establishment of a B class reserve for Recreation and Foreshore Protection purposes as shown on Map 11.
- . Council and the Department of Land Administration will consider the realignment of Kavite road as shown on Map 11 when proceeding with development and subdivision near Riddell Beach.
- . Council will undertake the rehabilitation of dunes which have been degraded by past quarrying and off-road vehicle activity, as resources become available.
- . Council will limit access to the eastern end of Riddell Beach to protect wading bird populations using the area.
- . Council will reconsider altering the zoning of land in the Riddell Beach area to provide for residential and holiday accommodation developments.

5.5 COASTAL MANAGEMENT AREA 5

Coastal Management Area 5, shown on Map 3 covers the coastal strip between the Broome meatworks and the Harbour reserve. The major features are the gently curved bay linking basement outcrops near Entrance Point and the Roebuck Bay caravan park, backed by steep pindan cliffs between two and five metres high, and a high system of sand dunes which get lower and narrower toward the north. The beach is muddy and not very attractive, and access to the foreshore is limited by the existence of the golf course, industrial developments and the steep nature of the dunes. Most attractive views of Roebuck Bay are available from the top of the dune system. While the Pindan cliff is receding as outlined in Section 2.1.4, wind erosion is not a serious problem because the dune system generally comprises Pleistocene sands which are relatively stable.

Generally, the area is vacant Crown land with the exception of a narrow foreshore reserve along a portion of the coast near the cattle yards. The

Port Road lies between 500 and 1 000 metres inland, but development has been limited to construction of the golf course, the cattle yards and the sand quarry which are located immediately to the west of coastal management area 5. A holiday resort will also be developed immediately south of the golf course and similar land exists in the vicinity, although its development would require rezoning and some soil stabilisation works.

Recommended policies:

- . Council will approach the Minister for Lands seeking the establishment of a B class reserve for Recreation and Foreshore Protection purposes as shown on Map 11.
- . Council and the Department of Land Administration will ensure that any developer using land immediately west of coastal management area 5 will undertake adequate coastal management works.

5.6 COASTAL MANAGEMENT AREA 6

Coastal management area 6, shown on Map 3, includes Cable Beach between Bali Hai and Willies Creek and the associated dune system. The major features of this area are the continuation of the sandy beach, a wide zone of mostly vegetated sand dunes and a broken chain of nearshore limestone reefs. Further north near Waterbank Station the hinterland comprises an abandoned tidal flat.

Roads are limited to Lullfitz Drive near Bali Hai and McGuigan Road near Coconut Wells. At present vehicles are allowed on the beach north of Bali Hai and can also obtain beach access at Coconut Well and Willies Creek. Vehicles on the heavily used areas of the beach create some safety problems and reduce the amenity of the area (Photograph 16).



Photograph 16. Off-road vehicle tracks - Cable Beach.

The area contains a development opportunity in the vicinity known as Hidden Valley. Here the beach is wide and sandy with subdued and well vegetated dunes. In addition a window of pindan which forms the bottom of a coast parallel hollow provides a protected and safe-site for development (see Figure 11 and Photograph 17). With careful planning and management, the southern portion could be developed into a tourist and medium density residential node.

The area also provides a potential site to construct a road to the beach giving vehicular access to Cable Beach north of the most popular bathing areas.

Recommended policies:

- . Council will approach the Minister for Lands seeking the establishment of a B class reserve for Recreation and Foreshore Protection purposes as shown on Map 11.
- . Council will implement a dune stabilisation programme as resources become available.
- . Council will zone beach use to avoid conflict between various activities including bathers, nude bathers, dog owners and off-road vehicles.
- . Council will control the movements of off-road vehicles.
- . Council will construct a road to Cable Beach from the northern end of Suburban Road when resources become available, as shown on Map 11 and Lullfitz Road.
- . Council and the Department of Land Administration will consider rezoning the area of Hidden Valley for tourist development as shown on Map 11.



Photograph 17. Hidden Valley.

5.7 COASTAL MANAGEMENT AREA 7

Coastal management area 7, shown on Map 3, comprises the coast between Dampier Creek and Crab Creek. Major features are Dampier Creek tidal flat and mangroves, a broken but generally straight coast of pindan cliffs fronted by narrow pindan-stained beaches terminating in a narrow curved sandy spit at Crab Creek, and a large supratidal tidal flat and mangrove system.

Dampier Creek is utilised at present as a lugger harbour and much of the cliff coast has been quarried for laterite. The rest of the coast is frequently used by illegal campers, squatters and other visitors. There has been no development of coastal land apart from the area around the western margin of Dampier Creek. Access is provided by a coast parallel track which is within metres of the cliff top in some places, and drainage from the road causes erosion.

The coast has two habitats vital to the ecosystem, Dampier Creek and Crab Creek, while the sandy beaches are important for migrant waders. There appears to be limited opportunity for tourist development due to the lack of sandy beach though the pindan hinterland would provide a safe site for near coastal developments. The land east of Dampier Creek is at present reserved for the use and benefit of Aborigines.

Recommended policies:

- . Council and CALM will approach the Minister for Lands seeking the establishment of a reserve for Recreation and the Conservation of Flora and Fauna, which would be managed by both authorities in cooperation.
- . Council will rationalise the laterite quarrying operations along the coast and rehabilitate existing pits as funds become available.
- . Council will realign the Crab Creek Road as resources become available. The new alignment will be about 70-100 metres from the cliff coming closer in places to obtain occasional access to the beach and views. Care will be required to ensure drainage design for the road does not result in further erosion of the cliff.
- . Council and the Royal Australian Ornithologists Union will cooperate in the selection of a site for the Union's proposed field station.
- . Council will prohibit illegal camping and shack construction.
- . Council will control the movements of off-road vehicles.
- . Council will close off all tracks around Dampier Creek tidal flat to ensure protection of the tidal flat and mangrove system.
- . Council will construct a formalised carpark and access track to the sandy beach at Crab Creek when resources become available.
- . Council will close off access tracks along parts of the coast that are important to the migrant waders.

5.8 PORT AREA

Although not included in the Town Planning Scheme, management recommendations for the port area should be included in this plan. The port area includes a rocky and cliffed coast with a 24 m high sand dune (Beacon Hill). The rocky coast near Entrance Point offers a good boat launching site, while the coast and wharf are popular fishing spots. The area has been extensively modified during construction of the grain terminal and other harbour-related storage facilities. Further north the land is flat apart from the dune belts along both the Riddell and Roebuck coasts. Although it is expected that harbour works require extensive modification of landscapes there is no need to affect the coastal landscape. In addition harbour works can suffer from natural processes that lead to continual maintenance. Map 10 shows existing roads in the harbour area as well as proposed land classification, roads and tracks and pedestrian access points.

Recommended policies:

- . Closure of Kavite Road and closure of the southern extremity of the road which provides access to the southern end of Riddell Beach.
- . Provide access to and upgrading of Entrance Point boat launching site.
- . Provide suitable reserves for lead lights and, other port facilities outside the port reserve.
- . Better control of surface drainage.
- . Protect and manage the foreshores reserve on the southern side of the Harbour reserve.

6. PROPOSED RESEARCH

It is clear from this report that there is much to learn about the natural environment at Broome. From experience and results of studies elsewhere, parallels between Broome and other environments can be drawn that enable management decisions to be made. Further research will probably not change the direction of management but may change emphasis and priority. Management proposals on protecting the integrity of the dune/vegetation system, mangrove/tidal flats system, wading bird habitats, have been made in the light of existing knowledge. In order to refine management techniques further research into the effects of shellfish collecting, drainage discharge into mangroves and protection of wading bird habitats is warranted if funds can be found. Of more immediate concern to Broome is the status of Cable Beach which, as previously mentioned, is probably a temporary and fragile anomaly. Establishing how temporary and how fragile in the light of its tourist potential appears to be a priority.

Recommended Research Priorities:

- . To establish the bedrock and pindan profile beneath Cable Beach and its immediate hinterland. This can be done by hand or power drilling and will enable an estimate of the thickness and volume of Holocene sands and the proximity of a pindan cliff, if any, behind the beach. Hopefully, the Holocene sands will prove to be thick and the pindan well covered. If total sediments are inadequate, work required to conserve existing sand stocks should become a priority.

- The amount of sand offshore which is still available to come onshore can be estimated by grab sampling and seabed coring (SCUBA and slip hammer). This would give some idea of the potential for natural sand renourishment for south Cable Beach.

An estimation of longshore transport on Cable Beach could be made by drilling and dating the beach ridges at Willies Creek. If the dating is successful the volume of sand in the ridges can be estimated and the rate of accumulation of sand calculated. This will put the volume of sand at south Cable Beach into perspective in relation to annual rates of transport to the north. If this research is carried out, a quantitative estimate of the sediment transport budget will be possible. This should give a good idea of the potential 'stability' and 'length of life' of Cable Beach.

The rate of erosion of the pindan cliffs around the coast should be measured to determine the actual range of erosion rates of the pindan cliffs at a variety of locations around the coast. This information will assist in making sound planning decisions about near coast development.

7. IMPLEMENTATION

The implementation of the recommendations in this plan is primarily the responsibility of the Shire of Broome, but assistance is available from a number of sources.

7.1 ROLES OF STATE AND LOCAL GOVERNMENT

As set out in the Government Position Paper on Coastal Management⁽³⁷⁾, the State Government is committed to sound planning and management of the WA coast. A Coastal Management Coordinating Committee has been set up and its functions are outlined in the position paper. Various government authorities can provide advice and financial assistance for management of the coast.

Coastal management plans are generally prepared by or in conjunction with the local authority who can provide and coordinate local public participation. Local authorities can fulfil an important role in the management of coastal lands if they are given technical and financial assistance. Often the local authority has local knowledge, equipment on site, an existing land management role, and an established liaison with State government departments. One of the important aims of this plan has been to provide a guide to potential uses of various land areas and to recommend management strategies in the coastal zone so that the Broome Shire Council can more effectively manage land under its jurisdiction.

7.2 FUNDING

Finance is required to implement land management programmes. Currently much of this cost is being borne by the Shire, with occasional assistance from State government departments. The Coastal Management Coordinating Committee will be able to coordinate applications for finance through various government departments so that adequate and long term funding can be ensured.

While recommendations which require funding for their implementation must be delayed pending budgetary decisions, those which only involve administrative action can be implemented relatively quickly.

In the present climate of tourist promotion and unemployment relief, the two bodies that should be approached immediately are the Western Australian Tourism Commission and the Commonwealth Department of Labour and Industry. Other State government departments that do provide grants include: the Department of Sport and Recreation (community sport and recreation facilities fund); Main Roads Department (tourist road grants); SPC (beach management grants); Department of Agriculture (soil conservation grants); Marine and Harbours (foreshore and erosion repair grants). As mentioned in the introduction to this report, experience indicates that applications for funding are likely to be more successful if presented in the context of a long term management plan. The fact that a coastal management plan has been prepared and accepted by Council should assist these agencies in making funds available.

7.3 CROWN LAND VESTING

Implementation of this plan would require changes to the vesting of many areas of Crown land which is outlined in various recommendations, and Council will approach the Minister for Lands about recommendations in Section 5.

7.4 TOWN PLANNING SCHEME AMENDMENTS

The implementation of many of the recommendations in this report will require amendments to the Shire of Broome's Town Planning Schemes 2⁽³⁸⁾ and 3⁽³⁹⁾. Council will approach the Department of Land Administration and their Town Planning Consultants and request that they consider this report when preparing amendments to the schemes or when preparing new schemes.

8. REFERENCES

1. Taylor and Burrell (1982), Shire of Broome Preliminary Town Planning Scheme No 2, Taylor and Burrell, Perth, Western Australia.
2. Taylor and Burrell (1983), Shire of Broome, Preliminary Town Planning Scheme No 3, Taylor and Burrell, Perth, Western Australia.
3. Chalmers, C E and Woods, P J (1984), Draft Coastal Management Plan Shire of Broome, Department of Conservation and Environment, Perth, Western Australia.
4. Taylor and Burrell (1985a), Shire of Broome Town Planning Scheme No 2, Taylor and Burrell, Perth, Western Australia.
5. Taylor and Burrell (1985b), Shire of Broome Town Planning Scheme No 3, Taylor and Burrell, Perth, Western Australia.
6. Western Australia Department of Tourism (1981), Kimberley Regional Tourism Survey, Department of Tourism, Perth, Western Australia.
7. Western Australia Department of Tourism (1982), Caravan Parks Survey of North Western Australia, Department of Tourism, Perth, Western Australia.
8. Chalmers and Woods, op cit.
9. Taylor and Burrell (1985a), op cit.
10. Taylor and Burrell (1985b), op cit.
11. Richards, D and O (1983), Gardens and Trees in the Kimberley, Western Australia, National Trust of Australia (WA), (unpublished).
12. Fox, J J (1977), Harvest of the Palm: Ecological Change in Eastern Australia, Harvard University Press.
13. Hearne, D A (1975), Trees for Darwin and Northern Australia, AGPS, Canberra.
14. Stace, H C T, Hubble, G D, Brewer, R, Northcote, K M, Sleeman, J R, Mulcahy, M J and Hallsworth, E G (1968), A Handbook of Australian Soils, Rillim Technical Publications, Glenside, South Australia.
15. McKenzie, N L and Kenneally, K F (1983), Background and Environment in N L McKenzie, 'Wildlife of the Dampier Peninsula, South-west Kimberley, Western Australia', Wildlife Research Bulletin No 11, Department of Fisheries and Wildlife, Perth, Western Australia.
16. Craig, G F (1983), Pilbara Coastal Flora, Department of Agriculture, Perth, Western Australia.
17. Speck, N H, Wright, R L, Rutherford, G K, Fitzgerald, K, Thomas, F, Arnold, J M, Basinski, J J, Fitzpatrick, E A, Lazarides, M and Perry, R A (1964), General Report on Lands of the Western Kimberley Area, WA, Land Research Series No 9, CSIRO, Melbourne.

18. Craig (1983), op cit.
19. McKenzie and Kenneally (1983), op cit.
20. Craigh (1983), op cit.
21. Ibid.
22. McKenzie and Kenneally (1983), op cit.
23. Ibid.
24. Ibid.
25. Ibid.
26. Ibid.
27. Semeniuk, V, Kenneally, K F and Wilson, P G (1978), Mangroves of Western Australia, WA Naturalists Club, Perth, Western Australia, p 2.
28. Semeniuk et al, op cit, p 5.
29. Ibid.
30. Semeniuk, et al, op cit.
31. George, R W and Jones, D S (1982), A Revision of the Fiddler Crabs of Australia (Ocypodinae : Uca), Records of the WA Museum, Supplement No 14, Perth, Western Australia.
32. Ibid.
33. Western Australia, Department of Tourism (1981), op cit.
34. Taylor and Burrell (1985a), op cit.
35. Ibid.
36. Taylor and Burrell (1985b), op cit.
37. Western Australia, Department of Premier and Cabinet, Coastal Planning in Western Australia, A Government Position Paper, Department of Premier and Cabinet, Perth, Western Australia.
38. Taylor and Burrell (1985a), op cit.
39. Taylor and Burrell (1985b), op cit.

APPENDICES

PLANTS SUITABLE FOR ORNAMENTAL PLANTING IN BROOME

SHRUBS

Cassia species: shrubs from 1 m to 3 m all bushy with yellow flowers, hardy, and quick growing, five different species.

Acacia species: wattles all northern native shrubs from 2 m to 4 m, drought resistant, lemon, white and yellow flowering, 15 different species.

CLIMBERS AND GROUND COVERS

Ipomoea brasiliensis, used as a ground cover or climber, mauve flowers.

FRUITING TREES AND SHRUBS

Anacardium occidentale: cashew nut tree. Ornamental tree with an edible vitamin filled apple; the nut is toxic until treated, hardy salt tolerant to 12 m.

ORNAMENTAL SHADE TREES

Alstonia scholaris cheesewood ornamental shade tree to 12 m.

Brachychiton paradoxum Kimberley kurrajong, red flowers, tree to 8 m.

B gregorii, desert kurrajong, attractive.

B trichosiphon kurrajong.

Calophyllum inophyllum Indian oil nut tree.

Cassia fistula golden shower.

Casuarina equisetifolia sheoak.

Instia bijuga Moluccan ironwood.

Melaleuca leucadendron paperbark tree.

Terminalia arostrata weeping nutwood.

T petiolaris native blackberry.

T species.

WILDLIFE FOUND ON MUDFLATS AND REEFS, AND MANGROVES

WADING BIRDS FOUND ON MUDFLATS AND REEFS

Beach Thick-knee	Greytailed Tattler
Pied Oystercatcher	Common Sandpiper
Sooty Oystercatcher	Greenshank
Grey Plover	Terek Sandpiper
Lesser Golden Plover	Blacktailed Godwit
Mongolian Plover	Bartailed Godwit
Large Sand Plover	Red Knot
Oriental Plover	Great Knot
Redcapped Plover	Sharptailed Sandpiper
Blackwinged Stilt	Rednecked Stint
Ruddy Turnstone	Curlew Sandpiper
Eastern Curlew	Sanderling
Whimbrel	

ANIMAL SPECIES FOUND IN MANGROVES

MAMMALS

<i>Trichosurus arnhemensis</i>	Northern brush possum
<i>Pteropus scapulatus</i>	Red Flying-fox
<i>P alecto</i>	Black Flying fox
<i>Taphozous flaviventus</i>	Yellow-Bellied bat
<i>Chaerephon jobensis</i>	Northern Mastiff-bat
<i>Mormopteru loriae*</i>	
<i>Chalinolobus nigrogriseus</i>	Hoary Bay
<i>Scotorepens greyi</i>	Little Broad-nosed Bat
<i>Nyctophilus arnhemensis</i>	Long-eared Bat

BIRDS

Mangrove Heron*	Mangrove Grey Fantail*
Sacred Ibis	Broad-billed Flycatcher*
Osprey	Mangrove Flyeater*
Brahminy Kite	Dusky Flyeater*
Little Tern	Variegated Fairy-wren
Bar Shouldered Dove	
Sacred Kingfisher	Brown Honeyeater
Mangrove Kingfisher*	Red-headed Honeyeater*
Mangrove Golden Whistler*	Little Friar Bird*
	White-Breasted Wood Swallow

* range limited to mangroves.

FIDDLER CRABS, *UCA* SPECIES, FOUND IN ROEBUCK BAY

U capricornis
U elegans
U pavo
U flammula
U hirsutimanus
U seismella
U polita
U dampieri
U mjobergi

TYPICAL CARPARK DESIGN

